LASER COMMUNICATION EXPERIMENT

N73-31471

(NASA-CR-132805) LASER COMMUNICATION EXPERIMENT. VOLUME 1: DESIGN STUDY REPORT: SPACECRAFT TRANSCEIVER. PART 3: LCE DESIGN (Aerojet-General Corp., Azusa, Calif.) 277 p HC $16.00 CSCL 20E

G3/16

Unclas 14724

DESIGN STUDY REPORT
VOL. I PART 3
SPACECRAFT TRANSCEIVER

CONTRACT NAS5-21072
REPORT NO. 4033

NASA GODDARD SPACE FLIGHT CENTER

JULY 1970

AEROJET GENERAL ELECTRONICS DIVISION - AZUSA, CALIFORNIA

FOREWORD

This report was prepared in conformance with the requirements of NASA Specification S-460-ATS-19, which is GSFC's specification pertaining to the ATS-F experiments, design study, and fabrication. Additional requirements are contained in GSFC specification S-524-P-4C, "10.6 Micron Laser Communications Systems Experiment for ATS-F." This is Part 3 of the three-part Volume I Design Study Report pertaining to the LCE spacecraft transceiver. and contains the LCE design specifications. Part I is a comprehensive, self-contained report of the transceiver design while Part 2 contains the appendices.

Volume II, which will be delivered in late fall of 1970, will cover the remaining elements of the LCE, including the Operational Ground Equipment, Data Acquisition Plan, and Data Processing, Reduction, and Analysis Plan.

AEROJET GENERAL TIRE GENERAL

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CODE IDENT. NO. 70143

AGC-20186 C

RECEIVER SUBSYSTEM, OPTICAL HETERODYNE, 10.6 MICRON

SUPERSEDING:		
AGC-20186B DATE 27 May 1970	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	i	ii	iii	iv	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	PAGE ADDITIONS
	31 July 69																					
A	20 Aug 69	A	A	A		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
B	27 May 70	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	
C	10 Jul 70	C				C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	pages ii, iii & iv deleted

REV LTR	RELEASE DATE	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	App. A
A	20 Aug 69	A															
B	27 May 70	B	B	B	B	B	B	B	B	B	B	B	B	B			B
C	10 Jul 70	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification covers the requirements for the design, fabrication, performance, and testing of a 10.6 Micron Optical Heterodyne Receiver Subsystem for use in a Laser communications system.

1.2 Application.- The Receiver Subsystem, as a part of the Laser Communication Experiment (LCE), will be operating in the ATS-F spacecraft and in a transportable ground station establishing two-way laser communications between the spacecraft and the transportable ground station. The Receiver Subsystem shall be capable of meeting the requirements herein while operating within the spacecraft as well as in the transportable ground station. Modifications required for operation due to the differences in environment shall be held to a minimum.

1.3 Classification.- The Laser Receiver covered herein shall be classified as follows:

Suffix No.	Description	
-1	Flight Model	
-2	Ground Model:	The ground model shall be functionally the same as the flight model except the ground model shall include a means to cryogenically cool the mixer. (See appendix A)

Each classification shall be specified by referencing the specification number and the suffix number for the specific receiver model desired. Example: Furnish a flight model receiver in accordance with AGC-20186-1.

2. APPLICABLE DOCUMENTS

2.1 Unless otherwise specified, the following documents of the exact issue shown forms a part of this specification to the extent specified herein. In the event of conflict between documents referred to herein and the contents of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall apply.

SPECIFICATIONS

NASA Documents

NHB 5300.4 (3A)	Requirements for Soldered Electrical Connections
S-300-P-1	Printed Wiring Boards
S-323-P-10	Connectors, Subminiature, Electrical and Coaxial Contact, for Space Flight Use

Military

MIL-D-1000	Drawing, Engineering and Associated List

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components
AGC-20521	Telemetry and Commands, LCE
AGC-20522	Thermal and Structural Requirements, LCE

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Item Definition.- The 10.6 Micron Receiver Subsystem shall include the following major components:

(a) Mixer Assembly

(b) Preamplifier Assembly

(c) Processor Assembly

3.1.1 Receiver Subsystem Block Diagram.- The Receiver Subsystem shall be in accordance with the Block Diagram as shown in Figure 1A. Figure 1B is for reference only and shows the relationship of the Receiver Subsystem to the Laser Communications Experiment (LCE).

3.1.2 Interface Definition.- The electrical components and voltages affecting the input/output impedances on both sides of the interface electrical connector shall be as shown on Figure 2. The performance and mechanical interfaces shall be in accordance with 3.2.1 and 3.2.3, respectively.

3.2 Characteristics.-

3.2.1 Performance.- The Receiver Subsystem shall be capable of meeting the FM video channel performance requirements specified in Table IA, the acquisition and tracking channel performance requirements specified in Table IB, and the AM video channel performance requirements specified in Table IC while being subjected to any combination of environmental conditions imposed on the operating equipment as specified 3.2.6.1. Demonstration of compliance shall only be required to the extent specified in section 4.0. Performance characteristics shall not be predicated upon the selective use of components or devices of the same part number (mixer of elements excluded).

3.2.1.1 Power.- The Receiver Subsystem shall operate within the voltages and power levels specified in Table II.

why limit ?

TABLE II. Input Power to the Receiver Subsystem

Input Power (Watts Max.)	Operating DC Voltage (Volts)	Current (Milliamperes) (Max)	Ripple at 5 Hz to 1 KHz Total of the Operating Voltage Peak-to-Peak (mv)
1.76	+ 12 ± 0.23	88	15
1.76	- 12 ± 0.23	88	15
0.11	+ 5 ± 0.25	21	300

Table IA. FM Video Channel Performance Requirements

Requirement	Specification
(1) Receiver Video Output: (2 required)	
(a) Level over 1 MHz to 6 MHz	1 volt peak-to-peak ± 0.5 db
(b) Impedance over 1 MHz to 6 MHz	75 ohms, unbalanced, with minimum return loss of 20 db
(2) Preamplifier	
(a) Bandwidth	30 ± 6 MHz, consistent with video distortion and noise requirements
(b) Input saturation	-40 dbm or greater at the input to the mixer assembly
(3) Demodulation Characteristics	
(a) Demodulation sense (at video output)	Increase in positive potential for increase in carrier frequency deviation
(b) Instantaneous bandwidth	Consistent with the video distortion and noise requirements specified herein
(c) Center frequency	30 MHz
(d) Output sensitivity over -72 dbm to -56 dbm carrier input power levels at mixer window at any frequency from 26.0 to 34.0 MHz	Constant within ± 0.3 db
(e) Baseband amplitude - frequency characteristics	see below
(f) Group delay over 12 MHz bandwidth	± 0.7 n sec/MHz slope 0.5 n sec/MHz² parabolic 6.0 n sec peak-to-peak ripple
(g) Demodulation Amplitude	A carrier deviation of ± 4.0 MHz shall produce a 1 volt ± 0.5 db peak-to-peak output signal
(4) Video Distortion and Noise	
(a) Amplitude of the synchronizing signal	Synchronizing pulses shall be 0.29 ± 0.02 volts
(b) Periodic noise (ratio of P-P picture signal amplitude to the P-P noise amplitude)	
1. Power Supply Hum.. (Including the fundamental frequency and low harmonics)	38 db min.
2. Single frequency noise between 1 KHz and 2 MHz.........	62 db min. ≈ 10^{-3} voltage amplitude
3. Single-frequency noise between 2 and 6 MHz............	46 db min.
(5) Automatic Gain Control	
(a) Recovery time (for instantaneous carrier power level changes up to 41 db with respect to Carrier to Noise Ratio (C/N) of -18 db to -6 db)	Receiver automatic gain control shall set the output power to its nominal level ± 1 db within 0.2 seconds and pass amplitude modulation
(b) Telemetry output of the AGC	0 to 5 volts corresponding to a carrier dynamic range of -72 dbm to -56 dbm with an output impedance of 1000 ohm or less. The bandwidth of the telemetry channel shall be 10 Hz at the 3 db points.

(3)(e) Baseband amplitude - frequency characteristics:

Reference Frequency	Design Goal	Minimum Acceptable
1.025 MHz	0 db	0 db
1.0 to 1.840 MHz	± 0.1 db	± 0.25 db
1.840 to 6.0 MHz	± 0.2 db	± 0.4 db

Table IB. Acquisition and Tracking Channel Performance Requirements

(1) **Acquisition**	
(a) Input:	-18 db minimum 1/
(b) Output:	
1. Amplitude:	3.8 ± 1.4 volts
2. Pulse Width:	50 ± 10 milliseconds
3. Rise and Fall Time:	1 millisecond, maximum
(2) **Acquisition Tracking**	
(a) Input:	-19 db to -7db and 1.5% amplitude modulated 2/ -23 db to -11db and 40% amplitude modulated 2/
(b) Output:	0 ± 0.1 volt corresponding to -19 db to -7db 1.5% modulated input, minimum, peak-to-peak with a linear signal of ± 5 volts corresponding to -23db 40% modulated input.
(3) **$2 f_n$ (Acquisition) Signal**	
(a) Input:	-19 db to -7db and 15% amplitude modulated 2/ -23 db to -11db and 70% amplitude modulated 2/
(b) Output:	3.8 ± 1.4 volts
(4) **Operational Tracking**	
(a) Input Signal:	23 db and 1.0% amplitude modulated 2/ 19 db and 15% amplitude modulated 2/
(b) Output Signal:	0 ± 0.1 volt corresponding to 23 db, 1.0% modulated input, minimum, peak-to-peak with a linear signal of ± 5 volts corresponding to 19 db, 15% modulated input

1/ Peak carrier power/rms noise ratio with Gussian shaped signal

2/ Minimum average carrier power/rms noise ratio.

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Table IC. AM Video Channel Performance Requirements

Parameter	Requirement
(1) Receiver Video Output	
(a) Level over 20 Hz to 5 MHz	1 volt peak-to-peak ± 0.5 db
(b) Impedance over 20 Hz to 5 MHz	75 ohms, unbalanced, with minimum return loss of 20 db
(2) Preamplifier	
(a) Bandwidth	30 ± 6 MHz, consistent with video distortion and noise requirements
(b) Input saturation	-40 dbm or greater
(3) Demodulation characteristics	
(a) Demodulation sense	Increase in positive potential for increase in carrier amplitude
(b) Instantaneous bandwidth	Consistent with video distortion and noise requirements specified herein
(c) Center frequency	30 MHz
(d) Output sensitivity (over -72 dbm to -56 dbm carrier input power level at mixer window at a 30 % amplitude modulation and 30 Hz to 5.0 MHz envelope modulation frequencies	Constant within ± 0.3 db.
(e) Baseband amplitude - frequency characteristics	See below
(f) Group delay over 10 MHz bandwidth	± 0.7 nano sec/MHz slope 0.5 nano sec/MHz^2 parabolic 6.0 nano sec peak-to-peak ripple
(g) Demodulation amplitude	A carrier amplitude modulated 30 % shall produce a 1 volt ± 0.5 db peak-to-peak output signal
(4) Video Distortion and Noise	
(a) Amplitude of the synchronizing signal	Synchronizing pulses shall be 0.29 ± 0.02 volts
(b) Noise Periodic noise (ratio of P-P picture signal amplitude to the P-P noise amplitude)	
1. Power supply hum.................... (Including the fundamental frequency and low harmonics)	38 db min.
2. Single frequency noise between 1 KHz and 2 MHz...........................	62 db min.
3. Single-frequency noise between 2 and 5 MHz...............................	46 db min.
(5) Automatic Gain Control	
(a) Recovery time (for instantaneous carrier power level changes up to 41 db with respect to carrier to noise ratio (C/N) of -18 db to -6 db)	Receiver AGC shall set the output power to its nominal level ± 1 db within 0.2 seconds and pass amplitude modulation
(b) Telemetry output (corresponding to input carrier level -72 dbm to -86 dbm)	Range 0 to 5 volts Bandwidth: Zero to 10 Hz at 3 db point Output Impedance: 1 Kohm or less

(3)(e) Baseband amplitude - frequency characteristics:

Reference Frequency	Design Goal	Minimum Acceptable
25 KHz	0 db	0 db
20 Hz to 840 KHz	± 0.1 db	± 0.25 db
840 KHz to 5.0 MHz	± 0.2 db	± 0.4 db

3.2.1.2 Commands.- The Commands to the receiver subsystem, if required, shall have the characteristics shown in Table III. The commands are specified in detail in AGC-20521.

Table III. Receiver Subsystem Commands

Command	Type
(If commands are required, they shall be added herein at a later date.)	

NOTE: Discrete commands shall have voltage levels of 0.0 V ± 0.5 V for logic zero, 5.0 V ± 0.5 V for logic one. The duration shall be 50 ± 5 msec. The rise and fall times shall be less than 3 msec between 10% and 90% amplitude levels. Source impedance shall be less than 1000 ohms.

3.2.1.3 Telemetry data.- Telemetry monitoring outputs shall be isolated from operating outputs so that a shorted or open circuit in the telemetry function will not cause the operating function to perform out of specification limits. Telemetry functions shall be as shown in Table IV (reference AGC-20521).

TABLE IV. Analog Telemetry Outputs

SIGNAL	UNITS	RANGE		BDWTH	RESOLUTION	OUTPUT IMPEDANCE
		Min	Max			
AGC	Volts	0	5	10 Hz	0.5%	< 1 K ohm
Mixer Bias Current	Volts/ Milliampers	0	5	0.1 Hz	1%	< 1 K ohm
AFC Error	Volts	0	5	1 Hz	1%	< 1 K ohm

3.2.2 Useful life.-

3.2.2.1 Operating life.- The operational life of the Receiver Subsystem shall be 2,000 hours with the operating periods equally distributed within the two year period. A minimum of 500 power-on/power-off cycles and operating periods of up to 24 hours over a two year period in a space environment shall be possible without degradation of the requirements specified herein. The Receiver Subsystem shall be considered in operation when it is performing one or more of its functions.

3.2.2.2 Shelf life.- The Receiver Subsystem shall be capable of meeting the operating life of 3.2.2.1 after a shelf life of greater than one year when packaged and stored in a protective enclosure.

3.2.3 Physical characteristics.-

3.2.3.1 Weight.- The weight of the Receiver Subsystem shall be a minimum consistent with the required performance, but shall not exceed a total weight of 3.5 pounds.

3.2.3.2 Envelope dimensions.- The Receiver Subsystem Envelope dimensions shall be as follows:

(a) The Mixer Assembly (Flight Configuration) shall comply with the envelope dimensions shown in Figure 3.

(b) The Preamplifier Mixer Assembly shall comply with the envelope dimensions shown in Figure 4.

(c) The Processor Assembly shall comply with the envelope dimensions shown in Figure 5.

3.2.3.3 Center of gravity.- The center of gravity for the envelopes shown in Figures 3, 4 and 5, shall be established to within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis as related to a reference point on the mounting surface. The reference point location shall be defined in the inspection report.

3.2.3.4 Mounting and alignment provisions.- The mounting and alignment (if necessary) provisions shall be as shown in Figures 3, 4, and 5. The mounting design shall permit torquing of the mounting screws to 17 ± 1 in-lbs.

3.2.3.5 Thermal interface.-

3.2.3.5.1 Preamplifer and Processor Assemblies conduction path.- To provide the required contact conductance (8.3×10^{-2} w/cm^2 - °K) for the mounting surface constituting the primary heat conduction path, the surface shall have the following characteristics (Reference AGC-20522):

(a) Surface flatness within 0.005 inches along any direction of the respective surface.

(b) Surface finish of 32 micro-inches rms, or less.

3.2.3.5.2 Mixer Assembly Conduction Path.- The mounting surface constituting the primary heat conduction path shall have the following characteristics:

(a) Surface flatness within 0.002 inches.

(b) Surface finish of 16 micro-inches, rms, or less.

3.2.3.5.3 Radiation environment.- For design purposes, the average radiation environment for each assembly will be a temperature of $30 \pm {}^{15}_{20}$ °C and an emissivity of 0.6 or greater.

3.2.3.5.4 Finish on non-mounting surfaces of preamplifier and processor assemblies.- The non-mounting surface of the mixer assembly shall have an emissivity of 0.05 or less.

3.2.3.6 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds, and shield grounds. These grounds shall be isolated from each other and shall be brought out on separate pins of the interface electrical connector. The shielded wire ground, as a general rule, shall be grounded at the input end.

3.2.3.7 Connector.- The electrical connectors shall be in accordance with the requirements of S-323-P-10. The type of connector and the pin assignment shall be as shown in Figure 2.

3.2.3.8 Test points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a convenient location.

3.2.3.9 Package venting.- All units except as specified in 3.3.1.3 shall be vented so that the unit internal pressure equals the ambient pressure.

3.2.4 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from, the design to achieve the electrical and mechanical characteristics specified in this specification. The Receiver Subsystem shall be designed and fabricated to provide 98% probability of an operational life-time as specified in 3.2.2.1. This lifetime is based on the active operation time being equally distributed within the two year period. The groundbased Receiver Subsystem shall have a mean-time-between failures of at least 2000 hours.

3.2.5 Maintainability.- The design for maintainability, as applicable to the flight model, shall occur simultaneously with, rather than separately from, the design of the Receiver Subsystem. The Receiver Subsystem shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.2.3.8 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible and compatible with the EMI requirements. Repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the Receiver Subsystem. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the Receiver Subsystem.

3.2.6 Environmental conditions.- The Receiver Subsystem shall be designed and constructed in accordance with the thermal and structural requirements of AGC-20522 and the requirements specified herein.

3.2.6.1 Equipment operating.- The Receiver Subsystem, while operating in any orientation, shall be capable of meeting the requirements of Tables IA, IB, and IC while being subjected to any combination of the following environments (demonstration of compliance shall be performed only to the extent specified in section 4.0):

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to an acceleration of from zero up to a 1 g gravitational field.

(c) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(d) Thermal-vacuum conditions for LCE subsystem as specified in AGC-20511.

(e) Temperature for equipment operating as specified in AGC-20511.

3.2.6.2 Equipment nonoperating.- The Receiver Subsystem shall be capable of withstanding the following environmental conditions in accordance with the levels specified in AGC-20511 and thereafter meet the performance requirements of Tables IA, IB, and IC.

(a) Sinusoidal and Random Vibrations, Test level I or II in AGC-20511.

(b) Acceleration (AGC-20511).

(c) Leakage (AGC-20511).

(d) Storage (AGC-20511).

3.2.6.3 Ground model.- The Receiver Subsystem shall be capable of meeting the ground model operating and nonoperating environmental requirements as specified in AGC-20511.

3.2.7 Design and construction.-

3.2.7.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be selected or prepared in accordance with AGC-STD-2312.

3.2.7.2 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312.

3.2.7.3 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.2.7.4 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.2.7.5 Interchangeability and Replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.2.7.6 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.2.7.7 Electromagnetic Interference.- The electromagnetic interference characteristics of the Receiver Subsystem shall comply with the applicable requirements for Class IC or ID equipment as specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.2.7.8 Printed wiring boards.- The design and construction of printed wiring boards shall be in accordance with NASA specification S-300-P-1.

3.2.7.9 Soldering of electrical connections.- Soldering of electrical connections shall be in accordance with NASA specification NHB-5300.4(3A) with the following exceptions:

(a) 3A304 - Delete paragraph 4

(b) 3A309 - Solid solder not usable

(c) 3A310 - Liquid solder flux not usable

(d) 3A505 - Lap joints shall not be used for structural mounting

(e) 3A604 - Page 6-6 Multiple conductor cable will not be used

(f) Chapter 9- Delete.

3.2.7.10 Identification and Marking.- The Receiver Subsystem shall have an identification nameplate attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number.

(b) Manufacturer's name and location.

(c) Code identification.

(d) Contract number.

(e) Unit name, model number, and serial number.

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above. The detector, preamplifier, receiver and separate cables shall be serialized.

3.3 Receiver Subsystem Components.- The Receiver Subsystem shall include but not be limited to the following components:

(a) Mixer assembly (see 3.3.1 for flight model requirements and Appendix A for ground model requirements)

(b) Preamplifier assembly (see 3.3.2)

(c) Processor electronics assembly (see 3.3.3)

3.3.1 Mixer assembly.- 1/

3.3.1.1 HgCdTe Mixer.- The Mixer Assembly shall consist of a HgCdTe photovoltaic mixer, shielded coaxial cable, and a mixer housing. The mixer shall possess the following characteristics:

(a) A frequency response consistent with the requirements of Table I.

(b) Maximum NEP of 10^{-19} watts/Hz when incident (reflected and absorbed) local oscillator power on the mixer element (including losses in the window) is 6 mwatts maximum, at a mixer temperature of 110 ± 15°K. The NEP includes the mixer intrinsic noise, local oscillator induced shot noise, background noise, bias current noise, and the noise contributed by the preamplifier.

(c) NEP fluctuation in the bandwidth of 5 to 45 Hz measured at the output of the matched filter shall be 0.5% rms when the mixer element is not illuminated by the local oscillator.

(d) Bias power dissipation in the detector of less than 3.0 mw.

(e) The mixer sensitive area shall be 0.200 ± 0.025 mm.

3.3.1.2 Shielded coaxial cable.- The coaxial cable shall be the only electrical connection between the detector and bias and preamplifier circuits. The coaxial cable heat load on the radiation cooler shall be 15 milliwatts when the temperature difference is 200°C and the mixer temperature is -173°C (100°K). The cable length shall be 12.0 inches and the conductor outer diameter shall be .0865 inches.

1/ See Appendix A for ground model requirements.

3.3.1.3 Mixer Housing.- The mixer housing shall be heremetically sealed. The housing shall be mounted to the interface reference surface as shown in Figure 3. The housing shall provide structural support for the mixer element, electrical leads, output coaxial connector, and the entrance window. The entrance window shall be ___*___ mm thick and thin film coated to prevent passage of all IR wavelengths (2 to 40 micron) except 10.6 ± 1.0 micron at the 3 db points. The diameter of the entrance window shall be sufficiently large to accommodate a diffraction limited, f/6.0 signal beam. Efforts shall be made in the design of the mixer/aperture/housing assembly to minimize the percentage absorption of any local oscillator power not incident on the mixer element (with 10% as a design goal). For reference purposes, the diameter of the local oscillator Airy disk shall not exceed 0.8mm. The mixer housing shall provide EMI shielding for the mixer and associated electrical leads, as required.

3.3.2 Preamplifier.- The gain of the preamplifier shall be nominally 26 db over a frequency range of 24 to 36 MHz. The gain and phase stability of the preamplifier shall be such as to meet the performance specified in Tables IA, IB, and IC. The preamplifier shall also have provisions to introduce a test signal into the front end.

3.3.2.1 Mixer Bias Current.- Mixer Bias Current circuit shall be part of the preamplifier assembly. As part of the mixer bias current circuit, provision shall be made to generate a telemetry output ranging 0 to 5 volts corresponding to expected bias current range having a bandwidth of 0.1 Hz and an output impedance of 1 kilohm or less.

3.3.3 Processor Assembly.-

3.3.3.1 FM video channel.- The Processor FM video channel shall consist of a noise bandwidth filter, post-amplifier, automatic gain control, equalizer, limiter, bandpass filter, discriminator, video filter, and video amplifier. The performance of the FM video channel, including the detector and preamplifier, shall be as specified in the Table IA. Two separate isolated FM video outputs shall be provided. Isolation between the two video outputs shall be such that a short or open on one output shall not cause the video signal from the other to be out of specification.

3.3.3.2 AM video channel.- The Processor AM video channel shall consist of an AM detector, video filter, video amplifier, and buffer amplifier. The performance characteristics of the AM video channel, including the detector, preamplifier, noise bandwidth filter, IF post amplifier, AGC detector and amplifier, and equalizer (if used), shall be in accordance with Table IC.

* To be added at a later date.

3.3.3.3 AFC channel.- The processor shall provide an AFC error voltage that will be proportional to the IF center frequency deviation from its nominal design value of 30 MHz. It shall consist of a narrow band IF discriminator (if required), low-pass filter and output amplifier. It shall possess the following characteristics:

(a) Zero error voltage:	30.0 ± 0.1 MHz
(b) Bandwidth:	0.1 Hz to 10 KHz at 3 db with fall off of 6 db/octive
(c) Slope	
(1) Over frequency range 29.5 to 30.5 MHz:	at least -5 volts to + 5 volts
(2) Over frequency range 27.5 to 29.5 MHz:	between -5 to -13 volts
(3) Over frequency range 30.5 to 32.5 MHz:	between +5 to +13 volts
(d) Output impedance	less than 1 kilohm

3.3.3.4 Acquisition and tracking channel.- The performance of the acquisition and tracking channel shall be consistent with the requirements of Table IB. The circuits comprising the Acquisition and Tracking Channel shall be as follows:

(a) IF filter.- The IF filter shall be provided to increase the signal-to-noise ratio of the acquisition and tracking signal. The characteristics of the filter shall be such that the signal at its output (including the effect of the IF band-pass filter) shall have a bandwidth of 4 MHz at the 0.5 db points centered at 30 MHz. The minimum attenuation rate shall be 24 db per octave.

(b) AM detector.- The AM detector shall be a square law detector and its operation shall be in accordance with the following equation:

$$\left(\frac{S}{N}\right)^2_{input} = K \left(\frac{S}{N}\right)_{output}$$

when: $\left(\frac{S}{N}\right)_{input}$ is $\ll 1.0$

where: the constant K has a value of unity or less.

(c) Acquisition subchannel.- The acquisition subchannel shall consist of a bandpass filter and threshold detector. The bandpass filter shall have a 3 db lower cutoff frequency of 2 Hz and a 3 db upper cutoff frequency of 14 Hz. The filter shall have a minimum attenuation rate of 12 db per octave. The filter shall be designed to operate between the AM detector as specified in 3.3.3.2 (b) and the threshold detector as specified below. The filter shall be designed to minimize the loss in signal-to-noise ratio.

The threshold detector shall monitor the amplitude of the bandpass filtered acquisition signal. The threshold level of the detector shall be equal to the amplitude of a threshold reference level supplied to the Receiver Subsystem. The threshold reference level shall have an amplitude range of 0.5 to 5 volts d.c. The load resistance presented to the threshold reference signal shall be at least 10 kilohms. When the amplitude of the acquisition signal exceeds the threshold reference level, an acquisition pulse shall be generated with the following characteristics

(1)	Amplitude (signal on): Amplitude (signal off):	3.8 ± 1.4 volts 0.0 ± 0.5 volts
(2)	Pulse width:	50 ± 10 millisecond
(3)	Rise time:	1 millisecond, maximum
(4)	Fall time:	1 millisecond, maximum
(5)	Output impedance:	1 kilohm or less

The acquisition pulse shall be capable of driving a load capacitance of 1000 pf, maximum and a load resistance of 1 kilohm, minimum. Thresholding accuracy shall be ± 25 millivolts. Time delay in generating the acquisition signal shall not exceed 0.5 millisecond measuring from the time of threshold exceedence to the leading edge of the signal (50% amplitude point) when the peak of the acquisition signal exceeds the threshold reference level by at least 25 mv.

(d) <u>f_n signal subchannel</u>.- The f_n signal subchannel shall consist of an active bandpass filter and two phase detectors. The active bandpass filter shall be provided to limit the signal bandwidth of the nutator error signal. The filter shall have a bandwidth of 40 Hz at the 3 db points, centered at 100 Hz. The minimum attenuation rate shall be 12 db per octave.

Phase detectors shall be incorporated to provide a north-south axis and an east-west axis error signal. Using a nutation drive signal, $e_1 = E \sin wt$, from the acquisition and tracking subsystem as reference, the detector shall provide a north-south axis error signal, the amplitude of which is proportional to the phase difference between the input and the reference signal. The other detector shall use a nutation drive signal, $e_2 = E \cos wt$, from the acquisition and tracking channel as reference and produce an east-west axis error signal, the amplitude of which is proportional to the difference between the input and the referenced signal. The amplitude of the reference signals shall be 5 ± 1 volt rms. The output tracking error signals shall meet the requirements in Table IB. The output impedance of the tracking error signal shall be 1 kilohm or less.

(e) <u>$2f_n$ signal subchannel</u>.- The $2f_n$ signal subchannel shall consist of an active bandpass filter, phase detector, low pass filter, and threshold detector. Signal from the AM detector specified in 3.3.3.2 shall be routed throughout the active bandpass filter. The filter shall have the following characteristics:

(1)	Bandwidth:	80 Hz (3 db points)
(2)	Center Frequency:	200 Hz
(3)	Minimum Attenuation	12 db/octave

The $2f_n$ signal shall be synchronously detected by the synchronous detector using a nutation drive signal $e_3 = E \sin 2\,wt$ from the acquisition and tracking subsystem as reference. The amplitude of e_3 shall be 5 ± 1 volts rms. A low pass filter shall be incorporated to provide an effective 3 db bandwidth of 1.0 Hz for the detected signal. The threshold detector shall be provided to monitor the low pass filtered signal. The threshold reference level shall be equal to the amplitude of a threshold reference level supplied to the Receiver Subsystem. The threshold reference level shall have an amplitude range of 0.5 to 5 volts dc. The load resistance presented to the threshold reference level shall be at least 10 kilohms. When the amplitude of the acquisition signal exceeds the threshold level, a dc signal shall be generated with the following characteristics:

(1)	Amplitude (signal on):	8.0 ± 4.0 volts
	Amplitude (signal off):	0.0 ± 0.5 volts
(2)	Output impedance	less than 1000 ohms

Thresholding accuracy shall be ± 25 millivolts.

Time delay in generating the acquisition confirm signal shall not exceed 0.5 milliseconds measured from the time of threshold exceedence to the leading edge of the signal (50% amplitude point) when the peak of the acquisition confirm signal exceeds the threshold reference level by at least 25 millivolts.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for two years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements. Any deficiencies noted as a result of tests conducted by the procuring activity shall be corrected.

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall implement and maintain a quality assurance program in accordance with AGC-STD-2311.

4.1.2 Subcontractor's reliability assurance program.- The subcontractor shall implement and maintain a reliability assurance program in accordance with AGC-STD-2312.

4.1.3 Processing changes.- The subcontractor shall make no changes in the Receiver Subsystem design, specifications, materials, and processes after FTM design approval without prior written approval in accordance with AGC-STD-2312.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration. The tolerance allowed on test conditions and inputs are intended only to provide accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification and Flight Model and Ground Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model or Ground Model Acceptance Inspection (see 4.6).

4.3 Test plan.- The subcontractor shall prepare a test plan which includes all of the examinations and tests specified in 4.5 and 4.6 such that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers' designations of all the commerical test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process inspection.- In-process examinations and tests shall be performed as required to comply with AGC-STD-2311.

4.5 Design Qualification Inspection.- Design Qualification Inspection shall consist of all the tests described in Table V as a minimum. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the Receiver Subsystem under ambient conditions and the specified operational environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order.

4.6 Acceptance Inspection.- As a part of the overall test plan, a detailed procedure of the acceptance inspection shall be generated by the subcontractor and approved by AGC prior to final inspection. The acceptance inspections shall be extensive enough to demonstrate satisfactory workmanship and that the Receiver Subsystem performance is within tolerance. The examinations and tests designated in Table VI shall be performed for flight model and ground model acceptance, as a minimum.

TABLE V. DESIGN QUALIFICATION INSPECTION

Examination or Test	Requirement Paragraph	Method
(a) Analysis		
(1) Reliability	3.2.4	4.7.1
(2) Maintainability	3.2.5	4.7.1
(3) Thermal Analysis	3.2.6.1(e)	4.7.1
(b) Visual Examination and Measurements		
(1) Connectors	3.2.3.7	4.7.1.1
(2) Weight	3.2.3.1	4.7.3
(3) Envelope Dimensions	3.2.3.2	4.7.1.1
(4) Center of gravity	3.2.3.3	4.7.3
(5) Mounting and Alignment	3.2.3.4	4.7.1.1
(6) Surface Characteristics	3.2.3.5	4.7.1.1
(7) Grounding	3.2.3.6	4.7.1.1
(8) Test Points	3.2.3.8	4.7.1.1
(9) Venting	3.2.3.9	4.7.1.1
(10) Selection of specifications & standards	3.2.7.1	4.7.1.1
(11) Materials, parts & processes	3.2.7.2	4.7.1.1
(12) Moisture and fungus resistance	3.2.7.3	4.7.1.1
(13) Corrosion of metal parts	3.2.7.4	4.7.1.1
(14) Interchangeability and replaceability	3.2.7.5	4.7.1.1
(15) Workmanship	3.2.7.6	4.7.1.1
(16) Printed wiring boards	3.2.7.8	4.7.1.1
(17) Soldered electrical connections	3.2.7.9	4.7.1.1
(18) Identification and marking	3.2.7.10	4.7.1.1
(c) Testing		
(1) Functional Characteristics at Minimum and Maximum Temperatures	3.2.6.1(e) & Table VII	4.7.2, 4.7.4
(2) Leak Detection after temperature tests (1)	3.2.6.2(c)	as required
(3) Vibration (nonoperating)	3.2.6.2(a) Level I	4.7.4
(4) Functional Characteristics (after vibr)	Table VII	4.7.2
(5) Acceleration (nonoperating)	3.2.6.2(b)	4.7.4
(6) Functional Characteristics (after accel)	Table VII	4.7.2
(7) Functional Characteristics During Thermal Vacuum	3.2.6.1(d) and Table VII	4.7.2, 4.7.4
(8) Leak Detection after thermal vacuum	3.2.6.2(c)	as required
(9) EMI Tests	3.2.7.7	4.7.5
(10) Functional Characteristics at Maximum Temperature	Table VII	4.7.2, 4.7.4

Table VI. Acceptance Inspection

Description	Flight Model	Ground Model	Requirements	Method
(a) <u>Visual Examination & Measurements</u>				
(1) Weight	X		3.2.3.1	4.7.3
(2) Envelope Dimensions	X	X	3.2.3.2	4.7.1.1
(3) Surface Characteristics	X	X	3.2.3.5.1	4.7.1.1
(4) Connectors	X	X	3.2.3.7	4.7.1.1
(b) <u>Testing</u>				
(1) Functional Characteristics at Maximum and Minimum Temperature	X	X	3.2.6.1 (e) and Table VII	4.7.2, 4.7.4
(2) Leak Detection After Temp. Tests (1)	X		3.2.6.2(c)	As Required
(3) Vibration (nonoperating)	X		3.2.6.2 (a), Level II	4.7.4
(4) Functional Characteristics -After Vibration	X		Table VII	4.7.2
(5) Functional Characteristics During Thermal Vacuum Tests 1/	X		3.2.6.1 (d) and Table VII	4.7.2, 4.7.4
(6) Leak Detection After Thermal Vacuum Test (5)	X		3.2.6.2 (c)	As Required
(7) Electromagnetic Interference (EMI)	X	X	3.2.7.7	4.7.5
(8) Functional Characteristics at Maximum Temperature	X		Table VII	4.7.2, 4.7.4

1/ The thermal vacuum test shall be conducted at 10^{-5} torr for 12 hours

4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the design study report or other written reports, if required. Systems engineering data shall be used where appropriate to support analysis.

4.7.1.1 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.2 Functional performance.- Specific tests as specified below and Table VII shall be performed to verify that the requirements of 3.2.1 are met. Whenever possible, tests shall be made on the Subsystem with all electrical, mechanical and thermal interfaces simulated as closely as possible to the actual operating conditions. Functional tests in accordance with Table VII shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.2.1, which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests which will not verify all the requirements of 3.2.1 but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.2.1 Functional tests.- The functional performance tests shall be performed at the specified vacuum pressure or ambient pressure as applicable after the chamber has been stablized at the specified pressure for a minimum of two hours and the temperature of the mounting has stabilized at the specified temperature. The performance shall be verified for each of the functional characteristics checked in Table VII.

Table VII. Functional Testing - 10.6 Micron Receiver

Requirement	Requirement Paragraph 3.2.1	Functional During Temperature Test Min.	Functional During Temperature Test Max.	Functional After Vibration Qual. Level I	Functional After Vibration Flight Level II	Functional After Acceleration	Functional During Thermal-Vacuum	Functional During EMI Tests	Functional Test At Max. Temp.
(a) Receiver Output	Table IA								
Output Level	Item 1 (a)	X	X						X
Power Input	Table II	X	X						
	Table IA								X
(b) Preamplifier Bandwidth	Item 2 (a)	X	X				X		X
(c) Demodulation Characteristics									
Sense	Item 3 (a)	X							
Output Sensitivity	Item 3 (d)	X	X						X
Baseband Amp/Freq. Char.	Item 3 (e)	X	X				X		X
Group Delay	Item 3 (f)	X	X				X		X
(d) Video Distortion and Noise									
(1) Non-Linearity Distortion of Synchronizing Signal	Item 4(a)(3)	X	X	X	X	X	X		X
(2) Noise									
Periodic Noise	4(b)(1)(a)-(c)	X	X					X	X
(e) Automatic Gain Control	Item 5 (a)	X	X						
(f) NEP	3.3.1.1 (b)	X	X						X
(g) NEP Fluctuation	3.3.1.1 (c)	X	X					X	X
(h) Bias Power	3.3.1.1 (d)	X	X					X	X
(i) Mixer Bias Current	3.3.2.1								
(j) AM Video Channel	3.3.3.1.2								
(k) AFC Channel	3.3.3.1.3	X	X	X	X	X	X		X
	Table IB	X	X						X
(l) Acquisition Channel	Item 1	X	X						X
(m) Acquisition Tracking	Item 2	X	X						X
(n) $2f_n$ Signal	Item 3	X	X						X
(o) Operational Tracking	Item 4	X	X	X	X	X	X		X
(p) Commands		X	X						X
(q) Telemetry Outputs	Table IA Item 5 (b)	X	X						X

4.7.2.2 Receiver output level.- *

4.7.2.3 Preamplifier bandwidth.- *

4.7.2.4 Demodulation characteristics.- Using the test set-up specified in the test plan which includes the preamplifier and receiver video channel, the following demodulation characteristics shall be determined and shall comply with the requirements specified in Table IA:

(a) Demodulation Sense

(b) Output Sensitivity

(c) Baseband Amplitude - Frequency Characteristic

(d) Group Delay over 12 MHz Bandwidth

4.7.2.5 Video distortion and noise.- The video distortion and noise shall be measured in accordance with the test plan to verify compliance with the requirements in Table IA. The ratio of the peak-to-peak signal amplitude to the peak-to-peak noise amplitude shall be as follows to verify compliance with Table IA:

(a) Power Supply Hum........................ 38 db
(Including the fundamental frequency and lower harmonics)

(b) Single-frequency noise between 1 KHz and 2 MHz.................................. 62 db

(c) Single-frequency noise between 2 and 5 MHz.................................. 46 db

4.7.2.6 NEP.- *

4.7.2.7 NEP fluctuation.- *

4.7.2.8 Bias power.- *

4.7.2.9 AM channel.- *

4.7.2.10 AFC channel.- *

4.7.2.11 Acquisition channel.- *

4.7.2.12 Acquisition tracking.- *

*The test method for these characteristics shall be as specified in the Test Plan.

4.7.2.13 $2f_n$ signal.- *

4.7.2.14 Operational tracking.- *

4.7.2.15 Commands.- *

4.7.2.16 Telemetry outputs.- *

4.7.3 Weight and center of gravity.- The weight of the items shall be determined to verify compliance with 3.2.3.1. The center of gravity shall be determined for each item along each of three mutually perpendicular axes as specified in 3.2.3.3.

4.7.4 Environmental tests.- The following environmental tests shall be performed as specified in AGC-20511 to verify compliance with the requirements herein. During the tests the item shall be attached to the test fixture so as to simulate the actual element mounting to the transceiver baseplate.

(a) Leak detection

(b) Vibration

(c) Acceleration

(d) Thermal-vacuum

4.7.5 Electromagnetic interference.- EMI testing shall be in accordance with the requirements of 3.2.7.7 for tests CE01, CS01 and RS03 as specified in MIL-STD-461.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

*The test method for these characteristics shall be as specified in the Test Plan.

(c) Specification number and revision letter (AGC-20186C)

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable.

6. NOTES

6.1 Intended use.- The Receiver Subsystem specified herein is intended for use in the ATS-F Spacecraft as well as in a transportable ground station without exhibiting any differences in performance or functional capabilities due to the differences in these environments. Any differences in hardware which may be necessary shall not degrade the specified performance levels. In its final form, this basic specification will describe the Receiver Subsystem as required for use in the space environment while the differences which make it suitable for use in the ground environment will be noted in a brief addendum.

6.2 Definitions.-

6.2.1 Failure.- A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.3 Oral statements.- Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.

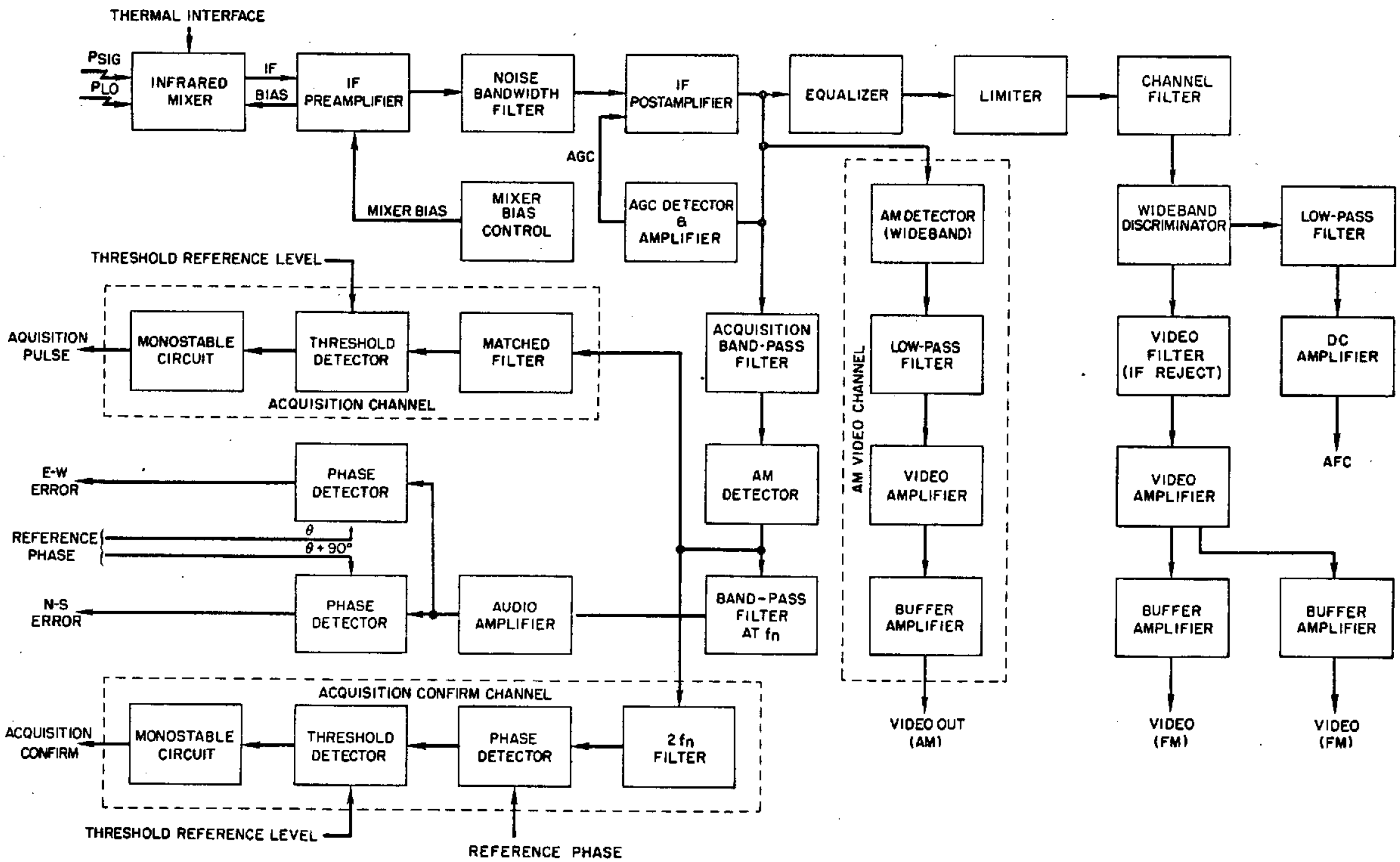

Figure 1A. Receiver Subsystem Block Diagram

FOLDOUT FRAME 1

FOLDOUT FRAME 2

AGC-20186

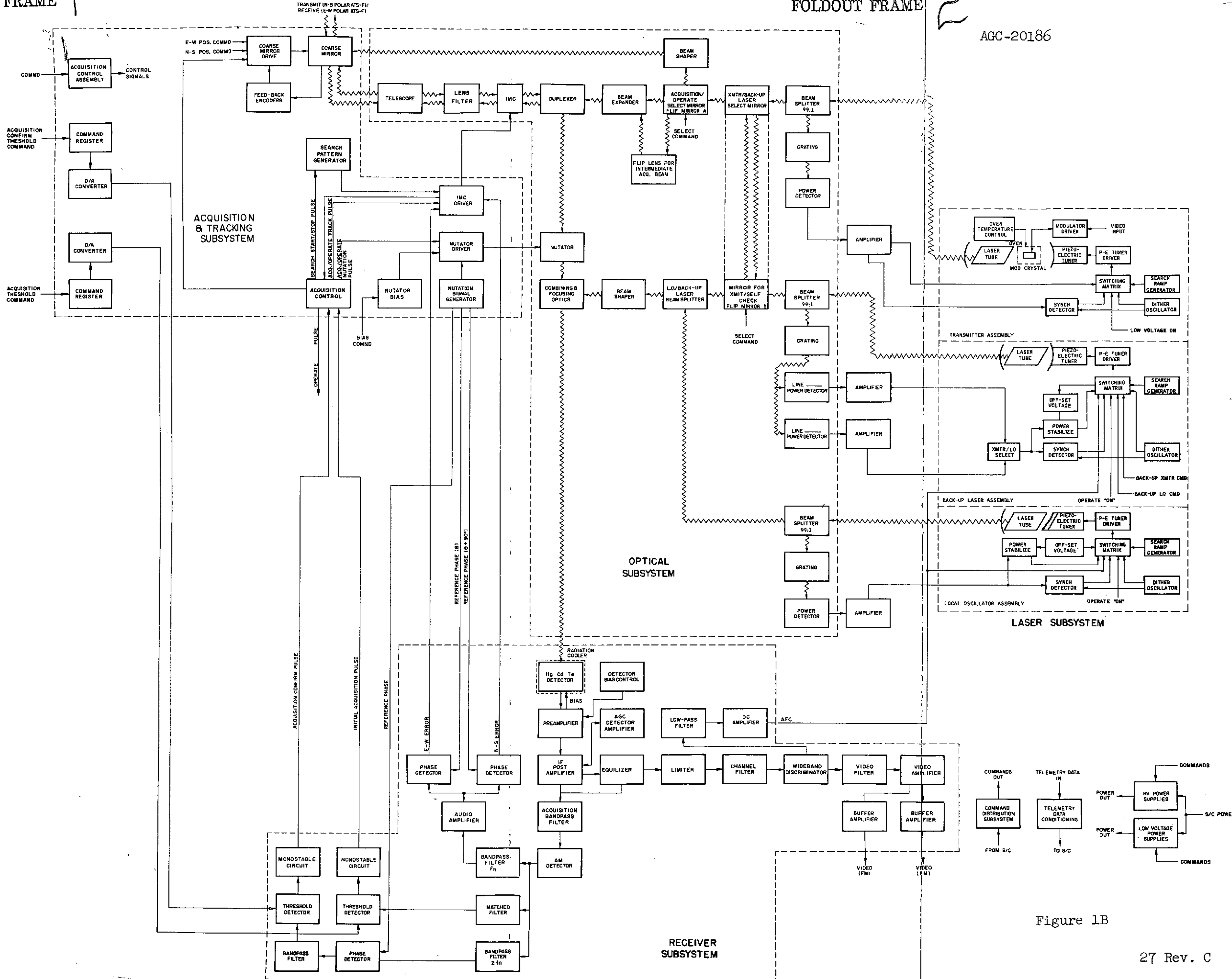

Figure 1B

TO BE ADDED AT A LATER DATE

Figure 2. Electrical Interface Drawing

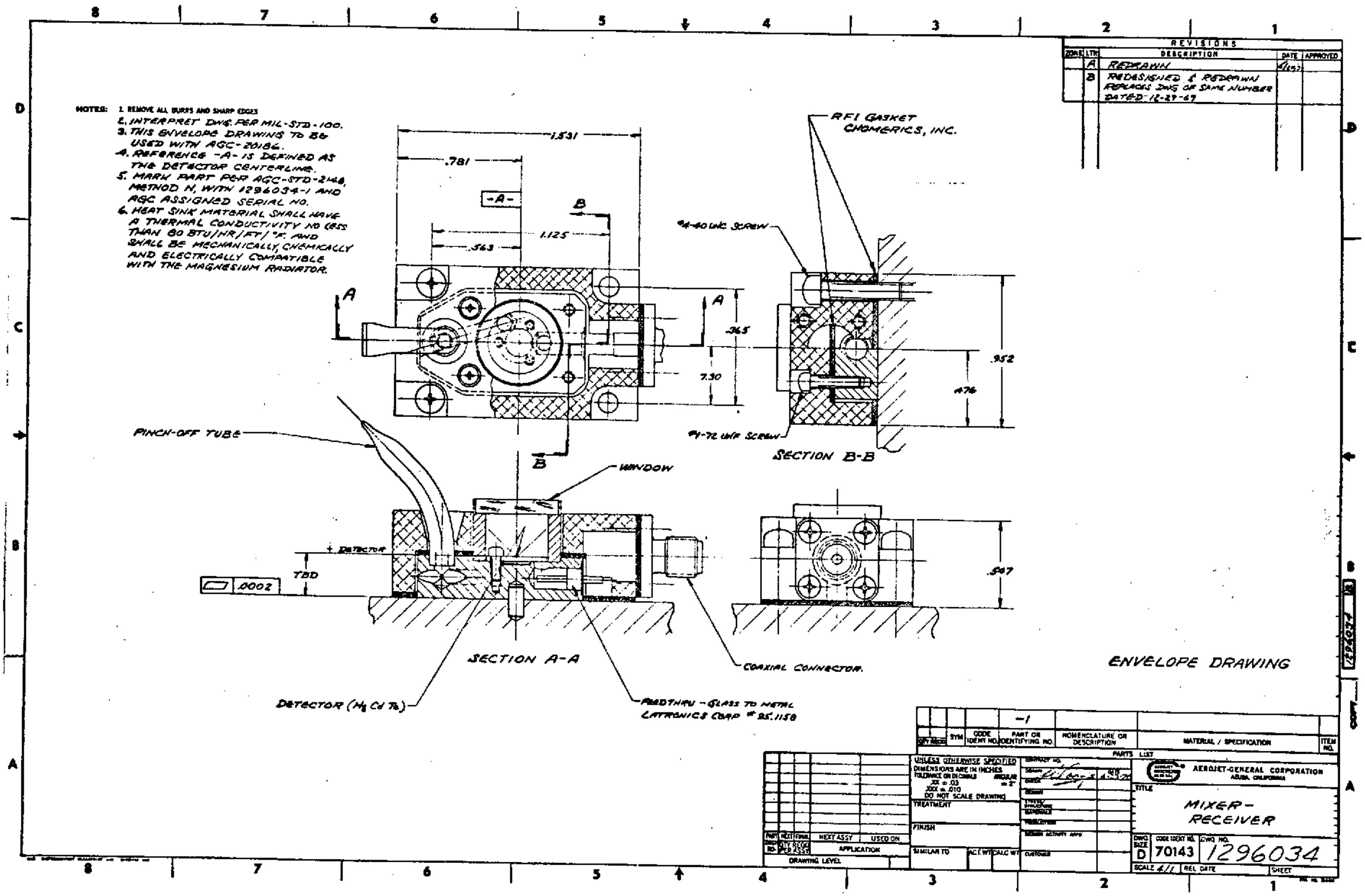

Figure 3. Mixer-Receiver Envelope

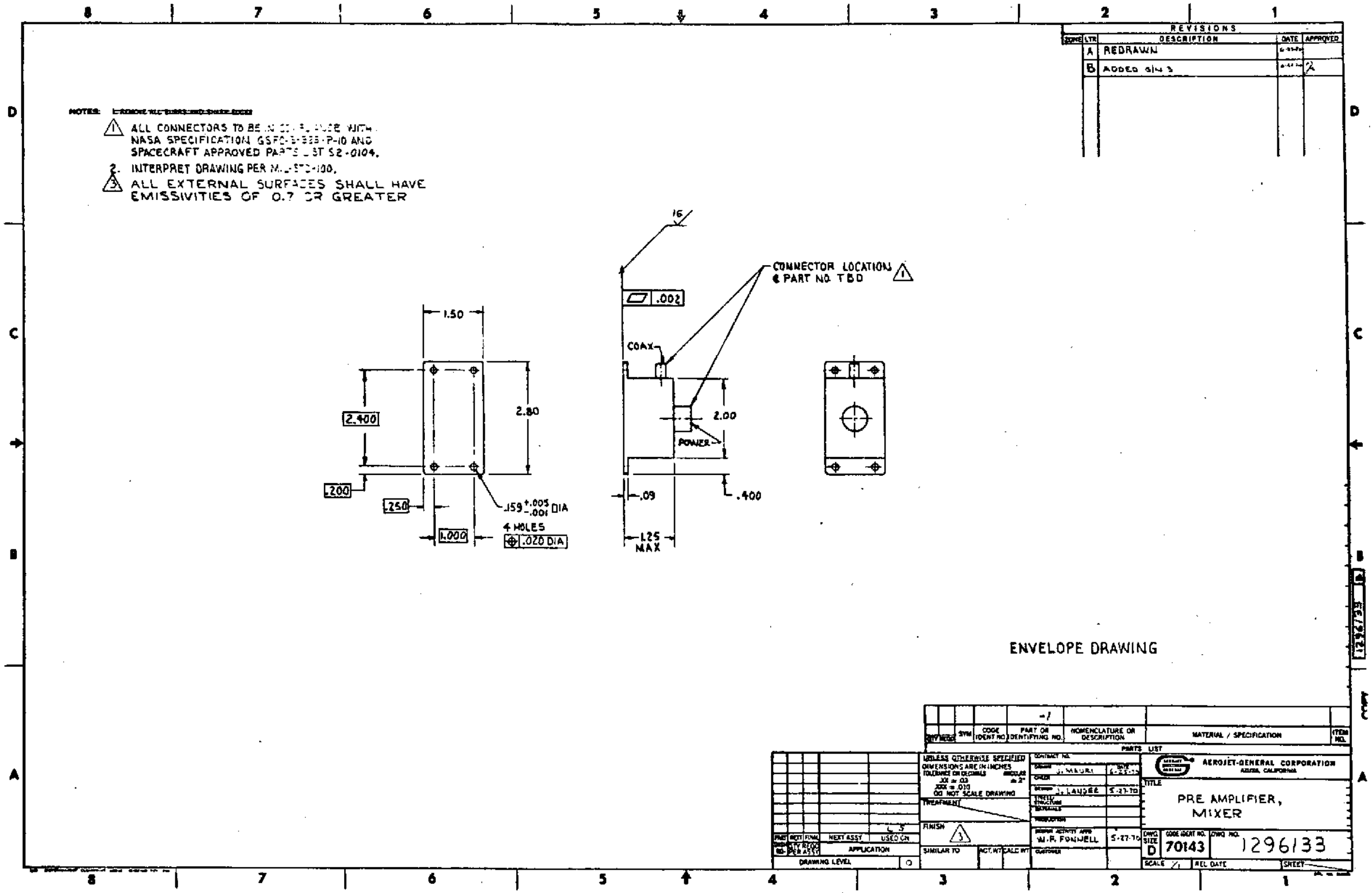

Figure 4. Pre-Amplifier, Mixer Envelope

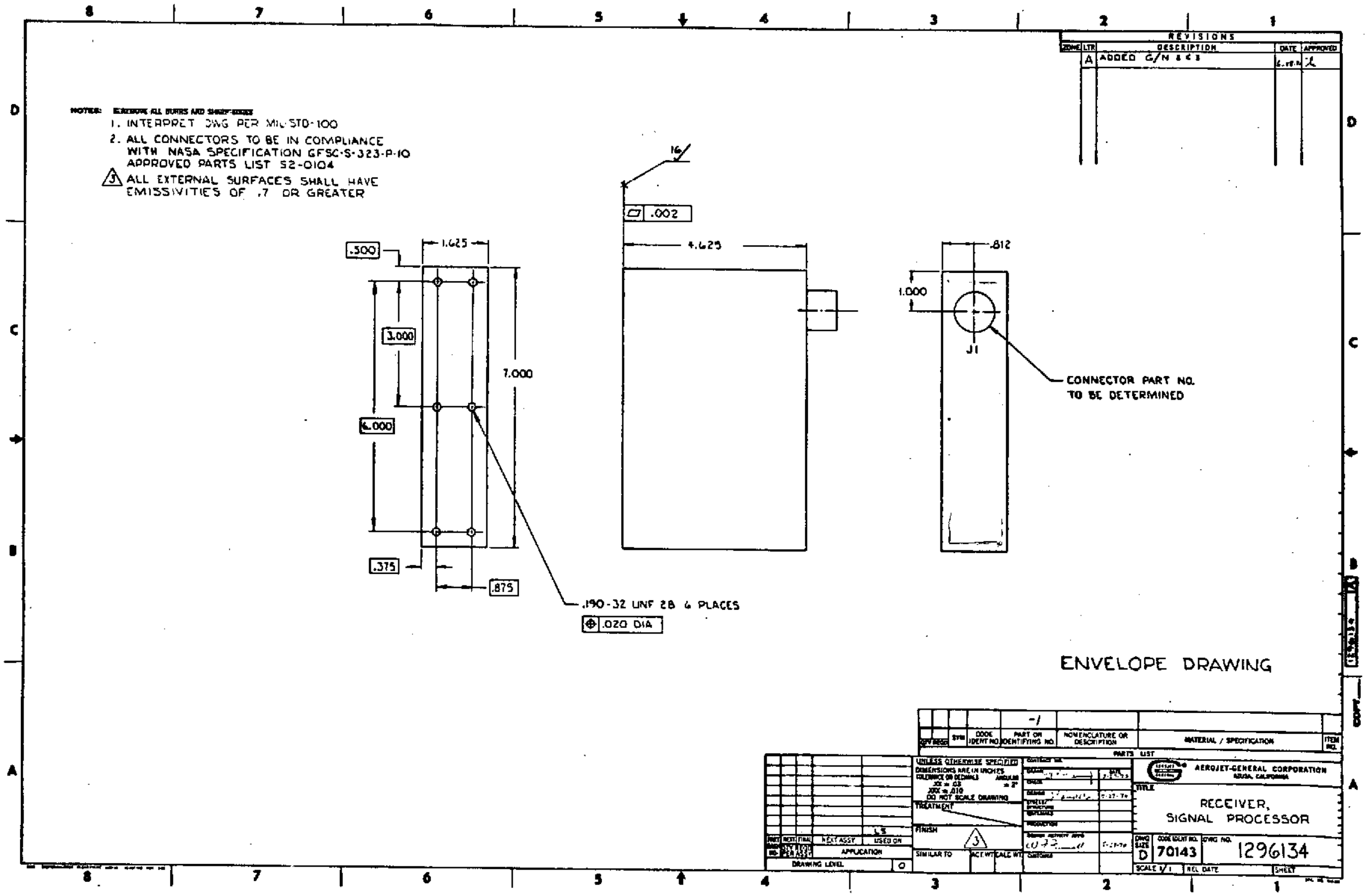

Figure 5. Receiver, Signal Processor Envelope

APPENDIX A

Receiver Subsystem Modifications for Ground Model

10. SCOPE

10.1 This appendix covers the requirements which are necessary for the ground model Receiver Subsystem and are specifically different from the flight model. These requirements will be specified herein as an addition or modification to the flight model.

20. APPLICABLE DOCUMENTS

(none applicable)

30. RECEIVER SUBSYSTEM MODIFICATIONS FOR GROUND MODEL

30.1 Receiver Mixer Assembly.- The ground model of the receiver mixer assembly shall include a temperature-controlled and monitored Joule-Thompson refrigerator capable of covering a minimum temperature range of from 85°K to 130°K, with a stability of ± 2.0°K. An associated control panel, equipped with monitor points and a gas regulation capability, shall be provided. A detector and a vacuum shroud with a window in the end shall also be provided. The detector and shroud shall be capable of being operated at a distance of at least 10 ft from the control panel. The associated electronics, including a preamplifier, and cables and connectors, shall be provided as required. The mixer assembly and all components except for the control panel shall be suitable for operation in a vacuum chamber as well as a ground environment. The entrance window of the mixer housing shall be thermally decoupled from the cold detector to permit operation in a 50 percent relative humidity and 90°F atmosphere.

ref. LCS specs.

30.1.1 Mixer assembly configuration.- The mixer assembly ground model configuration and surface finishes shall comply with the envelope dimensions and requirements shown in Figure A-1.

should this be Figure 3?

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20186C

TITLE

RECEIVER SUBSYSTEM, OPTICAL HETERODYNE, 10.6 MICRON

	DEPT.	EXT.
PREPARED BY		
SPEC. ENGINEER J. M. McDonough	7981	5311

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein	3591	7-8-70
CHIEF PROJECT ENGINEER - A. H. Gale	3574	7-8-70
SYSTEM ENGINEERING - J. V. Cernius	3575	July 8, 1970
QUALITY ENGINEERING - J. H. Bassett	7831	
RELIABILITY - P. W. Stockdill	4072	7-7-70
RELEASE ACTIVITY -	1147	7-10-70

7/6/70

AEROJET-GENERAL CORPORATION

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC- 20187 C

LASER SUBSYSTEM, 10.6 MICRON

SUPERSEDING:		
AGC-20187B DATE 10 March 1970	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
N/C	1 Aug 69																			
A	20 Aug 69																			
B	10 Mar 70	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
C	8 July 70	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

REV LTR	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

REV LTR	35	36	37	38	PAGE ADDITIONS
B	B	B	B		
C	C	C	C		38

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough (signature)

for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification covers the requirements for the design, fabrication, performance, and testing of a 10.6 Micron Laser Subsystem for use in a laser communications system.

1.2 Application.- The Laser Subsystem, as a part of a Laser Communication Experiment (LCE), will be operating in the ATS-F spacecraft and in a transportable ground station establishing two-way laser communications between spacecraft and between the spacecraft and the transportable ground station. The laser subsystem shall be capable of meeting the requirements herein while operating within the spacecraft as well as in the transportable ground station. Modifications required for operation due to the differences in environment shall be held to a minimum.

2. APPLICABLE DOCUMENTS

2.1 Unless otherwise specified, the following documents of the latest issue in effect form a part of this specification to the extent specified herein. In the event of conflict between documents referred to herein and the contents of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall apply.

NASA DOCUMENTS

NHB 5300.4(3A)	Requirements for Soldered Electrical Connections
S-300-P-1	Printed Wiring Boards
S-323-P-10	Connectors, Subminiature, Electrical and Coaxial Contact, for Space Flight Use

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List
MIL-F-14072	Finish for Ground Signal Equipment

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components
AGC-20521	Telemetry and Commands, LCE
AGC-20522	Thermal and Structural Requirements, LCE

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Supplier of Laser Communications Experiment Equipment

OTHER PUBLICATION

CCIR Rec. 421-1 Oslo 1966	Requirements for the Transmission of Television Signals Over Long Distances (System 1 Excepted)

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Item definition.- The 10.6 Micron Laser Subsystem shall include the following major components:

(a) Laser Transmitter Assembly

(b) Laser Local Oscillator Assembly

(c) Back-up Laser Assembly

(d) Laser Baseplate

(e) Laser Electronics Assembly

3.1.1 Laser subsystem block diagram.- The Laser Subsystem shall be in accordance with the Block Diagram as shown in Figure 1, which also shows the relationship of the Laser Subsystem to the Laser Communications Experiment (LCE).

3.1.2 Interface definition.- The electrical components and voltages affecting the input/output impedances on both sides of the interface electrical connector shall be as shown on Figure 2. The performance and mechanical interfaces shall be as specified in 3.2.1 and 3.2.3, respectively.

3.2 Characteristics.-

3.2.1 Performance.- The Laser Subsystem shall be capable of meeting the performance requirements specified in Tables IA and 1B while being subjected to any combination of the environmental conditions imposed on the operating equipment as specified in 3.2.6. After a normal warm-up time of 30 minutes, the frequency and amplitude stability of both the Laser Transmitter and Laser Local Oscillator shall meet the performance requirements herein under the environmental conditions, aging and tolerance variations specified. Performance characteristics shall not be predicated upon the special selection of components or devices.

3.2.1.1 Power.- The Laser Subsystem shall operate at the power inputs specified in Table II. Power necessary for the modulator driver and temperature control heater elements shall be drawn from the LCE 28 vdc bus. Heater power shall be kept separate and isolated from other circuitry.

Table II. Power Inputs to the Laser Subsystem

	2/ Power [Watts Max.]	Starting Voltage	Operating dc Voltage Nominal (Volts)	Regulation Load/Line (Volts)	RIPPLE at 5 Hz to 10 KHz	RIPPLE at 5 Hz to 1 KHz	RIPPLE at 5 Hz to 1 MHz
(a) Transmitter Tube	13.5	1/	1/			N/A	
(b) Local Oscillator Tube	5.0	1/	1/			N/A	
(c) Backup Laser Tube	8.5	1/	1/			N/A	
(d) Electronics Assembly (1) Modulator Driver	10.6		28	± .57		10 mv, rms 3/	N/A
(2) Other Circuitry	1.5		225	±3.4		150 mv peak-to-peak	N/A
	1.0		12	± .23		15 mv peak-to-peak	N/A
	1.0		-12	± .23		15 mv peak-to-peak	N/A
	0.4		5	± .25		300 mv peak-to-peak	N/A
(e) Heater Power	3.0		28 ± 2%		10 mv, rms 3/		N/A

1/ To be added at a later date

2/ Deleted

3/ Transient spikes will not exceed ± 2 volts peak, and transient energy level will not exceed 30 millijoules.

N/A - Not applicable

TABLE IA. TRANSMITTER ASSEMBLY PERFORMANCE REQUIREMENTS

	Characteristic	Transmitter Assembly Performance
(1)	Power Output, minimum (At the output of the laser cavity)	650 mw at line center at 25°C
(2)	Mode	TEM_{00}
(3)	Polarization	Linear with electric field perpendicular to the baseplate ± 2°
(4)	Output power beam width (at output of cavity end mirror)	** millimeters (mm) beam diameter between $(0.367)^2$ relative power levels, diffraction limited, collimated beam
(5)	Operating lines	
	Flight Model	P 20
	Ground Model	P 16
(6)	Operating line width	Compatible with the video transmission requirements
(7)	Power frequency profile	Compatible with stabilization requirements of the assembly
(8)	Operating frequency	Line center frequency ± 100 KHz over a time period of 10 to 100 seconds at a dither frequency of 75 ± 5 Hz with peak-to-peak frequency deviation not to exceed ± 300 KHz.
(9)	Frequency stability	
	0.1 Hz to 5 Hz	100 KHz rms
	5 Hz to 800 KHz	50 KHz rms deviation
	800 KHz to 6.0 MHz	2.7 KHz rms deviation (exclusive of dither modulation).
(10)	Amplitude stability	2% rms at line center over a bandwidth of 5 to 45 Hz
(11)	Modulation characteristics (FM)	
	Deviation capability	Provide deviation of up to ± 4.0 MHz
	Modulation sense	Increase in carrier frequency deviation for increase in positive potential.
	Input frequency bandwidth	1 MHz to 6.0 MHz
	Baseband amplitude - Frequency characteristics	Reference Frequency / Design Goal / Minimum Acceptable: 1.025 MHz / 0 db / 0 db 1.0 to 1.840 MHz / ± 0.1 db / ± 0.25 db 1.840 to 6.0 MHz / ± 0.2 db / ± 0.4 db
	Modulator/Driver Sensitivity	8.0 MHz/volt input
(12)	Modulator/Driver Sensitivity Stability (MHz deviation/volt input)	Within ± 0.1 db during environmental stresses for one operating period, (24 hours or less)
(13)	Modulator/Driver group delay over 6.0 MHz bandwidth output, maximum	± 0.2 ns/MHz slope 0.04 ns/MHz^2 parabolic 0.6 ns peak-to-peak ripple
(14)	Modulator linearity (Deriative method), maximum	2% for center 90 percent of * MHz band 1% over 75 percent of bandwidth
(15)	Amplitude of the synchronizing signal	Synchronizing pulses shall be between 0.27 and 0.31 volts
(16)	Noise	
	Periodic noise (ratio of P-P picture signal amplitude to the P-P noise amplitude)	
	Power Supply Hum..................... (Including the fundamental frequency and low harmonics)	38 db min.
	Single frequency noise between 1 KHz and 2 MHz......................	62 db min.
	Single-frequency noise between 2 and 6 MHz............................	46 db min.

* To be added at a later date.

** To be added at a later date but nominally 3.0 ± 0.12 millimeters.

TABLE IB. LOCAL OSCILLATOR AND BACK-UP LASER PERFORMANCE REQUIREMENTS

	Local Oscillator	Back up Laser: Line Center Operation	Back up Laser: Line Center -30 MHz Operation
(1) Power Output, Minimum (At the output of the laser cavity)	85 mw at line center minus 30 MHz at 25°C	650 mw at line center at 25°C	500 mw at line center minus 30 MHz at 25°C
(2) Mode	TEM_{00}	TEM_{00}	TEM_{00}
(3) Polarization	Linear with electric field perpendicular to the baseplate ± 2°	Linear with electric field perpendicular to the baseplate ± 2°	Linear with electric field perpendicular to the baseplate ± 2°
(4) Output Power Beam Width (At output of the cavity end mirror)	__**__ millimeters (mm) beam diameter between $(0.367)^2$ relative power levels, diffraction limited, collimated beam	__**__ millimeters (mm) beam diameter between $(0.367)^2$ relative power levels, diffraction limited collimated beam	__**__ millimeters (mm) beam diameter between $(0.367)^2$ relative power levels, diffraction limited, collimated beam.
(5) Operating Lines			
Flight Model Operating	P 16	P 20	P 16
Ground Model Operating	P 20	P 16	P 20
Flight Model Test	P 16	P 16	P 20
Ground Model Test	P 20	P 20	P 16
(6) Oscillator Power/frequency profile	Compatible with stabilization requirements of the assembly	Compatible with stabilization requirements of the assembly	Compatible with stabilization requirements of the assembly
(7) Operating Frequency	30 ± 0.05 MHz below received signal frequency	Line center frequency ± 100 KHz over a time period of 10 to 100 seconds at a dither frequency of 75 ± 5 Hz with peak-to-peak frequency deviation not to exceed ± 300 KHz	30 ± 0.05 MHz below received signal frequency
(8) Frequency uncertainty during acquisition	30 ± 1.1 MHz below line center with additional drift not to exceed 0.5 MHz over a 5 minute period	Line center frequency ± 100 KHz over a bandwidth of 0.1 to 1.0 MHz	30 ± 1.1 MHz below line center with additional drift not to exceed ± 0.5 MHz over a 5 minute period
(9) Frequency Stability			
0.1 Hz to 5 Hz	100 KHz rms deviation	100 KHz rms deviation	100 KHz rms deviation
5 Hz to 800 KHz	50 KHz rms deviation	50 KHz rms deviation (Exclusive of Dither Modulation)	50 KHz rms deviation
800 KHz to 6.0 MHz	2.7 HKz rms deviation	2.7 KHz rms deviation	2.7 KHz rms deviation
(10) Amplitude Stability	0.3 % rms over band width from 5 to 45 Hz Design goal is 0.1% rms	2% rms at the line center over a bandwidth of 5 to 45 Hz.	0.3% rms over band width from 5 to 45 Hz Design goal is 0.1% rms.
(11) AFC Cavity/Mirror Variation, minimum, (piezo electric tuner)	6 microns	6 microns	6 microns

* To be added at a later date.

** To be added at a later date but the nominal value will be 3.0 ± 0.12 millimeters.

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3.2.1.2 Commands.- The following Discrete Commands shall be available for subsystem control (ref. AGC-20521):

(a) Back-up laser line (P-16) select

(b) Back-up laser line center (P-16) offset

(c) Back-up laser line (P-20) select

(d) Back-up laser line center (P-20) offset

(e) Modulator, video input select

NOTE: Discrete Commands shall have voltage levels of 0.0 V ± 0.5 V for logic zero, 5.0 V ± 0.5 V for logic one. The duration shall be 50 ± 5 msec. The rise and fall times between the 10% and 90% amplitude levels shall be less than 3 msec. Source impedance shall be less than 1000 ohms.

3.2.1.3 Telemetry data.- Telemetry monitoring output functions shall be isolated from operating outputs with sufficient isolation so that a shorted or open circuit in the telemetry function will not cause the operating function to perform out of specification limits. Telemetry functions shall be as shown in Table III (ref. AGC-20521).

Table III. Telemetry Data

Signal	Analog Telemetry Output				Accuracy	Output Impedance
	Units	Range		BDWTH		
		Min	Max			
(a) Local Osc. Laser Tuner Voltage	Volts	0	5 V		± 2%	< 1 K Ω
(b) Transmitter Laser Tuner Voltage	Volts	0	5 V		± 2%	< 1 K Ω
(c) Back-up Laser Tuner Voltage	Volts	0	5 V		± 2%	< 1 K Ω
(d) Modulator Current	Volts/amps	0	5 V		± 2%	< 1 K Ω
(e) Modulator Oven Temperature	Volts	0	5 V		± 2%	< 1 K Ω

3.2.1.4 Video signal in.- The Laser Subsystem shall be capable of meeting the performance requirements of Table IA with an input TV video signal having the following characteristics:

(a) 1 volt ± 0.5 db peak-to-peak, uptranslated in a vestigial sideband modulator.

(b) A translator carrier frequency of 1.4 MHz.

(c) The upper sideband flat to 5.8 MHz and down to 3 db at 6.0 MHz.

(d) The lower sideband flat to 1.2 MHz and down to 3 db at 1.0 MHz.

Prior to vestigial filtering, the envelope modulation on the carrier is negative.

3.2.2 Useful life.-

3.2.2.1 Operating life.- The operating life of the Laser Subsystem, including the lifetime of the laser tubes, shall be greater than 2,000 hours with a minimum of 500 start-stop cycles and operating periods of up to 24 hours over a two year period in a space environment without degradation of the requirements specified herein. The Laser Subsystem shall be considered in operation when the Laser plasma discharge is on.

3.2.2.2 Shelf life.- The Laser Subsystem shall be capable of meeting the operating life of 3.2.2.1 after a shelf life of greater than 6 months when packaged and stored in a protective enclosure.

3.2.3 Physical characteristics.-

3.2.3.1 Weight.- The weight of the Laser Subsystem shall be a minimum consistent with the required performance, but shall not exceed a total weight of 12.70 pounds assigned as follows:

	Item	Weight (pounds)
(a)	Laser Transmitter Tube	
(b)	Laser Transmitter Tube Mount	
(c)	Laser Modulator, Oven and Mount, and Modulator Driver.	
(d)	L.O. Tube	5.50
(e)	L.O. Tube Mount	
(f)	Back-up Laser	
(g)	Back-up Laser Tube Mount	
(h)	Laser Transmitter Cavity End Mirrors and Mounts	
(i)	L.O. Cavity End Mirrors and Mounts	2.20
(j)	Back-up Laser Mirrors and Mounts	
(k)	Laser Subsystem Electronics	5.00 (Design Goal of 4.03)

3.2.3.2 Envelope dimensions.- Envelope dimensions for the Laser Subsystem components shall be in accordance with Figures 3 through 7.

3.2.3.3 Center of gravity.- The center of gravity for the envelopes shown in Figures 3 thru 7 shall be established to within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis, as related to a reference point on the mounting surface. The reference point location shall be defined in the inspection report.

3.2.3.4 Mounting and alignment.- The mounting and alignment provisions (if necessary) shall be as shown in Figures 3 through 7. The mounting screws shall be torqued to 17 $\pm$ 1 inch-pounds.

3.2.3.5 Thermal interface.-

3.2.3.5.1 Thermal characteristics of mounts.- The LCE heat sink surface on which the transmitter, local oscillator, back-up lasers, AFC electronics, laser driver, and modulator mounts are to be mounted shall have an average temperature of 25^{+15}_{-10} °C. The temperature gradient across the heat sink shall not exceed 0.2°C per inch under the following conditions:

(a) Transmitter laser conducted heat $\leq$ 12.6 watts

(b) L.O. laser conducted heat $\leq$ 4.0 watts

(c) Back-up laser conducted heat $\leq$ 9.1 watts

(d) Modulator conducted heat $\leq$ 7.0 watts (includes heater and modulator driver)

3.2.3.5.2 Surface characteristics of mount.- To provide the required contact conductance (24.1×10^{-2} w/cm^2 - °K) the laser baseplate, transmitter, local oscillator, back-up lasers, and modulator mounts shall have the following surface characteristics:

(a) Surface flatness within 0.002 inches along any direction of the respective surfaces.

(b) Surface finish of 16 micro-inches, rms, or less.

3.2.3.5.3 Component radiation environment.- The average radiation environment for each component shall be a temperature of 30 $\pm$ 15°C and an emissivity of 0.8.

3.2.3.5.4 Component finish on non-mounting surfaces.- The non-mounting surfaces of each component shall have an emissivity of 0.6 or greater, except for the modulator which has no restriction.

3.2.3.6 Test points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a convenient external location.

3.2.3.7 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds, and shield grounds. These grounds shall be isolated from each other and shall be brought out on separate pins of the interface electrical connector. The shielded wire ground, as a general rule, shall be grounded only at one end.

3.2.3.8 Electrical connectors.- Electrical connectors shall be in accordance with NASA Publication S-323-P-10. The type and pin assignment of the connectors shall be as shown in Figure 2.

3.2.3.9 Package venting.- All enclosures shall be vented so that the unit internal pressure equals the ambient pressure.

3.2.4 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from the design to achieve the electrical and mechanical characteristics specified in this specification. The Laser Subsystem shall be designed and fabricated to provide 98% probability of an operational lifetime as specified in 3.2.2.1. This lifetime is based on the active operation time being equally distributed within the two year period. The groundbased Laser Subsystem shall have a mean-time-between failures of at least 2000 hours.

3.2.5 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from the design of the Laser Subsystem. The Laser Subsystem shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.2.3.6 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible. Ground station repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the Laser Subsystem. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the Laser Subsystem.

3.2.6 Environmental conditions.- If any unit fails to meet the performance requirements herein or shows signs of damage after being subjected to the environmental conditions, the subcontractor shall advise AGC immediately and proceed with plans to modify the design as necessary to eliminate the cause of failure. All design modifications resulting from such corrective action shall be subject to AGC approval prior to incorporation into the unit. Subsequent environmental testing to demonstrate suitability of the redesigned unit to meet the requirements herein shall be subject to approval by AGC.

3.2.6.1 Equipment operating.- The Laser Subsystem, while operating in any orientation, shall be capable of meeting the requirements of Tables IA and IB being subjected to any combination of the following environments:

(a) While the baseplate is subjected to sinusoidal vibrations in accordance with Table IV (see 4.7.4).

(b) While being subjected to an acceleration of from zero up to a 1 g gravitational field.

(c) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(d) Thermal-vacuum conditions for LCE subsystems as specified in AGC-20511.

(e) Temperature for equipment operating as specified in AGC-20511.

Table IV. Laser Baseplate Sinusoidal Vibration Levels During Operation

Frequency (Hz)	Velocity (cm/sec, rms)
20	3.9×10^{-2}
100	7.8×10^{-3}
200	3.9×10^{-3}
400	2.0×10^{-3}
600	1.3×10^{-3}
800	1.0×10^{-3}
1000	7.8×10^{-4}

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3.2.6.2 Equipment nonoperating.- The Laser Subsystem shall be capable of withstanding the following environmental conditions in accordance with the levels and test procedures specified in AGC-20511 and thereafter meet the performance requirements of Tables IA and IB.

(a) Storage Temperature

(b) Sinusoidal and Random Vibration, Test level I or II

(c) Acceleration

3.2.6.3 Ground model.- The Laser Subsystem shall be capable of meeting the ground model operating and nonoperating environmental requirements as specified in AGC-20511 except relative humidity shall not exceed 60%.

3.2.7 Design and construction.- The laser subsystem shall be designed and constructed in accordance with the thermal and structural requirements of AGC-20522 and the requirements specified herein.

3.2.7.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be approved for use by Aerojet-General Corporation on concurrence with the cognizant NASA Goddard Space Flight Center Office.

3.2.7.2 Materials, Parts, and Processes.- Maximum use shall be made of established standard materials, parts, and processes. Variations in dimensions, types, and protective finishes of parts shall be limited to the maximum extent consistent with the intended application.

3.2.7.3 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312. Parts lists may be submitted in the subcontractors documentation format which shall contain as a minimum, the part number, name, rating, specification number and supplier.

3.2.7.4 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients connot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.2.7.5 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.2.7.6 Interchangeability and Replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.2.7.7 Printed wiring boards.- Printed wiring boards shall be in accordance with NASA Publication S-300-P-1.

3.2.7.8 Soldered electrical connections.- Soldering of electrical connections shall be in accordance with NBH 5300.4(3A) except for the following:

(a) Noncontact heat sources shall not be used (paragraph 3A304.4).
(b) Solid solder shall not be used (paragraph 3A309).
(c) Liquid solder flux shall not be used (paragraph 3A310).
(d) Lap joints shall not be used for structural mounting (paragraph 3A505).
(e) Multiple conductor cable shall not be used (paragraph 3A604 and page 6-6).
(f) Chapter 9 is not applicable .

3.2.7.9 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the Aerojet-approved workmanship manual.

3.2.7.10 Electromagnetic Interference.- The electromagnetic interference characteristics of the Laser Subsystem shall comply with the applicable requirements for Class IB and ID equipment specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.2.7.11 Identification and Marking.- The Laser Subsystem shall have an identification nameplate or tag attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number

(b) Manufacturer's name and location

(c) Code identification

(d) Contract number

(e) Unit name, model number, and serial number

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above. The reference cavity, modulator crystal subassembly, laser tube subassembly, and cavity and end mirror subassembly shall be serialized.

3.3 Laser Subsystem Components.-

3.3.1 Laser Transmitter Assembly.- The Laser Transmitter Assembly shall include but not be limited to the following components:

(a) Laser Tube

(b) Laser Tube Mount

(c) Laser Modulator Crystal

(d) Laser Modulator Mount & Oven

(e) Cavity End Mirrors & Mounts

(f) Modulator Driver

(g) Transmitter Start-Up Control

(h) Transmitter AFC Loop

(g) and (h): The electronic circuitry portion shall be enclosed in an electronics housing.

3.3.1.1 Transmitter laser tube.- The laser tube shall generate the power specified in Table IA. The laser tube material, dimensions, and gas mixture control shall be such that when any production laser tubes are mounted essentially identically within the laser cavity their performance shall be within 5% of the nominal values specified in Table IA.

3.3.1.2 Transmitter laser tube mount.- The laser tube mount shall structurally support and position the laser tube in the laser cavity. The laser tube mount shall be attached to the laser LCE heat sink as shown in Figure 3.

3.3.1.3 Laser modulator crystal.- A laser modulator crystal shall be used to frequency modulate the transmitter carrier as specified in Table IA.

3.3.1.4 Modulator crystal mount and oven.- The crystal mount inside the oven shall be made of a material that induces minimum strain and deformation into the modulator crystal consistent with the operational and thermal requirements. The oven shall be designed so that the crystal modulator operates within specification limits when in a vacuum or at standard sea level atmosphere. The mount shall contain provisions to support the high voltage wires connecting the crystal electrodes and the modulator driver. The mount shall contain the temperature control provisions such that the modulator crystal temperature shall not vary by more than ± 1°C with a design goal of ± 0.1°C when the LCE heat sink temperature varies -5°C to 40°C with and without power dissipation in the crystal.

3.3.1.5 Laser modulator mount.- The modulator oven mount shall structurally support and position the modulator oven and crystal within the laser cavity. The modulator mount shall be attached to the laser base as shown in Figure 6.

3.3.1.6 Output cavity end mirror and mount.- The output cavity end mirror and mount shall include the cavity end mirror, optical elements required to shape the beam, mounts, and a temperature compensator if required. The output cavity end mirror shall be shaped, in conjunction with other optical elements as required, to permit extration of the laser energy and sustain lasing action as specified in Table IA. The mount shall structurally support and position the cavity end mirror assembly in the laser cavity. The hole pattern of the mount for attachment to the laser base shall be coordinated with AGC.

3.3.1.7 AFC cavity end mirror and mount.- The AFC cavity end mirror and mount shall include a cavity end mirror, a piezo-electric tuner, and a mount. The cavity end mirror shall be shaped so that it sustains lasing action as specified in Table IA. The cavity end mirror shall be mounted on the piezo-electric tuner and shall structurally support the cavity end mirror which shall be attached to the mount. The piezo-electric tuner shall be designed to allow a change of at least 6 micrometers in the effective laser cavity length. The mount shall structurally support and position the cavity end mirror and piezo-electric tuner assembly in the laser cavity. The hole pattern of the mount for attachment to the laser base shall be coordinated with AGC.

3.3.1.8 Modulator driver.- The modulator driver shall drive the modulator crystal so that the performance requirements specified in Tables IA and IB are achieved. The modulator driver shall include video switching to permit the driver input to be selected from one of two video input lines. Switching between the two video input lines shall be upon command; the command shall be discrete. Provisions for the two video input lines to the modulator driver-switching assembly shall be provided.

3.3.1.9 Transmitter start-up control.- The transmitter start-up sequence shall be initiated upon application of power from the low-voltage supplies to the transmitter electronics. The sequence shall include:

(a) Spectral line search

(b) AFC to line center

3.3.1.9.1 Transmitter start-up loop.- The transmitter start-up loop shall effect the search for the laser operating spectral line. The search waveform applied to the piezoelectric tuner shall be a triangular wave having a slope with a magnitude of 230 ± 15% volts/second. The AFC shall be initiated and search shall be discontinued when the DC level from the power meter exceeds a predetermined threshold.

3.3.1.10 Transmitter AFC loop.- The transmitter AFC loop shall accept the frequency error voltage from the power meter amplifier assembly. The power meter amplifier shall have two outputs; one shall be used for telemetry monitoring purposes and the other shall be used for AFC loop control. Each output shall be isolated sufficiently such that a short on one output shall not affect the other by more than one percent. Each output of the power meter amplifier shall have the following characteristics:

3.3.1.10.1 AC signal characteristics

(a) 75 Hz ripple on 2.5 ± 0.5 vdc level when laser is tuned to line center.

(b) Less than 1000 ohms impedance

(c) When power modulation is 0.3% per MHz displacement, the 75 Hz ripple (dither) component shall be 880 microvolts, rms, signal amplitude/MHz displacement.

(d) Noise density of less than 100 $\mu v/\sqrt{Hz}$

(e) Frequency response of 3 db down at less than 5 Hz and greater than 150 Hz.

3.3.1.10.2 DC signal characteristics.-

(a) 2.5 V ± 0.5 V when tuned to line center.

(b) Linearity of 1% over an output range of 0.5 to 3 volts.

(c) Not more than 3 mv drift in a 5 minute period

(d) Increase in power level produces an increase in output voltage level.

3.3.1.10.3 AGC loop response.- In response to the error voltage, the AFC loop shall generate appropriate piezo-electric tuner driver voltages such that the rms deviation at rates within the 0.1 to 1.0 Hz range will not exceed 100 K Hz.

3.3.2 Laser Local Oscillator Assembly.- The Laser Local Oscillator Assembly shall consist of the following subassemblies:

(a) Laser Tube

(b) Laser Tube Mount

(c) Cavity End Mirrors (or Grating, as required) and Mounts

(d) L.O. Start-Up Control }

(e) L.O. AFC Loop }

The electronic circuitry porition shall be housed in the electronics housing.

3.3.2.1 L.O. laser tube.- The laser tube shall generate the power specified in Table 1B. The laser tube material, dimensions, and gas mixture control shall be such that when any production laser tubes are mounted essentially identically within the laser cavity their performance shall be within 5% of the nominal values specified in Table IB.

3.3.2.2 L.O. laser tube mount.- Laser tube mount shall structurally support and position the laser tube in the laser cavity. Laser Mount shall be attached to the laser base as shown in Figure 7.

3.3.2.3 Output cavity end mirror and mount.- The output cavity end mirror and mount shall include the cavity end mirror, optical elements required to shape the beam, mounts, and a temperature compensator if required. The output cavity end mirror shall be shaped, in conjunction with other optical elements as required, to permit extraction of the laser energy and sustain lasing action as specified in Table IA. The mount shall structurally support and position the cavity end mirror assembly in the laser cavity. The mount shall be attached to the laser base as shown in Figure 5.

3.3.2.4 AFC cavity end mirror and mount.- The AFC cavity end mirror and mount shall include a cavity end mirror, a piezo-electric tuner, and a mount. The cavity end mirror shall be shaped so that it sustains lasing action as specified in Table IB. The cavity end mirror shall be mounted on the piezo-electric tuner and shall structurally support the cavity end mirror which shall be attached to the mount. The piezo-electric tuner shall be designed to allow a change of at least 6 micrometers in the effective laser cavity length. The mount shall structurally support and position the cavity end mirror and piezo-electric tuner assembly in the laser cavity. The mount shall be attached to the laser base as shown in Figure 4.

3.3.2.5 L.O. start-up control.- The L.O. start-up sequence shall be initiated upon application of power from the low-voltage supplies to the L.O. electronics. The sequence shall include:

(a) Spectral line search

(b) AFC to line center

(c) Frequency offset (line center minus 30 MHz ± 1.1 MHz).

3.3.2.5.1 L.O. spectral line search.- The local oscillator start-up loop shall effect the search for the laser operating spectral line. The search waveform applied to the piezo-electric tuner shall be a triangular wave having a slope with a magnitude of 230 ± 15% Volts/second. The AFC shall be initiated and the search discontinued when the DC level from the power meter exceeds a predetermined threshold. The output of the power meter shall be as described in 3.3.1.10.

3.3.2.5.2 L.O. frequency setting.- Upon completion of the spectral line search and the AFC, the local oscillator frequency shall be set at 30 ± 1.1 MHz below the line center frequency and shall not drift by more than ± 500 KHz from the initial offset frequency over a 5-minute period.

3.3.2.6 L.O. AFC Loop.- The local oscillator AFC loop shall accept the frequency AFC error voltage from the receiver porportional to deviation from the 30 MHz center frequency. The error signal shall possess the following characteristics:

(a) Zero error voltage at 30.0 ± 0.1 MHz

(b) Bandwidth of 0.1 Hz to 10 KHz at 3 db with fall off of 6 db/active

(c) Slope of:

(1) At least -5 to +5 Volts over frequency range 29.5 to 30.5 MHz.

(2) Between -5 to -13 Volts over frequency range 27.5 to 29.5 MHz.

(3) Between +5 to +13 Volts over frequency range 30.5 to 32.5 MHz.

(d) Output impedance of less than 1000 ohms.

In response to the error voltage, the AFC shall generate an appropriate piezo-electric tuner driving voltage such that the local oscillator operating frequency shall be kept at 30 ± 0.05 MHz below the received transmitter frequency over a frequency bandwidth of 0.1 to 1 Hz. Local oscillator AFC shall be closed after receipt of an operate "ON" pulse.

3.3.3 Back-up laser assembly.- The back-up laser assembly shall consist of the following subassemblies:

(a) Laser Tube

(b) Laser Tube Mount

(c) Cavity End Mirror and Mounts

(d) Back-Up Laser Start-Up Control

(e) Back-Up Laser AFC Loop

} The electronic circuity portion shall be enclosed in an electronics housing.

3.3.3.1 Back-Up Transmitter/Local Oscillator Selection.- Provisions shall be made to operate the back-up laser as a transmitter or local oscillator upon receipt of the "Back-Up Transmitter On" or "Back-Up L.O. On" commands, respectively.

3.3.3.1.1 Back-up laser as a transmitter.- The back-up laser characteristics shall be in accordance with the requirements specified in Table IB. The start-up loop shall be as specified in 3.3.1.9 and as follows:

(a) Respond to the back-up transmitter "ON" command

(b) Effect Spectral line search (same as 3.3.1.9(a).

(c) Effect selection of the line center frequency and continue operating at the line center frequency ± 2.8 MHz.

3.3.3.1.2 Back-Up Laser as a Local Oscillator.- The back-up laser characteristics, when operating as a local oscillator, shall be in accordance with Table IB. Upon receipt of a backup L.O. "ON" command, the start-up sequence shall be as described in 3.3.2.5.

3.3.4 Laser Baseplate Assembly.- A one piece baseplate will be used in the LCE system to mount the transmitter, local oscillator, and back-up laser assemblies. The baseplate will be made of CER-VIT (Owens-Illinois). The baseplate shall have provisions to mount parts of the optical subsystem consisting of the diffraction gratings, power meters, beam splitters, mirrors, buffers and including mountings structures and associated hardware.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for two years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements. Any deficiencies noted as a result of tests conducted by the procuring activity, shall be corrected at the subcontractor's expense and subsequent testing shall be at the subcontractor's expense.

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall implement and maintain a quality assurance program in accordance with AGC-STD-2311.

4.1.2 Subcontractor's reliability assurance program.- The subcontractor shall implement and maintain a reliability assurance program in accordance with AGC-STD-2312.

4.1.3 Processing changes.- The subcontractor shall make no changes in the Laser Subsystem design, specifications, materials, or material processes after AGC design approval without prior written approval of the Aerojet LCE Program Manager.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration in accordance with the calibration system requirements of MIL-C-45662. The tolerance allowed on test conditions and inputs are intended only to provide for accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification Inspection and Flight Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Acceptance Inspection (see 4.6).

4.3 Test plan.- The subcontractor shall prepare a test plan which includes all of the inspections specified in 4.2 and is developed so that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers' designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process examinations and tests.- In-process examinations and tests shall be performed as required to determine conformance to applicable drawings, specifications, approved workmanship standards, identification, traceability, and any special process controls required to insure repeatability of hardware performance.

4.5 Design Qualification Inspection. - Design Qualification Inspection shall consist of all the tests described in Table V, as a minimum. The examinations and tests shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the Laser Subsystem under ambient conditions and the specified operational environments. The detailed Design Qualification Inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order.

Table V. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Test Method
Analysis		
Reliability	3.2.4	4.7.1
Maintainability	3.2.5	4.7.1
Thermal analysis	3.2.6	4.7.1
Visual examination and measurements		
Selection of specifications and standards	3.2.7.1	4.7.1.1
Materials, parts and processes	3.2.7.2	↑
Standard and commercial parts	3.2.7.3	
Moisture and fungus resistance	3.2.7.4	
Corrosion of metal parts	3.2.7.5	
Interchangeability and replaceability	3.2.7.6	
Workmanship	3.2.7.9	
Printed wiring boards	3.2.7.7	
Soldered electrical connections	3.2.7.8	↓
Identification and marking	3.2.7.11	4.7.1.1
Weight	3.2.3.1	4.7.3
Envelope dimensions	3.2.3.2	4.7.1.1
Center of gravity	3.2.3.3	4.7.1.1
Mounting and alignment	3.2.3.4	4.7.3
Surface characteristics	3.2.3.5.2	4.7.1.1
Power	3.2.1.1	↑
Grounding	3.2.3.7	
Telemetry points	3.2.1.3	
Commands	3.2.1.2	
Connector	3.2.3.8	
Electrical interface	3.1.2	
Test points	3.2.3.6	↓
Venting	3.2.3.9	4.7.1.1
Testing		
Functional characteristics at minimum and maximum temperatures (operating)	3.2.6.1 (e) Tables VIII,IX,& X	4.7.2 & 4.7.4
Leak Detection	As required	
Vibration (non-operating)	3.2.6.2(a), Level I	4.7.4
Functional characteristics (after vibration)	Tables VIII,IX,& X	4.7.2
Acceleration	3.2.6.2(b)	4.7.4
Functional characteristics (after acceleration)	Tables VIII,IX & X	4.7.2
Functional characteristics during thermal vacuum	3.2.6.1(d) Tables VIII,IX & X	4.7.2 & 4.7.4
Leak detection	As required	
Electromagnetic interference	3.2.7.10	4.7.5
Functional characterisitics at maximum temperature (operating)	3.2.6.1(e), Tables VIII,IX, & X	4.7.2 & 4.7.4

4.6 Acceptance inspection.- A detailed procedure of the acceptance inspection shall be generated as a part of the overall test plan, by the subcontractor and approved by AGC prior to final inspection. Acceptance inspection shall be accomplished on each subsystem offered for delivery including the flight and ground models. The inspections shall be extensive enough to demonstrate satisfactory workmanship and that the Laser Subsystem performance is within tolerance.

4.6.1 Flight acceptance inspection.- As a minimum, the inspections and tests in Table VI shall be performed for acceptance of the flight model.

Table VI. Flight Acceptance Inspection

Examination or Test	Requirements	Method
Visual examination and measurements		
Weight	3.2.3.1	4.7.1.1
Envelope dimensions	3.2.3.2	4.7.1.1
Surface characteristics	3.2.3.5.2	4.7.1.1
Connectors	3.2.3.8	4.7.1.1
Testing		
Functional characteristics at minimum and maximum temperature (operating)	3.2.6.1(e), Tables VIII, IX, & X 1/	4.7.2 & 4.7.4
Leak detection	As required	
Vibration (non-operating)	3.2.6.2(a), Level II	4.7.4
Functional characteristics	Tables VIII, IX, & X 1/	4.7.2
Functional characteristics during thermal vacuum	3.2.6.1(d), Tables VIII, IX, & X 1/	4.7.2 & 4.7.4
Leak detection	as required	
Functional characteristics at maximum temperature (operating)	Tables VIII, IX, & X 1/	4.7.2 & 4.7.4

1/ Excluding storage and acceleration and associated functional tests.

4.6.2 Ground model acceptance inspection.- The ground model acceptance inspection shall be in accordance with Table VII.

4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the written report. Systems engineering data shall be used where appropriate to support analysis.

4.7.1.1 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of testing, subject to agreement of the Aerojet representative.

Table VII. Ground Model Acceptance Inspection

Examination or Test	Requirement	Method
Visual examination		
Envelope dimensions	3.2.3.2	4.7.1.1
Surface characteristics	3.2.3.5.2	4.7.1.1
Connectors	3.2.3.8	4.7.1.1
Testing		
Functional performance at maximum and minimum temperature	3.2.6.1(e), Tables VIII, IX and X 1/	4.7.2 & 4.7.4
Electromagnetic interference	3.2.7.10	4.7.5

1/ Excluding storage and acceleration and associated functional tests.

4.7.2 Functional performance.- Specific tests as specified in 4.7.2, and Tables VIII, IX and X shall be performed to verify that the requirements of 3.2.1 are met. Whenever possible, test shall be made on the subsystem with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Functional tests in accordance with Tables VIII, IX and X shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.2.1, which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.2.1, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.2.1 Performance test.- The functional performance test shall be performed at the specified vacuum pressure or ambient pressure, as applicable, after the chamber has stabilized at the specified pressure or vacuum for a minimum of two hours and the temperature of the baseplate has stabilized at the specified temperature. The performance shall be verified for each of the functional characteristics in Tables VIII, IX, and X. The Laser Subsystem shall utilize an appropriate standard laser cavity for each type of laser tube. These standard laser cavities may be the functional test model Laser Subsystem. The unit, when placed in its standard laser cavity, shall perform nominal lasing with only minor optical/mechanical alignment.

Table VIII. Functional Testing - Transmitter Assembly

Requirement	Requirement Paragraph		Temperature Test		Functional After Storage	Functional After Vibration		Functional After	Functional During	Functional Test
	Table	Item No	Min.	Max.	Temp. Test	Qual.	Flight	Acceleration	Thermal-Vacuum	At Max. Temp.
Operating Line	IA	5	X	X					X	X
Mode	IA	2	X	X					X	X
Polarization	IA	3	X	X						X
Power Output	IA	1	X	X	X	X	X	X	X	X
Power Input	II		X	X	X	X	X	X	X	X
Operating Line Width	IA	6	X	X						X
Collimation	IA	4	X	X						X
Output Power Beam Diameter	IA	4	X	X						X
Carrier Frequency	IA	8	X	X						X
Modulation Characteristics	IA	11	X	X						X
Non-Linearity Distortion	IA	15	X	X						X
Noise	IA	13c	X	X						X
Frequency Stability 1/	IA	9	X	X						X
Amplitude Stability 1/	IA	10	X	X						X
AFC Cavity Mirror Range	IA	14	X	X						X
Modulator Oven Temp. Control	3.3.1.4		X	X						X

1/ These tests shall be conducted under the specified operational vibration levels.

TABLE IX. Functional Testing - Local Oscillator Assembly

Requirement	Requirement Paragraph		Temperature Test		Functional After Storage Temp. Test	Functional After Vibration		Functional After Acceleration	Functional During Thermal-Vacuum	Functional Test At Max. Temp.
	Table	Item No	Min.	Max.		Qual.	Flight			
Operating Line	IB	5	X	X						X
Mode	IB	2	X	X						X
Polarization	IB	3	X	X						X
Power Output	IB	1	X	X	X	X	X	X	X	X
Power Input	II		X	X	X	X	X	X	X	X
Collimation	IB	4	X	X						X
Output Power Beam Diameter	IB	4	X	X						X
Operating Frequency	IB	7	X	X						X
Acquisition Frequency Uncertainty	IB	8	X	X						X
Frequency Stability 1/	IB	9	X	X						X
Amplitude Stability 1/	IB	10	X	X						X
AFC Cavity Mirror Range	IB	11	X	X						X

1/ These tests shall be conducted under the specified operational vibration levels.

Table X. Functional Testing - Backup Laser Assembly

Requirement	Requirement Paragraph		Temperature Test		Functional After Storage Temp. Test	Functional After Vibration		Functional After Acceleration	Functional During Thermal-Vacuum	Functional Test At Max. Temp.
	Table	Item No	Min.	Max.		Qual.	Flight			
Operating Lines	IB	5	X	X						X
Mode	IB	2	X	X						X
Polarization	IB	3	X	X						X
Power Output	IB	1	X	X	X	X	X	X	X	X
Power Input	II		X	X	X	X	X	X	X	X
Collimation	IB	4	X	X						X
Output Power Beam Diameter	IB	4	X	X						X
Operating Frequency	IB	7	X	X						X
Acquisition Frequency Uncertainty	IB	8	X	X						X
Frequency Stability 1/	IB	9	X	X						X
Amplitude Stability 1/	IB	10	X	X						X
AFC Cavity Mirror Range	IB	11	X	X						X

1/ These tests shall be conducted under the specified operational vibration level.

4.7.2.2 Power output.- *

4.7.2.3 Mode.- *

4.7.2.4 Polarization.- *

4.7.2.5 Collimation.- *

4.7.2.6 Operating line.- *

4.7.2.7 Operating line width.- *

4.7.2.8 Output power beam diameter.- *

4.7.2.9 Carrier frequency.- *

4.7.2.10 Frequency stability.- *

4.7.2.11 Amplitude stability.- *

4.7.2.12 Modulation characteristics.- The modulation characteristics shall be determined using the test setup shown in Figure 8 and shall comply with the requirements specified in Table IA and as follows:

(a) Modulation - FM.

(b) Deviation capability - Capable of providing peak deviations of up to ± 4.0 MHz.

(c) Modulation sense - The Modulation shall be positive, (i.e., positive frequency deviation corresponds to a lighter picture visual).

(d) Input frequency bandwidth: 1 MHz to 6.0 MHz.

(e) Baseband amplitude-frequency characteristics -

	Reference Frequency	Design Goal	Minimum Acceptable
(1)	1.025 MHz	0 db	0 db
(2)	1.0 to 1.840 MHz	± 0.1 db	± 0.25 db
(3)	1.840 to 6.0 MHz	± 0.2 db	± 0.4 db

(f) Modulator/Driver Sensitivity - * MHz/volts input.

(g) Modulator/Driver Sensitivity Stability (MHz deviation/volt input) stable within ± 0.1 db over the full operating environmental range during one operating period (not to exceed 24 hrs.).

(h) Group Delay - The group delay of the laser transmitter shall be such that, when measured over a 6.0 MHz output bandwidth and using the test setup of Figure 8, shall not exceed the following:

(1) ± 0.2 ns/MHz slope
(2) 0.04 ns/MHz^2 parabolic
(3) 0.6 ns peak-to-peak ripple

* The test methods specified in the test plan shall be used to verify conformance of these characteristics.

(i) Modulator Linearity - The modulator linearity measured by the derivative method, using Figure 8 test setup, shall not exceed 2 percent, the center 90 percent of ____ MHz, and shall not exceed 1 percent over 75 percent of the bandwidth.

4.7.2.13 Video distortion and noise.- The video distortion and noise shall remain within limits specified in the following subparagraphs in baseband-to-baseband test using the test setup shown on Figure 9. The vestigial sideband modulator and demodulator shown will be provided by AGC and their baseband-to-baseband video distortion and noise characteristics shall be subtracted from measured data, and the difference data shall then be applicable to the distortion and noise limits specified in the following subparagraphs.

4.7.2.13.1 Non-linearity distortion.- The non-linerarity shall be measured as follows to verify compliance with Table IA:

(a) Non-linearity distortion of the synchronizing signal - Using Test Signal No. 3, the amplitude for the synchronizing pulses shall be between the limits of 0.25 and 0.30 volts, measured at a point of 0 db insertion gain, irrespective of whether the intermediate lines of the test signal are at black level or white level.

4.7.2.13.2 Noise.- The noise characteristics shall be received as follows to verify compliance with Table IA:

(a) Periodic Noise - The ratio of the peak-to-peak picture signal amplitude to the peak-to-peak noise amplitude shall be as follows:

(1) Power Supply Hum.................... 38 db min.
(Including the fundamental frequency and lower harmonics)

(2) Single frequency noise between 1 KHz and 2 MHz...................... 62 db min.

(3) Single-frequency noise between 2 and 6 MHz........................... 46 db min.

4.7.3 Weight and center of gravity.- The weight of the item and its major components shall be determined to verify compliance with 3.2.3.1. The center of gravity shall be determined along each of three mutually perpendicular axes as specified in 3.2.3.3.

4.7.4 Environmental tests.- The following environmental tests shall be performed as specified in AGC-20511 to verify compliance with the requirements herein. During the tests the item shall be attached to the test fixture so as to simulate the actual element mounting to the transceiver baseplate.

(a) Vibration. (The vibration amplitude may be reduced up to 25 percent with the approval of AGC to facilitate using existing laboratory equipment.

(b) Acceleration.

(c) Thermal-vacuum

4.7.5 Electromagnetic interference.- EMI testing shall be accomplished in accordance with the requirements of 3.2.7.10 for tests CE01, CS01, and RE02 as specified in MIL-STD-461.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. If the component does not meet the requirements herein because of such contamination or damage, an acceptable replacement component shall be furnished within a reasonable time by the subcontractor at no cost to AGC. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter (AGC-20187C)

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable

6. NOTES

6.1 Intended use.- The Laser Subsystem specified herein is intended for use in the ATS-F Spacecraft as well as in a transportable ground station without exhibiting any differences in performance or functional capabilities due to the differences in these environments. Any differences in hardware which may be necessary shall not degrade the specified performance levels. In its final form, this basic specification will describe the Laser Subsystem as required for use in the space environment while the differences which make it suitable for use in the ground environment will be noted in a brief addendum.

6.2 Supplementary References.- The following documents are for information only and are not contractually binding in this specification.

(a) "10.6 Micron Laser Communications System Experiment for ATS-F and ATS-G," GSFC Document X-524-68-206, May, 1968.

(b) "Heat Pipes and Vapor Chambers for Thermal Control of Spacecraft," S. Katzoff, Progress in Astronautics and Aeronautics, Vol. 20, 1967.

6.3 Definitions.-

6.3.1 Failure.- A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.4 Oral statements.- Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.

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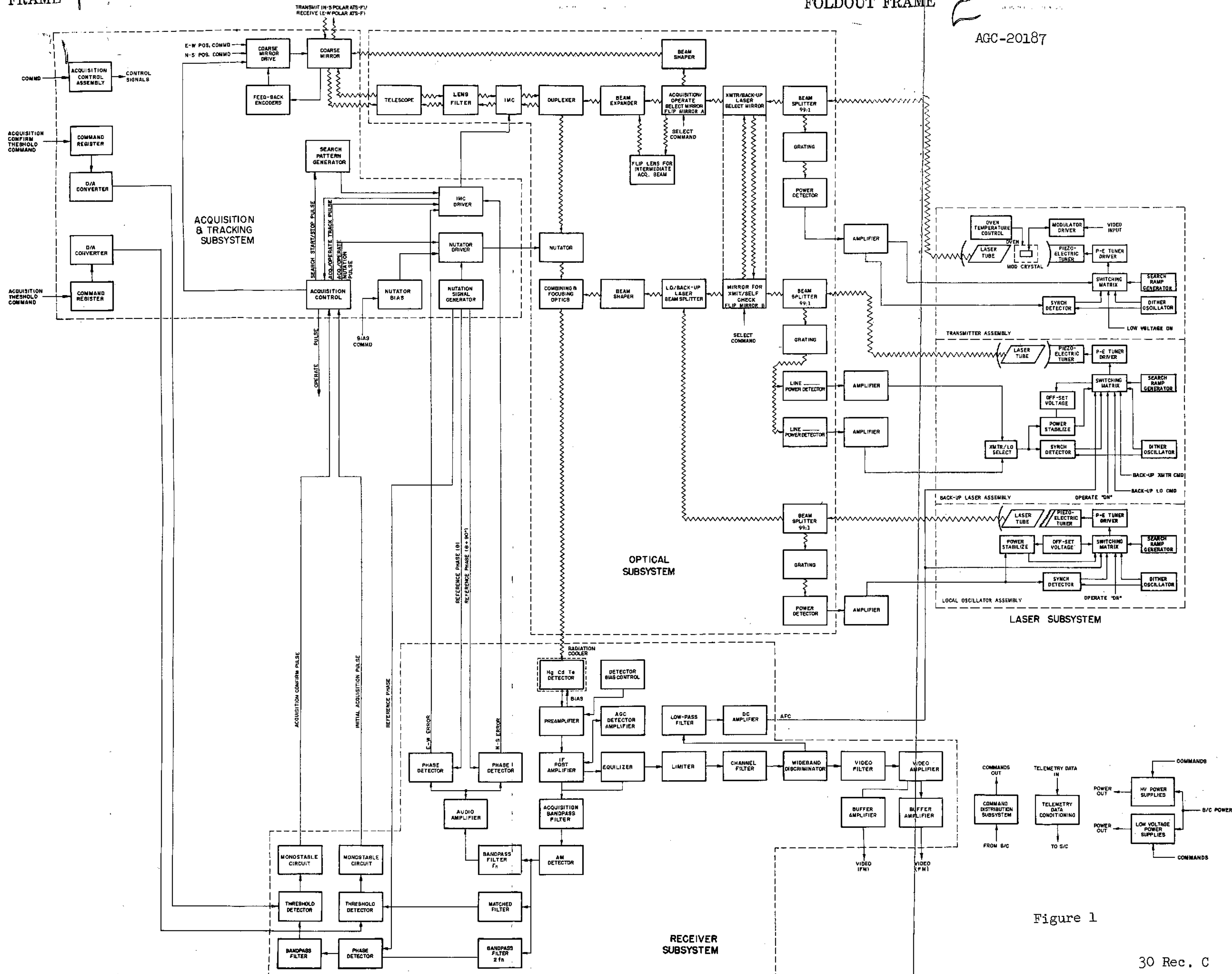

Figure 1

To be added later.

Figure 2. Electrical Interface Drawing

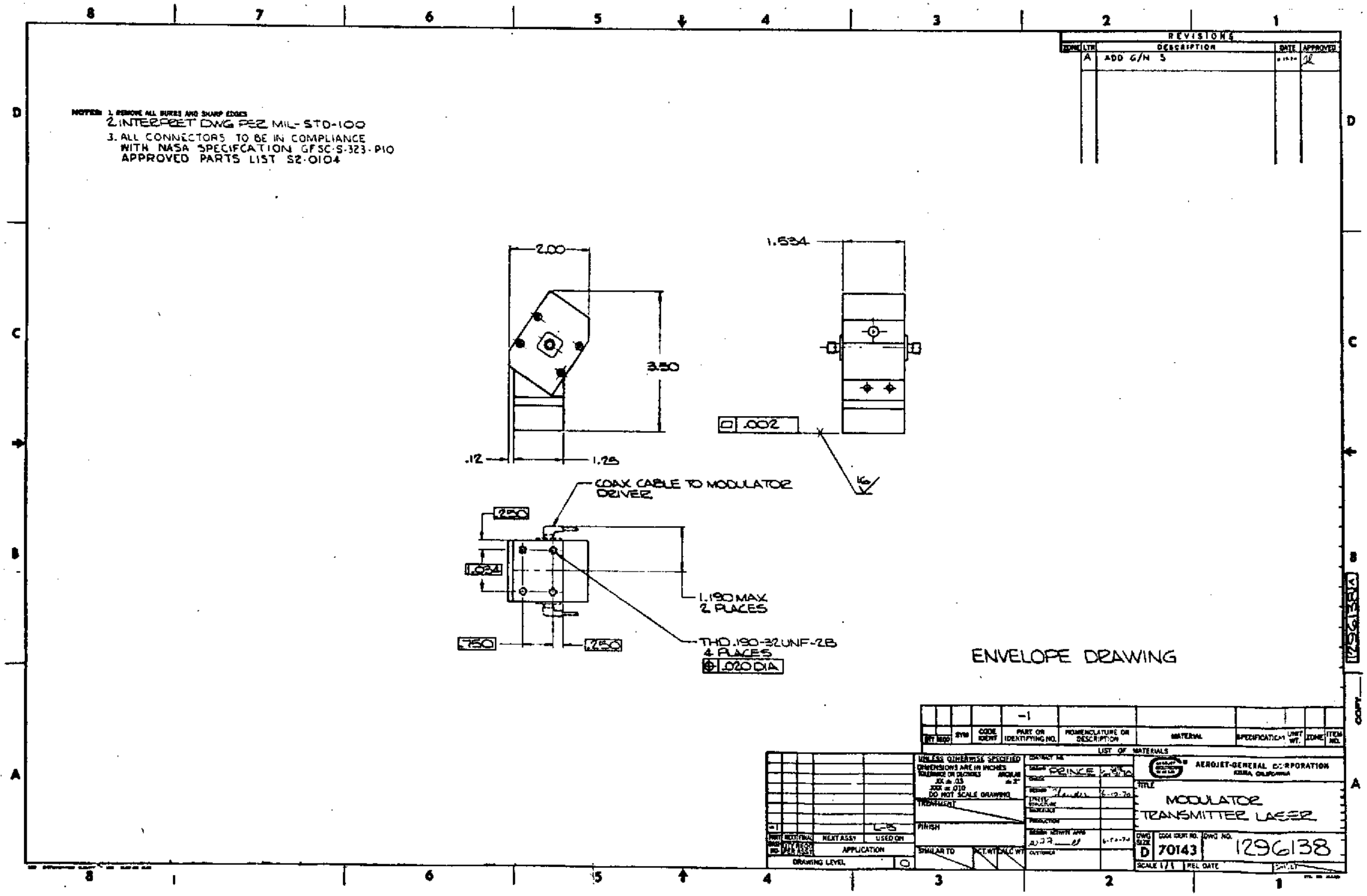

Figure 3. Modulator Transmitter, Laser Envelope

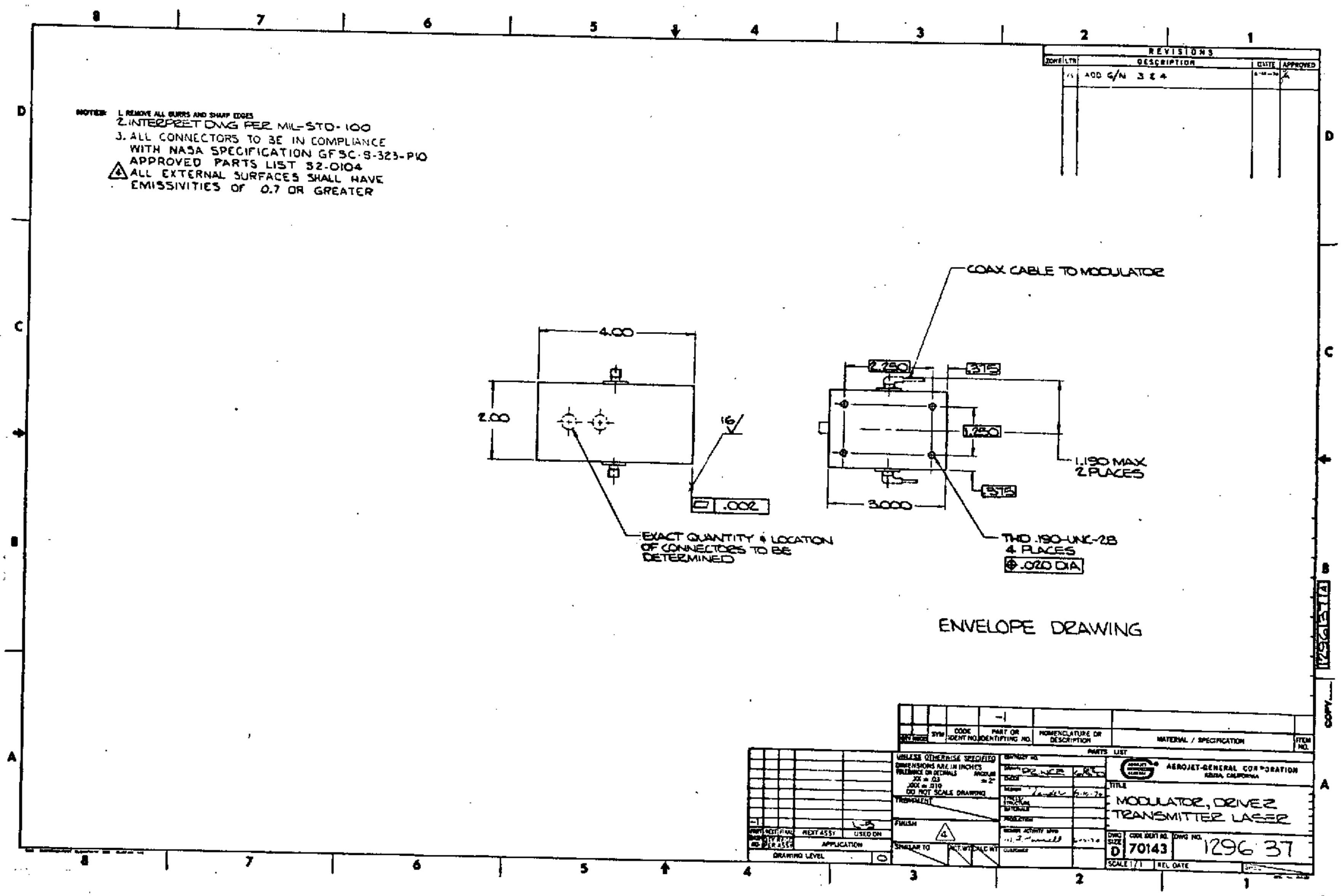

Figure 4. Modulator Driver Envelope

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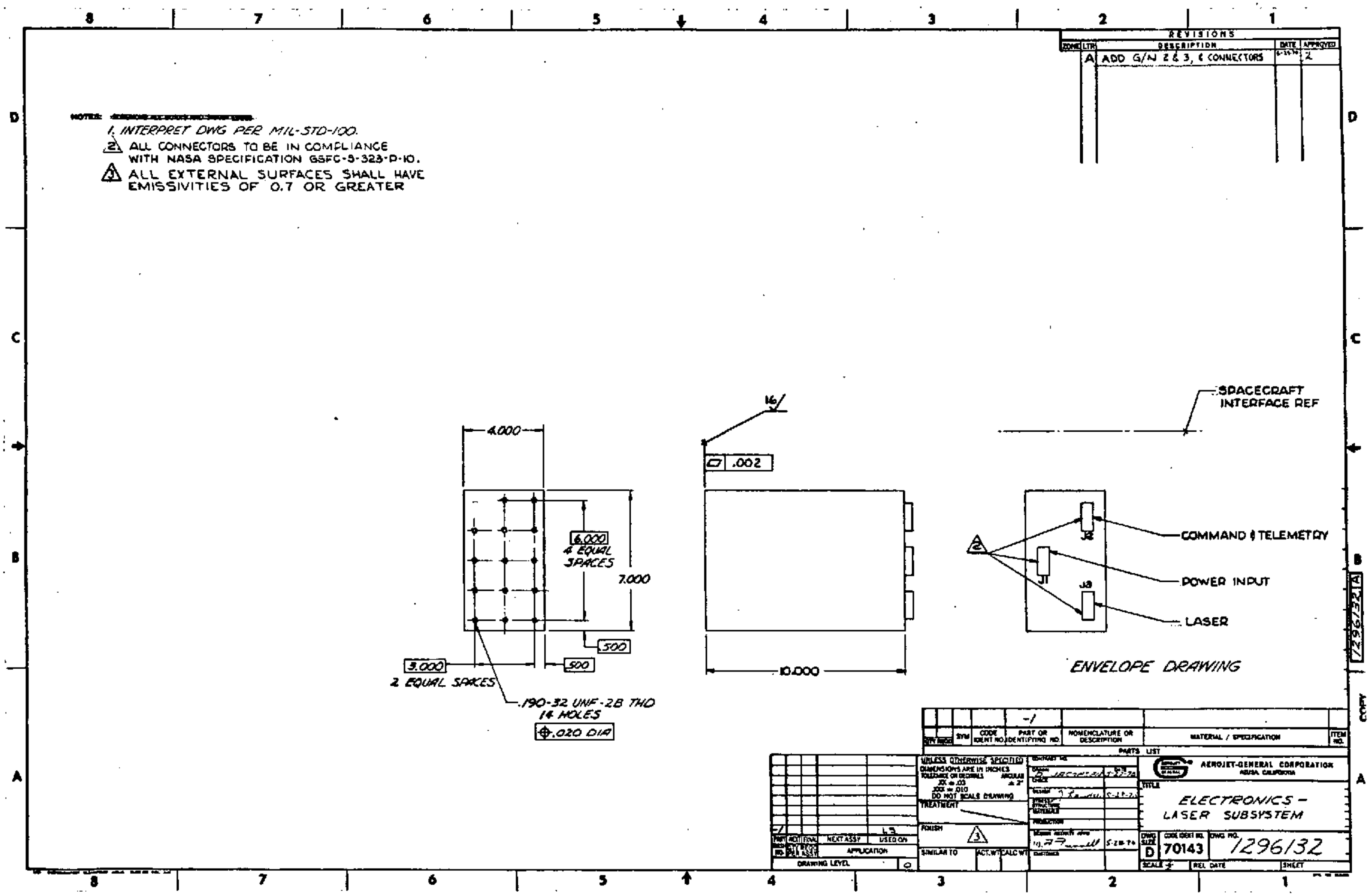

Figure 5. Laser Subsystem Electronics Envelope

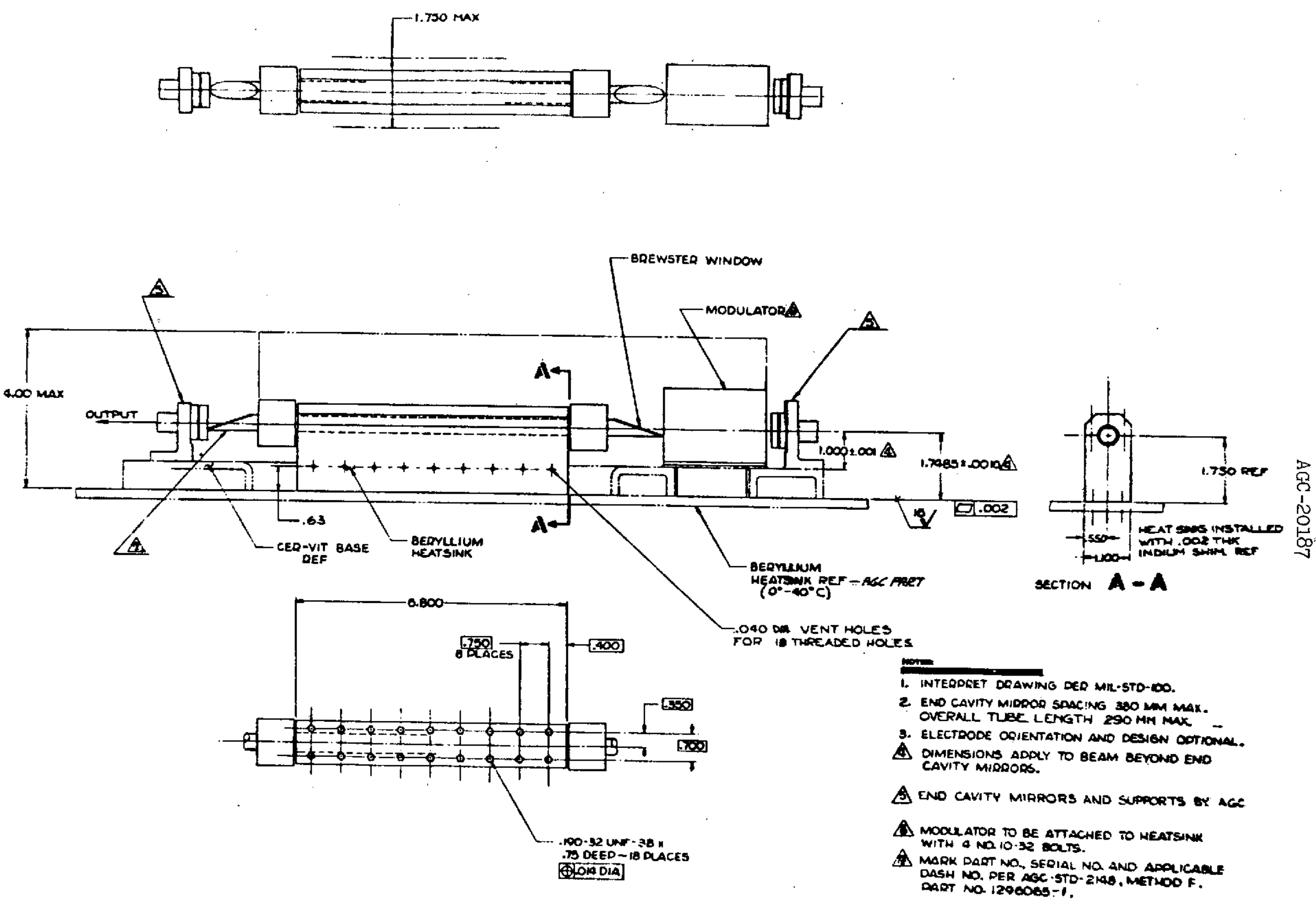

Figure 6. Laser Transmitter Envelope Drawing
(Revision Forthcoming)

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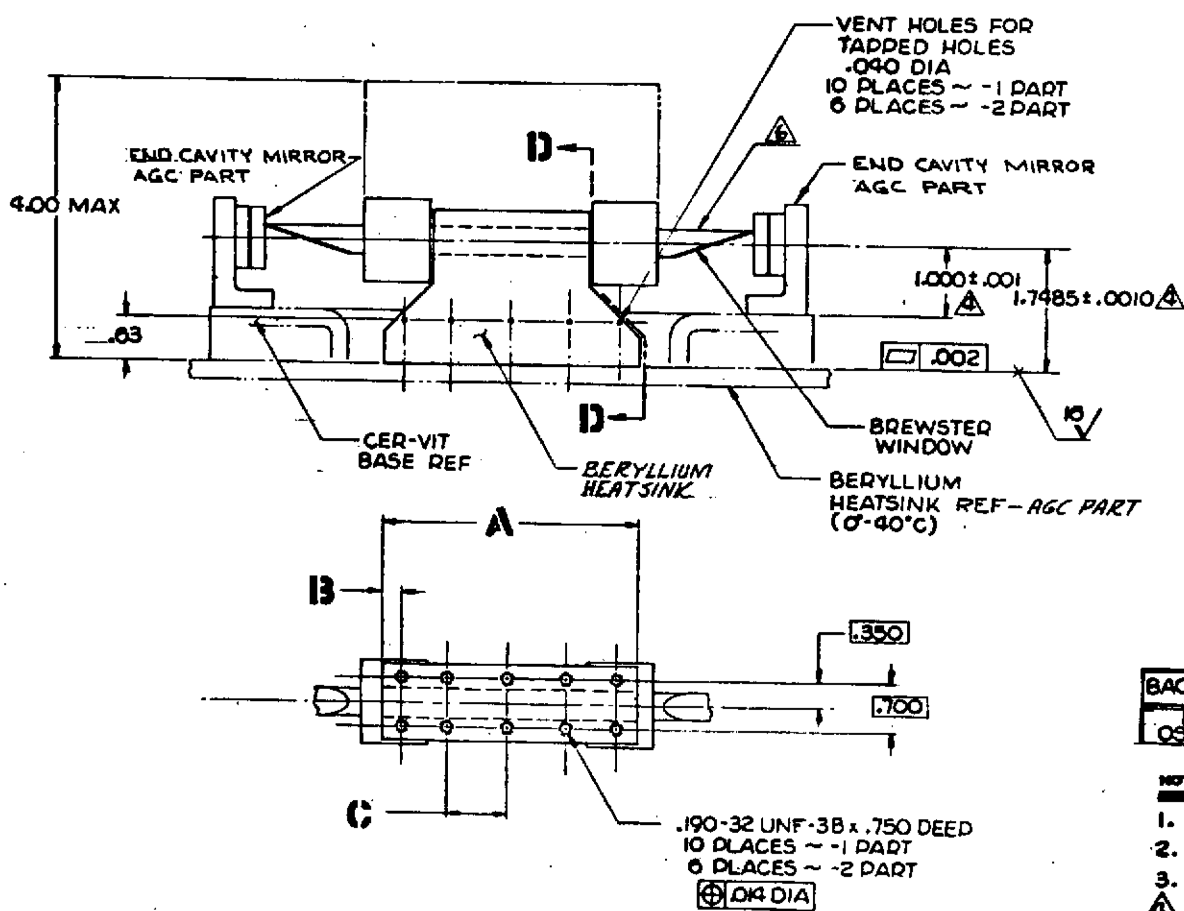
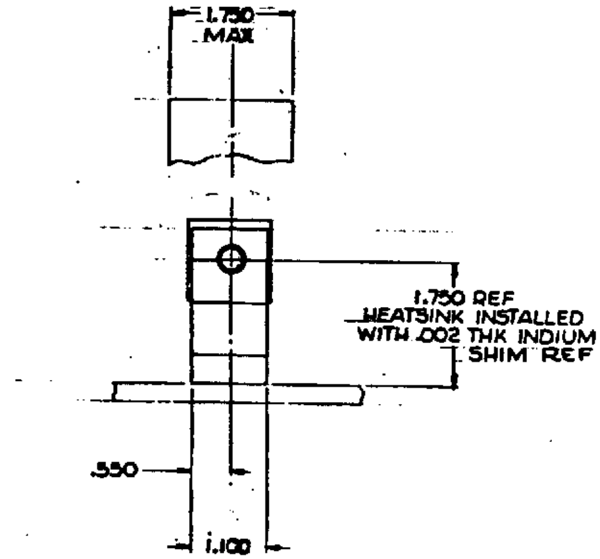




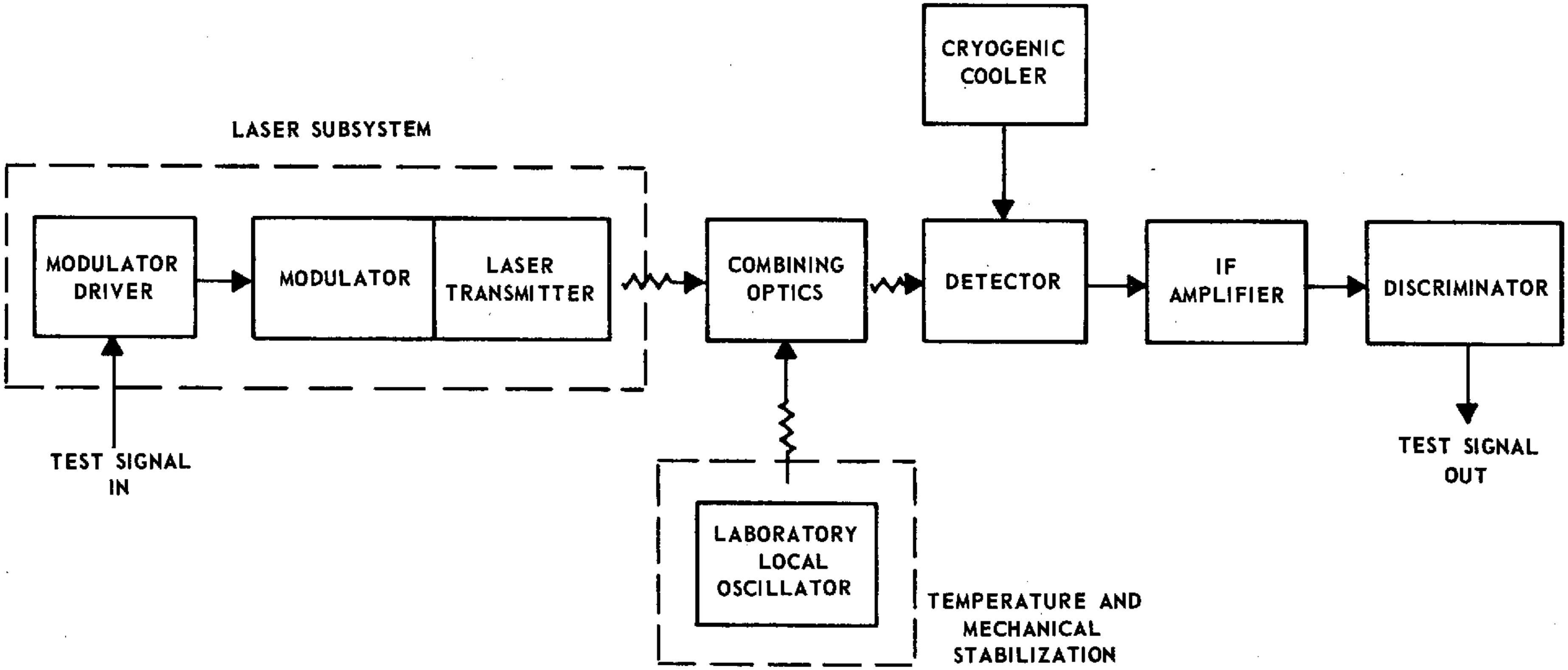
SECTION D-D

	DASH NO.	A	B	C
BACKUP LASER	-1	3.600	.300	.750 4 PLACES
LOCAL OSCILLATOR	-2	2.200	.350	.750 2 PLACES

NOTES:

1. INTERPRET DRAWING PER MIL-STD-100.
2. END CAVITY MIRROR SPACING 200 MM MAX.
3. ELECTRODE ORIENTATION & DESIGN OPTIONAL.
4. (4) DIMENSIONS APPLY TO BEAM BEYOND END CAVITY MIRRORS.
5. END CAVITY MIRRORS & SUPPORTS BY AGC.
6. (6) MARK PART NO., 1296066, SERIAL NO. & APPLICABLE DASH NO. PER AGC-STD-2148, METHOD F.

Figure 7. Local Oscillator and Backup Laser Envelope Drawing
(Revision Forthcoming)



AGC-20187

Figure 8. TEST SET-UP – MODULATION CHARACTERISTICS

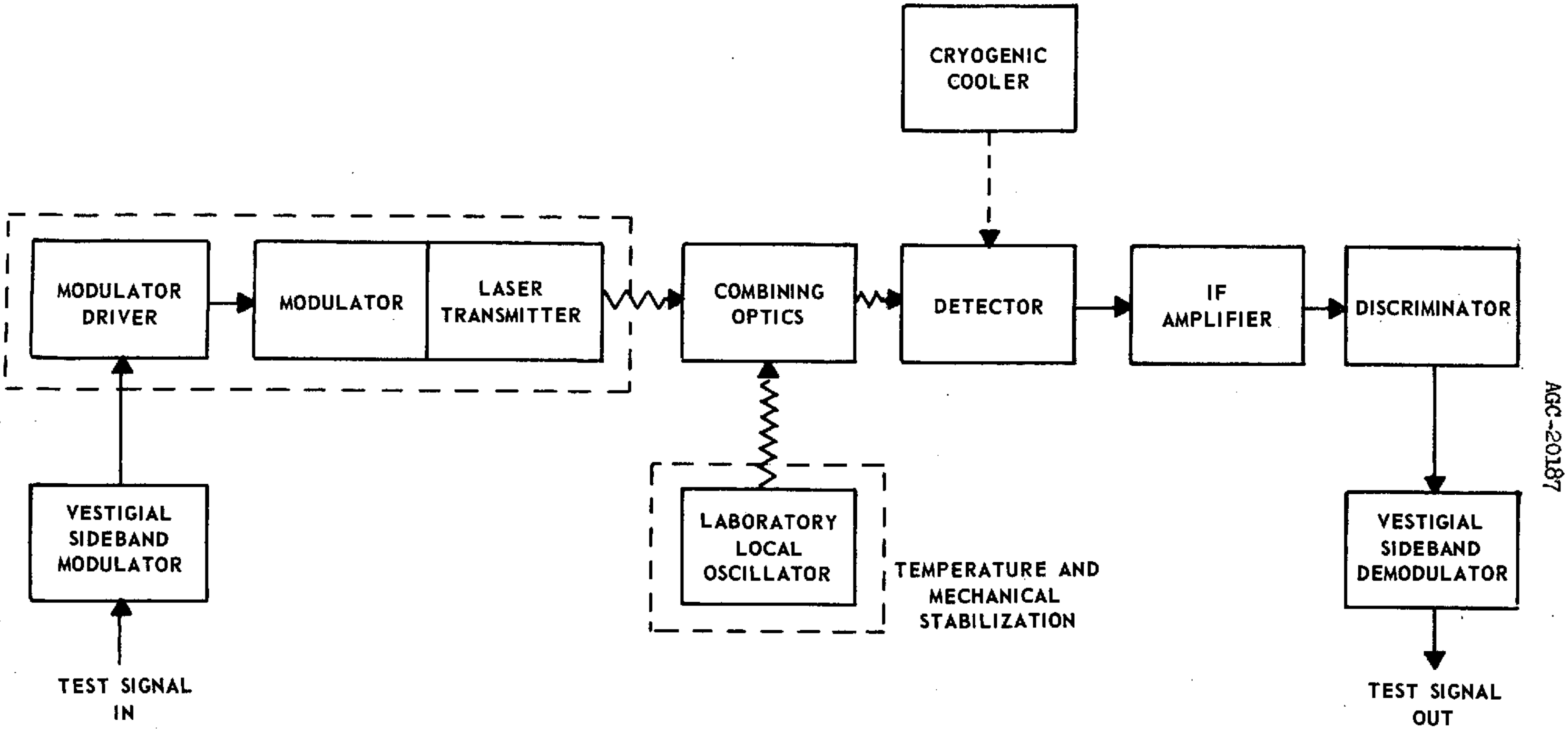


Figure 9. TEST SET-UP – VIDEO DISTORTION AND NOISE

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20187 C

TITLE

LASER SUBSYSTEM, 10.6 MICRON

PREPARED BY	DEPT.	EXT.
SPEC. ENGINEER J. COFF	7981	6571

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein *R Goldstein*	3591	7-8-70
CHIEF PROJECT ENGINEER - A. H. Gale *A H Gale*	3574	7-8-70
SYSTEM ENGINEERING - J. V. Cernius *J. V. Cernius*	3575	7-8-70
QUALITY ENGINEERING - J. H. Bassett *J Bassett*	7831	7 July
RELIABILITY - P. W. Stockdill *P W Stockdill*	4072	7 July 70
RELEASE ACTIVITY - *C. R. Cantrell*	1147	7-9-70

/H/AP/TP/

7/6/70

AEROJET-GENERAL CORPORATION

AEROJET-GENERAL CORPORATION

CODE IDENT. NO.

SPECIFICATION AGC-20511A

ENVIRONMENTAL DESIGN CRITERIA AND TEST LEVELS FOR THE LASER COMMUNICATION EXPERIMENT AND ASSOCIATED COMPONENTS

SUPERSEDING:		
AGC-20511 DATE 10 March 1970	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	PAGE ADDITIONS
	13 Mar 70																		
A	9 Jul 70	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough (signature)
for J. Coff, Supervisor
Specifications and Standards

Why No FTM

1. SCOPE

1.1 Scope.- This specification covers the minimum requirements for the environmental design criteria and test levels for the Laser Communications Experiment (LCE) prototype, flight model, ground model, and their respective subsystems.

1.2 Classification of tests.- The environmental tests specified herein have been classified as follows:

(a) Design qualification tests.- Design qualification tests were designed to simulate conditions more severe than field and flight conditions to locate design deficiencies. However, the conditions are not expected to excite unrealistic modes of failure; should such modes occur, pertinent requirements may be waived by express approval of AGC LCE Program Manager. Generally, test exposure levels were arrived at by multiplying the normally expected levels by 1.5 or increasing the expected temperature range by ±15°C. These tests shall be conducted on the LCE Prototype Model and its subsystems.

(b) Flight model acceptance tests.- Flight model acceptance tests were designed to disclose latent material and workmanship defects in an item of proven design before its incorporation in a flight spacecraft or acceptance as a flight spare. Exposure levels for these tests were derived from criteria normally expected during the spacecraft life cycle.

(c) Ground model acceptance tests.- Ground model acceptance tests were designed to disclose latent material and workmanship defects in an item of proven design before its incorporation in the Operational Ground Equipment (OGE). Exposure levels for these tests were derived from criteria normally associated with the transportation and operation of the OGE.

1.3 Applicability.- This specification shall be applicable only to the extent to which it is referred to in the applicable equipment specification or the test plan. The tests herein have been developed to provide a high degree of confidence that the LCE will meet the following objectives:

(a) Survive handling and transportation environments.

(b) Survive launch and orbit injection environments.

(c) Operate in the orbital and ground environment, as applicable.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the content of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall be considered a superseding requirement.

SPECIFICATIONS

Military

MIL-C-45662	Calibration of Standards

STANDARDS

Federal

FED-STD-209	Controlled Environment Clean Room and Work Station Requirements

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference, Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units Electromagnetic Interference Technology
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment
MIL-STD-1472	Human Engineering Design Criteria for Aerospace Systems and Equipment

Aerojet-General Corporation

AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of documents required by contractors in connection with specified procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 General.- The test environments specified herein represent those conditions which the prototype, flight, and ground models and associated subsystems shall be required to withstand to assure satisfactory performance in accordance with the detail equipment specification.

3.2 Test sequence.- The sequence to be followed for the environmental tests shall be as specified in the equipment specification consistant with the sequence shown below. Deviation from the sequence specified shall require prior approval of the Aerojet LCE Program Manager or his authorized representative.

		Design Qualification	Flight Acceptance	Ground Acceptance
(a)	Weight and Center of Gravity	X	X	
(b)	Leak*	X	X	X
(c)	Storage and Operational Temp.	X		X
(d)	Vibration	Level I	II & III	II & III
(e)	Acceleration	X	X	X
(f)	Radiation	X		
(g)	Thermal-balance*	X		
(h)	Thermal-vacuum	Level I	Level II	
(i)	Leak*	X	X	X

3.3 Weight and center of gravity.- The weight of the LCE and its subsystems shall be determined to verify compliance with the detail component specification. The center of gravity shall be determined for the LCE along each of three mutually perpendicular axes (X, Y & Z) as shown in Figure 1.

3.4 Detail environmental requirements.-

3.4.1 Leakage.- Items which are hermetically sealed shall contain an internal vacuum. The leakage rate of an item shall be determined using a helium mass spectrometer method and shall be less than 1×10^{-6} standard cc/second of helium.

3.4.2 Temperature.- The item shall be capable of satisfactory performance in accordance with the detailed specification while being exposed to the temperature environments for equipment operating as specified in Table I. The item shall operate satisfactorily at room ambient temperature following storage exposure and during transitions to and from the exposure limits. For cyclically operated items (on/off orbital operation) cold start capability shall be demonstrated at least three times during the cold test.

* When specified in the equipment specification.

Table I. Temperature Tests During Storage and Equipment Operation

Test Type	Test Phase	Stabilized Temperature	Duration (hours)
Storage	Cold Storage	-30° C (-22° F)	6
	Hot Storage	+ 60° C (+140° F)	6
Equipment Operating	Cold Operation	-5° C (+23° F)	6 (minimum)
	Hot Operation	+40° C (+104° F)	6 (minimum)

3.4.3 Vibration.- The item shall be capable of satisfactory performance in accordance with the detailed specification while being subjected to sinusoidal sweeps at test level III as specified in Table IIA. The item shall be capable of satisfactory performance in accordance with the detail specification after being subjected to sinusoidal sweeps and random vibration at test level I or II as specified in Table IIA and IIB. The vibration shall be applied in each direction along the three orthogonal axes, with one direction being parallel to the thrust axis (see Figure 1).

Table IIA. Sinusoidal Vibration

Test Level	Axis	Frequency (Hz)	Input Level	Sweep Rate	Test Time
Design Qualification Test I (Equipment Nonoperating)	Thrust and Lateral (Z-Z, X-X and Y-Y)	5 to 22	0.5-inch double amplitude constant displacement	2 octaves/ minute	13.0 minutes (total)
		22 to 200	12.0 g (0-to-peak)		
		200 to 2000	5.0 g (0-to-peak)		
Flight & Ground Acceptance Test II (Equipment Nonoperating)	Thrust and Lateral (Z-Z, X-X, and Y-Y)	5 to 18	0.5-inch double amplitude constant displacement	4 octaves/ minute	6.5 minutes (total)
		18 to 200	8.0 G (0-to-peak)		
		200 to 2000	3.3 g (0-to-peak)		
Flight & Ground Acceptance Test III (Equipment Operating)	Thrust and Lateral (Z-Z, X-X, and Y-Y)		Velocity (cm/sec, rms)	*	*
		20	3.9×10^{-2}		
		100	7.8×10^{-3}		
		200	3.9×10^{-3}		
		400	2.0×10^{-3}		
		600	1.3×10^{-3}		
		800	1.0×10^{-3}		
		1000	7.8×10^{-4}		

* To be added at a later date.

Table IIB. Random Vibration

Test Level	Axis	Frequency (Hz)	PSD Level (g^2/Hz)	Overall Acceleration (g-rms)	Test Time
Design Qualification Test I (Equipment Nonoperating)	Thrust and Lateral (Z-Z, X-X, and Y-Y)	20 to 250	0.0010 to 0.16 increasing from 20 Hz at the rate of 6 db/octave	17.0	4.0 minutes each axis (Total 12 minutes)
		250 to 2000	0.16		
Flight&Ground Acceptance Test II (Equipment Nonoperating)	Thrust and lateral (Z-Z, X-X, and Y-Y)	20 to 250	0.00046 to 0.07 increasing from 20 Hz at the rate of 6 db/octave	11.3	2.0 minutes each axis (Total 6 minutes)
		250 to 2000	0.07		

3.4.4 Acceleration.- The item shall be capable of satisfactory performance in accordance with the detailed specification while in any orientation and while being subjected to a zero to 1 g acceleration field and after being subjected to the following acceleration environments. The acceleration shall be applied along the longitudinal and either lateral axis at the center of gravity of the test item and not vary by more than ± 10% across the item (see Figure 1).

(a) Longitudinal Axis (Z-Z) in forward direction at 9 g's and 3.9 g's in aft direction for 3 minutes at each level.

(b) Lateral axis (either) at 3.9 g's in each direction for 3 minutes.

3.4.5 Space radiation environment.- The item shall be capable of withstanding the Van Allen Belt radiation for an exposure time of __*__ hours while on route to a synchronous orbit and thereafter meet the performance requirements of the applicable detail equipment specification. The item shall be capable of satisfactory operation in accordance with the applicable equipment specification while being subjected to the integral electron environment specified in Table III.

* To be added at a later date.

Table III. Integral Electron Environment
(Synchronous Equatorial Orbit, Averaged Over Local Time)

Electron Energy -E (MEV)	Time Averaged Omnidirectional Electron Flux Greater than Energy E electrons/cm^2/sec
0.01	6.51E+07
0.02	5.80E+07
0.03	5.33E+07
0.04	4.97E+07
0.05	4.65E+07
0.10	3.50E+07
0.20	2.10E+07
0.30	1.29E+07
0.40	7.94E+06
0.50	4.93E+06
0.60	3.07E+06
0.70	1.91E+06
0.80	1.19E+06
0.90	7.45E+05
1.00	4.66E+05
1.10	2.91E+05
1.20	1.82E+05
1.30	1.14E+05
1.40	7.14E+04
1.50	4.47E+04
1.60	2.80E+04
1.70	1.75E+04
1.80	1.10E+04
1.90	6.89E+03
2.00	4.32E+03
2.50	4.18E+02
3.00	4.06E+01
3.50	3.95E+00
4.00	3.84E-01
5.00	3.64E-03

3.4.6 Thermal balance.- The thermal balance test shall be performed with a test chamber vacuum of 1 x 10^{-5} torr or less with cold walls at -185°C (300°F) or less and solar simulation capability. The item shall be capable of satisfactory performance in accordance with the detailed specification during and after exposure to the environment.

3.4.7 Thermal vacuum.- The item shall be capable of satisfactory performance in accordance with the detailed specification after and while being (as applicable) exposed to the applicable thermal vacuum test of Table IV. Items that are normally operative during the launch phase shall be operating while the chamber is evacuated to 1 x 10^{-5} torr from standard atmospheric conditions. Corona effects shall be monitored throughout the evacuation period. For items that are operated after injection into orbit, turn-on times upon reaching a chamber vacuum pressure of 1 x 10^{-5} torr shall be established prior to test. For cyclically operated items (on/off orbital operation), a cold start capability shall be demonstrated at least three times during the cold soak period. Each operation cycle shall be preceded by a reversion to stabilized conditions at the minimum specified termperature. Provisions shall be incorporated to monitor all critical internal element temperatures continuously during the test. Test conditions and test specimen performance shall be recorded periodically. After the temperature has stabilized at each of the maximum and minimum temperature levels, the functional test as specified in the detail specification shall be performed. Upon completion of the test, the elements shall be examined for evidence of damage or deformation.

3.4.8 Electromagnetic interference.- The electromagnetic interference characteristics of the transceiver and associated components shall meet the requirements of MIL-STD-461 for Class I equipment. The applicable subclass breakdown and frequency range shall be in accordance with the detail specification or AGC approved test plan.

3.5 Ground model operating environment.- The ground equipment shall be capable of satisfactory performance in accordance with the detailed specification during and after being subjected to any of the following conditions successively or in any combination.

(a) Operation, continuously 24 hours per day.

(b) Temperature, from -5°C to +40°C (23°F to 104°F) for three days.

(c) Elevation, up to 10,000 feet above sea level.

(d) Relative humidity of 50% or less.

Table IV. Thermal-Vacuum Test

Test Level & Application	Test Phase	Temperature	Pressure (torr)	Duration (hours)
Level I. Design Qualification Test (Equipment Operating)	Pretest checkout	Ambient	Ambient	As required
	Cold soak	-5°C (+23°F)	1×10^{-5} or less	24
	Cold-to-hot transition	Increasing from +5 to + 40°C	1×10^{-5} or less	As required
	Hot soak	+40 C (+104°F)	1×10^{-5} or less	24
	Post-test Checkout	Ambient	Ambient	As required
Level II Flight Acceptance Test (Equipment Operating)	Pretest checkout	Ambient	Ambient	As required
	Cold soak	+10°C (+50°F)	1×10^{-5} or less	24
	Cold-to-hot transition	Increasing from +10 to +30°C	1×10^{-5} or less	As required
	Hot soak	+30°C (+86°F)	1×10^{-5} or less	24
	Post-test check-out	Ambient	Ambient	As required

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for testing.- Responsibility for environmental testing shall be as specified in the component specification, procurement document, or test plan. Test procedures, facilities, and equipment used shall be approved by AGC. The requirements of MIL-STD-1472 shall be used as a general guide where man/machine interfaces are required in the flight model and ground model transceiver.

4.1.1 Safety.- Preventative measures shall be taken to minimize the possibility of human errors causing damage during routine handling, testing, installation, or checkout. Test or handling equipment or fixtures shall be designed and constructed so that operation or failure cannot cause damage to the test item. The design shall preclude exposure of operating and test personnel to safety hazards during routine handling, testing, installation, or checkout of the item.

4.2 Test equipment.-

4.2.1 Test configuration.- The prototype bracketry and baseplates for mounting of components to the structure shall be used in all shock, vibration, and acceleration tests in order to achieve adequate dynamic similarity. The fixture design shall eliminate or minimize fixture resonance within the test frequency range. It shall support the specimen in a manner simulating vehicle installation. When mechanical or electrical connections are not used, they shall be adequately protected.

4.3 Test facilities.- Test facilities, chambers and apparatus used in the conduct of tests in accordance with this specification shall be fully capable of producing and maintaining the required conditions with the test item under test, installed on or in the apparatus, and operating or non-operating, as required.

4.3.1 Chamber.- The test chamber shall be such that the item under test will not interfere with the generation and maintenance of test conditions. The heat source of the test chamber shall be located so that radiant heat will not fall directly on the test item, except where application of radiant heat is one of the test conditions.

4.3.2 Temperature sensors.- The thermocouples or equivalent temperature sensors utilized to determine or control the specified chamber temperature shall be centrally located within the test chamber where possible, or in the return air stream and shall be baffled otherwise protected against direct impingement of supply air and against radiation effects. The temperature sensors to indicate stabilization shall be attached to the component or experiment in sufficient number and at such locations as to measure the highest and lowest case temperatures. Exposure items shall be based on time after stabilization, when the control sensor varies by no more than 1.0°C per hour.

4.3.3 Vacuum pressure.- The pressure will be considered stabilized when the pressure in the environmental test chamber has reached a level of 1 x 10^{-5} torr or lower.

4.3.4 Monitoring system.- All data-gathering instrumentation shall be calibrated in accordance with the requirements of MIL-C-45662. All monitoring instrumentation used as a part of the environmental control system herein shall:

(a) Conform to laboratory standards whose calibration is traceable to the prime standards at the U.S. Bureau of Standards.

(b) Have an accuracy of at least one-third the tolerance for the parameters to be measured.

4.3.5 Instrumentation.- The test facility shall include adequate instrumentation and data-reduction equipment required to determine that the specification requirements are met within the specified tolerances. Adequate instrumentation, gages, accelerometers, pressure pickups, etc. shall be applied to the test specimen to provide data to afford an adequate post-test analysis of the test specimen. Techniques shall be used which provide a minimum effect from instrumentation on the test specimen. For vibration and shock tests, control accelerometer(s) shall be mounted on the test fixture at the point where the specimen attaches to the fixture. The test frequencies, acceleration levels, and pulses herein specified are to be sensed by the control accelerometer(s) during testing. All instrumentation shall show evidence of current calibration in accordance with the requirements of MIL-C-45662. Documentation specifying instrument accuracy, calibration periods, calibration facilities, and the procedure used to control instrument certification shall be made available upon request by Aerojet-General Corporation.

4.3.6 Tolerances.- Unless specifically stated otherwise in the test procedures, the test tolerances shall be as follows:

(a) Temperature: ±2°C (± 3.6°F) on control temperature sensors

(b) Relative humidity: $^{+0}_{-5}$ percent

(c) Vibration amplitude: (overall g rms) sinusoidal ± 10 percent, random ± 10 percent, power spectral ± 3 db

(d) Vibration frequency: ± 2 percent or 1 Hz, whichever is greater

(e) Linear acceleration: $^{+0}_{-5}$ percent

(f) Weight: 0.01 pound or ± 0.1 percent of the total weight, whichever is greater

(g) Center of gravity: ±0.1 inch

(h) Pressure: When measured by devices such as manometers: ± 5% or ± 1.5 mm of mercury, whichever provides the greatest accuracy.

When measured by devices such as ion gage:

$\pm 10\%$ to 10^{-5} torr

4.3.7 Installation of test item.- The test item shall be installed in the test facility in a manner that will simulate service usage, making connections and attaching instrumentation as necessary. Plugs, covers, and inspection plates not used in operation, but used in servicing shall remain in place. The test item shall then be operated to determine that no malfunction or damage was caused due to faulty installation or handling.

4.4 Test conditions.- Unless otherwise specified in the detailed procedure, all tests required by this specification shall be made at local test site ambient conditions. Actual ambient test conditions shall be recorded periodically during the test performance. The ambient conditions for conducting a test item functional and operational checkout before, during (if applicable), or after environmental test exposures shall be, as follows:

(a) Temperature: 25° ± 4°C (70° to 84°F)

(b) Relative humidity (RH): 55 percent or less

(c) Barometric pressure: room ambient

(d) Cleanliness: equal to or better than class 300,000 conditions as defined in FED-STD-209

Note: If an item is sealed, protected, or otherwise functionally insensitive to temperature variations and humidity, checkout at room ambient conditions shall be acceptable. Components with more stringent requirements than those specified above shall have their requirements specified in the detailed test procedure; special handling requirements shall also be specified.

4.4.1 Spacecraft axes.- Unless otherwise specified, the test axes shall be the orthogonal axes of the unit in accordance with the applicable detailed specification. The coordinate axis representation of the Spaceborne Model shall correlate the spacecraft coordinate system as shown in Figure 1.

4.5 Failure and corrective action.-

4.5.1 Failure, repair, and adjustment.- An item shall be considered as having failed the test if satisfactory operation is not demonstrated in the post-test performance tests, or if post-tests inspection reveals deterioration, alignment outside of specified design limits, or structural damage. All test specimen failures shall be reported immediately to AGC in accordance with AGC-STD-2312. If a test equipment failure occurs, the test will be discontinued and the trouble corrected (always accompanied by a failure report indicating the failure mode, cause of failure and corrective action taken). Unless otherwise specified in the detailed test procedures, or at the direction of the cognizant engineer, the test sequence shall be continued from the point of failure, whenever practical.

4.5.2 In-line failures*.- If an in-line failure occurs during a test (e.g., loss of transmitter output), the test shall be discontinued until failure analysis and corrective action have been made. The test in which the failure occurred shall then be repeated in its entirety without failure before proceeding to the next event.

4.5.3 Retest failures.- If failures occur that require corrective action affecting the validity of previously completed tests, all prior tests affected shall be repeated.

4.5.4 Limited effect.- For those failures having a limited effect on the overall performance of the item being tested, the Aerojet Project Manager or his authorized representative shall determine the feasibility and value of continuing the test before corrective action is undertaken.

4.6 Test procedures.- The detailed environmental test procedures shall be prepared in accordance with the requirements specified in AGC-STD-2312 covering tests intended to verify environmental design integrity of the item and submitted to AGC for approval before tests are initiated. A functional test shall be performed on the item in accordance with the component test plan prior to environmental testing to demonstrate satisfactory operation. Satisfactory operation is defined as that state in which the item maintains the performance as specified in the respective specification. Following the environmental testing, functional tests shall be performed again to determine if performance still is in accordance with the component specification. No adjustment to compensate for environmental extremes shall be allowed unless it is in the detailed specification.

* An in-line failure would prevent a subsystem from meeting its functional requirements.

Special considerations of individual assemblies may require modifications of the general test procedure as outlined by this specification. The sequence of testing shall be in accordance with the appropriate detailed specification.

4.7 Test methods.-

4.7.1 Environmental tests.- Unless otherwise specified, the environmental exposure shall be of sufficient duration or shall be repeated at appropriate intervals to insure a record of comprehensive comparative data for comparison with data recorded under standard ambient conditions. Where applicable, provisions shall be made to verify satisfactory performance of redundant parts. A visual inspection shall be conducted and a record made of any damage or deterioration resulting from the environmental exposure. This inspection is required before returning to ambient condition tests.

4.7.2 Leak detection.- The leak test* shall be performed as specified in the implementation document, but is usually conducted before and after the environmental sequence. Where feasible, the item shall be placed in an atmosphere of essentially 100 percent helium within the sealed pressurized volume (ensure that the unit can withstand the implosive pressure specified in the test procedure). The unit shall remain in this environment for 30 minutes. The component shall be tested with a mass spectrometer leak detector by placing the item in a vacuum chamber that is reduced to 1×10^{-5} torr or less and monitored to determine conformance to the leakage requirement of 3.4.1. Duration of the leak test shall be determined by test item characteristics.

4.7.3 Temperature.- The item shall be exposed to either or both of the temperatures specified in 3.4.2 in accordance with the implementing document. Temperature test requirements are divided into storage tests and equipment operating tests. The temperature tests shall be conducted in a chamber with humidity control and forced air circulation. During testing, including temperature transitional periods, the test chamber conditions shall be maintained at 80 percent relative humidity or less.

4.7.4 Humidity.- The humidity test shall not be required for the item if normal humidity protection is provided by use of ground support equipment. The humidity tests shall be performed in a chamber with temperature control and forced air circulation to determine conformance with the requirements of 3.5.

* Where applicable, leak tests shall be repeated as appropriate during other phases of testing.

4.7.5 Vibration.- The item shall be subjected to the applicable vibration levels specified in 3.4.3, both while operating and non-operating, in accordance with the implementing document. The item, while non-operating, shall be subjected to a sinusoidal swept-frequency test and a random gaussian motion test in each of three orthogonal axes using test level I or II, as applicable. Each item may have any of its elements vibrated separately if the vibration fixture simulates the actual mounting at the items interface. All attachments to the vibration fixture shall simulate actual interface mounting conditions. The item, while operating as specified in the detail specification shall be subjected to the sinusoidal sweep using test level III in each of the orthogonal axes. Any instability indication in performance of the item during any vibration schedule phase shall be reported. The report shall state the frequency or frequency bandwidth where instability and resonance were detected and the corresponding subassembly axis found to be most sensitive to vibratory excitation. The vibrations shall be controlled using accelerometers, attached to the fixtures in accordance with the appropriate implementing documentation.

4.7.5.1 Sinusoidal.- The test shall be performed by sweeping the applied frequency once through each range in accordance with Table II-A. During sinusoidal vibration testing, the three accelerometer signals shall be recorded continuously.

4.7.5.2 Random.- During the random vibration tests the control accelerometer response shall be equalized so that the specified power spectral density (PSD) values are within ± 3 db in the frequency band and the overall rms level is within ± 10 percent of that specified. The filter roll off characteristic above 2000 Hz shall be at the rate of 40 db per octave or greater. The signal from the control accelerometer shall pass through a spectrum analyzer having the following characteristics:

(a) Filter bandwidths shall not exceed 25 Hz below 1200 Hz or 100 Hz above 1200 Hz.

(b) Averaging times shall be at least 2.5 seconds for each filter band where the bandwidth is 10 Hz or greater. For narrower filter bandwidths, the averaging time shall be at least 25 divided by the filter bandwidth.

4.7.6 Acceleration.- The item shall be exposed to the accelerations specified in 3.4.4 in accordance with the implementing document. Steady-state acceleration testing is to be determined.

4.7.7 Space radiation.- The item shall be subjected to the radiation conditions specified in 3.4.5 while being tested in accordance with an AGC approved subcontractor test procedure consistant with MIL-STD-810, Method T517.

4.7.8 Thermal balance.- The item shall be exposed to the requirement* specified in 3.4.6 in accordance with the implementing document. The test shall be conducted so that part or all of the requirements for thermal-vacuum testing (3.4.7) are in accordance to the detailed specification.

* If applicable.

4.7.9 Thermal-vacuum.- The test item shall be subjected to the environment to determine conformance with the requirement of 3.4.7. The item shall be exposed to maximum and minimum bus voltages in accordance with the detailed specification. Temperatures shall be monitored continuously during test exposure. Stabilized temperatures shall be achieved when the reference temperature varies by no more than 1.0°C per hour. The maximum rate of temperature changes during testing shall conform with spacecraft thermal characteristics to avoid unrealistic thermal gradients.

4.7.10 Electromagnetic interference (EMI) and magnetic field.- The item shall be exposed to the EMI requirements and test levels specified in 3.4.8 in accordance with MIL-STD-462 unless otherwise specified in the implementing document.

4.8 Test reports.- The test facility shall submit test reports for each unit tested as specified in the statement of work and component specification. The reports shall include completed data sheets for each test performed, actual test values observed and evidence of quality control surveillance.

5. PREPARATION FOR DELIVERY

5.1 Transportation and handling.- The packaging of items stored or transported separately shall provide protection from the transportation and handling environmental conditions. The packaging itself shall not deteriorate under storage and transportation environments to the degree that its ability to provide this protection is impaired. Document analyses and/or test results shall be provided to assure that adequate protective devices and procedures are used during handling and transportation of items.

6. NOTES

6.1 Intended use.- The environmental levels specified herein are intended to be applied as design criteria to the components of the Spaceborne LCE and the Ground Support Equipment of the Laser Communication Experiment.

6.2 Precedence.- When the requirements of this specification are in conflict with the requirements of the implementing specification, the requirements of the implementing specification shall prevail.

6.3 Ordering data.- Implementing documents should specify the title, number, revision and date of this specification.

6.4 Information.- The technical data used in this document have been derived and are compatible with the data presented in the NASA GSFC Environmental Specification S-320-ATS-2B dated 29 October 1969.

FOLDOUT FRAME

FOLDOUT FRAME 2

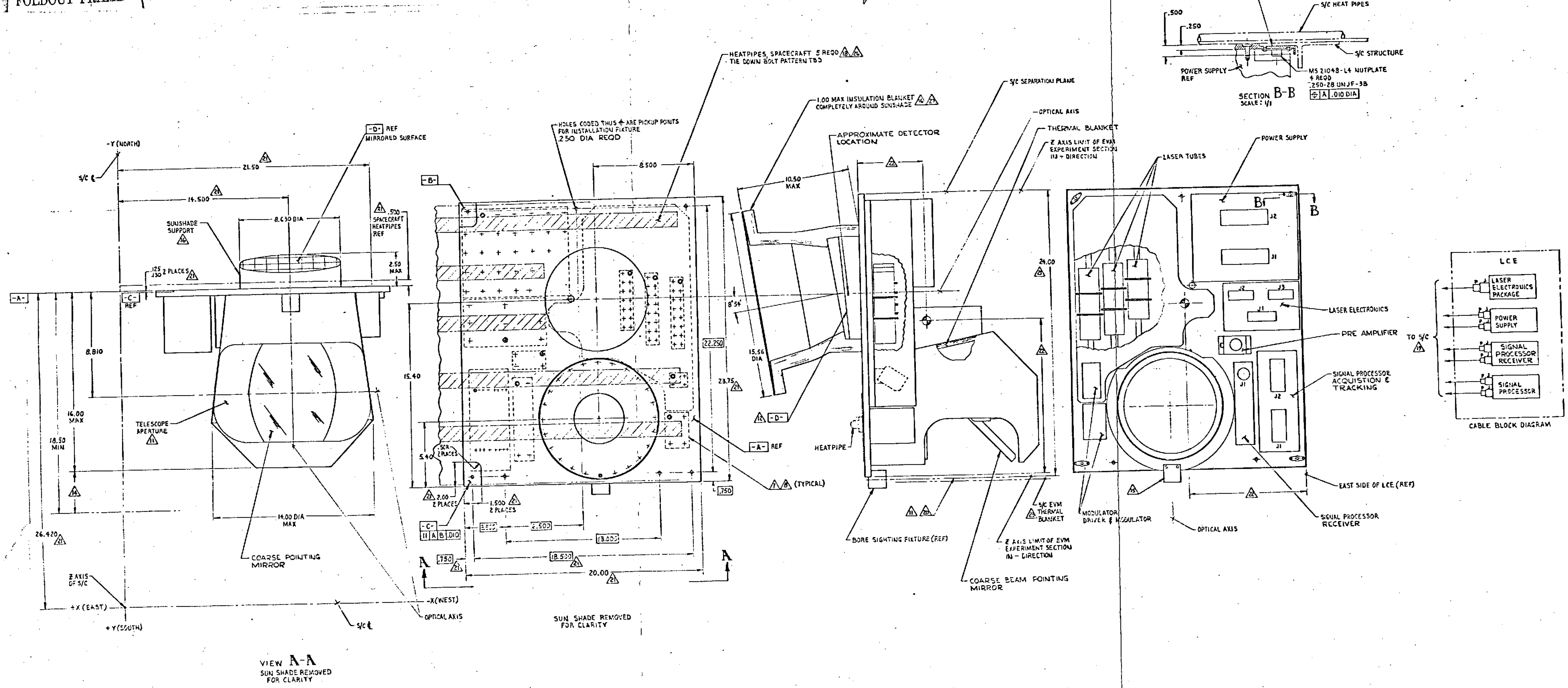


Figure 1. AGC Laser/Spacecraft Interface

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT		DOCUMENT NO.	
SPECIFICATION		AGC-20511A	
TITLE: ENVIRONMENTAL DESIGN CRITERIA AND TEST LEVELS FOR THE LASER COMMUNICATION EXPERIMENT AND ASSOCIATED COMPONENTS			
PREPARED BY		DEPT.	EXT.
SPEC. ENGINEER: J. M. McDONOUGH		DEPT. 7981	EXT. 5311

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein *R Goldstein*	3591	7-8-70
CHIEF PROJECT ENGINEER - A. H. Gale *A H Gale*	3574	7-8-70
SYSTEM ENGINEERING - J. V. Cernius *J. V. Cernius*	3575	8 July 70
QUALITY ENGINEERING - J. H. Bassett *John Bassett*	7831	8 July 70
RELIABILITY - P. W. Stockdill *P W Stockdill*	4072	8 July 70
RELEASE ACTIVITY - *C. R. Cantrell*	1147	7-9-70

7/7/70 AEROJET-GENERAL CORPORATION

C2

Preliminary Draft
14 July 1970

AEROJET GENERAL TIRE GENERAL

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC-20513

LASER COMMUNICATION EXPERIMENT SYSTEM

SUPERSEDING:			
AGC- DATE	AGC- DATE	AGC- DATE	
RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)			
REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	PAGE ADDITIONS
		20 21 22 23 24 25 Appendix A	

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Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification covers the requirements for the design, fabrication, performance and testing of a 10.6-Micron Laser Communication Experiment System, referred to herein as the LCE Transceiver.

1.2 Application.- The objective of LCE System as part of an ATS-F spacecraft is to ascertain the practicality of wideband communications between a spacecraft and a ground station and between two orbiting spacecraft using the 10.6 micron radiation from a carbon dioxide laser; and to establish the resulting efficiency that can be effected in terms of communication bandwidth per pound on the spacecraft. To this end, a number of related experiments, tests, and measurements will be performed including, but not limited to, the following: (1) S/N* as a function of atmospheric parameters, (2) S/N as a function of receiver aperture (spatial coherence), (Note: Another ground station, which is outside the requirements of this specification, will be developed separately to meet this objective.), (3) S/N as a function of zenith angle, (4) Space background noise (sun, stars, etc.), (5) Laser power output as a function of total elapsed time and operating time in the space environment, (6) Temperature and noise value of the mixer/radiation cooler as a function of satellite orientation and time of year, (7) Round trip and one-way data quality compared to a reference microwave link, (8) Laser frequency stability in the space environment, and (9) Spacecraft attitude determination from laser data.

1.3 Classification.- The LCE System covered herein shall be classified as the Flight Model. The ground model will be the prototype flight model and shall be functionally the same as the flight model except the ground model shall include a means to cryogenically cool the receiver mixer assembly. (See Appendix A.)

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, shall form a part of this specification to the extent specified herein.

SPECIFICATIONS

NASA

S-524-P-4	10.6-Micron Laser Communication System Experiment for ATS-F
S-460-ATS-42	10.6 Micron Laser, Interface Requirements
S-460-ATS-38	ATS-F and G Experiment Interface Specification
S-320-ATS-2	ATS-F and G Environmental Test Specification for Components and Experiments
NHB 5300.4(3A)	Requirements for Soldered Electrical Connections

* S/N = Signal to noise ratio

S-323-P-10	Connectors, Subminiature Electrical and Coaxial Contact, for Space Flight Use
S-300-P-1	Printed Wiring Boards

Military

MIL-D-1000	Drawing, Engineering and Associated List
MIL-C-45662	Calibration of Standards

Aerojet-General Corporation

AGC-20186	Receiver Subsystem, Optical Heterodyne, 10.6 Micron
AGC-20187	Laser Subsystem, 10.6 Micron
AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communication Experiment and Associated Components
AGC-20512	Interface Requirements, LCE/ATS Spacecraft
AGC-20514	Installation and Handling, LCE
AGC-20515	Power Supply Subsystem, LCE
AGC-20518	Frequency UP Translator, 30 Hz-4.6 MHz/1.4 MHz-6 MHz
AGC-20519	Frequency Down Translator 1.4 MHz-6 MHz/30 Hz-4.6 MHz
AGC-20520	Optical/Mechanical Subsystem, LCE
AGC-20521	Telemetry and Commands, LCE
AGC-20522	Thermal and Structural Requirements, LCE
AGC-20523	Acquisition and Tracking Subsystem, LCE
AGC-20525	Radiator, Sun Shield, Passive, Receiver Mixer

STANDARDS

NASA

GSFC-STD-256-4	Preparation of Operation and Maintenance Manuals

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communication Experiment Equipment
AGC-STD-1235	Quality Accept/Reject Criteria for Electronic Manufacturing

DRAWINGS

1296001	AGC Laser Spacecraft, Interface Control Drawing

OTHER PUBLICATIONS

AGC No. 3987	Quality Program Plan for the LCE Program; Contract No. NAS 5-21077
AGC No. 3988	Reliability Program Plan for the LCE Program; Contract No. NAS 5-21077

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Item Definition.- The LCE system shall be comprised of various functional subsystems. Each functional subsystem shall be accepted after passing prescribed test in accordance to the subsystem specification and test plan. The subsystems after formal acceptance, shall be integrated into the LCE system. The functional subsystems and the corresponding specification are as follows:

(a) Receiver Subsystem (AGC-20186)

(b) Laser Subsystem (AGC-20187)

(c) Optical Mechanical Subsystem (AGC-20520)

(d) Power Supply Subsystem (AGC-20515)

(e) Acquisition and Tracking Subsystem (AGC-20523)

(f) Passive Radiator and Sun Shield, Receiver Mixer (AGC-20525)

The following specifications although not functional subsystems are included as supporting requirements to the above subsystems and to the LCE system described herein:

(a) Thermal and Structural Requirements, LCE (AGC-20522)

(b) Telemetry and Commands, LCE (AGC-20521)

3.1.1 LCE System Block Diagram.- LCE System Block Diagram, depicting the major functional blocks and optical paths, is shown in Figure 1.

3.1.2 Interface Definition.- The LCE subsystems shall be designed to interface with the LCE baseplate structure in accordance with the thermal structural requirements specified herein and in AGC-20522. The LCE system shall be designed to interface with the ATS-F spacecraft in accordance with the requirements specified herein and in specifications S-460-ATS-42 and AGC-20512.

3.1.2.1 Location.- The LCE system will be located in the ATS-F spacecrafts Earth Viewing Module (EVM) shown in Figure 2. It will be installed in the lower square section of the EVM in the north-west corner along the north wall.

3.2 Characteristics.-

3.2.1 Power Consumption.- The LCE system shall not consume more than 58.8 watts of the spacecraft's primary power when it is performing all acquisition, tracking and normal operational functions.

3.2.2 Functional Characteristics.- Functions to be accomplished by the LCE system shall be as specified in Table I and the following subparagraphs:

(a) Transmission and reception.- Simultaneous transmission and reception of 10.6 micron wavelength radiation between two terminals shall be provided.

(b) Power level.- For atmospheric experiments, the transmitted power level shall provide a minimum flux density at the earth from the ATS-F spacecraft of 10^{-9} watts/meter^2. In laser communication and data relay operation the minimum predetection carrier to noise ratio shall be 23 db within a 10 MHz bandwidth. The corresponding post-detection S/N ratio shall be a minimum of 23 db.

(c) Laser beam shape and direction.- A means to control the laser beam shape and direction of flow of laser radiation, both within and ex ternal to the LCE shall be provided. A telescope shall be utilized to form the transmitted laser beam, and a beam-pointing mirror to direct the beam toward the receiving terminal. The telescope will also collect received radiation from a distant terminal and along with image forming optics, beam-splitters and directing mirrors superimpose the received radiation on radiation from the local oscillator laser upon a receiver mixer in order to produce heterodyne action.

(d) Baseband characteristics.- The frequency response of the system shall accommodate baseband signals over the range from 30 Hz to 4.6 MHz minimum. The characteristics of the system shall be such that high quality television and multi-channel telephony signals can be accommodated.

(e) Beam-pointing mechanism.- The direction of the receiver viewing axis and the transmitted beam from each terminal shall be controlled according to three modes of operation:

(1) By command

(2) By an automatic acquisition program

(3) By an autotrack signal.

The ATS-F spacecraft will be stabilized in space attitude so that three orthogonal axes in the spacecraft can be considered as being generally fixed with respect to corresponding directions on the earth below. These are:

(1) The earth-viewing axis

(2) An axis parallel to the equator in the east-west direction

(3) An axis parallel to the meridian in the north-south direction

With respect to these S/C directions, the beam-pointing mechanism shall permit the optical axis to be directed anywhere within an angular range of $\pm 40^{\circ}$ about the earth-viewing axis in the east-west direction, and $\pm 8^{\circ}$ about the earth-viewing axis in the north-south direction.

(f) Command Pointing Mode.- The transmitter or receiver optical axis shall be capable of being positioned anywhere within the available angular coverage upon command, and its resulting pointing direction, described by two angles with respect to the spacecraft axis, shall not differ from the command position by more than $\pm .02$ degrees.

(g) Pointing Acquisition Mode.- The line of sight between terminals, whether measured with respect to spacecraft or ground coordinates, shall be assumed to have an a priori uncertainty within $\pm 0.2^{\circ}$. After being positioned by command to a direction of maximum likelihood, the beam-steering mechanism shall be capable of executing a search and acquisition routine over the region of uncertainty, which will result in locking onto the other terminal.

TABLE I

LCE TRANSCEIVER SYSTEM SPECIFICATIONS

ITEM NUMBER	PARAMETER	PERFORMANCE
1	Transmitter Beamwidth (1) Operational (2) Acquisition	 12 arc seconds 0.177 arc seconds
2	Receiver Beamwidth	30 arc seconds
3	Predetection Carrier-to-Noise Ratio (CNR)	Not less than 23 db
4	Post Detection Peak Signal-to-Noise Ratio (P/N)	Not less than 23 db
5	Modulation	FM
6	Modulation Sense	Increase in carrier frequency deviation for increase in positive potential
7	Peak Frequency Deviation	$\pm$ 4 MHz
8	Receiver Video Output	1 volt peak to peak $\pm$ 0.5 db
9	Receiver IF Bandwidth	30 $\pm$ 6 MHz
10	Receiver Output Impedence	75 ohm unbalanced with a minimum return loss of 20 db
11	Baseband Response (1) Spaceborne Transceiver (2) Ground Transceiver	 30 Hz to 4.6 MHz, translated up to 1.0 to 6.0 MHz 1.0 to 6.0 MHz
12	Receiver Noise Figure	10^{-19} watts per Hz Bandwidth
13	Flux Density at Receiver Telescope Aperture	10^{-9} watts/meter^2
14	Coarse Mirror Pointing	Range: $\pm$ 40° E-W; $\pm$ 8° N-S Pointing in 0.2° increments each axis
15	Acquisition	Target Location Coverage: $\pm$ 0.2° each axis Acquisition Probability: 0.9 False Alarm Time: 1100 seconds Acquisition Time: 220 seconds
16	Acquisition Tracking	Tracking Range: $\pm$ 0.208° each axis Nutation Radius: 8 arc seconds
17	Operational Tracking	Tracking Range: $\pm$ 0.208° each axis Nutation Radius: 1.5 arc second Tracking Accuracy: $\pm$ 3 arc second Tracking Bandwidth: 5.1 Hz Response Time: 0.11 seconds
18	Telemetry & Commands	As specified in AGC-20521
19	Power Consumption	58.8 w*
20	Weight	69.6 lbs*
21	Size	17 in x 22 in x 15 in plus radiation cooler shield, satisfies ATS interface requirements.
22	Lifetime	2000 hrs in 2 years at 90 o/o probability of success.
23	Environment (1) Temperature (2) Vibration	 Qualification -5°C to 45°C Nominal S/C LCE Interface Temperature 20°C $\pm$ 10°C.

* Design Goal

(h) Autotrack Pointing Mode.- After acquisition, the transmitted and received beams at both terminals shall remain locked in direction to one another by active servo loops throughout the range of spacecraft angular velocities not to exceed $\pm 0.001^\circ/\text{sec}$ and accelerations not to exceed $\pm 0.0003^\circ/\text{sec}^2$. Beam-pointing adjustments and angle error-sensor sensitivities shall be sufficient to maintain receiver and transmitter alignment with an accuracy sufficient for the required system performance.

(i) Telescope.- In order to optimize the telescope magnification, diffraction-limited resolution compatible with the aperture of the telescope shall be maintained. Filters, baffles, and masks shall be designed to permit communications under all orbital conditions, including presence of the sun within or near the receiver field of view.

(j) Optical Alignment.- Procedures and auxiliary equipment shall be provided for aligning all components of the optical system with respect to a rigid structural member. A fiducial mark or mirror shall be provided that is visible external to the LCE enclosure to indicate the direction of the receiver and transmitter optical axis to within the optical tolerance. It shall serve as a reference for the zero position of the beam-pointing mechanism with respect to the spacecraft coordinate system. Any alignment and focussing adjustments shall be capable of being locked positively so as to maintain their positions during and after launch to within a small fraction of the Airy disc size. Imposition of the launch environment shall not result in subsequent degradation of the heterodyne receiver sensitivity by more than 1 db.

(k) CO_2 lasers.- The LCE shall utilize three CO_2 lasers; a transmitter laser, a local oscillator laser and a back-up laser. The back-up laser shall be capable of performing the functions of both a transmitter and or a local oscillator. Its operating modes and beam path shall be controlled by discrete ground commands. Power output of the lasers shall be compatible with the system performance requirements specified in (b). The lasing action of each laser shall be controlled by appropriate utilization of control circuitry and judicious design such that the required operating frequency and stability will be obtained.

The transmitter laser modulator input shall be provided with two data (video) input lines. Each of the inputs shall be selected by ground command. One input will be supplied from the receiver signal processing FM video output and the other will be from the spacecraft baseband distribution subsystem.

(l) Operability.- The receiver signal-to-noise ratio shall not be degraded by insufficient L.O. power, including when the sun is within the receiver field of view. Operating lifetime of each laser shall be greater than 2,000 hours without causing degradation beyond specified system performance. Operating lifetime is that time after launch during which the laser plasma discharge is on. Shelf life shall be greater than 20,000 hours. After a nominal warm-up time of 30 minutes, the frequency and amplitude stability of both the laser transmitter and laser local oscillator shall not limit the performance of the communication system. The transmitter and receiver portions of the system shall be sufficiently isolated to permit simultaneous transmission and reception between the two terminals within the performance specifications. Sensors shall be provided to monitor the output power of the lasers.

(m) Receiver mixer.- The receiver mixer (converter) shall be maintained at the required operating temperature by a passive radiation cooler. Temperature shall be maintained independent of seasonal changes in the satellite-sun angle. The mixer-converter output may contain beam-pointing error signals in addition to its regular data signal.

(n) Sensitivity.- To meet the experiment objectives, the receiver noise figure must be as close to optimum as possible, i.e., approaching a sensitivity of 1×10^{-19} watts per Hz of bandwidth, including the periods when the sun is within the receiver field of view. This shall be a design goal.

(o) Frequency Response.- The data channel mixer unit must have a flat frequency response to at least 30 MHz. The error sensor unit shall have a frequency response which is compatible with the acquisition and tracking servo loop parameters.

(p) Signal processing.- Signal processing shall provide amplification of the mixer-converter IF output data, FM demodulation of the IF carrier, amplification of the video data and provide two isolated video outputs. One video output will be an input to the transmitter laser modulator driver the other will be provided to spacecraft baseband switching.

Acquisition and tracking error signals shall be detected, processed and provided as outputs from the receiver signal processor for use for acquisition and tracking purposes. Functional block diagrams of signal processing, acquisition and tracking and control of the LCE system is shown in Figure 1.

(q) Telemetry.- Telemetry is to be used to the extent necessary to monitor experiment performance during tests, qualification, and operation. The number of telemetry outputs and the functions performed shall be as specified by AGC-20521.

(r) Commands.- The LCE system shall be controlled by command signals in accordance to the requirements specified by AGC-20521. Where command signals operate relays directly, each relay coil shall be energized through a series diode and be shunted by a diode to suppress inductive voltage surges. All inputs to the coils of such relays shall be isolated from ground. The experiment command circuitry shall be designed so that any improper sequence of commands will not cause a lockup or a malfunction of the experiment.

(s) Power Supply.- Power supply shall supply all of the necessary operating voltages and currents for the LCE system. The primary power source for the LCE power supply shall be the spacecraft primary power buss. The primary power to each of the ATS- spacecraft's experiments shall be controlled on and off by the spacecraft command subsystem. The LCE system shall perform all of its functions within tolerance when supplied with spacecraft power having the following characteristics:

Voltage:	+27.4 to 28.6 volts direct current
Ripple:	10 millivolts, rms (transient spikes will not exceed ± 2 volts peak, and transient energy level will not exceed 30 millijoules)

A conducted noise level of 10 millivolts peak with impedance versus frequency characteristics as specified below.

A transient capacitive load of __*__ microfarads.

An effective impedance of 0.1 ohm, or less, at 0 to 15 kilohertz.

* To be added at a later date.

3.2.3 Useful life.-

3.2.3.1 Operating life.- The operational life of the LCE transceiver shall be 2,000 hours with the operating periods equally distributed within the two yea r period. A minimum of 500 power-on/power-off cycles and operating periods of up to 24 hours over a two year period in a space environment shall be possible without degradation of the requirements specified herein. The transceiver shall be considered in operation when the laser discharge is on.

3.2.3.2 Shelf life.- The LCE transceiver shall be capable of meeting the operating life of 3.2.3.1 after a shelf life of greater than one year when packaged and stored in a protective enclosure.

3.2.4 Physical characteristics.-

3.2.4.1 Weight and moment of inertia.- The weight of the LCE transceiver shall be a minimum consistent with the required performance, but shall not exceed a total weight of 69.6 pounds. The moment of inertia of the system shall be determined, with respect to three orthogonal axes referenced to the mounting surface, within ± 5 percent.

3.2.4.2 Envelope dimensions.- The LCE transceiver envelope dimensions shall be as shown in AGC Drawing 1296001.

3.2.4.3 Center of gravity.- The center of gravity for the LCE transceiver shall be established to within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis as related to a reference point on the mounting surface. The reference point location shall be defined in the inspection report.

3.2.4.4 Mounting and alignment provisions.- The mounting and alignment (if necessary) provisions shall be as shown in AGC Drawing 1296001. The mounting design shall permit torquing of the mounting screws to _*_ in-lbs.

3.2.4.5 Thermal interface.- The thermal interface between the LCE and the spacecraft shall be as defined in AGC Drawing 1296001.

3.2.5 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from, the design to achieve the electrical and mechanical characteristics specified in this specification. The system shall be designed and fabricated to provide 90% probability of an operational lifetime as specified in 3.2.3.1. This lifetime is based on the active operation time being equally distributed within the two year period. The groundbased transceiver system shall have a mean-time-between failures of at least _____ hours.

3.2.6 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from, the design of the LCE transceiver. The sys tem shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with ______ and any other required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible. Repair of replacement

* To be added at a later date.

of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the LCE transceiver. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the system.

3.2.7 Environmental conditions.- The LCE Transceiver shall be designed and constructed in accordance with the thermal and structural requirements of AGC-20522 and the requirements specified herein.

3.2.7.1 Equipment operating.- The LCE Transceiver, while operating in any orientation, shall be capable of meeting the requirements of Section 3.2 while being subjected to any combination of the following environments (demonstration of compliance shall be performed only to the extent specified in section 4.0):

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to an acceleration of from zero up to a 1 g gravitational field at any orientation.

(c) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(d) Thermal-vacuum and balance conditions for LCE subsystem as specified in AGC-20511.

(e) Temperature for equipment operating as specified in AGC-20511.

(f) Vibration, Test Level III in AGC-20511.

3.2.7.2 Equipment nonoperating.- The Receiver Subsystem shall be capable of withstanding the following environmental conditions in accordance with the levels specified in AGC-20511 and thereafter meet the performance requirements of Tables IA, IB, and IC.

(a) Sinusoidal and Random Vibrations, Test Level I or II in AGC-20511.

(b) Acceleration (AGC-20511).

(c) Leakage (AGC-20511).

(d) Storage Temperature (AGC-20511).

3.2.7.3 Ground model.- The transceiver system shall be capable of meeting the ground model operating and nonoperating environmental requirements as specified in AGC-20511.

3.2.8 Design and construction.-

3.2.8.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be selected or prepared in accordance with AGC Report No. 3988.

3.2.8.2 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC Report No. 3988.

3.2.8.3 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.2.8.4 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.2.8.5 Interchangeability and Replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.2.8.6 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.2.8.7 Electromagnetic Interference.- The electromagnetic interference characteristics of the LCE system shall comply with the applicable requirements for Class IC or ID equipment as specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.2.8.8 Printed wiring boards.- The design and construction of printed wiring boards shall be in accordance with NASA specification S-300-P-1.

3.2.8.9 Soldering of electrical connections.- Soldering of electrical connections shall be in accordance with NASA specification NHB-5300.4(3A) with the following exceptions:

(a) 3A304 - Delete paragraph 4

(b) 3A309 - Solid solder not usable

(c) 3A310 - Liquid solder flux not usable

(d) 3A505 - Lap joints shall not be used for structural mounting

(e) 3A604 - Page 6-6 Multiple conductor cable will not be used

(f) Chapter 9-Delete.

3.2.8.10 Grounding.- The system shall comply with the following grounding requirements:

(a) All system return leads requiring grounding shall be connected together at a common location to be known as the "system grounding point."

(b) There shall be no electrical connection between any component case and its internal circuitry. All electrical circuit connections shall be accomplished through the component connector. A component case may be considered a shield. One connector pin on each component may be grounded by mechanically contacting a system ground plane or by wiring to the case ground connector pin.

(c) There shall be no electrical connection between the shield of any shielded wire and any electrical circuitry. The shield of a shielded wire shall be grounded only at one end.

(d) All connectors shall be chosen in accordance with, "GSFC Connector Specification," GSFC S-323-P-10.

3.2.8.11 Voltage drop.- The electrical power and signal distribution system shall be so designed that voltage drop from point-to-point is minimized, and at no time shall any terminal voltage fall below rated value due to excessive voltage drop in response to transmission of rated currents.

3.2.8.12 Mechanical strength of wire.- All wire selections shall be based upon consideration of mechanical strength characteristics such as flexibility and tensile strength. In no case shall wires smaller than size AWG-26 be used in the electrical power and signal distribution system.

3.2.8.13 Experiment System Test Points.- Test points shall be brought out to a centrally located test connector for use during normal prelaunch system tests or for troubleshooting. This connector shall not be the telemetry connector used during space flight. Source output impedance shall be low, and signal levels shall be so isolated that noise pickup on the harness wire will not adversely affect the operation of the source unit. Testpoint output impedance, signal level, and isolation characteristics shall be so chosen that standard hookup may be used to transmit the test signals to the system test connector. All test points shall be made fail-safe.

3.2.8.14 Package venting.- The LCE Transceiver shall be vented so that the unit internal pressure equals the ambient pressure during launch or vacuum testing within ___*___.

3.2.8.15 Dust Protection.- A cover shall be provided for the telescope and optical components on the LCE for protection against dust and handling damage.

3.3 LCE Subsystem Description.-

3.3.1 Laser subsystem.- The laser subsystem shall consist of three lasers and associate control loops. The laser transmitter generates frequency modulated carrier radiation at 10.6 microns. The local oscillator laser generates reference radiation to be mixed with radiated signal received to produce an instantaneous intermediate frequency of 30 + 4 MHz. The backup laser is used as a backup CW transmitter (no modulation) or as a backup local oscillator. In addition, it is used to mix with the transmitter or local oscillator to permit system self check. The details of the laser subsystem is specified by AGC-20187.

3.3.1.1 Control electronics.- The control electronics of the transmitter laser shall accomplish the following functions:

(a) Place the transmitter laser into an operational status. Two steps are involved:

 (1) Search for the correct operating line. (P-20 for flight transmitter and P-16 for ground transmitter).

 (2) Locate the peak of the laser power-frequency profile.

(b) Track the laser power output and continuously reposition its operating point on the peak of the power-frequency profile.

3.3.2 Optical/Mechanical subsystem.- The optical/mechanical subsystem shall perform the following coupling and beam shaping functions:

(a) Couple the transmitter output to the telescope.

(b) Separate the transmitted and received beams to permit operation with a single telescope assembly.

(c) Provide means to track the angle of the received beam and to point the transmitted beam.

(d) Couple transmitter output to the coarse mirror by by-passing the telescope in order to facilitate acquisition.

(e) Perform same functions as (a) to (d) when backup laser is used.

(f) Couples received energy (collected by telescope aperture) and focus on the receiver mixer.

(g) Couple the local oscillator power, and combine with receiver signal for required illumination of the mixer.

(h) Perform same function as when backup laser is used.

(i) Couple and combine transmitter and backup laser power to the mixer for self-checking and FM noise measurement.

(j) Couple and combine local oscillator and backup laser power to the mixer for self-checking and FM noise measurements.

(k) Extract fraction (1 percent) of laser power output for power measurement and identification of laser operating line.

(l) Provide gimbals for the coarse pointing mirror, Image Motion Compensation (IMC) mirror, and nulating mirror.

The details of the optical/mechanical subsystem are specified by AGC-20520.

3.3.3 Optical Heterodyne Receiver subsystem.- The receiver subsystem mixes the received FM carrier with local oscillator using a HgCdTe photovoltic mixer resulting in an instantaneous intermediate frequency of 30 $\pm$ 4 MHz. The receiver IF bandwidth is 30 $\pm$ 6 MHz. Outputs of the receiver are:

(a) Two Video Signal channels

(b) Tracking Error Signals

(c) Automatic Frequency (AFC)

(d) Acquisition Pulse

(e) Acquisition Confirm Pulse

The AFC output shall provide both automatic frequency control and a telemetry monitoring point as data on the spaceborne laser FM noise distribution. The latter will require a wider bandwidth than necessary for AFC correction. The details of the receiver subsystem is specified by AGC-20186.

3.3.4 Acquisition and Tracking subsystem.- The acquisition and tracking subsystem shall perform several key functions in order to acquire the far distant station and then track in angle the incoming energy. The major functions required are as follows:

(a) Provide the required electronics to position the coarse mirror such that the optical axis of the telescope intersects the nominal position of the far-distant station within $\pm 0.02^\circ$ over an angular aperture of $80^\circ \times 16^\circ$.

(b) Provide the required receiver beam sweep such that the angle of uncertainty ($0.4^\circ \times 0.4^\circ$) of the far-distant station is covered during acquisition.

(c) Upon acquiring the far-distant station, track the received energy and position the coarse mirror such that the optical axis of the telescope intersects (within $\pm 0.05^\circ$) the far distance station.

(d) Upon completion of the acquisition phase, initiate switching to operational tracking and cause tracking to occur within ± 4 arc seconds at tracking rates up to 0.01 degree/sec.

The details of the Acquisition and Tracking subsystem is specified in AGC-20523.

3.3.5 High Voltage and Low Voltage Power Supply subsystem.- The power supply subsystem provides the required laser operating voltages and the low voltages required to operate the transceiver. The transmitter and local oscillator high voltage power supplies shall be redundant for greater reliability. The details of the power supply subsystem is specified by AGC-20515.

3.3.6 Telemetry and Commands, LCE.- The telemetry and command functions for the LCE system provide the necessary monitoring and control of the experiment. The monitoring points and command functions, and their characteristics, shall be as detailed by specification AGC-20521.

3.3.7 Passive Radiator/Sunshield subsystem.- The radiation cooler subsystem shall maintain the receiver mixer temperature at $110 \pm 15^\circ K$ while the spacecraft is in orbit. The details of the Passive Radiator/Sunshield subsystem are specified by AGC-20525.

3.3.8 Thermal/Structural Requirements.- The thermal and structural requirements for the LCE system are defined in detail by specification AGC-20522.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, all inspection shall be performed as specified herein. Inspection records of the examination and tests shall be kept complete and available at the time of acceptance of the equiipment. Any deficiencies noted as a result of tests conducted shall be corrected.

4.1.1 Quality assurance program.- A quality assurance program, in accordance with AGC-Report No. 3987, shall be implemented and maintained.

4.1.2 Reliability assurance program.- A reliability assurance program, in accordance with AGC-Report No. 3988, shall be implemented and maintained.

4.1.3 Processing changes.- No changes in the subsystem design, specifications, materials or material processes after design approval shall be made without prior written approval of the Aerojet LCE Program Manager.

4.1.4 Test conditions.- Unless otherwise specified in a detailed test method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration in accordance with the calibration system requirements of MIL-C-45662. The tolerance allowed on test conditions and inputs are intended only to provide for accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification and Flight Model and Ground Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-Report No. 3988 and delivered with the hardware. Test reports shall be prepared and submitted for approval after completion of testing.

4.2 Classification of Inspections.- Inspections to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model or Ground Model Acceptance Inspection (see 4.6).

4.3 Test plan.- A test plan shall be prepared and shall include all of the inspections specified in 4.2. The test plan shall be so developed that the test results will verify that the requirements specified herein have been met. The test plan shall be submitted for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process examinations and tests.- In-process examinations and tests shall be performed as required to determine conformance to applicable drawings, specifications, approved workmanship standards, identification, traceability, and any special process controls required to insure repeatability of hardware performance.

4.5 Design Qualification Inspection.- Design Qualification Inspection shall consist of all the tests described in Table II as a minimum. The test sequence shall be as shown in Table II. Deviation from the sequence presented shall require prior approval of the Aerojet LCE Program Manager. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the Subsystem under ambient conditions and the specified operational environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests.

4.6 Flight Model Acceptance Inspection.- A detailed procedure of the Flight Model Acceptance Inspection shall be generated as a part of the overall test plan, and approved by AGC prior to final inspection. The Flight Model Acceptance Inspections shall include the examinations and tests of Table III as a minimum and shall be extensive enough to demonstrate satisfactory workmanship and that the Subsystem performance is within tolerance. The test sequence shall be as shown in Table III and shall require prior approval of the Aerojet LCE Program Manager for any deviations.

4.6.1 Ground Model Acceptance Inspection.- The Ground Model Acceptance Inspection shall be in accordance with Table IV. The test sequence shall be as shown in Table IV and shall require prior approval of the Aerojet LCE Program Manager for any deviation.

TABLE II. DESIGN QUALIFICATION INSPECTION

Examination or Test	Requirement Paragraph	Method Paragraph
Analysis		
Operating Life	3.2.3.1	4.1.2 and 4.7.1
Moment of Inertia	3.2.4.1	4.7.1
Reliability	3.2.5	4.1.2 and 4.7.1
Maintainability	3.2.6	4.7.1
Radiation Resistance	3.2.7.1	4.7.1
Thermal Analysis	3.3.7.1	4.7.1
Visual Examination Measurements		
Electrical Interface	3.1.2	4.7.2
Weight	3.2.4.1	
Envelope Dimensions	3.2.4.2	
Center of Gravity	3.2.4.3	
Mounting Provisions	3.2.4.4	
Grounding	3.2.8.10	
Connectors	3.2.8.10(d)	
Test Points	3.2.8.13	
Venting	3.2.8.14	
Selection of Specifications and Standards	3.2.8.1	
Materials, Parts and Processes	3.2.8.2	
Moisture and Fungus Resistance	3.2.8.3	
Corrosion of Metal Parts	3.2.8.4	
Interchangeability and Replaceability	3.2.8.5	
Workmanship	3.2.8.6	
Printed Wiring Boards	3.2.8.8	
Soldered Electrical Connectors	3.2.8.9	
Wire and Voltage Drop	3.2.8.11 and 3.2.8.12	↓
Tests		
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.3(a)
Storage Temperature	3.2.7.2(d)	4.7.4
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.3(b)
Vibration (non-operating)	3.2.7.2(a), Level I	4.7.5
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.3(b)
Acceleration	3.2.7.2(b)	4.7.6
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.3(b)
Thermal Balance and Thermal Vacuum	3.2.7.1(d)	4.7.7
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.3(a)

TABLE III. FLIGHT MODEL ACCEPTANCE INSPECTION

Examination or Test	Requirement Paragraph	Method Paragraph
Visual Examination and Measurement		
Weight	3.2.4.1	4.7.2
Envelope Dimensions	3.2.4.2	
Center of Gravity	3.2.4.3	
Mounting Provisions	3.2.4.4	
Connectors	3.2.7.10(d)	
Workmanship	3.2.8.6	
Testing		
Functional Characteristics	3.2.1, 3.2.2 and Table V	4.7.3(a)
Vibration (Non-operating)	3.5.2(b), Level II	4.7.5
Functional Characteristics	3.2.1, 3.2.2 and Table V	4.7.3(b)
Thermal Vacuum	3.5.1(d)	4.7.7
Functional Characteristics	3.2.1, 3.2.2, Table V	4.7.8(a)

TABLE IV. GROUND MODEL ACCEPTANCE INSPECTION

Examination or Test	Requirement Paragraph	Method Paragraph
Visual Examination and Measurement		
Envelope Dimensions	3.2.4.2	4.7.2
Mounting Provisions	3.2.4.4	
Connectors	3.2.8.10(d)	
Workmanship	3.2.8.6	
Testing		
Functional Characteristics	3.2.1, 3.2.2 and Table V	4.7.3(a)

4.7 Test methods. -

4.7.1 Analysis. - Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the written report. Systems engineering data shall be used where appropriate to support analysis.

4.7.2 Visual examination and measurements. - Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical exmination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.3 Functional characteristics. - Specific tests as specified in Table V shall be performed to verify that the requirements of 3.2.1, 3.2.2, and Table I are met. Whenever possible, tests shall be made on the system with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Functional tests in accordance with Table V shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.2.1, 3.2.2, and Table I, which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.2.1, 3.2.2, and Table I, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.3.1 Ambient testing. - Functional testing at ambient temperature and atmospheric conditions shall require the utilization of the ground model receiver mixer cooler assembly in place of the passive radiator/sunshield cooler.

4.7.4 Storage temperature tests. - The unit shall be subjected to the storage temperature environments specified in AGC-20511.

4.7.5 Vibration. - While nonoperating, the unit shall be subjected to the random and sinusoidal vibrations specified in AGC-20511, Test level I or II, as applicable. Upon completion of the test, the unit shall be examined for evidence of damage or deformation.

Table V. Functional Tests

Requirement	Reqm't. Para.	Table I Item No.	Test Method Paragraph 4.7.3(a)	Test Method Paragraph 4.7.3(b)
Laser Startup Loops -				
Transmitter, Local Oscillator & Backup	3.2.2(k)		X	X
Transmitter Beamwidth	3.2.2(c)	1	X	
Receiver Beamwidth	3.2.2(c)	2	X	
Predetection Carrier to Noise Ratio	3.2.2(b)	3	X	
Post Detection Peak Signal to Noise Ratio	3.2.2(b)	4	X	
Flux Density at Receiver Telescope Aperture	3.2.2(b)	13	X	
Receiver Noise Figure	3.2.2(n)	12		
Baseband-Baseband Amplitude Frequency Characteristics	3.2.2(d)	11	X	X
Coarse Pointing Mirror	3.2.2(e)	14	X	X
Acquisition Characteristics		15	X	X
Acquisition Tracking	3.2.2(g)	16	X	X
Operational Tracking	3.2.2(h)	17	X	X
Modulation Characteristics		5, 6	X	
Demodulation Characteristics		11	X	
Video Signal Output Signal Characteristics	3.2.2(p)	8, 10	X	
Telemetry Output Signal Characteristics	3.2.2(q)	18	X	X
Operate & Control Command Functions	3.2.2(r)	18	X	X
Power Consumption	3.2.1	19	X	X

4.7.6 Acceleration. - While nonoperating, the unit shall be subjected to the longitudinal and lateral accelerations specified in AGC-20511. Upon completion of the test, the unit shall be examined for evidence of damage or deformation.

4.7.7 Thermal vacuum and thermal balance. - The unit shall be subjected to combined vacuum and balance tests specified in AGC-20511. After the temperature has stabilized during the last high and low temperature dwell, a functional test in accordance with 4.7.3(a) shall be performed.

4.7.8 Electromagnetic interference. - EMI testing shall be in accordance with the requirements of 3.2.8.7 for tests CE01, CE02, CE03, CS01, CS06 and RE01 as specified in MIL-STD-461. EMI testing will be accomplished on the Functional Test Model only.

5.1 Preservation, packaging, and packing. - Unless otherwise specified, the perservation, packaging, and packing shall be in accordance with the best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. If the component does not meet the requirements herein because of such contamination or damage, and acceptable replacement, component shall be furnished within a reasonable time. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at the spacecraft contractor's facility, in an undamaged condition.

5.2 Marking for shipment. - Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter

(d) Date of final assembly

(e) Purchase order number

(f) Warning and caution notes, as applicable.

6. Notes

6.1 Intended use. - The Experiment specified herein is intended for use in the ATS-F Spacecraft as well as in a transportable ground station without exhibiting any differences in performance or functional capabilities due to the differences in these environments. Any differences in hardware which may be necessary shall not degrade the specified performance levels. In its final form, this basic specification will describe the system as required for use in the space environment while the differences which make it suitable for use in the ground environment will be noted in the appendix.

6.2 Definitions. -

6.2.1 Failure. - A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.3 Oral statements. - Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.

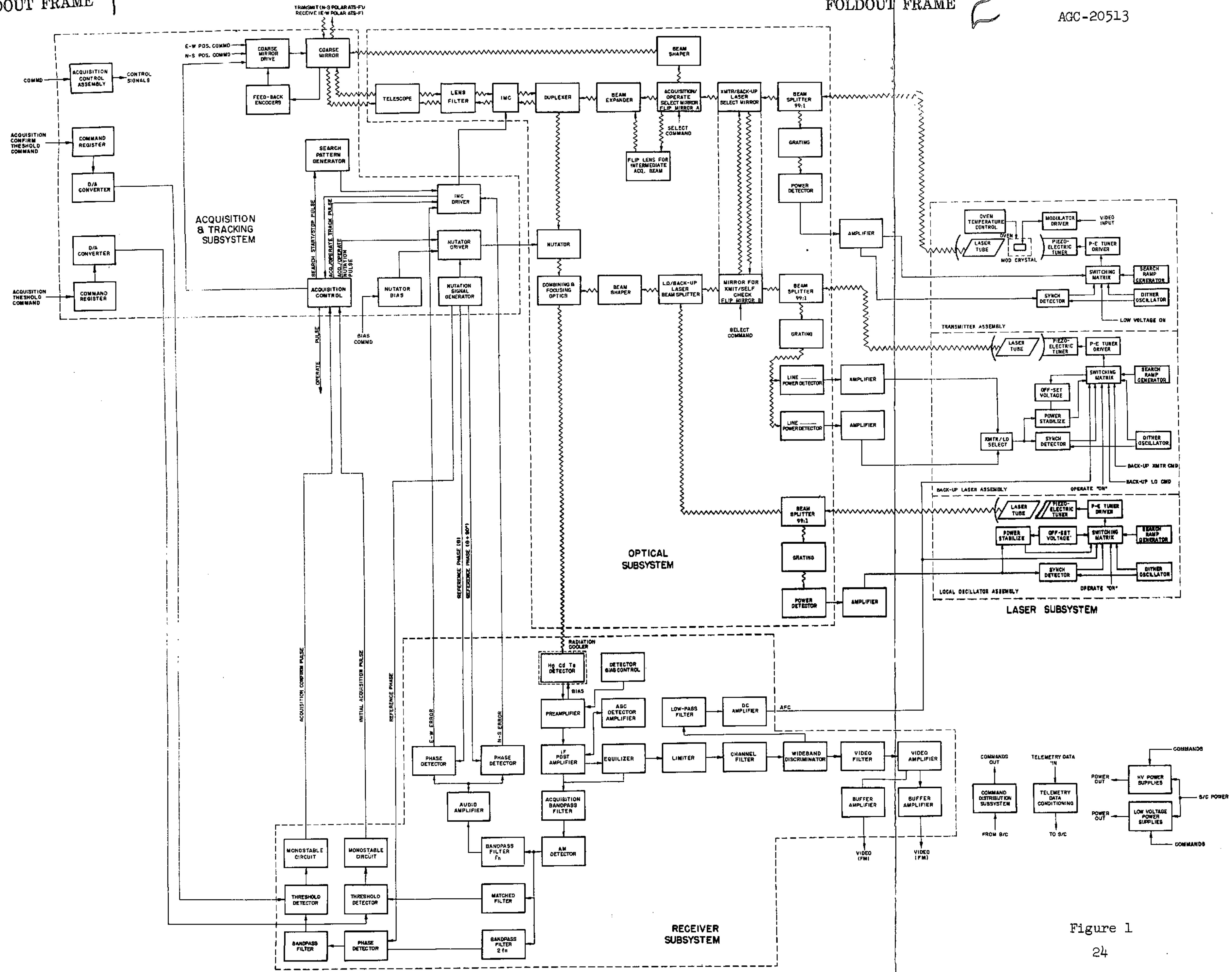
ACQUISITION & TRACKING SUBSYSTEM
OPTICAL SUBSYSTEM
LASER SUBSYSTEM
RECEIVER SUBSYSTEM
ACQUISITION CONTROL ASSEMBLY
CONTROL SIGNALS
COMMD
COMMAND REGISTER
D/A CONVERTER
ACQUISITION CONFIRM THESHOLD COMMAND
ACQUISITION THESHOLD COMMAND
E-W POS. COMMD
N-S POS. COMMD
COARSE MIRROR DRIVE
COARSE MIRROR
FEED-BACK ENCODERS
SEARCH PATTERN GENERATOR
IMC DRIVER
NUTATOR DRIVER
NUTATOR BIAS
NUTATION SIGNAL GENERATOR
ACQUISITION CONTROL
BIAS COMMD
PULSE
OPERATE
TELESCOPE
LENS FILTER
IMC
DUPLEXER
BEAM EXPANDER
BEAM SHAPER
SELECT COMMAND
FLIP LENS FOR INTERMEDIATE ACQ. BEAM
BEAM SPLITTER 99:1
GRATING
POWER DETECTOR
AMPLIFIER
NUTATOR
COMBINING & FOCUSING OPTICS
LO/BACK-UP LASER BEAM SPLITTER
LINE POWER DETECTOR
OVEN TEMPERATURE CONTROL
MODULATOR DRIVER
VIDEO INPUT
LASER TUBE
MOD CRYSTAL
PIEZO-ELECTRIC TUNER
P-E TUNER DRIVER
SWITCHING MATRIX
SEARCH RAMP GENERATOR
SYNCH DETECTOR
DITHER OSCILLATOR
LOW VOLTAGE ON
TRANSMITTER ASSEMBLY
OFF-SET VOLTAGE
POWER STABILIZE
XMTR/LO SELECT
BACK-UP XMTR CMD
BACK-UP LO CMD
BACK-UP LASER ASSEMBLY
OPERATE "ON"
LOCAL OSCILLATOR ASSEMBLY
RADIATION COOLER
Hg Cd Te DETECTOR
DETECTOR BIAS CONTROL
BIAS
PREAMPLIFIER
AGC DETECTOR AMPLIFIER
LOW-PASS FILTER
DC AMPLIFIER
AFC
IF POST AMPLIFIER
EQUILIZER
LIMITER
CHANNEL FILTER
WIDEBAND DISCRIMINATOR
VIDEO FILTER
VIDEO AMPLIFIER
BUFFER AMPLIFIER
VIDEO (FM)
PHASE DETECTOR
E-W ERROR
N-S ERROR
AUDIO AMPLIFIER
ACQUISITION BANDPASS FILTER
AM DETECTOR
MONOSTABLE CIRCUIT
THRESHOLD DETECTOR
MATCHED FILTER
BANDPASS FILTER
ACQUISITION CONFIRM PULSE
INITIAL ACQUISITION PULSE
REFERENCE PHASE
COMMANDS OUT
COMMAND DISTRIBUTION SUBSYSTEM
FROM S/C
TELEMETRY DATA IN
TELEMETRY DATA CONDITIONING
TO S/C
POWER OUT
HV POWER SUPPLIES
LOW VOLTAGE POWER SUPPLIES
COMMANDS
S/C POWER

Figure 1

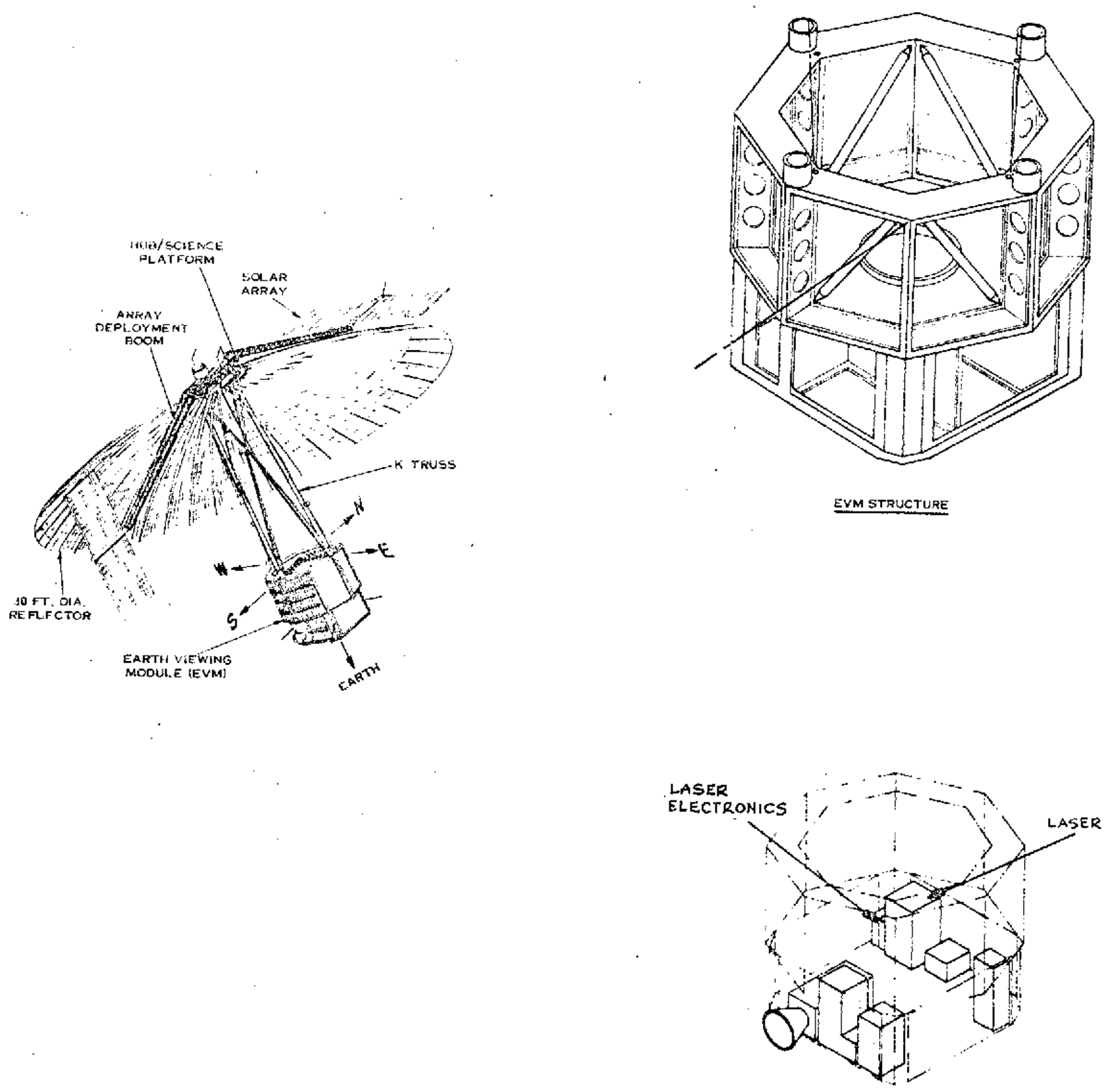

Figure 2. ATS-F Spacecraft Configuration

APPENDIX A

LCE System Modifications for Ground Model

10. SCOPE

10.1 This appendix covers the requirements which are necessary for the ground model LCE Transceiver system and are specifically different from the flight model. These requirements will be specified herein as an addition or modification to the flight model.

20. APPLICABLE DOCUMENTS

(none applicable)

30. SYSTEM MODIFICATIONS FOR GROUND MODEL

30.1 Receiver mixer assembly. - The ground model of the receiver mixer assembly shall include a temperature-controlled and monitored Joule-Thompson refrigerator capable of covering a minimum temperature range of from 85°K to 130°K, with a stability of ± 2.0°K. An associated control panel, equipped with monitor points and a gas regulation capability, shall be provided. A detector and a vacuum shroud with a window in the end shall also be provided. The detector and shroud shall be capable of being operated at a distance of at least 10 ft from the control panel. The associated electronics, including a preamplifier, and cables and connectors, shall be provided as required. The mixer assembly and all components except for the control panel shall be suitable for operation in a vacuum chamber as well as a ground environment. The entrance window of the mixer housing shall be thermally decoupled from the cold detector to permit operation in a 50 percent relative humidity and 90°F atmosphere.

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC-20515

POWER SUPPLY SUBSYSTEM, LCE

SUPERSEDING:		
AGC- DATE	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	PAGE NUMBERS	PAGE ADDITIONS
		i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	
	10 July 70		
		20 21 22	

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough for

J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 This specification covers the requirements for performance, design, fabrication, and test of a power supply used to provide operating power to a laser communications experiment.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein.

NASA DOCUMENTS

NHB 5300.4(3A)	Requirements for Soldered Electrical Connections
GSFC S-323-P-10	Connectors, Subminiature, Electrical and Coaxial Contact, for Space Flight Use
S-300-P-1	Printed Wiring Boards

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components
AGC-20521	Telemetry and Commands, LCE
AGC-20522	Thermal and Structural Requirements, LCE

STANDARDS

Military

MIL-STD-461	Electromagnetic Interface Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagentic Interference Technology

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communication Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communication Experiment Equipment

(Copies of government specifications, standards, drawings, bulletins, and publications required in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Item definition.-

3.1.1 Major component list.- The power supply subsystem, hereinafter referred to as the power supply shall consist of the following major components:

(a) Laser Transmitter High Voltage Current Regulator

(b) Laser L.O. High Voltage Current Regulator

(c) Back-up Laser High Voltage Current Regulator

(d) Modulator Driver Power Supply

(e) Nutator Control Power Supply

(f) Laser Control Electronics Power Supply

(g) Data Processing Power Supply

(h) Coarse Pointing Control Power Supply

3.1.2 Block diagram.- The power supply shall operate in accordance with the block diagrams shown in Figures 1 and 2.

3.2 Performance characteristics.-

3.2.1 Input power.- Primary power lines shall be fused before input to the EMI filters of each section. Fuse ratings shall be __*__ times the average input current. The power supply shall be capable of performing as specified herein when provided with the following operating power and input characteristics from a regulated bus:

* To be added at a later date.

(a) A maximum power input of 95 watts at an operating voltage of +27.4 to + 28.6 volts direct current.

(b) A ripple of 10 millivolts, rms (transient spikes will not exceed ± 2 volts peak, and transient energy level will not exceed 30 millijoules).

(c) A conducted noise level of 10 millivolts peak with impedance versus frequency characteristics as specified in (e) below.

(d) A transient capacitive load of <u>*</u> micofarads.

(e) An effective impedance of 0.1 ohms, or less, at 0 to 15 kilohertz.

3.2.2 <u>Commands and telemetry data</u>.- The power supply shall be designed to respond to the commands indicated in Table I, the commands specified in specification AGC-20521, and in accordance with the following requirements. Provisions shall be included to provide telemetry data as shown in Table II.

(a) "ON" commands and "OFF" commands shall be supplied for control of the power supplies in accordance with Table I and Figure 1.

(b) Discrete command signals shall be +5.0 ± 0.5 (logic one level) volts from a 1000 ohm or less source with duration of 50 ± 5 milliseconds. Pulse rise and fall time will be less than <u>*</u> milliseconds from 10 to 90% points. Logic zero level of the signal will be 0.0 ± 0.5 volts

3.2.2.1 <u>Telemetry data</u>.- The voltage and currents listed in Table II shall be provided as isolated telemetry output signals such that a short or open circuit on the telemetry output shall not effect the corresponding operating voltage output. These signals shall be an analog voltage not exceeding 5 volts. The telemetry signal voltage provided shall be proportional to the voltage or current monitored and shall be within the accuracy specified in Table II. The specified accuracy is applicable from 25 to 75% of full scale. Telemetry and command signal and interface circuit requirements shall be as specified in AGC-20521.

3.2.3 <u>Functional characteristics</u>.- When provided with operating power and a turn-on command, the power supply shall supply the following operating voltages to the laser communication system:

(a) Positive high voltage with current regulation to the transmitter, local oscillator and back-up laser.

(b) Positive intermediate level voltages for Nutator Control and the Modulator Driver.

(c) Low dc voltages for the Laser Control Electronics, Data Processing and Coarse Pointing Controls

3.2.4 Output power.- The power supply shall provide output power in accordance with Table III when supplied with input power as specified in 3.2.1. The individual voltage regulators shall be synchronized from a common source (Pulse Generator).

TABLE I. Power Supply Subsystem Commands

COMMAND	TYPE
1. Transmitter H. V. No. 1 "ON"	Discrete
Transmitter H. V. No. 2 "ON"	Discrete
Transmitter H. V. No. 1 "OFF"	Discrete
Transmitter H. V. No. 2 "OFF"	Discrete
2. Local Oscillator H. V. No. 1 "ON"	Discrete
Local Oscillator H. V. No. 2 "ON"	Discrete
Local Oscillator H. V. No. 1 "OFF"	Discrete
Local Oscillator H. V. No. 2 "OFF"	Discrete
3. Back-up Laser H. V. "ON"	Discrete
Back-up Laser H. V. "OFF"	Discrete
4. Low Voltage Converters "ON"	Discrete
Low Voltage Converters "OFF"	Discrete

TABLE II. Telemetry Data

Signal	Units	ANALOGUE TELEMETRY DATA		Bandwidth
		Accuracy	Impedance	
Transmitter Laser Current	ma	2%	<1000	1 Hz
Transmitter Laser Voltage	V	5%	<1000	1 Hz
L.O. Laser Current	ma	2%	<1000	1 Hz
L.O. Laser Voltage	V	5%	<1000	1 Hz
Backup Laser Current	ma	2%	<1000	1 Hz
Backup Laser Voltage	V	5%	<1000	1 Hz
Modulator Current	ma	2%	<1000	1 Hz

Table III. Power Supply Power Output

	LASER TRANSMITTER H.V. CURRENT REGULATOR	LASER L.O. H.V. CURRENT REGULATOR	BACKUP LASER H.V. CURRENT REGULATOR	NUTATOR & IMC DRIVER POWER SUPPLY	LOW VOLTAGE POWER SUPPLY ±12V	LOW VOLTAGE POWER SUPPLY + 5V
1.) OPERATING CURRENT 8/ (Milliamperes, DC)	4 ± 0.2 1/	5 ± 0.25 1/	4 ± 0.2 1/	1 to 25	100 to 235 10/	1500 to 2500
2.) OPERATING VOLTAGE 8/ (Volts, DC)	2000 ± 100 1/	800 ± 50 1/	2000 ± 100 1/	225 ± 3.4 1/	±12±0.225 1/	5 ± 0.25 1/
3.) STARTING VOLTAGE (Volts)	5000 ± * 1/	2600 ± * 1/	5000 ± * 1/	-	-	-
4.) RIPPLE CURRENT (Max.)						
(6.5 Hz to 50 Hz)	0.5% rms	0.08% rms	0.08% rms	-	-	-
(50 Hz to 1 KHz)	1% rms	1% rms	1% rms	-	-	-
(1 KHz to 10 KHz)	3% rms	3% rms	3% rms	-	-	-
5.) RIPPLE VOLTAGE (Max.)						
(Millivolts P-P)	-	-	-	150	15	300
(Millivolts RMS)	-	-	-	50	2	100
6.) LOAD/LINE REGULATION 3/ (Milliamperes, DC) 9/	0.2 3/	0.0625 4/	0.2 5/			
(Millivolts, DC) (5 Hz to 50 KHz)				3400 6/	225 6/	250 11/
7.) EFFICIENCY 7/						
8.) TEMPERATURE COEFFICIENT (0° to 140°F)	.5%/°C	.5%/°C	.5%/°C	.1%/°C	.1%/°C	.1%/°C

1/ Initial Tolerance
2/ Line Change ± 7%.
3/ Load change resulting in a 400-volt change in output voltage.
4/ Load change resulting in a 100-volt change in output voltage.
5/ Load change resulting in a 150-volt change in output voltage.
6/ Load ΔI of 50%.
7/ Overall efficiency shall be greater than 70% from 50% of full load to maximum rated load.
8/ To each of the tubes two anodes.
9/ Load impedance variation of ± 20%.
10/ Current required from each 12V source
11/ Load ΔI of 30%

* To be added later

NOTE: Cathodes of the Laser tubes shall be operated near ground potential.

3.2.4.1 High voltage.- The high voltage outputs (3.2.3(a)) shall be current regulated and perform as specified in Table III under the following conditions:

(a) Output current shall be divided between the two anodes of each laser tube as specified in Table III.

(b) Maximum negative resistance exhibited by the laser tubes in their operating range will be 100 K ohms. The voltage-current characteristics of the laser tubes will be as shown in Figure 3.

(c) Maximum voltage difference between the two anodes of the laser tube will be 150 volts. The initial voltage difference will not change more than __*__ volts with changes in operating conditions or tube life.

3.2.4.2 Short circuit.- Individual outputs of the power supply shall withstand any short circuit for one half hour and resume normal operation after removal of the short circuit. The short circuit current shall be limited to 120% of the nominal input operating current.

3.2.4.3 Response.- Individual outputs of the power supply shall respond to within __*__% of nominal output in less than __*__ milliseconds for a no load to full load change.

3.2.4.4 Status Monitors.- Status monitors for telemetry purposes shall be provided for the power supply. Status monitoring of the voltages and currents listed in Table II shall be required.

3.2.4.5 Starting Voltage.- The starting voltages specified in Table III shall be provided at the output of each power supply commanded "ON" until the laser starts or the power supply is commanded "OFF". When the laser starts the output voltage shall be reduced to the operating voltages specified in Table III.

3.2.5 Efficiency.- The overall efficiency of the power supply shall be greater than 70% at half load to a maximum rated load of 66 watts (output).

3.2.6 Dielectric strength.- With power off, the power supply shall withstand a test voltage of twice the maximum operating voltage associated with that output without corona, arcing, breakdown, damage or degradation in performance.

3.2.6.1 Corona discharge.- The design shall be such that no corona discharge or arcing will occur while the unit is operating during vacuum pull-down and at the specified vacuum environment.

* To be added at a later date.

3.2.7 Insulation resistance.- The insulation resistance of the power supply shall be at least 10 kilohms between all mutually isolated terminals, between all terminals connected together and the enclosure, and between the input and output grounds.

3.3 Useful life.-

3.3.1 Operating life.- The operational life of the power supply shall be 2,000 hours with the operating periods equally distributed within the two year period. A minimum of 500 power-on/power-off cycles and operating periods of up to 24 hours over a two year period in a space environment shall be possible without degradation of the requirements specified herein. The power supply shall be considered in operation when it is performing one or more of its functions.

3.3.2 Shelf life.- The power supply shall be capable of meeting the operating life of 3.3.1 after a shelf life of greater than 20,000 hours when packaged and stored in a protective enclosure.

3.4 Operability.-

3.4.1. Reliability.- The design for reliability shall occur simultaneously with, rather than separately from the design to achieve the electrical and mechanical characteristics specified in this specification. The power supply shall be designed and fabricated to provide _*_ probability of an operational lifetime as specified in 3.3.1. This lifetime is based on the active operation time being equally distributed within the two year period. The groundbased power supply shall have a mean-time-between failures of ___*___ hours.

3.4.2 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from the design of the power supply. The power supply shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.6.14 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible and compatible with the EMI requirements. Repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the power supply. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the power supply.

3.5 Environmental conditions.-

3.5.1 Equipment operating.- The power supply, while operating in any orientation, shall be capable of meeting the requirements in Table III while being subjected to any combination of the following environments:

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

* To be added at a later date.

(b) While being subjected to an acceleration of from zero up to a 1 g gravitational field.

(c) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(d) Thermal-vacuum conditions for LCE subsystem as specified in AGC-20511.

(e) Temperature for equipment operating as specified in AGC-20511.

3.5.2 Equipment nonoperating.- The power supply shall be capable of withstanding the following environmental conditions in accordance with the levels specified in AGC-20511 and thereafter meet the performance requirements in Table III.

(a) Sinusoidal and Random Vibrations, Test Level I or II in AGC-20511.

(b) Acceleration (AGC-20511).

(c) Storage Temperature (AGC-20511).

3.5.3 Ground model.- The Functional Test Model (FTM) will be used as the ground model and shall be capable of meeting the ground model operating and nonoperating environmental requirements as specified in AGC-20511. The FTM shall be equivalent to the flight model in design, construction and configuration.

3.6 Design and construction.- The power supply shall be designed and constructed in accordance with the thermal and structural requirements of AGC-20522 and the requirements specified herein.

3.6.1 Selection of specifications and standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be selected or prepared in accordance with AGC-STD-2312.

3.6.2 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312.

3.6.3 Moisture and fungus resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.6.4 Corrosion of metal parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.6.5 Interchangeability and replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.6.6 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.6.7 Electromagnetic Interference.- The electromagnetic interference design requirements of the power supply shall comply with the applicable requirements for Class IC or ID equipment as specified in MIL-STD-461. Ripple feedback to the payload regulation shall be less than 150 millivolts. The methods of inspection and definitions shall be as defined in MIL-STD-462 and MIL-STD-463, respectively.

3.6.8 Weight.- The weight of the power supply shall be a minimum consistent with the required performance, but shall not exceed a total weight of 7.7 pounds.

3.6.9 Envelope dimensions.- The power supply envelope dimensions shall be as shown in Figure 4.

3.6.10 Center of gravity.- The center of gravity shall be established to within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis as related to a reference point on the mounting surface. The reference point location shall be defined in the inspection report.

3.6.11 Mounting provisions.- The mounting provisions shall be as shown in Figure 4. The mounting design shall permit torquing of the mounting screws to 17 ± 1 in-lbs.

3.6.12 Thermal interface.-

3.6.12.1 Conduction path.- To provide the required contact conductance (8.3×10^{-2} w/cm^2 - °K) for the mounting surface constituting the primary heat conduction path, the surface shall have the following characteristics:

(a) Surface flatness within 0.005 inches along any direction of the respective surface.

(b) Surface finish of 32 micro-inches, rms, or less.

3.6.12.2 Radiation environment.- For design purposes, the average radiation environment for each assembly will be a temperature of $30 \pm {}^{15}_{20}$ °C and an emissivity of 0.6 or greater.

3.6.12.3 Assembly finish on non-mounting surfaces.- The non-mounting surfaces of each assembly shall have an emissivity of 0.6 or greater.

3.6.13 Electrical interface.-

3.6.13.1 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds and shield grounds. These grounds shall be isolated from each other and shall be brought out to separate pins of the interface electrical connector. There shall be no electrical connection between the shield of any shielded wire and any electrical circuitry. The shield of a shielded wire shall be grounded at only one end.

3.6.13.2 Connectors.- The electrical connectors shall be in accordance with specification S-323-P-10 and shall be of the type and pin assignment shown in Figure 5. Connectors shall not be used for the high voltage cables.

3.6.14 Test points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a separate connector if required.

3.6.15 Package venting.- All units shall be vented so that the unit internal pressure equals the ambient pressure.

3.6.16 Redundant circuits.- Two separate sets of high voltage circuits which are redundant and connected to output terminals by a suitable isolating circuit shall be provided for the operating current and voltage circuits of the regulators specified in 3.1.1 (a) and (b).

3.6.17 Arcing.- The power supply packaging design shall be such that if arcing does occur it will occur only between a high voltage point and ground and not to other circuitry.

3.6.18 Identification and Marking.- The power supply shall have an identification nameplate attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number.

(b) Manufacturer's name and location.

(c) Code identification number.

(d) Contract number.

(e) Unit name, model number, and serial number.

The information contained on the nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above.

3.6.19 Printed wiring boards.- If required, printed wiring boards shall be in accordance with GSFC Specification S-300-P-1.

3.6.20 Soldered electrical connections.- Soldering of electrical connections shall be in accordance with NBH 5300.4(3A) except for the following:

(a) Noncontact heat sources shall not be used (paragraph 3A304.4).

(b) Solid solder shall not be used (paragraph 3A309).

(c) Liquid solder flux shall not be used (paragraph 3A310).

(d) Lap joints shall not be used for structural mounting (paragraph 3A505).

(e) Multiple conductor cable shall not be used (paragraph 3A604 and page 6-6).

(f) Chapter 9 is not applicable.

3.6.21 Fail-safe provisions.- A failure of a component in one supply or section shall not cause any other section or supply to fail. A failure of any component in the unit shall not cause the input power to exceed 150% of the value specified in 3.2.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for two years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements. Any deficiencies noted as a result of tests conducted by the procuring activity, shall be corrected

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall maintain a quality assurance program in accordance with AGC-STD-2311.

4.1.2 Subcontractors reliability assurance program.- The subcontractor shall implement and maintain a reliability assurance program in accordance with AGC-STD-2312.

4.1.3 Processing changes.- The subcontractor shall make no changes in the power supply design, specifications, materials, or material processes after AGC design approval without prior written approval of the LCE project manager.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration. The tolerance allowed on test conditions and inputs are intended only to provide accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Flight Model and Ground Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model or Ground Model Acceptance Inspection (see 4.6).

4.3 Test plan.- A test plan shall be prepared which includes all of the examinations and tests specified in 4.5 and 4.6 such that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers' designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process inspection.- In-process inspection shall be performed to examine the unit and its detail parts and materials during the fabrication process for conformance to the applicable drawings and requirements herein. In-process inspection shall include, as a minimum, inspection of welded joints, electrical connections, electrical wiring, and workmanship. Tests for dielectric strength, corona, and insulation resistance shall be performed on component parts at appropriate stages of manufacture and assembly to assure compliance with 3.2.6 and 3.2.7.

4.5 <u>Design Qualification Inspection</u>.- Design Qualification Inspection shall consist of all the tests described in Table IV as a minimum. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the power supply under ambient conditions and the specified environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order and shall be conducted in the sequence presented in Table IV.

Table IV. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Test Methods
(a) <u>Analysis</u>		
(1) Reliability	3.4.1	4.7.1 ↓
(2) Maintainability	3.4.2	
(3) Thermal analysis	3.6.12	
(4) Radiation resistance	3.5.1 (a)	
(b) <u>Visual Examination and Measurements</u>		
(1) Connectors	3.6.13.2	4.7.2 ↓
(2) Weight	3.6.8	
(3) Envelope Dimensions	3.6.9	
(4) Center of gravity	3.6.10	
(5) Mounting and Alignment	3.6.11	
(6) Surface Characteristics	3.6.12.1	
(7) Grounding	3.6.13.1	
(8) Test Points	3.6.14	
(9) Venting	3.6.15	
(10) Printed wiring boards	3.6.19	
(11) Soldered electrical connections	3.6.20	
(12) Moisture and fungus resistance	3.6.3	
(13) Corrosion of metal parts	3.6.4	
(14) Interchangeability and replaceability	3.6.5	
(15) Workmanship	3.6.6	
(16) Identification and marking	3.6.18	
(c) <u>Testing</u>		
(1) Functional Characteristics at Minimum and Maximum Temperatures	Table VI	4.7.5 & 4.7.6
(2) Vibration (nonoperating)	3.5.2, Level I	4.7.6
(3) Functional Characteristics after Vibration	Table VI	4.7.5
(4) Acceleration (nonoperating)		4.7.6
(5) Functional Characteristics after Acceleration	3.5.2 (b)	4.7.5
(6) Functional Characteristics During Thermal Vacuum	3.5.1(d) & Table VI	4.7.5 & 4.7.6
(7) EMI Tests	3.6.7 (4.7.7)	4.7.7
(8) Functional Characteristics at Maximum Temperature	3.5.1(e) & Table VI	4.7.5 & 4.7.6

4.6 Flight Model Acceptance Inspection.- A detailed procedure of the Flight Model Acceptance Inspection shall be generated as a part of the overall test plan by the subcontractor and approved by AGC prior to final inspection. The Flight Model Acceptance Inspections shall include the examinations and tests of Table V as a minimum and shall be extensive enough to demonstrate satisfactory workmanship and that the Power Supply performance is within tolerance.

Table V. Flight Model Acceptance Inspection

	Requirement Paragraph	Test Method Paragraph
(a) Visual Examination & Measurements		
(1) Weight	3.6.8	4.7.2
(2) Envelope Dimensions	3.6.9	4.7.2
(3) Surface Characteristics	3.6.12.1	4.7.2
(4) Connectors	3.6.13.2	4.7.2
(b) Testing		
(1) Functional characteristics at maximum and minimum temperature	Table VI	4.7.5 & 4.7.6
(2) Vibration (nonoperating)	3.5.2, Level II	4.7.6
(3) Functional characteristics after vibration	Table VI	4.7.5
(4) Functional characteristics during thermal vacuum test1/	3.5.1 (d); Table VI	4.7.5 & 4.7.6
(5) Functional characteristics at maximum temperature	3.5.1 (e) & Table VI	4.7.5 & 4.7.6

1/ The thermal vacuum test shall be conducted at 10^{-5} torr for 12 hours.

4.6.1 Ground Model Acceptance Inspection.- The Ground Model Acceptance Inspection shall, as a minimum, consist of the visual examination and measurements and the functional test at minimum and maximum temperatures specified in Table V, items (a)(1) through (a)(4) and item (b)(1).

4.6.2 Acceptance inspection conditions.- Unless otherwise specified, acceptance inspections shall be performed under the following ambient atmospheric conditions:

(a) Temperature: + 25 ± 10°C (+77 ± 18°F)

(b) Relative Humidity: Up to 90% (no condensation)

(c) Atmospheric Pressure: 710 - 810 Torr (28-32 in. of mercury)

4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied by a review of analytical data. Such data shall be summarized or included as appropriate in the design study report or other written reports, if required. Systems engineering data shall be used where appropriate to support analysis.

Table VI. Functional Testing - Power Supply

Requirement	Requirement Paragraph	Functional During Temperature Test		Functional After Vibration		Functional After Acceleration	Functional During Thermal-Vacuum	Functional Test at Maximum Temperature	Functional During EMI
		Min	Max	Qual. Level I	Flight Level II				
Input Power	3.2.1	X	X					X	
Commands	3.2.2	X	X					X	
Short Circuits	3.2.4.2	X	X					X	
Response	3.2.4.3	X	X					X	
Status (telemetry) monitors	3.2.4.4	X	X					X	
Operating Voltage	Table III Item 2	X	X	X	X	X	X	X	
Starting Voltage	Table III Item 3	X	X	X	X	X	X	X	
Ripple Voltage	Table III Item 5	X	X					X	
Operating Current	Table III Item 1	X	X					X	
Ripple Current	Table III Item 4	X	X					X	
Load/Line Regulation	Table III Item 6	X	X					X	
Efficiency	Table III Item 7	X	X					X	
Corona	3.2.6.1						X		
Weight	3.6.8	at ambient environment							
Center of Gravity	3.6.10	at ambient environment							

4.7.2 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.3 Dielectric strength.- Each power supply shall be tested in accordance with MIL-STD-202, Method 301 and the requirements herein for compliance with 3.2.6. Evidence of corona shall be monitored during application of the maximum test voltage by a suitable detection network. Tests shall be conducted under normal ambient conditions. Maximum test voltage (twice the operating voltage) shall be applied at least once. On subsequent tests, the voltage may be reduced to 130% of operating voltage to avoid possible damage to the insulation. Test voltages shall be held for 1 hour during qualification testing and 1 minute for quality conformance tests.

4.7.4 Insulation resistance.- Each power supply shall be tested in accordance with MIL-STD-202 Method 302 for compliance with 3.2.7.

4.7.5 Functional performance.- Specific tests as specified in Table VI shall be performed to verify that the requirements of 3.2 are met. Whenever possible, tests shall be made on the Subsystem with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Tests requiring the combined operations of the Subsystems of the LCE shall be described in the Test Plan. Functional tests in accordance with Table VI shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.2, which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.2, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.6 Environmental tests.- Environmental tests shall be performed on the power supply in accordance with Table IV using the methods specified in AGC-20511. Functional tests as specified in Tables IV and V shall be performed in accordance with the detailed test plan.

4.7.7 Electromagnetic interference.- EMI testing shall be accomplished in accordance with the requirements of 3.6.7 for tests CE01, CE02, CE03, CS01, CS06, and RE01 as specified in MIL-STD-461.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable.

6. NOTES

6.1 Intended use.- The power supply specified herein is intended for use in the LCE of the ATS-F Spacecraft as well as in a transportable ground station without exhibiting any differences in performance or functional capabilities due to the differences in these environments. Any differences in hardware which may be necessary shall not degrade the specified performance levels.

6.2 Definitions.-

6.2.1 Failure.- A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.2.2 Corona.- An incomplete or partial voltage breakdown of the air adjacent to one or both terminals or conductors, resulting in a current flow of 10^{-7} to 10^{-6} amperes.

6.3 Oral statements.- Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.

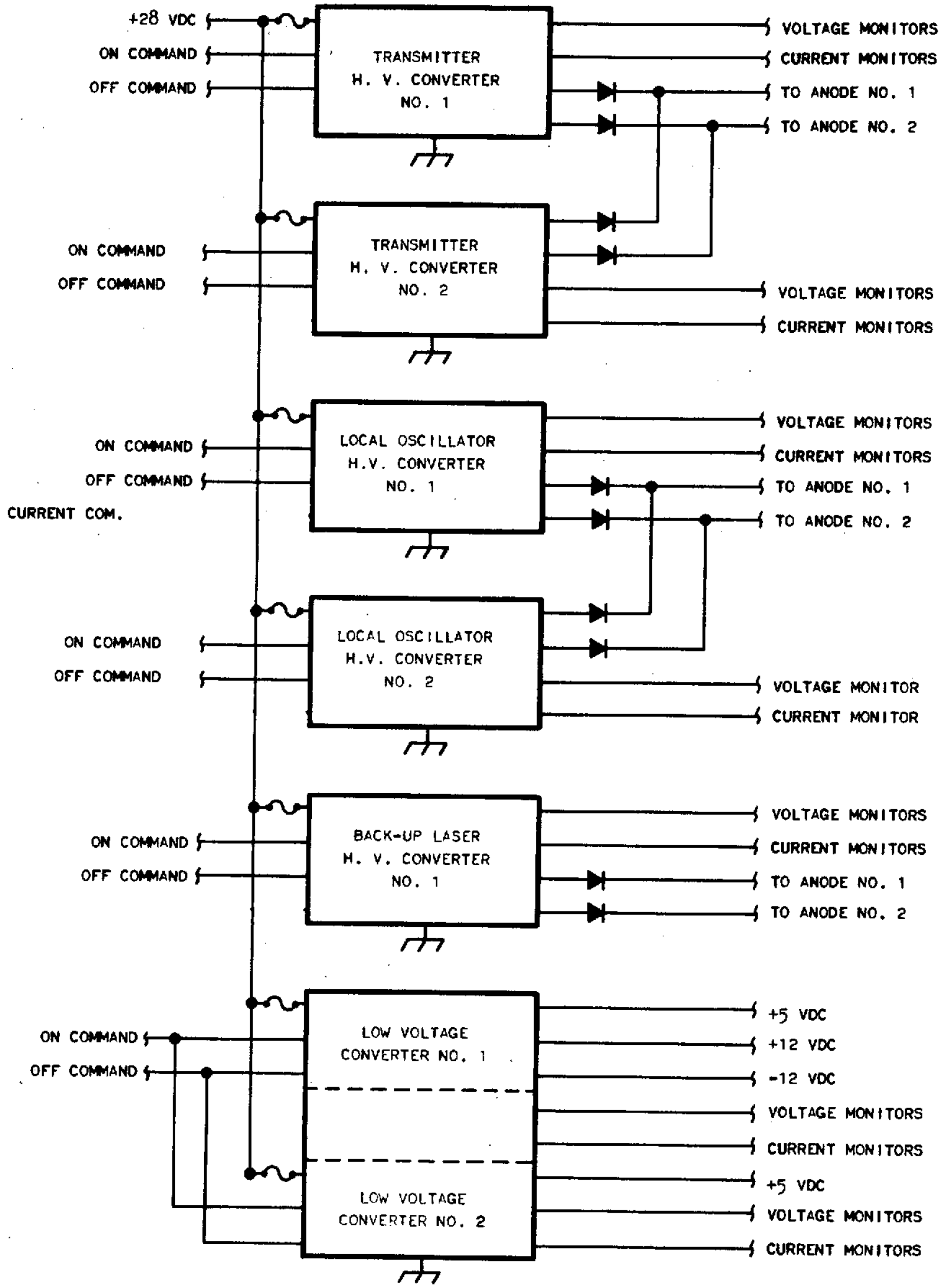

Figure 1. Power Supply Subsystem Block Diagram

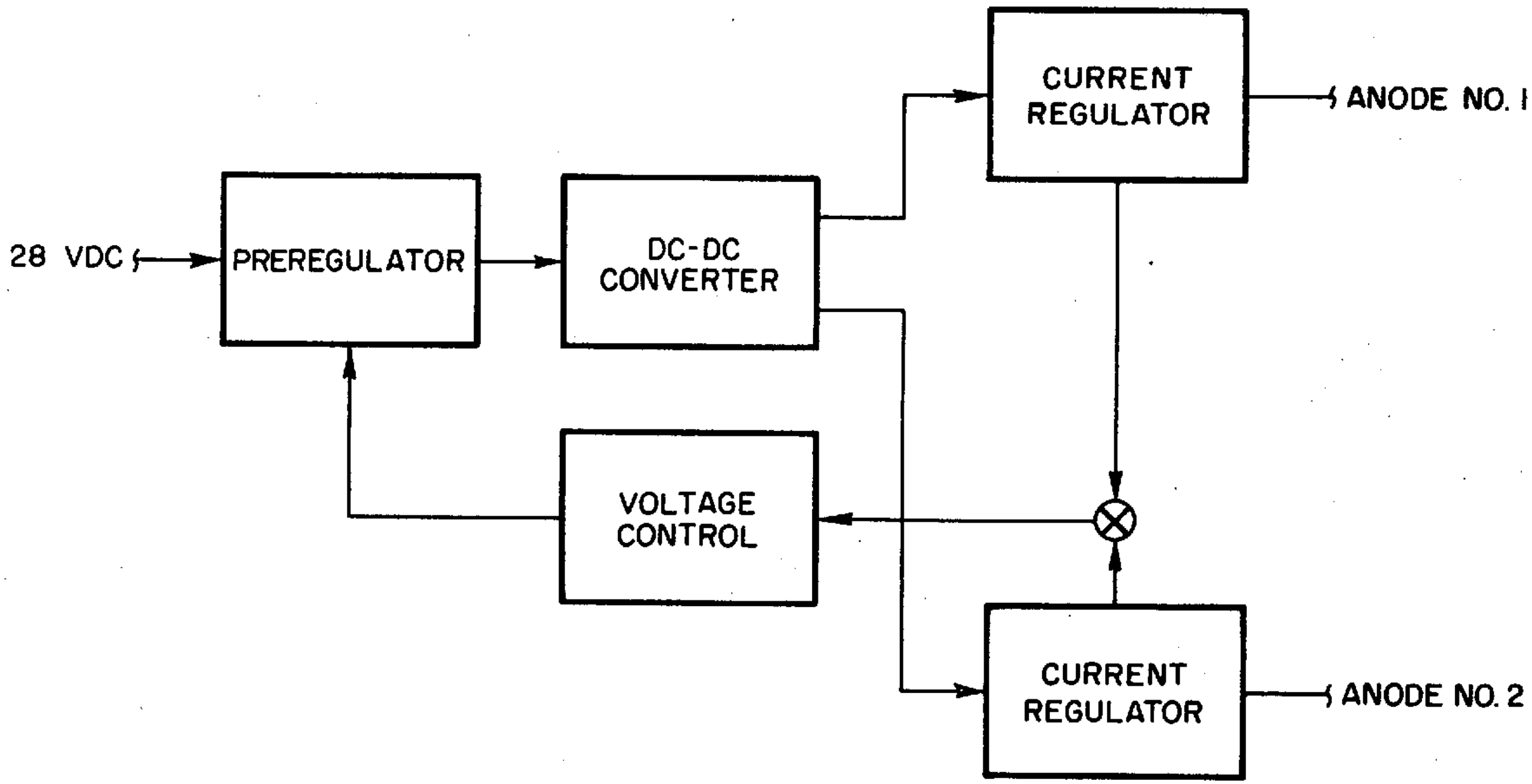

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Figure 2. Block Diagram of a Typical H.V. Power Section

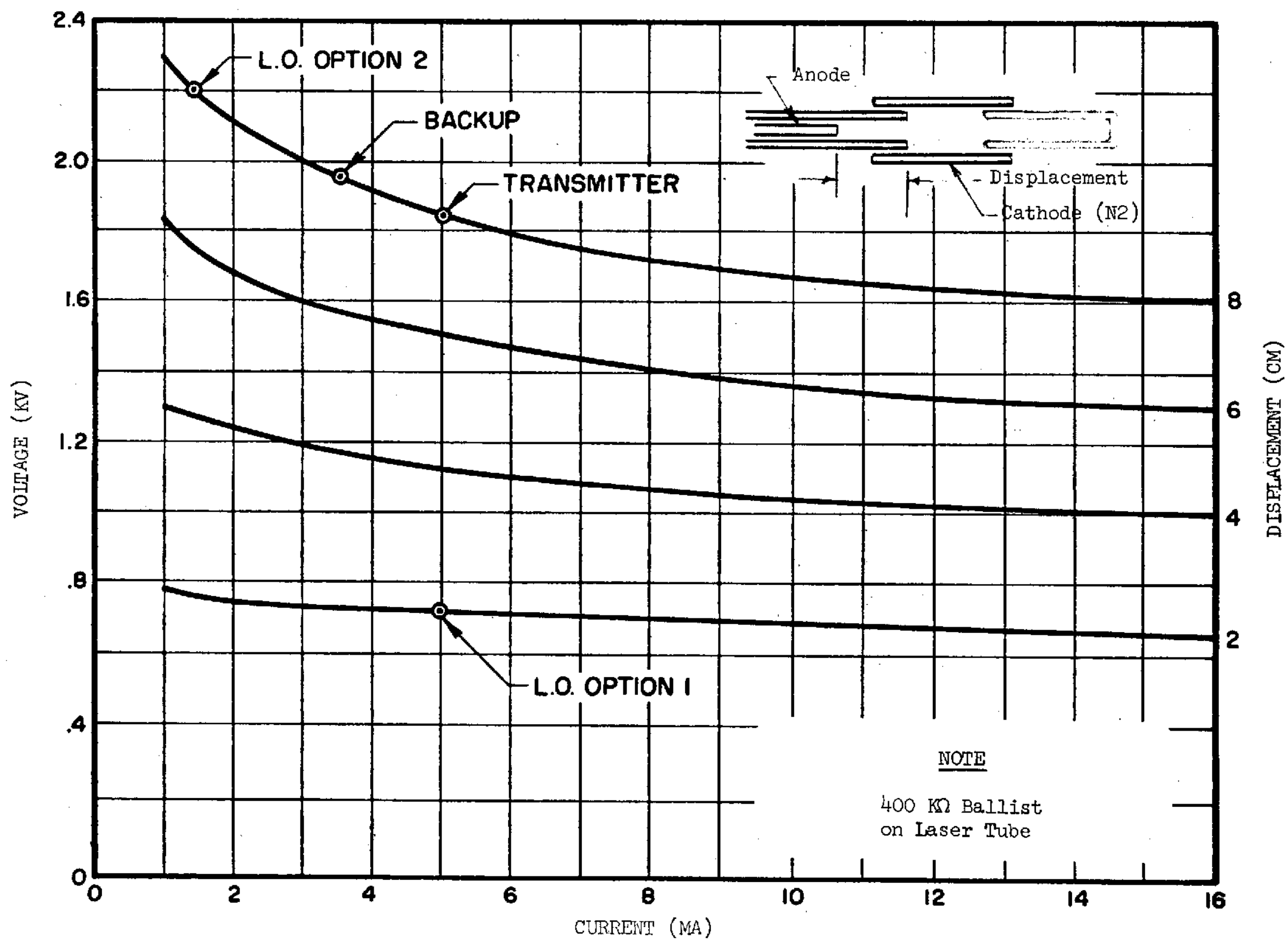

Figure 3. Voltage-Current Characteristics of Laser Tube

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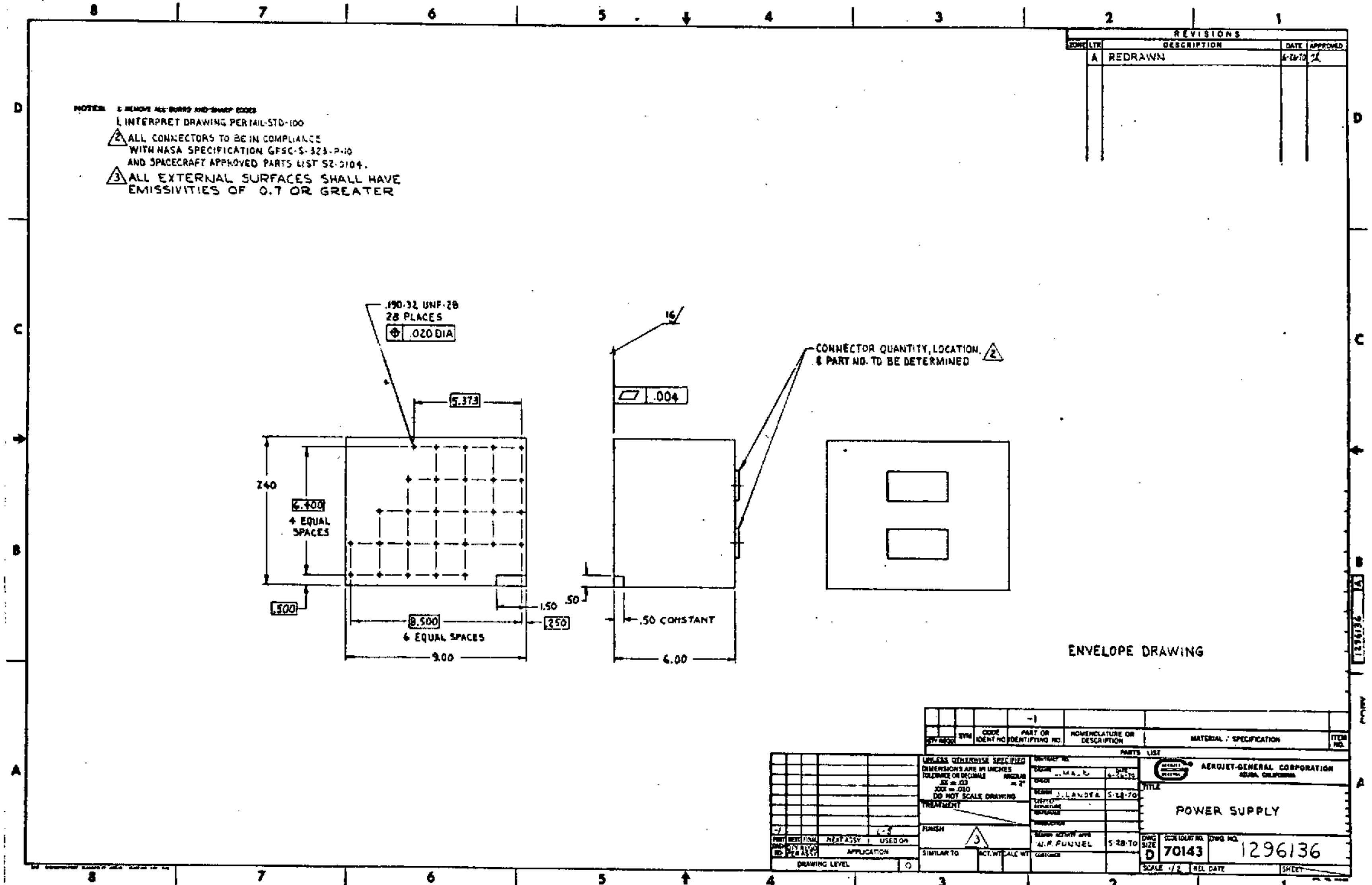

Figure 4. Power Supply Envelope

To be added later.

Figure 5. Electrical Interface Connections

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20515

TITLE

POWER SUPPLY SUBSYSTEM , LCE

	DEPT.	EXT.
PREPARED BY		
SPEC. ENGINEER J. M. McDonough	7981	5311

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein R. Goldstein	3591	7-9-70
CHIEF PROJECT ENGINEER - A. H. Gale A. H. Gale	3574	7-9-70
SYSTEM ENGINEERING - J. V. Cernius J. V. Cernius	3575	8 July '70
QUALITY ENGINEERING - J. H. Bassett J. H. Bassett	7831	7 July 70
RELIABILITY - P. W. Stockdill P. W. Stockdill	4072	7-8-70
RELEASE ACTIVITY - C. R. Cantrell	1147	7-10-70

7/6/70 AEROJET-GENERAL CORPORATION

AEROJET GENERAL TIRE GENERAL

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC-20518

FREQUENCY UP TRANSLATOR, 30 Hz - 4.6 MHz / 1.4 MHz - 6 MHz

SUPERSEDING:		
AGC- DATE	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	PAGE ADDITIONS
	29 Jun 70		

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough

for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification establishes performance and design requirements for a frequency up translator to be used to up translate the video baseband for a laser communication system. The Frequency Up Translator functions shall be accomplished by using the lower sideband and vestigial sideband techniques.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the content of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall be considered a superseding requirement.

NASA DOCUMENTS

NHB 5300.4(3A)	Requirements for Soldered Electrical Connections
S-300-P-1	Printed Wiring Boards
S-323-P-10	Connectors, Subminiature, Electrical and Coaxial Contact, for Space Flight Use

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Performance.- The Frequency up translator, hereinafter referred to as the unit, shall translate an input frequency band of 30 Hz to 4.6 MHz to an output frequency band of 1.4 MHz to 6 MHz using solid state circuitry where practicable. The up translation process shall be performed in accordance with the scheme presented in Figure 1. The vestigial sideband filter used in the unit shall be consistant with the characteristics specified in 3.1.13 and Figure 2.

3.1.1 Primary power input.- Primary power lines shall be fused before input to the EMI filters of each section. Fuse ratings shall be __*__ times the average input current. The unit shall be capable of performing as specified herein when provided with the following direct current power and input characteristics from a regulated bus:

(a) A maximum power input of 950 milli-watts and an operating voltage of + 27.4 to 28.6 volts direct current.

(b) A maximum ripple of 10 millivolts, rms (transient spikes will not exceed ± 2 volts peak, and transient energy level will not exceed 30 millijoules).

(c) A maximum conducted noise level of 10 millivolts peak with impedance versus frequency characteristics as specified in (e) below.

(d) A transient capacitive load of __*__ micofarads.

(e) An effective impedance of 0.1 ohms, or less, at 0 to 15 kilohertz.

3.1.2 Input signal characteristics.- The unit shall be capable of meeting the performance herein with the following input signal characteristics:

(a)	Input frequency:	30 Hz to 4.6 MHz
(b)	Input level:	1 volt peak-to-peak ± 0.5 db
(c)	Impedance:	75 ohm unbalanced
(d)	Return Loss:	26 db or less

3.1.3 Gain.- The overall gain shall be adjustable to ± 0.5 volt peak-to-peak.

3.1.4 Noise figure.- The noise figure of the unit shall not exceed 5 db, measured at the input to the up translator channel.

* To be added at a later date.

3.1.5 Output.- The translation of 30 Hz input frequency shall correspond to a 1.4 MHz output and the 4.6 MHz input frequency shall correspond to a 6 MHz output. Output characteristics of the unit shall be as follows:

(a) Frequency: 1.4 MHz to 6 MHz

(b) Output Level: 1 volt peak to peak, adjustable ± 0.5 volts

(c) Bandwidth: 4.6 MHz

(d) Impedance: 75 unbalanced

(e) Return Loss: (To be added at a later date.)

3.1.6 Spurious output.- The spurious output shall be -50 dbv, minimum.

3.1.7 Conversion gain stability.- The conversion gain stability shall be ± 0.1 db, maximum, per day.

3.1.8 Gain variation.- Total gain variation shall be less than -0.5 db over the bandwidth.

3.1.9 Stop-band attenuation.- The out of band attenuation shall be 40 db, minimum.

3.1.10 Input/output frequency sense.- There shall be no inversion of frequency sense so that an increase in input frequency shall result in a corresponding change in the output frequency.

3.1.11 Gain slope.- The variation of gain slope at any frequency shall not exceed ± 0.02 db/MHz in the band from 9.6 MHz to 14.2 MHz.

3.1.12 Pilot carrier.-

3.1.12.1 Frequency.- The frequency of pilot carrier shall be 1.4 ± 100 Hz.

3.1.12.2 Frequency stability.- The pilot carrier frequency stability shall be better than 50 PPM.

3.1.12.3 Amplitude.- The amplitude of the pilot carrier measured at this output of the video amplifier shall not exceed 0.1 V peak-to-peak when terminated in a 75 ohm unbalanced load.

3.1.12.4 Pilot carrier incidental phase modulation.- Pilot carrier incidental phase modulation shall not exceed ± 1.5°.

3.1.13 Translator phase linearity.- The overall phase linearity of the translator shall not exceed ± 4 degrees over the bandwidth.

3.1.14 Local oscillator re-radiation.- Local oscillator re-radation from the unit input terminal shall be -90 dbm or less.

3.1.15 Vestigial sideband filter.- The vestigial sideband filter used in the frequency up translator shall comply with the characteristics specified in in Figure 2 and as follows:

(a) Attenuation: The frequency characteristics shall be as follows:

(1) -3 db maximum at 9.4 MHz and 14.4 MHz

(2) -20 db minimum at 9.2 MHz and 14.6 MHz

(b) Gain slope: The gain slope at any frequency in the band of 9.6 to 14.2 MHz shall not exceed ± 0.02 db per MHz.

(c) Phase linearity: The deviation in phase linearity shall be less than ± 3.5 degrees, between 9.6 MHz and 14.2 MHz.

(d) Ripple: The peak-to-peak ripple shall not exceed ± 0.05 db amplitude in this pass band of the filter.

3.2 Characteristics.-

3.2.1 Operability.-

3.2.1.1 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from the design to achieve the electrical and mechanical characteristics specified in this specification. The Translator shall be designed and fabricated to provide __*_% probability of an operational lifetime as specified in 3.2.2.1. This lifetime is based on the active operation time being equally distributed within the two year period.

3.2.1.2 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from the design of the Translator. The Translator shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.2.3.8 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible and compatible with the EMI requirements. Repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the unit. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the unit.

3.2.2 Useful life.-

3.2.2.1 Operating life.- The operational life of the Translator shall be 2,000 hours with the operating periods equally distributed within the two year period. A minimum of 500 power-on/power-off cycles and operating periods of up to 24 hours over a two year period in a space environment shall be possible without degradation of the requirements specified herein. The Translator shall be considered in operation when it is performing one or more of its functions.

* To be added at a later date.

3.2.2.2 Shelf life.- The Translator shall be capable of meeting the operating life of 3.2.2.1 after a shelf life of greater than 20,000 hours when packaged and stored in a protective enclosure.

3.2.3 Physical characteristics.-

3.2.3.1 Weight.- The weight of the Translator shall be a minimum consistent with the required performance, but shall not exceed a total weight of 2.8 pounds with a design goal of 1.8 pounds.

3.2.3.2 Envelope dimensions.- The Translator envelope dimensions shall be as small as possible, but shall not exceed the dimensions shown in Figure 3.

3.2.3.3 Center of gravity.- The center of gravity shall be as shown in Figure 3 and shall be located within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis. The center of gravity shall be related to a reference point on the mounting surface, the location of which shall be defined in the inspection report.

3.2.3.4 Mounting provisions.- The mounting provisions shall be as shown in Figure 3. The mounting design shall permit torquing of the mounting screws to 17 ± 1 in-lbs.

3.2.3.5 Thermal interface.-

3.2.3.5.1 Conduction path.- To provide the required contact conductance (8.3×10^{-2} w/cm^2 - °K) for the mounting surface constituting the primary heat conduction path, the surface shall have the following characteristics:

(a) Surface flatness within 0.005 inches, rms, along any direction of the respective surface.

(b) Surface finish of 32 micro-inches or less.

3.2.3.5.2 Radiation environment.- For design purposes, the average radiation environment for each assembly will be a temperature of $30 \pm^{15}_{20}$ °C and an emissivity of 0.6 or greater.

3.2.3.5.3 Assembly finish on non-mounting surfaces.- The non-mounting surfaces of each assembly shall have an emissivity of 0.6 or greater.

3.2.3.6 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds, and shield grounds. These grounds shall be isolated from each other and shall be brought out on separate pins of the interface electrical connector as shown in Figure 4. The shielded wire ground, as a general rule, shall be grounded at the input end.

3.2.3.7 Electrical connectors.- Electrical connectors shall be in accordance with NASA Publication S-300-P-10. The type and pin assignment of the connectors shall be as shown in Figure 4.

3.2.3.8 Test points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a convenient location.

3.2.3.9 Package venting.- All units shall be vented so that the unit internal pressure equals the ambient pressure.

3.3 Environmental conditions.-

3.3.1 Equipment operating.- The Translator, while operating in any orientation, shall be capable of meeting the requirements specified herein, while being subjected to any combination of the following environments (demonstration of compliance shall only be performed to the extent specified in section 4.0):

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(c) Thermal-vacuum conditions for LCE subsystem as specified in AGC-20511.

(d) Temperature for equipment operating as specified in AGC-20511.

3.3.2 Equipment nonoperating.- The Translator shall be capable of withstanding the following environmental conditions in accordance with the levels specified in AGC-20511 and thereafter meet the performance requirements as specified herein.

(a) Sinusoidal and Random Vibrations, Test Level I or II in AGC-20511.

(b) Acceleration (AGC-20511).

(c) Storage temperature (AGC-20511).

3.4 Design and construction.-

3.4.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be selected or prepared in accordance with AGC-STD-2312.

3.4.2 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312. Printed wiring boards shall be in accordance with NASA Publication S-300-P-1.

3.4.3 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.4.4 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.4.5 Interchangeability and replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.4.6 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.4.7 Electromagnetic Interference.- The electromagnetic interference characteristics of the Translator shall comply with the requirements for Class IC or ID equipment as applicable and limits of RE-1, (T)RE04, and RS-1 as specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.4.8 Identification and Marking.- The Translator shall have an identification nameplate attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number.

(b) Manufacturer's name and location.

(c) Code identification.

(d) Contract number.

(e) Unit name, model number, and serial number.

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above. Separate units shall be serialized.

3.4.9 Soldered electrical connections.- Soldering of electrical connections shall be in accordance with NBH 5300.4(3A) except for the following:

(a) Noncontact heat sources shall not be used (paragraph 3A304.4).

(b) Solid solder shall not be used (paragraph 3A309).

(c) Liquid solder flux shall not be used (paragraph 3A310).

(d) Lap joints shall not be used for structural mounting (paragraph 3A505).

(e) Multiple conductor cable shall not be used (paragraph 3A604 and page 6-6).

(f) Chapter 9 is not applicable

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for three years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements. Any deficiencies noted as a result of tests conducted by the procuring activity, shall be corrected.

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall maintain a quality assurance program in accordance with AGC-STD-2311.

4.1.2 Subcontractor's reliability assurance program.- The subcontractor shall implement and maintain a reliability assurance program in accordance with AGC-STD-2312.

4.1.3 Processing changes.- The subcontractor shall make no changes in the Translator design, specifications, materials, or material processes after AGC design approval without prior written approval in accordance with AGC-STD-2312.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration. The tolerance allowed on test conditions and inputs are intended only to provide accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification and Flight Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In-process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model Acceptance Inspection (see 4.6).

4.3 Test plan.- The subcontractor shall prepare a test plan which includes all of the examinations and tests specified in 4.5 and 4.6 such that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance paramter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers' designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process inspection.- In-process examinations and tests shall be performed as required to comply with AGC-STD-2311.

4.5 Design Qualification Inspection.- Design Qualification Inspection shall consist of all the tests described in Table I as a minimum. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the unit under ambient conditions and the specified operational environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order.

Table I. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Test Method
Analysis		
Reliability	3.2.1.1	4.7.1
Maintainability	3.2.1.2	4.7.1
Thermal analysis	3.2.3.5	4.7.1
Visual examination and measurements		
Selection of specifications and standards	3.4.1	4.7.1.1
Standard and Commercial parts	3.4.2	4.7.1.1
Moisture and fungus resistance	3.4.3	4.7.1.1
Corrosion of metal parts	3.4.4	4.7.1.1
Interchangeability and replaceability	3.4.5	4.7.1.1
Workmanship	3.4.6	4.7.1.1
Identification and marking	3.4.8	4.7.1.1
Weight	3.2.3.1	4.7.1.1
Center of gravity	3.2.3.3	4.7.1.1
Envelope Dimensions	3.2.3.2	4.7.1.1
Mounting	3.2.3.4	4.7.1.1
Surface Characteristics	3.2.3.5	4.7.1.1
Testing		
(1) Functional Characteristics at minimum and Maximum temperatures	3.3.1(d) & Table III	4.5
(2) Vibration (non-operating)	3.3.2(a) Level I	4.5
(3) Functional characteristics after vibration	Table III	4.5
(4) Acceleration (non-operating)	3.3.2(b)	4.5
(5) Functional characteristics after accel.	Table III	4.5
(6) Functional characteristics during thermal vacuum	3.3.1(c)	4.5
(7) Functional characteristics at maximum hot operating temperature	3.3.1(d) & Table III	4.5

4.6 Flight Model Acceptance Inspection.- A detailed procedure of the Flight Model Acceptance Inspection shall be generated as a part of the overall test plan by the subcontractor and approved by AGC prior to final inspection. The Flight Model Acceptance Inspections shall include the examinations and tests of Table II as a minimum and shall be extensive enough to demonstrate satisfactory workmanship and that the Translator performance is within tolerance. The functional parameters to be verified shall be as specified in Table III and conducted in accordance with 4.7.3.

Table II. Flight Model Acceptance Inspection

Examination or Test	Requirement Paragraph	Test Method
(a) Visual Examination & Measurements		
(1) Weight	3.2.3.1	4.7.1.1
(2) Envelope Dimensions	3.2.3.2	4.7.1.1
(3) Surface Characteristics	3.2.3.5	4.7.1.1
(4) Connector	3.2.3.7	4.7.1.1
(b) Testing		
(1) Functional characteristics at minimum & maximum temperature	3.3.1(d) & Table III	4.6
(2) Vibration (non-operating)	3.3.2(a) Level II	4.6
(3) Functional characteristics after vibration	Table III, Level II	4.6
(4) Functional characteristics during thermal vacuum 1/	3.3.1(c)	4.6
(5) Functional characteristics at maximum temperature	Table III	4.6

1/ The thermal vacuum test shall be conducted at 10^{-5} Torr for 12 hours.

TABLE III FUNCTIONAL TESTING-UP TRANSLATOR

	Requirement Paragraph	Functional During Temperature Test		Functional After Vibration		Functional After Acceleration	Functional During Thermal Vacuum	Functional Test at Max. Temp.	Function During EMI
		Min	Max	Qual. Level I	Flight Level II				
Gain	3.1.3	X	X	X	X	X	X	X	
Noise Figure	3.1.4	X	X					X	
Output	3.1.5	X	X	X	X	X	X	X	
Spurious Output	3.1.6	X	X	X			X		
Conversion Gain Stability	3.1.7	X	X	X			X		
Gain Variation	3.1.8	X	X	X			X	X	
Stopband Attenuation	3.1.9							X	
Input/Output Freq. Sense	3.1.10	X	X					X	
Gain Slope	3.1.11	X	X				X	X	
Pilot Carrier	3.1.12								
Frequency	3.1.12.1	X	X				X	X	
Stability	3.1.12.2	X	X				X	X	
Amplitude	3.1.12.3	X	X				X	X	
Incidental Phase Mod.	3.1.12.4						X	X	
Phase Linearity	3.1.13	X	X				X	X	
L.O. Re-radiation	3.1.14	X	X					X	
Vestigial Sideband Filter	3.1.15								
Attenuation	↓								
Gain Slope	↓								
Phase Linearity	↓								
Ripple	↓								

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4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the design study report or other written reports, if required. Systems engineering data shall be used where appropriate to support analysis.

4.7.2 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be staisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.3 Functional characteristics.- Specific tests as specified in Table III shall be performed to verify that the requirements of 3.1 are met. Whenever possible, tests shall be made on the Subsystem with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Tests requiring the combined operations of the Subsystems of the LCE shall be described in the Test Plan. Functional tests in accordance with Table III shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.1 which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.1, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.4 Environmental tests.- Environmental tests shall be performed on the translator in accordance with Table I using the methods specified in AGC-20511. Functional parameters as specified in Table III shall be tested in accordance with the detailed test plan.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter (AGC-20518).

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable.

6. NOTES

6.1 Intended use.- The unit described by this specification is to be installed in an ATS-F spacecraft and used with a Laser Communication System.

6.2 Precedence.- In the event of a conflict between the contract and this specification and any applicable documents, the following order of precedence shall apply:

(a) The contract

(b) This specification

(c) Other applicable documents.

6.3 Deviations.- All deviations or exceptions to the requirements of this specification or any document referred to herein shall be referred in writing to AGC, using the Supplier's Discrepancy Action Request (SDAR), AGC Form No. 00-009-030. The disposition of the SDAR must be approved by AGC prior to shipment. Two copies of the approved SDAR shall accompany each affected shipment.

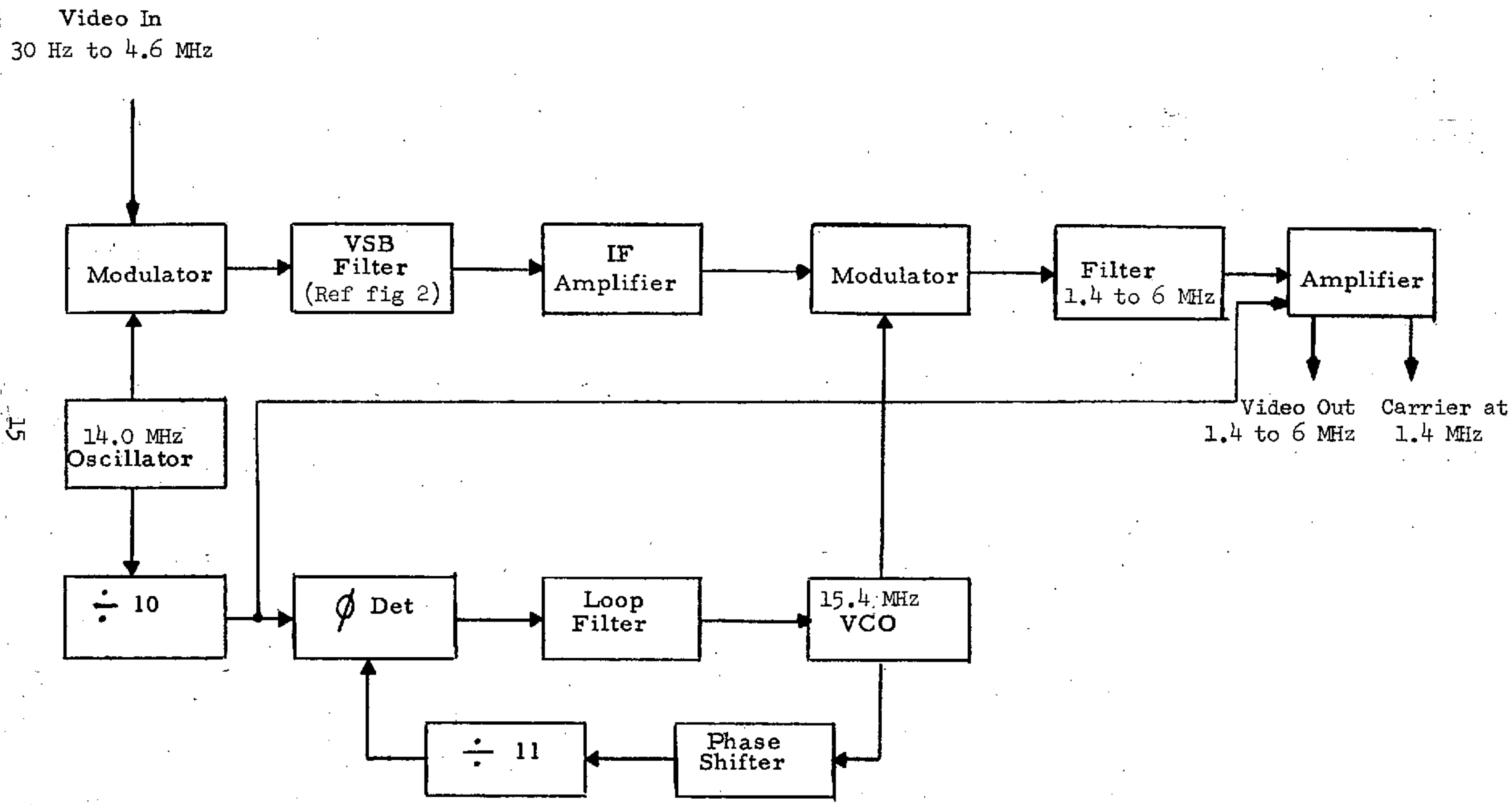

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Figure 1. Up Translation Equipment Block Diagram

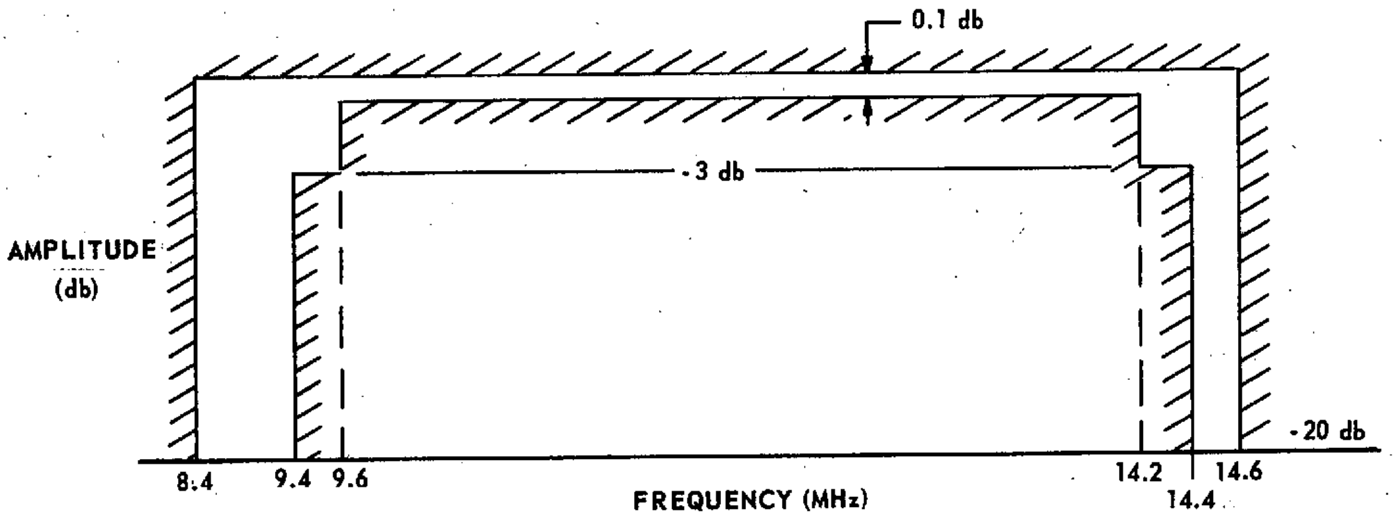
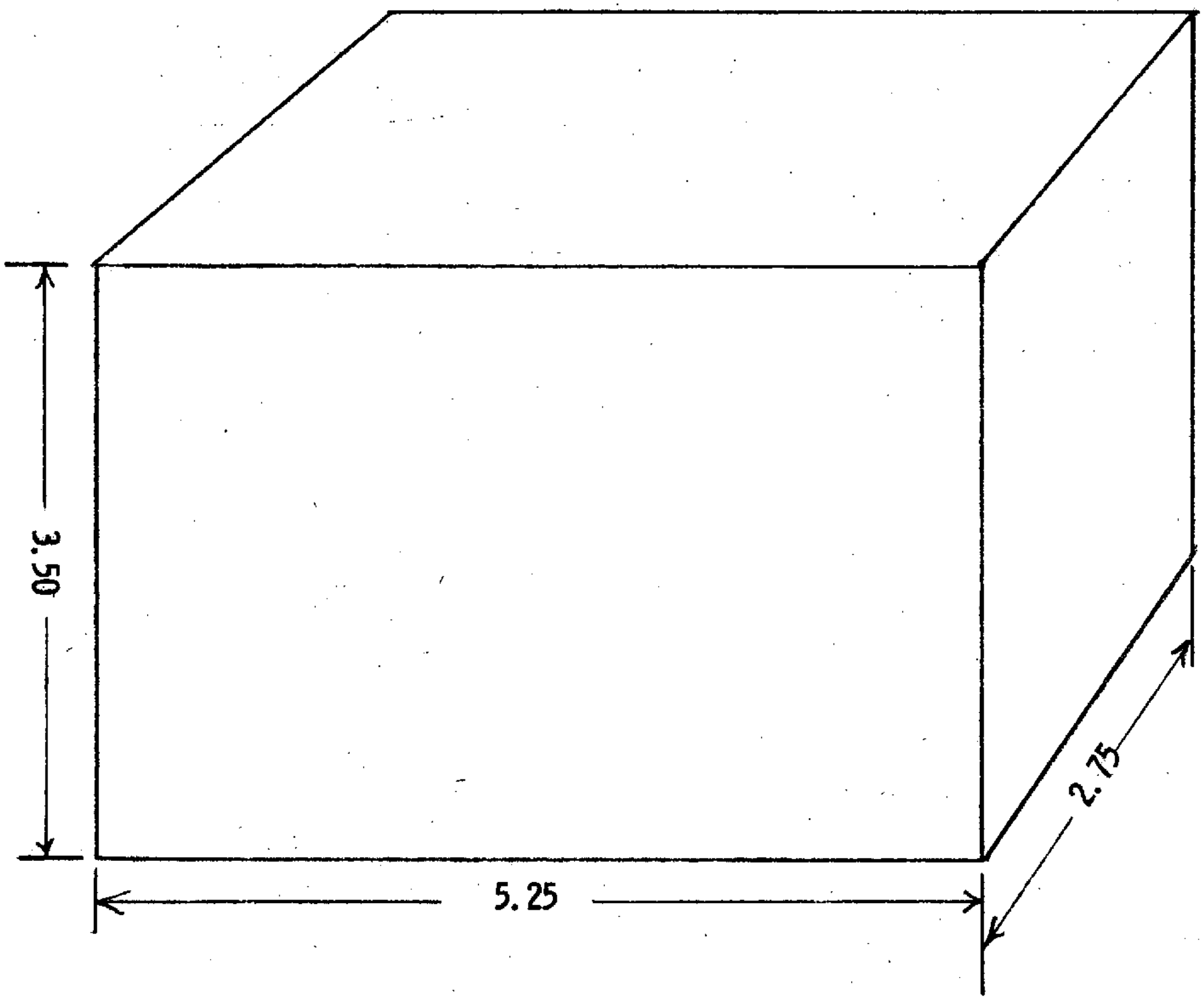


Figure 2. Vestigial Sideband Filter Amplitude Response



NOTE:
All dimensions
are in inches

AGC-20518

Figure 3. Envelope-Translator

To be added at a later date.

Figure 4. Interface Electrical connections

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20518

TITLE

FREQUENCY UP TRANSLATOR, 30 Hz - 4.6 MHz/1.4 MHz - 6 MHz

	DEPT.	EXT.
PREPARED BY T. Aziz	3552	5258
SPEC. ENGINEER J. COFF	7981	6571

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein	3591	R Goldstein
CHIEF PROJECT ENGINEER - A. H. Gale	3574	A H Gale
SYSTEM ENGINEERING - J. V. Cernius	3575	J.V. Cernius
QUALITY ENGINEERING - J. H. Bassett	7831	J H Bassett
RELIABILITY - P. W. Stockdill	4072	P W Stockdill
RELEASE ACTIVITY - Pat Hadley	1147	6-29-70

6/23/70 AEROJET-GENERAL CORPORATION

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC-20519

FREQUENCY DOWN TRANSLATOR, 1.4 MHz - 6 MHz / 30 Hz - 4.6 MHz

SUPERSEDING:		
AGC- DATE	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW)

REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	PAGE ADDITIONS
	29 Jun 70		

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough

for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 This specification establishes performance and design requirements for a frequency down translator to be used to down translate the video baseband for a laser communication system. The Frequency Down Translator functions shall be accomplished by using the lower sideband and vestigial sideband techniques.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the content of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall be considered a superseding requirement.

NASA DOCUMENTS

NHB 5300.4(3A)	Requirements for Soldered Electrical Connections
S-300-P-1	Printed Wiring Boards
S-323-P-10	Connectors, Subminature, Electrical and Coaxial Contact, for Space Flight Use

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Performance.- The Frequency Down Translator, hereinafter referred to as the unit, shall translate an input frequency band of 1.4 MHz to 6 MHz to an output frequency band of 30 Hz to 4.6 MHz using solid state circuitry where practicable. The down translation process shall be performed in accordance with the scheme presented in Figure 1. The vestigial sideband filter used in the unit shall be consistent with the characteristics specified in 3.1.13 and Figure 2.

3.1.1 Primary power input.- Primary power lines shall be fused before input to the EMI filters of each section. Fuse ratings shall be __*__ times the average input current. The unit shall be capable of performing as specified herein when provided with the following direct current power and input characteristics from a regulated bus:

(a) A maximum power input of 1200 milli-watts and an operating voltage of + 27.4 to 28.6 volts direct current.

(b) A maximum ripple of 10 millivolts, rms (transient spikes will not exceed ± 2 volts peak, and transient energy level will not exceed 30 millijoules).

(c) A maximum conducted noise level of 10 millivolts peak with impedance versus frequency characteristics as specified in (e) below.

(d) A transient capacitive load of __*__ micofarads.

(e) An effective impedance of 0.1 ohms, or less, at 0 to 15 kilohertz.

3.1.2 Input signal characteristics.- The unit shall be capable of meeting the performance herein with the following input signal characteristics:

(a) Input frequency: 1.4 MHz to 6 MHz

(b) Input level: 1 volt peak-to-peak ± 0.5 db

(c) Impedance: 75 ohm unbalanced

(d) Return Loss: 26 db or less

3.1.3 Gain.- The overall gain shall be adjustable to ± 0.5 volt peak-to-peak.

3.1.4 Noise figure.- The noise figure of the unit shall not exceed 5 db, measured at the input to the down translator channel.

3.1.5 Local oscillator re-radiation.- Local oscillator re-radiation from the unit input terminal shall be -90 dbm or less.

3.1.5.1 Local oscillator stability.- The local oscillator frequency stability shall be better than 50 ppm.

* To be added at a later date.

3.1.6 Output.- The translation of 1.4 MHz input frequency shall correspond to a 30 Hz output and the 6 MHz input frequency shall correspond to a 4.6 MHz output. Output characteristics of the unit shall be as follows:

(a) Frequency: 30 Hz to 4.6 MHz

(b) Output Level: 1 volt peak to peak, adjustable ± 0.5 volts

(c) Bandwidth: 4.6 MHz

(d) Impedance: 75 unbalanced

(e) Return Loss: *

3.1.7 Spurious output.- The spurious output shall be -50 dbv, minimum.

3.1.8 Conversion gain stability.- The conversion gain stability shall be ± 0.1 db, maximum, per day.

3.1.9 Gain variation.- Total gain variation shall be less than -0.5 db over the bandwidth.

3.1.10 Stop-band attenuation.- The out of band attenuation shall be 40 db, minimum.

3.1.11 Input/output frequency sense.- There shall be no inversion of frequency sense so that an increase in input frequency shall result in a corresponding change in the output frequency.

3.1.12 Gain slope.- The variation of gain slope at any frequency shall not exceed ± 0.02 db/MHz in the band from 9.6 MHz to 13.8 MHz.

3.1.13 Phase locked loop pull-in range.- The phase locked loop pull-in range shall be 50 Hz minimum.

3.1.14 Phase locked loop tracking rate.- *

3.1.15 Phase locked loop phase accuracy.- Phase locked loop phase shall not exceed ± 0.5 degrees maximum.

3.1.16 Translator phase linearity.- The overall phase linearity of the translator shall not exceed ± 4 degrees over the bandwidth.

3.1.17 Vestigial sideband filter.- The vestigial sideband filter used in the frequency down translator shall comply with the characteristics specified in Figure 2 and as follows:

(a) Attenuation: The frequency characteristics shall be as follows:

(1) -6 db ± 0.3 db at 14.0 MHz

(2) 0 ± 0.1 db at 13.8 MHz

(3) -20 db minimum at 14.2 MHz

(4) -20 db minimum at 9.2 MHz

(5) 0 db ± 0.1 db at 9.4 MHz

* To be added at a later date.

(b) Gain slope: The gain slope at any frequency in the band of 9.4 to 13.8 MHz shall not exceed ± 0.02 db per MHz.

(c) Phase linearity: The deviation in phase linearity shall be less than ± 3.5 degrees, between 9.4 MHz and 13.8 MHz.

(d) Ripple: The peak-to-peak ripple shall not exceed ± 0.05 db amplitude in this pass band of the filter.

3.2 Characteristics.-

3.2.1 Operability.-

3.2.1.1 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from the design to achieve the electrical and mechanical characteristics specified in this specification. The Translator shall be designed and fabricated to provide __*_% probability of an operational lifetime as specified in 3.2.2.1. This lifetime is based on the active operation time being equally distributed within the two year period.

3.2.1.2 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from the design of the Translator. The Translator shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.2.3.8 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible and compatible with the EMI requirements. Repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the unit. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the unit.

3.2.2 Useful life.-

3.2.2.1 Operating life.- The operational life of the Translator shall be 2,000 hours with the operating periods equally distributed within the two year period. A minimum of 500 power-on/power-off cycles and operating periods of up to 24 hours over a two year period in a space environment shall be possible without degradation of the requirements specified herein. The Translator shall be considered in operation when it is performing one or more of its functions.

3.2.2.2 Shelf life.- The Translator shall be capable of meeting the operating life of 3.2.2.1 after a shelf life of greater than 20,000 hours when packaged and stored in a protective enclosure.

* To be added at a later date.

3.2.3 Physical characteristics.-

3.2.3.1 Weight.- The weight of the Translator shall be a minimum consistent with the required performance, but shall not exceed a total weight of 3.5 pounds with a design goal of 2.3 pounds.

3.2.3.2 Envelope dimensions.- The Translator envelope dimensions shall be as small as possible, but shall not exceed the dimensions shown in Figure 3.

3.2.3.3 Center of gravity.- The center of gravity shall be as shown in Figure 3 and shall be located within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis related to a reference point on the mounting surface. The reference point location shall be defined in the inspection report.

3.2.3.4 Mounting provisions.- The mounting provisions shall be as shown in Figure 3. The mounting design shall permit torquing of the mounting screws to 17 ± 1 in-lbs.

3.2.3.5 Thermal interface.-

3.2.3.5.1 Conduction path.- To provide the required contact conductance (8.3×10^{-2} w/cm^2 - °K) for the mounting surface constituting the primary heat conduction path, the surface shall have the following characteristics:

(a) Surface flatness within 0.005 inches, rms, along any direction of the respective surface.

(b) Surface finish of 32 micro-inches or less.

3.2.3.5.2 Radiation environment.- For design purposes, the average radiation environment for each assembly will be a temperature of $30 \pm^{15}_{20}$ °C and an emissivity of 0.6 or greater.

3.2.3.5.3 Assembly finish on non-mounting surfaces.- The non-mounting surfaces of each assembly shall have an emissivity of 0.6 or greater.

3.2.3.6 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds, and shield grounds. These grounds shall be isolated from each other and shall be brought out on separate pins of the interface electrical connector as shown in Figure 4. The shielded wire ground, as a general rule, shall be grounded at the input end.

3.2.3.7 Electrical connectors.- Electrical connectors shall be in accordance with NASA Publication S-300-P-10. The type and pin assignment of the connectors shall be as shown in Figure 4.

3.2.3.8 Test points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a convenient location.

3.2.3.9 Package venting.- All units shall be vented so that the unit internal pressure equals the ambient pressure.

3.3 Environmental conditions.-

3.3.1 Equipment operating.- The Translator, while operating in any orientation, shall be capable of meeting the requirements specified herein, while being subjected to any combination of the following environments (demonstration of compliance shall only be performed to the extent specified in section 4.0):

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(c) Thermal-vacuum conditions for LCE subsystem as specified in AGC-20511.

(d) Temperature for equipment operating as specified in AGC-20511.

3.3.2 Equipment nonoperating.- The Translator shall be capable of withstanding the following environmental conditions in accordance with the levels specified in AGC-20511 and thereafter meet the performance requirements as specified herein.

(a) Sinusoidal and Random Vibrations, Test Level I or II in AGC-20511.

(b) Acceleration (AGC-20511).

(c) Storage temperature (AGC-20511).

3.4 Design and construction.-

3.4.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be selected or prepared in accordance with AGC-STD-2312.

3.4.2 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312. Printed wiring boards shall be in accordance with NASA Publication S-300-P-1.

3.4.3 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.4.4 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.4.5 Interchangeability and replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.4.6 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.4.7 Electromagnetic Interference.- The electromagnetic interference characteristics of the Translator shall comply with the requirements for Class IC or ID equipment as applicable and limits of RE-1, (T)RE04, and RS-1 as specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.4.8 Identification and Marking.- The Translator shall have an identification nameplate attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number.

(b) Manufacturer's name and location.

(c) Code identification.

(d) Contract number.

(e) Unit name, model number, and serial number.

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above. Separate units shall be serialized.

3.4.9 Soldered electrical connections.- Soldering of electrical connections shall be in accordance with NBH 5300.4(3A) except for the following:

(a) Noncontact heat sources shall not be used (paragraph 3A304.4).

(b) Solid solder shall not be used (paragraph 3A309).

(c) Liquid solder flux shall not be used (paragraph 3A310).

(d) Lap joints shall not be used for structural mounting (paragraph 3A505).

(e) Multiple conductor cable shall not be used (paragraph 3A604 and page 6-6).

(f) Chapter 9 is not applicable.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for three years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements. Any deficiencies noted as a result of tests conducted by the procuring activity, shall be corrected.

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall maintain a quality assurance program in accordance with AGC-STD-2311.

4.1.2 Subcontractor's reliability assurance program.- The subcontractor shall implement and maintain a reliability assurance program in accordance with AGC-STD-2312.

4.1.3 Processing changes.- The subcontractor shall make no changes in the Translator design, specifications, materials, or material processes after AGC design approval without prior written approval in accordance with AGC-STD-2312.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration. The tolerance allowed on test conditions and inputs are intended only to provide accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification and Flight Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In-process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model Acceptance Inspection (see 4.6).

4.3 Test plan.- The subcontractor shall prepare a test plan which includes all of the examinations and tests specified in 4.5 and 4.6 such that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance paramter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers' designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process inspection.- In-process examinations and test shall be performed as required to comply with AGC-STD-2311.

4.5 Design Qualification Inspection.- Design Qualification Inspection shall consist of all the tests described in Table I as a minimum. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the unit under ambient conditions and the specified operational environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order.

Table I. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Test Method
Analysis		
Reliability	3.2.1.1	4.7.1
Maintainability	3.2.1.2	4.7.1
Thermal analysis	3.2.3.5	4.7.1
Visual examination and measurements		
Selection of specifications and standards	3.4.1	4.7.1.1
Standard and Commercial parts	3.4.2	4.7.1.1
Moisture and fungus resistance	3.4.3	4.7.1.1
Corrosion of metal parts	3.4.4	4.7.1.1
Interchangeability and replaceability	3.4.5	4.7.1.1
Workmanship	3.4.6	4.7.1.1
Identification and marking	3.4.8	4.7.1.1
Weight	3.2.3.1	4.7.1.1
Center of gravity	3.2.3.3	4.7.1.1
Envelope Dimensions	3.2.3.2	4.7.1.1
Mounting	3.2.3.4	4.7.1.1
Surface Characteristics	3.2.3.5	4.7.1.1
Testing		
(1) Functional Characteristics at minimum and Maximum temperatures	3.3.1(d) & Table III	4.5
(2) Vibration (non-operating)	3.3.2(a) Level I	4.5
(3) Functional characteristics after vibration	Table III	4.5
(4) Acceleration (non-operating)	3.3.2(b)	4.5
(5) Functional characteristics after accel.	Table III	4.5
(6) Functional characteristics during thermal vacuum	3.3.1(c)	4.5
(7) Functional characteristics at maximum hot operating temperature	3.3.1(d) & Table III	4.5

4.6 Flight Model Acceptance Inspection.- A detailed procedure of the Flight Model Acceptance Inspection shall be generated as a part of the overall test plan by the subcontractor and approved by AGC prior to final inspection. The Flight Model Acceptance Inspections shall include the examinations and tests of Table II as a minimum and shall be extensive enough to demonstrate satisfactory workmanship and that the Translator performance is within tolerance. The functional parameters to be verified shall be as specified in Table III and shall be conducted in accordance with 4.7.3.

Table II. Flight Model Acceptance Inspection

Examination or Test	Requirement Paragraph	Test Method
(a) Visual Examination & Measurements		
(1) Weight	3.2.3.1	4.7.1.1
(2) Envelope Dimensions	3.2.3.2	4.7.1.1
(3) Surface Characteristics	3.2.3.5	4.7.1.1
(4) Connector	3.2.3.7	4.7.1.1
(b) Testing		
(1) Functional characteristics at minimum & maximum temperature	3.3.1(d) & Table III	4.6
(2) Vibration (non-operating)	3.3.2(a) Level II	4.6
(3) Functional characteristics after vibration	Table III, Level II	4.6
(4) Functional characteristics during thermal vacuum 1/	3.3.1(c)	4.6
(5) Functional characteristics at maximum temperature	Table III	4.6

1/ The thermal vacuum test shall be conducted at 10^{-5} Torr for 12 hours.

TABLE III FUNCTIONAL TESTING-UP TRANSLATOR

	Requirement Paragraph	Functional During Temperature Test Min	Max	Functional After Vibration Qual. Level I	Flight Level II	Functional After Acceleration	Functional During Thermal Vacuum	Functional Test at Max. Temp.	Function During EMI
Gain	3.1.3	X	X	X	X	X	X	X	
Noise Figure	3.1.4	X	X					X	
L.O. Re-radiation	3.1.5	X	X						
Output	3.1.6	X	X	X	X	X	X		
Spurious Output	3.1.7	X	X	X			X		
Conversion Gain Stability	3.1.8	X	X	X			X		
Gain Variation	3.1.9	X	X	X			X	X	
Stopband Attenuation	3.1.10							X	
Input/Output Freq. Sense	3.1.11	X	X				X	X	
Gain Slope	3.1.12	X	X					X	
Phase Locked Loop									
Pull in Range	3.1.13	X	X				X		
Tracking Rate	3.1.14	X	X				X		
Phase Accuracy	3.1.15	X	X				X		
Phase Linearity	3.1.16	X	X				X	X	
Vestigial Sideband Filter	3.1.17								
Attenuation	↓								
Gain Slope									
Phase Linearity									
Ripple									

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4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the design study report or other written reports, if required. Systems engineering data shall be used where appropriate to support analysis.

4.7.2 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be staisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.3 Functional characteristics.- Specific tests as specified in Table III shall be performed to verify that the requirements of 3.1 are met. Whenever possible, tests shall be made on the Subsystem with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Tests requiring the combined operations of the Subsystems of the LCE shall be described in the Test Plan. Functional tests in accordance with Table III shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.1 which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.1, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.4 Environmental tests.- Environmental tests shall be performed on the translator in accordance with Table I using the methods specified in AGC-20511. Functional parameters as specified in Table III shall be tested in accordance with the detailed test plan.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter (AGC-20518).

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable.

6. NOTES

6.1 Intended use.- The unit described by this specification is to be installed in an ATS-F spacecraft and used with a Laser Communication System.

6.2 Precedence.- In the event of a conflict between the contract and this specification and any applicable documents, the following order of precedence shall apply:

(a) The contract

(b) This specification

(c) Other applicable documents.

6.3 Deviations.- All deviations or exceptions to the requirements of this specification or any document referred to herein shall be referred in writing to AGC, using the Supplier's Discrepancy Action Request (SDAR), AGC Form No. 00-009-030. The disposition of the SDAR must be approved by AGC prior to shipment. Two copies of the approved SDAR shall accompany each affected shipment.

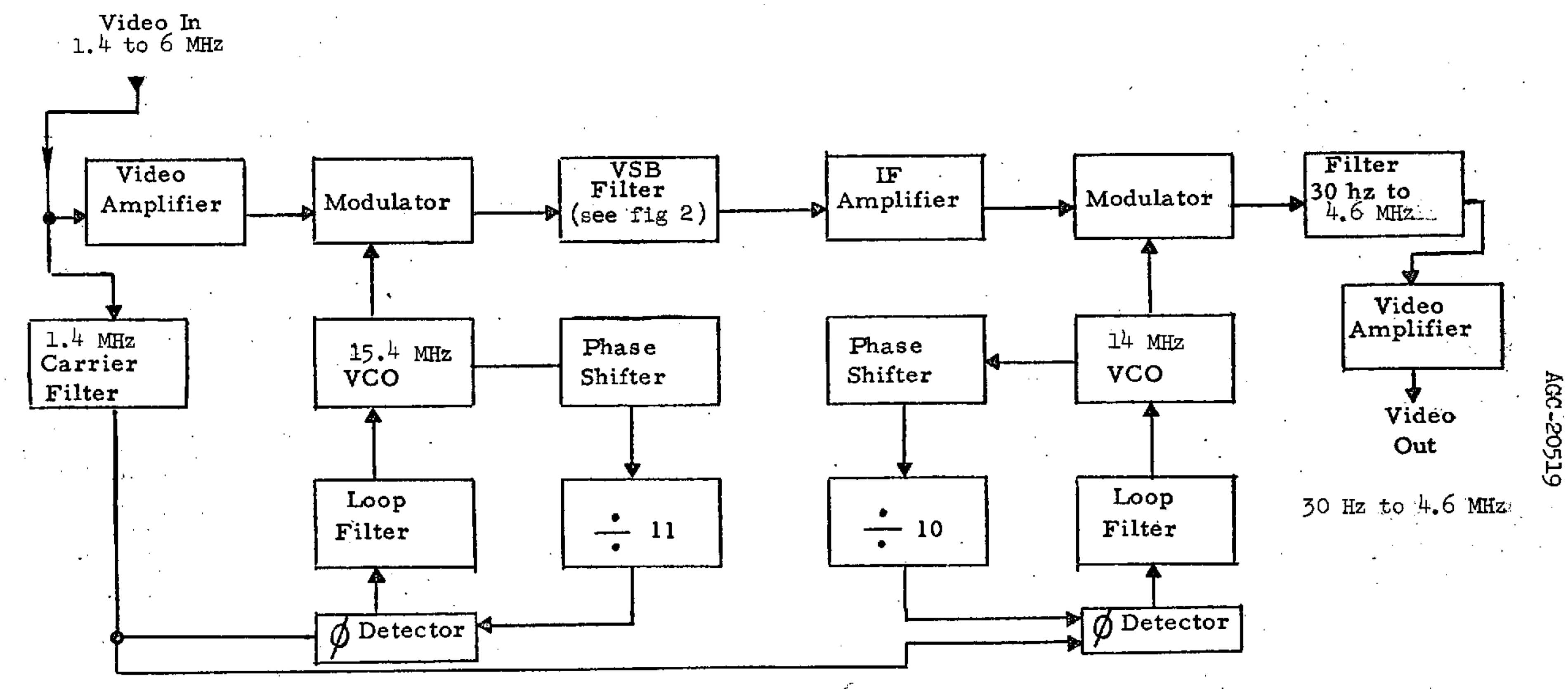


Figure 1. - Down Translation Equipment Block Diagram

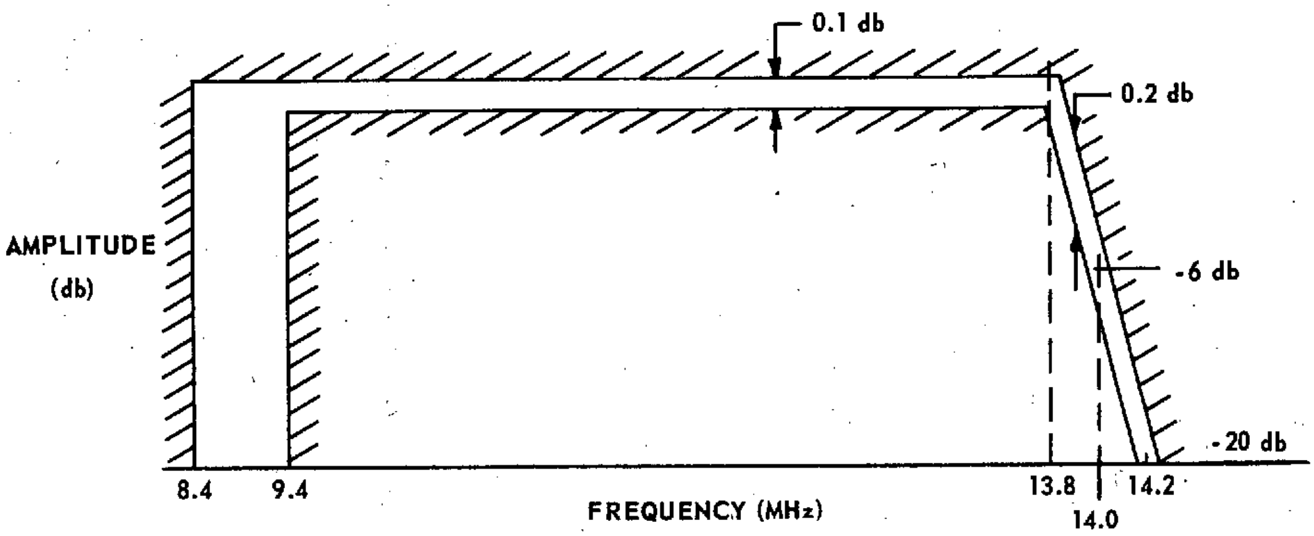
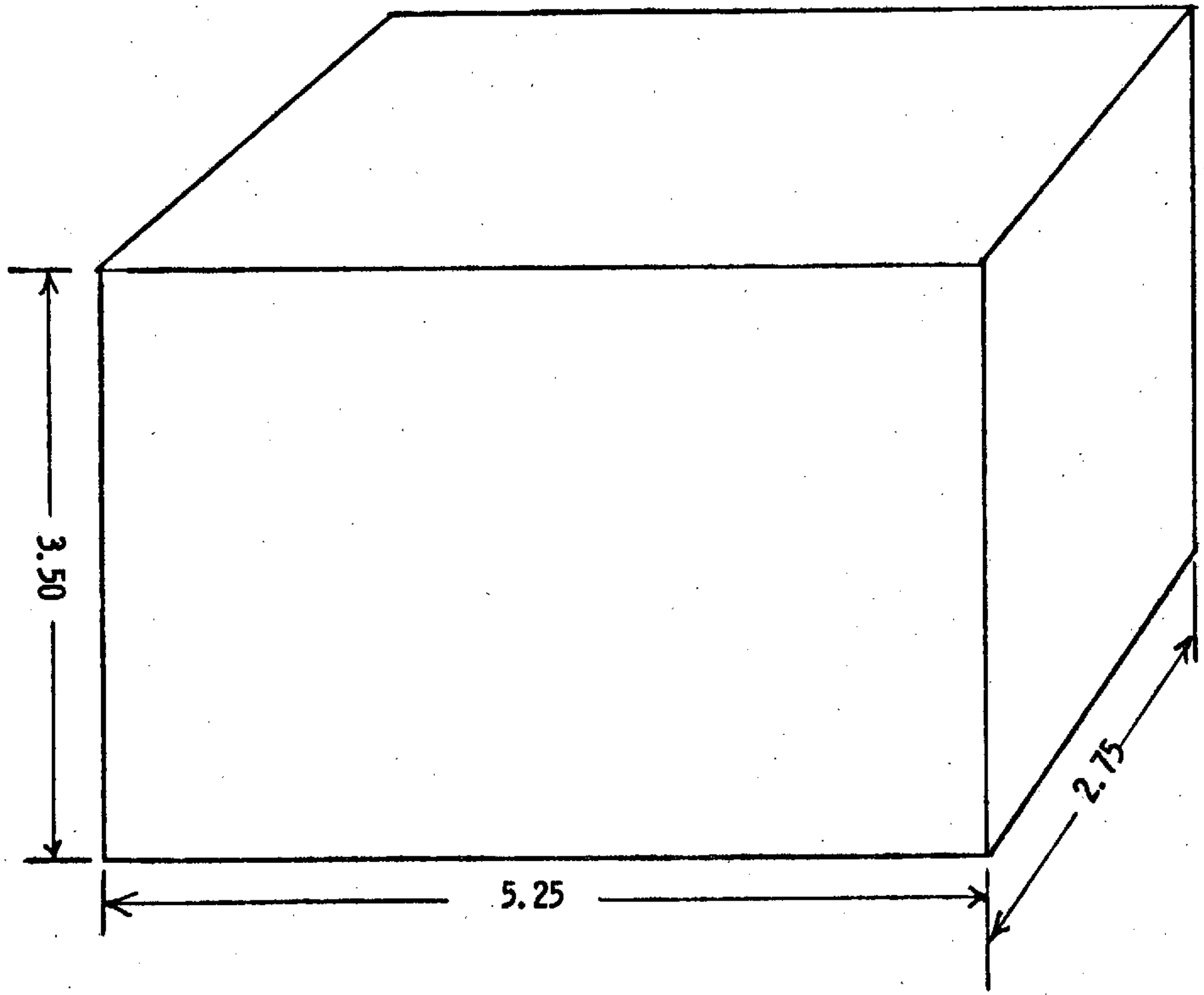


Figure 2. Vestigial Sideband Filter Amplitude Response



NOTE:

All dimensions are in inches.

AGC-20519

Figure 3. Envelope-Translator

To be added at a later date.

Figure 4. Interface Electrical connections

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20519

TITLE

FREQUENCY DOWN TRANSLATOR, 1.4 MHz - 6 MHz / 30 Hz - 4.6 MHz

	DEPT.	EXT.
PREPARED BY T. Aziz	3552	5258
SPEC. ENGINEER J. COFF	7981	6571

APPROVAL SIGNATURE	DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein	3591	R Goldstein
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SYSTEM ENGINEERING - J. V. Cernius	3575	J. V. Cernius
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RELIABILITY - P. W. Stockdill	4072	P W Stockdill
RELEASE ACTIVITY - Pat Hadley	1147	6-29-70

6/23/70 AEROJET-GENERAL CORPORATION

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

AGC-20521

TELEMETRY AND COMMANDS - LCE

SUPERSEDING:			
AGC- DATE	AGC- DATE	AGC- DATE	
RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)			
REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14	PAGE ADDITIONS
	9 July 70		

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough

for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification defines the Telemetry and Command characteristics at LCE interface, and identifies the Laser Communication Experiment System (LCE) monitoring points to be telemetered and the commands required to control the LCE system.

1.2 Application.- The LCE system is intended to be used on an ATS-F spacecraft to establish two-way laser communications.

1.3 Classification.- Telemetry and command signals shall each consist of analog and digital signals, and each type will be covered under separate sections of the specification.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the content of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall be considered a superseding requirement.

SPECIFICATIONS

NASA

S-460-ATS-38 ATS-F and -G Experiment Interface Specification

3. REQUIREMENTS

3.1 Telemetry.-

3.1.1 Telemetry Subsystem Characteristics.- Analog and/or digital data shall be telemetered via a redundant spacecraft PCM telemetry system. Digital information shall be multiplexed and transmitted directly, while analog information shall be first converted to a 9-bit digital word multiplexed with other data, and then transmitted at a bit rate of 400 bps. The sampling intervals shall be approximately * seconds. The error rate shall be less than 10^{-5}. The overall accuracy shall be 0.25 percent of full scale. The system shall comply with the following:

(a) A/D Conversion Accuracy.- The A to D converter shall digitize to a 9-bit accuracy.

(b) Data Storage.- There is no provision for data storage incorporated in the ATS-F and -G telemetry system. Buffering shall be the responsibility of the experimenter. An interrogation pulse shall be supplied by the spacecraft contractor, if required.

(c) TM Transmitter.- The TM transmitter shall utilize phase modulation.

* To be added at a later date.

(d) Deviation.- The maximum deviation shall be * radians. The phase deviation sensitivity shall be * radians per volt.

(e) Bandwidth.- The input bandwidths shall be sufficient to handle 2,000 bits per second. (That is the T/M transmitter circuitry shall not degrade the data bit error rate.)

(f) Impedance.- The transmitter video input shall have an impedance greater than 10 K .

(g) Wideband Data.- The spacecraft transponder shall convert experiment wideband data signals into FM modulated signal by using a voltage controlled oscillator (VCO).

(h) VCO Characteristics.

(1) Bandwidth: The input bandwidth limitation shall be 0.1 Hz to 5 MHz.

(2) Impedance: The input impedance shall be 75 ohms.

(3) Frequency Stability: *

(4) Sensitivity: *

(5) Linearity: The VCO linearity shall be one percent or better. For the ranges from 0.1 Hz to 200 KHz and 200 KHz to 800 KHz, the VCO linearity shall be ten percent or better for the range from 30 Hz to 5 MHz.

(6) Frequency Range and Limitations: The input bandwidth limitation shall be 0.1 Hz to 5 MHz.

(7) Voltage Range and Limitations: The input voltage range shall be zero to one volt peak-to-peak.

(8) Source Impedance Constraints: The source impedance shall be 75 ohms.

(i) Demodulator Characteristics.

(1)	Impedance:	75 ohms
(2)	Voltage:	one volt peak-to-peak
(3)	Linearity:	one percent
(4)	Bandwidth:	30 Hz to 5 MHz

3.1.2 Analog Telemetry Signals.- The analog signals from the LCE to the spacecraft telemetry interface shall have the following characteristics:

* To be added at a later date.

(a) DC Signals

(1)	Voltage amplitude:	0 to 5 Volts
(2)	Source impedance:	less than 1.0 K ohm
(3)	Accuracy:	As specified

(b) AC Signals (Wideband data).

(1)	Voltage amplitude:	zero to one volt peak-to-peak
(2)	Source impedance:	75 ohm unbalanced
(3)	Frequency:	0.1 Hz-to-5MHz
(4)	Linearity:	Reference 3.1.1 (e) (Wideband data)

3.1.2.1 Interface Circuits.- The interface circuits to be used between the LCE system and the spacecraft telemetry subsystem for the analog telemetry signals are shown in Figure 1.

3.1.3 Digital Telemetry Signals.- The digital telemetry signals from the LCE to the space craft interface shall have the following digital inputs:

(a) Voltage Limits.

(1)	Logic zero:	-2.0 volts to ±1.0 volt
(2)	Logic one:	+5.0 volts to ±8.0 volts

(b) Source Impedance: less than 10 K ohms

3.1.3.1 Interface Circuits.- The interface circuits to be used between the LCE system and the spacecraft telemetry system for the digital telemetry signals are shown in Figure 2.

3.1.4 LCE System Telemetry Signals.- The LCE system shall provide telemetry output signals for the purpose of monitoring the performance and status of the experiment. Analog and digital telemetry signals will be utilized in meeting these requirements and shall have the characteristics specified in 3.1.2 for analog signals and 3.1.3 for digital signals.

3.1.4.1 Analog functions.- The following LCE analog telemetry functions shall be made available at the spacecraft telemetry interface:

3.1.4.1.1 Power Supply Subsystem.-

	Function	Level	Accuracy[1]	Bandwidth
(a)	Transmitter Laser current	0 to 5 V	± 2%	1 Hz
(b)	Transmitter Laser voltage	0 to 5 V	± 5%	"
(c)	Local oscillator Laser current	0 to 5 V	± 2%	"
(d)	Local oscillator Laser voltage	0 to 5 V	± 5%	"
(e)	Backup Laser current	0 to 5 V	± 2%	"
(f)	Backup Laser voltage	0 to 5 V	± 5%	"

3.1.4.1.2 Optical/Mechanical Subsystem.-

	Function	Level	Accuracy	Bandwidth
(a)	Transmitter Laser power output	0 to 5 V	± 2%	0.1 Hz
(b)	Local oscillator Laser power output	0 to 5 V	± 2%	"
(c)	Back-up Laser power output(A)[2]	0 to 5 V	± 2%	"
(d)	Back-up Laser power output(B)[3]	0 to 5 V	± 2%	"
(e)	LCE baseplate temperature	0 to 5 V	± 2%	"
(f)	Radiation cooler temperature	0 to 5 V	± 2%	"
(g)	Sun shield temperature	0 to 5 V	± 2%	"

3.1.4.1.3 LCE Subsystem.-

	Function	Level	Accuracy	Bandwidth
(a)	Local oscillator Laser tuner voltage:	0 to 5 V	± 2%	10 Hz
(b)	Transmitter Laser tuner voltage	0 to 5 V	± 2%	10 Hz
(c)	Backup Laser tuner voltage	0 to 5 V	± 2%	10 Hz
(d)	Modulator current	0 to 5 V	± 2%	0.1 Hz
(e)	Modulator oven temperatures	0 to 5 V	± 2%	0.1 Hz

3.1.4.1.4 Receiver Subsystem.-

	Function	Level	Accuracy	Bandwidth
(a)	Receiver AGC voltage	0 to 5 V	± 1%	10 Hz
(b)	Mixer bias current[4]	0 to 5 V	± 2%	0.1 Hz
(c)	AFC Error output	0 to 5V	± 2%	10 K Hz

1. Accuracy applies from 25% of full scale to 75% of full scale.
2. Back-up Laser in L.O. mode (P 16 line)
3. Back-up Laser in XMTR mode (P 20 line)
4. Accuracy applies from 10% of full scale to 50% of full scale.

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3.1.4.1.5 Acquisition and Tracking Subsystem.-

	Function	Level	Accuracy[1]	Bandwidth
(a)	Coarse pointing mirror-position (North-South)	0 to 5 V	±1%	2 Hz
(b)	Coarse pointing mirror-position (East-West)	0 to 5 V	↑	2 Hz
(c)	Image motion compensation position (North-South)	0 to 5 V		5 Hz
(d)	Image motion compensator position (East-West)	0 to 5 V		5 Hz
(e)	Acquisition threshold voltage	0 to 5 V		0.1 Hz
(f)	Acquisition confirm threshold voltage	0 to 5 V		0.1 Hz
(g)	Nutator bias voltage, (North-South)	0 to 5 V		0.1 Hz
(h)	Nutation bias voltage, (East-West)	0 to 5 V	↓	0.1 Hz

3.1.4.1.6 Spares.-

(a) *

(b) *

(c) *

3.1.4.2 Digital functions.- The following LCE digital functions shall be made available at the spacecraft telemetry interface.

3.1.4.2.1 Acquisition and Tracking Subsystem.-

	Function	Bits	Bit Rate
(a)	Coarse pointing mirror position (East-West)	12	128 bps
(b)	Coarse pointing mirror position (North-South)	10	128 bps

Note: These digital signal outputs (22 total) shall be in parallel.

1. Accuracy applies from 25% of full scale to 75% of full scale.

* To be added at a later date.

3.2. Commands.-

3.2.1 Command Subsystem General Characteristics.- The command system shall provide the capability of sending discrete (relay) or digital word commands. The system capacity shall be 512 discrete and __*__ magnitude commands. A maximum command rate of 2 commands per second shall be available, and ground verification capability via telemetry shall be provided.

3.2.2 Discrete Command Signal Characteristics.- The discrete command signals at the interface between the spacecraft and LCE shall have the following discrete commands:

(a) Voltage Level:

(1) Logic zero: $0.0\ V \pm 0.5\ V$

(2) Logic one: $+5.0\ V \pm 0.5\ V$

(b) Source Impedance: *

(c) Source Capacitance: *

(d) Pulse duration: 50 ± 10 milliseconds

(1) Rise time (10 to 90% points): * millisec max.

(2) Fall time (90 to 10% points): * millisec max.

3.2.2.1 Interface Circuit.- The interface circuit to be used between the LCE system and the spacecraft command control subsystem for the discrete command signals are shown in Figure 3.

3.2.3 Digital word command signals.- The digital word commands between the LCE system and the spacecraft command subsystem shall have the following digital word commands:

(a) Voltage level

(1) Logic zero: $0.0 \pm 0.5\ V$

(2) Logic one: $+5.0 \pm 0.5\ V$

(b) Word length: Nine(serial) bits on a data line

(c) Bit rate: 128 bits per second (bps)

* To be added at a later date

3.2.3.1 Interface Circuits.- The interface circuits to be used between the LCE system and the spacecraft command control subsystem for the digital commands are shown in Figure 4.

3.2.3.2 Enable Signal.- An address line will be provided which identifies to the user that his command is to be transmitted. The signal characteristics at the interface are as follows:

(a)	Enable "OFF":	0.0 ± 0.5 V
(b)	Enable "ON":	+5.0 ± 0.5 V

3.2.3.3 Clock Signal.- A 128 bps clock signal will be provided for shifting the data into the users register. The signal characteristics at the interface are as follows:

(a)	Logic Zero:	0.0 ± 0.5 V
(b)	Logic One:	+5.0 ± 0.5 V

3.2.3.4 Execute Signal.- An execute signal will be provided for the purpose of ground verification prior to execution of the command. The characteristics of this signal are identical to those of the discrete command signal.

3.2.4 Timing/Synchronizing Signals.- Timing and synchronizing signals shall be supplied from the TM clock to the LCE system as required. The signal characteristics are as follows:

(a)	Logic zero voltage level:	*
(b)	Logic one voltage level:	*
(c)	Source impedance:	*
(d)	Pulse duration:	*
(e)	Rise time (10 to 90% points):	*
(f)	Fall time (90 to 10% points):	*

3.2.5 LCE Command Functions.- The command functions assigned to the LCE systems for controlling all LCE operational modes shall be in accordance with 3.2.5.1 and 3.2.5.2.

* To be added at a later date

3.2.5.1 Discrete Commands.- The following discrete commands have been assigned for LCE system operating control:

(a) Power Supply Subsystem.-

	Command	Function
(1)	Transmitter Laser High voltage No. 1	On
(2)	Transmitter Laser High voltage No. 1	OFF
(3)	Transmitter Laser High voltage No. 2	On
(4)	Transmitter Laser High voltage No. 2	OFF
(5)	Transmitter Laser High voltage Nos. 1 & 2	Adjust current
(6)	Local oscillator Laser High voltage No. 1	On
(7)	Local oscillator Laser High voltage No. 1	Off
(8)	Local oscillator Laser High voltage No. 2	On
(9)	Local oscillator Laser High voltage No. 2	Off
(10)	Local oscillator Laser High voltage Nos. 1 & 2	Adjust current
(11)	Backup Laser High voltage No. 1	On
(12)	Backup Laser High voltage No. 1	Off
(13)	Backup Laser High voltage No. 2	On
(14)	Backup Laser High voltage No. 2	Off
(15)	Backup Laser High voltage Nos. 1 & 2	Adjust current
(16)	Low voltage converter	On
(17)	Low voltage converter	Off

(b) LCE Subsystem.-

(1)	Backup Laser line (P-16) select	Select
(2)	Backup Laser line center offset (P-16)	Offset
(3)	Backup Laser line (P-20) select	Select
(4)	Backup Laser line center offset (P-20)	Offset
(5)	Modulator, video input Nos. 1 & 2	Select

(c) Acquisition and Tracking Subsystem.-

	Function
(1) Nutator Bias Adjust (Beam Alignment)	
a. Command, North-South axis (one pulse)	Counter reset
b. Command, North-South axis (series of pulses)	Counter input
c. Command, North-South axis (one pulse)	Execute
d. Command, East-West axis (one pulse)	Counter reset
e. Command, East-West axis (series of pulses)	Counter input
f. Command, East-West axis (one pulse)	Execute
(2) Acquisition threshold	
a. Command (one pulse)	Counter reset
b. Command (series of pulses)	Counter input
c. Command (one pulse)	Execute
(3) Acquisition Confirm Threshold	
a. Command (one pulse)	Counter reset
b. Command (series of pulses)	Counter input
c. Command (one pulse)	Execute
(4) Acquisition Control	
a. Initiate search	Initiate
b. Inhibit search	Inhibit
c. Center IMC	Initiate
d. Initiate normal tracking	Initiate
(5) Spare discrete commands	
a. *	
b. *	
c. *	
d. *	

* To be added at a later date

(d) Optical/Mechanical.-

		Function
(1)	Acquisition/operate flip mirror	Mirror in
(2)	Acquisition/operate flip mirror	Mirror out
(3)	Transmitter/backup Laser to mixer flip mirror (self check)	Mirror in
(4)	Transmitter/backup Laser to mixer flip mirror (self check)	Mirror out

3.2.5.2 Digital Commands.- The following digital commands have been assigned for control of the coarse pointing mirror position of the LCE system:

(a)	East-West axis positioning	12 bits (serial)
(b)	North-South axis positioning	10 bits (serial)

4. QUALITY ASSURANCE PROVISIONS

4.1 Subcontractor responsibility.- The subcontractor is responsible for design, design analysis, and testing of LCE components and subsystems to demonstrate compliance with the requirements herein, except as otherwise specified in the component specification or purchase contract.

4.2 Testing.- Testing of components to assure compliance with the thermal and structural requirements specified herein shall be performed in accordance with the applicable component specification.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be in accordance with the applicable component specification.

6. NOTES

6.1 Intended use.- The thermal and structural parameters specified herein are intended for use in the design and construction of components for the Laser Communication Experiment.

To be added later

LCE Telemetry Interface
Analog Circuit

To be added later

Spacecraft Telemetry Subsystem Interface
Analog Circuit

Figure 1

To be added later

LCE Telemetry Interface
Digital Circuit

To be added later

Spacecraft Telemetry Subsystem Interface
Digital Circuit

Figure 2

To be added later

LCE Discrete Command Interface Circuit

To be added later

Spacecraft Command Control Interface Circuits

Figure 3

To be added later

LCE Digital Command Interface
Circuit

To be added later

Spacecraft Digital Command Control Interface
Circuit

Figure 4

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20521

TITLE

TELEMETRY AND COMMANDS - LCE

	DEPT.	EXT.
PREPARED BY		
SPEC. ENGINEER J. M. McDonough	7981	5311

APPROVAL SIGNATURE		DEPT.	DATE
LCE PROGRAM MANAGER - Dr. R. Goldstein	R Goldstein	3591	7-8-70
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RELEASE ACTIVITY	C R Cantrell	1147	7-9-70

7/6/70

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CODE IDENT. NO. 70143

SPECIFICATION AGC-20522

THERMAL AND STRUCTURAL REQUIREMENTS, LCE

SUPERSEDING:		
AGC- DATE	AGC- DATE	AGC- DATE

RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)

REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	PAGE ADDITIONS
	10 Jul 70		

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough

for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification covers the thermal and structural requirements for the design of equipment for the Laser Communication Experiment (LCE) Spacecraft.

1.2 Application.- The thermal and structural requirements referred to herein are applicable to the following subsystems and components of the LCE which will be used to establish simultaneous two-way communications between the ATS-F spacecraft and a transportable ground station:

	LCE Subsystem or Component	AGC Specification
(a)	10.6 Micron Laser Subsystem	AGC-20187
(b)	10.6 Micron Optical Heterodyne Receiver Subsystem	AGC-20186
(c)	Power Supply Subsystem	AGC-20515
(d)	Optical-Mechanical Subsystem	AGC-20520
(e)	Passive Radiator and Sun Shield	AGC-20525
(f)	Acquisition and Tracking Subsystem	AGC-20523

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced here and the content of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall be considered a superseding requirement.

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List

Aerojet-General Corporation

AGC-20186	Receiver Subsystem, Optical Heterodyne, 10.6 Micron
AGC-20187	Laser Subsystem, 10.6 Micron
AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components
AGC-20520	Optical/Mechanical Subsystem, Laser Communication Experiment
AGC-20521	Telemetry and Command, LCE

AGC-20525	Radiator, Sun Shield Receiver Mixer
AGC-20515	Power Supply Subsystem, LCE
AGC-20523	Acquisition and Tracking Subsystem, LCE

STANDARDS

Military

MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of government specifications, standards, drawings, bulletins, and publications required in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Spacecraft description.- The ATS-F spacecraft provides an environmentally controlled structure for the GFE experiments and consists of an earth-viewing module (EVM), a 30-foot parabolic reflector and a solar array assembly as shown in Figure 1. The EVM of the ATS-F spacecraft is a structure consisting of three sections. The center section contains a majority of the basic housekeeping equipment provided as part of the Attitude Control System and Telemetry and Command System. The section on top of the EVM (toward the reflector) contains equipment associated with the communications system. The remaining four experiments require earth-view and therefore have been located in the lower section of the EVM. The LCE will be located in the lower square section of the EVM along the north wall and against the north-west corner (see Figure 1).

3.1.1 Spacecraft temperature control.- The temperature control subsystem for the EVM is semi-passive utilizing louvers, insulation, coatings and heat pipes. North to south facing panels are used as heat rejection surfaces although electronic equipment can be located in any compartment around the periphery of the EVM. Heat pipes are used to distribute the heat within the module and minimize structural thermal gradients.

3.2 Spacecraft design constraints.- Major spacecraft restraints which must be considered as design constraints for the experiment subsystems are the following:

3.2.1 Operating restraints.- The experiment must be capable of operating in a 1 G field (any axis).

3.2.2 Minimum natural frequency.- The minimum natural frequency of all items and their supporting brackets shall be 100 Hz to avoid coupling with the spacecraft structure.

3.2.3 Sensor and equipment installations.- Sensor and payload equipment installations must have capability for static and dynamic loading in all directions. Adquate load paths must be provided for shear and axial forces and bending and torsional moments. Yeild and ultimate strengths must not be exceeded.

3.2.4 Non-redundant mounting.- Mounting arrangements must be non-redundant (statically determinant) to avoid overstressing or distorting sensors during installation.

3.2.5 Preloading.- Components are preloaded to provide good thermal contact. This preload will be __*__. Each module must be capable of sustaining this preload.

3.2.6 Sensor field-of-view provisions.- The position of all viewing and reception sensors shall be specified relative to the module to which they are physically attached. The desired viewing or reception center axis shall be specified with respect to the spacecraft coordinate system. The required field of view shall be specified by angular designation relative to the center axis.

3.2.7 Materials.- Materials used in the fabrication of the experiment shall be nonmagnetic to the extent possible. Materials shall meet the following requirements for weight loss and volatile condensable material (VCM) for the specified life of the experiment:

Weight loss:	1% maximum
VCM:	0.1% maximum

Material strengths and other physical properties shall be consistent with the ATS environment and the design environment in which the material is utilized.

3.2.8 Compatibility with spacecraft structural material.- All materials must be compatible with the aluminum and magnesium spacecraft structure to inhibit electrolytic action. Any other conducting material used by the experimenter or the subcontractcr shall be approved by the project manager.

3.2.9 Environmental considerations.- All material applications must be considered on the basis of expected environments, as well as on structural and electrical needs.

3.2.10 Finishes.- The surface finish of component mounting surfaces (underside of tabs and flanges) shall be 32 microinches, rms, or better. Module materials shall be coated or surface treated as follows:

* To be added at a later date.

(a) Aluminum - Alodine 600 or Iridite 14-2

(b) Magnesium - Dow 23

(c) Steel - Electroless Nickel

3.2.11 Sensor alignment.- The experiment sensors which must be aligned, or whose alignment relative to the spacecraft axes must be defined, shall incorporate alignment surfaces or indices.

3.2.12 Alignment pads.- Alignment pads must be located on rigid elements of the component structure.

3.2.13 Component alignment.- The spacecraft contractor will align or measure between the component alignment index and the spacecraft axes only. The relationship between the index surface and the component is the responsibility of the experimenter.

3.2.14 Alignment surfaces.- Alignment surfaces need not be continuous, but must define a plane parallel or perpendicular to the component mounting face. The required geometric properties for alignment surfaces or indices are dependent on alignment tolerances given in Table I.

Table I

Component Alignment Limits	Surface Finish (microinches)	Pad Flatness	Max Surface Slope	Pad Size or Span (Min.)
$\pm 0.5^{\circ}$	125 rms	0.001 in.	0.005 in/ft	1.0 in.
$\pm 0.1^{\circ}$	32 rms	0.0005 in.	0.0004 in/ft	1.0 in.

3.2.15 Axes alignment.- For items requiring alignment with respect to all three axes, two mutually perpendicular alignment surfaces, must be provided. For alignment with respect to two axes, one alignment surface will suffice.

3.2.16 Orientation marking and axis identification.- Any required orientation of a module must be clearly marked on that module and on the mechanical interface drawing. As a minimum, the outboard directions must be indicated.

3.2.17 Adjustment.- Preferably, provision for adjustment of component alignment must be internal to the component. If, however, the adjustment must be made at the spacecraft/component interface, a three point system is preferable as it allows for shimming to adjust the alignment plane. Rotational adjustment is to be provided using one tight tolerance controlled hole with two other holes with suitable clearances which will then be located by a final pinning operation using dowels adjacent to the holes.

3.2.18 Mass properties.- Mass property information shall include weight, center of gravity with reference to three defined surface planes, and principle axes with three moments of inertia about these axes. Mass properties information shall be updated and reported to the project office periodically.

3.3 Thermal subsystem performance.- The thermal subsystem shall be designed to control the operating temperature of assemblies, subassemblies, and components of the LCE under any combination of environments as specified in AGC-20511 during handling, storage, transportation, ground test, launch, parking orbit, transfer ellipse, and the orbiting phase of the mission. Thermal control of the LCE shall be designed such that thermal outputs of the individual experiment subsystems shall not degrade the performance of adjacent subsystems, and performance degradation of subsystems shall not occur due to any environmental conditions specified in AGC-20511. To the maximum extent possible, thermal control of the LCE and its subsystems shall be accomplished by passive means with the use of active compensation techniques only as required.

3.3.1 Contamination

3.3.1.1 Use.- Degradation of thermal control and/or optical surfaces by deposition of foreign particles or contaminants originating from either the ATS spacecraft, the launch vehicle or other experiments shall be no greater then 0.01 in total hemispherical emittance, solar absorption, or specularity of mirrors (front and back surface) and sunshade coatings.

3.3.1.2 Storage and handling.- During handling, storage, transportation, and laboratory usage the LCE and its subsystems shall be protected from dirt, moisture, excessive temperatures, etc. through the use of suitably conditioned air and/or hermetically sealed containers. The allowable storage and transportation temperature range shall be $-30^{\circ}C$ to $+60^{\circ}C$. Degradation of thermal control and/or optical surfaces by deposition of foreign particles or contaminants originating from storage and handling shall be no greater than that specified in 3.3.1.1.

3.3.2 Passive radiator.- The LCE passive radiator shall be designed to keep the temperature of the receiver mixer within the temperature range of $110 \pm 15^{\circ}K$ ($-163 \pm 15^{\circ}C$) through the entire first two-year period of on-station operation. During normal on-station operation, the temperature of the receiver mixer will oscillate by no more than $\pm 10^{\circ}K$ about the nominal temperature. The receiver mixer coax cable, shall be at least 12 inches in length and may contribute up to 20 milliwatts of heat.

3.3.2.1 Steady-state temperatures during sun exposure.- The passive radiator shall be designed such that sunlight can impinge normally on the radiator for a period of time sufficient to achieve steady-state temperatures. During this time, the maximum temperature of the radiator shall not cause damage to the receiver mixer.

3.3.2.2 Passive radiator shield.- The maximum shield temperature shall be below $275^{\circ}K$ ($+2^{\circ}C$) as a design goal. Internal surfaces of the sunshades shall have a low emittance (ϵ), low solar absorption (α_s), and specularity of at least 95%.

3.3.3 Laser tubes.- The temperature of the three laser tubes within the LCE shall be controlled to 25 ± 15°C during normal operation of the LCE in-orbit.

3.3.4 Optical/Mechanical subsystem.- The optical/mechanical subsystem shall be designed so that the thermal environment is controlled within operating ranges specified below. The optical schematic in Figure 2 shows the various elements discussed herein.

3.3.4.1 Coarse beam pointing mechanism.- The coarse beam pointing mechanism shall be designed to comply with the following thermal requirements:

(a) Coarse beam pointing mirror.- The coarse beam pointing mirror shall be capable of operating within a temperature range of -40°C to +85°C. The radial or circumferential temperature difference between any two points on the mirror shall not exceed 5°C. The temperature differential (ΔT) from the front to back faces of the mirror shall not exceed 5°C.

(b) North-South gimbal.- The north-south gimbal shall be capable of operating within a temperature range of -40°C to +85°C. The ΔT between N-S and E-W gimbals shall be less then 40°C. The ΔT between the two N-S gimbals shall be less than 5°C.

(c) East-West gimbal.- The east-west gimbal shall be capable of operating within a temperature range of -40°C to +85°C.

(d) Gear head drive motors (2).- The gear head drive motors shall be capable of operating within a temperature range of -40°C to +85°C. The non-operating survival temperature range shall be -65°C to +100°C.

(e) Shaft position encoders (2).- The shaft position encoders shall be capable of operating within a temperature range of -40°C to +65°C. The non-operating survival temperature range shall be -65°C to +100°C. The maximum power dissipation shall be less than 50 mw.

3.3.4.2 Telescope.- The telescope shall be constructed to facilitate thermal equalization of all components and to maintain focus and alignment. The thermal design shall maintain the thermal environment of the telescope so as to preserve the resolution requirements, the sensitivity requirements, and the alignment requirements of the telescope as specified in AGC-20520. The telscope shall be designed to comply with the following thermal requirements:

(a) Primary mirror.- The primary mirror shall be capable of operating within a temperature range of -20°C to +60°C. The maximum radial or circumferential temperature difference between any two points on the mirror shall not exceed 5°C. The ΔT between the front and back surfaces of the mirror shall not exceed 5°C.

(b) Secondary mirror.- The secondary mirror shall be capable of operating within a temperature range of -25°C to +65°C. The radial or circumferential temperature difference between any two points on the mirror shall not exceed 5°C. The ΔT between the front and back surfaces of the mirror shall not exceed 5°C.

(c) Spider or secondary mirror support.- The secondary mirror support shall be capable of maintaining its required function with a temperature range of -25°C to +65°C. The temperature difference between the primary and secondary mirrors shall not exceed 6°C along the spider legs.

(d) Deflection mirror mount.- The deflection mirror mount shall be capable of performing its function within a temperature range of -40°C to +65°C. The temperature difference from mirror to mounting surface shall not exceed 5°C.

3.3.4.3 Optical filter (germanium).- The optical filter shall be capable of operating within a temperature range of -5°C to +55°C. The radial or circumferential temperature difference between any two points on the filter shall not exceed 2°C. The ΔT from the front to back faces of the filter shall not exceed 1°C.

3.3.4.4 Beam splitter (duplexer/wire grid polarizer).- The beam splitter shall be capable of operating within a temperature range of -5°C to +55°C. The radial or circumferential temperature difference between any two points on the beam splitter shall not exeed 5°C. The ΔT from the front to back faces of the beam splitter shall not exceed 1°C.

3.3.4.5 Beam expander.- The beam expander shall be capable of operating within a temperature range of -5°C to +55°C. The ΔT circumferentially or radially between any two points on the optics shall not exceed 3°C. The ΔT between faces of the optics element shall not exceed 1°C.

3.3.4.6 Beam motion compensator (nutator).- The nutator shall be capable of operating within a temperature range of -5°C to +55°C. The heat dissipation shall not exceed 25 milliwatts.

3.3.4.7 Transmitter deflection mirror.- The transmitter deflection mirror shall be capable of operating within a temperature range of -5°C to +55°C. The temperature differences across the face of the mirror shall be less than 0.5°C.

3.3.4.8 L.O. deflection mirrors.- The L.O. deflection mirrors shall be capable of operating within a temperature range of -5°C to +55°C. The temperature differences across the face of the mirrors shall be less than 0.5°C.

3.3.4.9 80/20 beam splitter.- The 80/20 beam splitter shall be capable of operating with a temperature range of -5°C to +55°C.

3.3.4.10 Backup laser mirrors.- The backup laser mirrors shall be designed to comply with the following thermal requirements:

(a) Flip mirrors.- The flip mirrors shall be capable of operating within a temperature range of -5°C to +55°C. The temperature differences across the mirror face shall be less then 0.5°C.

(b) Flip mirror motors (2).- The flip mirror motors shall be capable of operating within a temperature range of -5°C to +55°C. The maximum heat dissipation shall be less than 0.75 watts.

(c) Deflection mirrors.- The deflection mirrors shall be capable of operating within a temperature range of $-5^{\circ}C$ to $+55^{\circ}C$. The temperature differences across the mirror face shall be less than $0.5^{\circ}C$.

3.3.5 Laser subsystem.-

3.3.5.1 Transmitter laser assembly.- The transmitter laser assembly and its subcomponents shall be capable of operating in a temperature range of -5 to $+55^{\circ}C$ and meeting the following thermal requirements:

(a) Deflection mirrors.- The ΔT across the mirror face shall be less than $0.5^{\circ}C$.

(b) Diffraction grating (Quartz).- The ΔT across the face of the grating shall be less than $2^{\circ}C$. The heat absorbed shall be less than 1 mw. The ΔT between the front and back faces of the grating shall be less than $1^{\circ}C$.

(c) Power meter assembly.-

(1) Power meter window.- The radial or circumferential ΔT shall not exceed $2^{\circ}C$. The ΔT from the front to back face shall not exceed $1^{\circ}C$.

(2) Power meter optics.- The radial or circumferential ΔT shall not exceed $2^{\circ}C$. The ΔT from the front to back face shall not exceed $1^{\circ}C$.

(3) Power meter.- The maximum heat absorbed by the power meter shall not exceed 1 mw.

(d) End cavity mirrors and piezoelectric crystal.- The temperature difference, within the mounting base, between the two end cavity mirrors shall not exceed $4^{\circ}C$. The heat absorbed in the piezoelectric crystal shall not exceed 200 mw. The radial or circumferential ΔT in the end cavity mirrors shall not exceed $2^{\circ}C$.

3.3.5.2 Local oscillator laser assembly.- The local oscillator laser assembly and its subcomponents shall be designed to operate in a temperature range of -5 to $+55^{\circ}C$ and to comply with the following thermal requirements:

(a) Power meter assembly.-

(1) Power meter window.- The radial or circumferential ΔT shall not exceed $2^{\circ}C$. The ΔT between faces shall not exceed $1^{\circ}C$.

(2) Power meter optics.- The radial or circumferential ΔT shall not exceed $2^{\circ}C$. The ΔT between front and back faces of an optical element shall not exceed $1^{\circ}C$.

(3) Power meter.- The maximum heat absorbed by the power meter shall not exceed 1 mw.

(b) End cavity mirrors and piezoelectric crystal.- The maximum temperature difference, within the mounting base, between the two end cavity mirrors shall not exceed 2°C.

3.3.5.3 Backup laser assembly (can be used as either transmitting laser or L.O.).- When operating as an L.O., the thermal conditions will be identical to the Local Oscillator Laser Assembly. When operating as a Transmitter, the following thermal conditions shall apply:

(a) Deflection mirrors.- Temperature difference across the face of the mirrors shall be less than .5°C.

(b) Diffraction grating.- The heat absorbed shall not exceed 1 mw. The ΔT across the face of the grating shall not exceed 2°C. The ΔT across the face of the grating shall not exceed 2°C. The ΔT between the front and back faces of the grating shall not exceed 1°C.

(c) Power meter assembly.-

(1) Power meter window.- The radial or circumferential ΔT shall not exceed 2°C. The ΔT between faces shall not exceed 1°C.

(2) Power meter optics.- The radial or circumferential ΔT shall not exceed 2°C. The ΔT from the front to back face shall not exceed 1°C.

(3) Power meter.- The maximum heat absorbed shall not exceed 1 mw.

(d) End cavity mirrors and piezoelectric crystal.- Temperature difference within the mounting base, between the two end cavity mirrors shall not exceed 2°C. The heat absorbed in the mirrors shall not exceed 160 mw. The heat absorbed in the piezoelectric crystal shall not exceed 180 mw. The radial or circumferential ΔT in the end cavity mirrors shall not exceed 2°C.

3.3.6 Receiver Mixer subsystem.- The receiver mixer subsystem shall be designed to meet the following thermal requirements:

3.3.6.1 Imaging optics.- The operating temperature range shall be -5°C to +55°C. The radial or circumferential temperature difference between any two points in the imaging optics shall not exceed 1°C. Emittance of exposed surfaces of the optics holder shall be 0.70 minimum.

3.3.6.2 Mixer assembly.- The operating temperature range shall be 90°K to 130°K (-183 to -143°C). The maximum bias and L.O. heat load shall not exceed 9 mw. The detector housing heat load resulting from IR radiation from the optics and conduction up the detector leads shall not exceed 20 mw. Emittance of the external surfaces of the detector cover shall not exceed 0.1.

3.3.6.3 Receiver electronics.- Heat dissipation shall not exceed 2.0 w. The mounting surface temperature range for the electronics package shall be -5°C to +55°C. Enclosure cover emittance shall be 0.70 or greater. The ΔT from the mounting surface to the electronic package shall not exceed 5°C. The contact conductance at the mount surface shall be at least 0.3 Btu/hr-°F-bolt.

3.3.7 Electronics subsystem.-

3.3.7.1 General requirements.- The electronics subsystem shall be designed to meet the following general requirements:

(a) Maximum temperature difference between any electronics box and its mounting surface shall be 6°C.

(b) Boxes shall be capable of radiating 30% of the internal power dissipation to the environment ($\epsilon = 0.6$ assumed).

(c) The operating temperature range for resistors, capacitors and other components shall be -5°C to +60°C.

(d) The operating temperature range for IC's, diodes, and transistors (junction temperatures) shall be -5°C to +85°C.

(e) The non-operating or storage temperature range shall be -65°C to +71°C.

(f) Power dissipating electronic components shall be distributed on a thermally conductive mounting surface to achieve as uniform a power density as possible, with high power dissipators as close to the enclosure mounting points as possible.

3.3.7.2 Electronics package.- The electronics package of the electronics subsystem shall comply with the following requirements:

(a) Laser electronics.- The heat dissipated shall be less than 4.0 w.

(b) Transmitter laser modulator driver.- The heat dissipated shall be less than 5.0 w.

(c) Baseband distribution electronics.- The heat dissipated shall be less than 0.5 w.

(d) Acquisition and Tracking electronics.- The heat dissipated shall be less than 2.25 w for continuous operation. Short duration operation ($\leq$ 100 seconds) shall dissipate no more than 6.0 w.

(e) Telemetry and command electronics.- The heat dissipated shall be less than 2.0 w.

(f) High and low voltage power supplies.- The maximum heat dissipated shall be less than 6.6 w (for Backup Laser operating as L.O.).

3.4 Structure and Housing.- The main structure of the LCE shall be the baseplate/heat sink structure (LCE baseplate). The LCE baseplate shall form the structural and thermal interface between the spacecraft and the experiment, as shown in Figure 3, and shall be in direct physical contact with the spacecraft heat sink. The LCE baseplate shall support all assemblies, components, housings and hardware listed in Table II which comprises the LCE.

Table II. LCE Components and Subassemblies

Item No.	Item	Weight, lbs	
1.	Laser baseplate (CER VIT)	6.57	
2.	Transmitter laser assembly	8.77	
3.	Local oscillator laser assembly	4.77	
4.	Backup laser assembly	4.77	
5.	Coarse beam pointing mechanism	5.47	
6.	Telescope Assembly	2.25	
7.	Image Motion Compensator Assembly	0.28	
8.	Optical train	1.53	
9.	Laser electronic assembly }	4.03	
10.	Modulator driver assembly }		
11.	Receiver signal processor assembly	3.0	
12.	Receiver Mixer Pre-amplifier assembly	0.3	
13.	Receiver mixer assembly	0.2	
14.	Acquisition/Tracking electronics assembly	2.5	
15.	Power Supply Assembly	7.7	
16.	Connectors and Cabling	0.80	
17.	Telescope enclosure	0.42	
18.	Laser enclosure	3.05	
19.	Radiator/Sun Shield Assembly	3.50	
20.	LCE/Spacecraft boot interface	2.35	
21.	Miscellaneous hardware	0.54	

3.4.1 Ascent and orbital temperature.- The temperature of the LCE baseplate shall at all times remain within the temperature range of -5°C to +55°C. No more than 40 watts shall be transferred from the LCE baseplate to the spacecraft heat sink. When the LCE is in a nonoperating mode, no more than 10 watts shall be transferred from the spacecraft heat sink to the LCE baseplate.

3.4.2 LCE baseplate/heat sink structure.- Items 2 through 9 in Table I will be attached to item 1, the Laser blaseplate, which shall be attached to the LCE baseplate along with the balance of the items. The LCE baseplate shall have attachment provisions for these items. LCE baseplate design shall meet the following physical requirements:

(a) Width and length of the LCE baseplate shall not be greater than 20 x 23.75 inches. The LCE height shall not exceed 16 inches.

(b) The LCE baseplate shall be flat to within 0.005 inches and the surface finish shall be 32 microinches, rms, or better.

(c) The LCE baseplate shall not weigh more than 3.8 pounds.

3.4.3 LCE/laser baseplate assembly.- The LCE and laser baseplate assembly shall be of such a design that the optical components, when mounted on the laser baseplate and aligned, will retain their alignment within the tolerances specified in Table III. A layout of the LCE/laser baseplate with components attached is presented in Figure 4.

Table III. Optical Component Misalignment Tolerances

Component	Random Misalignment Tolerance (Sec)	Temperature Misalignment Tolerance (Sec)
Flat laser end mirror	15	4
Modulator	50	"
Laser Tube	"	"
Curved end mirror	15	"
Reflecting mirrors	"	"
Beam expander	"	"
Duplexer	100	20
IMC	370	"
Reflecting mirrors	"	"
Filter relay lens	"	"
Nutator	"	"
Imaging lens	"	"

* To be added later

3.4.4 Laser baseplate.- The laser baseplate shall be designed so that the zero coefficient of expansion is at a nominal temperature of +25 ± 3°C. The operating temperature range shall be -5 to + 55°C. The maximum temperature difference between the warmest and the coldest points on the baseplate shall be less than 5°C. The envelope of the laser baseplate shall be in accordance with Figure 5.

3.4.5 Passive radiator.- The radiator support structure assembly will be rigidly mounted to the LCE. Structural/thermal decoupling necessary to meet the requirements specified herein shall be employed in the design.

3.4.5.1 Alignment provisions!- The radiator support structure shall have provisions for the initial positioning of the receiver mixer assembly within ± 0.001 inches each axis in respect to the LCE reference axis when the mixer assembly is mounted to the radiation cooler.

3.4.5.2 Structural stability.- The radiation support structure assembly shall maintain its initial alignment as described in 3.4.5.1 to within 0.001 inches in each axis through launch and orbital environment over the LCE specified operating life of two years. The sun shield/radiator assembly shall be of sufficient stiffness so that resonance amplification in excess of the specified vibration frequency range is less than 40. Response amplifications shall not exceed 10 at the receiver mixer assembly.

3.4.5.3 Removable sun shield design.- The radiator/shield shall be designed, as a goal, so that the sun shield can be readily removed from the radiator during handling and transportation to minimize damage to the shield.

4. QUALITY ASSURANCE PROVISIONS

4.1 Subcontractor responsiblity.- The subcontractor is responsible for design, design analysis, and testing of LCE components and subsystems to demonstrate compliance with the requirements herein, except as otherwise specified in the component specification or purchase contract.

4.2 Testing.- Testing of components to assure compliance with the thermal and structural requirements specified herein shall be performed in accordance with the applicable component specification.

5. PREPARATION FOR DELIVERY

5.1 Preparation for delivery shall be in accordance with the applicable component specification.

6. NOTES

6.1 Intended use.- The thermal and structural parameters specified herein are intended for use in the design and construction of components for the Laser Communication Experiment.

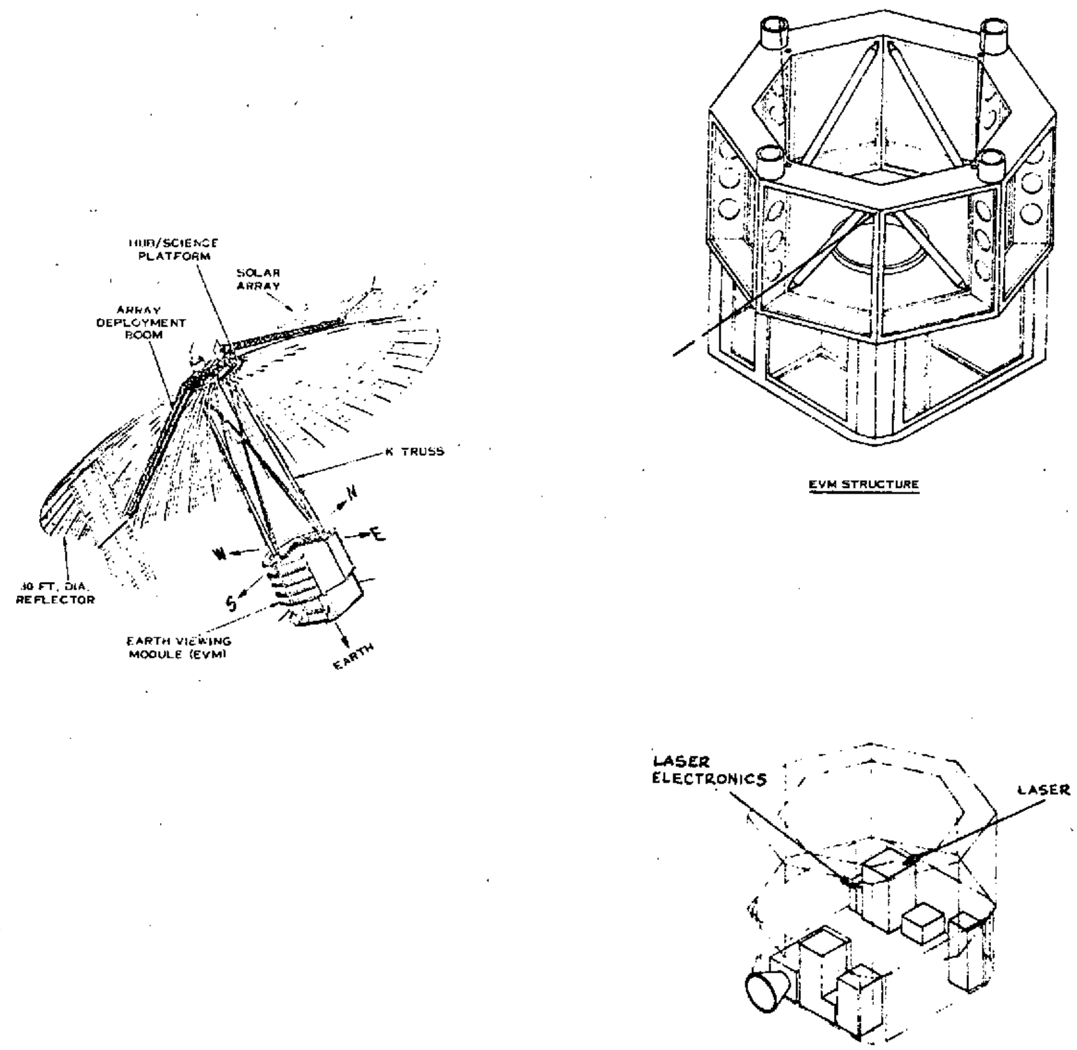

Figure 1. ATS-F Spacecraft Configuration

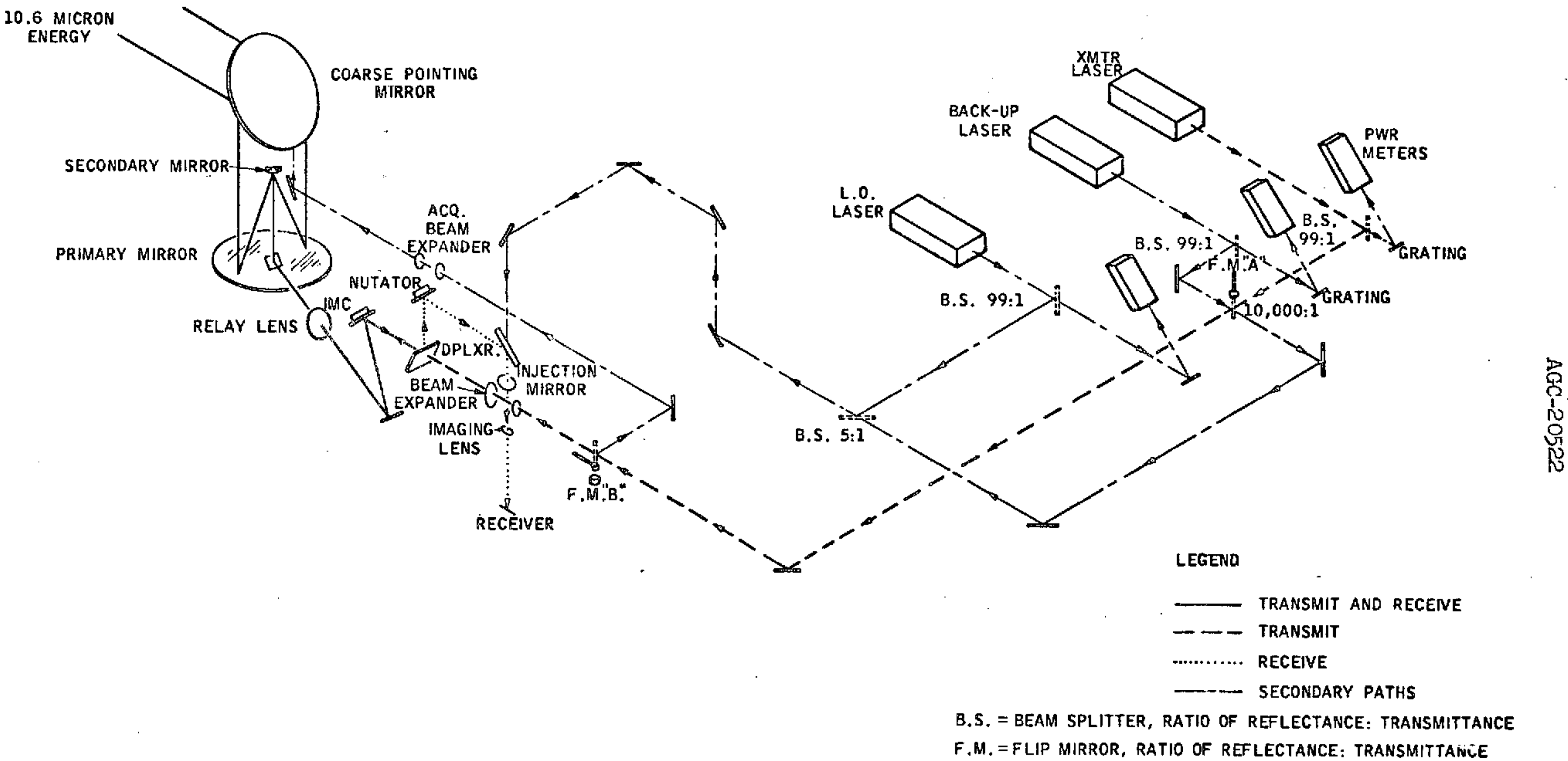

Figure 2. LCE Optical Path Schematic

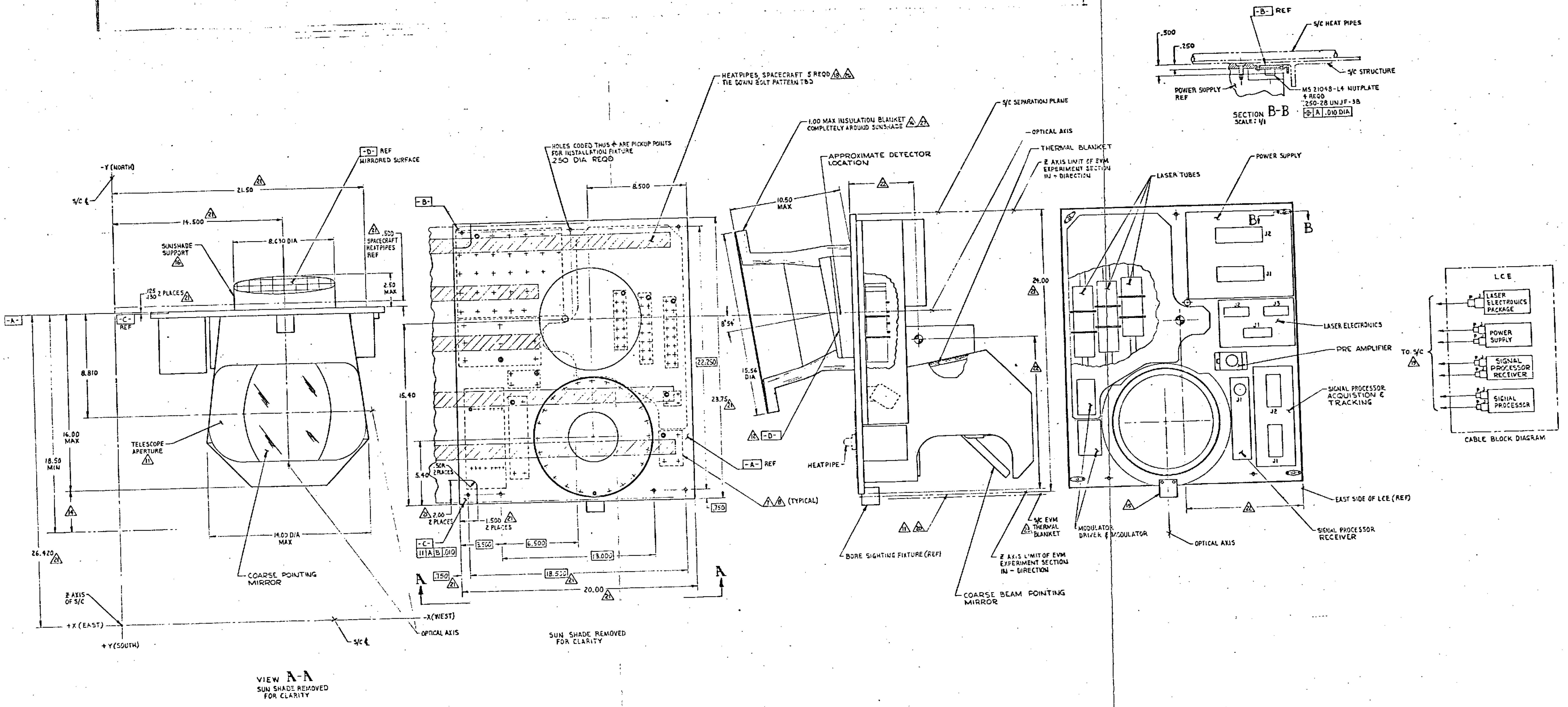

Figure 3. AGC Laser Spacecraft Interface Control Drawing

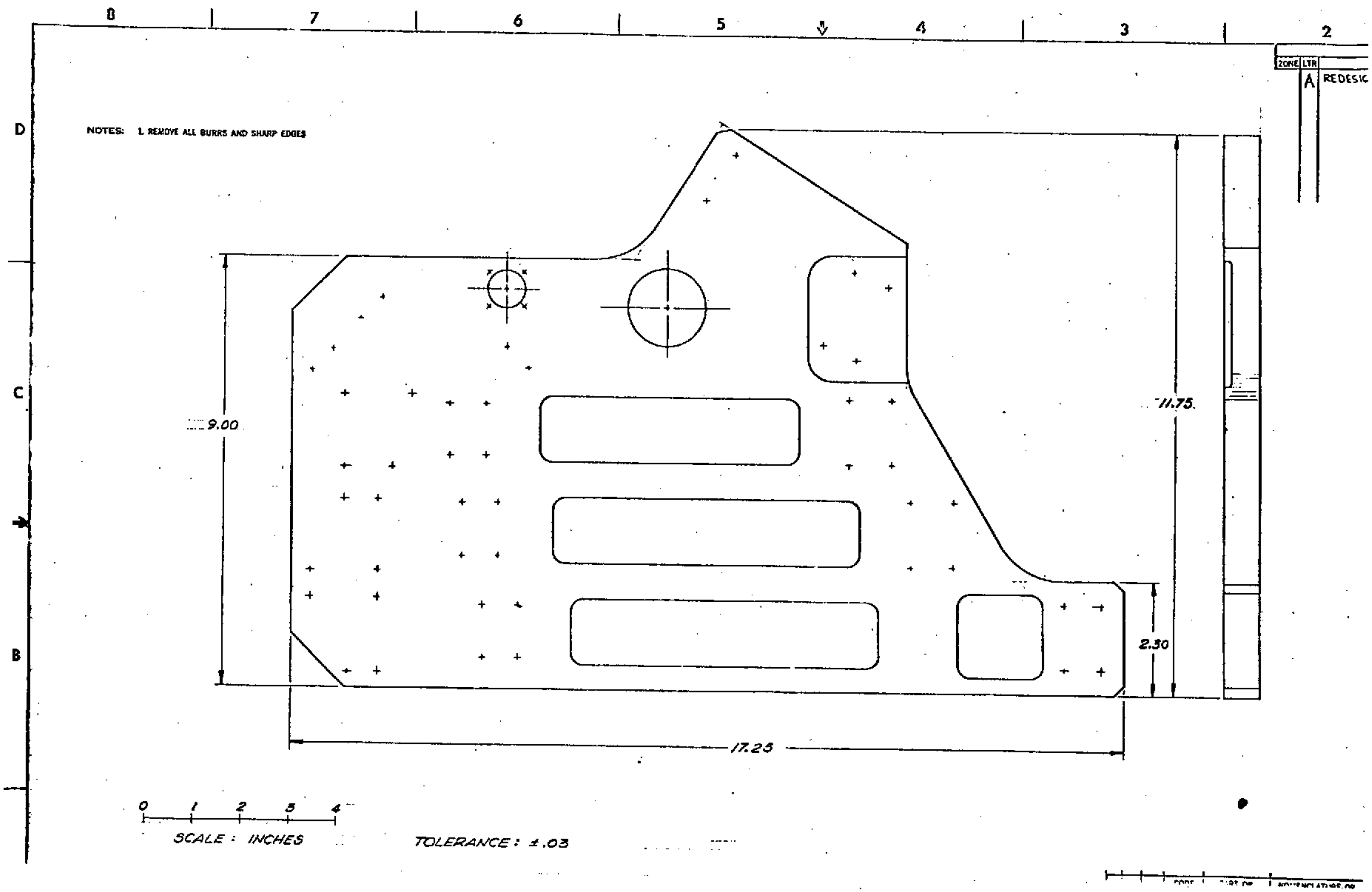

Figure 5. Laser CER-VIT Baseplate

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT: SPECIFICATION	DOCUMENT NO. AGC-20522

TITLE

THERMAL AND STRUCTURAL REQUIREMENTS, LCE

	DEPT.	EXT.
PREPARED BY		
SPEC. ENGINEER J. COFF	7981	6571

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7/8/70 AEROJET-GENERAL CORPORATION

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CODE IDENT. NO. 70143

SPECIFICATION AGC-20523

ACQUISITION AND TRACKING SUBSYSTEM, LCE

SUPERSEDING:			
AGC- DATE	AGC- DATE	AGC- DATE	
RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)			
REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	PAGE ADDITIONS
	10 July 70		
		20 21 22 23 24 25 26 27 28 29 30 31	

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. McDonough
for J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification establishes the requirements for performance, design and testing of the Acquisition and Tracking Subsystem of the Laser Communication Experiment (LCE). The Subsystem will accept and store coarse pointing coordinates from the spacecraft or ground command system and provide driving signals to point the coarse pointing mirror in the proper direction. The Subsystem will also provide signals to scan the received beam in a rectangular search pattern to acquire the transmitter beam of a remote station. Upon completion of the initial acquisition, the Subsystem utilizes the received beam to maintain the pointing on the remote station using the error signals developed by nutation of the received image on a detector of the LCE.

1.2 Application.- The Acquisition and Tracking Subsystem referred to herein as the Subsystem will be operating in the ATS-F and ATS-G spacecraft and in a transportable ground station establishing two-way laser communications between spacecraft and between the spacecraft and the transportable ground station. The Subsystem shall be capable of meeting the requirements herein while operating within the spacecraft as well as in the transportable ground station. Modifications required for operation due to the differences in environment shall be held to a minimum.

2. APPLICABLE DOCUMENTS

2.1 Unless otherwise specified, the following documents of the latest issue in effect form a part of this specification to the extent specified herein. In the event of conflict between documents referred to herein and the contents of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall apply.

NASA DOCUMENTS

NHB 5300.4(3A)	Requirements for Soldered Electrical Connections
S-300-P-1	Printed Wiring Boards
S-323-P-10	Connectors, Subminiature, Electrical and Coaxial Contact, for Space Flight Use

SPECIFICATIONS

Military

MIL-D-1000	Drawing, Engineering and Associated List
MIL-C-45662	Calibration of Standards

Aerojet-General Corporation

AGC-20186	Receiver Subsystem, Optical Heterodyne, 10.6 Micron
AGC-20187	Laser Subsystem, 10.6 Micron
AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components

	AGC-20523
AGC-20520	Optical/Mechanical Subsystem, Laser Communication Experiment
AGC-20521	Telemetry and Commands Subsystem, Laser Communication Experiment
AGC-20522	Thermal and Structure Subsystem, Laser Communication Experiment
AGC-20515	Low and High Voltage Power Supply Subsystem, Laser Communication Experiment

STANDARDS

Military

MIL-STD-461	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement Of
MIL-STD-463	Definitions and System of Units, Electromagnetic Interference Technology
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment
AGC-STD-2312	Reliability Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

3. REQUIREMENTS

3.1 Item Definition.- The Acquisition and Tracking Subsystem shall include the following major components as a minimum:

(a) Coarse beam pointing assembly

(b) Searching assembly

(c) Tracking assembly

(d) Image motion compensator drivers

(e) Acquisition control assembly

3.1.1 Subsystem Block Diagram.- The Subsystem shall be in accordance with the Block Diagram as shown in Figure 1. Figure 1A is included for reference to show the relation of this subsystem with the other LCE subsystems.

3.1.2 Interface Definition.- The electrical interface shall be in accordance with Figure 2. The mechanical interface shall be in accordance with 3.4.2 through 3.4.4.

3.2 Performance.-

3.2.1 Compatibility with LCE Subsystems.- The Subsystem shall operate as specified herein while operating in conjunction with the following companion Subsystems of the LCE:

(a) Optical/mechanical subsystem as specified in Specification AGC-20520.

(b) Telemetry and Commands subsystem as specified in Specification AGC-20521.

(c) Laser subsystem as specified in Specification AGC-20187.

(d) Receiver subsystem as specified in Specification AGC-20186.

(e) Thermal and structure subsystem as specified in Specification AGC-20522.

(f) Low and High Voltage Power Supply as specified in Specification AGC-20515 and Table I.

Table I. Regulated DC Input Power

Input Power Watts Max.	Current Regulated to ± 1% (Milliamperes)	Nominal Voltage (Volts)	Voltage Regulation (Percent)	Ripple (Millivolts) rms	Ripple (Millivolts) peak-to-peak
8	1600	+5	± 5	< 150	< 300
.096	80	+12	± 2	< 5	< 50
.096	80	-12	± 2	< 5	< 50
*	*	+28	± 3	< 20	1/
5.63	25	+225	± 5	< 70	< 180

* To be added at a later date.

1 Peak-to-Peak transients will not exceed 2 volts

3.2.2 Functional characteristics.- Functions to be accomplished by the Subsystem shall be as follows:

(a) Accept and store coarse pointing coordinates from the spacecraft or ground command system.

(b) Position the coarse pointing mirror to the desired coordinates within the specified resolution over a range of ± 40 degrees in the east-west direction and ± 4 degrees in the north-south direction.

Note: The angles specified in this section refer to internal angles.

(c) Accept and store threshold data from the spacecraft or ground command system. Generate acquisition and acquisition confirm threshold signals.

(d) Inhibit image nutation. Scan the receiver beam in a rectangular pattern to search the transmitted beam from a remote station.

(e) Terminate search scan and initiate acquisition tracking with an 80 arc second radius nutation in the east-west direction and 40 arc second radius nutation in the north-south direction.

(f) Generate two-phase driving signals to nutate the received image with a 80 by 40 arc second nutation on the mixer of the Receiver Subsystem. Generate a double frequency driving signal to move the received image on one axis only 80 arc second peak-to-peak.

(g) Provide a two axis error signal to the IMC drivers to cause the received beam to be centered on the mixer. Use an acquisition confirm signal to indicate that the transmitted beam has acquired and the Subsystem is tracking the beam. In absence of the acquisition confirm signal, the subsystem shall revert to the search operation.

(h) Using the image motion compensator (IMC) position voltages as references, drive the coarse pointing mirror to center the IMC.

(i) Initiate normal tracking operation. Generate two-phase driving signals to nutate the received image with a 15 arc second radius nutation in one direction and 7.5 arc second radius nutation in the other direction. Provide two axis error signals to the IMC drivers to cause the received beam to be centered on the mixer.

(j) Accept and execute external commands as specified.

(k) Provide status monitor signals as specified.

3.2.3 Power Consumption.- The total power consumption shall not exceed that given in Table I for each operating voltage listed.

3.2.4 Input (ground) Commands.- Up link commands from ground control shall be available for LCE operating control. Detailed characteristics and interface circuits for the commands shall be specified in specification AGC-20521. Two types of commands shall be provided as follows:

(a) Discrete Commands.- These commands shall have the following primary characteristics:

Voltage Level - Logic "0"	0.0 V ± 0.5 V
Logic "1"	+5.0 V ± 0.5 V
Pulse duration	50 ± 5 millisec
Rise and fall times (10 to 90% points)	< 3 millisec
Source impedance:	< 1000 ohm
Source capacitance:	*

(b) Digital word commands.- These commands shall have the following primary characteristics:

Nine Digital bits (serial) on a data line.

Voltage level: Logic "0"	0.0 V ± 0.5 V
Logic "1"	+5.0 V ± 0.5V
Bit rate	128 bps

(c) Enable Signal.- An address signal shall be provided which will be turned on to identify the user; his command is to be transmitted. The line characteristics are:

OFF	0.0 V ± 0.5 V
Enable	+5.0 V ± 0.5V

(d) Clock.- A 128 bps clock signal shall be provided for shifting the data into the users register. The voltage levels are as follows:

Logic "0"	0.0 V ± 0.5 V
Logic "1"	+5.0 V ± 0.5 V

(e) Execute.- An execute signal with the characteristics of the discrete command signal shall be provided. Utilization of this signal allows ground verification prior to execution of the command.

* To be added at a later date.

3.2.4.1 Command functions.- The following command functions shall be used to control the various operating modes of the equipment specified herein.

	Function	Type	Quantity
(a)	Nutator bias Adjust(beam alignment)-(north-south axis)	Discrete	3
(b)	Nutator bias Adjust (beam alignment)-(east-west axis)	Discrete	3
(c)	Acquisition threshold	Discrete	3
(d)	Acquisition confirm threshold	Discrete	3
(e)	Acquisition control	Discrete	4
(f)	Spares	Discrete	4
(g)	Coarse pointing mirror position-(east-west axis)	Digital	12 bits
(h)	Correspcinting mirror position-(north-south axis)	Digital	10 bits

3.2.5 Telemetry data.- Telemetry monitoring outputs functions shall be isolated from operating outputs with sufficient isolation such that if a telemetry function is shorted or opened the operating function shall not be caused to perform out of specification requirement. Telemetry signals shall not exceed 5 volts. Telemetry functions to be provided shall be as shown in Tables II A and II B. Characteristics of the telemetry signal and interfaces shall be as described in AGC-20521.

Table II A . Analog Telemetry Data

FUNCTION	UNIT	ACCURACY	IMPEDANCE	BAND-WIDTH
Coarse pointing mirror position (north-south axis)	V/degree	± 1%	1 K ohm	2 Hz
Coarse pointing mirror position (east-west axis)	V/degree	↓	↓	2 Hz
Image motion compensator position (north-south axis)	V/degree	↓	↓	5 Hz
Image motion compensator position (east-west axis)	V/degree	↓	↓	5 Hz
Acquisition threshold voltage	V	↓	↓	0.1 Hz
Acquisition confirm threshold voltage	V	↓	↓	0.1 Hz
Nutator bias voltage (east-west axis)	V	↓	↓	0.1 Hz
Nutator bias voltage (north-south axis	V	↓	↓	0.1 Hz

Table II B . Digital Telemetry Data

Function	Number of Bits
Coarse pointing mirror position (east-west axis)	12
Coarse pointing mirror position (north-south axis)	10

3.3 Operability.-

3.3.1 Useful life.-

3.3.1.1 Operating life.- The operating life of the Subsystem shall be greater than 2,000 hours with a minimum of 500 on and off cycles and continuous operating periods of up to 24 hours over a two year period in a space environment without degradation of the requirements specified herein. The Subsystem shall be considered in operation when it is performing one or more of its functions.

3.3.1.2 Shelf life.- The Subsystem shall be capable of meeting the operating life of 3.3.1.1 after a shelf life of greater than 20,000 hours when packaged and stored in a protective enclosure.

3.3.2 Reliability.- The Subsystem shall be designed and fabricated to provide 95.843% probability of an operational lifetime as specified in 3.3.1.1. This lifetime is based on the active operation time being equally distributed within the two year period. The groundbased Subsystem shall have a mean-time-between failures of at least * hours.

3.3.3 Maintainability.- The Subsystem shall be designed so as not to require maintenance, repair or service during its operating life. However, test points in accordance with 3.4.8 and any required means for determining the performance, accuracy, or alignment of any part of the system shall be readily accessible. Ground station repair or replacement of components shall be possible with a minimum of disturbance to other parts and wiring. If special tools are required for installation, tuning or adjustment, they shall be furnished with the Subsystem. Adjustment provisions will be allowed if no other means are available to assure proper functional operation or interchangeability. If adjustment provisions are incorporated, a positive locking device shall be used to insure that the adjustment setting will withstand the environmental conditions and not change during the operating life of the Subsystem.

3.4 General features of Design and Construction.-

3.4.1 Weight.- The weight of the Subsystem shall be a minimum consistent with the required performance, but shall not exceed a total weight of 2.5 pounds.

3.4.2 Envelope dimensions.- The Subsystem envelope dimensions shall be in accordance with Figure 3.

3.4.3 Center of Gravity.- The center of gravity shall be determined to within a tolerance of 0.1 inch of the actual center of gravity along any of the three coordinate axis in relation to a reference point on the mounting surface. The reference point shall be defined in the inspection report.

3.4.4 Mounting Provisions.- Mounting provisions shall be in accordance with Figure 3.

3.4.5 Thermal Interface.-

* To be added at a later date.

3.4.5.1 Conduction path.- To provide the required contact conductance (8.3×10^{-2} w/cm^2 - °K) for the mounting surface constituting the primary heat conduction path, the surface shall have the following characteristics:

(a) Surface flatness within 0.005 inches along any direction of the respective surface.

(b) Surface finish of 32 micro-inches, rms, or less.

3.4.5.2 Radiation environment.- For design purposes, a temperature of +10 to +45°C and an emissivity of 0.6 or greater shall be used as the average radiation environment for each assembly.

3.4.6 Grounding.- The grounding system shall be divided into signal grounds, power grounds, component case grounds, and shield grounds. These grounds shall be isolated from each other and shall be brought out on separate pins of the interface electrical connector. The shielded wire ground, as a general rule, shall be grounded at the input end.

3.4.7 Connector.- The electrical connectors shall be in accordance with specification S-300-P-10; type and pin assignments shall be in accordance with Figure 2.

3.4.8 Test Points.- Electrical test points, necessary for adjustment, tuning, and trouble shooting, shall be provided at a convenient external location.

3.4.9 Package Venting.- All units shall be vented so that the unit internal pressure equals the ambient pressure.

3.4.10 Selection of Specifications and Standards.- All standards and specifications utilized other than those listed in Section 2 shall be approved for use by Aerojet-General Corporation on concurrence with the cognizant NASA Goddard Space Flight Center Office.

3.4.11 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in AGC-STD-2312. Parts lists shall contain as a minimum, the part number, name, rating, specification number and supplier. Printed wiring boards shall be in accordance with specification S-300-P-1.

3.4.12 Moisture and Fungus Resistance.- Materials which are nonnutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.4.13 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of Standard MIL-STD-889 shall apply to the identification of dissimilar metals.

3.4.14 Interchangeability and replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.4.15 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-peculiar shall be detailed in drawing notes which shall include appropriate criteria of workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be in accordance with the best aerospace standards.

3.4.16 Electromagnetic Interference.- The electromagnetic interference characteristics of the Subsystem shall comply with the applicable requirements for Class IC or ID equipment as specified in MIL-STD-461. The methods of inspection and definitions shall be in accordance with MIL-STD-462 and MIL-STD-463, respectively.

3.4.17 Identification and Marking.- The Subsystem shall have an identification nameplate attached. Information on the nameplate shall include the following:

(a) Manufacturer's part number.

(b) Manufacturer's name and location.

(c) Code identification.

(d) Contract number.

(e) Unit name, model number, and serial number.

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer. All parts delivered as spares shall be identified in accordance with (a), (c) and (e) above.

3.4.18 Soldered electrical connections.- Soldering of electrical connections shall be in accordance with NBH 5300.4(3A) except for the following:

(a) Noncontact heat sources shall not be used (paragraph 3A304.4).
(b) Solid solder shall not be used (paragraph 3A309).
(c) Liquid solder flux shall not be used (paragraph 3A310).
(d) Lap joints shall not be used for structural mounting (paragraph 3A505).
(e) Multiple conductor cable shall not be used (paragraph 3A604 and page 6-6).
(f) Chapter 9 is not applicable.

3.5 Environmental Conditions.- If any unit fails to meet the specified performance requirements or shows signs of damage after being subjected to the environmental conditions, corrective actions shall be taken in accordance with AGC-STD-2312. Subsequent environmental testing to demonstrate suitability of the redesigned unit to meet the specified requirements shall be required.

3.5.1 Equipment Operating.- While operating, the Subsystem shall be capable of meeting the requirements specified in this specification when subject to any combination of the following environments:

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to an acceleration of from zero up to a 1-g gravitational field.

(c) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(d) Thermal-vacuum conditions for LCE subsystems as specified in AGC-20511 (Level I and Level II).

(e) Temperature for equipment operating as specified in AGC-20511.

3.5.2 Equipment nonoperating.- The Subsystem shall be capable of withstanding the following environmental conditions in accordance with the levels and test procedures specified in AGC-20511 and thereafter meet the performance requirements specified herein.

(a) Storage Temperature

(b) Sinusoidal and Random Vibrations, Test level I or II

(c) Acceleration

3.5.3 Ground model.- The Subsystem shall be capable of meeting the ground model operating and nonoperating environmental requirements as specified in AGC-20511.

3.6 Subsystem Components.- The Subsystem shall include but not be limited to the following components:

(a) Coarse beam pointing assembly (see 3.6.1)

(b) Searching assembly (see 3.6.2)

(c) Tracking assembly (see 3.6.3)

(d) Image motion compensator drivers (see 3.6.4)

(e) Acquisition control assembly (see 3.6.5)

3.6.1 Coarse beam pointing assembly.- The assembly shall position the mirror over a range of ± 40 degrees in the east-west direction and ± 4 degrees in the north-south direction. The orientation of the two directions shall be as shown on Figure 4. The selection of mirror position and the mirror traverse rate shall be as follows:

(a) The assembly shall accept the pointing coordinates from the spacecraft command system. Each of the two direction coordinates shall be stored in a shaft position register. Upon receiving an execute command from the acquisition control assembly, the mirror shall be traversed with an angular rate of 2 degrees per second in each of the two directions to a position of one degree from the required angular position. At that time the angular rate may be reduced as dictated by the inertial considerations. The assembly shall position the mirror with a resolution of $\pm$ 0.02 degrees in the east-west axis and $\pm$ 0.01 degrees in the north-south axis.

(b) Using the image motion compensator position voltages as references, the assembly shall traverse the mirror to a position within ± 0.005 degree of the IMC center position. The mirror shall be traversed with an angular rate of 0.012 degree per second in the east-west axis and 0.006 degree per second in the north-south axis. The angular acceleration shall not exceed 5 degrees/sec^2 in each of the two directions. The coarse beam pointing assembly shall consist of a mirror, gimbal subassembly, command registers, shaft position registers, comparator, motor driving circuitry, and IMC position error detector.

3.6.1.1 Course Pointing Mirror.- The surface reflectivity shall be equal to or higher than 98 percent at 10.6 microns wavelength. Surface accuracy shall be 1/4 λ or 1/2 fringe (green light, λ = 0.5 micron) over the entire aperture area. The mirror shall be designed to reflect an incident beam over the range specified in 3.6.1.

3.6.1.2 Gimbal subassembly.- The gimbal subassembly shall consist of the north-south gimbal with its gear train, stepping motor and shaft position encoder and the east-west gimbal with its gear train, stepping motor and shaft position encoder. The north-south gimbal shall be used to mount the mirror. The east-west gimbal shall be used to mount the north-south gimbal and mirror assembly. Each stepping motor shall be driven at the rate of not more than 2.2 steps per second during normal tracking. For each step, the stepping motor shall traverse the mirror 18^{+2}_{-4} arc seconds in the east-west direction and 9^{+1}_{-2} arc seconds in the north-south direction. The 3σ error in angular position as indicated by the encoder output shall not exceed $\pm$ 0.02 degree from the true mirror position in the east-west direction and $\pm$ 0.01 degree from the true mirror position in the north-south direction. The error in angular position shall include:

(a) Orthogonality of the axis of rotation

(b) Bearing radial run-out error

(c) Gear backlash

(d) Encoder quantizing error

(e) Driving motor axis position error

(f) Temperature gradient deformation error

3.6.1.3 Command registers.- The command registers shall receive and hold the mirror position data transmitted by ground commands. The east-west position register shall have a 12 bit capacity to accept 4000 different positions. The north-south position register shall have a 10 bit capacity to accept 800 different positions. The digital data shall be transferred to the registers serially at the rate of 128 bits per second.

3.6.1.4 Shaft position registers.- The shaft position registers shall contain the data indicating the shaft position of each gimbal. The east-west shaft position register shall consist of 12 bits and shall be driven by the output of the east-west gimbal encoder. The north-south shaft position register shall consist of 10 bits and shall be driven by the output of the north-south gimbal encoder. The registers shall be binary counters capable of counting up and down. Upon receiving a reset signal from the gimbal subassembly, each register shall be reset to a midpoint count with the most significant bit reset to "1" and all other bits reset to "0". The midpoint count of the registers shall be used to indicate the zero referenced positions of the mirror.

3.6.1.5 Comparator.- A comparator shall be incorporated to compare the contents of each command and shaft position register. Each of the two comparators shall provide "more than", "equal to" or "less than" outputs.

3.6.1.6 Motor driving circuitry.- The motor driving circuitry shall provide properly sequenced pulses to drive the stepping motors. The pulses shall be uniformly spaced and the pulse rate shall be 2.0 ± 0.2 pulses per second. The three modes of operation shall be as follows:

(a) Accept signals from the comparators and drive the stepping motors toward the null position, when an "execute coarse pointing" command is received. The null position shall be obtained by matching the content of the command register to the content of the shift position register.

(b) During acquisition tracking, the motor driving circuitry shall accept a "center IMC" signal from the acquisition control assembly and drive the stepping motors to center the IMC using the outputs of IMC position error detector specified in 3.6.1.7 as reference. The motor driving circuitry shall drive the stepping motors to a position within $\pm$ 0.005 degree from the IMC center position in each of the two directions.

(c) During normal tracking, the motor driving circuitry shall accept a "center IMC" signal from the IMC position reference converter and shall drive the stepping motors to a position within $\pm$ 0.005 degrees from the IMC center position.

3.6.1.7 IMC position error detector.- The detector shall accept the east-west and north-south axis IMC position voltages, properly scaled and converted to an analog or digital format as required. During normal tracking, the detector shall automatically examine the IMC positions. When the east-west and north-south axis positions exceeds 0.4 and 0.2 degrees respectively from the center position, a "center IMC" signal shall be generated. This signal shall be routed to the motor driving circuitry specified in 3.6.1.6 to center the IMC.

3.6.2 Searching assembly.- The searching assembly shall provide a horizontal and vertical scan signal to the IMC beam pointing drivers to cause the received beam to scan in a rectangular pattern. The search pattern shall cover ± 0.208 degree of external field of view on both the horizontal and vertical axes. Time required to scan one search pattern shall be 220 seconds or less. The search pattern shall have the following characteristics:

(a)	Number of scan raster lines:	128
(b)	Line-to-line displacement:	11.6 ± 0.1 arc sec
(c)	Horizontal field-of-view:	0.416 ± .006 degree (external)
(d)	Vertical field-of-view:	0.416 ± .006 degree (external)
(e)	Active scan time per line:	1.552 ± .005 second
(f)	Retrace time per line:	0.173 ± .005 second
(g)	Horizontal scan linearity:	± 3 percent

Upon receiving the acquisition signal from the acquisition control assembly, the search scanning shall cease within 3 milliseconds of the leading edge of the acquisition signal (50 percent amplitude point). When the acquisition signal is not received, the searching assembly shall revert to its scan mode and complete the search pattern. The search assembly shall consist of a clock, clock and command gate, line width counter, frame width counter and reset gate, line and frame with D/A converters, line width integrator, and auxiliary circuitry.

3.6.2.1 Clock.- An internal clock shall be provided to control the counting of the line and frame width counters. The clock shall have an operating frequency of 148 ± 2 Hz.

3.6.2.2 Clock and command gate.- A clock and command gate shall be provided to control the routing of the clock pulses to the line width counter. Upon receiving an acquisition command from the acquisition control assembly, the clock pulses routing to the line width counter shall be stopped. During each of the line scan retrace periods, the clock and command gate shall be used to disable the acquisition command so that clock pulses will be routed to the line width counter throughout the line retrace period.

3.6.2.3 Line width counter.- An 8-bit linear counter shall be incorporated as line width counter. The counter shall accept and count the clock pulses routed through the clock and command logic. The time required to reach the full count of 256 shall be used to control the width of the scan line. A "zero" count with all bits equal to zero shall be used to indicate the end of the line or the beginning of the line retrace.

3.6.2.4 Frame width counter and reset gate.- A 7-bit linear counter shall be incorporated as frame width counter. The counter shall accept and count the output pulses from the line width counter and shall be used to indicate the scan line number in a frame. A "zero" count with all bits equal to zero shall be used to indicate Line No. 1. A reset gate shall be incorporated to reset the counter to zero when the counter has reached the count of 112.

3.6.2.5 Line and frame width D/A converters.- The digital to analog converters shall be used to convert the contents of the counters to analog signals. A line width D/A converter shall accept 8-bit data in parallel and convert the data to an analog signal. A frame width D/A converter shall accept 7-bit data in parallel and convert the data to an analog signal. The converters shall meet the following requirements:

(a) Maximum conversion time: 1.0 milliseconds

(b) Analog signal range: ± 10 volts

(c) Maximum conversion error: ± 0.5 percent of full scale

3.6.2.6 Line width integrator.- The staircase analog signal from the line width D/A converter shall be integrated by the line width integrator. The integrator shall be incorporated to provide a smooth driving signal to the line driver. The time constant of the integrator shall be 1.0 to 1.2 milliseconds.

3.6.2.7 Auxiliary circuitry.- The auxiliary circuitry shall consist of:

(a) Fixed bias circuit

(b) Command inhibit monostable circuit

Upon receiving the acquisition signal from the acquisition control assembly, a fixed bias circuit shall introduce a fixed biased voltage to the output of the line width integrator. The bias shall be used to compensate for the time delay between target detection and execution of the acquisition command. The amplitude of the bias shall have a value equivalent to _*_ milliseconds of the line scan time.

The acquisition command inhibit monostable circuit shall generate a signal during each of the line retrace periods. The duration of the signal shall be 0.060 ± .010 seconds.

3.6.3 Tracking Assembly.- The tracking assembly shall perform a position sampling by nutating the received image over a receiver mixer. The assembly shall consist of a nutator drive, nutator drive bias circuitry, acquisition confirm signal and threshold signal generator, error amplifiers nutator drivers, and feedback subassembly.

(a) The tracking assembly shall amplify the error signals, which are originally developed at the mixer and demodulated by a receiver subsystem, and shall use the signals to control the motion of the image motion compensator to center the received image on the mixer. The effective bandwidth of the assembly shall be 5 Hz.

(b) The assembly shall utilize an externally furnished acquisition confirm signal to indicate that the transmitter beam of the remote station has been acquired and the assembly is tracking the transmitter beam. In the absence of the acquisition confirm signal during acquisition tracking, a control signal shall be generated to revert the Subsystem to the search operation. The assembly shall provide an acquisition confirm threshold signal as specified in 3.6.3.3.

(c) The tracking assembly shall provide two modes of operation as follows:

(1) During acquisition tracking, the assembly shall provide two-phase, 100 Hz ± 5 Hz signals to the north-south and east-west nutator drivers to nutate the received image. The radius of nutation shall be 80 arc seconds in the east-west axis and 40 arc seconds in the north-south axis. The assembly shall also provide a 200 ± 10 Hz signal to the north-south nutator driver to traverse the nutation mirror at a peak-to-peak nutator amplitude of 80 arc seconds.

* To be added at a later date.

(2) During normal tracking, the assembly shall provide two-phase 100 ± 5 Hz signals to the north-south and east-west drivers to nutate the received image. The radius of nutation shall be 15 arc seconds in the east-west axis and 7.5 arc seconds in the north-south axis. The assembly shall provide a function to traverse the coarse beam pointing mirror to center the IMC as specified in 3.6.1(b). The function shall be initiated automatically when the IMC, moving from its center position, reaches 0.4 degrees and 0.2 degrees in the east-west axis and north-south axis, respectively.

3.6.3.1 Nutator drive.- The nutator shall provide two sinusoidal driving signals to cause nutation of the received beam on the receiver mixer. The east-west driving signal, e_1, and the north-south driving signal, e_2, shall meet the following requirements:

(a) $e_1 = E_1 \cos 2\pi ft$

(b) $e_2 = E_2 \cos (2\pi ft + \theta)$

where:

E_1 = 10.0 ± 0.2 volts corresponding to 80 arc second nutational radius operating during acquisition tracking

E_1 = 1.88 ± 0.05 volts corresponding to 15 arc second nutational radius operating during normal tracking

E_2 = 5.0 ± 0.1 volts corresponding to 40 arc second nutational radius operating during acquisition tracking

E_2 = 0.94 ± 0.03 volts corresponding to 7.5 arc second nutational radius operating during normal tracking

f = 100 ± 5 Hz

θ = 90 ± 2 degrees

During acquisition tracking, the nutator drive shall provide a third sinusoidal driving signal. This signal shall be applied to the north-south driver. Frequency of the signal shall be 200 ± 10 Hz. The signal shall have an amplitude sufficient to drive the nutation mirror 80 arc seconds peak-to-peak.

3.6.3.2 Nutation drive bias circuitry.- The nutator drive bias circuitry shall provide a east-west and north-south bias signal to the nutator drivers. Each bias voltage shall be generated by a digital-to-analog converter. Each converter's dc output shall be controlled by a 9-bit command register. Each of the 9-bit command word shall enter the register serially at the rate of 128 bits per second. The bias signal shall have a resolution and a full scale amplitude corresponding to ±10 and ±500 arc seconds of nutator drive in the east-west direction and ±5 and ±250 arc seconds of nutator drive in the north-south direction.

3.6.3.3 Acquisition confirm signal and threshold signal generator.- During acquisition and tracking, an acquisition confirm signal will be received from the Receiver Subsystem specified in AGC-20186. The received signal shall have the characteristics specified in Table I of AGC-20186. The threshold signal generator shall provide an acquisition confirm threshold signal to the Receiver Subsystem. The signal shall be generated by a digital-to-analog converter. The converter's dc output shall be controlled by an 8-bit command register. The 8-bit command word shall enter the register serially at the rate of * bits per second. The threshold signal to the receiver shall have the characteristics specified in Table III.

Table III. Acquisition Confirm Signals To and From the Receiver

Characteristic	Acquisition Confirm Signals	
	From the Receiver	To the Receiver
(a) Wave form	DC	DC
(b) Amplitude (signal on)	3.8 ± 1.4 volts	
Amplitude (signal off)	0.0 ± 0.5 volts	
Amplitude range		0.5 to 5.0 volts
(c) Source resistance	1 kilohm, maximum	
(d) Resolution		0.28 ± 0.14 volts
(e) Load resistance	10 kilohms, minimum	10 kilohms, minimum

3.6.3.4 Error amplifiers.- The error amplifiers shall accept the east-west and north-south error signals and amplify the signals to the proper level to drive the IMC. The two input signals shall have the following characteristics:

(a) Wave form: Bipolar phase demodulated signal

(b) Amplitude range: ±5.0 volt

(c) Signal bandwidth: DC to 5 Hz

3.6.3.5 Nutator drivers.- The east-west and north-south axis nutator drivers shall accept the nutator driving signals and suitably amplify them to drive the PZT crystals of the nutator.

*To be added at a later date.

The maximum output rms noise shall be equivalent to $\pm$ 10 arc seconds. The linearity of the drivers shall be $\pm$ 1.0 percent over the range of $\pm$ 740 arc seconds in the east-west axis and $\pm$ 370 arc seconds in the north-south axis.

3.6.3.6 Feedback subassembly.- The feedback subassembly shall consist of a feedback bimorph sensor and feedback amplifier with compensator filter. The feedback bimorph sensor shall be used to convert the mechanicam motion to an electrical signal. The feedback amplifier with the compensating filter shall provide the feedback subassembly with a break point at 5 Hz.

3.6.4 Image motion compensator drivers.- The east-west and north-south axis image motion compensator (IMC) drivers shall each accept signals from the searching assembly or the tracking assembly and shall suitably amplify the signals to drive the PZT crystal of the IMC. The maximum rms output noise of the drivers shall be equivalent to $\pm$ 10 arc seconds. The linearity of the drivers shall be $\pm$ 1.0 percent over the range of $\pm$ 2.6 degrees in the east-west axis and $\pm$ 1.3 degree in the north-south axis referring to IMC center position. The effective bandwidth of the drivers shall be sufficient to permit traversing at an angular rate of 0.7 degree per second and the angular acceleration shall not exceed 50 degrees/second^2.

3.6.5 Acquisition control assembly.- The assembly shall accept external commands and generate various internal control commands required to acquire the transmitter beam of a remote station. The assembly shall be designed to accept commands and generate internal control signals as specified in Table IV.

Table IV. Acquisition Control Assembly Input Commands and Generated Internal Control Signals

Characteristic	Input Commands	Generated Internal Control Signals
Waveform	As described in 3.2.4	(To be completed at a later date)
Signal amplitude	↓	↓
Pulse width (50% amplitude point)	↓	↓
Rise time	↓	↓
Fall time	↓	↓
Source resistance	↓	↓
Source capacitance	↓	↓
Load resistance	↓	↓
Load capacitance	↓	↓

3.6.5.1 Search command.- Upon receiving the search command from the spacecraft or ground command system, the assembly shall generate signals to perform the following functions:

(a) Switch laser transmitter to the wide beam position.

(b) Switch coarse beam pointing assembly to operate under conditions specified in 3.6.1(a)

(c) Generate an acquisition threshold signal as specified in 3.6.5

(d) Command the searching assembly to remove nutation drive and initiate search pattern.

3.6.5.2 Acquisition command.- Upon receiving the acquisition signal from the Receiver Subsystem the assembly shall generate signals to perform the following functions:

(a) Command the searching assembly to cease searching. Time delay in generating this signal shall not exceed 0.5 milliseconds measuring from the leading edge of the acquisition command to the leading edge of the signal (50 percent amplitude points).

(b) Command the tracking assembly to initiate acquisition tracking as specified in 3.6.3 (c)(1).

3.6.5.3 Narrow transmitter beam command.- A narrow transmitter beam command shall be generated approximately 220 seconds after the occurence of acquisition command as specified in 3.6.5.2. The command shall generate signals to perform the following functions:

(a) Inhibit acquisition tracking

(b) Switch laser transmitter to the narrow beam position

(c) Initiate normal tracking as specified in 3.6.3(c)(2)

(d) Center IMC by driving the coarse beam pointing mirror as specified in 3.6.1(b)

3.6.5.4 Acquisition threshold signal generator.- A threshold signal generator shall be provided to generate an acquisition threshold signal to the Receiver Subsystem. The signal shall be generated by a digital-to-analog converter. The converter's d-c output shall be controlled by an 8-bit command register. The 8-bit command word shall enter the register serially at the rate of _*_ bit per second. The threshold signal shall have the following characteristics:

Wave form:	DC
Amplitude range:	0.5 to 5.0 volts
Resolution:	141 $\pm$ 71 millivolts
Load resistance:	10 kilohms, minimum

*To be added at a later date.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. - Unless otherwise specified, all inspection shall be performed as specified herein. Inspection records of the examination and tests shall be kept complete and available at the time of acceptance of the equipment. Any deficiencies noted as a result of tests conducted shall be corrected.

4.1.1 Quality assurance program. - A quality assurance program, in accordance with AGC-STD-2311, shall be implimented and maintained.

4.1.2 Reliability assurance program. - A reliability assurance program, in accordance with AGC-STD-2312, shall be implimented and maintained.

4.1.3 Processing changes. - No changes in the subsystem design, specifications, materials or material processes after design approval shall be made without prior written approval of the Aerojet LCE Program Manager.

4.1.4 Test conditions. - Unless otherwise specified in a detailed test method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration in accordance with the calibration system requirements of MIL-C-45662. The tolerance allowed on test conditions and inputs are intended only to provide for accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports. - The results of all Design Qualification and Flight Model and Ground Model Acceptance Inspection shall be documented in the form of test reports prepared in accordance with AGC-STD-2312 and delivered with the hardware. Test reports shall be prepared and submitted for approval after completion of testing.

4.2 Classification of Inspections. - Inspections to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Model or Ground Model Acceptance Inspection (see 4.6).

4.3 Test plan. - A test plan shall be prepared and shall include all of the inspections specified in 4.2. The test plan shall be so developed that the test results will verify that the requirements specified herein have been met. The test plan shall be submitted for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Every test shall be described in full detail; this shall include block diagrams of the test setup, manufacturers designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, all levels and impedances, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process examinations and tests. - In-process examinations and tests shall be performed as required to determine conformance to applicable drawings, specifications, approved workmanship standards, identification, traceability, and any special process controls required to insure repeatability of hardware performance.

4.5 Design Qualification Inspection. - Design Qualification Inspection shall consist of all the tests described in Table V as a minimum. The test sequence shall be as shown in Table V. Deviation from the sequence presented shall require prior approval of the Aerojet LCE Program Manager. The Design Qualification inspection shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the Subsystem under ambient conditions and the specified operational environments. The detailed Design Qualification inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests.

4.6 Flight Model Acceptance Inspection. - A detailed procedure of the Flight Model Acceptance Inspection shall be generated as a part of the overall test plan, and approved by AGC prior to final inspection. The Flight Model Acceptance Inspections shall include the examinations and tests of Table VI as a minimum and shall be extensive enough to demonstrate satisfactory workmanship and that the Subsystem performance is within tolerance. The test sequence shall be as shown in Table VI and shall require prior approval of the Aerojet LCE Program Manager for any deviations.

4.6.1 Ground Model Acceptance Inspection. - The Ground Model Acceptance Inspection shall be in accordance with Table VII. The test sequence shall be as shown in Table VII and shall require prior approval of the Aerojet LCE Program Manager for any deviation.

Table V. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Method Paragraph
(a) Analysis		
(1) Operating Life	3.3.1.1	4.1.2 and 4.7.1
(2) Center of Gravity	3.4.3	4.7.1
(3) Reliability	3.3.2	4.1.2 and 4.7.1
(4) Maintainability	3.3.3	4.7.1
(5) Radiation Resistance	3.5.1 (a)	4.7.1
(6) Thermal Analysis	3.5.1 (e)	4.7.1
(b) Visual Examination Measurements		
(1) Electrical Interface	3.1.2	4.7.2
(2) Weight	3.4.1	4.7.2
(3) Envelope Dimensions	3.4.2	4.7.2
(4) Mounting Provisions	3.4.4	4.7.2
(5) Grounding	3.4.6	4.7.2
(6) Connectors	3.4.7	4.7.2
(7) Test Points	3.4.8	4.7.2
(8) Venting	3.4.9	4.7.2
(9) Selection of Specifications and Standards	3.4.10	4.7.2
(10) Materials, Parts and Processes	3.4.11	4.7.2
(11) Moisture and Fungus Resistance	3.4.12	4.7.2
(12) Corrosion of Metal Parts	3.4.13	4.7.2
(13) Interchangeability and Replaceability	3.4.14	4.7.2
(14) Workmanship	3.4.15	4.7.2
(15) Identification and Markings	3.4.17	4.7.2
(16) Soldered Electrical Connectors	3.4.18	
Functional Characteristics	3.2.1, 3.2.2 and Table VI	4.7.3 (a)
Functional Characteristics	3.2.1, 3.2.2 and Table VI	4.7.3 (b)
Operating Temperature	3.5.1 (e)	4.7.4
Vibration, Sinusoidal & Random	3.5.2 (b), Level I	4.7.5
Functional Characteristics	3.2.1, 3.2.2, and Table VI	4.7.3 (b)
Acceleration	3.5.2 (c)	4.7.6
Functional Characteristics	3.2.1, 3.2.2 and Table VI	4.7.3 (b)
Thermal Vacuum	3.5.1 (b)	4.7.7
EMI	3.4.16	4.7.8

Table VI. Flight Model Acceptance Inspection

Examination or Test	Requirement Paragraph	Method Paragraph
(a) Visual Examination and Measurement		
(1) Weight	3.4.1	4.7.2
(2) Envelope Dimensions	3.4.2	4.7.2
(3) Mounting Provisions	3.4.4	4.7.2
(4) Connector	3.4.7	4.7.2
(5) Workmanship	3.4.15	4.7.2
(6) Identification and Markings	3.4.17	4.7.2
(b) Testing		
(1) Functional Characteristics	3.2.1, 3.2.2 and Table VIII	4.7.3 (a)
(2) Operating Temperature	3.5.1 (e) and Table VIII	4.7.4
(3) Vibration	3.5.2 (b), Level II	4.7.5
(4) Functional Characteristics	3.2.1, 3.2.2 and Table VIII	4.7.3 (b)
(5) Thermal Vacuum	3.5.1 (d)	4.7.7
(6) EMI	3.4.16	4.7.9

TABLE VII. Ground Model Acceptance Inspection

Examination or Test	Requirement Paragraph	Method Paragraph
Visual Examination and Measurement		
Envelope Dimensions	3.4.2	4.7.2
Mounting Provisions	3.4.4	4.7.2
Connector	3.4.7	4.7.2
Workmanship	3.4.16	4.7.2
Identification and Markings	3.4.18	4.7.2
Testing		
(a) Functional Characteristics at Minimum and Maximum Operating Temperatures	3.2.1, 3.2.2 and Table VIII	4.7.3 (a)

4.7 Test methods. -

4.7.1 Analysis. - Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the written report. Systems engineering data shall be used where appropriate to support analysis.

4.7.2 Visual examination and measurements. - Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of functional testing.

4.7.3 Functional characteristics. - Specific tests as specified in Table VIII shall be performed to verify that the requirements of 3.2.1 and 3.2.2 are met. Whenever possible, tests shall be made on the Subsystem with all electrical, mechanical and thermal interfaces simulated as closely to the actual operating conditions as possible. Tests requiring the combined operations of the Subsystems of the LCE shall be described in the Test Plan. Functional tests in accordance with Table VIII shall be of two types:

(a) Complete functional tests which verify specifically that the requirements of 3.2.1 and 3.2.2, which are amenable to measurements or other quantitative assessment, have been met. These tests shall be performed at specific points in the test cycle so that it is possible to verify that the unit and its elements are performing in accordance with specified requirements.

(b) Abbreviated tests, which will not verify all the requirements of 3.2.1 and 3.2.2, but are sufficient to show that the unit will perform its overall functions satisfactorily. These tests shall permit rapid assessment of unit performance during or after each of the principal environmental exposures.

4.7.4 Operating temperature tests. - The unit shall be subjected to the operating temperature environments specified in AGC-20511. During each of the cold and hot test phases, a performance characteristic test in accordance with 4.7.3 (b) shall be performed. Cold start capability shall be tested as specified in AGC-20511.

4.7.5 Vibration. - While nonoperating, the unit shall be subjected to the random and sinusoidal vibrations specified in AGC-20511, Test level I or II, as applicable. Upon completion of the test, the unit shall be examined for evidence of damage or deformation.

Table VIII. Functional Characteristic Test

Requirements	Requirement Paragraph	Test Method Paragraph 4.7.3 (a)	Test Method Paragraph 4.7.3 (b)
(a) Coarse Beam Pointing Assembly			
(1) Pointing Range	3.6.1	X	X
(2) Pointing Coordinate Command Capability	3.6.1 (a)	X	X
(3) Traverse Rate	3.6.1 (b)	X	
(4) Pointing Resolution and Accuracy	3.6.1 (b)	X	X
(b) Search Assembly			
(1) Search Pattern	3.6.2	X	X
(2) Scan Linearity	3.6.2 (g)	X	
(3) Line and Frame Time	3.6.2 & 3.6.2 (e)	X	
(4) Acquisition Capability	3.6.2	X	X
(c) Tracking Assembly			
(1) Nutator Drive	3.6.3.1	X	
(2) Acquisition Tracking Capability	3.6.3 & 3.6.3.3	X	X
(3) Center IMC Accuracy and Traverse Rate	3.2.2 (i) & 3.6.3	X	X
(4) Normal Tracking Capability	3.6.3	X	X
(5) Nutator Drive Biasing Command Capability	3.6.3.2	X	X
(6) Nutator Drive Biasing Accuracy and Resolution	3.6.3.2	X	X
(7) Nutator Driver's Dynamic Range	3.6.3.5	X	
(8) Nutator Driver's Linearity and Output Noise	3.6.3.5	X	X
(9) Generation of Acquisition Confirm Threshold Signal	3.6.3.3	X	X
(10) Feedback Subassembly	3.6.3.6	X	X
(d) IMC Drivers			
(1) Dynamic Range	3.6.4	X	
(2) Linearity and Output Noise	3.6.4	X	
(e) Acquisition Control Assembly			
(1) Command Acceptance	3.6.5	X	X
(2) Execution of Search Command	3.6.5.1	X	X
(3) Execution of Acquisition Command	3.6.5.2	X	X
(4) Execution of Narrow Transmitter Beam Command	3.6.5.3	X	X
(5) Generation of Acquisition Threshold Signal	3.6.5.4	X	X
(6) Operating Power	3.2.1 (f)	X	

4.7.6 Acceleration. - While nonoperating, the unit shall be subjected to the longitudinal and lateral accelerations specified in AGC-20511. Upon completion of the test, the unit shall be examined for evidence of damage or deformation.

4.7.7 Thermal Vaccum. - The unit shall be subjected to the thermal vaccum tests specified in AGC-20511. After the temperature has stabilized during the last high and low temperature dwell, a functional test in accordance with 4.7.3 (b) shall be performed.

4.7.8 Electromagnetic Interference. - EMI testing shall be in accordance with the requirements of 3.4.16 for tests CE01 and CS01 as specified in MIL-STD-461A.

5.1 Preservation, packaging, and packing. - Unless otherwise specified, the perservation, packaging, and packing shall be in accordance with the best aerospace practice provided that this practice is sufficient to protect the item against contamination and damage during shipment. If the component does not meet the requirements herein because of such contamination or damage, and acceptable replacement component shall be furnished within a reasonable time. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment. - Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter

(d) Date of final assembly

(e) Purchase order number

(f) Warning and caution notes, as applicable.

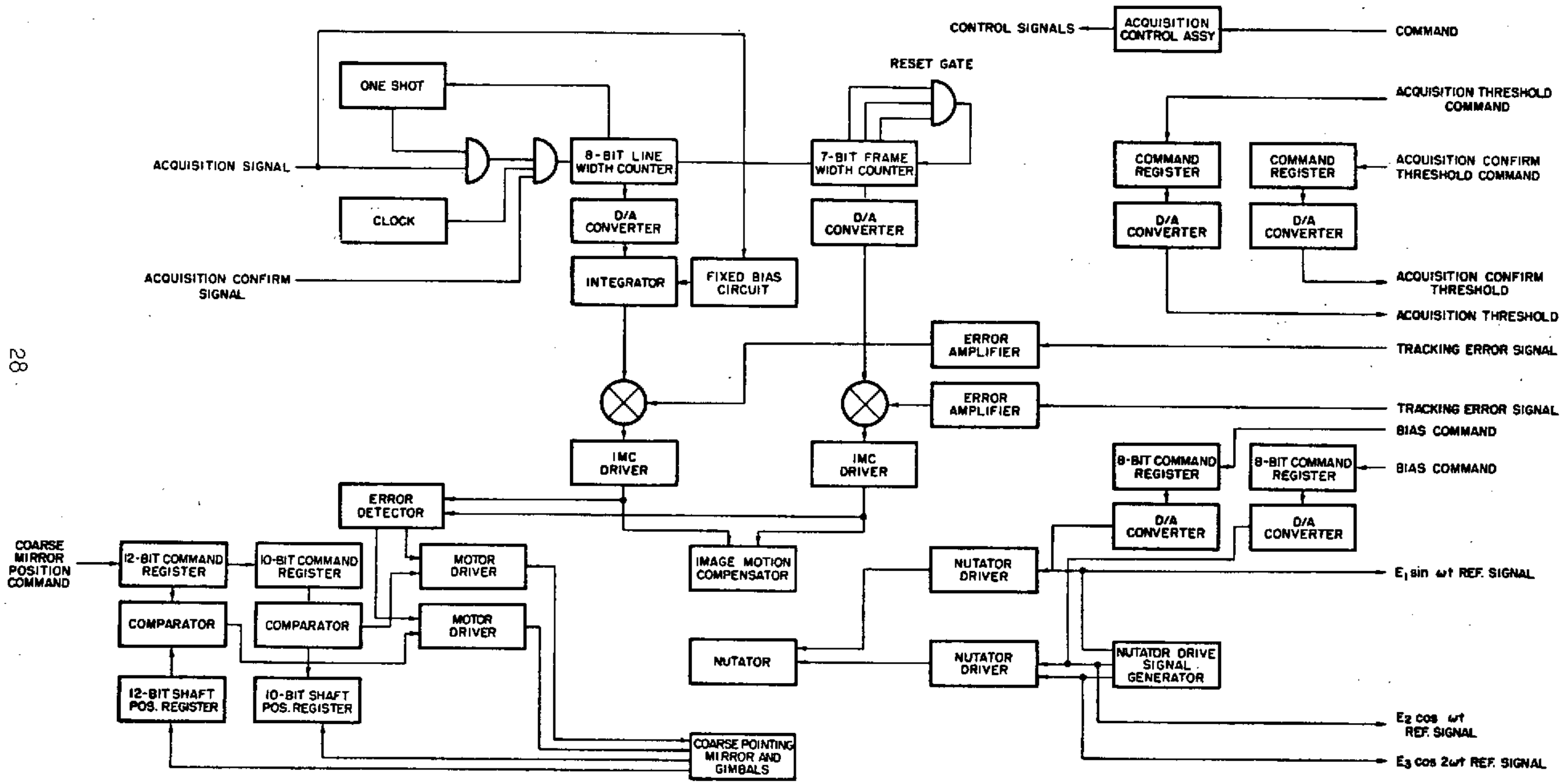
6. Notes

6.1 Intended use. - The Subsystem specified herein is intended for use in the ATS-F Spacecraft as well as in a transportable ground station without exhibiting any differences in performance or functional capabilities due to the differences in these environments. Any differences in hardware which may be necessary shall not degrade the specified performance levels. In its final form, this basic specification will describe the Subsystem as required for use in the space environment while the differences which make it suitable for use in the ground environment will be noted in the appendix.

6.2 Definitions. -

6.2.1 Failure. - A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.3 Oral statements. - Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.



AGC-20523

Figure 1. Acquisition and Tracking Subsystem Block Diagram

To be added at a later date -

Figure 2. Electrical Interface Drawing

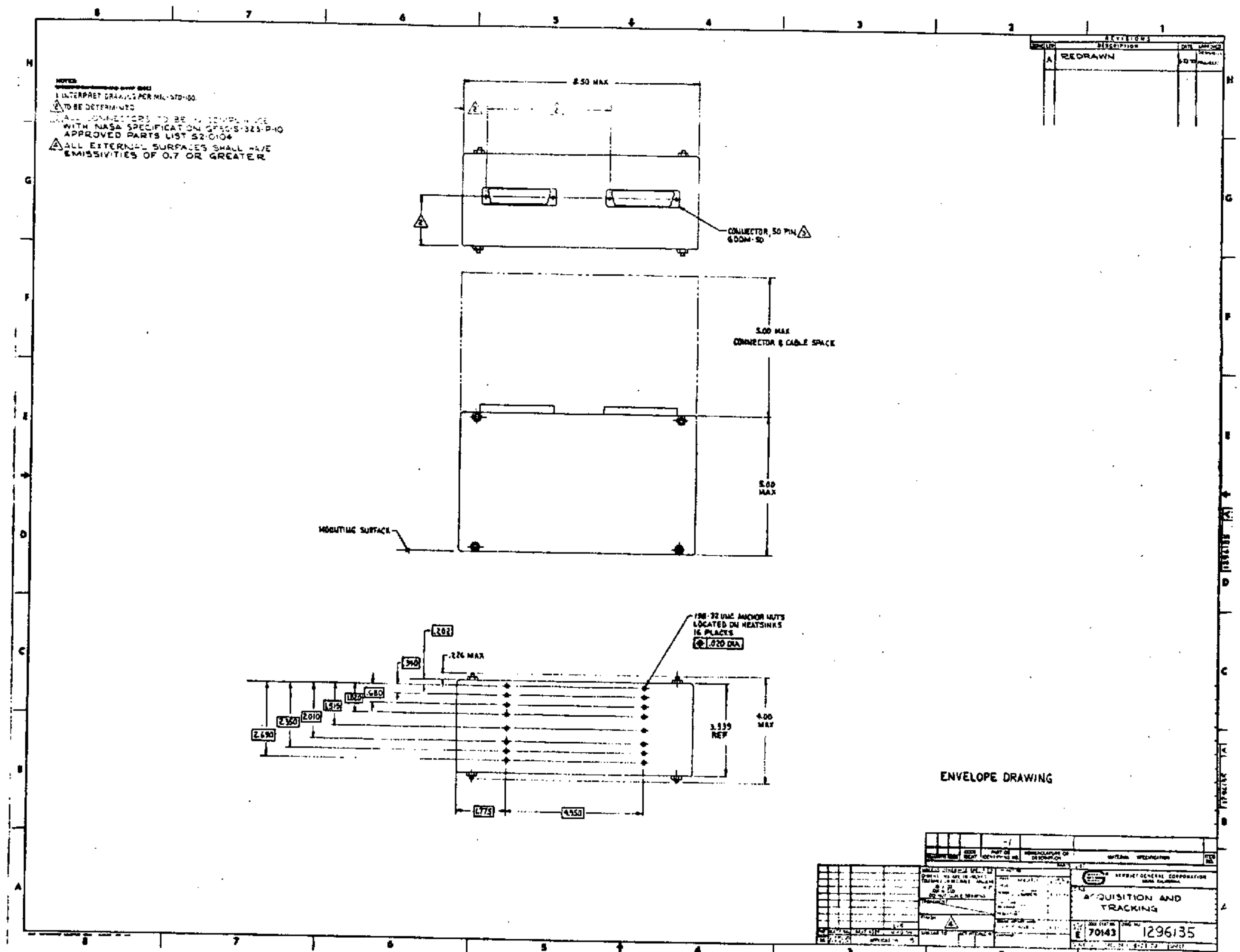


Figure 3. Acquisition and Tracking Subsystem Envelope

AGC-20523

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

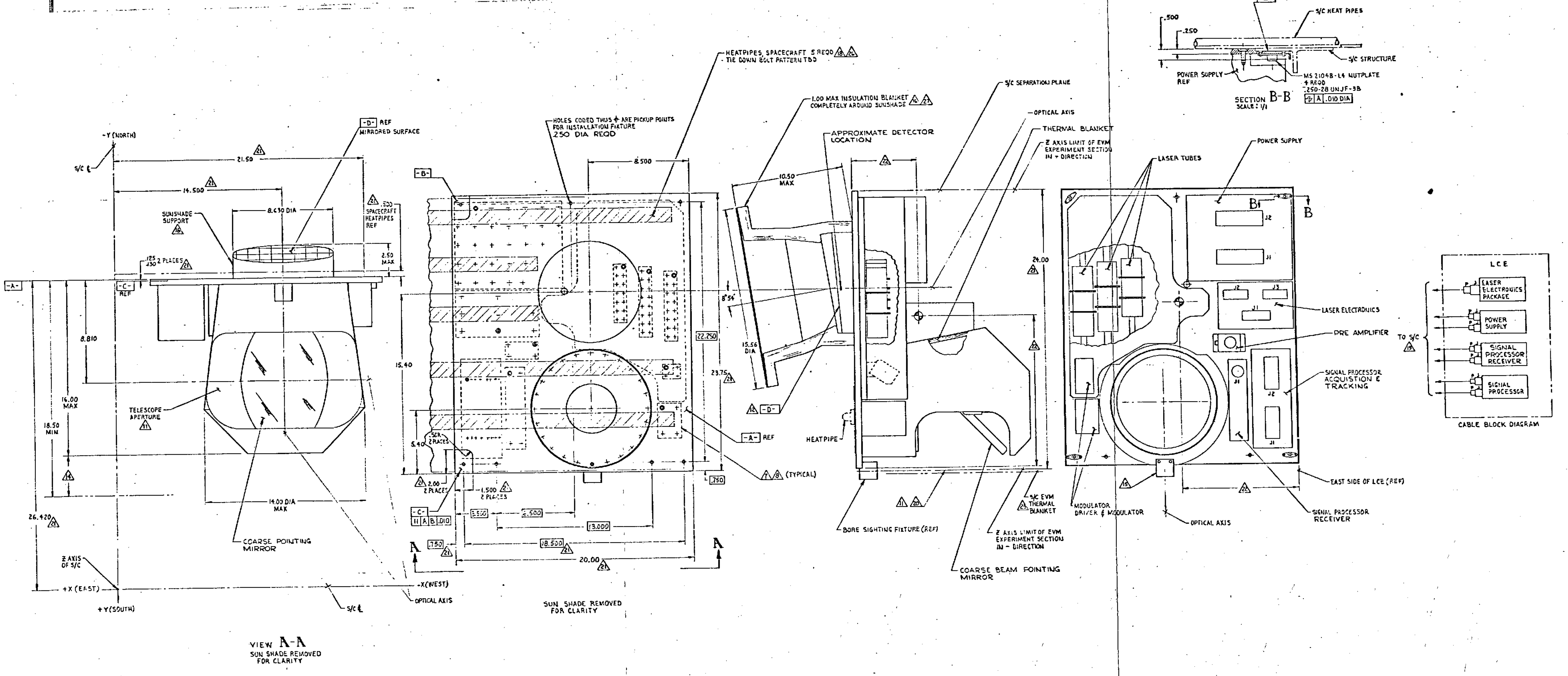


Figure 4. AGC Laser Spacecraft Interface Control Drawing

DOCUMENT APPROVAL SIGNATURE SHEET

TYPE OF DOCUMENT	DOCUMENT NO.
SPECIFICATION	AGC-20523

TITLE

ACQUISITION AND TRACKING SUBSYSTEM, LCE

PREPARED BY	DEPT.	EXT.
SPEC. ENGINEER J. COFF	7981	6571

APPROVAL SIGNATURE	DEPT.	DATE
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RELEASE ACTIVITY - *C R. Cantrell*	1147	7-10-70

7/7/70 AEROJET-GENERAL CORPORATION

Preliminary Draft
12 June 1970

AEROJET-GENERAL CORPORATION

CODE IDENT. NO. 70143

SPECIFICATION AGC-20525

RADIATOR, SUN SHIELD, PASSIVE, RECEIVER MIXER

SUPERSEDING:			
AGC- DATE	AGC- DATE	AGC- DATE	
RELEASES (REPLACE PAGES IN SPECIFICATION WITH LATEST CHANGE BELOW.)			
REV LTR	RELEASE DATE	PAGE NUMBERS i 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	PAGE ADDITIONS

PRELIMINARY COPY

Authorized for Release:
Electronics Systems Operations
Electronics Division
Azusa Facility

J. Coff, Supervisor
Specifications and Standards

1. SCOPE

1.1 Scope.- This specification covers the requirements for the design, fabrication, performance and testing of one type of passive Sun Shield Radiator which will be used to control the temperature on a Laser Receiver Mixer of a heterodyne communications system.

2. APPLICABLE DOCUMENTS

2.1 Unless otherwise specified, the following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between documents referred to herein and the contents of Sections 3, 4, and 5, the requirements of Sections 3, 4, and 5 shall apply.

SPECIFICATIONS

NASA

S-460-ATS-38	ATS-F and -G Experiment Interface Specification

Military

MIL-D-1000	Drawing, Engineering and Associated List
MIL-C-45662	Calibration of Standards

Aerojet-General Corporation

AGC-20511	Environmental Design Criteria and Test Levels for the Laser Communications Experiment and Associated Components

STANDARDS

Military

MIL-STD-130C	Identification Marking of U.S. Military Property
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Metal, Definition of Dissimilar

Aerojet-General Corporation

AGC-STD-2311	Quality Assurance Requirements for Suppliers of Laser Communications Experiment Equipment

(Copies of documents required by contractors in connection with specific procurement functions should be obtained as indicated in the Department of Defense Index of Specifications and Standards or as specified by the contracting officer.)

3. REQUIREMENTS

3.1 Item Definition.- The Receiver Mixer Passive Radiator hereinafter referred to as the Radiator shall include a passive radiator equipped with a sun shield, a temperature monitoring element, and provisions for mounting the unit to the LCE baseplate.

3.1.1 LCE Baseplate.- The Laser Communications Experiment (LCE) baseplate shall be the structure that supports all components which comprise the LCE and interface with the ATS-F spacecraft.

3.2 Performance characteristics.- The Radiator shall maintain the temperature of the receiver detector within the limits of 90°K to 125°K (-183° to -143°C) independent of seasonal and diurnal changes in the satellite-sun angle and including a ± 10° angle off the orbit plane. The environments in which the above performance shall be met is defined in 3.6.

3.2.1 Maximum Radiator Temperature.- The Radiator shall be designed such that sunlight can impinge normally on the radiator for a sufficient period of time such that steady-state temperatures are achieved. During this time, the maximum temperature of the radiator shall not be sufficient to cause damage to the receiver detector. During this period the radiator cooler temperature shall not rise above 275°K.

3.2.2 Structural stability.- The radiator shall have a structural stability sufficient to meet the requirements specified in 3.5.4.3.

3.2.3 Temperature transducer.- The radiator shall include a temperature transducer for the purpose of measuring and monitoring the temperature of the radiation cooler over the specified operating temperature range. This transducer shall be calibrated and a curve provided with calibration data of the temperature versus output. Accuracy of the transducer output when corrected with the supplied calibration data shall be within ± 0.5°K of the actual temperature. The electrical characteristics of the transducer shall be provided to Aerojet to permit the design of processing and instrumentation circuitry.

3.3 Operability.-

3.3.1 Reliability.- The design for reliability shall occur simultaneously with, rather than separately from the design to achieve the mechanical characteristics specified in this specification. The Radiator shall be designed and fabricated to provide 99.5% probability of an operational lifetime as specified in 3.4.1. This lifetime is based on the active operation time being equally distributed within the two year period.

3.3.2 Maintainability.- The design for maintainability shall occur simultaneously with, rather than separately from the design of the Radiator. The Radiator shall be designed so as not to require maintenance, repair or service during its operating life. Provisions shall be included to protect the reflective surfaces against contamination, corrosion or any form of degradation during handling and storage. This protective means shall insure that the unit will be capable of withstanding the environmental conditions and not degrade below the requirements of this specification for the shelf life specified in 3.4.2. A cleaning or restoration procedure shall be developed for the reflective coating so that any critical surface may be restored within specification limits if contamination should occur.

3.4 Useful life.-

3.4.1 Operating life.- The operating life of the Radiator shall be greater than 2,000 hours with a minimum of 500 cooling-heatup cycles and operating periods of up to 24 hours over a two year period in a space environment without degradation of the requirements specified herein.

3.4.2 Shelf life.- The Radiator shall be capable of meeting the operating life of 3.4.1 after a shelf life of greater than 6 months when packaged and stored in a protective enclosure as specified in Section 5.

3.5 Physical characteristics.-

3.5.1 Weight.- The weight of the Radiator shall be a minimum consistent with the required performance, but shall not exceed a total weight of 3.5 pounds.

3.5.2 Envelope dimensions.- The Envelope dimensions shall be a minimum not exceeding the dimensions specified in Figure 1 (AGC Drawing L-1297199).

3.5.3 Center of gravity.- The center of gravity of the Radiator, measured from the mounting surface interface, shall not exceed 2.0 inches. The mass moment of inertia about the axis normal to the interface, through the center of gravity should not exceed 75 $lb\text{-}in.^2$.

3.5.4 Mounting and alignment.- The Radiator will interface with the LCE structure. The mounting and alignment provisions shall be coordinated with Aerojet and be compatible with the interface requirements.

3.5.4.1 Mounting to LCE.- The Radiator shall be rigidly mounted to the LCE; therefore, the support structure and any structural/thermal decoupling necessary to meet the requirement specified herein shall be the responsibility of the subcontractor.

3.5.4.2 Alignment provisions.- The Radiator support structure shall have provisions for the initial positioning of the mixer assembly, shown in Figure 2, (SK 2486), within ± 0.010 inches each axis, when the mixer assembly is mounted to the radiation cooler, with respect to the LCE reference axis.

3.5.4.3 Structural stability.- The Radiator support structure assembly shall maintain its initial alignment as described in 3.5.4.2 to within 0.001 inches in each exis through launch and orbital environment over the specified operating life of the unit. The sun/shield radiator assembly shall be of sufficient stiffness as to have no resonance amplification in excess of 40 over the specified vibration frequency range. Response amplifications greater than 10 shall not be acceptable at the receiver mixer assembly.

3.5.4.4 Mounting with the Mixer Assembly.- The Radiator shall interface with the mixer assembly in Figure 2 and shall have the mounting hole pattern shown. In the area of mixer contact, the radiator shall have a surface flatness of .0002 inches and a finish of 16 microinches, rms.

3.5.4.5 Removable shield design.- The radiator/shield shall be designed, as a goal, so that the shield can be readily removed from the radiator during handling and transportation to minimize damage to the shield.

3.5.5 Radiator thermal interfaces.- The thermophysical properties and temperature history of the Titan IIIC fairing which will be used with the ATS spacecraft launch will be as defined in Figure 3. The lift-off temperature of the radiator assembly will be 20° ± 20° immediately prior to launch. Fairing jettison shall take place in nominally __*__ seconds after launch. The ATS Spacecraft Thermal Characteristics are covered in NASA Specification S-460-ATS-38.

3.5.5.1 Ascent period.- During the ascent (see 6.3.2) portion of the mission and immediately thereafter the orientation of the ATS spacecraft may be random. Therefore it is possible that the sun will shine normally on the radiator for periods of time sufficient to bring about steady-state temperatures. The radiator shall be designed so that if this condition exists, the performance of the assembly will not be permanently impaired.

3.5.5.2 Contamination or thermal degradation.- Degradation of thermal control and/or optical surfaces by deposition of foreign particles or contaminants originating from either the ATS spacecraft, the launch vehicle, or other experiments shall be no greater than:

(a) Change in total hemispherical emittance ($\Delta\epsilon$) equal to or less than 0.01.
(b) Change in solar absorptance (Δ_s) equal to or less than 0.01.
(c) Change in specularity of mirrors (front and back surface) and sunshade coatings shall be equal to or less than 0.01.

3.5.5.3 Receiver mixer interface.- The Radiator shall be compatible with the receiver mixer mechanical interface requirements of 3.5.4.4. A thermal heat load of 85 milliwatts of local oscillator power are incident on the Receiver mixer. Of that total, 25 milliwatts impinge directly on the mixer. However, only 30% of the 25 milliwatts or 7.5 mw are absorbed. The rest of the energy is reflected diffusely. The remaining 60 mw of energy hits the gold plated ($\epsilon\leq$) radiation cone and is reflected specularly. There is also 3 mw of detector bias dissipated within this assembly. Heat input to the mixer assembly from the coaxial cable shall not exceed 22 mw. The heat load of the mixer housing and optics will be no greater than 5 mw and shall be dynamically simulated during the testing of the radiator assembly. The mixer assembly shall weigh a maximum of 4 oz.

3.5.4.4 Laser Communications Experiment (LCE) Interface.- The Radiator shall be compatible with the LCE interface requirements shown in Figure 1 and 4 and as follows:

(a) Ascent Temperatures.- The temperature of the LCE heat sink during ascent will remain within the limits of -40°F (-40°C) to ±110°F (+43°C) at all times.

* To be added at a later date.

(b) Orbital Temperatures.- The temperature of the LCE heat sink during orbit will remain within the limits of -10°F (-12°C) to +110°F (43°C) at all times.

(c) Hemispherical emittance.- The total hemispherical emittance of the LCE heat sink shall be equal to or less than 0.7.

(d) Radiator mounting.- The radiator contractor shall provide sufficient mounting provisions so that the ΔT between the LCE heat sink and the radiator support is less than 2°C. A bolt conductance of at least 0.3 BTU/hr-bolt shall be provided.

3.5.6 Temperature transducer interface.- The electrical input/output of the transducer shall be insulated wire leads having a minimum length of 24 ± 2 inches.

3.5.7 Contamination during handling and storage.- During handling, storage, transportation, and laboratory usage the LCE and its subsystems shall be protected from dirt, moisture, excessive temperatures, ect. through the use of suitably conditioned air and/or hermetic containers. The allowable storage and transportation temperature range shall be -30°C to 60°C (-22°F to 140°F). Degradation of thermal control and/or optical surfaces by deposition of foreign particles or contaminants originating from the above mentioned environments shall be no greater than the values specified in 3.5.5.2.

3.6 Environmental Conditions.- If any unit fails to meet the specified performance requirements or shows signs of damage after being subjected to the environmental conditions, corrective actions shall be taken in accordance with Appendix C of the statement of work. Subsequent environmental testing to demonstrate suitability of the redesigned unit to meet the specified requirements shall be required. While operating in any orientation, the Radiator shall be capable of meeting the requirements specified in this specification when subject to any combination of the following environments:

(a) While being subjected to the Electron Radiation levels specified in AGC-20511.

(b) While being subjected to a dc magnetic field of from zero up to 0.6 gauss.

(c) Thermal-vacuum conditions for LCE subsystems (Level II) as specified in AGC-20511 except at temp ≤ 77°K (-186°C).

(d) While being subjected to an acceleration of from zero up to a 1-g gravitational field.

(e) While being subjected to the acceleration specified in AGC-20511, section 3.4.4.

(f) While being subjected to the vibration specified in AGC-20511, test level I or II.

3.7 General Features of Design and Construction.-

3.7.1 Selection of Specifications and Standards.- All standards and specifications utilized on this program other than those listed in Section 2 shall be approved for use by Aerojet-General Corporation on concurrence with the cognizant NASA Goddard Space Flight Center Office.

3.7.2 Materials, Parts, and Processes.- Maximum use shall be made of established standard materials, parts, and processes. Variations in dimensions, types, and protective finishes of parts shall be limited to the maximum extent consistent with the intended application.

3.7.3 Parts and materials program.- Parts and materials shall be selected in accordance with the parts and materials program specified in Appendix C of the statement of work.

3.7.4 Moisture and Fungus Resistance.- Materials which are non-nutrients for fungus shall be used wherever possible. Where the use of fungus nutrients cannot be avoided, treating, packing, or other protective means shall be used to ensure required performance. All parts, materials, or equipments shall be either designed or protected so that exposure to moisture encountered during the course of manufacture, test, shipment, and installation shall not degrade performance.

3.7.5 Corrosion of Metal Parts.- All metals shall be of corrosion-resistant type or shall be suitably processed to resist corrosion. The use of dissimilar metals in direct contact shall be avoided wherever possible or shall be protected against direct contact. The provisions of MIL-STD-889 shall apply to the identification of dissimilar metals.

3.7.6 Interchangeability and Replaceability.- All parts with the same manufacturer's part number shall be physically and functionally interchangeable. Part number changes shall be controlled in accordance with the requirements of Specification MIL-D-1000.

3.7.7 Workmanship.- Workmanship shall conform to the requirements of applicable process specifications relating to fabrication and assembly as invoked by the particular assembly drawing. Critical steps of fabrication which are item-particular shall be detailed in drawing notes which shall include appropriate criteria and workmanship. Workmanship relating to all other aspects of fabrication, general handling, and storage shall be sufficient to meet the requirements herein.

3.7.8 Identification and Marking.- The Radiator shall have an identification nameplate attached, marked in accordance with Standard MIL-STD-130. Information on the nameplate shall include the following:

(a) Manufacturer's part number

(b) Manufacturer's name and location

(c) Code identification

(d) Contract number

(e) Unit name, model number, and serial number.

The information contained on this nameplate shall permit a search of assembly detail drawings and documentation to be made to identify any part contained within the unit. All parts shall be identified with one part number which shall be that of the original manufacturer.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified, the subcontractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the subcontractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection records of the examination and tests shall be kept complete and available to the procuring activity for two years after acceptance of the equipment. The procuring activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Subcontractor's quality assurance program.- The subcontractor shall maintain a quality assurance program in accordance with AGC-STD-2311 except for any requirements deleted in the statement of work.

4.1.2 Subcontractors reliability assurance program.- The subcontractor shall maintain a reliability assurance program in accordance with Appendix C of the statement of work.

4.1.3 Processing changes.- The subcontractor shall make no changes in the Radiator design, specifications, materials, or material processes after AGC design approval without prior written approval of the Aerojet LCE Program Manager.

4.1.4 Test conditions.- Unless otherwise specified in a detailed method paragraph, all examinations and tests shall be performed under standard ambient conditions as specified in Specification AGC-20511. All test instrumentation shall bear visual evidence of current calibration in accordance with the calibration system requirements of MIL-C-45662. The tolerance allowed on test conditions and inputs are intended only to provide for accuracy tolerances of instrumentation, controls, etc. Test conditions shall be adjusted as closely as possible to nominal or center values specified, and in no instance shall they exceed the tolerance specified. Performance parameters are specified either as limits or as nominal values with plus-or-minus tolerances. These limits and tolerances shall be regarded as absolute, and the accuracy tolerance of measuring equipment shall not be interpreted as part of measured values in such a way that an out-of-tolerance or out-of-limit measurement may appear in-tolerance or in-limit.

4.1.5 Test Reports.- The results of all Design Qualification Inspection and Flight Acceptance Inspection shall be documented in the form of test reports prepared in accordance with MIL-STD-831 and delivered with the hardware. Test reports shall be prepared and submitted to AGC for approval after completion of testing.

4.2 Classification of Inspections.- Examinations and tests to be performed on the equipment shall be classified as follows:

(a) In process Inspection (see 4.4).

(b) Design Qualification Inspection (see 4.5).

(c) Flight Acceptance Inspection (see 4.6).

4.3 Test plan.- The subcontractor shall prepare a test plan which includes all of the inspections specified in 4.2 and is developed so that the test results verify that the requirements specified herein have been met. The Test Plan shall be submitted to Aerojet-General for review and approval prior to the commencement of testing. The plan shall describe every test to be made for measuring every significant performance parameter. Tests shall be described in full detail including block diagrams of the test setup, manufacturers' designations of all the commercial test equipment to be used in the tests, the designs of any special test equipment required, a full description of the test procedures to be followed, the test acceptance limits (which must be compatible with the overall performance requirements), and an estimate of the accuracy expected from each measurement. Any special calibrations of test equipment to assure its accuracy shall be adequately described. The detail given for each test method and setup shall be sufficient to allow the test to be duplicated with no information beyond that given in the test plan. In all cases where a test does not follow well-known conventional procedures and methods, sufficient information on the theory of the test should be given to allow an objective evaluation of the proposed test method.

4.4 In-process examinations and tests.- In-process examinations and tests shall be performed as required to determine conformance to applicable drawings, specifications, approved workmanship standards, identification, traceability, and any special process controls required to insure repeatability of hardware performance.

4.5 Design Qualification Inspection.- Design Qualification Inspection shall consist of all the tests described in Table I, as a minimum. The examinations and tests shall be designed to demonstrate the functional capability, structural integrity, and performance repeatability of the Radiator under ambient conditions and the specified operational environments. The detailed Design Qualification Inspection shall be included as a section of the overall test plan (see 4.3) and shall be reviewed and approved by AGC prior to the performance of the tests. Design Qualification Inspection shall be conducted only when and to the extent specified in the contract or purchase order.

Table I. Design Qualification Inspection

Examination or Test	Requirement Paragraph	Test Method
Analysis		
Reliability	3.3.1	4.7.1
Maintainability	3.3.2	4.7.1
Thermal analysis	4.7.1	4.7.1
Visual examination and measurements		
Selection of specifications and standards	3.7.1	4.7.2
Materials, parts and processes	3.7.2	4.7.2
Standard and Commercial parts	3.7.3	4.7.2
Moisture and fungus resistance	3.7.4	4.7.2
Corrosion of metal parts	3.7.5	4.7.2
Interchangeability and replaceability	3.7.6	4.7.2
Workmanship	3.7.7	4.7.2
Identification and marking	3.7.8	4.7.2
Weight	3.5.1	4.7.3
Envelope Dimensions	3.5.2	4.7.2
Center of Gravity	3.5.3	4.7.3
Moment of inertia	3.5.3	4.7.3
Mounting and Alignment	3.5.4	4.7.2
Surface Characteristics	3.5.4.4	4.7.2
Testing		
Vibration	3.6 (f), Test Level I	4.7.4
Acceleration	3.6 (c)	4.7.4
Thermal characteristics during thermal vacuum	3.6 (c)	4.7.4

4.6 Flight Acceptance Inspection.- A detailed procedure of the Flight Acceptance Inspection shall be generated as a part of the overall test plan, by the subcontractor and approved by AGC prior to final inspection. Flight Acceptance Inspection shall be accomplished on each flight model offered for delivery. The Flight Acceptance Inspections shall include the examinations and tests of Table II as a minimum, and shall be extensive enough to demonstrate satisfactory workmanship and that the Radiator performance is within tolerance.

Table II. Flight Acceptance Inspection

Examination or Test	Requirements	Method
Visual examination and measurements		
Weight	3.5.1	4.7.2
Envelope dimensions	3.5.2	4.7.2
Surface characteristics	3.5.4.4	4.7.2
Testing		
Vibration	3.6 (f) Test Level II	4.7.4
Thermal characteristics during thermal vacuum	3.6 (c)	4.7.4

4.7 Test methods.-

4.7.1 Analysis.- Those requirements to be verified by analysis shall be satisfied through a review of analytical data. Such data shall be summarized or included as appropriate in the written report. Systems engineering data shall be used where appropriate to support analysis.

4.7.2 Visual examination and measurements.- Those requirements to be verified by visual examination and measurements shall be satisfied by visual examination and by the use of standard measuring instruments to determine such characteristics as dimensions and weight. Drawings, bills of materials, specifications, and other engineering documentation shall be used as appropriate. With the exception of a detailed physical examination of the test specimen, which shall be performed immediately before the start of testing, compliance with these requirements may be demonstrated before the time of testing, subject to agreement of the Aerojet representative.

4.7.3 Weight, center of gravity, and moment of inertia.- The weight of the item and its major components shall be demonstrated to verify compliance with 3.5.1. The center of gravity and moment of inertia shall be determined for the item along each of three mutually perpendicular axes as shown in Figure 1, as related to the spacecraft axes (see Figure 4).

4.7.4 Environmental tests.- The vibration and acceleration tests shall be performed as specified in AGC-20511 to verify compliance with the requirements herein. During the test the item shall be attached to the test fixture so as to simulate the actual element mounting in relationship to the baseplate.

4.7.4.1 Vibration-Acceleration.- The unit when subjected to these tests shall include a structurally simulated receiver mixer assembly defined by 3.5.4.4 and 3.5.5.4.

4.7.4.2 Thermal vacuum test.- During thermal vacuum testing the unit shall include a dynamically simulated (structural and thermal) receiver mixer assembly defined by 3.5.4.4 and 3.5.5.4. The tests shall be performed as follows:

(a) Place the radiator in a thermal vacuum test chamber so that its performance can be evaluated empirically. A detailed analytical model of the radiator assembly in the test chamber shall be constructed prior to testing. A comparison of analytically predicted and actual system temperatures will be the basis for the fine tuning of the analytic model.

(b) The test article shall be subjected to both a steady-state and transient thermal environment. Test article temperatures should be quite close to those predicted on-orbit, however, a solar simulation test is not required. The pressure in the test chamber shall be $\leq 1 \times 10^{-5}$ Torr. The cryogen shroud temperature shall be $\leq 77°K$. Cyclic temperature changes shall be brought about by adding heat to the sunshade via heaters which are directly attached.

(c) A test shall be conducted to insure that the optical performance of the sunshade is within acceptable limits. This test will be designed to show that the contour and surface properties are within acceptable limits and to verify that the sunshade specularity is equal to or less than 97%.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing.- Unless otherwise specified, the preservation, packaging, and packing shall be in accordance with the subcontractor's best aerospace practice provided that this practice is sufficient to preserve quality requirements of para. 3.5.5.2 and para. 3.5.7, to fulfill good quality preventative practices, and to protect the item against contamination and damage during shipment. The subcontractor shall be responsible for any contamination or damage to the equipment as a result of insufficient or faulty packaging. If the component does not meet the requirements herein because of such contamination or damage, an acceptable replacement component shall be furnished within a reasonable time by the subcontractor at no cost to AGC. Exterior containers shall conform to Consolidated Freight Classification Rules or common carrier regulations to insure delivery at Aerojet-General Corporation, Azusa, California, in an undamaged condition.

5.2 Marking for shipment.- Each shipping container shall be marked with, as a minimum, the following information:

(a) Name of unit

(b) Part number, drawing number, revision letter, and serial number

(c) Specification number and revision letter (AGC-20525)

(d) Date of final assembly

(e) Purchase order number

(f) Subcontractor's name

(g) Warning and caution notes, as applicable

6. NOTES

6.1 Intended use.- The Radiator specified herein is intended for use in a Laser Communications Experiment which will be in the ATS-F Spacecraft.

6.2 Definitions.-

6.2.1 Failure.- A failure is defined as the inability of the equipment to perform the required function within the limits of the applicable detail specification.

6.2.2 Ascent.- Ascent as used in this specification is defined as the period from on-stand to __*__ ± __*__ hours after lift-off.

6.2.3 Orbital.- Orbital as used in this specification is defined as the period following satellite separation.

6.3 Oral statements.- Oral statements shall have no effect on the requirements prescribed in this document or any document referred to herein.

* To be added at a later date.

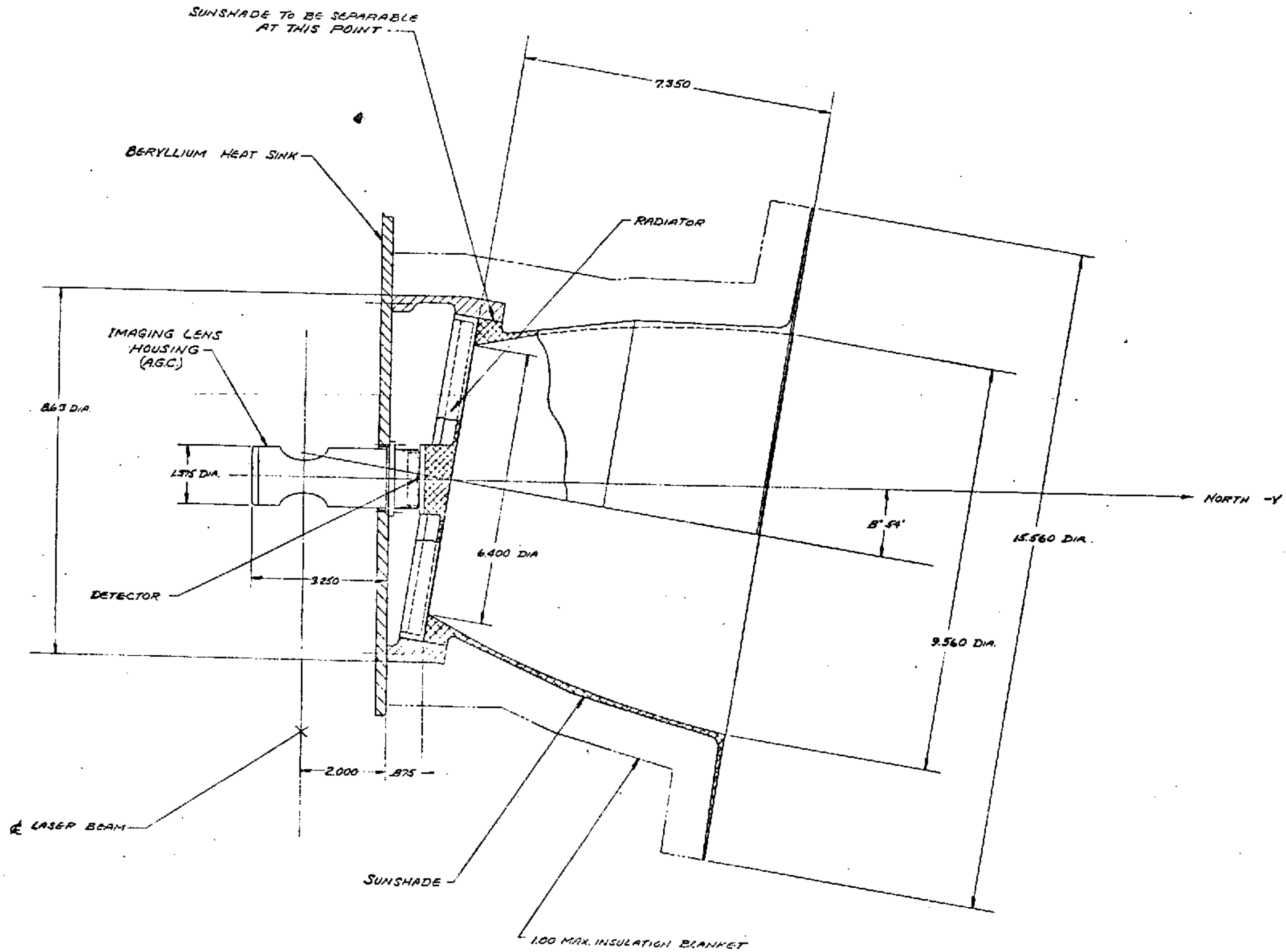

Figure 1. Envelope Drawing - Sun Shield/Radiator LCE

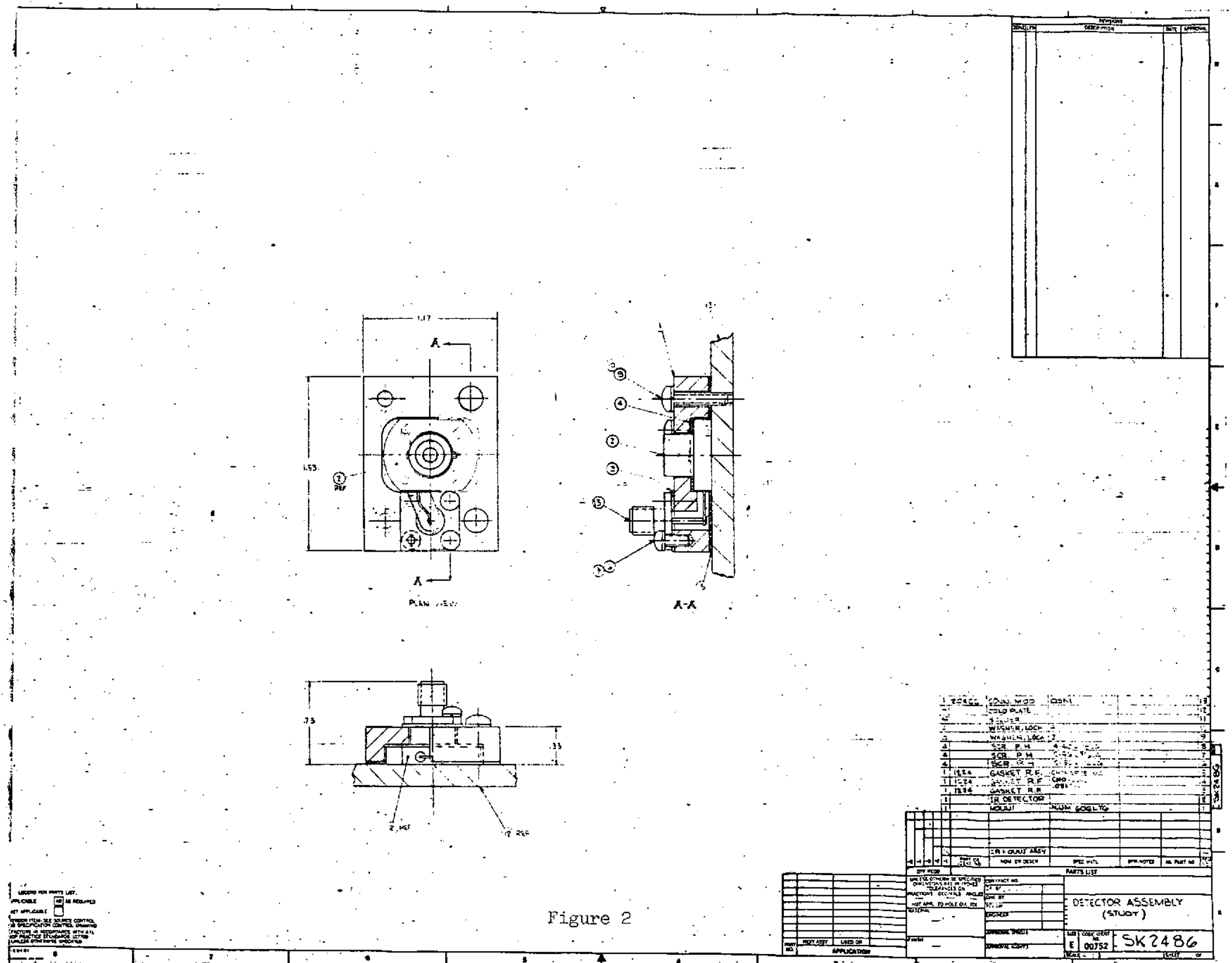

Figure 2

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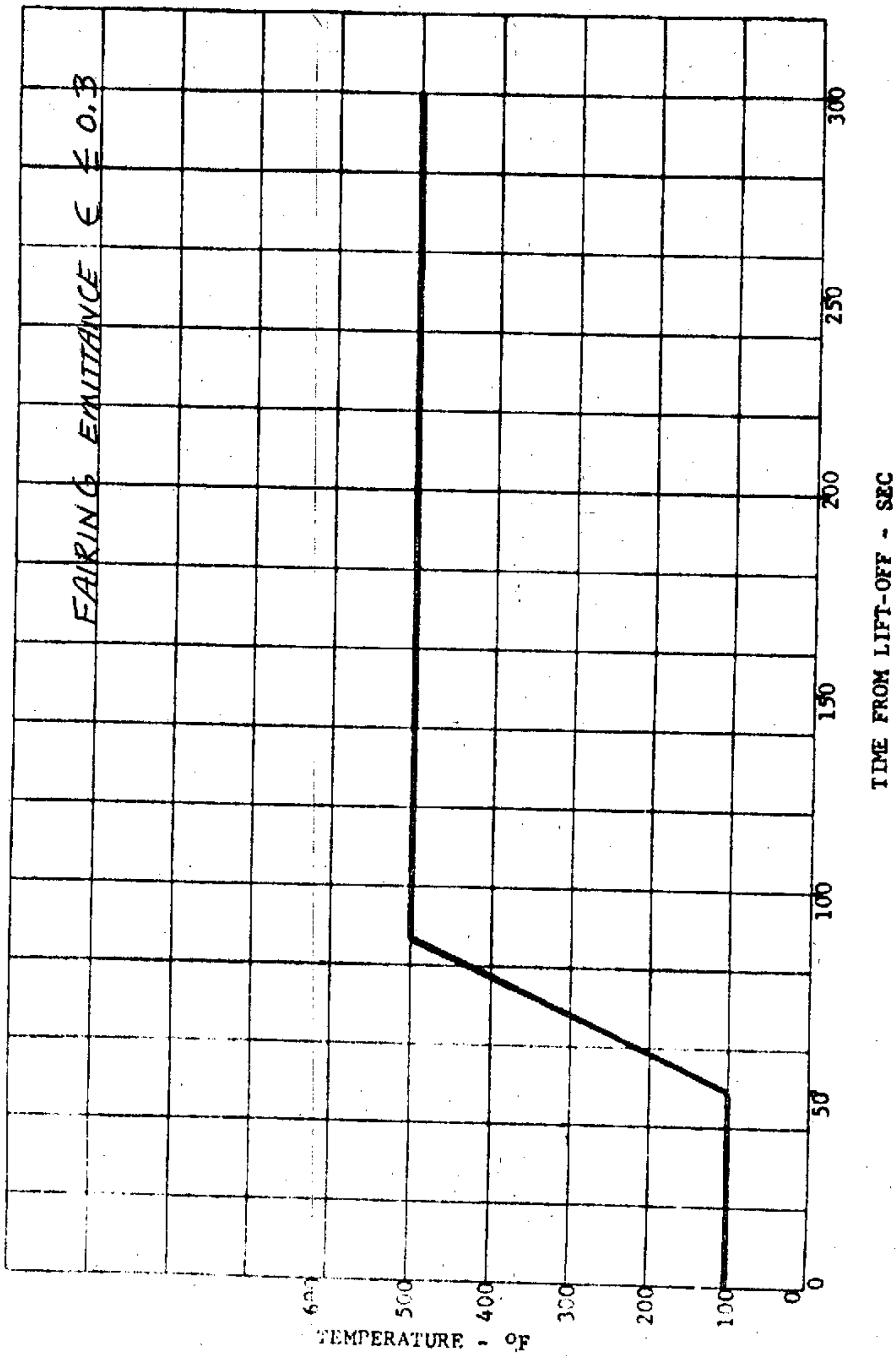

FIGURE 3 - TEMPERATURE PROFILE, PLF INSIDE SKIN