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SYNCOM ELECTRONIC PARTS RELIABILITY CONSIDERATIONS

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SYNCOM

ELECTRONIC PARTS

RELIABILITY CONSIDERATIONS

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Summary

This report very briefly describes the Syncom I Satellite and the manufacturer's parts reliability program, and lists the electronic parts used in its construction.

Spacecraft Description

a) General

The Syncom I Spacecraft was developed to demonstrate the feasibility of a "stationary" satellite which permits continuous communication between widely separated points on the surface of the earth. The satellite is placed in a circular orbit having precisely the same rotation period as the earth, and in a plane inclined about 33° from the equatorial plane. The satellite remains substantially at the same longitude, at a distance of about 22,750 nautical miles from the center of the earth, and oscillates about 33° north and south of the equator.

The satellite is equipped with a hydrogen-peroxide fueled pulse-jet system which can be controlled by ground command to achieve the exact orbital period, attitude, and position desired. A compressed nitrogen system is provided as a fine control for making small orbital and attitude corrections. In the event of failure of the nitrogen system, control can be maintained with the peroxide system alone. The peroxide system is capable of a total correction (sum of all velocity

changes) of about 350 ft./sec. and the nitrogen system capacity is about 40 ft./sec.

b) Communications System

The communication system consists of 2 redundant frequency-translation transponders each of which receives signals on two different carriers (7445.275 and 7447.000 Mc/s) and retransmits these signals on two lower carrier frequencies (1886.275 and 1888.000 Mc/s), with a nominal total output power of 2 watts. Each channel has a bandwidth of 500 Kc/s. In addition a reference c.w. signal (1881.953 Mc/s) derived from the satellite master oscillator is transmitted for use as a beacon and for range and range-rate measurements.

c) Telemetry System

The system consists of two redundant 136 Mc/s transmitters and encoders to transmit propulsion gas pressures, various temperatures, voltages and currents, solar aspect sensor outputs, and pulses to verify execution of commands controlling valves in the propulsion systems.

d) Command System

Two redundant 148 Mc/s command receivers and a decoder containing redundant tone filter channels receive and decode commands which turn communications receivers and transmitters, and telemetry transmitters and encoders on and off as required. Commands also control the valves to pulse the jets of the peroxide and nitrogen propulsion systems.

e) Control System

The control system provides a means of adjusting the orbital velocity of the spacecraft to achieve the exact synchronous orbit and position relative to the earth. It also provides for adjusting the orientation of the spacecraft axis so that the communications antenna beams are directed toward the earth. The control system consists of two units, the Hydrogen Peroxide System, and the Nitrogen (cold gas) System. Each has a radial jet for producing translation of the spacecraft, and an off center axial jet for producing a torque for changing the orientation of the axis. The jets are pulsed by ground control through the command system.

The aspect of the spacecraft is determined by pulses received via the telemetry system from an array of 5 sun sensors. Four of the sensors indicate angular position about the spin axis relative to the sun line, while the signal from the fifth, in conjunction with the signal from one of the others gives the inclination of the axis.

In order to change the velocity of the spacecraft the radial jet (which has its thrust line through the center of gravity) is pulsed at the appropriate time during each revolution of the spacecraft by signals generated by the ground support equipment. An alternate mode is provided as

a back-up to be used if the normal system fails. This permits direct pulsing of the jets by signals from the sun sensors, the appropriate sensors being selected by ground command.

In order to change the orientation of the spacecraft axis, one of the off-center axial jets is pulsed in a similar manner. This causes a small change in the orbital velocity, but a correction can be made for this if necessary by using the radial jets.

Power Supply System

The power supply consists of an array of silicon P on N solar cells protected by .006 in. glass, and mounted on the cylindrical surface of the satellite structure. A nickel-cadmium battery (17 watt hours) is provided to supply power during earth-shadow periods, and to provide the high peak current required during the launch sequence for igniting the rocket motor. The battery consists of two parallel strings of cells, each with its own charge current control. A diode isolates each string from the power bus in the event of failure.

Two redundant regulators supply the command receivers and decoders.

Separate voltage regulators, which also function as switches, supply power to each telemetry transmitter, each encoder, each communications receiver and each communications

transmitter. The regulators are turned on and off as required by signals from the command system.

The power supply is designed to maintain continuous operation of one communication system with 15% degradation of the solar cells.

Propulsion System

The Syncom I is designed to be launched into an elliptical transfer orbit by a Thor-Delta vehicle. A solid propellant "apogee kick motor" attached permanently to the spacecraft is fired by a preset timer or a command signal at or near the apogee of the transfer orbit to add the velocity necessary for a circular synchronous orbit.

Parts Reliability Considerations

Standard Electronic Parts

All "standard" electronic parts used in spacecraft are purchased to specifications prepared by the Hughes Aircraft Company from vendors qualified by Hughes. These are based on military specifications, but are more comprehensive, and include requirements for demonstration of the suitability of the part for operation in a space environment. Examples of such a specification are given in Appendix I.

All parts are subjected to thorough incoming inspection, are assigned Hughes part numbers, and are placed in a bonded store.

Special Parts

Special electronic and electro-mechanical parts for which no background reliability information is available are given an extensive series of tests to provide as much reliability information as possible in the available time. The traveling wave tube, antenna switching relay, and jet valves for the propulsion system have been thoroughly tested.

For example, in order to estimate the reliability of the traveling wave tube, accelerated life tests were performed by operating some sample tubes at heater power (and therefore cathode temperature) considerably above normal. Other tubes were operated at normal voltage as a control. Some tubes remained on life test for almost one year. The tubes were also tested at vibration levels considerably exceeding those expected during launch.

In the case of the antenna switching relay and jet valves, a test plan was carried out to determine the effects of prolonged exposure to the space environment on these devices since there was danger of "cold-welding" of contacts, or excessive friction between moving parts. Relays designed for R.F. switching were found to be unsatisfactory from a reliability standpoint, so a standard D.C. type relay was adapted for this function, and successfully passed the environmental and life tests.

Parts List

Appendix II is a list of Electronic Parts used in Syncom I. This list is reproduced from Syncom I Reliability Report #3 - March 1963 - published by the Hughes Aircraft Company, and shows the parts used in each subassembly.

Appendix III is a summary of the list in Appendix II, showing only the total number of each type of part used.

Appendix I

Examples of Manufacturer's Parts Procurement Specifications

1. SCOPE

1.1 This specification covers ultra-fast switching, silicon diodes for which special requirements (including a 100-percent screening, 240-hour intermittent life test) are imposed to assure performance reliability in the space and lunar environments for which the diodes are intended.

1.2 Maximum Ratings

AT T_A = 25° C					AMBIENT TEMPERATURE RANGE (°C)		ALTITUDE
V_R (Vdc)	I_O (1) (mAdc)	V_F AT I_F = 20 mAdc (Vdc)	i_f (mAdc)	P (mW)	OPERATING	STORAGE	(FEET)
50	75	1.0	225	250	-65 TO +175	-150 TO +175	UNLIMITED

(1) This average rectified output current, which is specified at an ambient temperature of 25° C, is for an expected life equal to or greater than 1,000 hours. For current derating at ambient temperatures higher than 25° C, see Figure 1.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the latest issue in effect shall apply to this specification to the extent specified herein:

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

MIL-S-19500 Semiconductor Devices, General Specification for

3. REQUIREMENTS

3.1 General.- The diodes shall meet the requirements specified in Tables II through IV of this specification.

3.2 Marking.- The body of each diode shall be clearly marked with the manufacturer's name and/or trademark and with either: (a) the manufacturer's part number and a stripe (or other suitable designation) to identify the cathode, or (b) conventionally coded color stripes near the cathode end identifying the numerical portion of the manufacturer's part number. Marking shall remain legible after all tests.

3.3 Lead Material.- The lead material shall be standard-type Dumet, flashed with gold.

3.4 Instability.- During the test specified in 4.4.3.1, no instability shall be displayed by the oscilloscope trace of the reverse characteristic.

3.5 Hard-Vacuum Environment.- Following the test specified in 4.4.3.2, the diodes shall show no evidence of physical damage. Based on a statistical analysis, there shall be no significant differences, at the 90-percent level of confidence, between the mean values of V_F and of I_R after the test, compared to the mean values as measured before the test.

3.6 Low-Temperature Exposure.- Following the test specified in 4.4.3.3, the diodes shall show no evidence of physical damage. Based on a statistical analysis, there shall be no significant differences, at the 90-percent level of confidence, between the mean values of V_F and of I_R after the test, compared to the mean values as measured before the test.

3.7 Sterilization Capability.- Each part shall be capable of withstanding two 36-hour cycles of exposure to a temperature of 125° C, and a 24-hour exposure to an atmosphere consisting of a mixture of 12 percent ethylene oxide and 88 percent trichlorofluoromethane (Freon 12) by weight, at a temperature of 37.8° C and a relative humidity of 30 to 50 percent, without degradation of applicable performance requirements. (The parts shall not be sterilized before shipment.)

3.8 Cleanliness.- The diodes shall be delivered with the surfaces clean and free of oil, grease, or particle contamination.

3.9 Screening Tests.- All diodes shall have been subjected to the 100-percent screening tests specified in Table II.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of Tests.- The inspection and testing of the diodes shall be classified as follows:

(a) Qualification tests. (See 4.2.)

(b) Acceptance tests. (See 4.3.)

4.1.1 Additional Tests.- Nothing shall prevent the manufacturer from taking such additional samples and performing such additional tests as he may deem necessary or desirable to assure conformance to the requirements of this specification. Additional tests may be conducted by Hughes Aircraft Company to verify data submitted by the manufacturer.

4.2 Qualification Tests.- Hughes Aircraft Company is responsible for the performance of the specified qualification tests. These tests, which shall consist of all Group A, B, and C tests specified in Tables II, III, and IV, will be conducted by, or at a laboratory designated by, Hughes Aircraft Company, to determine whether the diodes meet the requirements of this specification.

4.2.1 Qualification Test Sample and Routine.- The total qualification test sample, consisting of 30 specimens which have not been previously subjected to the intermittent life test by the manufacturer, shall undergo all the tests of Group A, Subgroups 1 through 4, specified in Table II (see page 8). Ten of these specimens shall then be subjected to the tests specified in Subgroups 1 through 5 of Group B, Table III. Diodes from this group of 10 which have not catastrophically failed the Group B tests shall be recombined with the remaining 20 specimens. The combined sample shall then undergo the Group C tests specified in Table IV. All tests shall be performed in the order indicated in Tables II, III, and IV.

4.2.2 Post-Test End Points.- The designated end-point tests shall be performed after each qualification test specified in Subgroup 4 of Group A and Subgroups 2, 3, and 4 of Group B; and after each test of Group C.

4.3 Acceptance Tests.- The manufacturer is responsible for performing all specified acceptance tests before the parts are shipped to Hughes Aircraft Company. The Group A acceptance tests shall be performed as specified in Table II, on each part number ordered. The Group B acceptance tests shall be performed on parts selected from each homogeneous population (manufacturing lot) from which parts had been drawn for the Group A acceptance tests. The Group B tests may be performed on any part number listed in the part-number table. (The Group C tests of Table IV shall not apply.) Tests within each subgroup shall be conducted in the order specified.

4.3.1 Test Equipment and Facilities.- The manufacturer may use his own or any other laboratory facilities approved by Hughes Aircraft Company. The quality of the facilities and the accuracy of the equipment shall be sufficient to assure performance of the Group A and B acceptance tests within the specified requirements.

4.3.2 Acceptance Test Sample Selection

4.3.2.1 100-Percent Screening Tests.- All diodes supplied against this specification shall be subjected to the 100-percent screening tests specified in Subgroups 2 through 4 of Group A.

4.3.2.2 Sampling Tests.- The number of specimens selected for the remaining acceptance tests (Subgroup 1 of Group A and Subgroups 1 through 5 of Group B) shall be that minimum sample size listed in Table I necessary to assure, with 90 percent confidence, the Lot Tolerance Percent Defective (LTPD) specified in Tables II and III.

4.3.2.3 Small Lot Procurement.- If the size of the lot shipped against one purchase order, for each part listed in the part-number table, is less than the minimum sample size specified in Table I, acceptance tests for that lot shall be limited to the Group A tests only, all of which shall be performed on a 100-percent inspection basis.

4.3.3 Screening-Test Rejections.- Defectives found during the 100-percent screening tests (see 4.3.2.1 and 4.3.2.3) shall be eliminated from the lot.

4.3.4 Sampling-Test Procedure

4.3.4.1 Additional Samples.- After the test has started, an additional quantity of specimens may be added to the initial sample, but this may be done only once for any subgroup and the added specimens must be subjected to all the tests within a subgroup. The final total sample (initial and added specimens) shall determine the new acceptance number. The total defects of the initial and additional samples shall be additive and must comply with the specified LTPD.

4.3.4.2 Tightened Inspection.- Tightened inspection may be instituted on lots that have failed acceptance. Tightened inspection is obtained by testing to an LTPD equal to, or less than half the specified initial LTPD. A lot which fails tightened inspection shall not be retested and shall not be shipped to Hughes Aircraft Company.

4.3.4.3 Disposition of Sampling-Test Specimens.- Specimens which have been subjected to the destructive tests of Group B shall not be shipped to Hughes Aircraft Company.

4.3.5 Post-Test End Points.- The designated acceptance-test end points shall be measured after the intermittent life test specified in Subgroup 4 of Group A, and after completion of all specified tests in each of Subgroups 2, 3, and 4 of Group B.

TABLE I

MINIMUM SIZE OF SAMPLE TO BE TESTED TO ASSURE, WITH A 90 PERCENT CONFIDENCE, A LOT TOLERANCE PERCENT DEFECTIVE (LTPD) OR LIFE-TEST FAILURE RATE (λ) NO GREATER THAN THAT SPECIFIED

ACCEPTANCE NUMBER (a)	MAXIMUM LOT TOLERANCE PERCENT DEFECTIVE (LTPD) OR LIFE-TEST FAILURE RATE (λ) (2)					
	15	10	7	5	3	2
(r = a + 1)	MINIMUM SAMPLE SIZES (3)					
0	15 (0.34)	22 (0.23)	32 (0.16)	45 (0.11)	76 (0.07)	116 (0.04)
1	25 (1.4)	38 (0.94)	55 (0.65)	77 (0.46)	129 (0.28)	195 (0.18)
2	34 (2.24)	52 (1.6)	75 (1.1)	105 (0.78)	176 (0.47)	266 (0.31)
3	43 (3.2)	65 (2.1)	94 (1.5)	132 (1.0)	221 (0.62)	333 (0.41)
4	52 (3.9)	78 (2.6)	113 (1.8)	158 (1.3)	265 (0.75)	398 (0.50)
5	60 (4.4)	91 (2.9)	131 (2.0)	184 (1.4)	308 (0.85)	462 (0.57)
6	68 (4.9)	104 (3.2)	149 (2.2)	209 (1.6)	349 (0.94)	528 (0.62)
7	77 (5.3)	116 (3.5)	166 (2.4)	234 (1.7)	390 (1.0)	589 (0.67)
8	85 (5.6)	128 (3.7)	184 (2.6)	258 (1.8)	431 (1.1)	648 (0.72)
9	93 (6.0)	140 (3.9)	201 (2.7)	282 (1.9)	471 (1.2)	709 (0.77)
10	100 (6.3)	152 (4.1)	218 (2.9)	306 (2.0)	511 (1.2)	770 (0.80)

(2) The life-test failure rate, lambda (λ), is defined as the LTPD per 1,000 hours.

(3) The minimum quality (approximate AQL) required to accept, on the average, 19 of 20 lots is shown in parentheses for information only.

4.3.6 Certification.- The supplier shall certify with each shipment that:

(a) The acceptance tests specified in 4.3 have been performed.

(b) The diodes meet all the specified requirements.

(c) The shipment does not contain diodes from a production lot that has failed tightened inspection (see 4.3.4.2).

Any deviations from this certification instruction shall be explained in detail in writing.

4.3.7 Data Submittal.- Within two weeks after shipment of the diodes, the manufacturer shall forward to Hughes Aircraft Company the following data, which shall be certified by a responsible company official:

(a) Test Records.- Complete records of all the acceptance tests performed by the manufacturer or his designated agency. The data supplied shall be variables data, unless specifically waived by Hughes Aircraft Company. It shall be reported in a manner that will facilitate following the behavior of each specimen from the beginning to the end of each test, and shall include explanatory comments which will aid in evaluating any unusual or abnormal events that may have occurred during the tests.

(b) Test-Equipment Report.- A detailed report identifying the test equipment by manufacturer's name, model number, and instrument calibration date.

(c) Quality-Control Documentation.- Evidence that conclusively shows that the manufacturer employs a recognized statistical quality-control procedure. This requirement is not to be construed as including proprietary information. The information shall be submitted only with the initial order and need be resubmitted only after the manufacturer has made a significant change in the procedures.

At least three copies of the data and report shall be sent to the procurement activity of Hughes Aircraft Company. Two of the copies shall be enclosed in a separate sealed envelope marked: "Attention: Components Department, M.S. D-147, Hughes Aircraft Company." The data forwarded under subparagraphs (a) and (b) above shall be marked "Code RA-1"; that submitted under subparagraph (c) shall be marked "Code RA-2." Acceptance of the shipment of parts shall be contingent upon acceptance by Hughes Aircraft Company of the data submitted.

4.4 Methods of Examination and Test

4.4.1 Standard Test Conditions.- Unless otherwise specified, all measurements and tests shall be performed at ambient pressure and humidity, and at an ambient temperature of 25° C ±3° C, with no direct draft on the diodes.

4.4.2 MIL-S-19500 Tests.- The tests described in 30.1, 30.2, 30.6, 30.9, 30.13, 40.1, 40.5, 40.6, 40.7.5, 40.8, 40.10, 40.13, 40.14, 40.16, 40.18, 40.20, 60.1.4, 60.1.8, 60.1.10, and 60.1.11.2 of MIL-S-19500 Appendix C, shall apply to these diodes, with the following exceptions and modifications:

(a) Detail Requirements.- References throughout to 3.1 of MIL-S-19500 shall be construed as pertaining to Tables II, III, and IV of this specification.

(b) Visual and Mechanical Examination.- In 30.13 of MIL-S-19500, Appendix C, the reference to 3.8 shall not apply. The marking shall be as specified in 3.2 of this specification.

(c) Barometric Pressure, Reduced.- In 40.1 of MIL-S-19500, Appendix C, the diode shall be electrically insulated from the test chamber, but a heat sink is not required. Using the oscilloscope waveform, I_R shall be monitored to observe any sudden variations indicating deterioration of the diode under test conditions.

(d) Lead Fatigue.- Devices subjected to the lead-fatigue test (40.5 of MIL-S-19500, Appendix C) may be selected from those which fail Group A and B inspection.

(e) Moisture Resistance.- In 40.6 of MIL-S-19500, Appendix C, subparagraph (a) shall be omitted.

(f) Intermittent Life.- All diodes shall be subjected to the intermittent life test (40.7.5 of MIL-S-19500, Appendix C) for a total period of 240 hours. The test current specified in Table II shall be applied intermittently, 15 minutes on and 5 minutes off. Following the test, the diodes shall be subjected to the end-point tests specified. The lot shall be acceptable if not more than 5 percent of the lot fails the test. Diodes (from acceptable lots) that have failed this test shall be eliminated from the lot but shall be preserved and shall be shipped to Hughes Aircraft Company in clearly marked, separate packages (see 5.1.2) for further study.

(g) Shock.- In 40.10 of MIL-S-19500, Appendix C, the test shall be performed with the diode not operating. The diode shall be subjected to five 500-G shocks in each of two directions along each of three mutually perpendicular axes (total of 30 shocks). The shock duration shall be approximately 1 millisecond.

(h) Vibration.- In 40.18 and 40.20 of MIL-S-19500, Appendix C, the tests shall be performed with the diode not operating. The peak acceleration shall be 10 G (instead of 20 G).

4.4.3 Supplementary Tests

4.4.3.1 Instability.- The device shall be swept through the reverse characteristic to 500 uAdc and the trace displayed on an oscilloscope. At the same time, the device shall be subjected to shocks with a minimum peak acceleration of 50 G, at a rate of 20 shocks per second for 2 seconds. (An acceptable alternative shock procedure may be substituted.) The reverse trace on the oscilloscope shall be observed for instability. (See 3.4.)

4.4.3.2 Hard-Vacuum Environment.- Before the test, the forward voltage and reverse currents of the recombined qualification test sample (see 4.2.1) shall be measured as

specified, under standard test conditions. The diodes shall be placed within a suitable container, which shall be evacuated to a pressure of 10^{-7} millimeters of mercury, or below. The pressure shall be maintained at 10^{-7} millimeters of mercury, or below, for 48 hours. The diodes shall then be removed from the container, shall be examined for physical damage, and the forward voltage and reverse current measured again. The data shall be plotted on Keuffel and Esser number 359-23 probability paper, and the results analyzed statistically. (See 3.5.)

4.4.3.3 Low-Temperature Exposure.- This test may be performed simultaneously with the hard-vacuum environment test specified in 4.4.3.2; otherwise it shall be performed on all qualification-test specimens which have survived that test without catastrophic failure. The diodes shall be mounted or suspended on thermal insulators and shall be placed within a metallic container, with the body of the diodes at least 1 inch away from the inner surface of the container. Connection leads shall be brought out of the container from the terminals of 6 of the diodes, and a thermocouple device shall be attached to the surface of each of these diodes, within the container, to monitor the temperature. The temperature of the specimens shall be gradually reduced, at a rate not exceeding -70° C per hour, until it has reached at least -150° C, or as near that of liquid nitrogen (-196° C) as can be attained. During the entire cycle of low-temperature exposure, the 6 specimens to which the leads have been connected shall be operated at the specified rms voltage, and the rectified output current shall be measured at the following temperatures: -45°, -115°, and the lowest temperature attained. The temperature of the specimens shall be maintained at -150° C, or below, for 48 hours, and shall then be gradually raised, at a rate not exceeding 70° C per hour, until it has returned to room ambient conditions. The rectified output current shall be measured again at the lowest temperature attained, at -115° C, and at -45° C, on the ascending cycle. The diodes shall be removed from the container, shall be examined for physical damage, and the forward voltage and reverse current shall be measured. The data shall be plotted on Keuffel and Esser number 359-23 probability paper; and the results analyzed statistically. (See 3.6.)

4.4.3.4 Sterilization Capability

TABLE II.- GROUP A QUALIFICATION AND ACCEPTANCE TESTS AND REQUIREMENTS

(4) TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM BOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 1						
30.13	Visual and Mechanical Examination (except 30.9 of MIL-S-19500)	See *4.4.2(b)	5.0	--	(See *3.2)		--
	Subgroup 2						
60.1.4	Forward Voltage	I_F = 20 mAdc	100% inspection	V_F	--	1.0	Vdc
60.1.10	Reverse Current	V_R = -50 Vdc		I_R	--	0.1	µAdc
30.1	Breakdown Voltage	I_R = -5.0 µAdc		BV	75	--	Vdc
30.2	Capacitance	V_R = 0 f = 1.0 mc		C	--	1.0	farad x10^{-12}
60.1.11.2	Reverse Recovery Time	I_F = 10 mAdc V_R = -6.0 Vdc R_L = 100 ohms		t_{rr}	--	2	sec x10^{-9}
*4.4.3.1	Instability				(See *3.4)		
	Subgroup 3						
30.6	High-Temperature Operation	T_A = 150° ±3° C	100% inspection				
	Test Point:						
60.1.10	Reverse Current	V_R = -50 Vdc		I_R	--	100	µAdc
	Subgroup 4						
40.7.5	Intermittent Life	T_A = 25° ±3° C V_{ac} = 30 Vrms R_L = 200 ohms 240 hours See *4.4.2(f)	100% inspection	--	--	--	--
	End Points:						
60.1.4	Forward Voltage	I_F = 20 mAdc		V_F	--	1.1	Vdc
60.1.10	Reverse Current	V_R = -50 Vdc		I_R	--	0.2	µAdc

(4) See footnote, page 11

TABLE III.- GROUP B QUALIFICATION AND ACCEPTANCE TESTS AND REQUIREMENTS

(4) TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM-BOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 1						
30.9	Physical Dimensions	--	10.0	--	(See Fig.2)		--
	Subgroup 2						
40.13	Soldering	--	10.0	--	--	--	--
40.14	Temperature Cycling	MIL-STD-202, Method 102, Condition C, except Step 3 high temperature = 175° ±3° C; 5 cycles					
40.6	Moisture Resistance	See*4.4.2(e)		--	--	--	--
	End Points: (Same as for Sub-group 4, Table II)						
	Subgroup 3						
40.10	Shock	See*4.4.2(g)	10.0	--	--	--	--
40.18	Vibration, Fatigue	f = 60 cps See*4.4.2 (h)		--	--	--	--
40.20	Vibration, Variable Frequency	See*4.4.2 (h)		--	--	--	--
40.16	Thermal Shock	T_1 = 100° C T_2 = 0° C		--	--	--	--
	End Points: (Same as for Sub-group 4, Table II)						

(4) See footnote, page 11

TABLE III (CONTINUED)

(4) TEST PARAGRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYMBOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 4						
40.1	Barometric Pressure, Reduced	V_R = -50 Vdc (60 seconds operation) Pressure = 0.315 inch Hg See*4.4.2 (c)	10.0	--	--	--	--
40.8	Salt Atmosphere (Corrosion)	48 hours		--	--	--	--
	End Points: (Same as for Subgroup 4, Table II)						
	Subgroup 5						
40.5	Lead Fatigue	See*4.4.2 (d)	10.0	--	--	--	--

TABLE IV.- GROUP C TESTS AND REQUIREMENTS (QUALIFICATION ONLY)

[4] TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM-BOL	LIMITS MIN	LIMITS MAX	UNIT
	Pre-Group C Measurements: (Same as Subgroup 4, Table II, end points)						
*4.4.3.2	Hard-Vacuum Environment	Pressure = 10^{-7} mm Hg or below; 48 hours					
	End Points: (Same as for Subgroup 4, Table II)					(See *3.5)	
*4.4.3.3	Low-Temperature Exposure	Reduce T_A at rate not exceeding -70° C/hour to -150° C or below; maintain at lowest temperature for 48 hours; then raise T_A at same max rate to 25° C					
	Test Point (6 specimens only):						
60.1.8	Average Rectified Output Current	V_{ac} = 30 Vrms R_L = 200 ohms (Measure I_o at -45°, -115° C, and at lowest temperature attained, on both descending and ascending cycles)		I_o			
	End Points: (Same as for Subgroup 4, Table II)					(See *3.6)	
*4.4.3.4	Sterilization Capability					(See *3.7)	

[4] Numbers marked with an asterisk refer to paragraphs in this specification; unmarked numbers, to paragraphs in MIL-S-19500, Appendix C.

5. PREPARATION FOR DELIVERY

5.1 Packaging

5.1.1 Acceptable Parts.- All acceptable parts shipped to Hughes Aircraft Company shall be suitably packaged, either individually or in groups of not more than 10 units, in sealed containers provided with one or more transparent surfaces through which a parts count can be made without removal of the contents. Each package shall contain only diodes with the same part number. The large external shipping container, which may contain unit packages of different part number, shall be constructed so as to ensure safe and undamaged delivery of the parts. Unit packages which are received in a broken or injured condition will be returned to the supplier as unacceptable.

5.1.2 Failed Specimens.- Parts submitted for purposes other than for use, such as specimens that have failed the intermittent life test and are being shipped to Hughes Aircraft Company for further study, shall be packaged as specified in 5.1.1, but with the additional marking specified in 5.2.2.

5.2 Marking of Packages

5.2.1 Acceptable Parts.- Both the unit packages and the large external shipping containers shall be clearly marked with the manufacturer's name and/or trademark, the manufacturer's part number, the lot identification or date code, and with the Hughes number in parentheses.

5.2.2 Failed Specimens.- Packages in which failed specimens (see 5.1.2) are shipped shall be marked as specified in 5.2.1, and with the following additional marking: "TESTED SPECIMENS. DO NOT USE."

6. NOTES

6.1 Definitions, Abbreviations, and Symbols.- The terms used in this specification are defined in Appendix A, and the abbreviations and symbols are defined in Appendix B of MIL-S-19500.

6.2 Application Notes

6.2.1 Current Derating.- The average rectified output current is derated as shown in Figure 1, assuming a constant failure rate over the entire derated range.

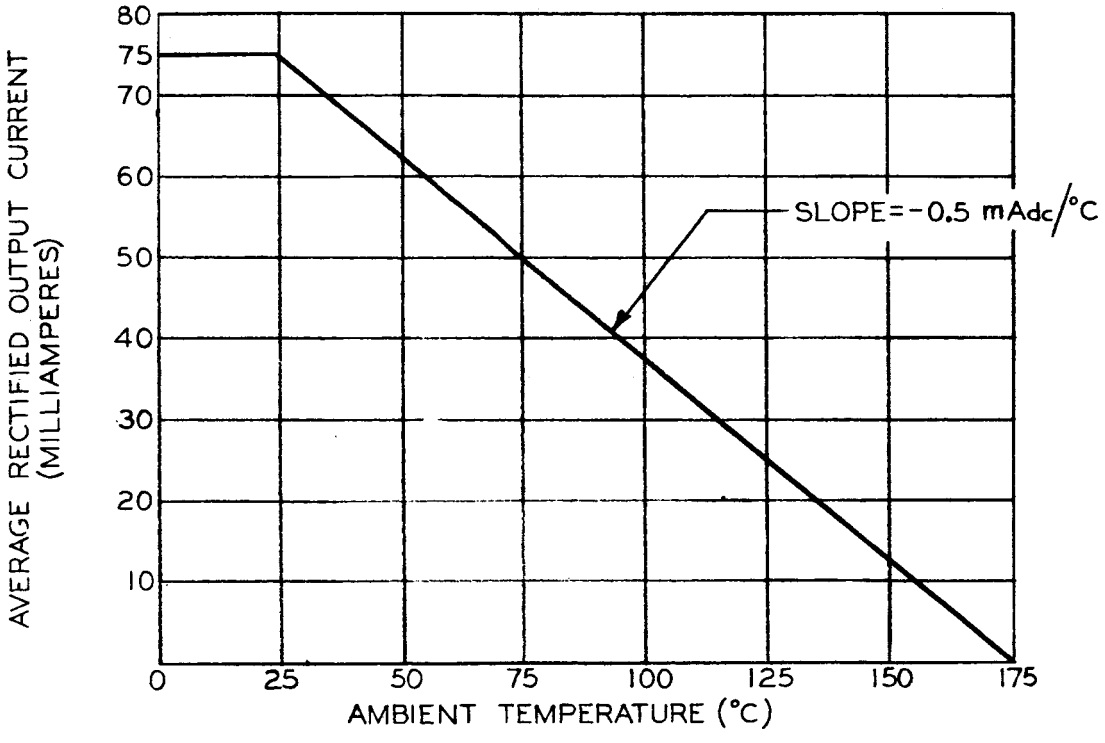


FIGURE 1

DERATING OF AVERAGE RECTIFIED OUTPUT CURRENT

6.3 Approval of Manufacturer

6.3.1 Performance Ability.- The manufacturer shall have demonstrated his ability to supply uniform, reliable products as specified below.

6.3.2 Approval of Military Qualified Products List.- As a minimum requirement, the capability of the manufacturer to supply semiconductor devices of the type described in this specification and in accordance with MIL-S-19500 shall be evidenced by inclusion of at least one of his products on a Military Qualified Products List.

6.3.3 Process Control.- The manufacturer shall submit sufficient information regarding product flow, process control, and any other related data that will establish his understanding and control of the product.

6.3.4 Technical Competence.- The manufacturer shall have demonstrated, by published articles or other information, that he is aware of the behavior of his product. Especially pertinent are reliability programs and statistical studies which aid in predicting failure rates and in determining derating for a-c and d-c stress levels.

6.3.5 Supplementary Information.- Manufacturer acceptability may be determined by the use of other information, including:

(a) Test data available within Hughes Aircraft Company.

(b) Test data from interservice data-exchange programs (IDEP).

(c) Previous history of the manufacturer (adherence to delivery schedules, pricing policy, etc.).

(d) The manufacturer's participation in other high-reliability programs.

(e) Field failure reports.

In recognition of the variable levels of confidence of the aforementioned items, proper consideration will be given to their significance.

6.4 Off-Premises Qualification Testing.- When qualification testing is performed at facilities other than those of Hughes Aircraft Company, the following requirements shall apply:

6.4.1 Preparation for Shipment.- Tested specimens shall be packaged in the condition in which they emerge upon conclusion of the final test, and in accordance with 5.1.2.

6.4.2 Data Submittal.- Data shall be submitted in accordance with 4.3.7, except that references to "acceptance testing performed by the manufacturer" shall be interpreted as "qualification testing performed by the off-premises facility," and references to the manufacturer's quality-control and production procedures shall not apply.

6.5 Incoming and Receiving Inspection

6.5.1 Preliminary Inspection.- In order to verify the shipping manifest, the incoming-inspection facility of Hughes Aircraft Company shall make a visual count of

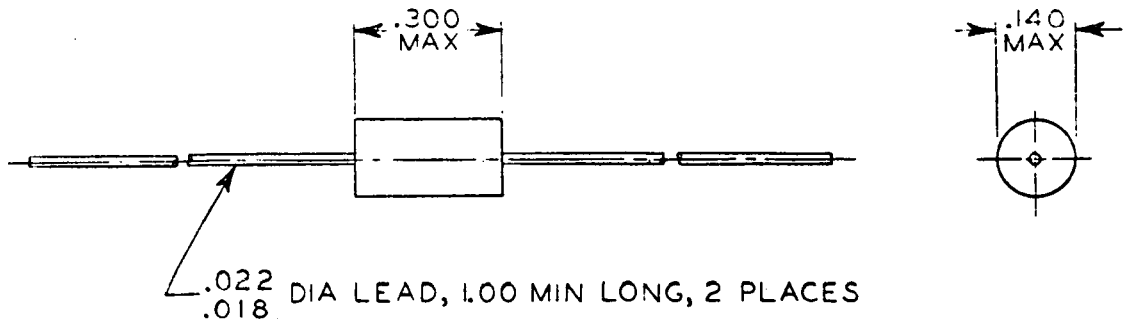
the parts without opening the transparent containers. Packages which are received in a broken or damaged condition shall be returned to the sender as unacceptable.

6.5.2 Disposition of Study Specimens.- Containers marked "TESTED SPECIMENS, DO NOT USE" shall be forwarded to the Components Department, Hughes Aircraft Company, Culver City.

6.5.3 Disposition of Usable Parts.- All other packages containing usable parts shall be placed in a bonded storage area, together with the accompanying test data, which shall be suitably identified to correspond with the parts received. Both the parts and the test data shall be retained in the bonded area until they have been released by the Components Department.

DO NOT SCALE

LIMITS UNLESS OTHERWISE SPECIFIED: .XXX =± .XX =± X° =±



SCHEMATIC DIAGRAM

FIGURE 2

PART-NUMBER TABLE

HUGHES NUMBER	FAIRCHILD PART NUMBER
X988718-1	

PROCUREMENT BY HUGHES AIRCRAFT COMPANY IS LIMITED TO THE MANUFACTURERS LISTED HEREIN:

FAIRCHILD SEMICONDUCTOR CORP., MOUNTAIN VIEW, CALIF. (CODE IDENT. NO. 07263)

SPECIFICATION CONTROL DOCUMENT

APPROVED / ISSUE DATE	HUGHES AIRCRAFT COMPANY CULVER CITY, CALIFORNIA	STANDARD X988718 PAGE 16 OF 16	REVISED
PROCUREMENT SPECIFICATION NONE	SEMICONDUCTOR DEVICE, DIODE — ULTRA-FAST SWITCHING		

FORM 3109 CC REV. 10-60

CODE IDENT. NO. 82577

1. SCOPE

1.1 This specification covers silicon, NPN, high-power transistors for which special requirements (including a 100-percent screening, 240-hour intermittent life test) are imposed to assure performance reliability in the space and lunar environments for which the transistors are intended.

1.2 Maximum Ratings (See 6.1)

HUGHES NUMBER 988817-	AT T_A = 25° C			AT T_C = 25° C	AMBIENT TEMPERATURE RANGE (° C)		ALTITUDE
	V_{CEO} (Vdc)	V_{CEX} (Vdc)	V_{EBO} (Vdc)	(1) P_C (W)	OPERATING	STORAGE	(FEET)
1	60	80	6	40	-65 TO +175	-150 TO +175	UNLIMITED
2	80	120					

(1) This collector power dissipation, which is specified at a case temperature of 25° C, is for an expected life equal to or greater than 1,000 hours. For power derating at case temperatures higher than 25° C, see Figure 1.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the latest issue in effect, shall apply to this specification to the extent specified herein:

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

MIL-S-19500 Semiconductor Devices, General Specification for

3. REQUIREMENTS

3.1 General.- The transistors shall meet the requirements specified in Tables II through IV of this specification.

3.2 Marking.- Each transistor shall be clearly marked with the manufacturer's name and/or trademark and the manufacturer's part number. Marking shall remain legible after all tests.

3.3 Terminal Material.- The terminal material shall be either (a) nickel-iron, flashed with copper and plated with nickel, or (b) Kovar, nickel-plated and flashed with gold.

3.4 Hard-Vacuum Environment.- Following the test specified in 4.4.3.2, the transistors shall show no evidence of physical damage. Based on a statistical analysis, there shall be no significant differences, at the 90-percent level of confidence, between the mean values of I_{CBO} and of h_{FE} after the test, compared to the mean values as measured before the test.

3.5 Los-Temperature Exposure.- Following the test specified in 4.4.3.3, the transistors shall show no evidence of physical damage. Based on a statistical analysis, there shall be no significant differences, at the 90-percent level of confidence, between the mean values of I_{CBO} and of h_{FF} after the test, compared to the mean values as measured before the test.

3.6 Sterilization Capability.- Each part shall be capable of withstanding two 36-hour cycles of exposure to a temperature of 125° C, and a 24-hour exposure to an atmosphere consisting of a mixture of 12 percent ethylene oxide and 88 percent trichlorofluoromethane (Freon 12) by weight, at a temperature of 37.8° C and a relative humidity of 30 to 50 percent, without degradation of applicable performance requirements. (The parts shall not be sterilized before shipment.)

3.7 Cleanliness.- The transistors shall be delivered with the surfaces clean and free of oil, grease, or particle contamination.

3.8 Screening Tests.- All transistors shall have been subjected to the 100-percent screening tests specified in Table II.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of Tests.- The inspection and testing of the transistors shall be classified as follows:

(a) Qualification tests. (See 4.2.)

(b) Acceptance tests. (See 4.3.)

4.1.1 Additional Tests.- Nothing shall prevent the manufacturer from taking such additional samples and performing such additional tests as he may deem necessary or desirable to assure conformance to the requirements of this specification. Additional tests may be conducted by Hughes Aircraft Company to verify data submitted by the manufacturer.

4.2 Qualification Tests.- Hughes Aircraft Company is responsible for the performance of the specified qualification tests. These tests, which shall consist of all Group A, B, and C tests specified in Tables II, III, and IV, will be conducted by, or at a laboratory designated by, Hughes Aircraft Company, to determine whether the transistors meet the requirements of this specification.

4.2.1 Qualification Test Sample and Routine.- The total qualification test sample, consisting of 30 specimens which have not been previously subjected to the intermittent life test by the manufacturer, shall undergo all the tests of Group A, Subgroups 1 through 5, specified in Table II (see page 8). Ten of these specimens shall then be subjected to the tests specified in Subgroups 1 through 5 of Group B, Table III. Transistors from this group of 10 which have not catastrophically failed the Group B tests shall be recombined with the remaining 20 specimens. The combined sample shall then undergo the Group C tests specified in Table IV. All tests shall be performed in the order indicated in Tables II, III, and IV.

4.2.2 Post-Test End Points.- The designated end-point tests shall be performed after each qualification test specified in Subgroup 5 of Group A and Subgroups 2, 3, and 4 of Group B; and after each test of Group C.

4.3 Acceptance Tests.- The manufacturer is responsible for performing all specified acceptance tests before the parts are shipped to Hughes Aircraft Company. The Group A acceptance tests shall be performed as specified in Table II, on each part number ordered. The Group B acceptance tests shall be performed on parts selected from each homogeneous population (manufacturing lot) from which parts had been drawn for the

Group A acceptance tests. The Group B tests may be performed on any part number listed in the part-number table. (The Group C tests of Table IV shall not apply.) Tests within each subgroup shall be conducted in the order specified.

4.3.1 Test Equipment and Facilities.- The manufacturer may use his own or any other laboratory facilities approved by Hughes Aircraft Company. The quality of the facilities and the accuracy of the equipment shall be sufficient to assure performance of the Group A and B acceptance tests within the specified requirements.

4.3.2 Acceptance Test Sample Selection

4.3.2.1 100-Percent Screening Tests.- All transistors supplied against this specification shall be subjected to the 100-percent screening tests specified in Subgroups 2 through 5 of Group A.

4.3.2.2 Sampling Tests.- The number of specimens selected for the remaining acceptance tests (Subgroup 1 of Group A and Subgroups 1 through 5 of Group B) shall be that minimum sample size listed in Table I necessary to assure, with 90-percent confidence, the Lot Tolerance Percent Defective (LTPD) specified in Tables II and III.

4.3.2.3 Small Lot Procurement.- If the size of the lot shipped against one purchase order, for each part listed in the part-number table, is less than the minimum sample size specified in Table I, acceptance tests for that lot shall be limited to the Group A tests only, all of which shall be performed on a 100-percent inspection basis.

4.3.3 Screening-Test Rejections.- Defectives found during the 100-percent screening tests (see 4.3.2.1 and 4.3.2.3) shall be eliminated from the lot.

4.3.4 Sampling-Test Procedure

4.3.4.1 Additional Samples.- After the test has started, an additional quantity of specimens may be added to the initial sample, but this may be done only once for any subgroup and the added specimens must be subjected to all the tests within a subgroup. The final total sample (initial and added specimens) shall determine the new acceptance number. The total defects of the initial and additional samples shall be additive and must comply with the specified LTPD.

4.3.4.2 Tightened Inspection.- Tightened inspection may be instituted on lots that have failed acceptance. Tightened inspection is obtained by testing to an LTPD equal to, or less than, half the specified initial LTPD. A lot which fails tightened inspection shall not be retested and shall not be shipped to Hughes Aircraft Company.

4.3.4.3 Disposition of Sampling-Test Specimens.- Specimens which have been subjected to the destructive tests of Group B shall not be shipped to Hughes Aircraft Company.

4.3.5 Post-Test End Points.- The designated acceptance-test end points shall be measured after the intermittent life test specified in Subgroup 5 of Group A, and after completion of all specified tests in each of Subgroups 2, 3, and 4 of Group B.

TABLE I

MINIMUM SIZE OF SAMPLE TO BE TESTED TO ASSURE, WITH A 90 PERCENT CONFIDENCE, A LOT TOLERANCE PERCENT DEFECTIVE (LTPD) OR LIFE-TEST FAILURE RATE (λ) NO GREATER THAN THAT SPECIFIED

ACCEPTANCE NUMBER (a)	MAXIMUM LOT TOLERANCE PERCENT DEFECTIVE (LTPD) OR LIFE-TEST FAILURE RATE (λ) (2)					
	15	10	7	5	3	2
(r = a + 1)	MINIMUM SAMPLE SIZES (3)					
0	15 (0.34)	22 (0.23)	32 (0.16)	45 (0.11)	76 (0.07)	116 (0.04)
1	25 (1.4)	38 (0.94)	55 (0.65)	77 (0.46)	129 (0.28)	195 (0.18)
2	34 (2.24)	52 (1.6)	75 (1.1)	105 (0.78)	176 (0.47)	266 (0.31)
3	43 (3.2)	65 (2.1)	94 (1.5)	132 (1.0)	221 (0.62)	333 (0.41)
4	52 (3.9)	78 (2.6)	113 (1.8)	158 (1.3)	265 (0.75)	398 (0.50)
5	60 (4.4)	91 (2.9)	131 (2.0)	184 (1.4)	308 (0.85)	462 (0.57)
6	68 (4.9)	104 (3.2)	149 (2.2)	209 (1.6)	349 (0.94)	528 (0.62)
7	77 (5.3)	116 (3.5)	166 (2.4)	234 (1.7)	390 (1.0)	589 (0.67)
8	85 (5.6)	128 (3.7)	184 (2.6)	258 (1.8)	431 (1.1)	648 (0.72)
9	93 (6.0)	140 (3.9)	201 (2.7)	282 (1.9)	471 (1.2)	709 (0.77)
10	100 (6.3)	152 (4.1)	218 (2.9)	306 (2.0)	511 (1.2)	770 (0.80)

(2) The life-test failure rate, lambda (λ), is defined as the LTPD per 1,000 hours.

(3) The minimum quality (approximate AQL) required to accept, on the average, 19 of 20 lots is shown in parentheses for information only.

4.3.6 Certification.- The supplier shall certify with each shipment that:

(a) The acceptance tests specified in 4.3 have been performed.

(b) The transistors meet all the specified requirements.

(c) The shipment does not contain transistors from a production lot that has failed tightened inspection (see 4.3.4.2).

Any deviations from this certification instruction shall be explained in detail in writing.

4.3.7 Data Submittal.- Within two weeks after shipment of the transistors, the manufacturer shall forward to Hughes Aircraft Company the following data,which shall be certified by a responsible company official:

(a) Test Records.- Complete records of all the acceptance tests performed by the manufacturer or his designated agency. The data supplied shall be variables data, unless specifically waived by Hughes Aircraft Company. It shall be reported in a manner that will facilitate following the behavior of each specimen from the beginning to the end of each test, and shall include explanatory comments which will aid in evaluating any unusual or abnormal events that may have occurred during the tests.

(b) Test-Equipment Report.- A detailed report identifying the test equipment by manufacturer's name, model number, and instrument calibration date.

(c) Quality-Control Documentation.- Evidence that conclusively shows that the manufacturer employs a recognized statistical quality-control procedure. This requirement is not to be construed as including proprietary information. The information shall be submitted only with the initial order and need be resubmitted only after the manufacturer has made a significant change in the procedures.

At least three copies of the data and report shall be sent to the procurement activity of Hughes Aircraft Company. Two of the copies shall be enclosed in a separate sealed envelope marked: "Attention: Components Department, Hughes Aircraft Company." Acceptance of the shipment of parts shall be contingent upon acceptance by Hughes Aircraft Company of the data submitted.

4.4 Methods of Examination and Test

4.4.1 Standard Test Conditions.- Unless otherwise specified, all measurements and tests shall be performed at ambient pressure and humidity, and at an ambient temperature of 25° ±5° C, with no direct draft on the transistors.

4.4.2 MIL-S-19500 Tests.- The tests described in 30.6, 30.7, 30.9, 30.13, 40.1, 40.6, 40.7.5, 40.8, 40.10, 40.13, 40.14, 40.15, 40.16, 40.17, 40.18, 40.20, 50.1, 50.4, 50.6, 50.25, 50.33, and 50.40 of MIL-S-19500, Appendix C, shall apply to these transistors, with the following exceptions and modifications:

(a) Detail Requirements.- References throughout to 3.1 of MIL-S-19500 shall be construed as pertaining to Tables II, III, and IV of this specification.

(b) Visual and Mechanical Examination.- In 30.13 of MIL-S-19500, Appendix C, the reference to 3.8 shall not apply. The marking shall be as specified in 3.2 of this specification.

(c) Barometric Pressure, Reduced.- In 40.1 of MIL-S-19500, Appendix C, the transistor shall be electrically insulated from the test chamber, but a heat sink is not required. Using the oscilloscope waveform, I_{CBO} shall be monitored to observe any sudden variations indicating deterioration of the transistor under test conditions.

(d) Tension and Torque.- Transistors subjected to the tension and torque tests (40.15 and 40.17 of MIL-S-19500, Appendix C) may be selected from those which fail Group A and B inspection. In the tension test, the specified force shall be applied to each terminal and the integral tab separately, in the longitudinal direction.

(e) Moisture Resistance.- In 40.6 of MIL-S-19500, Appendix C, subparagraph (a) shall be omitted.

(f) Intermittent Life.- All transistors shall be subjected to the intermittent life test (40.7.5 of MIL-S-19500, Appendix C) for a total period of 240 hours. The voltage specified in Table II shall be applied intermittently, 15 minutes on and 5 minutes off. Following the test, the transistors shall be de-energized and allowed to stabilize at standard temperature (see 4.4.1 of this specification) before being subjected to the end-point tests specified. The lot shall be acceptable if not more than 5 percent of the lot fails the test. Transistors (from acceptable lots) that have failed this test shall be eliminated from the lot but shall be preserved and shall be shipped to Hughes Aircraft Company in clearly marked, separate packages (see 5.1.2) for further study.

(g) Shock.- In 40.10 of MIL-S-19500, Appendix C, the test shall be performed with the transistor not operating. The transistor shall be subjected to five 500-G shocks in each of two directions along each of three mutually perpendicular axes (total of 30 shocks). The shock duration shall be approximately 1 millisecond.

(h) Vibration.- In 40.18 and 40.20 of MIL-S-19599, Appendix C, the tests shall be performed with the transistor not operating. The peak acceleration shall be 10 G (instead of 20 G).

(i) Pulsed Operation.- In 50.4, 50.25, and 50.40 of MIL-S-19500, Appendix C, the measurements shall be taken using pulse equipment to avoid transistor heating. The maximum pulse duration (t) shall be 300 microseconds; the duty cycle, not exceeding 2 percent.

4.4.3 Supplementary Tests

4.4.3.1 Collector-to-Emitter Breakdown Voltage with Reverse Bias Voltage between Base and Emitter.- The breakdown voltage shall be measured as described in 50.1 of MIL-S-19500, Appendix C, but in addition, a voltage shall be applied between the emitter and base during measurement. (See 3.4.)

4.4.3.2 Hard-Vacuum Environment.- Before the test, the collector cutoff current (I_{CBO}) and static forward-current transfer ratio (h_{FE}) of the recombined qualification test sample (see 4.2.1) shall be measured under standard test conditions. The transistors shall be placed within a suitable container, which shall be evacuated to a pressure of 10^{-7} millimeters of mercury, or below. The pressure shall be maintained at 10^{-7} millimeters of mercury, or below, for 48 hours. The transistors shall then be removed from the container, shall be examined for physical damage, and I_{CBO} and h_{FE} measured again. The data shall be plotted on Keuffel and Esser number 359-23 probability paper, and the results analyzed statistically. (See 3.4.)

4.4.3.3 Low-Temperature Exposure.- This test may be performed simultaneously with the hard-vacuum environment test specified in 4.4.3.2; otherwise, it shall be performed on all qualification-test specimens which have survived that test without catastrophic failure. The transistors shall be mounted or suspended on thermal insulators and shall be placed within a metallic container, with the body of the transistors at least 1 inch away from the inner surface of the container. Connection leads shall be brought out of the container from the terminals of 6 of the transistors, and a thermocouple device shall be attached to the surface of each of these transistors, within the container, to monitor the temperature. The temperature of the specimens shall be gradually reduced, at a rate not exceeding -70° C per hour, until it has reached at least -150° C, or as near that of liquid nitrogen (-196° C) as can be attained. During the entire cycle of low-temperature exposure, the 6 specimens to which the leads have been connected shall be operated at the specified voltage and current, and the ratio of collector current to base current shall be measured when the value of the base current is sufficient to produce I_C = 500 mAdc at V_{CE} = 10 Vdc. The ratio shall be measured at the following temperatures: -45°, -115°, and the lowest temperature attained. The temperature of the specimens shall be maintained at -150° C, or below, for 48 hours, and shall then be gradually raised, at a rate not exceeding 70° C per hour, until it has returned to room ambient conditions. The ratio of collector current to base current shall be measured again at the lowest temperature attained, at -115°, and at -45° C, on the ascending cycle. The transistors shall be removed from the container, shall be examined for physical damage, and I_{CBO} and h_{FE} shall be measured. The data shall be plotted on Keuffel and Esser number 359-23 probability paper, and the results analyzed statistically. (See 3.5.)

4.4.3.4 Sterilization Capability.-

TABLE II.- GROUP A QUALIFICATION AND ACCEPTANCE TESTS AND REQUIREMENTS

(4) TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM-BOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 1						
30.13	Visual and Mechanical Examination (except 30.9 of MIL-S-19500)	See *4.4.2 (b)	15.0	---	(See *3.2)		---
	Subgroup 2						
50.1	Collector-to-Emitter Breakdown Voltage, Open Base	I_C = 50 mAdc I_C = 0		BV_{CEO}			
	X988817-1				60	---	Vdc
	X988817-2				80	---	Vdc
*4.4.3.1	Collector-to-Emitter Breakdown Voltage	V_{EB} = 1 Vdc I_C = 250 uAdc		BV_{CEX}			
	X988817-1				80	---	Vdc
	X988817-2				120	---	Vdc
50.1	Emitter-to-Base Breakdown Voltage, Open Collector	I_E = 250 uAdc I_C = 0		BV_{EBO}	6.0	---	Vdc
50.4	Base-to-Emitter Voltage	V_{CE} = 10 Vdc I_C = 1.0 Adc See *4.4.2 (i)	100% inspection	V_{BE}	---	3	Vdc
50.6	Collector Cutoff Current, Open Emitter	V_{CB} = 60 Vdc I_E = 0		I_{CBO}	---	100	uAdc
50.25	Collector-to-Emitter Saturation Voltage	I_C = 1.0 Adc I_B = 100 mAdc See *4.4.2 (i)		V_{CE} (sat)	---	1.0	Vdc
50.40	Static Forward-Current Transfer Ratio (Condition 1)	V_{CE} = 10 Vdc I_C = 100 mAdc See *4.4.2 (i)		h_{FE_1}	20	---	---
50.40	Static Forward-Current Transfer Ratio (Condition 2)	V_{CE} = 10 Vdc I_C = 500 mAdc See *4.4.2 (i)		h_{FE_2}	30	90	---

(4) See footnote, page 12

TABLE II (CONTINUED)

④ TEST PARAGRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYMBOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 2 (Continued)						
50.40	Static Forward-Current Transfer Ratio (Condition 3)	V_{CE} = 10 Vdc I_C = 1.0 Adc See *4.4.2 (i)		h_{FE_3}	20	---	---
	Subgroup 3						
50.33	Small-Signal Short-Circuit Forward-Current Transfer Ratio	V_{CE} = 15 Vdc I_C = 50 mAdc f = 1 mc	100% inspection	h_{fe}	10	---	---
	Subgroup 4						
30.6	High-Temperature Operation	T_A = 150° (+3, -0)° C	100% inspection				
	Test Point:						
50.6	Collector Cutoff Current, Open Emitter	V_{CB} = 30 Vdc I_E = 0		I_{CBO}	---	30	uAdc
30.7	Low-Temperature Operation	T_A = -55° (+0, -3)° C					
	Test Point:						
50.40	Static Forward-Current Transfer (Condition 1)	V_{CE} = 10 Vdc I_C = 500 mAdc		h_{FE_1}	15	---	---
	Subgroup 5						
40.7.5	Intermittent Life	T_C = 25° ±3° C P = 40 W V_{CE} = 60 Vdc min 240 hours See *4.4.2 (f)	100% inspection	---	---	---	---
	End Points:						
50.6	Collector Cutoff Current, Open Emitter	V_{CB} = 60 Vdc I_E = 0		I_{CBO}	---	200	uAdc
50.40	Static Forward-Current Transfer Ratio (Condition 2)	V_{CE} = 10 Vdc I_C = 500 mAdc See *4.4.2 (i)		h_{FE_2}	24	135	---

④ See footnote, page 12

TABLE III.- GROUP B QUALIFICATION AND ACCEPTANCE TESTS AND REQUIREMENTS

(4) TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM-BOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 1						
30.9	Physical Dimensions	---	10.0	---	(See Fig.2)		---
	Subgroup 2						
40.13	Soldering	---	10.0	---	---	---	---
40.14	Temperature Cycling	MIL-STD-202, Method 102, Condition C, except Step 3 high temperature = 175° (+0, -3)° C; 5 cycles		---	---	---	---
40.6	Moisture Resistance	See *4.4.2 (e)		---	---	---	---
	End Points: (Same as for Sub-group 5, Table II)						
	Subgroup 3						
40.10	Shock	See *4.4.2 (g)	10.0	---	---	---	---
40.18	Vibration, Fatigue	f = 60 cps See *4.4.2 (h)		---	---	---	---
40.20	Vibration, Variable Frequency	See *4.4.2 (h)		---	---	---	---
40.16	Thermal Shock	T_1 = 100° C T_2 = 0° C		---	---	---	---
	End Points: (Same as for Sub-group 5, Table II)						

(4) See footnote, page 12

TABLE III (CONTINUED)

④ TEST PARAGRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYMBOL	LIMITS MIN	LIMITS MAX	UNIT
	Subgroup 4						
40.1	Barometric Pressure, Reduced	V_{CB} = 60 Vdc I_E = 0 (60 seconds operation) Pressure = 0.043 inch Hg Using oscilloscope, monitor I_{CBO} for sudden variations. See *4.4.2 (c)	10.0	---	---	---	---
40.8	Salt Atmosphere (Corrosion)	48 hours		---	---	---	---
	End Points: (Same as for Subgroup 5, Table II)			---	---	---	---
	Subgroup 5						
40.17	Torque	Inch-Pounds (Max) Stud 15 Terminal 0.5 See *4.4.2 (d)	10.0	---	---	---	---
40.15	Tension	5 pounds ±10 ozs. (each terminal and integral tab) See *4.4.2 (d)		---	---	---	---

④ See footnote, page 12

TABLE IV.-- GROUP C TESTS AND REQUIREMENTS (QUALIFICATION ONLY)

[4] TEST PARA-GRAPH	TEST	CONDITIONS	LTPD (PERCENT DEF)	SYM-BOL	LIMITS MIN	LIMITS MAX	UNIT
	Pre-Group C Measurements: (Same as Subgroup 5, Table II, end points)						
*4.4.3.2	Hard-Vacuum Environment	Pressure = 10^{-7} mm Hg or below; 48 hours					
	End Points: (Same as for Subgroup 5, Table II)					(See *3.4)	
*4.4.3.3	Low-Temperature Exposure	Reduce T_A at rate not exceeding -70° C/hour to -150° C or below; maintain at lowest temperature for 48 hours; then raise T_A at same max rate to 25° C					
	Test Point (6 specimens only): Ratio of Collector Current to Base Current	V_{CE} = 10 Vdc I_C = 500 mAdc (Measure I_C/I_B at -45°, -115° C, and at lowest temperature attained, on both descending and ascending cycles)		I_C/I_B			
	End Points: (Same as for Subgroup 5, Table II)					(See *3.5)	
*4.4.3.4	Sterilization Capability					(See *3,6)	

[4] Numbers marked with an asterisk refer to paragraphs in this specification; unmarked numbers, to paragraphs in MIL-S-19500, Appendix C.

5. PREPARATION FOR DELIVERY

5.1 Packaging

5.1.1 Acceptable Parts.- All acceptable parts shipped to Hughes Aircraft Company shall be suitably packaged, either individually or in groups of not more than 10 units, in sealed containers provided with one or more transparent surfaces through which a parts count can be made without removal of the contents. Each package shall contain only transistors with the same part number. The large external shipping container, which may contain unit packages of different part number, shall be constructed so as to ensure safe and undamaged delivery of the parts. Unit packages which are received in a broken or injured condition will be returned to the supplier as unacceptable.

5.1.2 Failed Specimens.- Parts submitted for purposes other than for use, such as specimens that have failed the intermittent life test and are being shipped to Hughes Aircraft Company for further study, shall be packaged as specified in 5.1.1, but with the additional marking specified in 5.2.2.

5.2 Marking of Packages

5.2.1 Acceptable Parts.- Both the unit packages and the large external shipping containers shall be clearly marked with the manufacturer's name and/or trademark, the manufacturer's part number, the lot identification or date code, and with the Hughes number in parentheses.

5.2.2 Failed Specimens.- Packages in which failed specimens (see 5.1.2) are shipped shall be marked as specified in 5.2.1, and with the following additional marking: "TESTED SPECIMENS. DO NOT USE."

6. NOTES

6.1 Definitions, Abbreviations, and Symbols.- The terms used in this specification are defined in Appendix A, and the abbreviations and symbols are defined in Appendix B of MIL-S-19500. The following additional symbol is used:

BV_{CEX} Collector-to-emitter breakdown voltage with reverse bias voltage between base and emitter.

6.2 Application Notes

6.2.1 Power Dissipation.- Collector power dissipation is derated as shown in Figure 1, assuming a constant failure rate over the entire derated range.

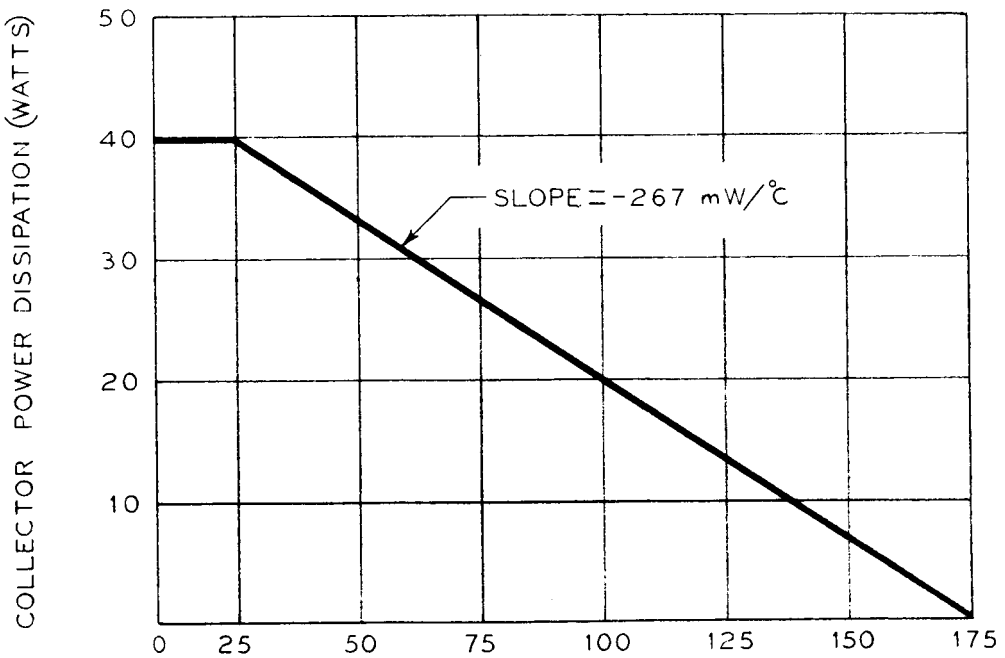


FIGURE 1
DERATING OF COLLECTOR POWER DISSIPATION

6.3 Approval of Manufacturer

6.3.1 Performance Ability.- The manufacturer shall have demonstrated his ability to supply uniform, reliable products as specified below.

6.3.2 Approval of Military Qualified Products List.- As a minimum requirement, the capability of the manufacturer to supply semiconductor devices of the type described in this specification and in accordance with MIL-S-19500 shall be evidenced by the inclusion of at least one of his products on a Military Qualified Products List.

6.3.3 Process Control.- The manufacturer shall submit sufficient information regarding product flow, process control, and any other related data that will establish his understanding and control of the product.

6.3.4 Technical Competence.- The manufacturer shall have demonstrated, by published articles or other information, that he is aware of the behavior of his product. Especially pertinent are reliability programs and statistical studies which aid in predicting failure rates and in determining derating for a-c and d-c stress levels.

6.3.5 Supplementary Information.- Manufacturer acceptability may be determined by the use of other information, including:

(a) Test data available within Hughes Aircraft Company.

(b) Test data from interservice data-exchange programs (IDEP).

(c) Previous history of the manufacturer (adherence to delivery schedules, pricing policy, etc.).

(d) The manufacturer's participation in other high-reliability programs.

(e) Field failure reports.

In recognition of the variable levels of confidence of the aforementioned items, proper consideration will be given to their significance.

6.4 Off-Premises Qualification Testing.- When qualification testing is performed at facilities other than those of Hughes Aircraft Company, the following requirements shall apply:

6.4.1 Preparation for Shipment.- Tested specimens shall be packaged in the condition in which they emerge upon conclusion of the final test, and in accordance with 5.1.2.

6.4.2 Data Submittal.- Data shall be submitted in accordance with 4.3.7, except that references to "acceptance testing performed by the manufacturer" shall be interpreted as "qualification testing performed by the off-premises facility," and references to the manufacturer's quality-control and production procedures shall not apply.

6.5 Incoming and Receiving Inspection

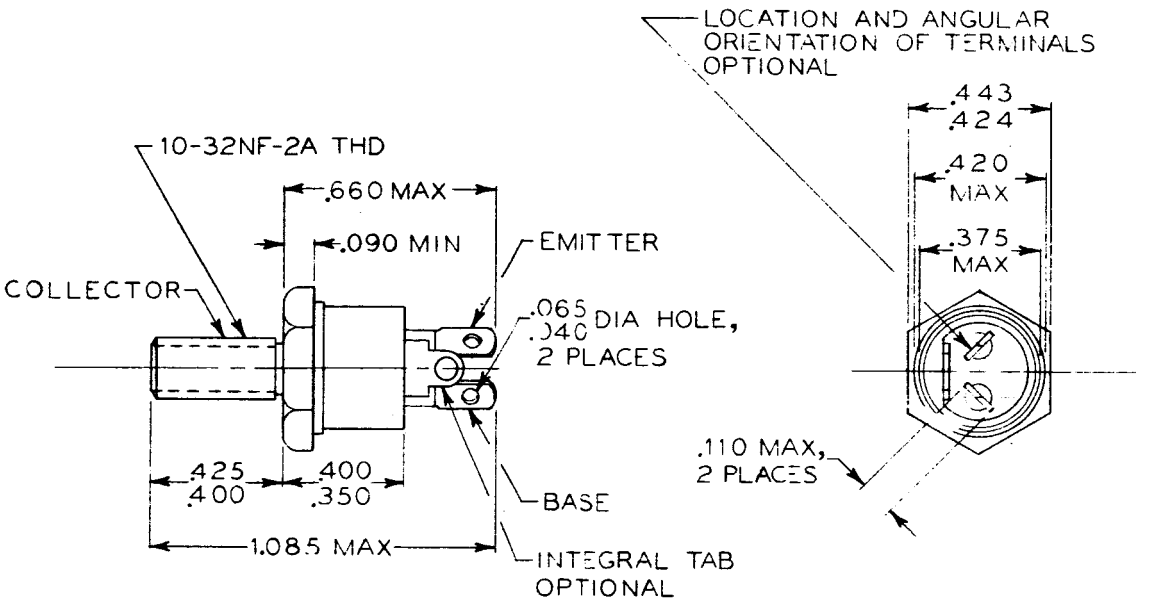
6.5.1 Preliminary Inspection.- In order to verify the shipping manifest, the incoming-inspection facility of Hughes Aircraft Company shall make a visual count of the parts without opening the transparent containers. Packages which are received in a broken or damaged condition shall be returned to the sender as unacceptable.

6.5.2 Disposition of Study Specimens.- Containers marked "TESTED SPECIMENS, DO NOT USE" shall be forwarded to the Components Department, Hughes Aircraft Company, Culver City.

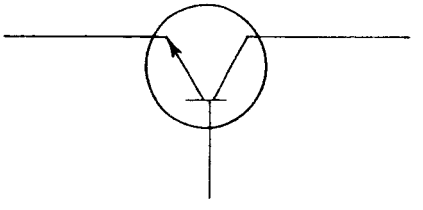
6.5.3 Disposition of Usable Parts.- All other packages containing usable parts shall be placed in a bonded storage area, together with the accompanying test data, which shall be suitably identified to correspond with the parts received. Both the parts and the test data shall be retained in the bonded area until they have been released by the Components Department.

DO NOT SCALE

LIMITS UNLESS OTHERWISE SPECIFIED: .XXX =± .XX =± X° =±



NOTE: A SLIP-ON SOLDER-TERMINAL LUG AND NORMAL MOUNTING HARDWARE SHALL BE SUPPLIED BY THE MANUFACTURER WITH EACH TRANSISTOR



SCHEMATIC DIAGRAM

FIGURE 2

PART-NUMBER TABLE

HUGHES NUMBER X988817-	TEXAS INSTRUMENTS PART NUMBER
1	
2	

PROCUREMENT BY HUGHES AIRCRAFT COMPANY IS LIMITED TO THE MANUFACTURER LISTED HEREIN:

TEXAS INSTRUMENTS INC., DALLAS, TEX. (CODE IDENT. NO. 06228)

SPECIFICATION CONTROL DOCUMENT

APPROVED / ISSUE DATE	HUGHES AIRCRAFT COMPANY CULVER CITY, CALIFORNIA	STANDARD X988817 REVISED
PROCUREMENT SPECIFICATION NONE	TRANSISTOR	PAGE 17 OF 17

FORM 3109 CC REV. 10-80

CODE IDENT. NO. 82577

1. SCOPE

1.1 This specification covers tantalum, solid electrolyte, polarized, hermetically sealed, fixed capacitors similar to Styles CS12 (uninsulated case) and CS13 (insulated case) covered by MIL-C-26655/2, but for which special additional requirements are imposed to assure performance reliability in the space and lunar environments for which the capacitors are intended.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the latest issue in effect, shall apply to this specification to the extent specified herein:

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-C-26655/2	Capacitors, Fixed, Solid Electrolyte, Tantalum, Styles CS12 and CS13

3. REQUIREMENTS

3.1 MIL-C-26655/2 Requirements.- The requirements for Styles CS12 and CS13 capacitors specified in MIL-C-26655/2 shall apply to these capacitors, with the following exceptions and modifications:

(a) Detail Requirements.- The dimensions and electrical characteristics for the individual capacitors specified in MIL-C-26655/2 shall be modified, as necessary, to conform to Figure 1 and the part-number table of this specification.

(b) D-C Leakage.- The d-c leakage shall not exceed the following values:

At Temperature (C)	D-C Leakage
+25°	The applicable value specified in the part-number table of this specification.
+85°	10 times the +25° C requirement.
+125°	12.5 times the +25° C requirement, at two-thirds of the rated 25° C voltage.

(c) Marking.- In addition to the marking specified, the body of each capacitor shall be permanently marked with the letter S in a circle.

S
6-10-62
B
2-23-62
A

3.2 Supplementary Requirements.- The capacitors shall meet the following additional requirements:

3.2.1 Production Requirements

3.2.1.1 Batch Control.- All capacitors supplied against a particular purchase order shall be produced on one production line, and processed with as much continuity as possible. Where similarities of process exist between capacitors supplied to the same purchase order, e.g., the formation voltage, they shall be processed with the same equipment, settings, personnel, etc.

3.2.1.2 Quantities.- Sufficient quantities shall be produced to allow for the destructive acceptance tests. No partial shipments of an individual part number shall be made except in instances where the quantity exceeds 500.

3.2.1.3 Fresh Product.- All the capacitors shall be fresh products, i.e., not drawn from stock unless the quantity ordered for a particular value and voltage rating is six or less. The parts shall be identified as belonging to a particular purchase order at that point in the processing where they may be so identified. If possible, the production personnel shall be informed of the ultimate use of the capacitors.

3.2.2 Material

3.2.2.1 Leads.- The material of both leads shall contain not less than 60 percent low carbon iron, by volume, and shall be sheathed in copper and flashed with tin.

3.2.3 Hard-Vacuum Operation.- After the capacitors are tested as specified in 4.5.2, there shall be no evidence of physical damage, the capacitance shall be within ±5 percent of the initial measurement, and the d-c leakage shall not exceed the applicable value specified in the part-number table.

3.2.4 Thermal Shock.- After the capacitors are tested as specified in 4.5.3, there shall be no evidence of physical damage, the capacitance shall be within ±5 percent of the initial measurement, and the d-c leakage shall not exceed the applicable value specified in the part-number table.

3.2.5 Sterilization Capability.- The capacitors shall be capable of withstanding each of the exposures specified in 4.5.4 without degradation of physical or electrical characteristics.

After the test specified in 4.5.4, the capacitance shall be within ±5 percent of the initial measurement and the d-c leakage shall not exceed the applicable value specified in the part-number table. (The capacitors shall not be sterilized before shipment.)

3.2.6 Accelerated Life.- When the capacitors are tested as specified in 4.5.5.1, and the results are analyzed statistically, based upon the multiple of rated voltage at which failure occurs and as described in 4.5.5.2, the following requirements shall be met:

(a) Failure shall not occur at less than 1.5 times the rated voltage, at 85°C. Failure is defined as the value of d-c leakage which exceeds:

$$I_{failure} > 5 \times I_o \times \frac{V_f}{V_o}$$

Where: I_o = rated d-c leakage at 85° C (see 3.1 b) at V_o

V_o = rated voltage

V_f = test voltage

For example, if the rated d-c leakage is 6 microamperes at 25° C, the test voltage is two times rated, and the test temperature is 85° C, failure occurs when the leakage current exceeds:

$$I_{failure} > 5 \times 6 \times 10 \times 2 = 600 \text{ microamperes.}$$

Failure is alternatively defined as the point where scintillation occurs, as evidenced by momentary surges of current recurring twice within a 5-second period.

(b) When three times the standard deviation is subtracted from the mean life, the result shall be not less than 10,000 hours.

3.2.7 Dielectric Breakdown.- When the capacitors are tested as specified in 4.5.9, no failure shall occur below one and one-half times the rated voltage. Failure is defined as a reading of d-c leakage above 1 milliampere steadily, or two successive surges of the d-c leakage above 1 milliampere within 5 seconds. For all capacitors in the test sample, the difference between the highest and the lowest voltages at which failure occurs shall not exceed 20 percent of the highest.

3.2.8 Workmanship.- The surfaces shall be clean and free from grease or oil. The leads shall be free of nicks or sharp bends. The soldered termination shall be smooth and small enough to prevent any accumulation of foreign matter between it and the edge of the case. No loose solder particles shall be present.

3.2.9 Screening Tests.- All capacitors shall have been subjected to the 100-percent screening tests specified in Table II.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of Tests.- The inspection and testing of the capacitors shall be classified as follows:

(a) Qualification tests. (See 4.2.)

(b) Acceptance tests. (See 4.3.)

4.1.1 Additional Tests.- Nothing shall preclude the manufacturer from taking such additional samples and performing such additional tests as he may deem necessary or desirable to assure conformance to the requirements of this specification. Additional tests may be conducted by Hughes Aircraft Company to verify data submitted by the manufacturer.

4.2 Qualification Tests.- Hughes Aircraft Company is responsible for the performance of the specified qualification tests. These tests will be conducted by, or at a laboratory designated by, Hughes Aircraft Company.

4.2.1 Test Sample and Routine.- A minimum of 36 specimens shall be subjected to the qualification tests specified in Table I, in the order listed. If a greater number of capacitors is used, the same relative proportions of specimens tested in each group shall be maintained.

TABLE I.- QUALIFICATION TESTS

TEST GROUP	NUMBER OF SPECIMENS	TEST	REFERENCE PARAGRAPH	
			REQUIREMENT	TEST
I	6 (1)	Hard-Vacuum Operation	3.2.3	4.5.2
II	6 (1)	Thermal Shock	3.2.4	4.5.3
		Sterilization Capability	3.2.5	4.5.4
III	24 (2)	Accelerated Life	3.2.6	4.5.5

(1) Any value or rating, at the discretion of Hughes Aircraft Company.

(2) 12 capacitors of the 2.2 microfarad ±10 percent value, at 20 volts dc, and 12 capacitors of the highest capacitance value and voltage rating, in the largest case size, for which approval is sought.

4.3 Acceptance Tests.- The manufacturer is responsible for the performance of all specified acceptance tests, and for supplying the necessary samples used in such tests. The acceptance tests shall include the 100-percent screening tests specified in Table II and the sampling test specified in Table III (as applicable), in the order listed.

TABLE II.- 100-PERCENT SCREENING TESTS

NUMBER OF SPECIMENS	TEST	REFERENCE PARAGRAPH	
		REQUIREMENT	TEST
All	Aging	--	4.5.6
	Temperature Cycling	--	4.5.7
	D-C Leakage	3.1(b)	(3)
	Capacitance	(3)	(3)
	Dissipation Factor	(3)	(3)
	Workmanship	3.2.8	4.5.8

(3) Applicable paragraph per MIL-C-26655.

TABLE III.- SAMPLING TESTS

INSPECTION LOT QUANTITY	SAMPLE SIZE	TEST (4)	REFERENCE PARAGRAPH	
			REQUIREMENT	TEST
3 to 25	4	Dielectric Breakdown	3.2.7	4.5.9
26 to 40	5	Accelerated Life	3.2.6	4.5.5
41 to 65	7			
66 to 110	10			
111 and over	12			

(4) Samples from inspection lots of 25 capacitors or less shall be subjected only to the dielectric breakdown test. Samples from inspection lots of 26 capacitors or more shall be subjected only to the accelerated life test.

4.3.1 Inspection Lot.- An inspection lot shall be consistent with the batch-control requirement (see 3.2.1.1) and shall consist entirely of capacitors of the same case size, capacitance value, and voltage rating, offered for inspection at the same time.

4.3.2 Rejections

4.3.2.1 Screening-Test Rejections.- Defectives found during the 100-percent screening tests specified in Table II shall be eliminated from the inspection lot. In the event that the quantity remaining in the lot is incompatible with the quantity requirement (see 3.2.1.2), the entire lot shall be rejected, unless a written waiver relaxing this requirement is granted by Hughes Aircraft Company.

4.3.2.2 Sampling-Test Rejections.- The samples shall meet the requirements of the applicable sampling test specified in Table III. Resubmission shall not be made without the approval of the Hughes Aircraft Company procurement activity, which shall obtain written agreement from the cognizant component-engineering activity.

4.3.3 Certification.- The supplier shall certify with each shipment that:

(a) The acceptance tests specified in 4.3, including the 250-hour aging procedure, have been performed.

(b) The capacitors meet all the specified requirements.

4.3.4 Data Submittal.- Within two weeks after shipment of the capacitors, the data accumulated in performing the acceptance tests shall be forwarded to Hughes Aircraft Company. The data shall include the measurements of d-c leakage, capacitance, and dissipation factor obtained during the 100-percent screening tests and the results of the applicable sampling test. At least three copies of the data shall be sent to the procurement activity of Hughes Aircraft Company. Two of the copies shall be enclosed in a separate sealed envelope marked "Attention: Components Department, Code RA-1, Culver City."

4.4 Standard Test Conditions.- Unless otherwise specified, all measurements and tests shall be performed at ambient pressure and humidity, and at an ambient temperature of 25° (+10, -5)° C.

4.5 Methods of Examination and Test

4.5.1 General.- Where no test method is described, the applicable method of MIL-C-26655 shall be used.

4.5.2 Hard-Vacuum Environment.- Before the test, the capacitance and d-c leakage shall be measured. The capacitors shall be placed within a glass container, which shall be evacuated to a pressure of 10^{-8} millimeters of mercury. The pressure shall be maintained at a maximum of 10^{-7} millimeters of mercury for 250 hours. The capacitors shall then be removed from the container, shall be examined for physical damage, and the capacitance and d-c leakage shall be measured. (See 3.2.3.)

4.5.3 Thermal Shock.- Before the test, the capacitance and d-c leakage shall be measured. The capacitors shall be subjected to 5 complete cycles of thermal shock. Each cycle shall be as follows: The capacitors, while at room ambient temperature, shall be quickly immersed in liquid nitrogen. After 10 minutes of immersion, the capacitors shall be removed and, within 1 minute, shall be placed in an air chamber held at +125° ±3° C. After 10 minutes, the capacitors shall be removed from the chamber and shall be exposed to room ambient temperature for 5 minutes. Upon completion of the 5 cycles, the capacitors shall be examined for physical damage and the capacitance and d-c leakage shall be measured. (See 3.2.4.)

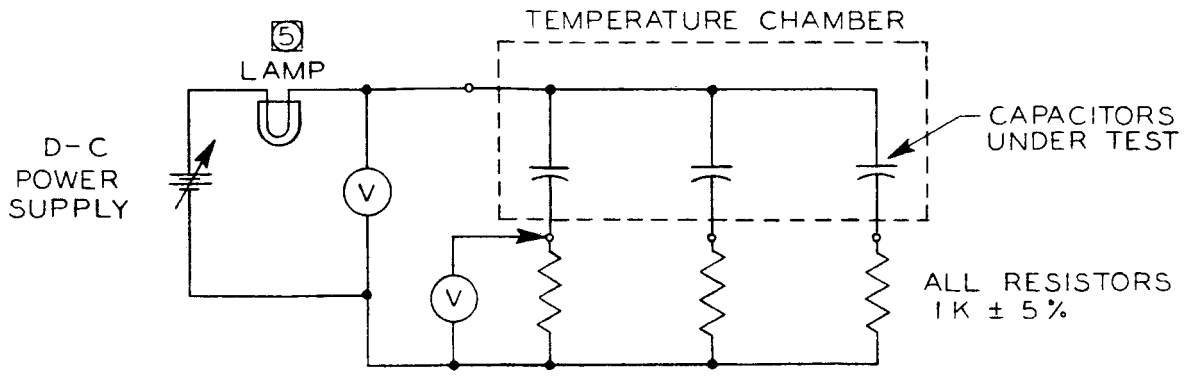
4.5.4 Sterilization Capability.- Before the test the capacitance and d-c leakage shall be measured. The capacitors shall then be subjected to the following tests. Upon completion, the capacitors shall be measured. (See 3.2.5.)

(a) High Temperature.- Two 36-hour cycles of exposure to a temperature of 125° C. This requirement is considered fulfilled as a consequence of the MIL approval defined in 6.1.2.

(b) Chemical.- A 24-hour exposure to an atmosphere consisting of a mixture of 12 percent ethylene oxide and 88 percent trichlorofluoromethane (Freon 12) by weight, at a temperature of 37.8° C and a relative humidity of 30 to 50 percent.

4.5.5 Accelerated Life

4.5.5.1 Test Procedure.- The capacitors shall be connected in a circuit similar to that shown in Figure A, and shall be conditioned for 1 hour in a chamber at a temperature of +85 ±2° C. Increasing voltage shall then be applied, approximately as shown in Figure B. The voltage shall be increased gradually between steps, at a rate not exceeding 2 volts per second. The tolerance at any step shall be (+1.0, -0.1) hours, and ±2 volts. Power may be completely turned off at any time, but care shall be taken to precondition the capacitors at chamber temperature prior to reapplication of voltage. A time log shall be kept to show accumulated time accurately at each increment. The current shall be monitored during the initial 2 minutes of each step, at approximately halfway through the step, and at the end of each step. The current at the end of each step shall be recorded. Failed parts shall be disconnected immediately. If failure occurs during the initial monitoring, the capacitor shall be credited with 0.01 hour at the higher voltage. If failure is detected subsequently, it shall be assumed to have occurred halfway between monitoring periods. The raw data from the time-log records shall be rearranged and presented on a chart similar to that shown in Figure C.



5 INCANDESCENT LAMP (125 VOLTS, 3 WATTS) USED AS A CURRENT-LIMITING RESISTANCE AND VISUAL INDICATOR FOR FAILURE

FIGURE A
ACCELERATED LIFE TEST CIRCUIT

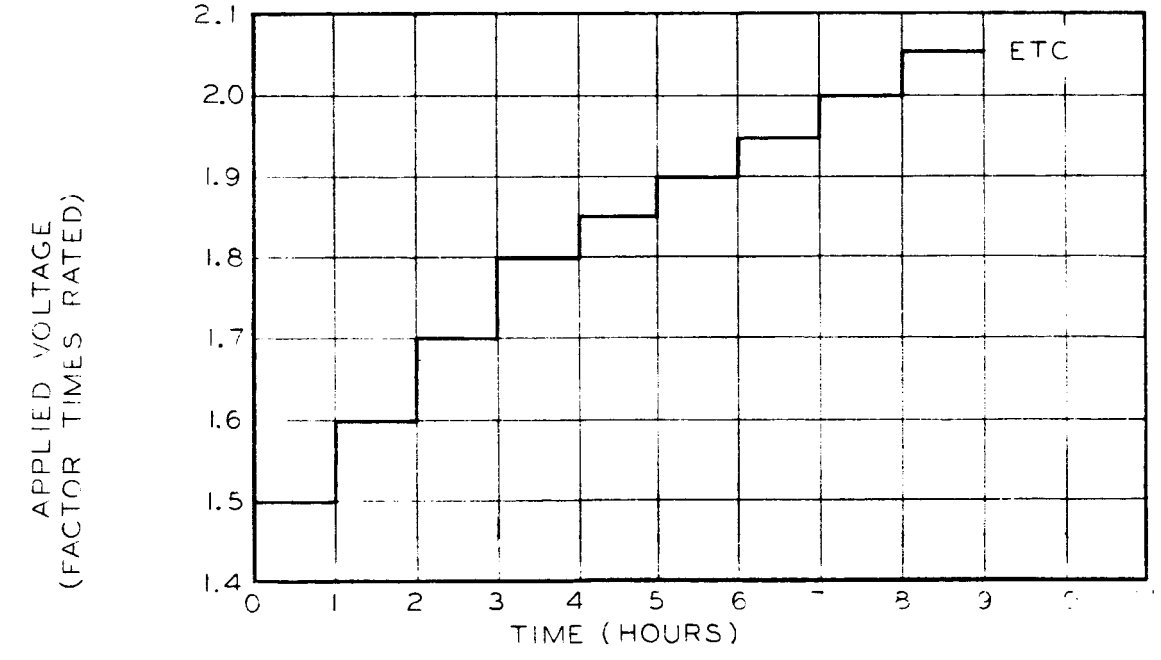


FIGURE B
VOLTAGE APPLICATION IN ACCELERATED LIFE TEST

SPECIFICATION CONTROL DOCUMENT

APPROVED / ISSUE DATE	HUGHES AIRCRAFT COMPANY CULVER CITY CALIFORNIA	STANDARD	REVISED
	CAPACITOR, FIXED, ELECTROLYTIC -- TANTALUM, SOLID ELECTROLYTE	X928500C	
		PAGE – OF 18	

FORM 3337 CC REV. 10-60

CODE IDENT. NO. 82577

ACCELERATED LIFE TEST DATA

Capacitance _____ µF
Rated Voltage _____ Vdc

Hughes Number
Hughes Order No. _____
Lot Quantity _____

Date Test Started _____
Date Test Completed _____
Date Prepared _____

Sample No.	Step 1			Step 2			Step 3			Etc.
	I [6]	T	T_n [7]	I	T	T_n	I	T	T_n	
1	.2	1.1	495							
2	.3									
3	.2									
4	.25									
5	.6									
6	.15									
7	.2									
8	.3									
9										
10										
11										
12										
Applied Voltage (V)		52.5			56					
V/V_o		1.5			1.6					
$(V/V_o)^{15}$		450			1150					

[6] Final current in microamperes.

[7] $T_n = T \times (V/V_o)^{15}$

FIGURE C
SAMPLE OF CHART FOR PRESENTATION OF
ACCELERATED LIFE TEST DATA

4.5.5.2 Statistical Analysis.- To obtain the mean life and standard deviation, the results of the accelerated life test shall be analyzed statistically by the following method:

(a) Capacitors with the same Hughes number shall be analyzed as an individual group.

(b) The first and last failures shall be omitted from the computations.

(c) The accumulated operating time at a particular voltage shall be normalized by using the 15th power of the voltage to account for the stress level. (For example, 1 hour at 1.5 times the rated voltage shall be credited with 1.5^{15} or 450 hours.)

(d) The total accumulated hours shall be averaged. This is the mean life.

(e) The square root of the mean of the deviations squared shall be computed. This is the standard deviation.

(f) Three times the standard deviation shall be subtracted from the mean life, and the result shall be recorded. (See 3.2.6.)

4.5.6 Aging.- Each capacitor shall be subjected to at least the rated voltage for 250 hours at a minimum temperature of 85° C. To provide a uniform failure rate, the rated voltage shall be derated at temperatures above 85° C as shown in Figure D. Records of the initial and final measurements shall be maintained, in order that capacitors which evidence anomalous behavior, even though they finally meet the requirements specified in the part-number table, may be culled out. During the aging period, voltage shall be removed from the capacitors for a continuous one hour period (±5 minutes) in each 24 hours. When voltage is reapplied it may be done at a gradual rate, the time interval for which shall be less than 2 minutes.

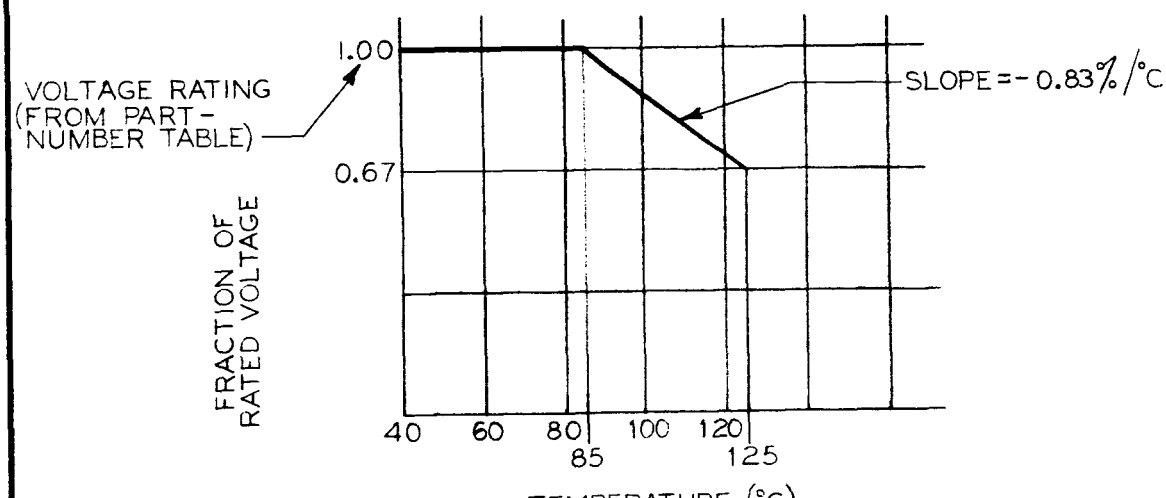


FIGURE D

DERATING OF RATED VOLTAGE AT HIGH TEMPERATURES

4.5.7 Temperature Cycling.- The capacitors shall be subjected to the temperature-cycling test specified in Method 102, Condition D, of MIL-STD-202, except that the step 3 high temperature shall be +125° C. No measurements are required either before or after cycling.

4.5.8 Workmanship.- The capacitors shall be visually examined. (See 3.2.8.)

4.5.9 Dielectric Breakdown.- The capacitors shall be connected in a circuit similar to that shown in Figure A, except that no temperature chamber is required. Increasing voltage shall be applied, approximately as shown in Figure B, except that the scale of time shall be in minutes instead of hours. The voltage shall be increased gradually between steps, at a rate not exceeding 2 volts per second. The tolerance at any step shall be (+3.0, -0.1) minutes, and ±2 volts. The current shall be monitored continuously, if possible, or at any time during the step, after the first 10 seconds. Failed parts shall be disconnected immediately. The test data shall be presented on a chart similar to that shown in Figure E. (See 3.2.7.)

DIELECTRIC BREAKDOWN TEST DATA

Capacitance_____µF
Rated Voltage_____Vdc

Hughes Number_____ Date of Test_____
Hughes Order No._____
Lot Quantity_____ Date Prepared_____

Sample No.	Voltage at Failure	Current at Failure
1		
2		
3		
4		

Highest Failure Voltage_____

Lowest Failure Voltage_____

$$\frac{\text{Highest - Lowest}}{\text{Highest}} = \_\_\_\_ = \_\_\_\_ \times 100 = \boxed{\quad\quad}\ \%$$

FIGURE E
SAMPLE OF CHART FOR PRESENTATION
OF DIELECTRIC BREAKDOWN TEST DATA

5. PREPARATION FOR DELIVERY

5.1 Packaging.- The unit package shall contain ten, or a multiple of ten, capacitors (except where obviously unattainable), all with the same part number. The large external shipping container may contain unit packages of different part number. The entire contents of the unit package shall be mounted on one structure that may be easily removed and replaced in the unit package. The arrangement of the capacitors on this structure shall be orderly. The leads shall be accessible without removal of the capacitors from the structure. The capacitors shall be protected by restricting their individual freedom to move and by preventing contact between individual capacitors within the unit package. The unit package shall preferably be provided with one transparent surface through which a parts count can be made without removal of the contents.

5.2 Marking of Unit Packages.- The unit packages shall be externally marked with the manufacturer's name and/or trademark, manufacturer's part number, capacitance, tolerance, rated voltage, date code, and the Hughes number in parentheses. Additional marking is optional. If possible, the specified marking shall appear on the side with the smallest dimension, to permit stacking of unit packages.

6. NOTES

6.1 Approval of Manufacturer

6.1.1 Performance Ability.- The manufacturer shall have demonstrated his ability to supply uniform, reliable products as specified below.

6.1.2 Approval on Military Qualified Products List.- As a minimum requirement, the capability of the manufacturer to supply Style CS12 and CS13 capacitors in accordance with MIL-C-26655/2 shall be evidenced by inclusion of his product on a Military Qualified Products List.

6.1.3 Process Control.- The manufacturer shall submit sufficient information regarding product flow, process control, and any other related data that will establish his understanding and control of the product.

6.1.4 Technical Competence.- The manufacturer shall have demonstrated, by published articles or other information, that he is aware of the behavior of his product. Especially pertinent are reliability programs and statistical studies which aid in predicting failure rates and in determining derating for a-c and d-c stress levels.

6.1.5 Supplementary Information.- Manufacturer acceptability may be determined by the use of other information, including:

(a) Test data available within Hughes Aircraft Company

(b) Test data from interservice data-exchange programs (IDEP)

(c) Previous history of the manufacturer (adherence to delivery schedules, pricing policy, etc.)

(d) The manufacturer's participation in other high-reliability programs.

(e) Field failure reports.

In recognition of the variable levels of confidence of the aforementioned items, proper consideration will be given to their significance.

Appendix II

4. SYNCOM ELECTRONIC PARTS LIST

INTRODUCTION

The Syncom electronic parts list covers all spacecraft assemblies using semiconductors, resistors, capacitors, and inductors.

Purchased assemblies and "low-population" units are listed on the first page. The remaining assemblies are itemized on subsequent pages.

Some standard electronic parts were selected which were not covered by Hughes specifications; conversely, specifications (X988000-XX) have called for parts not identifiable with commercial part numbers.

The following abbreviations are used throughout the parts list:

A-B = Allen-Bradley

A-B resistors: TR, 1/10 watt; CB, 1/4 watt; EB, 1/2 watt; GB, 1 watt; all 5 percent carbon composition.

TI = Texas Instruments

PSI = Pacific Semiconductor

GRFF = General RF Fittings

PURCHASED ASSEMBLIES AND "LOW-POPULATION" UNITS

Name	Hughes Number	Number per Space-craft	Notation	Note
Input filter	496106	1	*	
Input mixer	496107	1	*	4 diode D4142 M
IF attenuator	496109	2	*	2-1/10 w resistors A-B selected as matched pair 1-1/4 w resistors A-B required 2- GRFF - TM connectors
High-level mixer	496113	2	* **	1 diode Sylvania 1N21F 1 3-db directional coupler Hycon HDC1016
Single-sideband filter	496114	1	**	Rantec FS 211-1
3-db coupler	496117	1	**	Hycon HDC 1016 (see 496113)
Dual-filter, Hybrid	496118	2	**	Rantec FS 213-1
Isolator	496119	2	*	1 termination filmohm 5526
Traveling-wave tube	496121	2	*	Hughes 314H
Frequency doubler	496125	2	*	2 - X988905-5 Varicap Microwave Assoc. 2 - X988520-1 Johanson 1-10 μμf
Frequency doubler	496126	2	*	2 - X988913-1 Varicap Microwave Assoc. 2 - X988520-1 Johanson 1-10 μμf

*Hughes Aircraft Company manufacture and assembly.
** Purchased item.

PURCHASED ASSEMBLIES AND "LOW-POPULATION" UNITS (continued)

Name	Hughes Number	Number per Space-craft	Notation	Note
Coaxial attenuator	496130	2	**	Hycon HDC1016 (see 496113) 1 termination filmohm 5526
Coaxial relay	496139	1	*	2 - Erie Cap. GP3-24D4-152M feed-through 2 - X988500-11 Kemet 10 μf 50 v 1 Sigma relay 32 RJPD 780 GD GSP
20-db coupler	496140	1	**	Hycon HDC1027
Detector mount	496141	1	**	Hycon HDM1023 1 diode X988718-1 1N3062
Flight termi-ination timer	496405	1	**	Bulova TE-12
Batteries, 10-cell	496502	44	**	Sonotone (see Hughes Specification Control Drawing 254023)
Batteries, 12-cell	496503			
Pyrotechnic switch	496615		**	Atlas Powder Co. MS4. 4-D. 1-CT1 2 - X988610-30 resistor

*Hughes Aircraft Company manufacture and assembly.
**Purchased item.

TRANSPONDER AND TELEMETRY REGULATORS, 496008, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
4	X988601-16	Resistor	A-B	CB	11 1/4 w 5%
4	X988602-16	Resistor	A-B	EB	11 1/2 w 5%
2	X988834	Transistor	TI	T1X2150(SP352)	-
8	X988601-81	Resistor	A-B	CB	5600 1/4 w 5%
4	X988601-77	Resistor	A-B	CB	3900 1/4 w 5%
8	X988704-16	Diode	PSI	PS4261	-
8	X988610-289	Resistor	TI	CG	10.00K 1/8 w 1% carbon film
8	X988610-318	Resistor	TI	CG	20.0K 1/8 w 1% carbon film
2	X988603-77	Resistor	A-B	GB	3900 1 w 5%
8	X988600-57	Resistor	A-B	TR	2200 1/10 w 5%
10	X988602-71	Resistor	A-B	EB	2200 1/2 w 5%
8	X988602-52	Resistor	A-B	EB	360 1/2 w 5%
8	X988600-73	Resistor	A-B	TR	10K 1/10 w 5%
10	X988500-55	Capacitor	Kemet	K15J50K	15 μf 50 v 10% tantalum
4	X988500-144	Capacitor	Kemet	K22550K	22 μf 50 v 10% tantalum
8	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v 5% ceramic
8	X988804-1	Transistor	PSI	2N708	-
16	X988801-1	Transistor	Fairchild	S4979 2N722	-
6	X988817-2	Transistor	TI	2150	-
24	457221-1	Heat sink	-	-	-
8	457233	Insulator	-	-	-
1	457204	Cover	-	-	-
1	457205	Housing	-	-	-

COMMAND RECEIVER AND BATTERY REGULATOR, 496009, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
2	X988601-95	Resistor	A-B	CB	22K 1/4 w 5%
2	X988710-1	Diode	Hoffman	HU100(HU103A)	-
2	X988712-4	Diode	Hoffman	1N 2934	-
2	X988504-32	Capacitor	Vitramon	-	0.01 150 v 10% ceramic
2	X988500-55	Capacitor	Kemet	-	15 μf 50 v 10% tantalum
2	X988610-11	Resistor	TI	CG 1/8	12.7 1% carbon film
2	X988603-70	Resistor	A-B	GB	2000 1 w 5%
2	X988602-15	Resistor	A-B	EB	10 1/2 w 5%
4	X988611-300	Resistor	TI	CG 1/4	32.4K 1/4 w 1% carbon film
2	X988602-2	Resistor	A-B	EB	3 Ω 1/2 w 5%
2	X988601-81	Resistor	A-B	CB	15K 1/4 w 5%
2	X988600-73	Resistor	A-B	TR	10K 1/10 w 5%
2	X988600-57	Resistor	A-B	TR	2200 1/10 w 5%
2	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
2	X988622-18	Resistor	A-B	GAH	1.50 1 w 1% fixed film
4	X988610-250	Resistor	TI	CG-1/8	3.92K 1% carbon film
2	X988610-318	Resistor	TI	CG-1/8	20.0K carbon film
2	X988610-289	Resistor	TI	CG-1/8	10.00K carbon film
2	X988701-1	Diode	Hughes/PSI	HD4816/PS4585	-
2	X988700-2	Diode	Rheem	1N485B	-
2	X988704-16	Diode	PSI	PS4261	-
2	X988728-1	Diode	Westinghouse	1N1202	-
18	978207-2	Terminal	-	-	-
2	X988804-1	Transistor	PSI	2N 708	-
4	X988802-1	Transistor	Fairchild	S4967 2N871	-
4	X988801-1	Transistor	Fairchild	S4979 2N722	-
4	X988817-2	Transistor	TI	SP 345 (TIX 2150)	-
12	457221-1	Heat sink	Hughes	-	-
6	457233	Insulator	Hughes	-	-
1	457225	Cover	Hughes	-	-
1	457224	Housing	Hughes	-	-

TRANSPONDER – MASTER OSCILLATOR, 496101, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
7	X988670-16	Coil	Delevan	1537-30	-
1	X988670-14	Coil	Delevan	1537-26	-
2	X988212-3	Connector	-	-	-
1	X988660-1	Crystal	Bliley	-	28.8917 mc
1	X988704-4	Diode	PSI	1N472	4 v Zener
1	X988819-1	Transistor	Motorola	2N707A	-
1	X988826-1	Transistor	PSI	2N1506	-
5	X988828-1	Transistor	TI	2N1405	-
1	X988601-19	Resistor	A-B	CB	15 1/4 w
1	X988601-15	Resistor	A-B	CB	10 1/4 w
2	X988600-73	Resistor	A-B	TR	10K 1/10 w
1	X988600-70	Resistor	A-B	TR	7.5K 1/10 w
2	X988600-63	Resistor	A-B	TR	3.9K 1/10 w
2	X988600-56	Resistor	A-B	TR	2K 1/10 w
4	X988600-49	Resistor	A-B	TR	1K 1/10 w
1	X988600-29	Resistor	A-B	TR	150 1/10 w
1	X988602-68	Resistor	A-B	EB Insulated	1.6K 1/2 w
1	X988601-32	Resistor	A-B	CB	51 1/4 w
1	X988603-39	Resistor	A-B	GB Insulated	100 1 w
1	X988603-77	Resistor	A-B	GB	3.9K 1 w
1	X988541-50	Capacitor	Erie	Ceramic	5 $\mu\mu$f 25%
18	X988504-32	Capacitor	Vitramon	VK30CW103K	10000 ($\mu\mu$f) 150 v 10%
1	X988500-72	Capacitor	Kemet	K15J20K	15 μf 20 v
1	X988503-67	Capacitor	Corning	CYFM10C-102	0.001 μf 300 v 5% glass
2	X988503-43	Capacitor	Corning	CYFM10C-101	100 $\mu\mu$f 500 v 5% glass
1	X988503-29	Capacitor	Corning	CYFM10C-270	27 $\mu\mu$f 500 v 5% glass
1	X988503-19	Capacitor	Corning	CYFM10C-100	10 $\mu\mu$f 500 v 5% glass
1	X988503-9	Capacitor	Corning	CYFM10C-3R9	3.9 $\mu\mu$f 500 v 5% glass
1	X988503-4	Capacitor	Corning	CYFM10C-2R2	2.2 $\mu\mu$f 500 v 5% glass
7	X988520-1	Capacitor	Johanson	2950	1-10 $\mu\mu$f variable
13	X988526-1	Capacitor	Erie	909088-51	0.001 feedthrough
1	457235	Cover assembly	Hughes	-	-
1	457236	Base assembly	Hughes	-	-
1	457361	Transformer	Hughes	-	Core: T37-6 micrometals
1	457362	Transformer	Hughes	-	-
1	457363	Transformer	Hughes	-	-
1	457364	Transformer	Hughes	-	-
1	457365	Transformer	Hughes	-	-
1	457366	Transformer	Hughes	-	-
1	457367	Transformer	Hughes	-	-
1	457368	Coil	Hughes	-	-
10	X988670-22	Coil	Delavan	1537-42	-

X32 MULTIPLIER, 496102, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
2	X988918-2	Diode	Microwave Assoc.	4325F	Varicap
2	X988903-9	Diode	PSI	PC4006	Varicap
2	978207-2	Feedthrough term	-	-	-
4	978012-1	Feedthrough term	-	-	-
10	-	Capacitor	-	CB11RE102J	-
13	X988520-1	Capacitor	Johanson	-	1-10 $\mu\mu$f
1	457453	Coil	-	-	-
1	X988918-1	Diode	Microwave Assoc.	4325D	Varicap
6	-	Capacitor	Erie	2404-041-102	Feedthrough
2	X988905-6	Diode	Microwave Assoc.	4355A	Varicap
2	X988905-8	Diode	Microwave Assoc.	4355C	Varicap
1	X988214-1	Connector	GRFF	82-260	Coaxial

PREAMPLIFIER, 496108, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	457331	Transformer	Hughes	-	-
1	457330	Transformer	Hughes	-	-
1	457329	Transformer	Hughes	-	-
1	X988503-27	Capacitor	Corning	-	-
1	X988600-42	Resistor	A-B	TR	510 1/10 w 5%
1	457332	Choke	Hughes	-	-
3	X988828-1	Transistor	TI	2N1405	-
1	X988670-23	Choke	Delevan	-	22 μh 10%
9	X988670-22	Choke	Delevan	-	18 μh 10%
1	X988600-73	Resistor	A-B	TR	10K 1/10 w 5%
2	X988600-65	Resistor	A-B	TR	4700 1/10 w 5%
1	X988600-61	Resistor	A-B	TR	3300 1/10 w 5%
2	X988600-60	Resistor	A-B	TR	3000 1/10 w 5%
8	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf ceramic
1	X988503-67	Capacitor	Corning	CYFM15C-102	0.001 μf 500 v 5% glass
2	X988503-19	Capacitor	Corning	CYFM10C221	10 $\mu\mu$f 500 v 5% glass
8	X988526-1	Capacitor	A-B	(FASH-102W) 909088-51	0.001 μf 500 v ceramic
4	X988520-1	Capacitor	Johanson	JMC 2950	1-10 $\mu\mu$f 250 v
2	X988212-8	Connector	Microdot	51-214	-
1	457201	Cover	Hughes	-	-
1	457203	Base	Hughes	-	-

POSTAMPLIFIER, 496111, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988670-2	Choke	Delevan	1537-02	-
3	-	Transformer	Hughes	-	-
3	X988828-1	Transistor	TI	2N1405	-
1	X988600-42	Resistor	A-B	TR	510 1/10 w
2	X988600-65	Resistor	A-B	TR	4.7K 1/10 w
2	X988600-61	Resistor	A-B	TR	3.3K 1/10 w
1	X988600-55	Resistor	A-B	TR	1.8K 1/10 w
1	X988600-49	Resistor	A-B	TR	1K 1/10 w
10	X988670-22	Choke	Delevan	1537-42	18.0 μh 10%
8	X988504-32	Capacitor	Vitramon	VK30CW 103K	0.01 μf 10% 150 v
1	X988503-46	Capacitor	Corning	CYFM1DC-131	130 $\mu\mu$f 5% 500 v
2	X988503-17	Capacitor	Corning	CYFM1DC-8R2	8.2 $\mu\mu$f 5% 500 v
8	X988526-1	Capacitor	A-B	909088-51	1000 $\mu\mu$f 500 v (ABFA5-H-102)
3	X988520-1	Capacitor	Johanson	2950	1-10 $\mu\mu$f variable
2	X988212-3	Connector	Microdot	31-50	-
1	457201	Cover	Hughes	-	-
1	457200	Base	Hughes	-	-

AMPLIFIER FILTER-LIMITER, 496112, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
2	X988600-90	Resistor	A-B	TR	51K 1/10 w 5%
1	X988600-65	Resistor	A-B	TR	4700 1/10 w 5%
4	X988600-61	Resistor	A-B	TR	3300 1/10 w 5%
2	X988600-59	Resistor	A-B	TR	2700 1/10 w 5%
2	X988600-57	Resistor	A-B	TR	2200 1/10 w 5%
4	X988600-54	Resistor	A-B	TR	1600 1/10 w 5%
5	X988600-25	Resistor	A-B	TR	100 1/10 w 5%
2	X988600-103	Resistor	A-B	TR	180K 1/10 w 5%
2	X988600-35	Resistor	A-B	TR	270 1/10 w 5%
2	X988600-26	Resistor	A-B	TR	110 1/10 w 5%
2	X988601-15	Resistor	A-B	CB	10 1/4 w 5%
2	X988601-55	Resistor	A-B	CB	470 1/4 w 5%
1	X988601-27	Resistor	A-B	CB	33 1/4 w 5%
2	X988601-32	Resistor	A-B	CB	51 1/4 w 5%
1	X988601-17	Resistor	A-B	CB	12 1/4 w 5%
1	X988601-25	Resistor	A-B	CB	27 1/4 w 5%
2	X988500-69	Capacitor	Kemet	-	1.5 μf 20 v tantalum
32	X988504-32	Capacitor	Vitramon	VK	10,000($\mu\mu$f) 150 v 10% cerami
1	X988503-23	Capacitor	Corning	CYFR	15 $\mu\mu$f 500 v 5% glass
1	X988503-39	Capacitor	Corning	CYFR	68 $\mu\mu$f 500 v 5% glass
1	X988503-40	Capacitor	Corning	CYFR	75 $\mu\mu$f 500 v 5% glass
2	X988503-43	Capacitor	Corning	CYFR	100 $\mu\mu$f 500 v 5% glass
3	X988503-27	Capacitor	Corning	CYFR	22 $\mu\mu$f 500 v 5% glass
2	X988503-25	Capacitor	Corning	CYFR	18 $\mu\mu$f 500 v 5% glass
1	X988503-21	Capacitor	Corning	CYFR	12 $\mu\mu$f 500 v 5% glass
3	X988503-19	Capacitor	Corning	CYFR	10 $\mu\mu$f 500 v 5% glass
2	X988503-38	Capacitor	Corning	CYFR	62 $\mu\mu$f 500 v 5% glass
2	X988503-12	Capacitor	Corning	CYFM10C-5R1	glass
20	X988526-1	Capacitor	A-B	(FA 5H-102W)	1000 $\mu\mu$f 500 v ceramic
9	X988520-2	Capacitor	Johanson	JMC 2951	1-10 $\mu\mu$f 250 v
10	X988520-1	Capacitor	Johanson	JMC 2950	1-10 $\mu\mu$f 250 v
1	457221-1	Heat sink	-	-	-
18	457336	Spacer	-	-	-
1	457326	Cover assembly	-	-	-
1	457325	Base assembly	-	-	-
4	X988212-8	Connector	-	-	-
1	457389	Transformer	-	-	-
2	457388	Transformer	-	-	-
2	457387	Transformer	-	-	-
2	457390	Transformer	-	-	-
1	X988829	Transistor	TI	2N 1141	-
6	X988828-1	Transistor	TI	2N 1405	
2	X988212-3	Connector	Microdot	-	-
10	X988718-1	Diode	Fairchild	1N 3062	-
6	457373	Coil	-	-	-
2	457370	Coil	-	-	-
23	X988670-22	Coil	Delevan	-	18 μh 10%
2	X988670-20	Coil	Delevan	-	12 μh 10%
1	X988670-12	Coil	Delevan	-	2.7 μh 10%
1	X988670-5	Coil	Delevan	-	0.68 μh 10%

TWT CONVERTER, 496122, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988601-102	Resistor	A-B	CB	43K 1/4 w 5%
1	X988602-111	Resistor	A-B	EB	100K 1/2 w 5%
1	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
1	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
1	872813C	Transformer	Hughes	-	-
1	872814B	Transformer	Hughes	-	-
1	872837	Transformer	Hughes	-	-
1	X988503-67	Capacitor	Corning	CYFM15C-102J	0.001 μf 300 v 5% glass
2	X988500-55	Capacitor	Kemet	K15J50K	15.0 μf 50 v 10% tantalum
2	X988500-151	Capacitor	Kemet	K6R8J35K	6.8 μf 35 v 10% tantalum
1	X988501-47	Capacitor	Sprague	118P	0.1 μf 600 v 10% paper
1	X988501-38	Capacitor	Sprague	118P	0.0022 μf 600 v 10% paper
2	X988501-7	Capacitor	Sprague	118P	0.1 μf 200 v 5% paper
2	X988501-113	Capacitor	Sprague	118P	0.01 μf 200 v 5% paper
1	X988700-2	Diode	Rheem	1N485B(RD1817)	-
4	X988802-2	Transistor	Fairchild	S4967 2N871	-
1	X988801-1	Transistor	Fairchild	S4970 2N722	-
2	X988816-1	Transistor		SP341 2N1724	-
2	X988215-5	Retainer, Connector	GRFF	DEM9S-NM1	-
1	X988201-11	Connector	GRFF	DEM9S-NM1	-
4	978012-2	Terminal, feedthrough	Erie	-	-
2	978207-2	Terminal, feedthrough	Erie	AA40W-PP	-
1	457221-2	Heat sink	Hughes	-	-
3	457221-1	Heat sink	Hughes	-	-
1	457273	Board, component	Hughes	-	-
3	457219	Spacer, tube	Hughes	-	-
1	457218	Cover	Hughes	-	-
1	457217	Housing	Hughes	-	-
1	872816	Inductor	Hughes	-	-
1	872817	Inductor	Hughes	-	-
1	872826	Inductor	Hughes	-	-
2	872827	Inductor	Hughes	-	-
1	872846	Inductor	Hughes	-	-
1	X988601-123	Resistor	A-B	CB	330K 1/4 w 5%
1	X988601-46	Resistor	A-B	CB	200 1/4 w 5%
1	X988603-39	Resistor	A-B	GB	100 1 w 5%
1	X988604-63	Resistor	A-B	EB	1K 2 w 5%
1	X988500-144	Capacitor	Kemet	K22J50K	22 μf 50 v 10%
16	X988724-1	Diode	-	RD-500(RD2784)	-
2	-	Resistor	-	SA2W	100 ohms

IF WIDE-BAND PREAMPLIFIER, 496127, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	457331	Transformer	Hughes	-	-
1	457330	Transformer	Hughes	-	-
1	457329	Transformer	Hughes	-	-
1	X988600-42	Resistor	A-B	TR	510 5% 1/10 w
1	457332	Choke	Hughes	-	-
3	X988828-1	Transistor	TI	2N1405	-
1	X988670-23	Choke	Deleván	1537-44	22.0 μh 10%
9	X988670-22	Choke	Delevan	1537-42	18.0 μh 10%
1	X988600-73	Resistor	A-B	TR	10K 5% 1/10 w
2	X988600-65	Resistor	A-B	TR	4.7K 5% 1/10 w
1	X988600-61	Resistor	A-B	TR	3.3K 5% 1/10 w
2	X988600-60	Resistor	A-B	TR	3K 5% 1/10 w
8	X988504-32	Capacitor	Vitramon	VK30CW103K	3K 5% 1/10 w ceramic
1	X988503-67	Capacitor	Corning	CYFM15C-102	0.001 μf 5% 300 v glass
2	X988503-19	Capacitor	Corning	CYFM10C-100	10 μμf 5% 500 v glass
8	X988526-1	Capacitor	A-B (FA5H-102W)	904088-51	0.001 μf 5% 500 v glass
4	X988520-1	Capacitor	Johanson	JMC2950	0.8-10.0 μμf
2	X988212-8	Connector		51-214	-
1	457201	Cover	-	-	-
1	457203	Base	-	-	-
1	X988503-27	Capacitor	Corning	CYFM10C-220J	22 μμf300v 5%

IF WIDE-BAND LIMITER, 496129, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	457392	Transformer T2	Hughes	-	-
1	457374	Transformer T1	Hughes	-	-
1	X988670-1	Coil	Delevan	1537-00	-
8	X988670-22	Coil	Delevan	1537-42	-
1	X988704-12	Diode	Hughes	HZ8839	8 v Zener
2	X988718-1	Diode	Fairchild	FD1148 IN3062	-
1	X988829	Transistor	-	GM0150 2N1141	-
1	X988828-1	Transistor	TI	GM0159 2N1405	-
4	X988212-3	Connector	-	31-50	-
1	457391	Coil	Hughes	-	-
1	X988601-35	Resistor	A-B	CB	68 ohms 1/4 w 5%
1	X988602-55	Resistor	A-B	EB	470 1/2 w 5%
1	X988600-86	Resistor	A-B	TR	36K 1/10 w 5%
1	X988601-79	Resistor	A-B	CB	4.7K 1/4 w 5%
2	X988601-72	Resistor	A-B	CB	2.4K 1/4 w 5%
1	X988600-49	Resistor	A-B	TR	1K 1/10 w 5%
5	X988600-25	Resistor	A-B	TR	100 1/10 w 5%
1	X988500-69	Capacitor	Kemet	K1R5J20K	1.5 μf 20 v
1	X988503-39	Capacitor	Corning	CYFM10C680J	68 $\mu\mu$f 500 v
2	X988520-1	Capacitor	Johanson	3955	1-10 $\mu\mu$f
9	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 $\mu\mu$f
8	X988526-1	Capacitor	-	909088-51	-
1	X988520-2	Capacitor	Johanson	2951	1-10 $\mu\mu$f
1	X988600-84	Resistor	A-B	TR	30K 1/10 w 5%
1	457221-1	Heat sink	Hughes	-	-
1	457358	Cover assembly	Hughes	-	-
1	457357	Base assembly	Hughes	-	-
1	X988503-7	Capacitor	Corning	CYFM10C3R3C	3.3 $\mu\mu$f 400 v 5% glass
1	X988503-48	Capacitor	Corning	CYFM10C161J	160 $\mu\mu$f 100 v 5%
1	X988601-56	Resistor	A-B	CB	2K 1/4 w 5%
1	X988601-60	Resistor	A-B	CB	3K 1/4 w 5%
1	X988600-29	Resistor	A-B	TR	150 ohms 1/10 w 5%
1	X988600-90	Resistor	A-B	TR	51K 1/10 w 5%

INVERTER MULTIPLIER, 496137, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988601-50	Resistor	A-B	CB	300 1/4 w
2	457221-1	Heat sink-transistor	Hughes	-	-
1	X988600-61	Resistor	A-B	TR	3.3K 1/10 w
2	NAS1100C04-3	Screw	-	-	-
4	X988147-1	Terminal, stud	-	-	-
1	X988601-96	Resistor	A-B	CB	24K 1/4 w
1	X988504-16	Capacitor, fixed	Vitramon	-	0.01 μf 20 15 v
2	X988500-19	Capacitor, fixed	Kemet	-	6.8 μf 35 v tantalum
2	X988500-22	Capacitor, fixed	Kemet	-	22 μf 35 v tantalum
1	X872836-A	Transformer	-	-	-
1	X872816	Coil, fixed	-	-	-
14	X988601	Resistor	A-B	CB	Selected in test*
1	X988600-114	Resistor	A-B	TR	510K 1/10 w
3	X988700-2	Diode	Hughes-Rheem	IN485B	-
2	X988802-2	Transistor	TI-Fairchild	S4967	-
13	978207-2	Terminal, stud	-	-	-
1	457239	Cover	Hughes	-	-
1	457246	Housing	Hughes	-	-

*Voltage dividing network.

ENCODER AND SOLENOID DRIVER, 496201, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988915-1	Rectifier	TI	W174(2N1772A)	-
4	X988825-2	Transistor	TI	GP422-2(2N1041-2)	-
1	253148	Vector voltage controlled oscillator	-	Purchased assembly	-
2	449496	Bracket	-	-	-
1	449497	Spacer	-	-	-
2	449494	Holder, transistor	-	-	-
Encoder Commutator Module Assembly					
1	X988500-203	Capacitor	Kemet	K1j50J	1.0 μf 50 v 5%
88	X988713-1	Diode	Fairchild-Rheem	FD300	-
1	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
15	X988601-128	Resistor	A-B	CB	510K 1/4 w 5%
15	X988821-1	Transistor	Philco	2N2185	-
Encoder Isolation Amplifier Module Assembly					
4	X988500-81	Capacitor	Kemet	K4R7J10K	4.7 μf 10 v 10%
4	X988601-118	Resistor	A-B	CB	200K 1/4 w 5%
4	X988802-2	Transistor	Fairchild	54967(2N871)	-
Encoder Selection Counter Module Assembly					
2	X988500-203	Capacitor	Kemet	K1J50J	1.0 μf 50 v 5%
6	X988504-18	Capacitor	-	VK20CW561K	-
7	X988713-1	Diode	Fairchild-Rheem	FD300	-
1	X988708-2	Diode	Motorola	IN938(SZ927-1)	-
1	X988601-72	Resistor	A-B	CB	2.4K 1/4 w 5%
1	X988601-73	Resistor	A-B	CB	2.7K 1/4 w 5%
2	X988601-80	Resistor	A-B	CB	5.1K 1/4 w 5%
6	X988601-104	Resistor	A-B	CB	51K 1/4 w 5%
2	X988601-109	Resistor	A-B	CB	82K 1/4 w 5%
6	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
2	X988601-124	Resistor	A-B	CB	360K 1/4 w 5%
6	X988601-126	Resistor	A-B	CB	430K 1/4 w 5%
1	X988642-577	Resistor	Ultronix	103A	1K 1/10 w
1	X988642-633	Resistor	Ultronix	103A	1.96K 1/10 w
1	X988642-637	Resistor	Ultronix	103A	2.05K 1/10 w
1	X988642-641	Resistor	Ultronix	103A	2.15K 1/10 w
1	X988642-645	Resistor	Ultronix	103A	2.26K 1/10 w
1	X988642-649	Resistor	Ultronix	103A	2.37K 1/10 w
1	X988642-653	Resistor	Ultronix	103A	2.49K 1/10 w
1	X988642-683	Resistor	Ultronix	103A	3.57K 1/10 w
1	X988642-685	Resistor	Ultronix	103A	3.65K 1/10 w
1	X988642-687	Resistor	Ultronix	103A	3.74K 1/10 w
1	X988642-689	Resistor	Ultronix	103A	3.83K 1/10 w
1	X988642-691	Resistor	Ultronix	103A	3.92K 1/10 w
1	X988642-693	Resistor	Ultronix	103A	4.02K 1/10 w
1	-	Resistor	Ultronix	103A	1.90K 1/10 w
1	-	Resistor	Ultronix	103A	4.00K 1/10 w

ENCODER AND SOLENOID DRIVER, 496201 (continued)

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988642-695	Resistor	Ultronix	103A	4.12K 1/10 w
1	X988642-697	Resistor	Ultronix	103A	4.22K 1/10 w
1	X988642-699	Resistor	Ultronix	103A	4.32K 1/10 w
1	X988642-701	Resistor	Ultronix	103A	4.42K 1/10 w
1	-	Resistor	Ultronix	103A	4.90K 1/10 w
1	-	Resistor	Ultronix	103A	5.0K 1/10 w
1	-	Resistor	Ultronix	103A	5.1K 1/10 w
1	-	Resistor	Ultronix	103A	5.2K 1/10 w
1	X988642-716	Resistor	Ultronix	103A	5.3K 1/10 w
1	-	Resistor	Ultronix	103A	5.4K 1/10 w
1	-	Resistor	Ultronix	103A	5.4K 1/10 w
1	-	Resistor	Ultronix	103A	5.5K 1/10 w
1	-	Resistor	Ultronix	103A	5.6K 1/10 w
1	-	Resistor	Ultronix	103A	5.7K 1/10 w
1	X988642-725	Resistor	Ultronix	103A	5.8K 1/10 w
1	-	Resistor	Ultronix	103A	5.9K 1/10 w
1	-	Resistor	Ultronix	103A	6.0K 1/10 w
1	-	Resistor	Ultronix	103A	6.1K 1/10 w
8	X988821-1	Transistor	Philco	2N2185	-
2	X988802-2	Transistor	Fairchild	S4967/2N871	-
Solenoid Driver Module Assembly					
1	X988500-52	Capacitor	Kemet	K4R7J50K	47 μf 50 v 10%
10	X988713-1	Diode	Fairchild-Rheem	FD300	-
2	X925020-7	Diode	Motorola	IN-3022	-
3	X988714-1	Diode	Motorola	IN-3189	-
4	X988601-39	Resistor	A-B	CB	100 1/4 w 5%
3	X988601-63	Resistor	A-B	CB	1K 1/4 w 5%
16	X988601-64	Resistor	A-B	CB	1.1K 1/4 w 5%
1	X988601-70	Resistor	A-B	CB	2K 1/4 w 5%
4	X988601-74	Resistor	A-B	CB	3K 1/4 w 5%
1	X988601-76	Resistor	A-B	CB	3.6K 1/4 w 5%
1	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
2	X988601-96	Resistor	A-B	CB	24K 1/4 w 5%
1	X988601-98	Resistor	A-B	CB	30K 1/4 w 5%
2	X988801-1	Transistor	Fairchild	S4979 2N722	-
Encoder Amplifier Module Assembly					
2	X988500-48	Capacitor	Kemet	K1J50K	1.0 μf 50 v 10%
1	X988500-70	Capacitor	Kemet	K2R2J20K	2.2 μf 20 v 10%
1	X988500-52	Capacitor	Kemet	K4R7J50K	4.7 μf 50 v 10%
2	X988504-26	Capacitor	Vitramon	VK36CW332K	-
4	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v 10%
5	X988713-1	Diode	Fairchild-Rheem	FD300	-
1	X988601-63	Resistor	A-B	CB	1.0K 1/4 w 5%
1	X988601-86	Resistor	A-B	CB	9.1K 1/4 w 5%
1	X988601-99	Resistor	A-B	CB	33K 1/4 w 5%
2	X988601-100	Resistor	A-B	CB	36K 1/4 w 5%
1	X988601-103	Resistor	A-B	CB	47K 1/4 w 5%

ENCODER AND SOLENOID DRIVER, 496201 (continued)

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
Encoder Amplifier Module Assembly					
1	X988601-104	Resistor	A-B	CB	51K 1/4 w 5%
1	X988601-114	Resistor	A-B	CB	130K 1/4 w 5%
2	X988601-109	Resistor	A-B	CB	82K 1/4 w 5%
4	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
1	X988601-113	Resistor	A-B	CB	120K 1/4 w 5%
1	X988601-116	Resistor	A-B	CB	160K 1/4 w 5%
1	X988601-122	Resistor	A-B	CB	300K 1/4 w 5%
1	X988601-128	Resistor	A-B	CB	510K 1/4 w 5%
1	X988610-211	Resistor	A-B	CG	1.54K 1/8 w 5%
1	X988610-231	Resistor	A-B	CG	2.49K 1/8 w 5%
1	X988610-323	Resistor	A-B	CG	22.6K 1/8 w 5%
1	X988610-343	Resistor	A-B	CG	36.5K 1/8 w 5%
1	X988612-429	Resistor	Mepco	NF85	287K carbon film
6	X988802-2	Transistor	Fairchild	2N871(S49C7)	-
1	X988821-1	Transistor	Philco	2N2185	-

TELEMETRY BIAS SUPPLY, 496202, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
4	AN960-C3	Washer	-	-	-
8	NAS671-C0	Nut	-	-	-
8	NAS1101C-00-3	Screw	-	-	-
2	NAS1101C-04-3	Screw	-	-	-
1	X988500-52	Capacitor	Kemet	K4R7J50K	4.7 μf 50 v 10% tantalum
5	X988500-48	Capacitor	Kemet	K1J50K	1 μf 50 v 10% tantalum
1	X988503-67	Capacitor	Corning	CYFM	0.001 μf 300 v 5% glass
1	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v 5%
3	X988602-62	Resistor	A-B	EB	910 1/2 w 5%
6	X988602-18	Resistor	A-B	EB	12 1/2 w 5%
2	X988601-56	Resistor	A-B	CB	510 1/4 w 5%
2	X988601-92	Resistor	A-B	CB	16K 1/4 w 5%
1	X988601-107	Resistor	A-B	CB	68K 1/4 w 5%
4	X988724-1	Diode	Rheem	RD500 (RD2784)	-
1	X872816	Coil	Hughes	-	-
1	X873042	Transformer	Hughes	-	-
2	457221-1	Heat sink	Hughes	-	-
2	X988802-2	Transistor	Fairchild	S4967 2N871	-
3	978207-2	Terminal, stud	-	-	-
6	X988147-1	Terminal, stud, ground	-	-	-
1	457369	Terminal	Hughes	-	-
2	X988214-1	Connector, receptacle	GRFF	8-2260	Coaxial-TM
1	457760	Cover	Hughes	-	-
1	457761	Housing	Hughes	-	-

TELEMETRY TRANSMITTER, 496211 (continued)

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	457381	Transformer, RF core	Hughes	-	-
1	457380	Transformer, RF core	Hughes	-	-
2	X988670-11	Choke, RF	Delevan	1537-08	0.68 μh 10%
1	457379	Coil, RF	Hughes	-	-
1	-	Button	-	-	Boron nitride
1	-	Capacitor	-	-	15 μμf 500 v 5% glass
1	X988503-23	Capacitor	Corning	CYFM	22 μμf 500 v 5% glass
2	X988503-27	Capacitor	Corning	CYFM	56 μμf 500 v 5% glass
1	X988503-37	Capacitor	-	CYFM	100 μμf 500 v 5% glass
5	X988503-43	Capacitor	-	CYFM 10C560J	56 μμf 500 v 5%
1	X988500-17	Capacitor	Corning	CYFM 10C101J	100 μμf 500 v 5%
9	X988526-1	Capacitor	Kemet	909088-51	0.1 μf 50 v 20%
1	X988670-1	Choke	A-B	FA5H-102W	0.001 500 v ceramic
4	-	Core	Delevan	-	0.15 μh 10%
6	-	Core	-	-	-
1	-	Dissipator	-	-	-
1	-	Dissipator	-	-	-
2	-	Lock	-	-	-
2	X988601-32	Resistor	A-B	CB	51 ohms 1/4 w 5%
2	X988602-32	Resistor	A-B	EB	51 ohms 1/2 w 5%
2	X988601-33	Resistor	A-B	CB	56 ohms 1/4 w 5%
2	X988602-46	Resistor	A-B	EB	200 ohms 1/2 w 5%
2	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%

TELEMETRY TRANSMITTER, 496211, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
2	457378	Coil, RF	Hughes	-	-
2	457377	Coil, RF	Hughes	-	-
18	X988670-16	Choke, RF	Delevan	1537-30	5.60 μh 10%
1	457376	Coil, RF	Hughes	-	-
2	X988215-5	Screw lock assembly	-	D20418-11	-
8	X988520-1	Capacitor	Johanson	2950	0.8-10.0 μμf 250 v
2	X988520-2	Capacitor	Johanson	2951	0.8-10.0 μμf 250 v
1	X988500-72	Capacitor	Kemet	K15J20K	15.0 μf 10% 20 v
1	X988501-7	Capacitor	Sprague	-	0.1 μf 10% 200 v
12	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v
3	X988503-19	Capacitor	Corning	CYFR10C-100	-
2	X988503-59	Capacitor	Corning	CYFR15C-471	470 μμf 5% 500 v
1	X988503-14	Capacitor	Corning	CYFR10C-6R2	-
2	X988503-35	Capacitor	Corning	CYFR10C-470	47 μμf 5% 500 v
6	X988503-67	Capacitor	Corning	CYFR15C-102	1000 μμf 5% 300 v
2	X988603-15	Resistor	A-B	GB	10 1 w 5%
1	X988603-37	Resistor	A-B	GB	82 1 w 5%
1	X988603-56	Resistor	A-B	GB	510 1 w 5%
1	X988603-77	Resistor	A-B	GB	3.9K 1 w 5%
2	X988600-121	Resistor	A-B	TR	1 meg 1/4 w 5%
3	X988600-55	Resistor	A-B	TR	1.8K 1/4 w 5%
1	X988600-59	Resistor	A-B	TR	2.7K 1/4 w 5%
1	X988600-114	Resistor	A-B	TR	510K 1/4 w 5%
1	X988600-110	Resistor	A-B	TR	360K 1/4 w 5%
4	X988600-73	Resistor	A-B	TR	10K 1/4 w 5%
2	X988600-29	Resistor	A-B	TR	150 1/4 w 5%
3	X988600-49	Resistor	A-B	TR	1K 1/4 w 5%
1	X988600-44	Resistor	A-B	TR	620 1/4 w 5%
2	X988903-7	Diode	-	PC117-47 PC4005	Varicap
2	X988704-4	Diode, Zener	PSI	PS4249	4 v Zener
4	X988903-3	Diode	-	PC115-110 PC4002	Varicap
1	X988819-1	Transistor	Motorola	2N707A SM590	-
1	X988826-1	Transistor	PSI	2N1506 PRT1516	-
3	X988828-1	Transistor	TI	2N1405 GM0159	-
1	X988660-2	Crystal	Bliley	-	68.235 mc
1	X988813-1	Transistor	PSI	2N1709 PRT673	-
1	457207	Cover	-	-	-
1	457206	Chassis	-	-	-
1	X988503-12	Capacitor, fixed	Corning	CYFR10C-5R1	-
1	457808	Cap	-	-	-
1	457209	Retainer	-	-	-
1	X988214-2	Connector, RF	-	82265	-
1	X988201-1	Connector	-	DEM-9P-NM1	-
1	457385	Transformer, RF	Hughes	-	-
1	457384	Transformer, RF	Hughes	-	-
1	457383	Transformer, RF	Hughes	-	-
1	457382	Transformer, RF	Hughes	-	-

DIPLEXER, 136 MC, 496221, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
8	457336	Insulator, glass	Hughes	-	-
1	X988600-92	Resistor	A-B	TR	62K 1/10 w 5%
1	X988718-1	Diode	Fairchild	IN3062(FD1148)	-
1	457356-9	Coil	Hughes	-	-
1	457356-8	Coil	Hughes	-	-
1	457356-7	Coil	Hughes	-	-
1	457356-6	Coil	Hughes	-	-
1	457356-5	Coil	Hughes	-	-
1	457356-4	Coil	Hughes	-	-
1	457356-3	Coil	Hughes	-	-
1	457356-2	Coil	Hughes	-	-
1	457356-1	Coil	Hughes	-	-
1	X988601-52	Resistor	A-B	CB	360 1/4 w 5%
1	X988503-67	Capacitor	Corning	CYFM15C-102	0.001 μf 300 v 5% glass
2	X988503-7	Capacitor	Corning	CYFM10C-3R3	3.3 μf 400 v 5% glass
4	X988503-26	Capacitor	Corning	CYFM10C-200	20 $\mu\mu$f 500 v 5% glass
1	X988503-28	Capacitor	Corning	CYFM10C-240	24 $\mu\mu$f 500 v 5% glass
1	X988503-27	Capacitor	Corning	CYFM10C-220	22 $\mu\mu$f 500 v 5% glass
3	X988520-1	Capacitor	Johanson	JMC 2950	1-10 $\mu\mu$f 250 v
4	X988520-2	Capacitor	Johanson	JMC 2951	1-10 $\mu\mu$f 250 v
1	X988503-23	Capacitor	Corning	CYFR10C-150J	15 $\mu\mu$f 500 v 5% glass
7	987207-2	Terminal, feedthrough	-	-	-
1	X988526-1	Capacitor, feedthrough	A-B (FA5H-102W)	-	0.001 µf ceramic
1	X988212-3	Connector	Microdot	31-50	-
2	X988214-2	Connector	GRFF	8-2265	-
1	X988214-4	Connector	GRFF	2272	-
1	457223	Cover	Hughes	-	-
1	457222	Housing	Hughes	-	-

COMMAND RECEIVER, 496301, TWO PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988601-17	Resistor	A-B	CB	12 1/4 w 5%
1	X988601-23	Resistor	A-B	CB	22 1/4 w 5%
1	X988600-75	Resistor	A-B	TR	12K 1/10 w 5% composition
2	X988601-25	Resistor	A-B	CB	27 1/4 w 5% composition
1	X988603-77	Resistor	A-B	CB	3.9K 1 w 5% composition
1	X988601-74	Resistor	A-B	CB	3.0K 1/4 w 5% composition
1	X988600-97	Resistor	A-B	TR	100K 1/10 w 5% composition
8	X988600-73	Resistor	A-B	TR	10K 1/10 w 5% composition
1	X988600-72	Resistor	A-B	TR	9.1K 1/10 w 5% composition
2	X988600-69	Resistor	A-B	TR	6.8K 1/10 w 5% composition
1	X988600-66	Resistor	A-B	TR	5.1K 1/10 w 5% composition
6	X988600-61	Resistor	A-B	TR	3.3K 1/10 w 5% composition
2	X988600-59	Resistor	A-B	TR	2.7K 1/10 w 5% composition
6	X988600-57	Resistor	A-B	TR	2.2K 1/10 w 5% composition
1	X988600-53	Resistor	A-B	TR	1.5K 1/10 w 5% composition
1	X988600-49	Resistor	A-B	TR	1.0K 1/10 w 5% composition
2	X988600-32	Resistor	A-B	TR	200 1/10 w 5% composition
1	X988601-27	Resistor	A-B	CB	33 1/4 w 5% composition
1	X988500-55	Capacitor	Kemet	K15J50K	15 μf 50 v 10% tantalum
1	X988500-72	Capacitor	Kemet	K15J20K	15 μf 20 v 10% tantalum
1	X988503-60	Capacitor	Corning	CYFM15C-511	510 $\mu\mu$f 500 v 5% glass
1	X988503-36	Capacitor	Corning	CYFM10C-510	51 $\mu\mu$f 500 v 5% glass
2	X988503-67	Capacitor	Corning	CYFM15C-102	0.001 μf 300 v 5% glass
3	X988503-19	Capacitor	Corning	CYFM10C-100	10 $\mu\mu$f 300 v 5% glass
26	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v 5% ceramic
6	X988503-50	Capacitor	Corning	CYFM10C-201	200 $\mu\mu$ f 300 v 5% glass
2	X988503-12	Capacitor	Corning	CYFM10C-5R1	-
11	X988520-1	Capacitor	Johanson	3935	0.8-10.0 $\mu\mu$f
25	X988526-1	Capacitor	A-B (FA5H-102W)	904088-51	1000 $\mu\mu$f ceramic
1	X988214-4	Connector	Microdot	-	315D
2	X988212-3	Connector	Microdot	-	GRFF 82272
1	457214	Cover	Hughes	-	-
1	457215	Housing	Hughes	-	-
8	978323-1	Terminal, standoff	-	-	-
1	X988660-3	Crystal	Bliley	-	118.297 mc
1	A109395	Filter can	-	-	-
1	-	Crystal filter	Hughes	B295AA	-
6	457375	Transformer	Hughes	-	-
1	457352	Terminal	Hughes	-	-
2	457221-1	Heat sink	Hughes	-	-
1	X988914-1	Diode	Hughes Ray Syl	1N198	-
1	X988704-4	Diode IN748A	PSI	IN748	PS4249
6	X988718-1	Diode IN3062	Fairchild	IN3062	FD114B
1	457226-3	Coil	Coast Coil	-	-
2	457226-2	Coil	Coast Coil	-	-
1	457226-1	Coil	Coast Coil	-	-
14	X988670-20	Coil, fixed	Delevan	1537-38	12.0 μh 10%
1	X988670-1	Coil, fixed	Delevan	1537-00	0.15 μh 10%
1	X988670-2	Coil, fixed	Delevan	1537-02	0.22 μh 10%
11	X988670-10	Coil, fixed	Delevan	1537-18	1.80 μh 10%
1	X988802-2	Transistor	Fairchild	S4967	-
1	X988801-1	Transistor	Fairchild	2N722	FD4979
9	X988828-1	Transistor	TI	2N1405	GM0159
1	X988503-27	Capacitor	Corning	CYFM10C-220J	-
5	X988600-43	Resistor	A-B	TR	560 1/10 w 5% glass
1	X988600-29	Resistor	A-B	TR	150 1/10 w 5% glass

RANGE FILTER, 496310, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
2	X988503-13	Capacitor	Corning	-	39 $\mu\mu$f
1	X988802-1	Transistor	Fairchild	2N871	-
2	X988801-1	Transistor	Fairchild	2N722	-
3	X988718-1	Diode	Fairchild	1N3062	-
1	X988504-32	Capacitor	Vitramon	VK	0.01 μf
1	X988500-136	Capacitor	Kemet	K1J50K	1.0 μf 50 v 10%
1	X988500-149	Capacitor	Kemet	KR1J50K	0.1 μf 50 v 10%
2	X988500-154	Capacitor	Kemet	K22J50K	22 μf 35 v 10%
2	X988503-12	Capacitor	Corning	CYFR	5.1 $\mu\mu$f 500 v 5%
1	X988602-87	Resistor	A-B	EB	10K ohms 50 w
1	X988600-10	Resistor	A-B	TR	1/10 w 24 ohms 5%
1	X988600-9	Resistor	A-B	TR	1/10 w 22 ohms 5%
1	X988600-121	Resistor	A-B	TR	1/10 w 1.0M 5%
1	X988600-97	Resistor	A-B	TR	1/10 w 100K 5%
1	X988600-94	Resistor	A-B	TR	1/10 w 75K 5%
1	X988600-86	Resistor	A-B	TR	1/10 w 36K 5%
1	X988600-81	Resistor	A-B	TR	1/10 w 22K 5%
1	X988600-65	Resistor	A-B	TR	1/10 w 4.7K 5%
1	X988600-59	Resistor	A-B	TR	1/10 w 2.7K 5%
1	X988600-55	Resistor	A-B	TR	1/10 w 1.8K 5%
2	X988600-49	Resistor	A-B	TR	1/10 w 1K 5%
2	X988414-1	Coil	Coast coils	-	-
3	457221-1	Heat sink	Hughes	-	-
1	457318	Cover	Hughes	-	-
1	457317	Housing	Hughes	-	-

DECODER FILTER, 496311, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
10	X988503-53	Capacitor	Corning	CYFM 10C271J	270 μμf 300 v 5%
3	X988503-52	Capacitor	Corning	CYFM 10C241J	240 μμf 300 v 5%
3	X988503-51	Capacitor	Corning	CYFM 10C221J	220 μμf 300 v 5%
2	X988503-27	Capacitor	Corning	CYFM 10C220J	22 μμf 300 v 5%
1	X988503-50	Capacitor	Corning	CYFM 10C201J	200 μμf 300 v 5%
2	X988503-49	Capacitor	Corning	CYFM 10C181J	180 μμf 300 v 5%
5	X988503-47	Capacitor	Corning	CYFM 10C151J	150 μμf 500 v 5%
2	X988503-45	Capacitor	Corning	CYFM 10C121J	120 μμf 500 v 5%
4	X988503-43	Capacitor	Corning	CYFM 10C101J	100 μμf 500 v 5%
9	X988503-64	Capacitor	Corning	CYFM 15C751J	750 μμf 300 v 5%
4	X988503-165	Capacitor	Corning	CYFM 15C112J	1100 μμf 300 v 5%
2	X988504-32	Capacitor	Vitramon	VK30CW103K	0.01 μf 30 v 10%
2	X988500-55	Capacitor	Kemet	K15 J 50K	15 μf 50 v 10%
2	X988500-72	Capacitor	Kemet	K15 J 20K	15 μf 20 v 10%
2	X988500-15	Capacitor	Kemet	KR022J 50K	0.022 μf 50 v 20%
2	X988500-61	Capacitor	Kemet	KRI J 50K	0.1 μf 50 v 10%
2	X988500-16	Capacitor	Kemet	KR047J 50K	0.047 μf 50 v 20%
2	X988600-75	Resistor	A-B	TR	1/10 w 12K
2	X988600-49	Resistor	A-B	TR	1/10 w 1K
2	X988600-57	Resistor	A-B	TR	1/10 w 2.2K
4	X988600-97	Resistor	A-B	TR	1/10 w 100K
2	X988600-62	Resistor	A-B	TR	1/10 w 3.6K
2	X988600-86	Resistor	A-B	TR	1/10 w 36K
2	X988600-107	Resistor	A-B	TR	1/10 w 270K
2	X988600-118	Resistor	A-B	TR	1/10 w 750K
2	X988600-121	Resistor	A-B	TR	1/10 w 1 meg
2	X988600-77	Resistor	A-B	TR	1/10 w 15K
14	X988718-1	Diode	Fairchild	(IN-3062) FD 1148	-
10	X988801-1	Transistor	Fairchild	(2N-722) S 4970	-
2	X988802-1	Transistor	Fairchild	(2N-871) S 4967	-
1	X457393	Cover	Hughes	-	-
1	457216	Housing	Hughes	-	-
2	X988415-2	Coil	Coast Coils	457213-2	20 μh 1%
12	X988415-1	Coil	Coast Coils	457213-1	20 μh 1%
2	CY30C912J	Capacitor	Corning	CYRF 30C-912	9100 μμf 5%
2	X988502-30	Capacitor	Electro-Motive	HRDM-20	8200 μμf 300 v 5%
4	X988502-29	Capacitor	Electro-Motive	HRDM-20	7500 μμf 300 v 5%
4	X988502-28	Capacitor	Electro-Motive	HRDM-20	6800 μμf 300 v 5%
4	CY30C-622J	Capacitor	Corning	CYFR 30C-622	6200 μμf 300 v 5%
4	CY30C-562J	Capacitor	Corning	CYFR 30C-562	5600 μμf 300 v 5%
11	X988502-31	Capacitor	Electro-Motive	HRDM-20	10000 μμf 300 v 5%
2	X988503-79	Capacitor	Corning	CYFM 20C-362	3600 μμf 300 v 5%
4	X988503-78	Capacitor	Corning	CYFM 20C-332	3300 μμf 300 v 5%
4	X988503-77	Capacitor	Corning	CYFM 20C-302	3000 μμf 300 v 5%
2	X988503-76	Capacitor	Corning	CYFM 20C-272	2700 μμf 500 v 5%
2	X988503-75	Capacitor	Corning	CYFM 20C-242	2400 μμf 500 v 5%
2	X988503-74	Capacitor	Corning	CYFM 20C-222	2200 μμf 500 v 5%
2	X988503-72	Capacitor	Corning	CYFM 20C-182	1800 μμf 500 v 5%
2	X988503-70	Capacitor	Corning	CYFM 20C-152	1500 μμf 500 v 5%
4	X988503-66	Capacitor	Corning	CYFM 15C-911	910 μμf 300 v 5%
3	X988503-65	Capacitor	Corning	CYFM 15C-821J	820 μμf 300 v 5% glass
2	X988503-63	Capacitor	Corning	CYFM 15C-681J	680 μμf 300 v 5% glass
2	X988503-62	Capacitor	Corning	CYFM 15C-621J	620 μμf 300 v 5% glass
1	X988503-61	Capacitor	Corning	CYFM 15C-561J	560 μμf 300 v 5% glass
2	X988503-60	Capacitor	Corning	CYFM 15C-511J	510 μμf 500 v 5% glass
2	X988503-59	Capacitor	Corning	CYFM 15C-471J	470 μμf 500 v 5% glass
3	X988503-58	Capacitor	Corning	CYFM 15C-431J	430 μμf 500 v 5% glass
3	X988503-57	Capacitor	Corning	CYFM 15C-391J	390 μμf 500 v 5% glass

DECODER FILTER 496311 (continued)

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988503-56	Capacitor	Corning	CYFM 15C-361J	360 $\mu\mu$f 500 v 5% glass
4	X988503-55	Capacitor	Corning	CYFM 15C-331J	330 $\mu\mu$f 500 v 5% glass
16	X988503-68	Capacitor	Corning	CYFM 15C-122J	1200 $\mu\mu$f 300 v 5% glass
4	X988503-67	Capacitor	Corning	CYFM 15C-102J	1000 $\mu\mu$f 300 v 5% glass
2	X988503-41	Capacitor	Corning	CYFM 10C-820J	82 $\mu\mu$f 500 v 5% glass
2	X988503-39	Capacitor	Corning	CYFM 10C-680J	68 $\mu\mu$f 500 v 5% glass
2	X988503-35	Capacitor	Corning	CYFM 10C-470J	47 $\mu\mu$f 500 v 5% glass
2	X988503-33	Capacitor	Corning	CYFM 10C-390J	39 $\mu\mu$f 500 v 5% glass
2	X988503-31	Capacitor	Corning	CYFM 10C-330J	33 $\mu\mu$f 500 v 5% glass
6	X988503-54	Capacitor	Corning	CYFM 10C-301J	300 $\mu\mu$f 300 v 5% glass

ENCODER AND DECODER LOGIC, 496312, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
Encoder Commutator Module Assembly – 449446					
1	X988500-203	Capacitor	Kemet	K1J50K	1 μf 50 v 5%
88	X988713-1	Diode	Rheem/Fairchild	FD300	-
1	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
15	X988601-128	Resistor	A-B	CB	510 w 1/4 w 5%
15	X988821-1	Transistor	Philco	2N2185	-
Encoder Selection Counter Module Assembly – 449448					
2	X988500-203	Capacitor	Kemet	K1J50K	1 μf 50 v 5%
6	X988504-18	Capacitor	-	VK20CW561K	-
7	X988713-1	Diode	Rheem/Fairchild	FD300	-
1	X988708-2	Diode	Fairchild	IN938	-
1	X988601-72	Resistor	A-B	CB	2.4K 1/4 w 5%
1	X988601-73	Resistor	A-B	CB	2.7K 1/4 w 5%
2	X988601-80	Resistor	A-B	CB	5.1K 1/4 w 5%
6	X988601-104	Resistor	A-B	CB	51K 1/4 w 5%
2	X988601-109	Resistor	A-B	CB	82K 1/4 w 5%
6	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
2	X988601-124	Resistor	A-B	CB	360K 1/4 w 5%
6	X988601-126	Resistor	A-B	CB	430K 1/4 w 5%
1	X988642-577	Resistor	Ultronix	103A	1.0K 1/10 w 1%
1	-	Resistor	Ultronix	103A	1.9K 1/10 w 1%
1	X988642-633	Resistor	Ultronix	103A	1.96K 1/10 w 1%
1	X988642-637	Resistor	Ultronix	103A	2.05K 1/10 w 1%
1	X988642-641	Resistor	Ultronix	103A	2.15K 1/10 w 1%
1	X988642-645	Resistor	Ultronix	103A	2.26K 1/10 w 1%
1	X988642-649	Resistor	Ultronix	103A	2.37K 1/10 w 1%
1	X988642-653	Resistor	Ultronix	103A	2.49K 1/10 w 1%
1	X988642-683	Resistor	Ultronix	103A	3.57K 1/10 w 1%
1	X988642-685	Resistor	Ultronix	103A	3.65K 1/10 w 1%
1	X988642-687	Resistor	Ultronix	103A	3.74K 1/10 w 1%
1	X988642-689	Resistor	Ultronix	103A	3.83K 1/10 w 1%
1	X988642-691	Resistor	Ultronix	103A	3.92K 1/10 w 1%
1	-	Resistor	Ultronix	103A	4.0K 1/10 w 1%
1	X988642-693	Resistor	Ultronix	103A	4.02K 1/10 w 1%
1	X988645-695	Resistor	Ultronix	103A	4.12K 1/10 w 1%
1	X988642-697	Resistor	Ultronix	103A	4.22K 1/10 w 1%
1	X988642-699	Resistor	Ultronix	103A	4.32K 1/10 w 1%
1	X988642-701	Resistor	Ultronix	103A	4.42K 1/10 w 1%
1	-	Resistor	Ultronix	103A	4.9K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.0K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.1K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.2K 1/10 w 1%
1	X988642-716	Resistor	Ultronix	103A	5.3K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.4K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.5K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.6K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.7K 1/10 w 1%
1	-	Resistor	Ultronix	103A	5.8K 1/10 w 1%
1	X988642-725	Resistor	Ultronix	103A	5.9K 1/10 w 1%
1	-	Resistor	Ultronix	103A	6.0K 1/10 w 1%
1	-	Resistor	Ultronix	103A	6.1K 1/10 w 1%
1	-	Resistor	Ultronix	103A	6.2K 1/10 w 1%
8	X988821-1	Transistor	Philco	2N2185	-
2	X988802-2	Transistor	Fairchild	S4967 2N871	-

ENCODER AND DECODER LOGIC, 496312 (continued)

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
Encoder Amplifier Module Assembly – 449450					
2	X988500-48	Capacitor	Kemet	K1J50K	1 μf 50 v 10%
1	X988500-70	Capacitor	Kemet	K100J20K	2.2 μf 20 v 10%
1	X988500-52	Capacitor	Kemet	K4R7J50K	4.7 μf 50 v 10%
2	X988504-26	Capacitor	Vitramon	VK36CW332K	3300 μf 150 v 20%
4	X988504-32	Capacitor	Vitramon	VK	0.01 μf 150 v 10%
5	X988713-1	Diode	Rheem/Fairchild	FD300	-
1	X988601-63	Resistor	A-B	CB	1K 1/4 w 5%
1	X988601-86	Resistor	A-B	CB	9.1K 1/4 w 5%
1	X988601-99	Resistor	A-B	CB	33K 1/4 w 5%
2	X988601-100	Resistor	A-B	CB	36K 1/4 w 5%
1	X988601-103	Resistor	A-B	CB	47K 1/4 w 5%
1	X988601-104	Resistor	A-B	CB	51K 1/4 w 5%
1	X988601-114	Resistor	A-B	CB	130K 1/4 w 5%
2	X988601-109	Resistor	A-B	CB	82K 1/4 w 5%
4	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
1	X988601-113	Resistor	A-B	CB	120K 1/4 w 5%
1	X988601-116	Resistor	A-B	CB	160K 1/4 w 5%
1	X988601-122	Resistor	A-B	CB	300K 1/4 w 5%
1	X988601-128	Resistor	A-B	CB	510K 1/4 w 5%
1	X988610-211	Resistor	TI	CG	1.54K 1/8 w 1%
1	X988610-231	Resistor	TI	CG	2.49K 1/8 w 1%
1	X988610-323	Resistor	TI	CG	22.6K 1/8 w 1%
1	X988610-343	Resistor	TI	CG	36.5K 1/8 w 1%
1	X988612-429	Resistor	Mepco, Inc.	NF-85	287K 100 w 1%
6	X988802-2	Transistor	Fairchild	S4967 2N871	-
1	X988821-1	Transistor	Philco	2N2185	-
Decoder Input-Output Module Assembly – 449454					
1	X988500-47	Capacitor	Kemet	KR68J50K	-
26	X988713-1	Diode	Rheem/Fairchild	FD300	-
1	X988601-86	Resistor	A-B	CB	9.1K 1/4 w 5%
2	X988601-90	Resistor	A-B	CB	13K 1/4 w 5%
2	X988601-92	Resistor	A-B	CB	16K 1/4 w 5%
2	X988601-94	Resistor	A-B	CB	20K 1/4 w 5%
2	X988601-96	Resistor	A-B	CB	24K 1/4 w 5%
2	X988601-98	Resistor	A-B	CB	30K 1/4 w 5%
4	X988601-101	Resistor	A-B	CB	39K 1/4 w 5%
1	X988601-110	Resistor	A-B	CB	91K 1/4 w 5%
2	X988601-117	Resistor	A-B	CB	180K 1/4 w 5%
7	X988601-118	Resistor	A-B	CB	200K 1/4 w 5%
2	X988601-119	Resistor	A-B	CB	220K 1/4 w 5%
4	X988601-123	Resistor	A-B	CB	300K 1/4 w 5%
1	X988601-127	Resistor	A-B	CB	470K 1/4 w 5%
16	X988802-2	Transistor	Fairchild	S4967 2N871	-
Decoder Counter Module Assembly – 449452					
2	X988500-48	Capacitor	Kemet	K1J50K	1 μf 50 v 10%
20	X988504-22	Capacitor	Vitramon	VK30CW122K	-
42	X988713-1	Diode	Rheem/Fairchild	FD300	-
2	X988601-87	Resistor	A-B	CB	10K 1/4 w 5%
2	X988601-94	Resistor	A-B	CB	20K 1/4 w 5%
20	X988601-114	Resistor	A-B	CB	130K 1/4 w 5%
20	X988601-117	Resistor	A-B	CB	180K 1/4 w 5%
20	X988601-133	Resistor	A-B	CB	820K 1/4 w 5%
20	X988802-2	Transistor	Fairchild	S4967 2N871	-
Vector Voltage Controlled Oscillator					
Purchased Item – See Specification Control Drawing 253148					

DECODER SWITCHING UNIT, 496313, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	449487	Chassis subassembly	-	-	-
Decoder AND Gate Module Assembly					
156	X988713-1	Diode	Rheem-Fairchild	FD300	-
4	X988601-96	Resistor	A-B	CB	24K 1/4 w 5%
22	X988601-107	Resistor	A-B	CB	68K 1/4 w 5%
Quadrant Mode Module Assembly					
8	X988500	Capacitor	Kemet	KR33J50K	0.33 μf 50 v 10%
8	X988504-22	Capacitor	Vitramon	VK30CW122K	0.01 μf 30 v 10%
48	X988713-1	Diode	Rheem-Fairchild	FD300	-
4	X988601-92	Resistor	A-B	CB	16K 1/4 w 5%
4	X988601-98	Resistor	A-B	CB	30K 1/4 w 5%
8	X988601-101	Resistor	A-B	CB	39K 1/4 w 5%
4	X988601-102	Resistor	A-B	CB	43K 1/4 w 5%
4	X988601-103	Resistor	A-B	CB	47K 1/4 w 5%
8	X988601-114	Resistor	A-B	CB	130K 1/4 w 5%
8	X988601-117	Resistor	A-B	CB	180K 1/4 w 5%
4	X988601-118	Resistor	A-B	CB	200K 1/4 w 5%
4	X988601-123	Resistor	A-B	CB	330K 1/4 w 5%
4	X988601-128	Resistor	A-B	CB	510K 1/4 w 5%
8	X988601-133	Resistor	A-B	CB	820K 1/4 w 5%
4	X988601-135	Resistor	A-B	CB	1 meg 1/4 w 5%
24	X988802-2	Transistor	Fairchild	S4967/2N871	-
Decoder On-Off Module Assembly					
26	X988713-1	Diode	Rheem-Fairchild	FD300	-
2	X988601-96	Resistor	A-B	CB	24K 1/4 w 5%
2	X988601-135	Resistor	A-B	CB	1 meg 1/4 w 5%
14	X988802-2	Transistor	Fairchild	S4967/2N871	-
Inverter Module Assembly					
5	X988601-110	Resistor	A-B	CB	91K 1/4 w 5%
5	X988601-113	Resistor	A-B	CB	120K 1/4 w 5%
5	X988601-134	Resistor	A-B	CB	910K 1/4 w 5%
5	X988601-135	Resistor	A-B	CB	1 meg 1/4 w 5%
5	X988611-212	Resistor	A-B	CG	3.92K 1/4 w 1%
5	X988611-274	Resistor	A-B	CG	17.4K 1/4 w 1%
2	X988611-325	Resistor	A-B	CG	59.0K 1/4 w 1%
2	X988611-354	Resistor	A-B	CG	118K 1/4 w 1%
7	X988802-2	Transistor	Fairchild	S4967/2N871	-
Solenoid Drive Input Module Assembly					
1	X988500-48	Capacitor	Kemet	K1J50K	-
10	X988713-1	Diode	Rheem-Fairchild	FD300	-
2	X988601-83	Resistor	A-B	CB	6.8K 1/4 w 5%
2	X988601-95	Resistor	A-B	CB	22K 1/4 w 5%
5	X988601-96	Resistor	A-B	CB	24K 1/4 w 5%
1	X988601-98	Resistor	A-B	CB	30K 1/4 w 5%
1	X988601-111	Resistor	A-B	CB	100K 1/4 w 5%
1	X988601-122	Resistor	A-B	CB	300K 1/4 w 5%
2	X988601-124	Resistor	A-B	CB	360K 1/4 w 5%
3	X988601-134	Resistor	A-B	CB	910K 1/4 w 5%
5	X988601-135	Resistor	A-B	CB	1 meg 1/4 w 5%
15	X988802-2	Transistor	Fairchild	S4967/2N871	-

APOGEE MOTOR IGNITION TIMER, 496406, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988209-39	Connector	-	-	-
1	X988201-1	Connector	Cannon	DEM-9P-NM1	-
1	X988915-1	Silicon controlled rectifier	TI	W174 2N1772A	-
6	X988500-5	Capacitor	Kemet	K1R5J50K	1.5 μf 50 v 20%
4	X988504-16	Capacitor	A-B	Ceramic	0.01 μf 150 v 20%
2	X988500-11	Capacitor	Kemet	K15J50K	15 μf 50 v 20%
12	-	-	-	-	-
2	-	-	-	-	-
4	X988601-133	Resistor	A-B	CB	1/4 w 820K 5%
6	X988601-115	Resistor	A-B	CB	1/4 w 150K 5%
2	X988601-132	Resistor	A-B	CB	1/4 w 750K 5%
2	X988601-116	Resistor	A-B	CB	1/4 w 160K 5%
2	X988601-119	Resistor	A-B	CB	1/4 w 220K 5%
2	X988601-112	Resistor	A-B	CB	1/4 w 110K 5%
6	X988601-70	Resistor	A-B	CB	1/4 w 2K 5%
2	X988601-97	Resistor	A-B	CB	1/4 w 27K 5%
2	X988601-90	Resistor	A-B	CB	1/4 w 13K 5%
2	X988601-79	Resistor	A-B	CB	1/4 w 4.7K 5%
4	X988601-71	Resistor	A-B	CB	1/4 w 2.2K 5%
2	X988601-49	Resistor	A-B	CB	1/4 w 270K 5%
2	X988601-84	Resistor	A-B	CB	1/4 w 7.5K 5%
8	X988802-2	Transistor	Fairchild	S4967/2N871	-
6	X988801-1	Transistor	Fairchild	S4979/2N722	-
2	2N886 (GFE)	Silicon controlled switch	-	-	-
2	X988601-*	Resistor	-	-	*Selected
3	X988713-1	Diode	Fairchild-Rheem	FD-300	-
1	X988705-5	Diode	PSI	PS 4243	-
1	X988714-1	Diode	Motorola	SR 396	-
2	X988500-5	Capacitor	Kemet	K1R5J50K	1.5 μf 50 v 20%
2	X988610-371	Resistor	TI	CG	1/8 w 71.5K 1%
1	X988610-345	Resistor	TI	CG	1/8 w 38.3K 1%
2	X988601-112	Resistor	A-B	CB	1/4 w 110K 5%
1	X988601-95	Resistor	A-B	CB	1/4 w 22K 5%
4	X988601-74	Resistor	A-B	CB	1/4 w 3K 5%
1	X988601-63	Resistor	A-B	CB	1/4 w 1K 5%
1	X988601-87	Resistor	A-B	CB	1/4 w 10K 5%
1	X988601-83	Resistor	A-B	CB	1/4 w 6.8K 5%
3	X988801-1	Transistor	Fairchild	FD4979/2N722	-
2	NASA/GD-S74 1008-200 (GFE)	Decade, counter	-	-	-

SOLAR PANEL, 496501, FOUR PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
1	X988620-1	Resistor	A-B	CAH	4.02K 1% 1/4 w
1	X988620-88	Resistor	A-B	CAH	32.4K 1% 1/4 w
1	169975	Cable	Hughes	-	-
1	169976	Cable	Hughes	-	-
1	169951	Cable	Hughes	-	-
1	169946	Terminal board	Hughes	-	-
1	209185	Support	Hughes	-	-
16	169944	Tab	Hughes	-	-
16	169943	Tab	Hughes	-	-
8	988701-1	Diode	Hughes/PSI	PS4585/HD4816	-
192	805168	Solar cell module	Hoffman	B120CG	5 cells per module

WIRING HARNESS, 496602, ONE PER SPACECRAFT

Quantity	Hughes Number	Item	Manufacturer	Commercial Number	Note
5	X988201-11	Connector	Cannon	-	-
4	X988201-12	Connector	Cannon	-	-
3	X988201-15	Connector	Cannon	-	-
10	X988201-1	Connector	Cannon	-	-
1	-	Receptacle	Deutsch	DM 5610-3S-085	-
1	936909-1	Jack	-	-	-
1	X988207-47	Connector	-	-	-
1	X988601-135	Resistor	A-B	CB	1 meg 1/4 w 5%

Appendix III

SYNCOM I PARTS LIST SUMMARY

Resistors

Quantity	Description	Manufacturer	Type No.
11	Carbon Composition 1 watt 5%	Allen Bradley	GB
47	Carbon Composition $\frac{1}{2}$ watt 5%	Allen Bradley	EB
550	Carbon Composition $\frac{1}{4}$ watt 5%	Allen Bradley	CB
240	Carbon Composition 1/10 watt 5%	Allen Bradley	TR
33	Carbon Film 1/8 watt 1%	Texas Inst.	CG1/8
14	Carbon Film $\frac{1}{4}$ watt 1%	Texas Inst.	CG $\frac{1}{4}$
2	Wire Wound Power	Sage	SA2W
5	Wire Wound 1/10 watt	Ultronix	103A
2	Carbon Film	Mepco	NF85
8	Film $\frac{1}{4}$ watt 1%	Allen Bradley	CAH
2	Film 1 watt 1%	Allen Bradley	GAH
Total 914	11 Types		

Capacitors

232	Ceramic	Vitramon	
2	Ceramic	Erie	
96	Electrolytic-Solid Tantalum	Kemet	
261	Glass	Corning	CYFM & CYFR
115	Variable-trimmer	Johanson	
39	Feedthrough-ceramic	Erie	
20			CB11RE102J
102	Ceramic	Allen Bradley	

Capacitors (Cont'd.)

Quantity	Description	Manufacturer	Type No.
13	Paper	Sprague	118P
9	Capacitor		909088-51
21	Capacitor	Elmenco	HRDM-20
Total 910	11 Types		

Inductors (Coils)

196		Delevan	1537
19		Hughes	
11			
26		Coast Coil	
Total 252	4 Types		

Transformers

44	R.F.	Hughes
9	Power	Hughes

Diodes

Quantity	Description	Manufacturer	Type
10		PSI	PS4261
2		Hoffman	HU100
2	IN2934	Hoffman	
34		Hughes/PSI	HD4816
2	IN1202	Westinghouse	
1	IN472 4V.Zener	PSI	
4	Varicap	Microwave Ass.	4325F
4	Varicap	PSI	PC4006
2	Varicap	Microwave Ass.	4325D
4	Varicap	Microwave Ass.	4355A
4	Varicap	Microwave Ass.	4355C
10	IN3062	Fairchild	
10	IN485B	Hughes/Rheem	RD1817
36		Rheem	RD500
1	8V Zener	Hughes	HZ8839
45	IN3062	Fairchild	FD1148
421		Fairchild	FD300
2	IN938	Motorola (Fairchild)	
2	IN3022	Motorola	
3	IN3189	Motorola	
2	Varicap		PC117
2	4V Zener	PSI	PS4249
4	Varicap	PSI	PC115-110

Diodes (Cont'd.)

Quantity	Description	Manufacturer	Type
2	IN198	Hughes	
2	IN748A	PSI	
1		PSI	4243
1		Motorola	SR396
Total 614	28 Types		

Transistors

2	TIX2150(SP352)	TI	
10	2N708	PSI	
47	2N722	Fairchild	S4979
6		TI	2150
145	2N871	Fairchild	S4967
4	(SP345)	TI	TIX2150
3	2N707A	Motorola	
3	2N1506	PSI	
47	2N1405	TI	
1	2N1411	TI	
4	2N1724		SP341
1	2N1141		GN0150
4		TI Fairchild	S4967
4	2N1041-Z	TI	GP422-2
48	2N2185	Philco	
1	2N1709	PSI	PRT673
Total 330	16 Types		