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VOLUME II

FINAL ENGINEERING REPORT for PLASMA PROBE C, D&E

prepared for

NASA/AMES RESEARCH CENTER

(Contract No. NAS 2 3374)

14

TIME-ZERO corporation
3530 Torrance Boulevard, Torrance, California 90503

APPENDIX A

Integrated Circuit Logic

Integrated Circuit Logic

Description

Texas Instruments Series 51 IC's are used throughout the system. These Series 51 integrated circuits have been designed for high-speed, general purpose digital applications where high d-c noise margin and relatively low power dissipation are important system considerations. Definitive specifications are provided for operating characteristics over the full military temperature range of $-55^{\circ}C$ to $+125^{\circ}C$. This logic series includes the basic gates, flip-flop elements and complex logic and storage elements needed to perform all functions of general-purpose digital systems.

Comprehensive laboratory tests were conducted at Marshall Laboratories to determine noise immunity data of these units at temperatures of $0^{\circ}F$ to $130^{\circ}F$. The results are tabulated in this section along with the manufacturers specifications.

TYPE SN517A
BULLETIN NO DL-S 657860, AUGUST 1965
REPLACES BULLETIN NO DL-S 645069, MARCH 1964

A SERIES 51
MICROELECTRONIC "CLOCK DRIVER" NETWORK
FOR APPLICATION IN

● Digital Computer Systems ● Data Handling Systems ● Control Systems

description

The SN517A semiconductor network is designed for use as a low-impedance "clock driver" for Series 51 bistable networks The SN517A will drive up to 20 clock pulse inputs and is fully compatible with other units in Texas Instruments' Series 51 line of low-power circuits over the entire military temperature range of −55°C to +125°C.

logic diagram

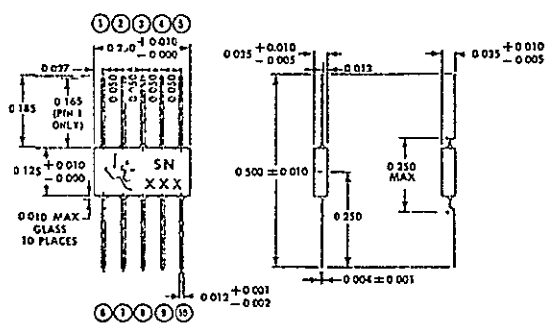
LOGIC	
INPUT	OUTPUT
A	A

mechanical data

SOLID CIRCUIT Semiconductor Networks are mounted in a glass-to-metal hermetically sealed welded package Leads are gold-plated F-15‡ glass-sealing alloy. Approximate weight is 0 1 gram. All external surfaces are metallic and are insulated from leads and circuit The SN517A is available with formed leads, insulator attac'ed; and/or mounted in a Mech-Pak carrier See ordering instructions

ORDERING INSTRUCTIONS

	NO MECH PAK CARRIER				MECH PAK CARRIER			
Lead Length	0 185 inch				Not Applicable			
Formed Leads	No	No	Yes	Yes	No	No	Yes	Yes
Insulators	No	Yes	No	Yes	No	Yes	No	Yes
Ordering Suffix	None	−6	−7	−1	−2	−3	−4	−5



NOTES a All dimensions in inches
b All decimals ± 0 005 except as noted
c Lead spacing tolerance is ± 0 015 at extremities and ± 0 005 at package, nonaccumulative
d Lead centerlines are located within ± 0 005 of their true positions relative to body centerlines

OUTLINE DRAWING — SEMICONDUCTOR NETWORK WELDED PACKAGE

†Patented by Texas Instruments Incorporated

‡F 15 is the ASTM designation for an iron nickel cobalt alloy containing nominally 53% iron, 29% nickel, and 17% cobalt

PRELIMINARY DATA SHEET
Supplementary data will be published at a later date

TYPE SN517A
DIFFUSED SILICON "CLOCK DRIVER" NETWORK

absolute maximum ratings over operating free-air temperature range

Supply Voltage, V_{CC} (See Note 1) . . . . +8 v
Input Voltage, V_{in} (See Notes 1 and 2) . . . . V_{CC}
Operating Free-Air Temperature Range . . . . −55°C to 125°C
Storage Temperature Range . . . . −55°C to 125°C

NOTES 1 Voltage values are with respect to network ground terminal
2 Input signals must be zero or positive with respect to network ground terminal

electrical characteristics

PARAMETER	TEST CONDITIONS	$V_{CC} = 3$ v MIN	$V_{CC} = 3$ v TYP	$V_{CC} = 3$ v MAX	$V_{CC} = 6$ v MIN	$V_{CC} = 6$ v TYP	$V_{CC} = 6$ v MAX	UNIT
Network Dissipation	Output Low, $T_A = 25°C$		7.5			33		mw
	Output High, $T_A = 25°C$		3.5			18		mw
Fan In	$T_A = -55°C$ to $125°C$			1			1	
D-C Fan Out	$T_A = -55°C$ to $125°C$			0			0	
A-C Fan-Out (See Note 3)	$T_A = -55°C$ to $125°C$			20			20	
Input Voltage That Will Ensure OFF Level	$T_A = 125°C$	1.15			2			v
	$T_A = -55°C$	1.6			2.5			v
ON Level	$T_A = 125°C$			0.22			0.3	v
	$T_A = -55°C$			0.4			0.5	v
Output Voltage OFF Level	$T_A = 125°C$, V_{out} not clamped, Fan-Out = 0	2.5			5			v
	$T_A = 125°C$, V_{out} clamped, Fan-Out = 0	0.95		1.25	1.4		2.1	v
	$T_A = -55°C$, V_{out} clamped, Fan-Out = 0	1.25		1.65	1.7		2.6	v
ON Level	$T_A = 125°C$			0.22			0.3	v
	$T_A = -55°C$			0.22			0.3	v

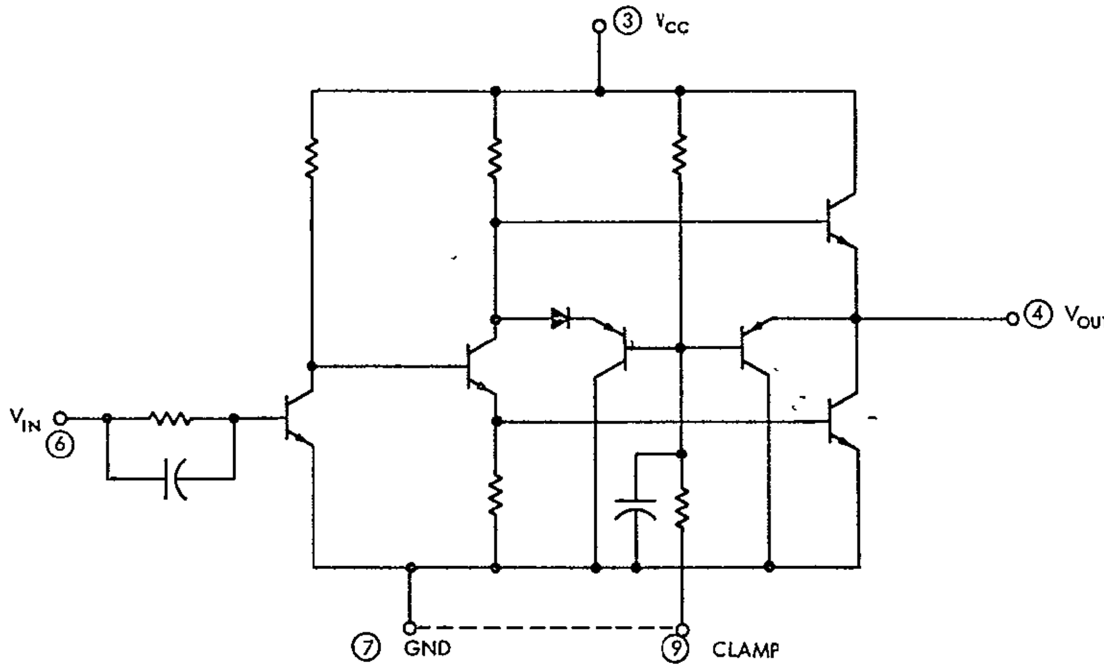
NOTE 3 When driving clock inputs of SN510A, SN511A, SN5101, or SN5111, pin 9 of the SN517A should be grounded (clamped) to limit the output voltage. When driving SN5112 or SN5113 clock inputs, output voltage should not be clamped and pin 9 should be connected to V_{CC}.

switching characteristics, $T_A = 25°C$, a-c fan-out = 20, V_{out} not clamped

PARAMETER	TEST CONDITIONS	$V_{CC} = 3$ v, $V_{in} = 2$ v		$V_{CC} = 6$ v, $V_{in} = 4$ v		UNIT
		TYP	MAX	TYP	MAX	
t_d Delay Time	*Input signal* $t_r = t_f = 100$ nsec, $t_p = 2$ µsec, f = 100 kc, See Figures 1 and 2	300	500	180	320	nsec
t_r Rise Time		300	500	300	500	nsec
t_s Storage Time		200	300	140	240	nsec
t_f Fall Time		0 6	1 4	0 8	1 6	µsec

schematic

CIRCUIT DIAGRAM



NOTES 1. Dotted connection shows clamped condition.
2. Pins ①, ②, ⑤, and ⑩ — no internal connection.
3. Do not make external connection at pin ⑧.

SOLID CIRCUIT® TYPE SN518A
DIFFUSED SILICON "ONE SHOT" NETWORK

TYPE SN518A
BULLETIN NO DL-S 645070, MARCH 1964

A SERIES 51
MICROELECTRONIC "ONE SHOT" NETWORK
FOR APPLICATION IN

- **Digital Computer Systems**
- **Data Handling Systems**
- **Control Systems**

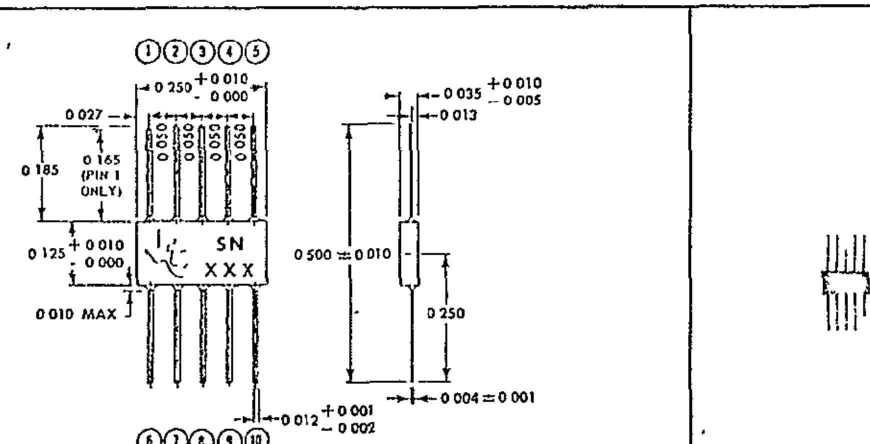
logic diagram

description

The SN518A is a versatile one-shot which has provision for external control of both pulse width and delay No inversion occurs from input to output, and the unit is compatible with all other Series 51 devices over the full military temperature range (—55°C to +125°C).

mechanical data

Solid Circuit Semiconductor Networks are mounted in a glass-to-metal hermetically sealed package. Leads are cold-plated Kovar Weight 0 1 gram All external surfaces are metallic and isolated from leads and circuit Mylar* insulators are available



All dimensions in inches
Top and bottom of network package are conductive – Circuit within package is electrically isolated from core

OUTLINE DRAWING – SEMICONDUCTOR NETWORK WELDED PACKAGE

*Reg Trademark, E I du Pont

PRELIMINARY DATA SHEET
Supplementary data will be published at a later date

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR COMPONENTS DIVISION
POST OFFICE BOX 5012 • DALLAS 22 TEXAS

NETWORK CHARACTERISTICS

absolute maximum ratings

Supply Voltage . . . . 8 volts
Input Voltage . . . . 8 volts
Operating Ambient Temperature Range . . . . −55°C to +125°C
Storage Temperature . . . . −55°C to +125°C

network electrical characteristics

	$V_{CC} = 3$ v			$V_{CC} = 6$ v			
	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Network Dissipation ($T_A = 25°C$)							
Input at High Voltage		4			15		mw
Input at Low Voltage		2			7 5		mw
Loading							
Fan-In (NOTE 1)			1			1	
DC Fan Out			5			5	
Initial Input Voltage Required to Insure Set-Up Prior to Negative Going Transition of Input Pulse							
($T_A = 125°C$)	1 15			2 0			volts
($T_A = -55°C$)	1 6			2 5			volts
Input Voltage Required to Insure One Shot Action After Negative Going Transition of Input Pulse ($t_r \leq 500$ nsec)							
($T_A = 125°C$)			0 22			0 30	volts
($T_A = -55°C$)			0 40			0 50	volts
Output Voltage							
OFF Level ($T_A = 125°C$, $N = 0$)	2 5			5 0			volts
($T_A = 125°C$, $N = 5$)	1 15			2 0			volts
ON Level ($T_A = -55°C$, $N = 5$)	1 60			2 5			volts
($T_A = 125°C$)			0 22			0 30	volts
($T_A = -55°C$)			0 40			0 50	volts
Switching Time ($T_A = 25°C$, $N = 1$) (NOTE 2) f = 40 kc, PW = 5 µsec, $t_r = t_f = 100$ nsec	Pulse Amp = 2 v			Pulse Amp = 2 v			
Delay Time (t_d)		0 80	1 00		0 45	65	µsec
Rise Time (t_r)		215	300		165	230	nsec
Fall Time (t_f)		0 85	1 20		0 85	1 20	µsec
Pulse Width	1 00		3 00	0 80		2 80	µsec
Time to Reach a Voltage to Set Flip Flop (t'_f) (NOTE 3)		160			160		nsec

NOTES 1 A Fan-in of 7 is possible by connecting an SN512A output terminal to Pin No 2 and Pin No 6 of the SN518A Pin No 3 of the SN512A should be left unconnected

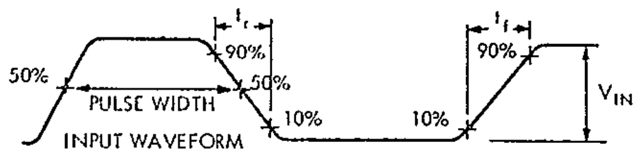
2 Switching times are obtained with Pin 2 connected to Pin 6 and Pin 4 connected to Pin 9

3 This is the delay time necessary to steer a zero into either the R or S inputs of an SN510A/SN511A

PULSE WIDTH AND DELAY CONNECTIONS

	Pin No — Pin No	Comments
Delay		
Internal	② ——— ⑥	
Increased Delay	② ——— ⑥ ② —C_d— ⑦	
Temperature Compensated Delay	② —R_d— ③ or ② —C_d— ⑦ ② —R_d— ③	$12\,K \geq R_d \geq 4\,K$ (Typical Range)
Pulse Width		
Internal	④ ——— ⑨	
Increased Pulse Width	④ ——— ⑨ ④ —C_{pw}— ⑤	(See Table Below)
Temperature Compensated Pulse Width	④ —R_{pw}— ③ or ④ —C_{pw}— ⑤ ④ —R_{pw}— ③	$24\,K \geq R_{pw} \geq 8\,K$ (Typical Range)

OUTPUT PULSE WIDTH VS EXTERNAL CAPACITANCE (C_{pw}) - TYPICAL



INPUT SIGNAL V_{IN} = 2 v (V_{CC} = 3 v)
4 v (V_{CC} = 6 v)
f = 5 Kc
t_r = t_f = 500 nsec
P.W. = 5 μsec

$V_{CC} = 3$ v

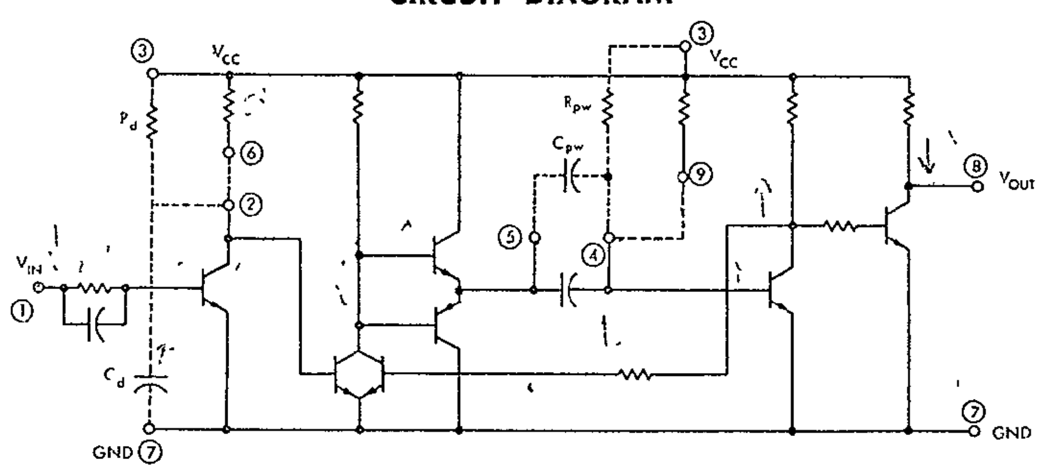
TEMP	PULSE WIDTH (μsec) C_{pw} = 200 pf	C_{pw} = 600 pf	C_{pw} = 1000 pf	C_{pw} = 2000 pf	C_{pw} = 3000 pf	C_{pw} = 5000 pf
+125°C	5.5	9.6	13.0	22.5	30.5	48.5
+25°C	4.4	8.4	12.0	21.5	30	49
−55°C	2.4	5.1	8.0	15.5	22	36

$V_{CC} = 6$ v

TEMP	PULSE WIDTH (μsec) C_{pw} = 200 pf	C_{pw} = 600 pf	C_{pw} = 1000 pf	C_{pw} = 2000 pf	C_{pw} = 3000 pf	C_{pw} = 5000 pf
+125°C	3.7	6.1	7.9	12.1	15.5	22.8
+25°C	2.7	4.6	6.5	10.5	14.5	22.0
−55°C	2.0	3.4	4.7	8.0	11.1	17.5

CIRCUIT DIAGRAM

C_d = 2000 pF → t_d = 4.3 ..



NOTE When using internal timing, Pin No 2 should be connected to Pin No 6, Pin No 4 should be connected to Pin No 9, and Pin No 5 should be left unconnected

SOLID CIRCUIT® SEMICONDUCTOR NETWORKS†

A SERIES 51
MICROELECTRONIC RESET-SET FLIP-FLOP NETWORK FOR APPLICATION IN

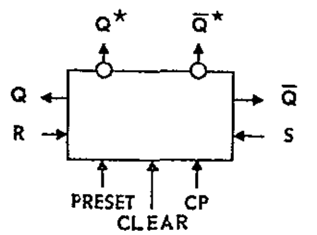
• Digital Computer Systems • Data Handling Systems • Control Systems

description

The SN5101 and SN5111 semiconductor networks† feature two presets, making the circuits readily adaptable for asynchronous operation. The SN5111 includes emitter-follower outputs. Except for the CLEAR input, the SN5101 and SN5111 networks are mechanically and electrically interchangeable with the SN510A and SN511A networks, respectively

The networks are fully compatible with other units in Texas Instrument's Series 51 line of low-power circuits over the full military temperature range of −55°C to +125°C A typical application is a shift-register having parallel load capacity without initial clear.

logic diagram



Neg Log.

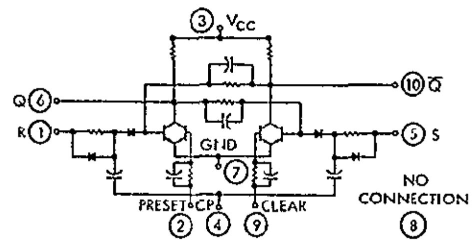
Truth Table		
t_n		t_{n+1}
R	S	Q
0	0	Q_n
0	1	1
1	0	0
1	1	Indeterminate

(Low voltage represents a ONE)

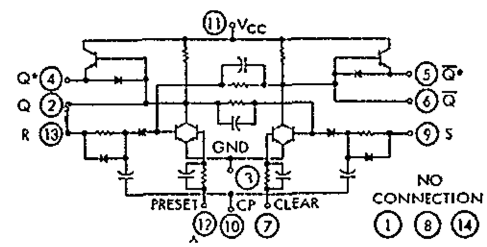
Pos. L.g.

Note * Indicates emitter follower output, (available only on SN 5111)

circuit diagrams



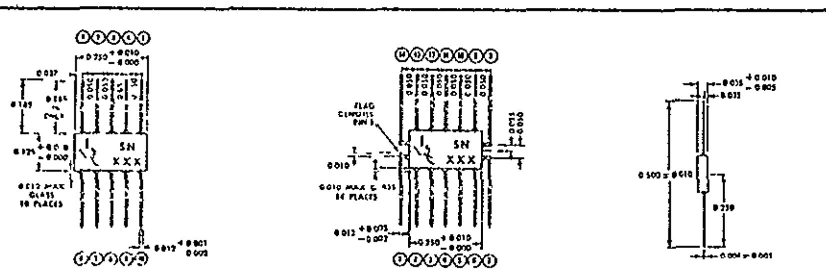
SN5101



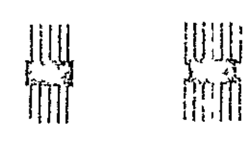
SN5111

mechanical data

SOLID CIRCUIT Semiconductor Networks are mounted in a glass-to-metal hermetically sealed, welded package. Leads are gold-plated F-15‡ glass-sealing alloy Approximate weight is 0.1 gram All external surfaces are metallic and are insulated from leads and circuit If requested, an insulator will be affixed to the bottom of the package.



SN5101 SN5111 BOTH



SN5101 SN5111

NOTES a All dimensions in inches
b All decimals ± 0 005 except as noted
c Lead spacing tolerance is ±0 015 at extremities and ±0 005 at package, nonaccumulative
d Lead centerlines are located within ±0 005 of their true positions relative to body centerlines
e Even though numerical lead designations of the two packages differ, the electrical functions are in the same physical location (except for the "CLEAR" Input)

†Patented by Texas Instruments Incorporated

‡F-15 is the ASTM designation for an iron nickel cobalt alloy containing nominally 29% nickel, 17% cobalt, and 53% iron

PRELIMINARY DATA SHEET
Supplementary data will be published at a later date

TEXAS INSTRUMENTS
INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 5012 • DALLAS 22 TEXAS

TYPES SN510T AND SN511T
DIFFUSED SILICON BISTABLE NETWORK

absolute maximum ratings of 25°C free-air temperature (unless otherwise noted)

Supply Voltage . . . . 8 v
Input Voltage (Set and Reset) . . . . 8 v
Clock Pulse Voltage (See Note 1) . . . . 8 v
Operating Free-Air Temperature Range . . . . –55°C to +125°C
Storage Temperature Range . . . . –55°C to +125°C

network electrical characteristics

	$V_{CC} = 3$ v			$V_{CC} = 6$ v			
	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
Network Dissipation ($T_A = 25°C$, Fan Out = 0)		2			8		mw
Loading							
Outputs Q and Q							
D C Fan Out, N (See Note 2)			4			4	
Outputs Q* and Q* (SN5111 only)							
D C Fan-Out, N			20			20	
Preset Voltage, ($T_A = 125°C$) TA 25	1.15			2.0			v
($T_A = -55°C$)	1.6	1.4		2.5			v
Set or Reset Voltage, ($T_A = 125°C$)	1.15			2.0			v
($T_A = -55°C$)	1.6			2.5			v
Output Voltages							
Outputs Q and Q							
OFF Level ($T_A = 125°C$, N = 0)	2.2			4.1			v
($T_A = 125°C$, N = 4)	1.15			2.0			v
($T_A = -55°C$, N = 4)	1.60			2.50			v
ON Level ($T_A = 125°C$, N = 4, See Note 3)			0.22			0.30	v
($T_A = -55°C$, N = 4, See Note 3)			0.40			0.50	v
Outputs Q* and Q* (SN5111 only)							
OFF Level ($T_A = 125°C$, N = 20)	1.5			3.8			v
OFF Level ($T_A = -55°C$, N = 20)	1.6					0.50	v
ON Level ($T_A = 125°C$, N = 20, See Note 3)			0.22			0.30	v
ON Level ($T_A = -55°C$, N = 20, See Note 3)			0.40	3.5			v

switching characteristics at 25°C free-air temperature (see note 4)

	$V_{CC} = 3$ v			$V_{CC} = 6$ v			
N = 1 (See Note 5), f = 100 kc, PW = 2 μsec, $t_r = t_f = 100$ nsec	MIN	TYP Pulse Amp = 2 v	MAX	MIN	TYP Pulse Amp = 4 v	MAX	UNIT
Delay Time, t_d		300	500		170	300	nsec
Rise Time, t_r		250	500		150	500	nsec
Storage Time, t_s		120	200		120	200	nsec
Fall Time, t_f		1.5	2.5		1.5	2.5	μsec
Time to Reach a Voltage to Set a Flip Flop, t_f' (See Note 6)		300	600		300	600	nsec

NOTES 1 The clock pulse must always be positive with respect to Pin 7

2 A C Fan Out When fanning out into flip flop clock pulse inputs (A C Loads) the emitter-follower outputs on the SN5111 should be used for fan outs above 2 or frequencies above 500 kc

3 The load is applied to the OFF output

4 Refer to SN510 data sheet for switching wave forms, circuits, and definitions

5 A load of N = 1 is defined by a circuit where C_s (See Figure A) is selected so that the total capacitance of the test fixture, connectors, and oscilloscope probe aggregates 50 pf

6 This is the delay time to steer a zero into either the R or S inputs of another flip flop

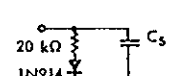


FIGURE A

TYPES SN516A, SN5161, SN5162
DIFFUSED SILICON "TRIPLE GATE" LOGIC NETWORKS

TYPES SN516A, SN5161, SN5162
BULLETIN NO DL-S 657900, AUGUST 1965
REPLACES BULLETINS NO DL-S 645068, MARCH 1964
AND NO. DL-S 655938, MARCH 1965

THREE SERIES 51 MICROELECTRONIC "TRIPLE GATES" FOR APPLICATION IN

- Digital Computer Systems
- Data Handling Systems
- Control Systems

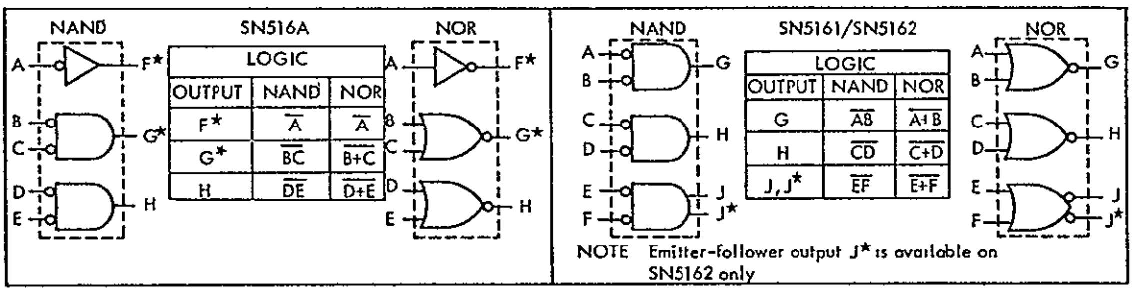
description

The SN516A is a multifunction semiconductor network containing two 2-input NAND/NOR gates and one inverter gate The output of the inverter and one of the NAND/NOR gates is from a high-fan-out emitter-follower circuit.

The SN5161 and SN5162 are multifunction semiconductor networks containing three 2-input NAND/NOR gates In addition to the three standard collector outputs, the SN5162 has a high-fan-out emitter-follower output circuit from one of the NAND/NOR gates.

These three networks are fabricated from the use-proven Series 51 Master Slice, and are fully compatible with all other Series 51 semiconductor networks over the entire military temperature range of −55°C to +125°C These units exhibit the same low power requirements as other Series 51 networks and are designed to reduce system package count thereby reducing system cost and improving reliability.

logic



SN516A LOGIC

OUTPUT	NAND	NOR
F*	$\overline{A}$	$\overline{A}$
G*	$\overline{BC}$	$\overline{B+C}$
H	$\overline{DE}$	$\overline{D+E}$

SN5161/SN5162 LOGIC

OUTPUT	NAND	NOR
G	$\overline{AB}$	$\overline{A+B}$
H	$\overline{CD}$	$\overline{C+D}$
J, J*	$\overline{EF}$	$\overline{E+F}$

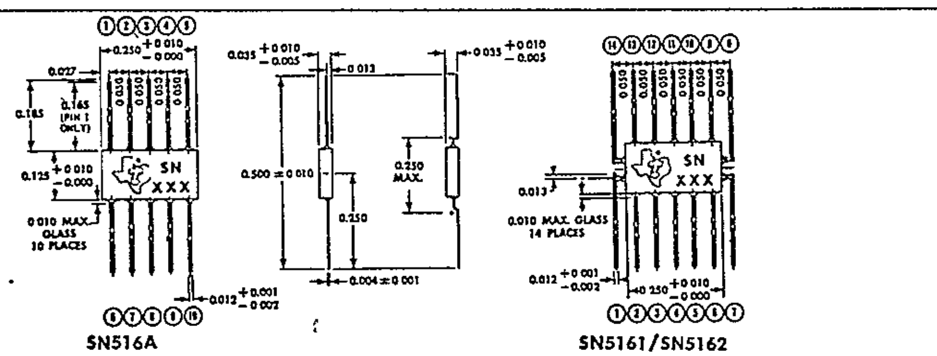
NOTE Emitter-follower output J* is available on SN5162 only

mechanical data

SOLID CIRCUIT Semiconductor Networks are mounted in a glass-to-metal hermetically sealed welded package Leads are gold-plated F-15‡ glass-sealing alloy Approximate weight is 0 1 gram. All external surfaces are metallic and are insulated from leads and circuit All Series 51 networks are available with formed leads, insulator attached, and/or mounted in a Mech-Pak carrier. See ordering instructions

ORDERING INSTRUCTIONS

	NO MECH PAK CARRIER				MECH PAK CARRIER			
Lead Length	0 185 inch				Not Applicable			
Formed Leads	No	No	Yes	Yes	No	No	Yes	Yes
Insulators	No	Yes	No	Yes	No	Yes	No	Yes
Ordering Suffix	None	−6	−7	−1	−2	−3	−4	−5



NOTES a All dimensions in inches
b All decimals ±0 005 except as noted
c Lead spacing tolerance is ±0 015 at extremities and ±0 005 at package, noncumulative
d Lead centerlines are located within ±0 005 of their true positions relative to body centerlines

OUTLINE DRAWING — SEMICONDUCTOR NETWORK WELDED PACKAGES

†Patented by Texas Instruments Instruments Incorporated

‡F-15 is the ASTM designation for an iron nickel cobalt alloy containing nominally 53% iron, 29% nickel, and 17% cobalt

PRELIMINARY DATA SHEET
Supplementary data will be published at a later date

absolute maximum ratings over operating free-air temperature range

Supply Voltage, V_{CC} (See Note 1)	8 v
Input Voltage, V_{in} (See Notes 1 and 2)	V_{CC}
Operating Free-Air Temperature Range	−55°C to +125°C
Storage Temperature Range	−55°C to +125°C

NOTES 1 Voltage values are with respect to network ground terminal
2 Input signals must be zero or positive with respect to network ground terminal

electrical characteristics

PARAMETER	TEST CONDITIONS	V_{CC} = 3 v MIN	V_{CC} = 3 v TYP	V_{CC} = 3 v MAX	V_{CC} = 6 v MIN	V_{CC} = 6 v TYP	V_{CC} = 6 v MAX	UNIT
Power Dissipation Per Gate	ON Condition, T_A = 25°C		2			8		mw
D C Fan Out (See Note 3)								
Output H of SN516A or outputs G, H, and J of SN5161/SN5162	T_A = −55°C to 125°C			5			5	
Outputs F★ and G★ of SN516A or output J★ of SN5162	T_A = −55°C to 125°C			25			25	
Input voltage required at all input terminals that will ensure turn off	T_A = 125°C			0.22			0.3	v
	T_A = −55°C			0.4			0.5	v
Input voltage required at any input terminal that will ensure turn on	T_A = 125°C	1.15			2			v
	T_A = −55°C	1.6			2.5			v
Output Voltage								
Output H of SN516A and outputs G, H, and J of SN5161/SN5162								
OFF Level	D-C Fan-Out = 0, T_A = 125°C, See Note 4	2.5			5			v
	D-C Fan-Out = 5, T_A = 125°C, See Note 4	1.15			2			v
	D-C Fan Out = 5, T_A = −55°C, See Note 4	1.6			2.5			v
ON Level	T_A = 125°C, See Note 5			0.22			0.3	v
	T_A = −55°C, See Note 5			0.4			0.5	v
Outputs F★ and G★ of SN516A and output J★ of SN5162								
OFF Level	D C Fan Out = 25, T_A = 125°C, See Note 4	1.8			3.8			v
	D-C Fan Out = 25, T_A = −55°C, See Note 4	1.6			3.5			v
ON Level	D C Fan-Out = 0, T_A = 125°C, See Note 5			0.22			0.3	v
	D C Fan Out = 0, T_A = −55°C, See Note 5			0.4			0.5	v

NOTES 3 When fanning out into flip flop clock-pulse inputs (a c loads) the emitter-follower outputs on the SN516A or SN5162 should be used for fan outs above N = 2 or frequencies above 500 kc

4 Inputs At 125°C, V_{in} = 0.22 v for V_{CC} = 3 v, V_{in} = 0.3 v for V_{CC} = 6 v,
at −55°C, V_{in} = 0.4 v for V_{CC} = 3 v, V_{in} = 0.5 v for V_{CC} = 6 v,

5 Each input is tested separately At 125°C, V_{in} = 1.15 v for V_{CC} = 3 v, V_{in} = 2 v for V_{CC} = 6 v,
at −55°C, V_{in} = 1.6 v for V_{CC} = 3 v, V_{in} = 2.5 v for V_{CC} = 6 v

switching characteristics, SN516A, $T_A = 25°C$

PARAMETER	TEST CONDITIONS	$V_{CC} = 3$ v, $V_{in} = 2$ v TYP	MAX	$V_{CC} = 6$ v, $V_{in} = 4$ v TYP	MAX	UNIT
Output H						
t_d Delay Time		65	105	35	60	nsec
t_r Rise Time		40	70	40	70	nsec
t_s Storage Time		60	105	55	90	nsec
t_f Fall Time		600	950	580	930	nsec
Output F★:						
t_d Delay Time	Input. $t_r = t_f = 100$ nsec, $t_p = 2$ μsec, f = 100 kc, See Note 6 and Figures 1 and 2	70	110	40	70	nsec
t_r Rise Time (See Note 7)		40	70	40	70	nsec
t_s Storage Time		150	280	85	140	nsec
t_f Fall Time		300	520	300	520	nsec
Output G★.						
t_d Delay Time		75	115	40	70	nsec
t_r Rise Time (See Note 7)		40	70	40	70	nsec
t_s Storage Time		160	300	90	160	nsec
t_f Fall Time		400	760	350	650	nsec

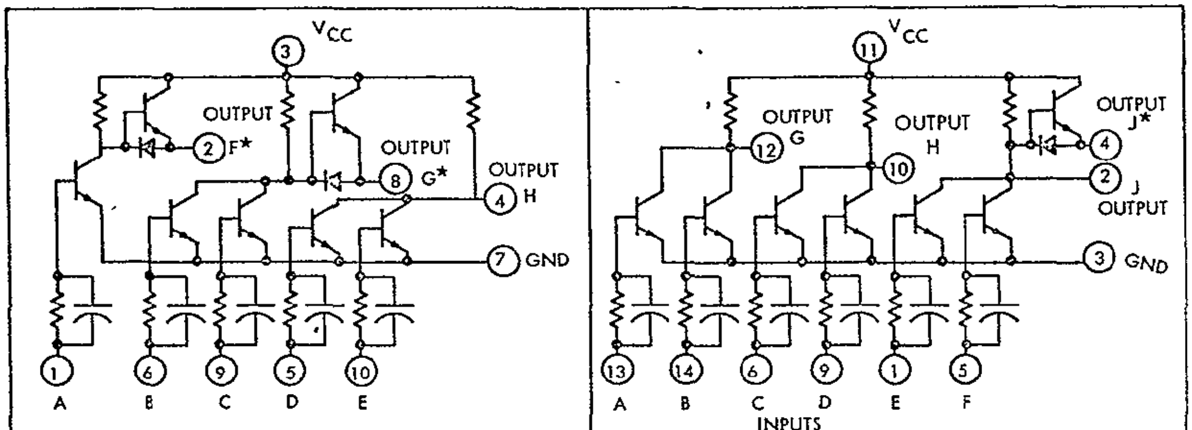
switching characteristics, SN5161/SN5162, $T_A = 25°C$

PARAMETER	TEST CONDITIONS	$V_{CC} = 3$ v, $V_{in} = 2$ v TYP	MAX	$V_{CC} = 6$ v, $V_{in} = 4$ v TYP	MAX	UNIT
Outputs G, H, and J						
t_d Delay Time		65	105	35	60	nsec
t_r Rise Time		40	70	40	70	nsec
t_s Storage Time		70	120	60	90	nsec
t_f Fall Time		750	1100	650	930	nsec
	Input. $t_r = t_f = 100$ nsec, $t_p = 2$ μsec, f = 100 kc, See Note 6 and Figures 1 and 2					
Output J★ (SN5162 Only)						
t_d Delay Time		75	115	40	70	nsec
t_r Rise Time (See Note 7)		40	70	40	70	nsec
t_s Storage Time		200	300	110	160	nsec
t_f Fall Time		550	760	450	650	nsec

NOTES 6 A switching load, applied only to the output being tested, is defined by a circuit where C_s is selected so that the total capacitance of the test fixture, connectors, oscilloscope probe, and C_s aggregates 50 pf See Figure 1

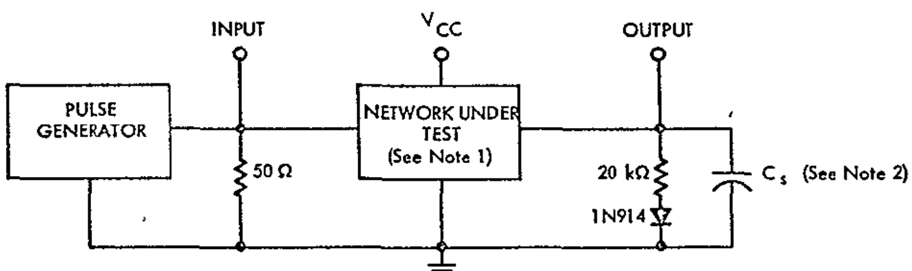
7. Emitter follower output rise time is measured between the 90 percent and 30 percent levels See Figure 2

schematic



NOTES 1 Emitter follower output J★ is available on SN5162 only
2 Pins (7) and (8) have no internal connections
3. No external connection should be made to pin (4) of the SN5161

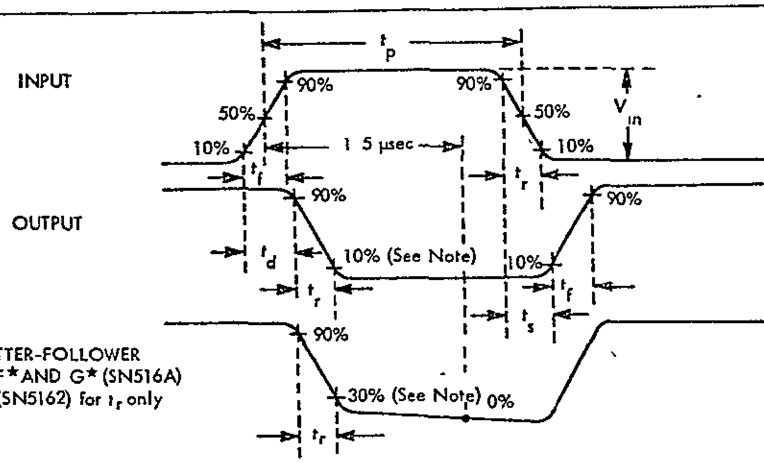
PARAMETER MEASUREMENT INFORMATION



NOTES 1 Each gate of each network is tested separately Pulse generator output is applied to one gate input and all other input terminals of the gate being tested are at ground potential Apply V_{CC} and ground and select corresponding gate output terminal as shown by the applicable schematic diagram

2 C_s is selected so that the total capacitance of the test fixtures, connectors, oscilloscope probe, and C_s aggregates 50 pf

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



NOTE Emitter follower output rise time is measured between the 90% and 30% levels

FIGURE 2 — SWITCHING TIME VOLTAGE WAVEFORMS

TEXAS INSTRUMENTS INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
POST OFFICE BOX 5012 • DALLAS 22 TEXAS

APPENDIX B

Master Drawing List (MDL)

Operational Test Specification

Flight Acceptance Test Specification

APPLICATION	
NEXT ASSY	FINAL ASSY

PARTS DISPOSITION
1. USE 3 CANNOT BE REWORKED
2 REWORK 4. RECORD 5

DWG NO MDL 544100-101 REV B

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPD
4	1&UP	A	REVISED "REV. LTR" & "DWG SIZE" COLUMNS	RG		23 AUG 67	
4	RCO	B	REVISED REV LTR TO REFLECT LATEST LETTER CHG	RS		4-1-67	

SHEET INDEX												
REV	B	B	B	B	B	B	B	B	B	B	B
SHEET	1	2	3	4	5	6	7	8	9	10	11

INTERPRET THIS DRAWING PER STANDARDS IN MIL-D-70327
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS: X ± 1, XX ± 03, XXX ± 010
ANGLES ± 0° 30'
XXXX ± 0050
SURFACE ROUGHNESS

HOLE DIA			TOLERANCE
0135	THRU	125	+ 004 − 001
126	THRU	250	+ 005 − 001
251	THRU	500	+ 006 − 001
501	THRU	750	+ 008 − 001
751	THRU	1 000	+ 010 − 001
1 000	THRU	2 000	+ 012 − 001
2 001	AND OVER		, LINEAR

CONTRACT NO NAS 2-3374
DRAWN R Golden 12 JAN 67
CHECK R. Richardson 1-13-67
MECH ENGR 1-16-67
ELECT ENGR 1/16/67
PROJ MGR 16 Jan 67
APPD R. Golden for 16 Jan 67
DESIGN ACTIVITY APPD
CUSTOMER

M L — MARSHALL LABORATORIES
TORRANCE, CALIFORNIA

TITLE INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C & D

SIZE A | CODE IDENT NO 13126 | DWG NO MDL 544100-101 | REV B

SCALE | RELEASED JAN 18 1967 | SHEET 1 OF 11

5-440 A & E

ML FORM 34A

LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1	X									1	544100-101	A	INSTRUMENT - FINAL ASSY	J
2														
3		X								REF	544000	D	MECHANICAL & THERMAL INTERFACE	E
4		X								REF	544001	E	ELECTRICAL INTERFACE	D
5		X								REF	544101	B	INTERCONNECT SCHEMATIC	J
6		X								REF	544144	B	WIRING LIST	A
7		/								1	544145-101	B	PURGE COVER ASSY	D
8			X							1	544145-1	B	COVER, DUST	D
9			X							1	544145-2	B	PLATE	D
10			X							1	544145-3	B	TUBE	D
11		X								REF	544146	N/C	RUBBER STAMP	B
12		X								REF	51404-101	A	CARRYING CASE ASSY	D
13			X							1	51404-1	A	BASE	D
14			X							1	51404-2	A	COVER	D
15			X							1	51404-3	A	SUB-BASE	D
16		X								1	544102-1	B	HOUSING	J
17		X								1	544106-101	N/C	COVER, HOUSING-TOP	D
18			X							1	544106-1	N/C	COVER	D
19														D
20			X							1	544109-1	A	COVER, HOUSING-LOWER	D
21		X								1	544110-1	N/C	COVER, CURRENT PROBE	D
22														D
23		X								1	544111-1	N/C	COVER, DUST-VOLTAGE PROBE	B
24														
25		X								1	544122-101	B	BUFFER STORAGE ASSY	E
26			X							1	544122-1	B	MATRIX SUB ASSY	E
27				X						1	544103-101	N/C	BUFFER MEMORY CORE PLANE ASSY	R
28					X					1	544103-100	N/C	WAFER	R
29					X					1	544103-200	NC	WAFER	R
30					X					1	544103-300	NC	WAFER	R
31					X					REF	546678	NC	TEST SPEC. - CORE PLANE	A
32				X						1	544124-101	N/C	MATRIX	A/W
33					X					1	T544124-1	N/C	WAFER	A/W
34					X					REF	SP30253-9	G	JIG-WAFER	F
35				X						1	SP30275( )	E	CAPACITOR	C
36				X						2	544125-1	N/C	SPACER	E
37				X						2	544125-2	N/C	SPACER	E
38				X						1	544149-101	N/C	HOOKUP & POSITION'G BOARD	A/W
39					X					1	544149-1	N/C	HOOKUP BOARD	A/W
40				X						1	544149-2	N/C	POSITIONING BOARD	A/W
41														
42				X						REF	W4334	A	MODULE - CURRENT SWITCH	E
43				X						6	W4334X1	N/C	- CURRENT SWITCH	A
44					X					REF	546033	B	- TEST SPEC	A
45														
46				X						REF	W4335	N/C	MODULE - CURRENT DRIVER	E
47				X						7	W4335X1	A	- CURRENT DRIVER	A
48					X					REF	546034	N/C	- TEST SPEC	A
49														
50														

MODEL NO.

TITLE— MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	SIZE A	CODE IDENT NO. 13126	DWG NO. MDL 544100-101	REV B
	SCALE	RELEASED	SHEET 2 OF	

ML FORM 204

LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1				X						REF	W4339	N/C	MODULE - X SWITCH / DRIVER GATINGS	E
2				X						1	W4339X1	N/C	- X SWITCH / DRIVER GATINGS	A
3					X					REF	S46035	N/C	- TEST SPEC	A
4														
5				X						REF	W4340	N/C	MODULE - Y SWITCH GATING	E
6				X						1	W4340X1	N/C	- Y SWITCH GATING	A
7					X					REF	S46036	B	- TEST SPEC	A
8														
9				X						REF	W4341	N/C	MODULE - Y DRIVER GATING	E
10				X						1	W4341X1	N/C	- Y DRIVER GATING	A
11					X					REF	S46037	A	- TEST SPEC	A
12														
13				X						REF	W4356	N/C	MODULE - GATE SWITCH	E
14				X						1	W4356X1	N/C	- GATE SWITCH	A
15					X					REF	S46128	N/C	- TEST SPEC	A
16														
17				X						REF	W4357	A	MODULE - WRITE TIMING CIRCUIT	E
18				X						1	W4357X1	N/C	- WRITE TIMING CIRCUIT	A
19					X					REF	S46065	N/C	- TEST SPEC	A
20														
21				X						REF	W4358	N/C	MODULE - STROBE DELAY & ONE SHOT	E
22				X						1	W4358X1	A	- STROBE DELAY & ONE SHOT	A
23					X					REF	S46061	N/C	- TEST SPEC	A
24														
25				X						REF	W4359	N/C	MODULE - READ TIMING	E
26				X						1	W4359X1	N/C	- READ TIMING	A
27					X					REF	S46037	A	- TEST SPEC	A
28														
29				X						REF	W7000	N/C	MODULE - SLEW SUPPLY - SENSE AMP	E
30				X						1	W7000X1	A	- SLEW SUPPLY - SENSE AMP	A
31					X					REF	S46052	N/C	- TEST SPEC	A
32														
33				X						REF	W7003	A	MODULE - X WRITE COUNTER	E
34				X						1	W7003X1	N/C	- X WRITE COUNTER	A
35					X					REF	S46057	A	- TEST SPEC	A
36														
37				X						REF	W7004	N/C	MODULE - Y WRITE COUNTER	E
38				X						1	W7004X1	N/C	- Y WRITE COUNTER	A
39					X					REF	S46058	N/C	- TEST SPEC	A
40														
41				X						REF	W7005	N/C	MODULE - Y READ COUNTER	E
42				X						1	W7005X1	N/C	- Y READ COUNTER	A
43					X					REF	S46059	N/C	- TEST SPEC	A
44														
45				X						REF	W7006	A	MODULE - X READ COUNTER	E
46				X						1	W7006X1	B	- X READ COUNTER	A
47					X					REF	S46060	N/C	- TEST SPEC	A
48														
49														
50														

MODEL NO.

TITLE	SIZE	CODE IDENT NO	DWG NO	REV
MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	A	13126	MDL 544100-101	B
	SCALE	RELEASED	SHEET 3 OF	

ML FORM 204

LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1				X						REF	W7007	N/C	MODULE - DRIVER INTERFACE	E
2				X						5	W7007X1	N/C	- DRIVER INTERFACE	A
3					X					REF	546062	B	- TEST SPEC	A
4														
5				X						REF	W7008	B	MODULE - B.S. (WRITE PULSE GEN)	E
6				X						1	W7008X1	N/C	- B.S. (WRITE PULSE GEN)	A
7					X					REF	546063	N/C	- TEST SPEC	A
8														
9				X						REF	W7009	C	MODULE - FRAME I.D. COUNTER	E
10				X						1	W7009X1	A	- FRAME I.D. COUNTER	A
11					X					REF	546057	A	- TEST SPEC	A
12														
13				X						REF	W7012	A	MODULE - INHIBIT READ-WRITE A	E
14				X						1	W7012X1	A	- INHIBIT READ-WRITE A	A
15					X					REF	546106	A	- TEST SPEC	A
16														
17				X						REF	W7013	N/C	MODULE - B.S. IS EMPTY	E
18				X						1	W7013X1	N/C	- B.S. IS EMPTY	A
19					X					REF	546107	N/C	- TEST SPEC	A
20														
21				X						REF	W7014	C	MODULE - INHIBIT READ-WRITE B	E
22				X						1	W7014X1	F	- INHIBIT READ-WRITE B	A
23					X					REF	546108	A	- TEST SPEC	A
24														
25				X						REF	W7015	N/C	MODULE - DRIVER INTERFACE № 2	E
26				X						1	W7015X1	N/C	- DRIVER INTERFACE № 2	E
27					X					REF	546109	N/C	- TEST SPEC	A
28														
29														
30			X							REF	546591	A	TEST SPEC.	A
31			X							1	544108-2	A	FRAME, BLIVIT BUFFER	E
32			X							REF	544123	NC	SCHEMATIC - BUFFER STORAGE	J
33														
34		X								1	544126-101	A	LOGIC ASSY	E
35			X							1	544126-1	A	MATRIX SUB ASSY	E
36			X							REF	SP30253	G	ASSY FIXTURE	F
37														
38				X						1	T544147-101	A	HOOKUP & POSITIONING BOARD	E
39					X					1	T544147-1	A	HOOKUP BOARD	E
40				X						1	T544147-102	A	HOOKUP & POSITIONING BOARD	E
41					X					1	T544147-2	A	POSITIONING BOARD	E
42														
43				X						1	T544129-101	A	MATRIX ASSY	E
44					X					1	T544129-1	A	WAFER	E
45				X						1	T544128-101	A	MATRIX ASSY #1	E
46					X					1	T544128-1	A	WAFER	E
47					X					1	T544128-1	A	INSULATOR	E
48														
49				X						1	544130-1	N/C	SPACER	E
50				X						1	544130-2	N/C	SPACER	E

MODEL NO.

TITLE— MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	SIZE A	CODE IDENT NO 13126	DWG NO MDL 544100-101	REV B
	SCALE	RELEASED	SHEET 4	OF

ML FORM 204

LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2				X						REF	W7019	N/C	MODULE - SECT. DET & A/D CONTROL	D
3				X						1	W7019X1	N/C	" - " " " "	A
4					X					REF	S46115	A	- TEST SPEC.	A
5				X						REF	W4361	N/C	MODULE - A/D CLOCK	E
6				X						1	W4361X1	N/C	- " "	A
7					X					REF	S46123	A	- TEST SPEC.	A
8				X						REF	W4344	A	MODULE - ION RAMP GEN.	E
9				X						1	W4344X1	N/C	- " " "	A
10					X					REF	S46040	N/C	- TEST SPEC.	A
11				X						REF	W4343	N/C	MODULE - ELECTRON RAMP DELAY	F
12				X						1	W4343X1	A	- " " "	A
13					X					REF	S46039	N/C	- TEST SPEC	A
14				X						REF	W4362	A	MODULE - ONE SHOT/GUN PULSE DELAY	F
15				X						1	W4362X1	E	- " " " " "	A
16					X					REF	S46122	N/C	- TEST SPEC.	A
17				X						REF	W7062	N/C	MODULE - DC INTERFACE	E
18				X						1	W7062X1	N/C	- " "	A
19					X					REF	S46181	N/C	- TEST SPEC.	A
20				X						REF	W7033	N/C	MODULE - HV PROGRAMMER #2	D
21				X						1	W7033X1	N/C	- " " "	A
22					X					REF	S46171	N/C	- TEST SPEC.	A
23				X						REF	W7057	N/C	MODULE - RIPPLE COUNTER	E
24				X						3	W7057X1	N/C	- " "	A
25					X					REF	S46261	A	- TEST SPEC.	A
26				X						REF	W4342	N/C	MODULE - RAMP BUFFER	E
27				X						1	W4342X1	N/C	- " "	A
28					X					REF	S46038	A	- TEST SPEC.	A
29				X						REF	W4365	B	MODULE - AC INTERFACE & TRIGGER	E
30				X						1	W4365X1	C	- " " "	A
31					X					REF	S46158	N/C	- TEST SPEC.	A
32				X						REF	W7034	N/C	MODULE - HV PROGRAMMER #1	F
33				X						1	W7034X1	N/C	- " " "	A
34					X					REF	S46170	B	- TEST SPEC.	A
35				X						REF	W4367	NC	MODULE - TEMP. SENSOR	F
36				X						1	W4367X1	A	- " "	A
37					X					REF	S46182	A	- TEST SPEC.	A
38				X						REF	W4366	A	MODULE - VCO & FILTER	E
39				X						1	W4366X1	N/C	- " "	A
40					X					REF	S46159	A	- TEST SPEC.	A
41				X						REF	W4193	A	MODULE - ONE SHOT	D
42				X						1	W4193X7	A	- " "	A
43					X					REF	S40397	A	- TEST SPEC.	A
44				X						REF	W7032	C	MODULE - ELECTROMETER	D
45				X						1	W7032X1	A	- "	A
46					X					REF	S46172	N/C	- TEST SPEC.	A
47				X						REF	W7001	N/C	MODULE - SECTOR PROGRAMMER	D
48				X						3	W7001X1	N/C	- " "	A
49					X					REF	S46054	B	- TEST SPEC.	A
50														

MODEL NO

TITLE	SIZE	CODE IDENT NO	DWG NO	REV
MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C & D	A	13126	MDL 544100-101	B
	SCALE	RELEASED	SHEET 5 OF	

ML FORM 204

LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1				X						REF	W7031	A	MODULE-HV PROGRAMMER #4	F
2				X						1	W7031X1	A	— " " "	A
3					X					REF	S46173	N/C	— TEST SPEC.	A
4				X						REF	W7024	N/C	MODULE- A/D TIMING	D
5				X						1	W7024X1	N/C	— " "	A
6					X					REF	S46120	A	— TEST SPEC.	A
7				X						REF	W7002	A	MODULE- A/D DIGITAL COMPARATOR	D
8				X						4	W7002X1	N/C	— " " "	A
9					X					REF	S46055	A	— TEST SPEC.	A
10				X						REF	W7016	N/C	MODULE-STABILIZATION SIGNAL A	F
11				X						1	W7016X1	N/C	— " " "	A
12					X					REF	S46112	N/C	— TEST SPEC.	A
13				X						REF	W7018	B	MODULE - GEN. AS & PS AT LBR.	F
14				X						1	W7018X1	C	— " " " " "	A
15					X					REF	S46114	A	— TEST SPEC.	A
16				X						REF	W7026	N/C	MODULE - SHIFT PULSE GEN.	D
17				X						1	W7026X1	N/C	— " " "	A
18					X					REF	S46124	B	— TEST SPEC.	A
19				X						REF	W7020	N/C	MODULE - SUN PULSE DELAY	D
20				X						1	W7020X1	N/C	— " " "	A
21					X					REF	S46116	A	TEST SPEC	A
22				X						REF	W7010	N/C	MODULE - DECODER #1-A	D
23				X						1	W7010X1	N/C	— " "	A
24					X					REF	S46070	A	— TEST SPEC.	A
25				X						REF	W7023	N/C	MODULE - RESET A/D	F
26				X						1	W7023X1	N/C	— " "	A
27					X					REF	S46119	N/C	— TEST SPEC.	A
28				X						REF	W7011	N/C	MODULE - DECODER #1-B	D
29				X						1	W7011X1	N/C	— " "	A
30					X					REF	S46071	A	— TEST SPEC.	A
31				X						REF	W7017	A	MODULE - TARGET PROGRAMMER	D
32				X						1	W7017X1	N/C	— " "	A
33					X					REF	S46113	A	— TEST SPEC.	A
34				X						REF	W7022	B	MODULE - SPOKE GEN.	D
35				X						1	W7022X1	A	— " "	A
36					X					REF	S46118	A	— TEST SPEC.	A
37				X						REF	W7021	N/C	MODULE - WRITE PULSE	D
38				X						1	W7021X1	N/C	— " "	A
39					X					REF	S46117	A	— TEST SPEC.	A
40				X						REF	W7025	N/C	MODULE - SECTOR	D
41				X						1	W7025X1	N/C	— "	A
42					X					REF	S46121	N/C	— TEST SPEC.	A
43				X						REF	W7030	N/C	MODULE - HV GEN./COMM. LOGIC	A
44				X						1	W7030X1	N/C	— " " " "	A
45					X					REF	S46160	A	— TEST SPEC.	A
46			X							1	544108-1	A	LOGIC BLIVIT FRAME	E
47			X							REF.	S46592	N/C	TEST SPEC.	A
48														
49			X							REF.	544127	B	SCHEMATIC DIAGRAM	J
50														

MODEL NO

TITLE— MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	SIZE A	CODE IDENT NO 13126	DWG NO MDL 544100-101	REV B
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LINE NO.	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2		X								1	544131-101	A	POWER SUPPLY ASSY	E
3			X							1	544131-1	A	H.V. POWER SUPPLY	E
4				X						1	T544133-101	A	Hook-Up & Positioning Brd. #1, HVA	E
5					X					1	544133-1	A	Hook-Up & Positioning Brd.	E
6														
7				X						1	T544134-101	A	Hook-Up & Positioning Brd. #2, HVPS	E
8					X					1	544134-1		Hook-Up & Positioning Brd.	E
9														
10														
11														
12				X						5	SP30126( )	B	WASHER - INSULATING	B
13				X						4	SP30126( )	B	WASHER - INSULATING	B
14				X						REF	W7075	N/C	MODULE - H.V. A/D I.C.	D
15				X						1	W7075X1	N/C	- " " "	A
16					/					REF	S46302	N/C	- TEST SPEC.	A
17				X						REF	W7068	A	MODULE - H.V. DC FEEDBACK AMPL.	E
18				X						1	W7068X1	E	- " " " "	A
19					X					REF	S46174	A	- TEST SPEC.	A
20				X						REF	W7068	A	MODULE - H.V. D.C. FEEDBACK AMPL.	E
21				X						1	W7068X2	D	- " " " "	A
22					X					REF	S46174	A	- TEST SPEC.	A
23				X						REF	W7050	A	MODULE - H.V. SIG. CHOPPER (ELECT)	E
24				X						1	W7050X1	A	- " " " "	A
25					X					REF	S46175	A	- TEST SPEC.	A
26				X						REF	W7051	N/C	MODULE - H.V. SIG. CHOPPER (ION)	E
27				X						1	W7051X1	A	- " " " "	A
28					X					REF	S46244	A	- TEST SPEC.	A
29				X						REF	W7052	N/C	MODULE - H.V. MULTI. & DUMP	E
30				X						1	W7052X1	C	- " " "	A
31					X					REF	S46176	N/C	- TEST SPEC.	A
32				X						REF	W7069	N/C	MODULE - AUX. POWER SUPPLY	E
33				X						1	W7069X1	N/C	- " " "	A
34					X					REF	S46177	A	- TEST SPEC.	A
35				X						REF	W7059	A	MODULE - H.V. A/D COMP. - A	E
36				X						1	W7059X1	C	- " " " "	A
37					X					REF	S46178	N/C	- TEST SPEC.	A
38				X						REF	W4381	N/C	MODULE - H.V. A/D - B	E
39				X						1	W4381X1	N/C	- " " "	A
40					X					REF	S46179	N/C	- TEST SPEC.	A
41				X						REF	W4382	N/C	MODULE - H.V. CONTROL GATES	E
42				X						1	W4382X1	B	- " " "	A
43					X					REF	S46180	N/C	- TEST SPEC.	A
44														
45														
46														
47			X								544131-2	A	L.V. POWER SUPPLY	E
48				X							T544135-101	B	Hook-Up & Positioning Brd.	E
49					X						544135-1	B	Hook-Up & Positioning Brd.	E
50														

MODEL NO

TITLE—	SIZE	CODE IDENT NO	DWG NO.	REV
MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	A	13126	MDL 544100-101	B
	SCALE	RELEASED		SHEET 7 OF

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LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2														
3				X						REF	W7063	A	MODULE — PREREGULATOR	E
4				X						1	W7063X1	B	— " "	A
5					X					REF	S46041	NC	— TEST SPEC.	A
6				X						REF	W4347	A	MODULE — CHOPPER	E
7				X						1	W4347X1	B	— "	A
8					X					REF	S46043	N/C	— TEST SPEC.	A
9				X						REF	W4346	N/C	MODULE — FILTER	E
10				X						1	W4346X1	N/C	— "	A
11					X					REF	S46042	N/C	— TEST SPEC	A
12				X						REF	W4350	N/C	MODULE — +15V. POST REG.	F
13				X						1	W4350X1	A	— " " "	A
14					X					REF	S46046	N/C	— TEST SPEC.	A
15				X						REF	W4351	N/C	MODULE — (−)25V. POST REG.	E
16				X						1	W4351X1	A	— " " "	A
17					X					REF	S46047	N/C	— TEST SPEC.	A
18				X						REF	W4349	A	MODULE — +12 V POST REG	F
19				X						1	W4349X1	A	— " " "	A
20					X					REF	S46045	A	— TEST SPEC.	A
21				X						REF	W4353	N/C	MODULE — +6V. POST REG.	F
22				X						1	W4353X1	A	— " " "	A
23					X					REF	S46049	A	— TEST SPEC.	A
24				X						REF	W4352	N/C	MODULE — (−)6V POST REG.	F
25				X						1	W4352X1	A	— " " "	A
26					X					REF	S46048	N/C	— TEST SPEC.	A
27				X						REF	W4348	A	MODULE — +3V RECT. FILTER	E
28				X						1	W4348X1	B	— " " "	A
29					X					REF	S46044	N/C	— TEST SPEC.	A
30														
31				X						1	SP30352	A	TRANSFORMER	A
32														
33				X						1	SP30353	B	TRANSFORMER	A
34														
35			X							REF.	544132	B	SCHEMATIC DIAGRAM	E
36		X								REF.	546593	N/C	TEST SPEC.	A
37			X							1	544107-1	A	BLIVET FRAME	E
38			X							1	544107-2	A	BLIVET FRAME COVER	E
39			X											
40														
41			X							1	544137-101	A	ANALYZER & OPTICS ASSY	E
42				X						1	544137-1	A	DRIFT TUBE ASSY	E
43					X					1	544805-1	C	DRIFT TUBE	D
44				X						1	544120-1	A	METALLIC FACE PLATE	F
45				X						1	544121-1	N/C	LEXAN FACE PLATE	F
46				X						1	544114-1	N/C	GROUND VANE	D
47				X						1	544804-1	B	ANALYZER PLATE INNER	J
48				X						1	544804-2	B	ANALYZER PLATE, OUTER	J
49														
50				X						REF	544101	B	INTERCONNECT DIAGRAM	E

MODEL NO.

TITLE— MASTER DRAWING LIST
INSTRUMENT, FINAL ASSY
ARC PLASMA PROBE
PIONEER C&D

SIZE	CODE IDENT NO	DWG NO	REV
A	13126	MDL 544100-101	B

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LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2														
3				X						1	544138-101	A	AMPLIFIER ASSY	E
4					X					1	544138-1	A	DRIVEN SHIELD ASSY	E
5						X				1	544112-1	N/C	DRIVEN SHIELD	F
6					X					1	544138-2	A	DRIVEN SHIELD ASSY	E
7						X				1	544112-2	N/C	DRIVEN SHIELD	F
8					X					1	544138-3	A	DRIVEN SHIELD ASSY	E
9						X				1	544112-3	N/C	DRIVEN SHIELD	F
10														
11					X					1	544140-101	B	ELECTROMETER F/E ASSY	D
12						X				1	544140-1	B	" CIRCUIT BRD.	D
13						X				REF	W7037	A	MODULE - ELECTROMETER	F
14						X				3	W7037X1	A	- "	A
15							X			REF	546193	N/C	- TEST SPEC.	A
16						X				REF	W7038	A	MODULE - STABILIZATION AMPL.	F
17						X				3	W7038X1	B	- " "	A
18							X			REF	546194	N/C	TEST SPEC.	A
19						X				REF	W7039	N/C	MODULE - STABILIZATION STORAGE	E
20						X				3	W7039X1	N/C	- " "	A
21							X			REF	546195	N/C	- TEST SPEC.	A
22														
23						X				REF.	544150	E	SCHEMATIC DIAGRAM	C
24														
25					X					1	544141-101	A.	COMPRESSION - PWM ASSY	E
26						X				1	7544148-101	N/C	HOOK-UP BOARD ASSY	E
27							X			1	7544148-1	N/C	" " "	E
28						X				1	7544148-2	N/C	POSITIONING BRD.	E
29						X				1	7544147-101	N/C	MATRIX ASSY	E
30							X			1	544147-1	N/C	"	E
31						X				2	7544143-1	N/C	SPACER	E
32						X				REF.	546293	N/C	TEST SPEC.	A
33														
34						X				REF	W7040	N/C	MODULE - P.S. FILTER	J
35						X				1	W7040X1	A	- " "	A
36							X			REF	546183	A	- TEST SPEC.	A
37						X				REF	W4406	N/C	MODULE - REFERENCE DRIVER	D
38						X				3	W4406X1	A	- " "	A
39							X			REF	546204	N/C	- TEST SPEC.	A
40						X				REF	W4459	B	MODULE - SUP. CIRCUIT	E
41						X				1	W4459X1	C	- " "	A
42							X			REF	546328	A	- TEST SPEC.	A
43						X				REF	W4403	N/C	MODULE - STABILIZER BUFFER	D
44						X				1	W4403X1	N/C	- " "	A
45							X			REF	546200	B	- TEST SPEC.	A
46						X				REF	W4404	N/C	MODULE - REFERENCE GEN.	D
47						X				1	W4404X1	N/C	- " "	A
48							X			REF.	546202	N/C	- TEST SPEC.	A
49														
50														

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TITLE— MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	SIZE	CODE IDENT NO.	DWG NO	REV
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LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2														
3						X				REF.	W4405	N/C	MODULE – OFFSET GEN.	F
4						X				1	W4405X1	A	– " "	A
5							X			REF.	546203	N/C	– TEST SPEC.	A
6						X				REF.	W4401	N/C	MODULE – NEG. COMPARATOR	E
7						X				3	W4401X1	N/C	– " "	A
8							X			REF	546198	A	– TEST SPEC.	A
9						X				REF.	W4402	N/C	MODULE – POS. COMPARATOR	E
10						X				3	W4402X1	N/C	– " "	A
11							X			REF.	546199	A	– TEST SPEC	A
12						X				REF.	W4360	N/C	MODULE – ATTEN. DRIVER	E
13						X				3	W4360X1	N/C	– " "	A
14							X			REF.	546196	A	– TEST SPEC.	A
15						X				REF	W4400	A	MODULE – ATTEN. & CALIB	F
16						X				3	W4400X1	A	– " "	A
17							X			REF.	546197	N/C	– TEST SPEC.	A
18						X				REF	W7041	A	MODULE – PWM OUTPUT LOGIC	E
19						X				1	W7041X1	N/C	– " " "	A
20							X			REF.	546201	N/C	– TEST SPEC.	A
21						X				REF.	W7044	A	MODULE – PWM PROG.	E
22						X				1	W7044X1	N/C	– " "	A
23							X			REF.	546225	N/C	– TEST SPEC.	A
24														
25														D
26														
27						X				REF.	SP30253	G	ASSY FIXTURE	F
28														
29					X					1	544116-1	B	AMPLIFIER HOUSING	E
30					X					1	544116-2	B	COVER – AMPL. HOUSING	E
31					X					1	544116-3	B	AMPLIFIER HOUSING	E
32					X					1	544116-4	B	" "	E
33					X					1	544116-5	B	" "	E
34					X					1	544118-1	N/C	DRIVEN SHIELD SUPPORT	D
35														
36					X					1	544113-1	N/C	TARGET	F
37					X					1	544113-2	N/C	TARGET	F
38					X					1	544113-3	N/C	TARGET	F
39					X					1	544115-1	N/C	TARGET INSULATOR GUARD	F
40					X					1	544115-2	N/C	" " "	E
41					X					1	544115-3	N/C	" " "	E
42					X					1	544117-1	N/C	TARGET SUPPORT	D
43					X					1	544117-2	N/C	" "	D
44														
45					X					REF	544139	B	SCHEMATIC DIAGRAM	D
46														
47		X								1	544152-101	N/C	RESISTOR BOARD ASSY	C
48			X							1	544152-1	N/C	RESISTOR BOARD	C
49		X								1	544151-1	N/C	ADAPTER PLATE	B
50														

MODEL NO

TITLE—	SIZE	CODE IDENT NO	DWG NO	REV
MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	A	13126	MDL 544100-101	B
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LINE NO	ASSEMBLY POSITION 1	2	3	4	5	6	7	8	9	QTY	DRAWING NUMBER	REV LTR	DRAWING TITLE	DWG SIZE
1														
2														
3										REF	S40111	B	IDENTIFICATION SPEC.	A
4										REF	S46250	D	OPERATIONAL TEST SPEC.	A
5										REF	S46251	B	FUNCTION TEST SPEC	A
6										REF	S46275	D	QUALIFICATION TEST SPEC.	A
7										REF	S46276	B	ACCEPTANCE TEST SPEC.	A
8														
9										REF	S40118	A	PAINT SPEC.	A
10										REF	S40093	A	POTTING-CONNECTOR, SPEC.	A
11														
12										REF	S40149	A	BONDING SPEC.	A
13										REF	S40072	A	MANUFACTURING SPEC.	A
14										REF	S40081	D	ASSY SPEC.	A
15														
16										REF	S40091	A	COATING SPEC.	A
17										REF	S40092	B	FOAMING SPEC.	A
18										REF	S40094	A	FABRICATION SPEC.	A
19														
20										REF	S40379	N/C	SPOT-POT SPEC.	A
21														
22														
23														
24										REF	S40306	A	SEALING SPEC.	A
25										REF	S40126	B	SOLDERING SPEC.	A
26														
27														
28														
29														
30														
31														
32														
33														
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MODEL NO.

TITLE— MASTER DRAWING LIST INSTRUMENT, FINAL ASSY ARC PLASMA PROBE PIONEER C&D	SIZE	CODE IDENT NO.	DWG NO	REV
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PARTS DISPOSITION

1 USE
2 REWORK
3 CANNOT BE REWORKED
4. RECORD
5.

SPEC NO. S 46250 — REV D

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPROVAL
4	1&Up	A	Sheet 1 recorded change, Page 21, Table 3a, Revised completely			5/8/67	
4	1 &Up	B	Revised pages 1, 12, 13, 14, 19, 20, 21, 22, 23, 24, 25	DP by DRC		7/24/67	
4	1, 3 &4	C	Revised pages 13, 14, and 21.		RJ	4/9/68	E. Aari 4.9.68
4	1, 3 &4	D	Revised pages 13, 24, 25, and 26.	RJ	RJ	11/1/68	E. Aari 11.4.68

REV D

SPEC NO. S 46250

SHEET INDEX	REV	D	B	A	B	D	C	B	B	B	B	D	D	C	D
	SHEET	1	21	18	12	13	14	19	20	22	23	24	25	21	26

CONTRACT NO. NAS 2-3374

PREP D. Petrics 6 Mar 67

CK

ENGR 4/3/67

APPD 4 Apr 67

APPD

QC APPD 4 April 67

DESIGN APPD

CUSTOMER

M L — MARSHALL LABORATORIES, TORRANCE, CALIFORNIA

TITLE: Operational Test Procedure Specification
ARC Plasma Probe - Pioneer C & D
Model ML 304-1

SIZE	CODE IDENT NO.	SPECIFICATION NO.	REV
A	13126	S 46250	D

RELEASED APR 4 1967 — SHEET 1 OF 26

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ACTIVE - CHANGED PAGE SUMMARY

Item	Paragraph	Description	Approval

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1.0 SCOPE

1.1 Introduction

This specification defines the scientific instrument operational test procedure for the Ames Research Center Plasma Probe Instrument, ML-304-1, for Pioneer C & D. Instrument ML-304-1 is an electrostatic energy per unit charge (E/q) spectrometer. It is capable of measuring solar plasma charged particles in terms of flux, corresponding to energy level and incident direction of arrival. A functional block diagram of the scientific instrument is shown in Figure 1.

1.2 Test Requirements

The test procedures established herein are in accordance with the requirements outlined in ARC/NASA Specification A-10202 Revision "C" entitled "Specification for ARC Plasma Probe - Pioneer C & D".

1.3 Responsibility

The responsibility and authority for decisions relative to the requirements of this specification rests with Marshall Laboratories subject to approval by NASA/ARC.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications

Ames Research Center

2.1.1	A-10202 Revision "C"	Specification for Ames Plamsa Probe for Pioneer C & D

Marshall Laboratories

2.1.3	S46251	Functional Test Procedure
2.1.4	S46275	Qualification Test Procedure
2.1.5	S46276	Flight Acceptance Test Procedure

M L MARSHALL LABORATORIES

CODE IDENT NO

TITLE Operational Test Procedure ARC Plasma Probe - Pioneer C & D Model ML 304-1

SPECIFICATION NO S 46250

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REV

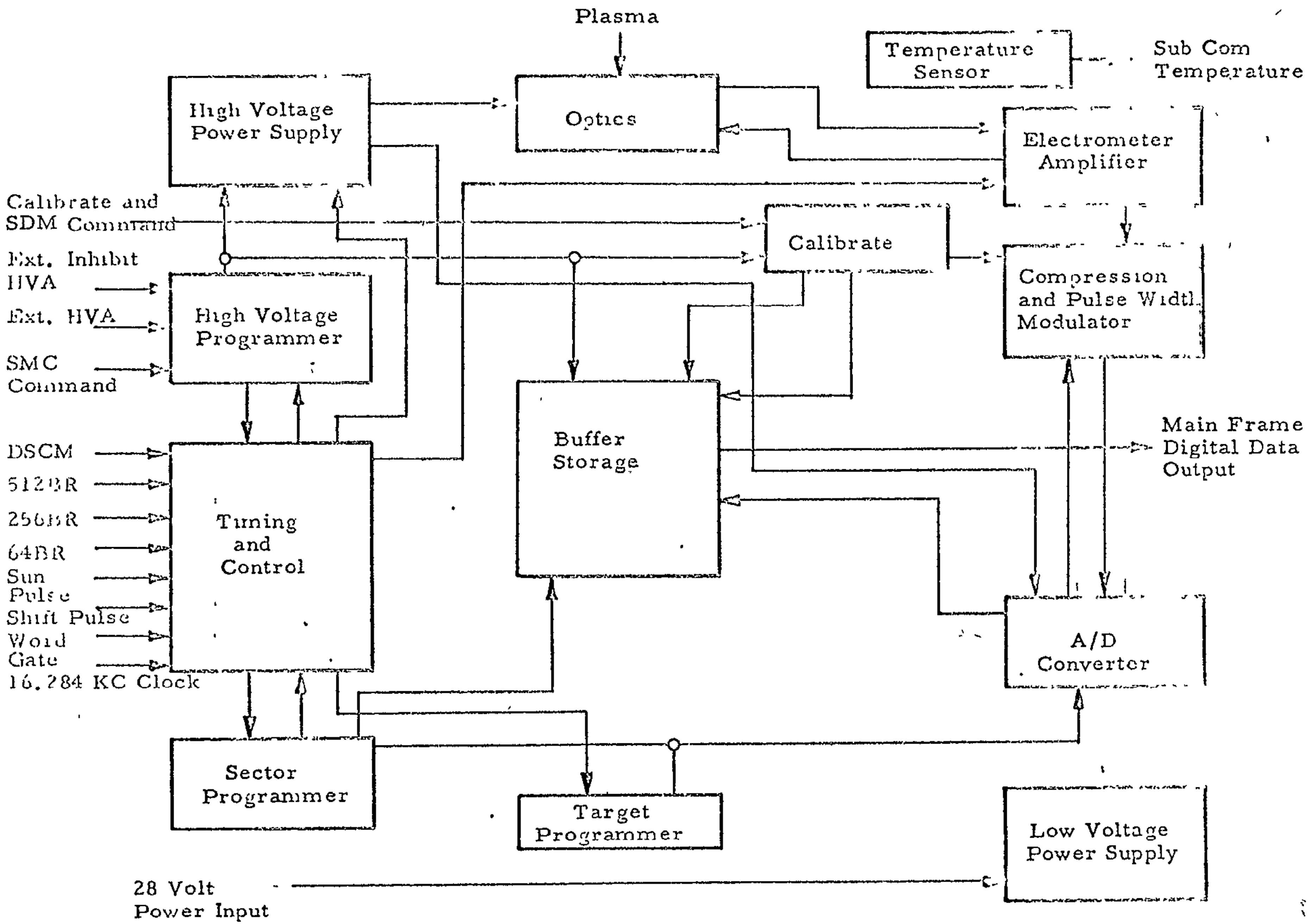


Figure 1. Block Diagram of Scientific Instrument

2.2 Drawings

Marshall Laboratories

2.2.1	544000	Mechanical and Thermal Interface Diagram
2.2.2	544001	Electrical Interface and Wiring Diagram
2.2.3	544100	Instrument Final Assembly
2.2.4	544101	Interconnection Diagram

3.0 ENVIRONMENTAL REQUIREMENTS

3.1 Expected Actual Environment

The electronic and mechanical assemblies within the Plasma Probe Instrument shall perform satisfactorily under the conditions expected to exist during time of operation in orbit and be able to withstand, with no out of tolerance degradation all environmental conditions expected to be encountered during storage, shipment, handling, standby, pre-flight, and flight prior to operational period as outlined in ARC Specification A-10202 Revision "C", paragraph B1.1.2.

4.0 TEST EQUIPMENT

4.1 Special Equipment

The following special Ground Support Equipment (GSE) shall be used:

a. GSE Simulator Unit - P/N 544516-101 ML 311-1.

b. GSE Monitor and Control Unit - P/N 544502-101 ML 312-1.

c. GSE Printer Unit - P/N 544510-101 ML 314-1.

d. Current Probe - P/N 544506-101 ML 315-1.

e. Meter Unit - P/N 544500-101 ML 313-2.

f. Isobox Unit - P/N 544526-101, ML 344-1.

g. Demodulator, Simulator Unit - P/N 544516-101, 102, ML339-1

5.0 TEST FACILITIES

The operational tests are to be conducted at Marshall Laboratories and outside vendor facilities as required by the prevailing test specification requirements.

5.1 Standard Conditions for Test Area

Conditions for conducting the scientific experiment operational test shall be as indicated below:

a. Temperature: $25 \pm 3^{\circ}C$ ($77^{\circ} \pm 5^{\circ}F$)

b. Relative Humidity: 55 percent or less

c. Barometric Pressure: Room ambient (corrected to 29.92 inches Hg if so specified in the applicable equipment specification)

6.0 TEST SEQUENCE

Unless otherwise specified the test sequence for the qualification of the Plasma Probe Instrument shall be as follows:

a. Initial control settings

b. Meter Unit Instrument Voltage

c. Instrument Current

d. Bit Rate 512 Operation

e. Calibrate Command

f. Suppression Mode Change Command

g. Bit Rate 64 Operation

7.0 PERFORMANCE RECORD

A chronological scientific instrument log of performance data shall be maintained and available at one central location throughout the test program and shall indicate accumulated running times suitable for reliability review. Entries shall be complete, self-explanatory and include, but not be limited to, the following:

a. Date and time of entry.

b. Identity of test or inspection

c. Environmental conditions

d. Test procedure reference (if applicable)

e. Characteristics being investigated

f. Parameter measurements

g. Complete identification of instrumentation used, including serial no. and calibration dates.

h. Failure observations and discrepancy report reference made as a result of failure or unusual performance.

i. Accumulated operating time

j. Record unusual or questionable occurrence involving the instrument being tested or other equipment being used in the test.

k. Identity of individual making entry

8.0 SETUP CHECK

Following test setup in the test configuration and prior to test, the scientific instrument shall be inspected sufficiently to insure that no malfunction or damage is caused due to faulty setup or handling.

9.0 CRITERIA FOR FAILURE

With the concurrence of the Marshall Laboratories authorized representative, degradation or change in performance of the Plasma Probe Instrument or any part thereof which exceeds limits established by its specification and applicable test procedure during any test period shall be considered as a failure. Testing shall be discontinued until the malfunction (including design defects) is corrected. If the corrective action consists of simple repair, such as replacement with identical parts, the complete test procedure under which failure occurred shall be repeated in its entirety without equipment failure before proceeding to the next test. If corrective action such as redesign, is required, the test procedure under which failure occurred shall be repeated as indicated above after repair action. In addition, if such redesign affects the results of previously completed tests, such tests shall be repeated.

10.0 FAILURE REPORTING

Should any discrepancy occur during the operational testing of the the scientific instrument resulting in criteria for failure as outlined in paragraph 9.0 the test shall be stopped and Marshall Laboratories shall report the failure as outlined in the prevailing test specification. Reference: Qualification Test Procedure S46275 and Flight Acceptance Test Procedure S46276.

11.0 TEST SETUP

The operational test setup is shown in Figure 2.

11.1 Initial GSE Control Settings

The initial control settings for the GSE are shown in Table 1.

GENERAL TEST SETUP CONFIGURATION

Note: Connect the Instrument and GSE in the configuration shown below. Then adjust the GSE control settings as shown in Table 1. Dotted lines represent AC Power Cord.

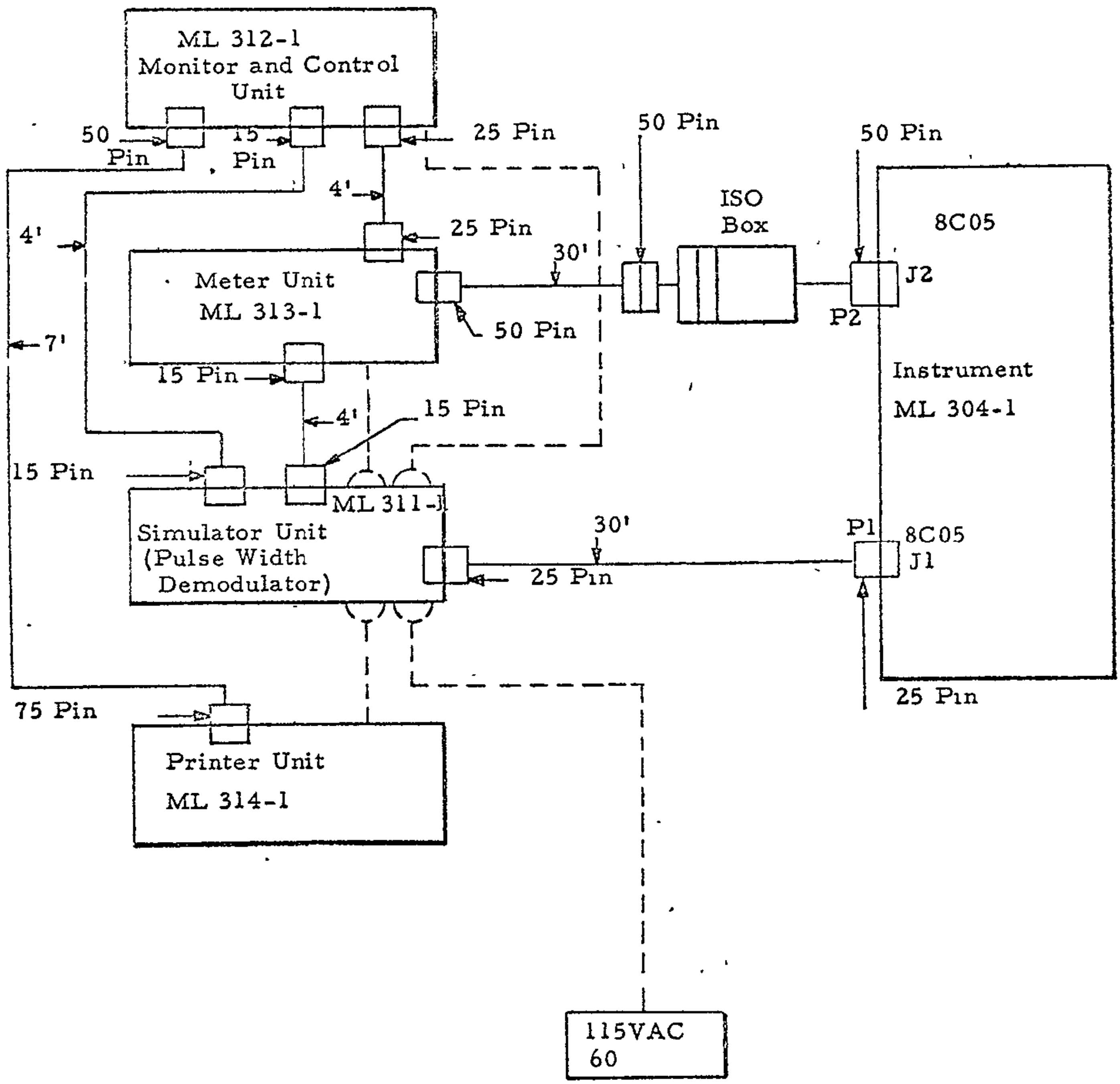


Figure 2.

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Operational Test Procedure ARC Plasma Probe - Pioneer C&D Model ML 304-1	SPECIFICATION NO. S 46250	REV
CODE IDENT NO	13126		SHEET 11 OF	

ML FORM 201

12.0 TEST PROCEDURE

Place the instrument in the general test setup configuration as shown in Figure 2 and set the GSE Control settings to the initial control settings as shown on Table 1. (appendix)

12.1 Meter Unit Instrument Voltage

Turn simulator main power switch to ON position and Instrument power to ON position. Measure voltages with Meter Unit Instrument and record data on Table 2.

ACCEPTABLE VOLTAGES

Monitor Select	Value	Acceptable Range
+28	+28V ± 1%	+27.72V to +28.28V
+3	+3V ±5%	+2.85V to 3.15V
+6	+6V ± 1%	+5.94V to +6.06V
+12	+12V ± 1%	+11.88V to +12.12V
+23.5	+23.5V ± 1%	+23.265V to +23.735V
+24	+24V ±5%	+22.8V to + 25.2V
+15	+15V ± 1%	+14.85V to +15.15V
+150	+150V ± 5%	+142.5V to +157.5V
3 VAC (scope)	approx. 0.1V peak to peak triangle waveform 5 KHz	
-6	-6V ± 1%	-5.94V to -6.06V
-25	-25V ± 1%	-24.75V to -25.25V
-150	-150V ±5%	-142.5V to -157.5V

12.2 Instrument Current

Turn Simulator Main Power Switch to ON position and Instrument Power to ON position. Measure Instrument Current on Simulator Unit and record on Table 2.

ACCEPTABLE CURRENT

Monitor Select	Value	Acceptable Range
Current	115 ma ± 10 ma	105 ma to 125 ma

12.3 Bit Rate 512 Operation

a. Allow Sun Pulse time (approximately 20 minutes) for the Spoke Generator to lock in.

b. When locked on, frame 01, word 1 sector data will be stable.

c. To perform the following tests by display indication only, set toggle switch on back panel of the Monitor and Control Unit to "NIXIE".

d Check for HV Supply stepping, Frame 02, Word 1, if it is stepping proceed, if it is locked, energize STEP COMMAND.

e. Check for HV Supply stepping per Table 3a (Inhibit Mode). Instrument should be in Inhibit Mode following application of power to the instrument.

f. Press COMMAND LINE.

12 4 Calibrate Command

a Sun Pulse Delay Check. Status of Frame 02, Word 1 should be 11 or 10. If Status is 11, Fluz/Sector of Frame 01, Word 1 should be 64. If Status is 10, Flux/Sector should be 60. Record Status of Frame 02 and Flux/Sector of Frame 01 on Data Sheet, (Pg. 26).

b. Press Calibrate Command to alternate Status of the Instrument. Allow time for data to change and record in data sheet, (Pg. 26).

c. IFC Check. Set Mode Select to OFF. Energize Step Command (51) and record in the data sheet, (Pg. 26). Allow time for data read-out.

d Press Calibrate Command and allow time for data to change. Record in the data sheet, (Pg. 26).

12.5 Suppression Mode Change Command

a. Set display to Frame 03, word 1 and record Status in the data sheet.

b. Press Suppression Mode Change Command.

c. Energize Step Command.

d. Allow time for data to change.

e. Record Status in the data sheet, (Pg. 26).

f. Status in Frame 03 should change in the sequence in the data sheet. (Repeat steps (b), (c), (d), and (e) until this sequence has been verified and record in the data sheet).

12.5.1 Control Setting Change

Change the following GSE Control Settings as shown below:

a. Toggle Switch on back panel of Monitor and Control to Normal

b. Mode Select ALL/ION (Monitor and Control).

12.5 2 HV Supply. Assure that the HV Supply is stepping by noting stepping of the HV data Frame 02, Word 1. Set Step Select to

51 and energize STEP COMMAND if locked in.

12.5.3 Non Delayed Sun Pulse

Put instrument in the following mode of operation.

a Set Display to Frame 02, Word 1.

b. If second status bit is 1, proceed to paragraph 12.5 4.

c. If second status bit is 0, press Calibrate Command on Simulator once and note that this bit changes to 1 (allow time for data readout).

12.5.4 All Unsuppressed Mode

a. Set Display to Frame 03, Word 1.
b If status bits are 00, run printer and obtain a complete ion and electron cycle.
c. If status bits are other than 00 (01 or 11) then press Suppression Mode Change Command on Simulator and energize Step Command.
d. Allow time for data read-out and note change of status If desired change, 00, has been obtained, run printer and obtain a complete ion and electron cycle, if desired change has not been obtained repeat steps (a) & (b). Data should correspond to Table 3 and Table 3a. Insert data sheets in an envelope and identify as 12.5.4
e. Press Command Line and repeat 12.5.4 d. Data should correspond to Table 3a (Inhibit Mode).

12.6 Bit Rate 64 Operation

Change to following control settings:

a. Simulator Bit Rate 64

b. GSE Mode Select ALL/ELECTRON

c. Allow time for instrument lock on at Bit Rate 64. Run Printer to obtain at least one electron and one ion cycle. Data should correspond to Table 4. Insert data sheets in an envelope and identify as 12.6.

12.6.1 64 Bit Rate - Step Select

a. Turn Mode Select to Step Select (ION).
b. Run Printer to obta n at least one electron and one ion cycle.
c. With SCS (Frame 12, second status bit) equal to 1, tape should correspond to Table 5. Insert data in an envelope and identify as 12.6 1.
d. With SCS equal to 0(delayed sun pulse), GSE generates a stimulus at the step (n + 1) - here step 6.

APPENDIX

OPERATIONAL
PERFORMANCE TEST LOG

Test	Operational Test No.				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

OPERATIONAL PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

TABLE 1

OPERATIONAL TEST INITIAL CONTROL SETTINGS

CONTROLS	SETTINGS	CHECK LIST
A. Monitor and Control Unit		
Probe Stimulus		
Step Select	05	
Sector Select	064	
Mode Select	All/Ion	
Level		
Channel 1	5 5	
Channel 2	5 5	
Channel 3	5.5	
Display Selection		
Frame	01	
Word	1	
H V Control	-	
Step Select	51	
B. Simulator Unit		
Sun Scan Pulse	60	
Mode - Bit Rate	512	
Voltage Control	28	
DCSM	Off	
Power	Off	
Instrument Power	Off	
C Printer Unit		
Power	Off	
Printer	Off	
D Meter Unit		
Power (DVM)	On-Turn 180°	
Range (DVM)	AUTO	

TABLE 2

ACCEPTABLE VOLTAGES AND CURRENT

Monitor Select	Acceptable Range	Measurement
+28	+27.72V to +28.28V	
+3	+2.85V to +3.15V	
+6	+5.94V to +6.06V	
+12	+11.88V to +12.12V	
+23.5	+23.265V to +23.735V	
+24	+22.8V to +25.2V	
+15	+14.85V to +15.15V	
+150	+142.5V to +157.5V	
3 VAC (scope)	approx. .01 V_{pp} triangle waveform, at 5 KHZ	
-6	5.94V to -6.06V	
-25	-24.75V to -25.25V	
-150	-142.5 V to -157.5V	
Current	105 ma to 125 ma	

TABLE 3

HIGH BIT RATE (512, 256)

(Place recorded data in envelope and identify as 12.5.4)

ACCEPTABLE RANGE

Frame	Status	Flux/HV	Flux/Sector
15	10 ± 1	008 ± 8	008 ± 8
15	10 ± 1	008 ± 8	008 ± 8
15	10 ± 1	008 ± 8	008 ± 8
14	00	008 ± 8	008 ± 8
14	00	008 ± 8	008 ± 8
14	00	008 ± 8	008 ± 8
13	00	008 ± 8	008 ± 8
13	00	008 ± 8	008 ± 8
13	00	024 ± 6	008 ± 8
12	11	064 ± 2	050 ± 4
12	11	008 ± 8	034 ± 4
12	11	016 ± 1	008 ± 8
11	0 ± 10	064 ± 2	064 ± 1
11	0 ± 10	064 ± 2	064 ± 1
11	0 ± 10	064 ± 2	064 ± 1
10	10 ± 1	008 ± 8	008 ± 8
10	10 ± 1	008 ± 8	008 ± 8
10	10 ± 1	008 ± 8	008 ± 8
09	00	008 ± 8	008 ± 8
09	00	008 ± 8	008 ± 8
09	00	008 ± 8	008 ± 8
08	00	008 ± 8	008 ± 8
08	00	008 ± 8	008 ± 8
08	00	024 ± 6	008 ± 8
07	11	064 ± 2	050 ± 4
07	11	008 ± 8	034 ± 4
07	11	012 ± 1	008 ± 8
06	0 ± 10	064 ± 2	064 ± 1
06	0 ± 10	064 ± 2	064 ± 1
06	0 ± 10	064 ± 2	064 ± 1
05	00 ± 1	008 ± 8	008 ± 8
05	00 ± 1	008 ± 8	008 ± 8
05	00 ± 1	008 ± 8	008 ± 8
04	00	008 ± 8	008 ± 8
04	00	008 ± 8	008 ± 8
04	00	008 ± 8	008 ± 8
03	00	008 ± 8	008 ± 8
03	00	008 ± 8	008 ± 8
03	00	024 ± 6	008 ± 8
02	11	064 ± 2	050 ± 4
02	11	008 ± 8	034 ± 4
02	11	008 ± 1	008 ± 8
01	0 ± 10	064 ± 2	064 ± 1
01	0 ± 10	064 ± 2	064 ± 1
01	0 ± 10	064 ± 2	064 ± 1

TABLE 3a

ION HV CYCLE

Frames 2,7 and 12, Word 1 indicate HV step. This is the only data that changes over the complete ION and ELECTRON cycle. During Frames 1, 6 and 11 the first status bit (HVP) will be 1 for Ion and) for Electron Cycle.

(Place recorded data in envelope and identify as 12.5.3)

ION HV CYCLE		ION HV CYCLE INHIBIT MODE	ELECTRON HV CYCLE	
30	124 ± 1	108 ± 1	15	124 ± 1
29	120 ± 1	108 ± 1	14	115 ± 1
28	116 ± 1	108 ± 1	13	106 ± 1
27	112 ± 1	108 ± 1	12	97 ± 1
26	108 ± 1	108 ± 1	11	88 ± 1
25	104 ± 1	104 ± 1	10	79 ± 1
24	100 ± 1	100 ± 1	9	70 ± 1
23	96 ± 1	96 ± 1	8	61 ± 1
22	92 ± 1	92 ± 1	7	52 ± 1
21	88 ± 1	88 ± 1	6	43 ± 1
20	84 ± 1	84 ± 1	5	34 ± 1
19	80 ± 1	80 ± 1	4	25 ± 1
18	76 ± 1	76 ± 1	3	16 ± 1
17	72 ± 1	72 ± 1	2	7 ± 1
16	68 ± 1	68 ± 1	1	0 ± 1
15	64 ± 1	64 ± 1		
14	60 ± 1	60 ± 1		
13	56 ± 1	56 ± 1		
12	52 ± 1	52 ± 1		
11	48 ± 1	48 ± 1		
10	44 ± 1	44 ± 1		
9	40 ± 1	40 ± 1		
8	36 ± 1	36 ± 1		
7	32 ± 1	32 ± 1		
6	28 ± 1	28 ± 1		
5	24 ± 1	24 ± 1		
4	20 ± 1	20 ± 1		
3	16 ± 1	16 ± 1		
2	12 ± 1	12 ± 1		
1	8 ± 1	8 ± 1		

TABLE 4

64 BIT RATE DATA - ALL MODE ELECTRON

NON-DELAYED SUN PULSE

ACCEPTABLE RANGE

	Frame	Status	Flux/HV	Flux/Sector
End Electron	10	10 ± 1	008 ± 8	008 ± 8
	10	10 ± 1	008 ± 8	008 ± 8
	10	10 ± 1	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	08	00	008 ± 8	008 ± 8
	08	00	008 ± 8	008 ± 8
	08	00	024 ± 6	008 ± 8
	07	01	064 ± 2	050 ± 4
	07	01	008 ± 8	034 ± 4
	07	01	052 ± 2	008 ± 8
	06	01	064 ± 2	064 ± 1
	06	01	064 ± 2	064 ± 1
	06	01	064 ± 2	064 ± 1
	05	11 ± 1	064 ± 2	064 ± 1
	05	11 ± 1	064 ± 2	064 ± 1
	05	11 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	03	01 ± 1	064 ± 2	064 ± 1
	03	01 ± 1	064 ± 2	064 ± 1
	03	01 ± 1	064 ± 2	064 ± 1
	02	00 ± 1	064 ± 2	064 ± 1
	02	00 ± 1	064 ± 2	064 ± 1
	02	00 ± 1	064 ± 2	064 ± 1
	01	00	064 ± 2	064 ± 1
	01	00	064 ± 2	064 ± 1
Start Electron	01	00	064 ± 2	064 ± 1

(Place recorded data in envelope and identify as 12.6)

TABLE 4 (Continued)

ACCEPTABLE RANGE

	Frame	Status	Flux/HV	Flux/Sector
End Ion	15	00 ± 1	008 ± 8	008 ± 8
	15	00 ± 1	008 ± 8	008 ± 8
	15	00 ± 1	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	13	00	008 ± 8	008 ± 8
	13	00	008 ± 8	008 ± 8
	13	00	026 ± 6	008 ± 8
	12	01	064 ± 2	050 ± 4
	12	01	008 ± 8	034 ± 4
	12	01	124 ± 2	008 ± 8
	11	10	064 ± 2	064 ± 1
	11	10	064 ± 2	064 ± 1
	11	10	064 ± 2	064 ± 1
	10	11 ± 1	064 ± 2	064 ± 1
	10	11 ± 1	064 ± 2	064 ± 1
	10	11 ± 1	064 ± 2	064 ± 1
	09	01 ± 1	064 ± 2	064 ± 1
	09	01 ± 1	064 ± 2	064 ± 1
	09	01 ± 1	064 ± 2	064 ± 1
	08	10 ± 1	064 ± 2	064 ± 1
	08	10 ± 1	064 ± 2	064 ± 1
	08	10 ± 1	064 ± 2	064 ± 1
	07	00 ± 1	064 ± 2	064 ± 1
	07	00 ± 1	064 ± 2	064 ± 1
	07	00 ± 1	064 ± 2	064 ± 1
	06	10	064 ± 2	064 ± 1
	06	10	064 ± 2	064 ± 1
	06	10	064 ± 2	064 ± 1
	05	01 ± 1	064 ± 2	064 ± 1
	05	01 ± 1	064 ± 2	064 ± 1
	05	01 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	04	00 ± 1	064 ± 2	064 ± 1
	03	10 ± 1	064 ± 2	064 ± 1
	03	10 ± 1	064 ± 2	064 ± 1
	03	10 ± 1	064 ± 2	064 ± 1
	02	01 ± 1	064 ± 2	064 ± 1
	02	01 ± 1	064 ± 2	064 ± 1
	02	01 ± 1	064 ± 2	064 ± 1
	01	10	064 ± 2	064 ± 1
	01	10	064 ± 2	064 ± 1
Start Ion	01	10	064 ± 2	064 ± 1

TABLE 5

BIT RATE 64 DATA - STEP 5

(Place recorded data in envelope and identify as 12.6.1)

ACCEPTABLE RANGE

	Frame	Status	Flux/HV	Flux/Sector
End Electron	10	10 ± 1	008 ± 8	008 ± 8
	10	10 ± 1	008 ± 8	008 ± 8
	10	10 ± 1	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	09	00	008 ± 8	008 ± 8
	08	00	008 ± 8	008 ± 8
	08	00	008 ± 8	008 ± 8
	08	00	008 ± 8	008 ± 8
	07	01	008 ± 8	008 ± 8
	07	01	008 ± 8	008 ± 8
	07	01	052 ± 2	008 ± 8
	06	01	016 ± 8	Any Sector
	06	01	016 ± 8	
	06	01	008 ± 8	
	05	11 ± 1	008 ± 8	
	05	11 ± 1	008 ± 8	
	05	11 ± 1	008 ± 8	
	04	00 ± 1	008 ± 8	
	04	00 ± 1	008 ± 8	
	04	00 ± 1	008 ± 8	
	03	01 ± 1	008 ± 8	
	03	01 ± 1	008 ± 8	
	03	01 ± 1	008 ± 8	
	02	00 ± 1	008 ± 8	Any Sector
	02	00 ± 1	064 ± 2	064 ± 1
	02	00 ± 1	008 ± 8	Any Sector
	01	00	008 ± 8	
	01	00	008 ± 8	
Start Electron	01	00	008 ± 8	Any Sector

TABLE 5 (Continued)

ACCEPTABLE RANGE

	Frame	Status	Flux/HV	Flux/Sector
End Ion	15	00 ± 1	008 ± 8	008 ± 8
	15	00 ± 1	008 ± 8	008 ± 8
	15	00 ± 1	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	14	00	008 ± 8	008 ± 8
	13	00	008 ± 8	008 ± 8
	13	00	008 ± 8	008 ± 8
	13	00	008 ± 8	008 ± 8
	12	01	008 ± 8	008 ± 8
	12	01	008 ± 8	008 ± 8
	12	01	024 ± 2	008 ± 8
	11	10	016 ± 8	Any Sector
	11	10	016 ± 8	
	11	10	008 ± 8	
	10	11 ± 1	008 ± 8	
	10	11 ± 1	008 ± 8	
	10	11 ± 1	008 ± 8	
	09	11 ± 1	008 ± 8	
	09	11 ± 1	008 ± 8	
	09	11 ± 1	008 ± 8	
	08	11 ± 1	008 ± 8	
	08	11 ± 1	008 ± 8	
	08	11 ± 1	008 ± 8	
	07	00 ± 1	008 ± 8	
	07	00 ± 1	008 ± 8	
	07	00 ± 1	008 ± 8	
	06	10	008 ± 8	
	06	10	008 ± 8	
	06	10	008 ± 8	
	05	11 ± 1	008 ± 8	
	05	11 ± 1	008 ± 8	
	05	11 ± 1	008 ± 8	
	04	01 ± 1	008 ± 8	
	04	01 ± 1	008 ± 8	
	04	01 ± 1	008 ± 8	
	03	10 ± 1	008 ± 8	
	03	10 ± 1	008 ± 8	
	03	10 ± 1	008 ± 8	
	02	01 ± 1	008 ± 8	Any Sector
	02	01 ± 1	064 ± 2	064 ± 1
	02	01 ± 1	008 ± 8	Any Sector
	01	10	008 ± 8	
	01	10	008 ± 8	
Start Ion	01	10	008 ± 8	Any Sector

DATA SHEET

Paragraph 12 4 (a)

Frame	Status	Flux/HV	Flux/Sector
02	______	xxx	xxx
01	xxx	xxx	______

Paragraph 12 4 (b)

Frame	Status	Flux/HV	Flux/Sector
02	______	xxx	xxx
01	xxx	xxx	______

Paragraph 12 4 (c)

Frame 01	Flux/HV
Word 1	______
Word 2	______
Word 3	______

Paragraph 12 4 (d)

Frame 01	Flux/HV
Word 1	______
Word 2	______
Word 3	______

Paragraph 12. 5 (a)

Frame	Status
03	______

Paragraph 12 5 (b)

Frame	Status
03	______

Paragraph 12. 5 (c)

Frame	Status
03	______

ACCEPTANCE CRITERIA

Paragraph 12 4 (a) and (b):
If Frame 02 Status is 11 then Frame 01 Flux/Sector shall be 64 If Frame 02 Status is 10 then Frame 01 Flux/Sector shall be 60

Paragraph 12. 4 (c):

Frame 01	Flux/HV
Word 1	008 ± 8
Word 2	016 ± 8
Word 3	016 ± 8

Paragraph 12. 4 (d):

Frame 01	Flux/HV
Word 1	064 ± 4
Word 2	064 ± 4
Word 3	064 ± 4

Paragraph 12. 5 (a), (b), and (c):

Upon successive application of Suppression Mode Change Commands, the Status bits in Frame 03 shall sequentially change in the following order:

00
11
01

PARTS DISPOSITION		SPEC NO.	REV
1. USE 2. REWORK	3. CANNOT BE REWORKED 4. RECORD 5. ________	S 46276	B

REVISIONS

DISP	EFF	REV	DESCRIPTION	BY	CK	DATE	APPROVAL
4	R.C.O.	A	1. ADDED PAGE 24A & PARAGRAPH 13.14.3	FS	FS	11/11/67	EA
4	R.C.O	B	1. REVISED PAGE 24, PARA 13.14	RJ.	RJ.	5/15/68	E. Hart 5.15.68

REV B

SPEC NO. S 46276

SHEET INDEX	REV	B	A	B
	SHEET	1	24A	24
SHEET INDEX	REV			
	SHEET			

CONTRACT NO.	NAS 2-3374	
PREP	Don Petrics	7/20/67
CK		
ENGR		
APPD		7/21/67
APPD		
QC APPD	J. Eggers	7-21-67
DESIGN APPD		
CUSTOMER		

M L — **MARSHALL LABORATORIES**
TORRANCE, CALIFORNIA

TITLE
Flight Acceptance Test Procedure Specification
ARC Plasma Probe - Pioneer C & D
Model ML-304-1

SIZE	CODE IDENT NO.	SPECIFICATION NO.	REV
A	13126	S 46276	B

RELEASED JUL 21 1967 | SHEET 1 OF 88

ML-FORM 202

ACTIVE - CHANGED PAGE SUMMARY

Item	Paragraph	Description	Approval

TABLE OF CONTENTS

LIST OF FIGURES

1.0 SCOPE

1.1 Introduction

This specification defines the scientific instrument flight acceptance procedure requirements for the Prototype Ames Research Center Plasma Probe Instrument, ML-304-I for Pioneer C & D. Instrument ML-304-I is an electrostatic energy per unit charge (Eq) spectrometer. It is capable of measuring solar plasma charged particles in terms of flux, corresponding to energy level and incident direction of arrival. A functional block diagram of the scientific instrument is shown in Figure 1.

1.2 Test Requirements

The test procedures established herein are in accordance with the requirements outlined in Marshall Laboratories Specification S46253 Revision "A" entitled Flight Acceptance Test Requirements for ARC Plasma Probe - Pioneer C & D".

1.3 Responsibility

The responsibility and authority for decisions relative to the requirements of this specification rests with Marshall Laboratories subject to approval by NASA/ARC.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications

Ames Research Center

2.1.1	A-10202 Revision "C"	Specification for Ames Plasma Probe for Pioneer C & D

Marshall Laboratories

2.1.3	S 46250	Operational Test Procedure
2.1.4	S 46251	Functional Test Procedure
2.1.5	S 46258	Qualification Test Requirements

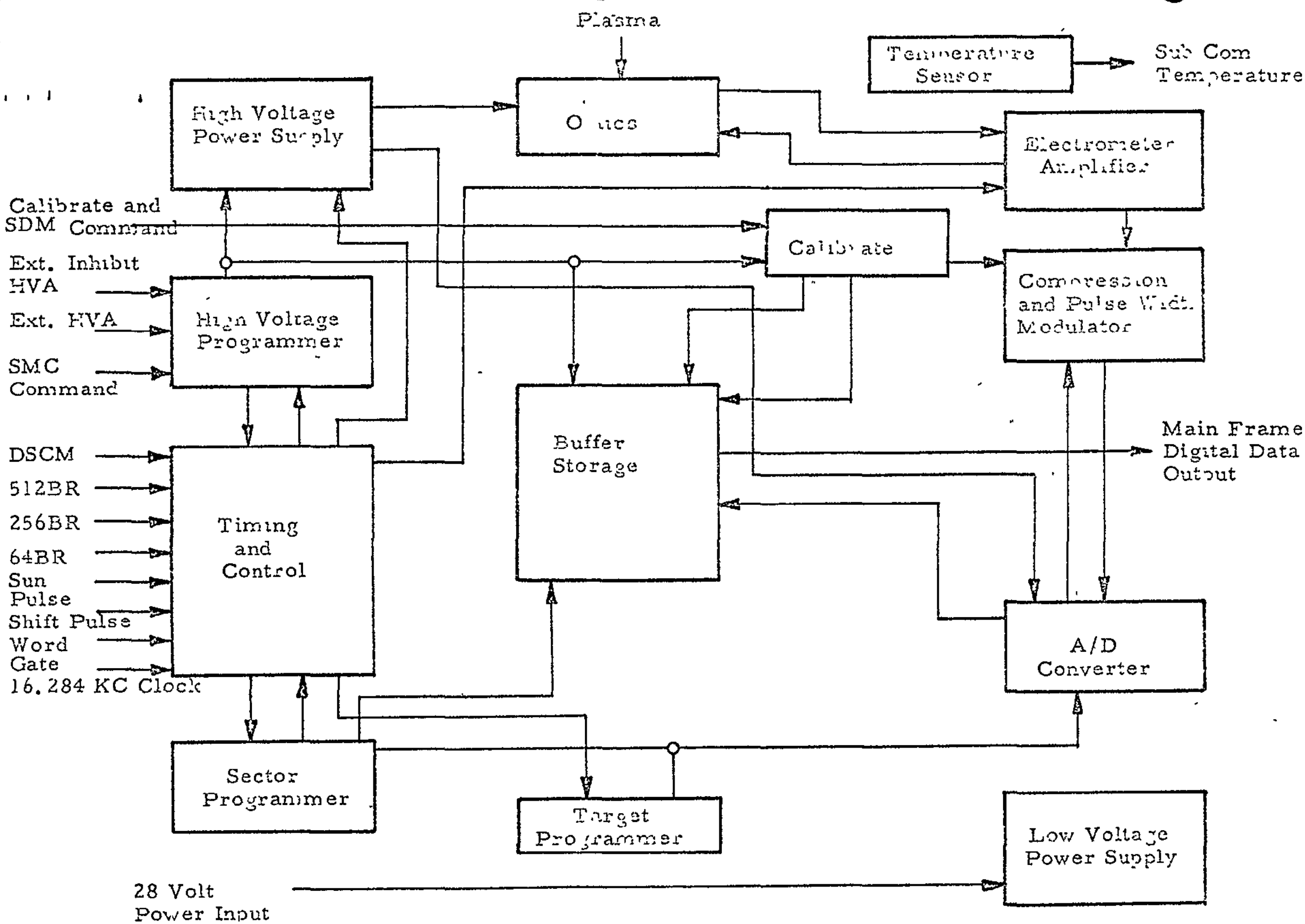


Figure 1. Block Diagram of Scientific Instrument

2.2 Drawings

Marshall Laboratories

2.2.1	544000	Mechanical and Thermal Interface Diagram
2.2.2	544001	Electrical Interface and Wiring Diagram
2.2.3	544100	Instrument Final Assembly
2.2.4	544101	Interconnection Diagram

3.0 ENVIRONMENTAL REQUIREMENTS

3.1 Expected Actual Environment

The electronic and mechanical assemblies within the Plasma Probe Instrument shall perform satisfactorily under the conditions expected to exist during time of operation in orbit and be able to withstand, with no out of tolerance degradation all environmental conditions expected to be encountered during storage, shipment, handling, stand-by, pre-flight, and flight prior to operational period as outlined in ARC Specification A-10202 Revision "C", paragraph B1.1.2.

3.2 Simulation of Environment

Laboratory Flight Acceptance tests are to ensure the instrument is equivalent to the qualified instrument and provide a debugging (burn-in) which will reduce infant mortality failures. The tests are designed to disclose failures, defects in materials, or defects in the workmanship not previously found. These tests shall not subject flight hardware to more than 100% of the stresses and loads that the units are expected to encounter.

4.0 TEST EQUIPMENT

4.1 Standard Equipment

The following standard test equipment shall be used:

a. Oscilloscope - Tektronix Model 535A.

b. Plug-In Unit - Tektronix, Type CA.

c. Digital Voltmeter - Cubic Corporation V-71.

d. Chart Recorder - Brush Mark 200.

e. Power Supply - Hewlett-Packard Model HP721A.

f. Current Probe - Tektronix, Model P6016 with termination Tektronix Part No. 011-028.

g. Multimeter - Triplett Model 630NA.

h. Pulse Generator - IC - PG2.

Additional standard test equipment shall be provided by a NASA approved source for certain of the environmental tests.

4.2 Special Equipment

The following special Ground Support Equipment (GSE) shall be used:

a. GSE Simulator Unit - P/N 544516-101 ML 311-1/ or BBD.
b. GSE Monitor and Control Unit - P/N 544502-101 ML 312-1.
c. GSE Printer Unit - P/N 544510-101 ML 314-1.
d. Current Probe - P/N 544506-101 ML 315-1.
e. Meter Unit - P/N 544515-101 ML 313-2.
f. Isobox Unit - P/N 544526-101, ML 344-1
g. Demodulator, Simulator Unit - P/N 544516-101, 102, ML 339-1
h. Associated Cables

NOTE: Alternate test equipment for items a thru e is the breadboard.

5.0 TEST FACILITIES

The flight acceptance testing is to be conducted at Marshall Laboratories and a NASA/ARC approved outside vendor facility using equipment which is maintained and calibrated by NASA/ARC approved outside source.

5.1 Apparatus and Conditions

The apparatus used in conducting tests shall be capable of producing and maintaining the test conditions required with the scientific instrument under test installed on or in the apparatus both operating and non-operating as applicable. Changes in apparatus conditions from the nominal conditions specified by the appropriate test procedure shall not exceed the assembly specification requirements or the requirements of paragraph 6.1 of this specification, whichever limits.

5.2 Volume

The volume of the test facilities shall be such that the bulk of the equipment under test shall not interfere with the generation or maintenance of the test conditions.

5.3 Standard Conditions for Test Area

Conditions for conducting the scientific experiment functional test shall be as indicated below:

a. Temperature: $25 \pm 3^{o}C$ ($77^{o} \pm 5^{o}F$)

b. Relative Humidity: 55 percent or less

c. Barometric Pressure: Room ambient (correct to 29.92 inches Hg if so specified in the applicable equipment specification)

6.0 MEASUREMENTS

All measurements shall be made with instruments which conform to acceptable accuracy standards and which are appropriate for the parameters measured and the environmental conditions concerned. The accuracy of these instruments shall be verified prior to conduct of test. Documentation specifying instrument accuracy, calibration periods, calibration facilities, and the procedure used to control instrument certification shall be available for review at all times.

6.1 Tolerances

The maximum allowable tolerances for test conditions shall be as follows, unless otherwise specified by the applicable test section in the test procedure.

a. Temperature: Plus or minus $2^{o}C$ (exclusive of accuracy of instruments)

b. Relative Humidity: Plus 3 percent RH, minus 2 percent RH

c. Vibration Amplitude: For Sinusoidal: Plus or minus 10 percent
For Random: Plus or minus 3 db

d. Vibration Frequency: Plus or minus 2 percent

e. Voltage: Plus or minus 1 percent

f. Additional Tolerances: Additional tolerances shall be as specified

7.0 TEST SEQUENCE

Unless otherwise specified the test sequence for the qualification of the prototype Plasma Probe Instrument shall be as follows:

a. Functional Test No. 1
b. Interface Verification
c. Operational Test No. 1
d. Abnormal Voltage Test
e. Operational Test No. 2
f. Operational Test No. 3
g. Weight and Center of Gravity
h. Moments of Inertia
i. Sinusoidal Vibration Test
j. Operational Test No. 4, 5, 6
k. Random Vibration Test

l. Operational Test No. 7, 8, 9

m. Temperature Test

n. Thermal Vacuum Test

o. Operational Test No. 10

p. Suppression Voltage Test

q. Operational Test No. 11

r. Magnetic Test

s. Functional Test No. 2

8.0 PERFORMANCE RECORD

Prior to conducting any of the tests specified herein, the Plasma Probe Instrument shall be subjected to a comprehensive operational test under standard conditions and a record made of all data necessary to determine compliance with the applicable instrument specification. This data shall provide a basis for checking satisfactory performance of the equipment during or after environmental tests. A chronological scientific instrument log of performance data shall be maintained and available at one central location throughout the test program and shall indicate accumulated running times suitable for reliability review. ntries shall be complete, self-explanatory and include, but not be mited to, the following:

. Date and time of entry

. Identity of test or inspection

. Environmental conditions

d. Test procedure reference (if applicable)

e. Characteristics being investigated

f. Parameter measurements

g. Complete identification of instrumentation used, including serial no. and calibration dates.

h. Failure observations and discrepancy report reference made as a result of failure or unusual performance.

i. Accumulated operating time

j. Repairs, adjustments and design changes made

k. Record unusual or questionable occurrence involving the instrument being tested or other equipment being used in the test.

l. Record "quick fixes" used during test or other changes that may not become design changes.

m. Identity of individual making entry

9.0 INSTALLATION CHECK

Following installation in the test apparatus and prior to test, the scientific instrument shall be inspected sufficiently to insure that no malfunction or damage was caused due to faulty installation procedure or handling.

CAUTION: Use 6-32 screws for mounting, 5 places. Torque 9 in-lbs ± 2 in-lbs (see Page 49).

10.0 CRITERIA FOR FAILURE

With the concurrence of the Marshall Laboratories authorized representative, degradation or change in performance of the Plasma Probe Instrument or any part thereof which exceeds limits established by its specification and applicable test procedure during any test period shall be considered as a failure. Testing shall be discontinued until the malfunction (including design defects) is corrected. If the corrective action consists of simple repair, such as replacement with identical parts, the complete test procedure under which failure occurred (such as vibration, shock, etc) shall be repeated in its entirety without equipment failure before proceeding to the next test. If corrective action such as redesign, is required, the test procedure under which failure occurred shall be repeated as indicated above after repair action. In addition, if such redesign affects the results of previously completed tests, such tests shall be repeated.

11.0 FAILURE REPORTING

Should any discrepancy occur during the flight acceptance testing of the scientific instrument resulting in criteria for failure as outlined in paragraph 10.0 the test shall be stopped. Marshall Laboratories shall notify NASA/ARC immediately (within 24 hours) by TWX of the failure and forward to NASA/ARC a report on the failure proposing corrective action. The failure report shall be completed on a "Scientific Instrument Failure Report" form supplied by NASA/ARC. An analysis shall be made of the cause of failure and changes proposed to correct the difficulty. The failure shall be entered in the scientific instrument log together with an analysis of the cause of failure and the course of action planned to eliminate the difficulty.

11.1 Failure Requiring Design Change

Should the failure require a design change, as determined by Marshall Laboratories, descriptive information must be forwarded to NASA/ARC for approval. This data shall include a description of how the change was developed, the nature of the change itself, justification that the change will provide adequate design margin to preclude recurrence of similar failures, evidence that the change will not cause detrimental interaction with other portions of the article under test, resulting in other failures at a later date and the amount of retest required.

11.2 Failure Requiring No Design Change

Should the failure not require a design change, as determined by Marshall Laboratories, justification for not changing the design shall be forwarded at once to NASA/ARC for approval.

11.3 Failure Report Form

A detailed report form (NASA form 103f) shall be made by Marshall Laboratories on each failure occurring during flight acceptance testing of the scientific instrument.

The reports shall include details relating to the failure and corrective action taken and shall include but not be limited to the following:

a. The component name and part number.

b. The cause of failure and analysis.

c. The end item operation time at failure.

d. The replacement components needed for repair.

e. The disposition of fix.

f. Corrective action.

12.0 EVALUATION OF INSTRUMENT

The scientific instrument under going environmental exposure shall be operated whenever applicable for obtaining performance data. Where practicable, provisions shall be included to verify satisfactory performance of redundant parts. The performance data of the instrument under conditions of succeeding tests shall be comparable to that data obtained in compliance with paragraph 8.0. A physical inspection shall be performed at the completion of each test to determine any evidence of visable deterioration.

13.0 TEST PROCEDURES

13.1 Functional Test No. 1

The functional test shall be performed in accordance with Marshall Laboratories Functional Test Procedure S 46251. Data shall be recorded on data sheets supplied with test procedure S 46251. The recorded data shall then become part of the scientific instrument test performance log.

13.2 Interface Verification

The data for interface verification shall be recorded in the appropriate section of the scientific instrument test performance log.

13.2.1 Mechanical

a. The sensor and electronics assemblies shall be checked to determine that both are fabricated in accordance with the interface drawings in the spacecraft interface specification PC-121.07 Revision 4. Verification will include dimensional size, mounting holes, connector locations, exterior finishes, intercabling and any other characteristics which may have influence on the spacecraft.

b. The connector types (including total number of pins) shall be checked against the connector and interconnecting wiring diagram ML No. 544001.

13.2.2 Electrical

a. The input signal load impedance at each pin of the spacecraft connector on the scientific instrument shall be measured in the following manner:

Pulses

Pulses shall be measured with a clip-on type AC current probe and monitored with an oscilloscope to measure input current per paragraph 13.3.4. Input signal load impedance shall be calculated by dividing the input voltage by the input current. Load impedance shall be as indicated below:

Pulse Test Points

	Function	Pin No. (J1)	Impedance
*	1.) 16.384 KC Clock	16	> 3.3K
*	2.) Shift Pulse	3	> 3.3K
*	3.) Sun Pulse	14	> 3.3K
	4.) Command Calibrate	9	> 1K
	5.) Command Suppression	21	> 1K

* Measure capacitance with G.R. Bridge

DC Levels

Input voltage shall be measured using a 10 mg high impedance probe per paragraph 13.3.2. For dc levels insert 1K, ± 1% resistor in series with subject line and measure voltage on both sides of the 1K resistance. Load impedance shall be determined by the following relationship:

$$R_1 = \frac{e_2}{e_1 - e_2} R_1$$

Where $R_1 = 1K\,\Omega$

$e_1 = > e_2$ as measured across R_1

DC Level Test Points

	Function	Pin No. (J1)	Impedance
* 1.)	Main Frame Word Gate	8	≥ 20 K + < 300 pf to ground
* 2.)	Bit Rate 512	7	
* 3.)	Bit Rate 256	18	≥ 100 K + < 300 pf to ground
* 4.)	Bit Rate 64	23	
* 5.)	Duty Cycle Storage Mode	6	

* Measure capacitance with GR Bridge

b. The total power required by the scientific instrument shall be measured with the scientific instrument operating at each of the spacecraft data rates and with a bus voltage of + 28.0 ± 0.3 VDC. The total power shall not exceed 3.5 watts. Power shall be calculated by multiplying 28 volts x the input current as measured per paragraph 13.3.3. The input surge current shall be measured with the instruments and method described in paragraph 13.3.4. and method described in ML Specification S46251, para. 11.1.1. The input noise level shall be measured with the instruments described in para. 13.3.5 and method described in ML Specification S46251 paragraph 11.1.2.

c. The signal wave shape levels of pulse width, rise and fall times (as applicable) of the scientific instruments output signals shall be within the tolerances specified as shown in Figure 2 when bus voltage is established at + 24.0 VDC and + 33.0 VDC. Signal wave shapes shall be measured per paragraph 13.3.1.

13.3 Measuring Instruments

The instruments used in performing the electrical measurements required for qualification testing of the Plasma Probe instrument shall have the following capabilities:

13.3.1 Pulses

Pulse characteristics shall be measured with an oscilloscope having the following characteristics:

a. Vertical Channel

Bandwidth	≥ 10 megacycles
Accuracy	≤ 3 percent
Input Impedance	≥ 10 megohm

b. Horizontal Sweep

Accuracy	≤ 3 percent

13.3.2 DC Voltages

DC voltages shall be measured with a Digital Voltmeter having the following characteristics:

Figure 2. Scientific Instrument Output Signals

Nomenclature			Digital Data	Analog Data
Signal Description			Series of pulses synchronized to within 10 µs of bit shift pulse. A pulse shall indicate one and no pulse shall indicate zero.	Normalized analog voltage. One line required for each word.
Orgin			Scientific Instrument	Scientific Instrument
No-Load Characteristics & Tolerances	Amplitude (+) Volts	On	11^{+3}_{-2} Across 3.9 K	Normalized 0 to + 3
		Off	0 ± 1 Across 3.9 K	—
	Duration µsec (50% - 50%)		3-13	—
	Rise Time (at generator output), µsec (10% - 90%)		≤ 1	—
	Fall Time (at generator output), µsec (90% - 10%)		≤ 3	—
Impedance, Ohms	Spacecraft		3.9 K ± 1%	Current to Instrument will be ≤ 25 µ amp.
	Instrument		—	≤ 1000 for ± 1 bit A/D Conversion Accuracy
Noise, Volts (p-p)	From Spacecraft		~ 0.5	None
	From Instrument		~ 0.1	~ 0.02

a. Accuracy ≤ 1 percent

b. Input Impedance ≥ 10 megohm

13.3.3 DC Current

DC current shall be measured with an insertion type ammeter or a clip-on type ammeter or by measuring the voltage drop across a precision resistor inserted in the line. The measurement technique selected shall have the following characteristics:

a. Accuracy ≤ 3 percent

b. Insertion Impedance ≤ 1 ohm

13.3.4 Current Surges

Note: Reference Functional Test S46251 paragraph 11.1.1 for data.

a. Accuracy ≤ 5 percent

b. Insertion Impedance ≤ 1 ohm

13.3.5 Noise

Note: Reference Functional Test S46251 paragraph 11.1.2 for data.

13.4 Operational Test No. 1

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of interface verification. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.5 Abnormal Voltage Test

The scientific instrument shall be subjected to the following abnormal voltages and tested to insure that no damage has resulted from these conditions. The test results shall be recorded in the appropriate section of the scientific instrument test performance log.

13.5.1 Fault Voltage

Fault voltage is defined as a voltage which exceeds the normal signal voltage level and which may be accidentally applied to the input lines of the instrument with no degradation of operation after removal of the fault voltage. The levels listed below shall be applied to the input lines of the instrument for not less than 1 second.

Function	Pin No. (J1)	Fault Voltage
16.384 KC Clock Pulse	16	6
Bit Shift Pulse	3	6
Word Gate	8	20
Command Pulse	9, 21	6
Sun Pulse	14	6
Analog Data	24	6
Bit Rate	7, 18, 23	20
Digital Data	12	20
Duty Cycle Storage Mode	6	20

13.5.2 Operational Test No. 2

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of the fault voltage test. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.5.3 Undervoltage

The voltage to the scientific instrument shall be stepped in the following sequence and shall remain in each step for not less than one minute. The scientific instrument shall operate normally in steps (1), (2) and (6).

1. + 28.0 ± 0.3 VDC
2. + 24.0 ± 0.2 VDC
3. + 15.0 ± 0.2 VDC
4. + 10.0 ± 0.1 VDC
5. + 5.0 ± 0.1 VDC
6. + 28.0 ± 0.3 VDC

During this test the input power to the converter and the levels, pulse width and rise and fall times of the output signals shall be measured of the output test points listed in paragraph 13.5.6 using the method described in paragraph 13.3.4.

13.5.4 Overvoltage Sustained

A voltage of +36.0 ± 0.4 VDC above zero volts reference shall be supplied to the scientific instrument for not less than 10 minutes to input power lines. During this test the input power to the converter and the levels, pulse width and rise and fall times of the output signals shall be measured of the output test points listed in paragraph 13.5.6 using the method described in paragraph 13.3.4.

13.5.5 Voltage Range

The scientific instrument shall operate normally at the following voltages for not less than 10 minutes per voltage level.

1. 24.0 ± 0.2 VDC
2. 28.0 ± 0.3 VDC
3. 33.0 ± 0.3 VDC

During this test the input power to the converter and the levels, pulse width, and rise and fall times of the output signals shall be measured using the method described in paragraph 13.3.4.

Test Points

Function	Pin No. (J1)	Pulse Description
Main Frame Data Output	12	11^{+3}_{-2} V, pulse width 10 µsec ± 2 µsec, $t_r \leq 1$ µsec, $t_f \leq 3$ µsec
Analog Output Temperature	24	1.5v ± .2v

13.6 Operational Test No. 3

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of abnormal voltage tests. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity.

The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.7 Weight and Center of Gravity

The weight and center of gravity of the scientific instrument shall be measured as outlined below and the data recorded in the scientific instrument test performance log.

a. The weight of each integral part of the scientific instrument (i.e., sensor, electronics, cabling, etc.) shall be determined to an accuracy of ± 0.01 pounds of ± 4.0 grams. The total instrument weight will be 6.3 ± 0.2 pounds.

b. The center of gravity of sensor and electronics assemblies shall be shown by a three view drawing, and shall be referenced to a common point.

13.8 Moments of Inertia

The moments of inertia of sensor and electronics assemblies shall be determined to an accuracy of ± 10% and the results recorded in the scientific instrument test performance log.

The moments of inertia will be: ($in\text{-}lb\text{-}sec^2$)

I_a = 0.110 (Calculated)

I_b = 0.110 (Calculated)

I_c = 0.110 (Calculated)

13.9 Sinusoidal Vibration Test

The scientific instrument shall be attached to the test apparatus via a rigid fixture and simulate the attachment of the scientific instrument in the spacecraft. The scientific instrument shall be vibrated in each of three orthogonal directions with one direction being parallel to the thrust axis ZZ. The scientific instrument shall not be operated during this test. The maximum allowable tolerance for vibration amplitude shall be ± 10% and for frequency shall be ± 2%. (Reference page 47 for axis orientation).

During all vibration testing, the 28v bus line shall be continuously monitored by strip chart recorder to detect momentary electrical grounding within the scientific instrument. The test configuration shall be as shown in Figure 3. The sensitivity of the recorder shall be adjusted to provide at least one volt/inch sensitivity from full scale deflection at 28v and shall be capable of response to 1000 cps or greater. Indications of voltage spikes shall be evidence of failure to pass vibration testing. The recording shall be submitted as part of the scientific instrument test performance log.

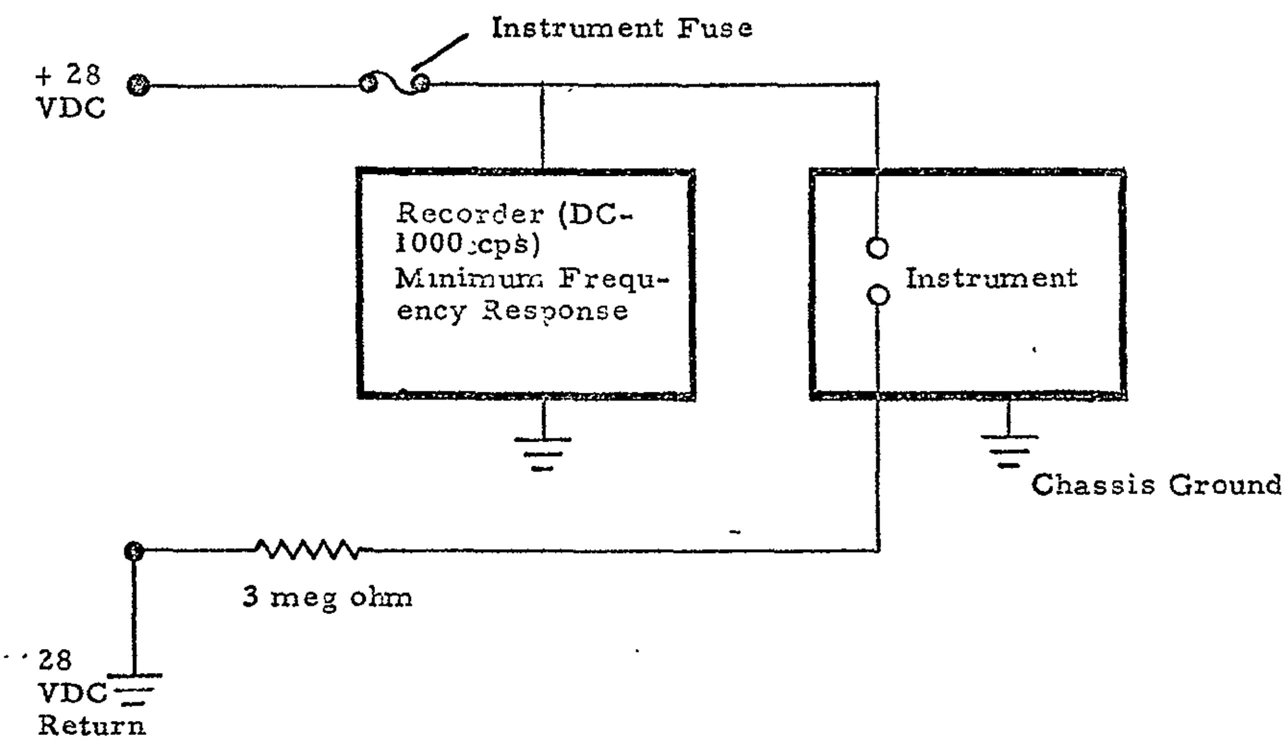


Figure 3. Vibration (Non-Operating) Test Configuration

13.9.1 Sinusoidal Sweep Frequency

The test shall be conducted by sweeping the applied frequency once through each range specified below. The rate of change of frequency shall be 2 octaves per minute. (Reference page 47 for axis orientation). Perform operational tests 4, 5 & 6 as outlined in paragraph 13.10 after each sine axis test.

Axis	Frequency Range, cps	Test Duration Minutes	Acceleration g, 0 to peak
Thrust (Z-Z)	10 - 50	1.17	5 *
	50 - 100	.5	21
	100 - 250	.65	14
	250 - 500	.50	5
	500 - 2000	1.00	14
Lateral (X-X) and (Y-Y)	10 - 50	1.17	5 *
	50 - 2000	2.65	14

* Or to maximum amplitude limit of test unit with approval of NASA/ARC.

13.10 Operational Test No. 4, 5, 6

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of each sinusoidal vibration axis. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.11 Random Vibration Test

The scientific instrument shall be attached to the test apparatus via a rigid fixture and simulate the attachment of the scientific instrument in the spacecraft. The scientific instrument shall be vibrated in each of three orthogonal directions with one direction being parallel to the thrust axis ZZ. The scientific instrument shall not be operated during this test. The maximum allowable tolerance for vibration amplitude shall be ± 10% and for frequency shall be ± 2%. (Reference page 47 for axis orientation). Perform operational tests 7, 8 & 9 as outlined in paragraph 13.12 after each random axis test.

During all vibration testing, the 28v bus line shall be continuously monitored by strip chart recorder to detect momentary electrical grounding within the scientific instrument. The test configuration shall be as shown in Figure 3. The sensitivity of the recorder shall be adjusted to provide at least one volt/inch sensitivity from full scale deflection at 28v and shall be capable of response to 1000 cps or greater. Indications of voltage spikes shall be evidence of failure to pass vibration testing. The recording shall be submitted as part of the scientific instrument test performance log.

13.11.1 Random Motion Vibration

Gaussian random vibration shall be applied with "G-peaks" clipped at three times the RMS acceleration specified below. With the scientific instrument installed, the control accelerometer response shall be equalized so that the power spectral density (PSD) values shall be within ± 3 db throughout the frequency band. The filter roll-off characteristics above 2000 cps shall be at the rate of 40 db per octave. The equalized control accelerometer response shall be passed through a spectrum analyzer with the following characteristics:

a. A filter bandwidth not to exceed 25 cps below 1200 cps or 100 cps above 1200 cps, and

b. Averaging time (seconds) of at least 75 divided by the filter bandwidth.

Axis	Frequency Range, cps	Test Duration Minute	PDS Level g^2 cps	All Instrument, Components, Acceleration, g-rms
(Z-Z)				
(X-X)	20 - 2000	2 each axis	0.032	8*
(Y-Y)				

* Or to maximum amplitude limit of test unit with approval of NASA/ARC.

13.12 Operational Test No. 7, 8, 9

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of each random vibration axis. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.13 Temperature Test

The scientific instrument shall be subjected to the thermal environments described below:

a. With the scientific instrument operating, the temperature shall be decreased from ambient to + 30°F in no less than 1/2 hour and no more than one hour, stabilized, and held for one (1) hour. Determine performance of instrument per Marshall Laboratories operational test S46250 during the period of stabilization.

b. With the scientific instrument operating, the temperature shall be increased from + 30°F to + 90°F in no less than 1/2 hour and no more than one (1) hour, stabilized, and held for one (1) hour. Determine performance of instrument per Marshall Laboratories operational test S46250 during the period of stabilization.

The recorded data resulting from the thermal operational tests shall become part of the scientific instrument test performance log.

13.14 Thermal Vacuum Test

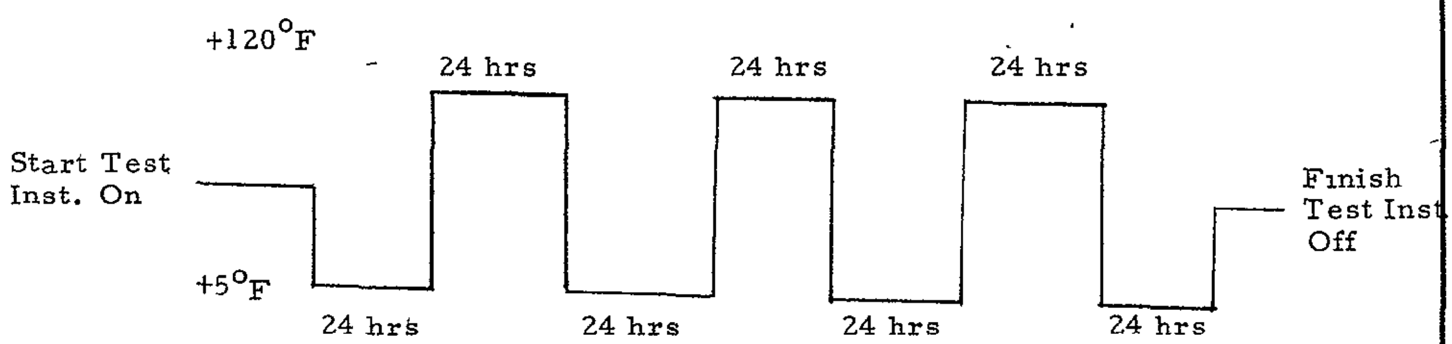
The scientific instrument shall be placed in a thermal vacuum chamber with a suitable nonconducting material between the instrument and the vacuum chamber. The chamber temperature shall be monitored using thermocouples placed on the scientific instrument.

13.14.1 Low Temperature Soak

Decrease the temperature from ambient to + 14°F in a vacuum to 10^{-5} mm of mercury. After stabilization of environment turn the scientific instrument on and operate at the following duty cycle for 24 hours:

During the 23rd hour of operation performance an operational test per Marshall Laboratories Specification S46250. The recorded data shall then become part of the scientific instrument test performance log.

13.14.3 Thermal Vacuum - Flight D&E



(1) Vacuum equal to or less than 10^{-5} mm of mercury.

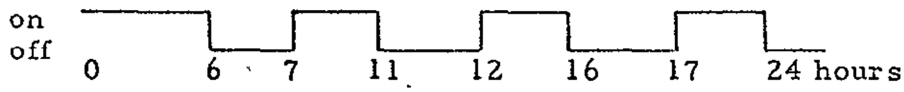
(2) The temperature change at each 24-hour period shall be accomplished in no less than 1/2 hour and no more than 1 hour.

(3) Perform an instrument operational test at approximately the 23rd hour of each 24-hour cycle.

(4) Perform an instrument OFF-ON sequence following each operational test.

13.14.2 High Temperature Soak

With the instrument still operating at 10^{-5} mm of mercury, increase the temperature to 120°F and operate at the following duty cycle for the next 24 hours:



During the 23rd hour of operation perform an operation test per Marshall Laboratories Specification S46250. The recorded data shall then become part of the scientific instrument test performance log.

13.15 Operational Test No. 10

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of the thermal vacuum test. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.16 Suppression Voltage Test

Suppression voltage shall be measured with a digital voltmeter having the capability outlined in paragraph 13.3.2. Measurements shall be made by partially disassembling the Plasma Probe instrument to expose the three driven shields. Measurements shall then be made from each driven shield, with the scientific instrument suppression mode in automatic operation, to indicate the potential referenced to ground. The sequenced suppression voltage shall be as follows:

Suppression Voltage	Tolerance
+ 6v	± 1v
-40v	± 3v
+ 6v	± 1v
0v	± 1v
-25v	± 2v

Test results shall be recorded in the appropriate section of the scientific instrument test performance log.

13.17 Operational Test No. 11

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of suppression voltage tests. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detriment effect in mechanical integrity.

The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

13.18 Magnetic Tests

The scientific instrument shall be magnetically tested at Ames Research Center during integration testing in both an operating and non-operating condition. Tests shall determine conformance to the magnetic specifications for qualification acceptance. Results of the magnetic tests shall be recorded in the appropriate section of the scientific instrument test performance log.

13.18.1 Magnetic Field Operating

With the scientific instrument in an operating mode and at a radius of 3 feet from the centroid of the scientific instrument, the steady state magnetic field induced by the scientific instrument shall be less than 2 gamma. The fluctuating magnetic field shall be held to less than ± 0.5 gamma after being subjected to a standardizing magnetic field of 25 oersteds.

13.18.2 Electro Magnetic Interference

The scientific instruments "signature" will be obtained utilizing test methods specified in MIL-I-26600. The "signature" will be a plot of amplitude versus frequency in each of three (3) RF categories:

a. Susceptibility

b. Conducted

c. Radiated

13.19 Functional Test No. 2

The functional test shall be performed in accordance with Marshall Laboratories Function Test Procedure S46251. Data shall be recorded on data sheets supplied with test procedure S46251. The recorded data shall then become part of the scientific instrument test performance log.

TEST FACILITY RESPONSIBILITY AND REQUIREMENTS

The test facility shall provide one person and one alternate to monitor the test program detailed in S 46276 These people shall be on 24 hour call during the duration of this test and shall be identified.

Test Facility Engineer:

Name ______________________

Address ______________________

Phone ______________________

Alternate

Name ______________________

Address ______________________

Phone ______________________

14.2 Responsible test person shall provide a formal report to include all raw data such as temperature vibration charts, tapes, special graphs, photographs and miscellaneous test notes.

14.3 Photography equipment to be provided that is capable of taking good quality negatives (35 mm or equivalent) approximately Twenty-Five (25) 8-1/2 x 11 prints required. *

14.4 Provide necessary data recorders for tests outlined in S 46276

14.5 Provide instrument handling and transporting carts with power strip.

14.6 Provide safe storage for scientific instrument during periods when not in use.

* One (1) reproducible and 6 prints of each. (One Half/Tone reproducible and six (6) 8-1/2 x 11 prints).

APPENDIX

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.1 Functional Test No. 1				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46251		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
CODE IDENT NO	13123		SHEET 30 OF	

ML FORM 201

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.2 Interface Verification				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			PC-121.07 Revision 4		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE	SPECIFICATION NO.	REV
CODE IDENT NO	13126	Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	S 46276	
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

MECHANICAL

Conformance to ML No. 544000 and ML No. 544001

ITEM	VERIFICATION OR REMARKS
Dimensional Check	
Mounting Holes	
Connector Locations	
Exterior Finishes	
Intercabling Characteristics	
Interface Characteristics	
J1 Connector and Wiring Check	
J2 Connector and Wiring Check	
Identification and Marking	

ELECTRICAL

Pulse Tests

FUNCTION	PIN	IMP	RESULTS AND REMARKS
16.384 KC Clock	16	> 3.3K	
Shift Pulse	3	> 3.3K	
Sun Pulse	14	> 3.3K	
Command Calibrate	9	> 1K	
Command Suppression	21	< 1K	

DC LEVELS

FUNCTION	PIN	IMP	RESULTS AND REMARKS
Main Frame Word Gate	8	≥ 20K	
Bit Rate 512	7	≥ 48K	
Bit Rate 256	18	≥ 48K	
Bit Rate 64	23	≥ 48K	
Duty Cycle Storage Mode	6	≥ 48K	

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

POWER, CURRENT AND NOISE

Function	Operational Limit	Results and Remarks
Total Power	3.5 Watts	
Input Surge Current	As indicated below	
Input Noise Level	$\leq$ 20 mv pp	

Input Surge Current

Current Surges, when switched to a power bus of 28^{+5}_{-4} VDC with a source impedance no greater than 1 ohm resistive, shall not exceed the following:

Load Current	Maximum Duration
Greater than 500 ma	5 microseconds
Greater than 200 ma	50 milliseconds
Greater than 110% of normal steady state	1 second

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.4 Operational Test No. 1				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure				ML-S 46250	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.5 Abnormal Voltage Test				
Date		Time		Performed At	

Conducted By		Organization	
Witnessed By		Organization	
Applicable Test Procedure			

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

M L MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO. S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

ML	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

FAULT VOLTAGE

Function	Pin	F. Volt	Results and Remarks
16.384 KC Clock	16	20	
Bit Shift Pulse	3	6	
Word Gate	8	20	
Command Pulse	9, 21	6	
Sun Pulse	14	6	
Analog Data	24	6	
Bit Rate	7, 18, 23	20	
Digital Data	12	20	
Duty Cycle Storage Mode	6	20	

UNDERVOLTAGE

Function	Pin	Volts	Pulse Description	Results
Main Frame Data Output	12	28±.3	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	28±.3	1.5v ± .2v	
Main Frame Data Output	12	24±.2	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	24±.2	1.5v ± .2v	
Main Frame Data Output	12	15±.2	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	15±.2	1.5v ± .2v	

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Function	Pin	Volts	Pulse Description	Results
Main Frame Data Output	12	10 ± .1	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	10 ± .1	1.5v ± .2v	
Main Frame Data Output	12	5 ± .1	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	5 ± .1	1.5v ± .2v	
Main Frame Data Output	12	28 ± .3	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Output Temperature	24	28 ± .3	1.5v ± .2v	

OVERVOLTAGE SUSTAINED

Function	Pin	Volts	Pulse Description	Results
Main Frame Data Output	12	36 ± .4	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Data Temperature	24	36 ± .4	1.5v ± .2v	

VOLTAGE RANGE

Function	Pin	Volts	Pulse Description	Results
Main Frame Data Output	12	24 ± .2	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Data Temperature	24	24 ± .2	1.5v ± .2v	
Main Frame Data Output	12	28 ± .3	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Data Temperature	24	28 ± .3	1.5v ± .2v	
Main Frame Data Output	12	33 ± .3	10v ± 2v, pulse width 10 μsec ± 2 μsec, t_r ≤ 1 μsec, t_f ≤ 3 μsec	
Analog Data Temperature	24	33 ± .3	1.5v ± .2v	

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.5.2 Operational Test No. 2				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure				ML-S 46250	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

M L MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.6 Operational Test No. 3				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

ML	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.7 Weight and Center of Gravity				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

M L — MARSHALL LABORATORIES, TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-I	SPECIFICATION NO S 46276	REV
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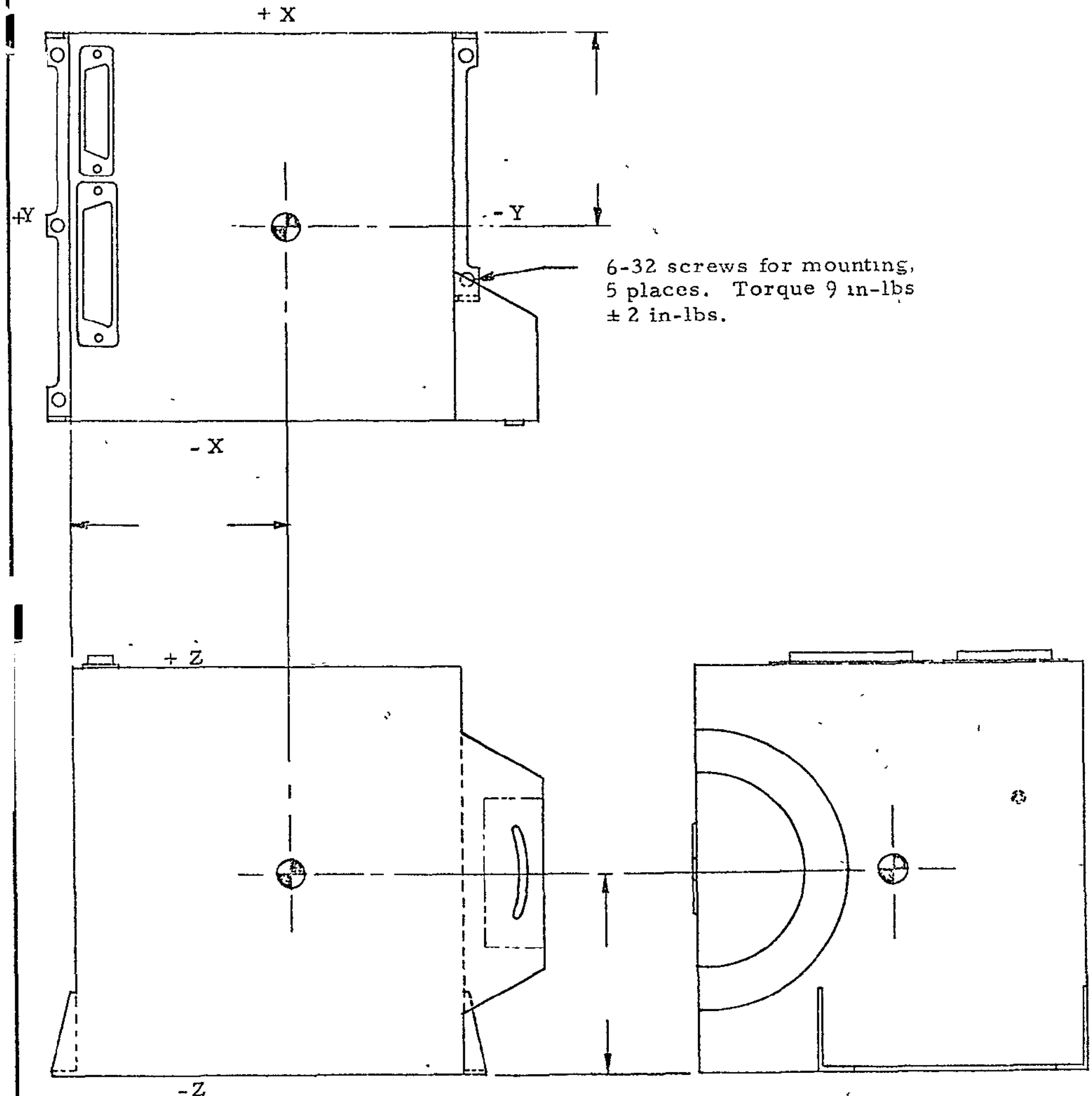
SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

WEIGHT

Item	Calculated	Actual
Sensor	2.1	
Electronics	1.8	
Cabling	.9	
Hardware	1.5	
Total	6.3 ± .2 lbs	



CENTER OF GRAVITY

Scientific Instrument Assembly

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.8 Moments of Inertia				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

MOMENTS OF INERTIA

Axis	Moments	Actual
Ia	0.110 in-lb-sec^2	
Ib	0.110 in-lb-sec^2	
Ic	0.110 in-lb-sec^2	

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.9 Sinusoidal Vibration Test				
Date		Time		Performed At	
Conducted By		Organization			
Witnessed By		Organization			
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SINUSOIDAL SWEEP

Axis	Frequency Range	Time	g Load	Remarks
Z-Z	10 - 50 cps	1.17 min	5	
Z-Z	50 - 100 cps	.5 min	21	
Z-Z	100 - 250 cps	.65 min	14	
Z-Z	250 - 500 cps	.5 min	5	
Z-Z	500 - 2000 cps	1.0 min	14	
X-X	10 - 50 cps	1.17 min	5	
X-X	50 - 2000 cps	2.65 min	14	
Y-Y	10 - 50 cps	1.17 min	5	
Y-Y	50 - 2000 cps	2.65 min	14	

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.10 Operational Test No. 4,				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure				ML-S 46250	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.10 Operational Test No. 5				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO. S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.10 Operational Test No. 6				
Date		Time		Performed At	

Conducted By		Organization	
Witnessed By		Organization	
Applicable Test Procedure		ML-S 46250	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE. Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.11 Random Vibration Test				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

RANDOM MOTION VIBRATION

Axis	Frequency Range	Time	PDS g^2	g RMS	Remarks
Z-Z	20 - 2000 cps	2 min	.032	[illegible].	
X-X	20 - 2000 cps	2 min	.032	[illegible].	
Y-Y	20 - 2000 cps	2 min	.032	[illegible].	

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.12 Operational Test No. 7				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure				ML-S 46250	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

M L — MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO. S 46270	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.12 Operational Test No. 8				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.12 Operational Test No. 9				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46270
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.13 Temperature Test				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-30[illegible]	SPECIFICATION NO S 46276	REV
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SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

LOW TEMPERATURE

Temperature	Duration	Remarks
Ambient to + 30°F	1 Hour	

NOTE: Conduct Operational Test ML-S 46250 During Stabilization

HIGH TEMPERATURE

Temperature	Duration	Remarks
From + 30°F to + 120°F	1 Hour	

NOTE: Conduct Operational Test ML-S 46250 During Stabilization

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.14 Thermal Vacuum Test				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

ML MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
CODE IDENT NO 13123		SHEET 73 OF	

ML FORM 201

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276
CODE IDENT NO 13123			REV
			SHEET 74 OF

ML FORM 201

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

LOW TEMPERATURE SOAK

Step	Temp	Vac	Mode	Duration	Remarks
1	14°F	10^{-5}	Off	Stabilize	
2	14°F	10^{-5}	On	6 Hours	
3	14°F	10^{-5}	Off	1 Hour	
4	14°F	10^{-5}	On	4 Hours	
5	14°F	10^{-5}	Off	1 Hour	
6	14°F	10^{-5}	On	4 Hours	
7	14°F	10^{-5}	Off	1 Hour	
8	14°F	10^{-5}	On	6 Hours	

Perform an operational test per ML-S 46250 during the 23rd hour of test

HIGH TEMPERATURE SOAK

Step	Temp	Vac	Mode	Duration	Remarks
1	+ 120°F	10^{-5}	On	Stabilize	
2	+ 120°F	10^{-5}	On	6 Hours	
3	+ 120°F	10^{-5}	Off	1 Hour	
4	+ 120°F	10^{-5}	On	4 Hours	
5	+ 120°F	10^{-5}	Off	1 Hour	
6	+ 120°F	10^{-5}	On	4 Hours	
7	+ 120°F	10^{-5}	Off	1 Hour	
8	+ 120°F	10^{-5}	On	6 Hours	

Perform an operational test per ML-S 46250 during the 23rd hour of test

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.21 Operational Test No. 10				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
CODE IDENT NO	13123		SHEET 77 OF	

ML FORM 201

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.1¹ Suppression Voltage Test				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure					

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

SUPPRESSION VOLTAGE

Volts	Tolerance	Reading	Remarks
+ 6	± 1v		
- 40	± 3v		
+ 6	± 1v		
0	± 1v		
- 25	± 2v		

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.23 Operational Test No. 12				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			ML-S 46250		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

M L	MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276	REV
CODE IDENT NO	13123		SHEET 82 OF	

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

Test	13.13 Magnetic Tests				
Date		Time		Performed At	
Conducted By			Organization		
Witnessed By			Organization		
Applicable Test Procedure			MIL-I-26600		

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

ML MARSHALL LABORATORIES TORRANCE CALIFORNIA	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276
CODE IDENT NO 13123		SHEET 84 OF

ML FORM 201

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

MAGNET FIELD OPERATING

Step	Field	Distance	Magnetic Limit	Measured Field
1	Steady State	3 Feet	2 Gamma	
2	Fluctuating	3 Feet	± .5 Gamma	

ELECTRO MAGNET INTERFERENCE

Characteristic	Measurement
Susceptibility	
Conducted	
Radiated	

SCIENTIFIC INSTRUMENT PERFORMANCE TEST LOG

Test	13.19 Functional Test No. 2				
Date		Time		Performed At	
Conducted By				Organization	
Witnessed By				Organization	
Applicable Test Procedure				ML-S 46251	

INSTRUMENT DATA

Title	ARC Plasma Probe for Pioneer C & D		
Model No.	ML-304	Unit	Prototype
Serial No.			

TEST AREA ENVIRONMENT

Temperature		Relative Humidity	
Barometric Pressure			

TEST APPARATUS AND INSTRUMENTATION

Description	Type	Mfgr.	Calibration Date

SUPPORT EQUIPMENT

Description	Type	Mfgr.	Calibration Date

ML MARSHALL LABORATORIES TORRANCE CALIFORNIA CODE IDENT NO 13126	TITLE Flight Acceptance Test Procedure Specification - ARC Plasma Probe Pioneer C & D, Assembly ML-304-1	SPECIFICATION NO S 46276 SHEET 86 OF	REV

ML FORM 201

SCIENTIFIC INSTRUMENT
PERFORMANCE TEST LOG

PERFORMANCE DATA

Total Operating Time		Test End Date	

NOTE: Applicable test procedure data forms shall be completed and attached to this performance test log as an integral part of it.

REPAIRS, QUICK FIXES AND ADJUSTMENTS

DESIGN CHANGES AND NOTES

APPENDIX C

Flight Acceptance Test Report

FLIGHT ACCEPTANCE TEST REPORT

ARC PLASMA PROBE INSTRUMENT

For

PIONEER C, D & E

SERIAL NUMBER 8C05-2

MODEL ML 304-1

CONTRACT NUMBER NAS 2-3374

FLIGHT ACCEPTANCE TEST REPORT
ARC PLASMA PROBE INSTRUMENT

For

PIONEER C, D, & E

SERIAL NUMBER 8C05-2

MODEL ML 304-1

CONTRACT NUMBER NAS 2-3374

Prepared By: L. F. Schutzenberger
L. F. Schutzenberger
Project Coordinator

Approved By: DEP
D. E. Petrics
Project Mechanical Engineer

Approved By: Rene Evelyn-Veere
R. Evelyn-Veere
Program Engineer

Approved By: Eric Azari
E. Azari
Program Manager

Approved By: D. Kratzer
D. Kratzer
Quality Assurance Manager

Reviewed By: J. Boswell
J. Boswell
DCASR Representative

MARSHALL LABORATORIES
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Torrance, California

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1.0 SCOPE

1.1 Introduction

The purpose of this report is to present the test results and test procedures used in performing the Flight Acceptance Test of the ARC Plasma Probe Instrument for Pioneer C, D and E. The flight acceptance test program was conducted to determine the conformance of the Flight One ARC Plasma Probe Instrument, part number 544100-101, model number ML 304-1, serial number 8C05-2, to the requirements specified in section 2.1.6 in accordance with section 2.1.1. The tests were performed at Marshall Laboratories, Torrance, California and Wyle Laboratories, El Segundo, California during the months of July 1967 through August 1967.

1.2 Requirements

The objectives of the acceptance tests were to verify mechanical and electrical spacecraft compatibility and experiment performance requirements when subjected to environmental tests designed to simulate conditions which were comparable to field flight conditions in order to provide better assurance of locating design deficiencies. The requirements and procedures for the flight acceptance test were outlined in Marshall Laboratories Specifications S46258 and S46276, respectively.

1.3 Experiment Configuration

The ARC Plasma Probe Instrument, model ML-304-1, is a rectangular magnesium structure 6.7" x 6.4" x 8.0". It is base mounted by five (5) 6-32 screws about the periphery flanges. It houses the electronics and optics for an electrostatic energy per unit charge (E/q) spectrometer. It is capable of measuring solar plasma charged particles in terms of flux, corresponding to energy level and incident direction of arrival. A functional block diagram of the scientific instrument is shown in Figure 1.

2.0 APPLICABLE DOCUMENTS

The following documents of the latest issue and revision letter in effect were applicable to the extent specified herein for flight acceptance.

2.1 Specifications

ARC/NASA

2.1.1 Contract NAS 2-3374

2.1.2	A-10202 Revision "C"	Specification for Ames Plasma Probe for Pioneer C & D
2.1.3	PC 121.07 Revision "4"	Spacecraft/Scientific Instrument Interface Specification, ARC Plasma Instrument

<u>Marshall Laboratories</u>

2.1.4	S 46250	Operational Test Procedure
2.1.5	S 46251	Functional Test Procedure
2.1.6	S 46258	Flight Acceptance Test Requirements
2.1.7	S 46276	Flight Acceptance Test Procedure

2.2 Drawings

<u>Marshall Laboratories</u>

2.2.1	544000	Mechanical and Thermal Interface Diagram
2.2.2	544001	Electrical Interface and Wiring Diagram
2.2.3	544100	Instrument Final Assembly
2.2.4	544101	Interconnection Diagram

3.0 SUMMARY

Results of the flight acceptance tests performed on the subject ARC Plasma Probe Instrument verified the experiment as being capable of meeting the requirements outlined in the reference 2.1.6 specification S 46528.

4.0 TEST CONDITIONS AND TEST EQUIPMENT

4.1 Ambient Conditions

Unless otherwise specified herein, all tests required by the Flight Acceptance Test Specification were performed at an atmospheric pressure of 29.92 ± 0.50 inches of mercury absolute, a temperature of 70 ± 20F, and a relative humidity of approximately 50 percent.

4.2 Instrumentation of Equipment

Measuring and test equipment utilized in the performance of this contract has been calibrated by the Wyle Laboratories Standards Laboratory or a commercial facility utilizing reference standards (or interim standards) whose calibration has been certified as being traceable to the National Bureau of Standards. All reference standards utilized in the above calibration system are supported by certificates, reports or data sheets attesting to the date, accuracy, and conditions under which the results furnished were obtained. All subordinate standards and measuring and test equipment are supported by like data when such information is essential to achieve the accuracy control required by the subject contract.

Wyle Laboratories attests that the commercial sources providing calibration services on the above referenced equipment, other than the National Bureau of Standards, are in fact capable of performing the required services to the satisfaction of the Wyle Laboratories Quality Control Department. Certificates and reports of all calibrations performed are retained in the Wyle Laboratories Quality Control files and are available for inspection upon request by the customer or Government representative.

4.3 Test Equipment

4.3.1 Vibration

Apparatus	Manufacturer/ Model	Range/ Accuracy	Wyle Number
Accelerometer	Endevco 2272	0 - 1000 g ± 5%	30527
Charge Amplifier	Unholtz-Dickie 8 PMCV	0 - 1000 g ± 2%	4530
Timer	Standard N. A.	1 Hour ± .1 sec.	6389
Visicorder	Honeywell 1108	8 inch mfg. Spec.	4380
Servo Oscillator	B & K 1018	5 - 10000Hz ± 1%	6271
Vibration Exciter	Ling B-300	8000 lbs. N. A.	6811
Power Amplifier	Ling 125/240	175 KVA N. A.	6374

Apparatus	Manufacturer/ Model	Range/ Accuracy	Wyle Number
Radom Console	Lang ASDE 80	85 channels N. A.	6812
RMS Meter	B & K 2416	1000 VAC ± 3%	6823
Timer	Standard N. A.	1 Hour ± .1 sec.	6835

4.3.2 Thermal Vacuum

Apparatus	Manufacturer/ Model	Range/ Accuracy	Wyle Number
Vacuum Chamber	CVC Special	N. A. N. A.	6863
Ion Guage	CVC GIC-100	10^{-3} to 10^{-12} torr mfg. spec.	6862
Temperature Recorder	Minn. Honey. 152C15-PSH-226 111-71	-200F to +200F ± 0.5% span	6402
Temperature Recorder & Controller	Minn. Honey. BY 152C(25)P (23C) W791	-150 to 250F ± 0.5% span	5578
Temperature Recorder	Minn. Honey. 153X60P8W7-2	-100F to 300F ± 0.5% span	3186

4.3.3 Functional Test

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Oscilloscope	Tektronix 535A	DC to 15MC Freq ± 3% Volt ± 3%	050
Plug-In Unit	Tektronix. CA	DC to 15MC .05v/cm to 20v/cm	090
Digital Voltmeter	Cubic Corp. V-71	0 - 999.9 vdc ± .01%	1054

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Chart Recorder	Brush Mark 200	10v/line 0.5%	GFE 454
Power Supply	Hewlett Packard HP 721A	0 - 30 vdc 150 ma ± 0.3%	733
Current Probe	Tektronix P 6016	2ma/mv-10ma/ mv ± 3%	1954
Termination	Tektronix 011-028	2ma/mv-10ma/ mv ± 3%	1955
Precision Thermometer	GSA Co. T3750-293	-20°C to +150° C ± 1%	1956
HV Probe	Tektronix P 6013	100 meg imped 12 kv max dc ± 3%	1957
VTVM	Hewlett Packard HP -410B	0 - 1000 v ± 3%	756
100:1 dc Divider	Hewlett Packard HP-11044A	0 - 30 kv ± 5%	1958
Simulator Unit	Marshall Labs ML 311-1	N/A	544416-101
Monitor & Control Unit	Marshall Labs ML 312-1	N/A	544502-101
Printer Unit	Marshall Labs ML 314-1	N/A	544510-101
Current Probe	Marshall Labs ML 315-1	N/A	544506-101
Meter Unit	Marshall Labs ML 313-2	N/A	544500-101
Isobox Unit	Marshall Labs ML 344-1	N/A	544526-101
Demodulator Unit	Marshall Labs ML 339-1	N/A	544516-102

4.3.4 Operational Test

Apparatus	Manuafcturer/ Model	Range/ Accuracy	Marshall Labs Number
Simulator Unit	Marshall Labs ML 311-1	N/A	544516-101
Monitor & Control Unit	Marshall Labs ML 312-1	N/A	544502-101
Printer Unit	Marshall Labs ML 314-1	N/A	544510-101
Current Probe	Marshall Labs ML 315 -1	N/A	544506-101
Meter Unit	Marshall Labs ML 313-2	N/A	544500-101
Isobox Unit	Marshall Labs ML 344-1	N/A	544526-101
Demodulator Unit	Marshall Labs ML 339 -1	N/A	544516-102
Oscilloscope	Tektronix 535A	DC to 15MC Freq ± 3% Volt ± 3%	050
Plug-In Unit	Tektronix CA	DC to 15MC .05v/cm to 20 v/cm	090

4.3.5 Abnormal Voltage Test

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Power Supply	HewlettPackard HP 721A	0 - 30 VDC 150ma ± 0.3%	733
Digital Voltmeter	Cubic Corp. V-71	0 - 999.9 VDC ± .01%	1054
Pulse Generator	Data Pulse 106A	10 mv to 12v into 50 ohms 50 nsec rise fall time Jitter ± .1%	1033

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Simulator Unit	Marshall Labs ML 311-1	N/A	544516-101
Monitor Control Unit	Marshall Labs ML 312-1	N/A	544502-101
Printer Unit	Marshall Labs ML 314-1	N/A	544510-101
Meter Unit	Marshall Labs ML 313-2	N/A	544500-101
Isobox Unit	Marshall Labs ML 344-1	N/A	544526-101
Demodulator Unit	Marshall Labs ML 339-1	N/A	544516-102
Oscilloscope	Tektronix 535A	DC to 15MC Freq ± 3% Volt ± 3%	050
Plug-In Unit	Tektronix CA	DC to 15MC .05 v/cm to 20 v/cm	090

4.3.5 Suppression Voltage Test

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Simulator Unit	Marshall Labs ML 311-1	N/A	544516-101
Monitor Control Unit	Marshall Labs ML 312-1	N/A	544502-101
Printer Unit	Marshall Labs ML 314-1	N/A	544510-101
Meter Unit	Marshall Labs ML 313-2	N/A	544500-101
Isobox Unit	Marshall Labs ML 344-1	N/A	544526-101

Apparatus	Manufacturer/ Model	Range/ Accuracy	Marshall Labs Number
Demodulator Unit	Marshall Labs ML 339-1	N/A	544516-102
Digital Volt Meter	Cubic Corp. V-71	0 - 999.9 VDC ± .01%	1054

5.0 TEST REQUIREMENTS, PROCEDURES AND RESULTS

5.1 Functional Test No. 1

Test By: Rene Evelyn-Veere

Performed: 22 July 1967 at Marshall Laboratories

5.1.1 Performance Criteria

The functional test shall be performed in accordance with Marshall Laboratories Functional Test Procedure S46251. Data shall be recorded on data sheets supplied with test procedure S46251. The recorded data shall then become part of the scientific instrument test performance log.

5.1.2 Test Procedure

The Plasma Probe Instrument was subjected to a functional test in accordance with the requirements of Marshall Laboratories Functional Test Specification S46251. Data was recorded in the instrument log and the functional test procedure performance log. The general test setup configuration is shown in Figure 2.

5.1.3 Test Results

All data were normal.

5.2 Mechanical Interface Verification

Test By: Jack Evans

Performed. 22 July 1967 at Marshall Laboratories

5.2.1 Performance Criteria

The sensor and electronics assemblies shall be checked to determine that both are fabricated in accordance with the interface drawings in the spacecraft interface specification PC 121.07 Revision 4. Verification will include dimensional size, mounting holes, connector locations, exterior finishes, intercabling and any other characteristics which may have influence on the spacecraft.

The connector types (including total number of pins) shall be checked against the connector and interconnecting wiring diagrams. given in the spacecraft interface specification PC 121.07 Revision 4.

5.2.2 Test Procedure

The Plasma Probe Instrument was visually inspected and measured to determine conformance with the applicable interface drawings and specifications.

5.2.3 Test Results

The instrument did conform to the applicable drawings and specifications.

5.3 Center of Gravity and Weight

Note. This test was not performed as agreed by Mr. R.H. Mason (ARC) and Mr. D. L. Chinburg (ML).

5.4 Moment of Inertia

Note: This test was not performed as agreed by Mr. R.H. Mason (ARC) and Mr. D. L. Chinburg (ML).

5.5 Sinusoidal Vibration

Test By:	Rene Evelyn-Veere
Performed:	22 July 1967 through
Completed:	26 July 1967 at Wyle Laboratories

5.5.1 Performance Criteria

The scientific instrument shall be attached to the test apparatus via a rigid fixture and simulate the attachment of the scientific instrument in the spacecraft. The scientific instrument shall be vibrated in each of three orthogonal directions with one direction being parallel to the thrust axis ZZ. The scientific instrument shall not be operated during this test. The maximum allowable tolerance for vibration amplitude shall be ± 10% and for frequency shall be ± 2%.

During all vibration testing, the 28v bus line shall be continuously monitored by strip chart recorder to detect momentary electrical grounding within the scientific instrument. The test configuration shall be as shown in Figure 4. The sensitivity of the recorder shall be adjusted to provide at least one volt/inch sensitivity from full scale deflection at 28v and shall be capable of response to 1000 cps or greater. Indications of voltage spikes shall be evidence of failure to pass vibration testing. The recording shall be submitted as part of the scientific instrument test performance log.

The test shall be conducted by sweeping the applied frequency once through each range specified below. The rate of change of frequency shall be 2 octaves per minute.

Aixs	Frequency Range, cps	Test Duration Minutes	Acceleration g, 0 to peak
Thrust	10 - 50	1.17	5 *
(Z-Z)	50 - 100	.5	21
	100 - 250	.65	14
	250 - 500	.50	5
	500 - 2000	1.00	14
Lateral	10 - 50	1.17	5
(X-X) and (Y-Y)	50 - 2000	2.65	14

The Plasma Probe Instrument shall exhibit no evidence of damage or deterioration as a result of this test.

5.5.2 Test Procedure

The Plasma Probe Instrument was attached to a vibration fixture typically as shown in photographs 1, 2, 3, 4, 5 and 6. The Plasma Probe Instrument was then subjected to one sweep from 10 - 2000 Hz at 2 octaves a minute in each of three axis at the following levels:

Thrust (Z)	10 - 17 Hz at 0.5 inch double amplitude
	17 - 50 Hz at 5 g
	50 - 100 Hz at 21 g
	100 - 250 Hz at 14 g
	250 - 500 Hz at 5 g
	500 - 2000 Hz at 14 g
Lateral	10 - 17 Hz at 0.5 inch double amplitude
(X and Y)	17 - 50 Hz at 5 g
	50 - 2000 Hz at 14 g

The Plasma Probe Instrument was monitored by strip chart recorder for any momentary electrical grounding during the sinusoidal vibration test.

5.5.3 Test Results

The Plasma Probe Instrument experienced temporary difficulty in passing the Flight Acceptance level vibration tests. Marshall Laboratories had completed vibration testing of the X and Y axes when a subsequent operational test indicated problems which later proved related to amplifier #2. Failure Report 008 was submitted to describe this difficulty. This amplifier was replaced by one allocated for instrument 8C05-3.

Marshall Laboratories resumed sinusoidal vibration testing without further incident.

5.6 Operational Test No. 4, 5, & 6

Test By: Rene Evelyn-Veere

Performed: 22 July 1967 through

Completed: 27 July 1967 at Wyle Laboratories

5.6.1 Performance Criteria

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of sinusoidal vibration of each axis. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detrimental effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the sicentific instrument test performance log.

5.6.2 Test Procedure

The Plasma Probe Instrument was subjected to an operational test in accordance with the requirements of Marshall Laboratories Operational Test Specification S46250. Data was recorded in the operational test procedure performance log and the instrument log. The general test setup configuration is shown in Figure 2.

5.6.3 Test Results

All data were normal.

5.7 Random Vibration

Test By: Rene Evelyn-Veere

Performed: 26 July 1967

Completed: 26 July at Wyle Laboratories

5.7.1 Performance Criteria

The scientific instrument shall be attached to the test apparatus via a rigid fixture and simulate the attachment of the scientific instrument in the spacecraft. The scientific instrument shall be vibrated in each of three orthogonal directions with one direction being parallel to the thrust axis ZZ. The scientific instrument shall not be operated during this test. The maximum allowable tolerance for vibration amplitude shall be $\pm$ 10% and for frequency shall be $\pm$ 2%.

During all vibration testing, the 28v bus line shall be continuously monitored by strip chart recorder to detect momentary electrical grounding within the scientific instrument. The test configuration shall be as shown in Figure 4. The sensitivity of the recorder shall be adjusted to provide at least one volt/inch sensitivity from full scale deflection at 28v and shall be capable of response to 1000 cps or greater. Indications of voltage spikes shall be evidence of failure to pass vibration testing. The recording shall be submitted as part of the scientific instrument test performance log.

The Plasma Probe instrument shall exhibit no evidence of damage or deterioration as a result of this test.

Gaussian random vibration shall be applied with "G-peaks" clipped at three times the RMS acceleration specified below. With the scientific instrument installed, the control accelerometer response shall be equalized so that the power spectral density (PSD) value shall be within $\pm$ 3 db throughout the frequency band. The filter roll-off chracteristics above 2000 cps shall be at the rate of 40 db per octave. The equalized control accelerometer response shall be passed through a spectrum analyzer with the following characteristics:

a) A filter bandwidth not to exceed 25 cps below 1200 cps or 100 cps above 1200 cps.

b) Averaging time (seconds) of at least 75 divided by the filter bandwidths.

Axis	Frequency Range, cps	Test Duration Minute	PDS Level g^2 cps	All Instrument, Components, Acceleration, g-rms
(Z-Z)				
(X-X)	20 - 2000	2 minutes each axis	0.032	8*
(Y-Y)				

* Or to maximum amplitude limit of test unit with approval of NASA/ARC.

5.7.2 Test Procedure

The Plasma Probe Instrument was submitted to a vibration fixture and subjected to random vibration in the X, Y and Z axes at the following:

20 - 2000 Hz   2 minutes per axis 0.032 g^2/Hz 8 g-rms

The Plasma Probe instrument was monitored by strip chart recorder for any momentary electrical grounding during random vibration.

5.7.3 Test Results

No visible degradation; all data were normal.

5.8 Operational Test No. 7, 8 & 9

Test By: Rene Evelyn-Veere

Performed: 26 July 1967 at Wyle Laboratories

5.8.1 Performance Criteria

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of random vibration of each axis. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detrimental effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

5.8.2 Test Procedure

The Plasma Probe Instrument was subjected to an operational test in accordance with the requirements of Marshall Laboratories Operational Test Specification S46250. Data was recorded in the instrument log and operational test procedure log. The general test setup configuration is shown in Figure 2.

5.8.3 Test Results

All data were normal.

5.9 Temperature Test

Test By. Rene Evelyn-Veere

Performed: 25 July 1967 at Marshall Laboratories

5.9.1 Performance Criteria

The scientific instrument shall be subjected to the thermal environments described below:

a) With the scientific instrument operating, the temperature shall be decreased from ambient to $+30^{\circ}F$ in no less than one-half (1/2) hour and no more than one (1) hour, stabilized and held for one (1) hour. Determine performance of instrument per Marshall Laboratories operational test S46250 during the period of stabilization.

b) With the scientific instrument operating, the temperature shall be increased from $+30^{\circ}F$ to $+90^{\circ}F$ in no less than one-half (1/2) hour and no more than one (1) hour, stabilized, and held for one (1) hour. Determine performance of instrument per Marshall Laboratories operational test S46250 during the period of stabilization.

The recorded data resulting from the thermal operational tests shall become part of the scientific instrument test performance log.

The Plasma Probe Instrument shall exhibit no evidence of damage or deterioration as a result of this test.

5.9.2 Test Procedure

The Plasma Probe instrument was installed in a temperature chamber at room ambient temperature of $70^{\circ}F$. Provisions were made for normal operation of the Plasma Probe Instrument during the test.

With the Plasma Probe Instrument operating, the temperature of the chamber was reduced until the Plasma Probe Instrument temperature read $+30^{\circ}F$. This temperature reduction period was no less than one-half (1/2) hour. Upon stabilization of the Plasma Probe Instrument at $30^{\circ}F$, the temperature was maintained for one (1) hour.

The Plasma Probe Instrument was then returned to room ambient temperature and removed from the temperature chamber.

5.9.3 Test Results

The Plasma Probe Instrument exhibited no evidence of physical damage or performance deterioration as a result of the performance of either temperature test. All data were normal. The Plasma Probe Instrument conformed to the requirements of the specification.

5.10 Thermal Vacuum

Test By:	Rene Evelyn-Veere
Performed.	26 July 1967 through 28 July 1967 at Wyle Laboratories
Terminated:	28 July 1967
Reperformed.	4 August 1967
Completed.	5 August 1967

5.10.1 Performance Criteria

The scientific instrument shall be suspended in a thermal vacuum chamber and subjected to the following environmental conditions:

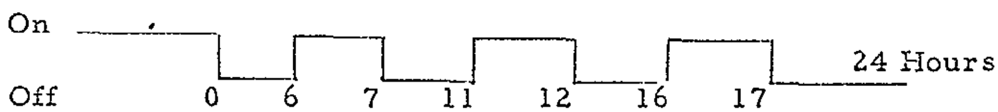
Low Temperature Soak

Decrease the temperature from ambient to $+14^{\circ}F$ in a vacuum to 10^{-5} mm of mercury. After stabilization of environment turn the scientific instrument on and operate at the following duty cycle for 24 hours.

During the 23rd hour of operation perform an Operational Test per Marshall Laboratories Specification S46250. The recorded data shall then become part of the scientific instrument test performance log.

High Temperature Soak

With the instrument still operating at 10^{-5} mm of mercury, increase the temperature to 120°F and operate at the following duty cycle for the next 24 hours.



During the 23rd hour of operation perform an Operational Test per Marshall Laboratories Specification S46250. The recorded data shall then become part of the scientific instrument test performance log.

The Plasma Probe Instrument shall exhibit no evidence of damage or deterioration as a result of this test.

5.10.2 Test Procedure

The Plasma Probe Instrument was placed in a temperature controlled vacuum chamber at room ambient conditions. Provisions were made for normal operation of the specimen during the test. The pressure within the chamber was reduced to 1×10^{-5} Torr (or lower). The temperature within the chamber was maintained at 77°F. The specimen was maintained at these conditions for two hours.

At the conclusion of the above, the temperature within the chamber was reduced to $+14^{\circ}$F and maintained for 24 hours. The Plasma Probe Instrument was then operated in accordance with operational test specification S46250.

The temperature within the chamber was then increased to $+116^{\circ}$F. The Plasma Probe Instrument was, however, maintained at 120°F for 8 hours. The test was stopped at this time due to improper electron mode data format at low data bit rate.

The Plasma Probe Instrument was returned to Marshall Laboratories for evaluation. The Plasma Probe Instrument was later returned to Wyle Laboratories and resubmitted to the thermal vacuum test as outlined above.

However, the Plasma Probe Instrument was maintained for 10 hours at +14°F and 10 hours at +120°F.

5.10.3 Test Results

The Plasma Probe Instrument exhibited no evidence of physical damage or deterioration as a result of either of the thermal vacuum tests. All data were normal. The Plasma Probe instrument conformed to the requirements of the specification.

NOTE: The thermal vacuum test was repeated due to a failure experienced during the high temperature portion of the test. The failure was twofold in nature· (1) during the electron mode in LRB, the data format was improper in that 15 frames appeared instead of 10, (2) the first line of frame 01 during electron mode was all zeros dependent on the spin rate between 56 and 58 RPM at 64 bit rate. Failure report 011 describes this situation fully.

5.11 Operational Test No. 10

Test by. Rene-Evelyn-Veere

Performed: 28 July 1967 at Wyle Laboratories

5.11.1 Performance Criteria

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of the low and high temperature tests. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detrimental effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

5.11.2 Test Procedure

The Plasma Probe Instrument was subjected to operational tests in accordance with the requirements of Marshall Laboratories Operational Test Specification S46250. Data was recorded in the instrument log and operational test procedure log. The general test setup configuration is shown in Figure 2.

5.11.3 Test Results

All data were normal.

5.12 Electrical Interface Verification

Test By. Rene Evelyn-Veere

Performed: 25 July 1967 at Marshall Laboratories

5.12.1 Performance Criteria

The input signal load impedance at each pin of the spacecraft connector on the scientific instrument shall be measured in the following manner:

Pulses

Pulses shall be measured with a clip-on type AC current probe and monitored with an oscilloscope to measure input current. Input signal load impedance shall be calculated by dividing the input voltage by the input current. Load impedance shall be as indicated below.

Pulse Test Points

Function		Pin No. (J1)	Impedance
1.	16.384 KC Clock	16	>3.3K
2.	Shift Pulse	3	>3.3K
3.	Sun Pulse	14	>3.3K
4.	Command Calibrate	9	>1K
5.	Command Suppression	21	>1K

DC Levels

Input voltage shall be measured using a 10 mg high impedance probe. For dc levels insert 1K, $\pm$ 1% resistor in series with subject line and measure voltage on both sides of the 1K resistance. Load impedance shall be determined by the following relationship:

$$R_1' = \frac{e_2}{e_1 - e_2} R_1$$

Where $R_1 = 1K\ \Omega$

$e_1 => e_2$ as measured across R_1

DC Level Test Points

Function		Pin No. (J1)	Impedance	
1.	Main Frame Word Gate	8	> 20K	<300 pf
2.	Bit Rate 512	7	> 20K	<300 pf
3.	Bit Rate 256	18	> 20K	<300 pf
4.	Bit Rate 64	23	>100K	<300 pf
5.	Duty Cycle Storage Mode	6	>100K	<300 pf

The total power required by the scientific instrument shall be measured with the scientific instrument operating at each of the spacecraft data rates and with a bus voltage of +28.0 $\pm$ 0.3 VDC. The total power shall not exceed 3.5 watts. Power shall be calculated by multiplying 28 volts times the input current. The input surge current shall be measured with the instruments and method described in ML Specification S46251, paragraph 11.1.1. The input noise level shall be measured with the method described in ML Specification S46251 paragraph 11.1.2.

The signal wave shape levels of pulse width, rise and fall times (as applicable) of the scientific instruments output signals shall be within the tolerances specified as shown in Figure 5 when bus voltage is established at +24.0 VDC and +33.0 VDC.

5.12.2 Test Procedure

The Plasma Probe Instrument was subjected to the electrical interface tests in accordance with the requirements of Marshall Laboratories Flight Acceptance Test Specification S46276. Data was recorded in the instrument log and qualification test specification log.

5.12.3 Test Results

The Plasma Probe Instrument conformed to the applicable specifications.

5.13 Abnormal Voltage Test

Test By. Rene Evelyn-Veere

Performed: 25 July 1967 at Marshall Laboratories

Completed: 25 July 1967

5.13.1 Performance Criteria

The scientific instrument shall be subjected to the following abnormal voltages and tested to insure that no damage resulted from these conditions. The test results shall be recorded in the appropriate section of the scientific instrument test performance log.

5.13.1.1 Fault Voltage Performance Criteria

Fault voltage is defined as voltage which exceeds the normal signal voltage level and which may be accidentally applied to the input lines of the instrument with no degradation of operation after removal of the fault voltages. The levels listed below shall be applied to the input lines of the instrument for not less than ten (10) seconds.

Function	Pin No. (J1)	Fault Voltage
16.384 KC Clock Pulse	16	6
Bit Shift Pulse	3	6
Word Gate	8	20
Command Pulse	9, 21	6
Sun Pulse	14	6
Analog Data	24	6
Bit Rate	7, 18, 23	20
Digital Date	12	20
Duty Cycle Storage Mode	6	20

5.13.1.2 Undervoltage

The voltage to the scientific instrument shall be stepped in the following sequence and shall remain in each step for not less than one (1) minute. The scientific instrument shall operate normally in steps (1), (2) and (6).

1. +28.0 ± 0.3 VDC
2. +24.0 ± 0.2 VDC
3. +15.0 ± 0.2 VDC
4. +10.0 ± 0.1 VDC
5. + 5.0 ± 0.1 VDC
6. + 28.0 ± 0.3 VDC

5.13.1.3 Overvoltage Sustained

A voltage of +36.0 ± 0.4 VDC above zero volts reference shall be supplied to the scientific instrument for not less than ten (10) minutes to input power lines. During this test the input power to the converter and the levels, pulse width and rise and fall times of the output signals shall be measured of the output test points as listed in S46276, Flight Acceptance Test Procedure.

5.13.1.4 Voltage Range

The scientific instrument shall operate normally at the following voltages for not less than ten (10) minutes per voltage level.

1. 24.0 ± 0.2 VDC
2. 28.0 ± 0.3 VDC
3. 33.0 ± 0.3 VDC

During this test the input power to the converter and the levels, pulse width, rise and fall times of the output signals shall be measured using the method described in S46276, Flight Acceptance Test Procedure.

Test Points

Function	Pin No. (J1)	Pulse Description
Main Frame Data Output	12	11^{+3}_{-2} V, pulse width 10 microseconds ± 2 microseconds, t_r ≤ 1 microsecond, t_f ≤ 3 microsecond.
Analog Output Temperature	24	1.5 V ± .2 V

5.13.2 Test Procedure

The Plasma Probe Instrument was subjected to the abnormal voltage tests as outlined by the requirements of Marshall Laboratories Flight Acceptance Test Procedure S46276.

5.13.3 Test Results

The Plasma Probe Instrument exhibited no evidence of damage or deterioration as the result of these tests.

5.14 Operational Tests No. 2 & 3

Test By: Rene Evelyn-Veere

Performed: 25 July 1967

5.14.1 Performance Criteria

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of the fault voltage and voltage range tests. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detrimental effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

5.14.2 Test Procedure

The Plasma Probe Instrument was subjected to an operational test in accordance with the requirements of Marshall Laboratories Operational Test Specification S46250. Data was recorded in the instrument log and operational test procedure log. The general test setup configuration is shown in Figure 2.

5.14.3 Test Results

All data were normal.

5.15 Suppression Voltage Test

Test By. Rene Evelyn-Veere

Performed: 6 August 1967 at Marshall Laboratories

5.15.1 Performance Criteria

Suppression voltage shall be measured with a digital voltmeter. Measurements shall be made by partially disassembling the Plasma Probe Instrument to expose the three driven shields. Measurements shall then be made from each driven shield, with the scientific instrument suppression mode in automatic operation, to indicate the potential referenced to ground. The sequenced suppression voltage shall be as follows:

Suppression Voltage	Tolerance
+ 6V	± 1V
-40 V	± 3V
+ 6V	± 1V
0V	± 1V
-25 V	± 2V

Tests results shall be recorded in the appropriate section of the scientific instrument test performance log.

5.15.2 Test Procedure

The Plasma Probe Instrument was subjected to suppression voltage measurements in accordance with the above paragraph. Results were recorded in the instrument log and the Flight Acceptance Test performance log.

5.15.3 Test Results

The Plasma Probe Instrument conformed to all applicable specifications.

5.16 Operational Test No. 11

Test By. Rene Evelyn-Veere

Performed. 6 August 1967 at Marshall Laboratories

5.16.1 Performance Criteria

An operational test shall be performed per Marshall Laboratories Specification S46250 upon completion of suppression voltage tests. In addition, a visual-mechanical inspection shall be conducted at this time to ascertain any detrimental effect in mechanical integrity. The visual-mechanical inspection shall be performed prior to performance of the operational test. The recorded data shall then become part of the scientific instrument test performance log.

5.16.2 Test Procedure

The Plasma Probe Instrument was subjected to an operational test in accordance with the requirements of Marshall Laboratories Operational Test Specification S46250. Data was recorded in the operational test procedure performance log and the instrument log.

5.16.3 Test Results

All data were normal.

5.17 Functional Test No. 2

Test By: Rene Evelyn-Veere

Performed. 6 August 1967

5.17.1 Performance Criteria

The functional test shall be performed in accordance with Marshall Laboratories Functional Test Procedure S46251. Data shall be recorded on data sheets supplied with test procedure S46251. The recorded data shall then become part of the scientific instrument test performance log.

5.17.2 Test Procedure

The Plasma Probe Instrument was subjected to a functional test in accordance with the requirements of Marshall Laboratories Functional Test Specification S46251. Data was recorded in the instrument log and the functional test procedure performance log. The general test setup configuration is shown in Figure 2.

5.17.3 Test Results

All data were normal.

5.18 Magnetic Tests

NOTE: This test was performed by ARC personnel at ARC.

APPENDIX I

FIGURES

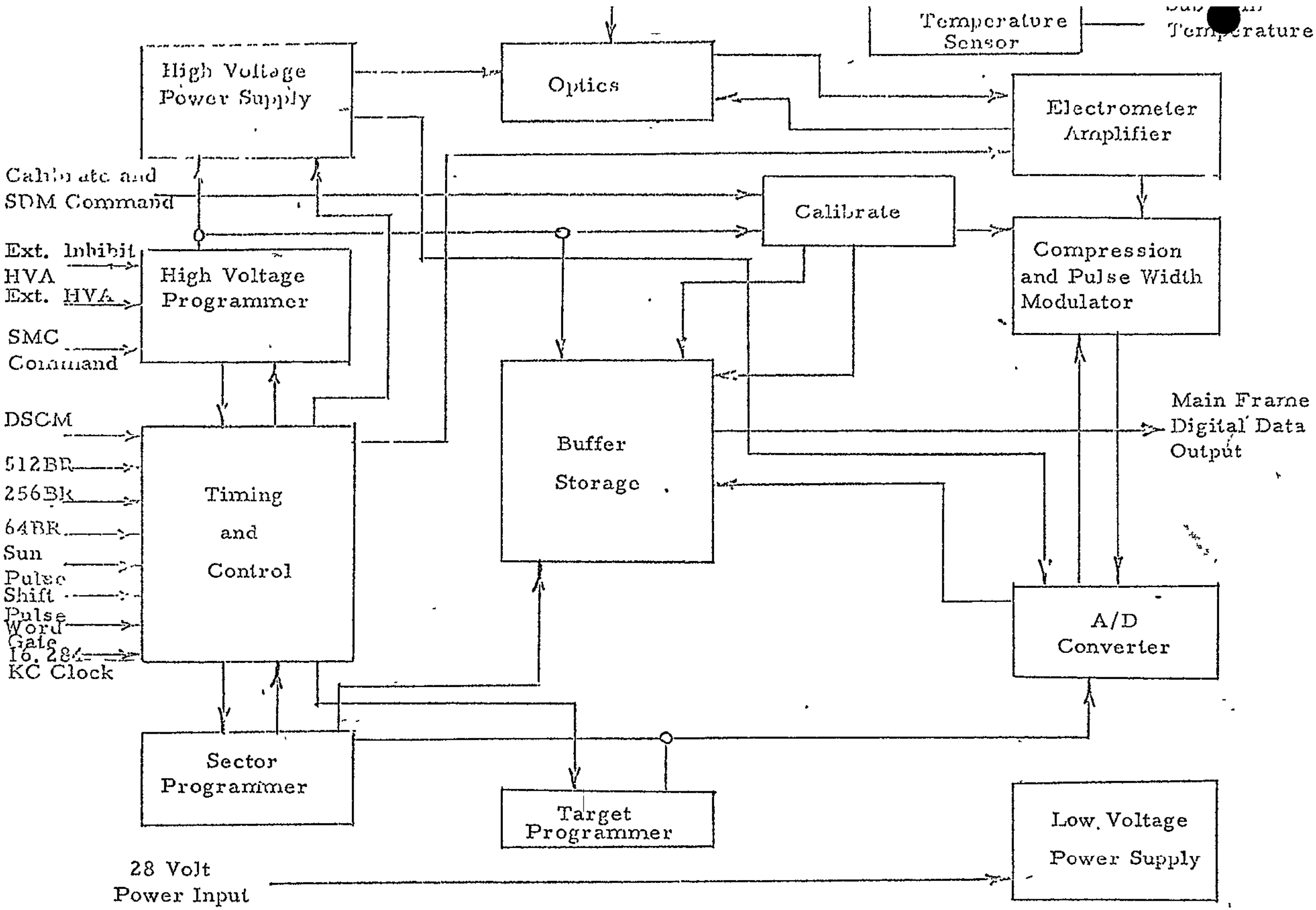
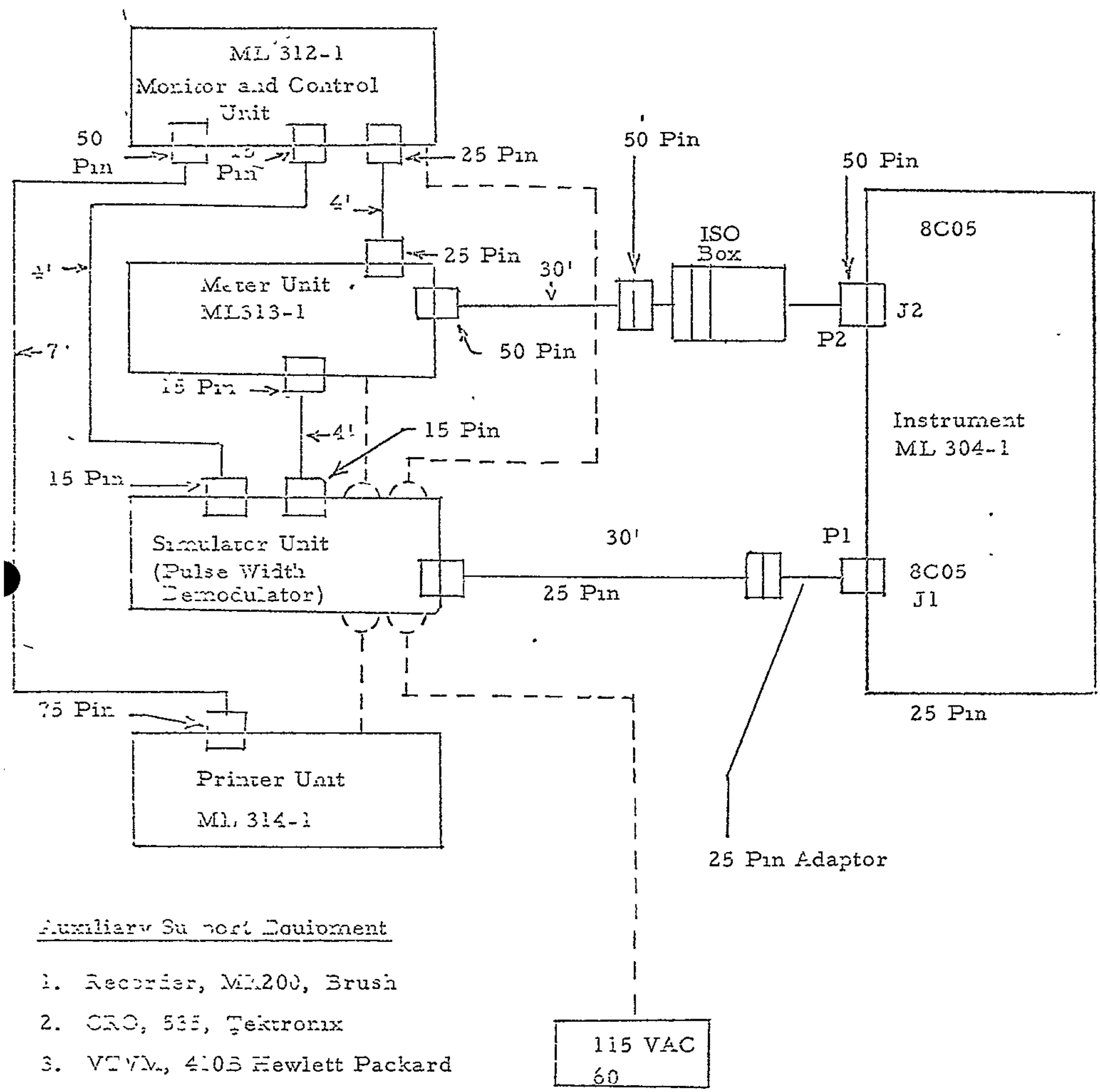


Figure 1. Block Diagram of Scientific Instrument

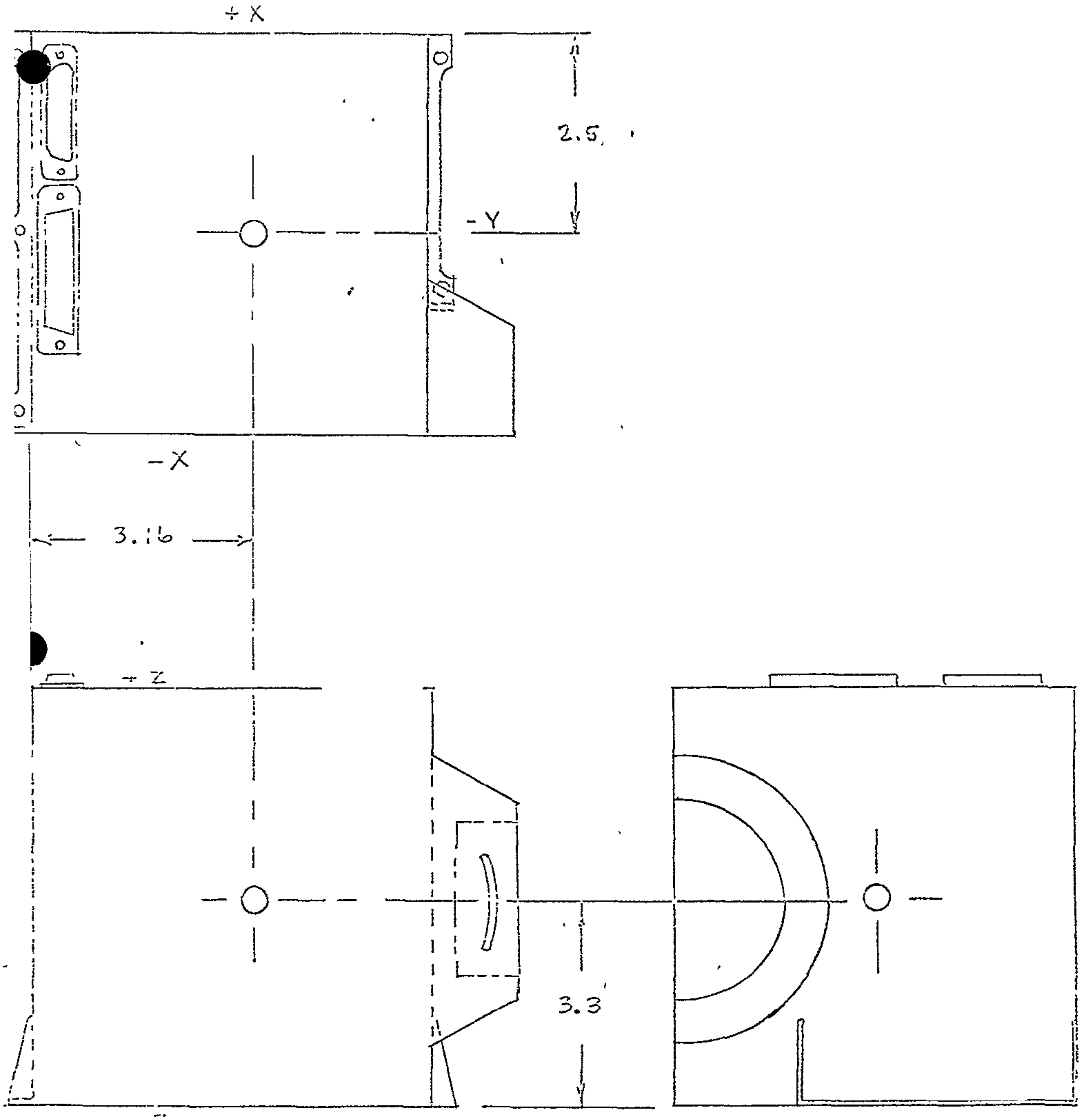
FUNCTIONAL/OPERATIONAL
TESTS



Auxiliary Support Equipment

1. Recorder, MK200, Brush
2. CRO, 535, Tektronix
3. VTVM, 410B Hewlett Packard
4. VTVM, 720, Fluke

Figure 2.



CENTER OF GRAVITY

Scientific Instrument Assembly

Figure 6

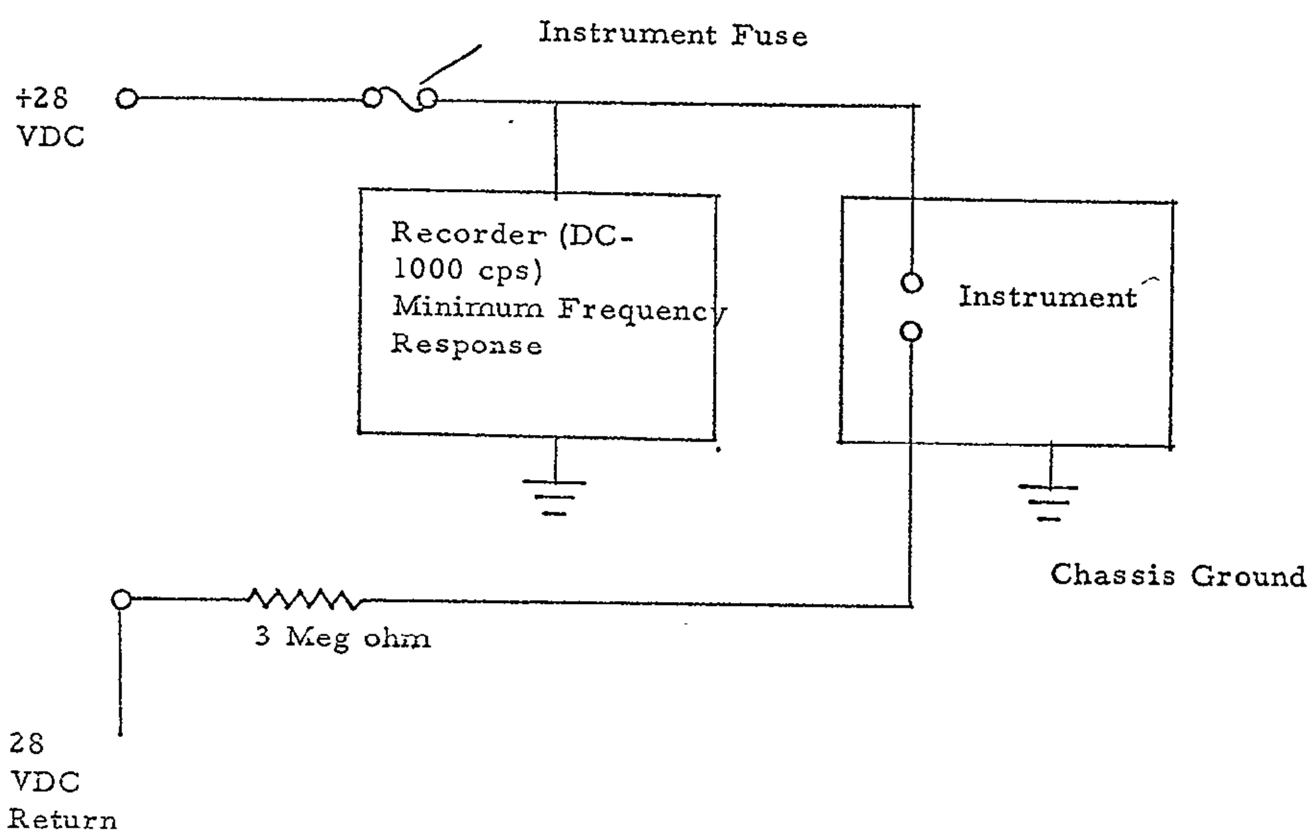


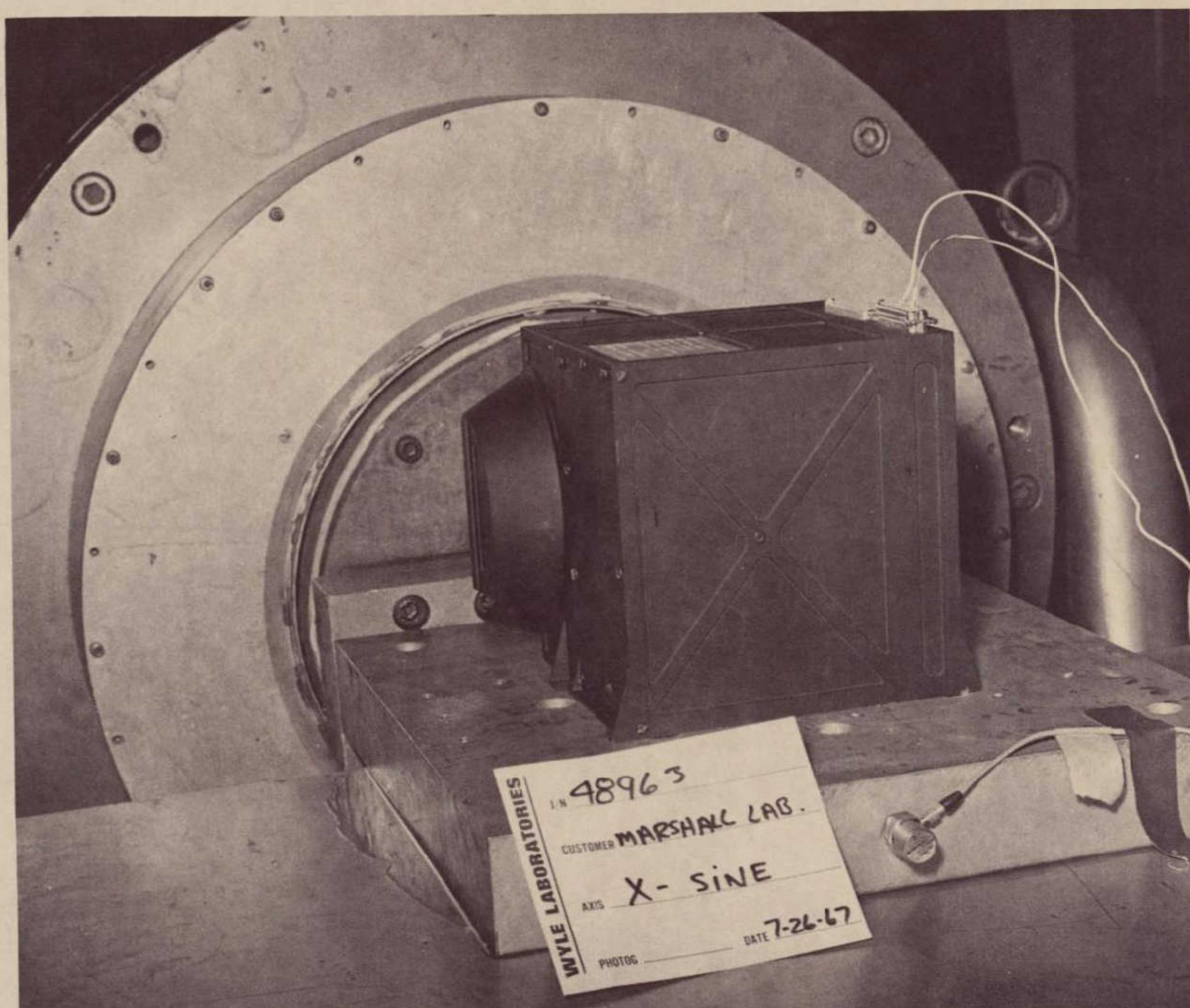
Figure 4. Vibration (Non-Operating) Test Configuration

			Digital Data	Analog Data
Noise, Volts (p-p)	From Instrument		< 0.1	< 0.02
	From Spacecraft		< 0.5	None
Impedance, Ohms	Instrument		--	≤1000 for ± 1 bit A/D Conversion Accuracy
	Spacecraft		3.9K ± 1%	Current to Instrument will be ≤ 25 micro-amps
N0-Load Characteriscits & Tolerances	Fall Time (at generator output), microsecond (90% -10%)		≤ 3	--
	Rise Time (at generator output), microsecond (10%-90%)		≤ 1	--
	Duration microsecond (50%-50%)		3-13	--
	Amplitude (+) Volts	Off	0 ± 1 across 3.9K	--
		On	11^{+3}_{-2} Across 3.9K	Normalized 0 to +3
	Orgin		Scientific Instrument	Scientific Instrument
	Signal Description		Series of pulses synchronized to within 10 microsecond of bit shift pulse. A pulse shall indicate one and no pulse shall indicate zero.	Normalized analog voltage. One line required for each word.
	Nomenclature		Digital Data	Analog Data

Figure
Scientific Instrument Output Signals

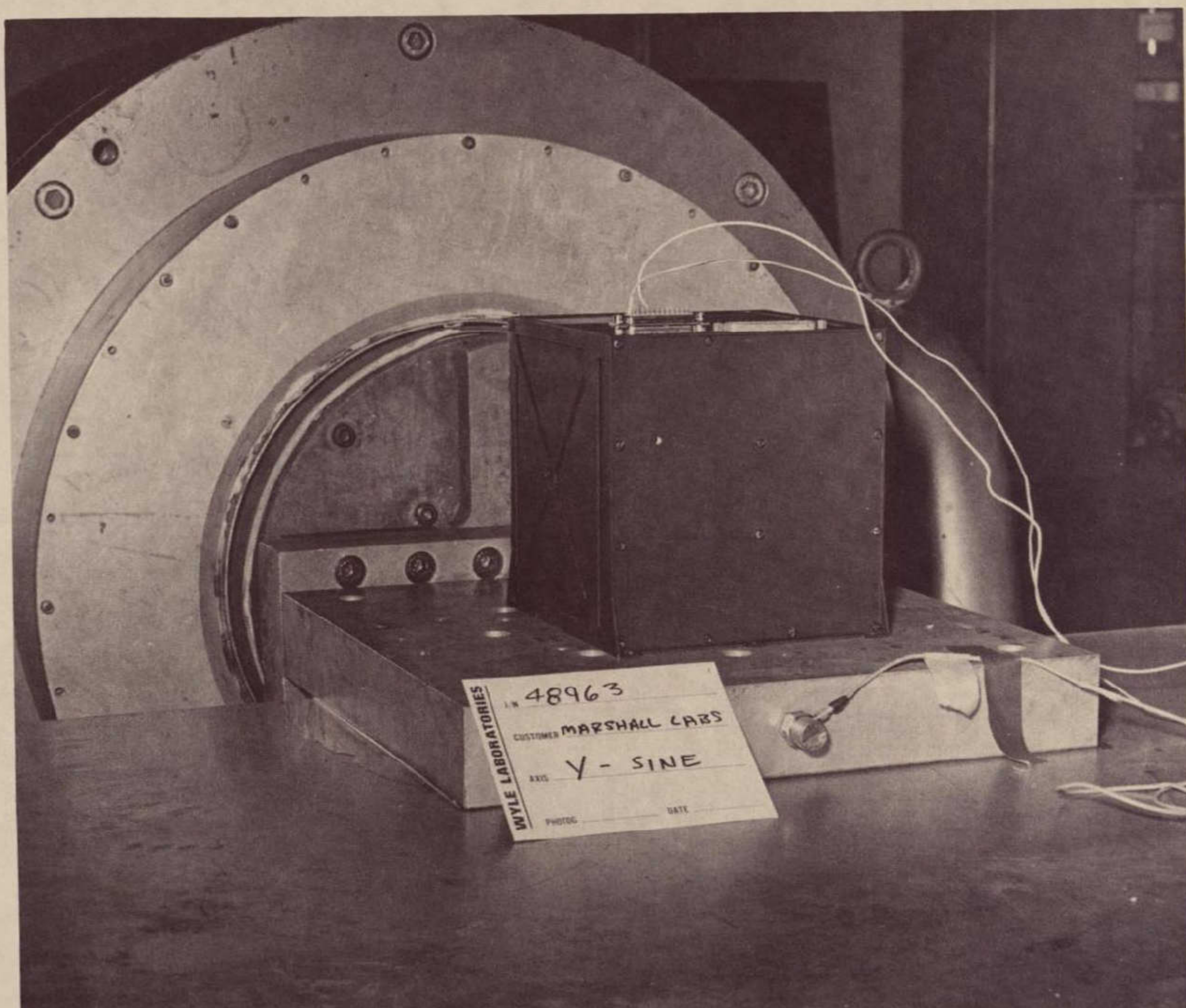
APPENDIX II

PHOTOGRAPHS



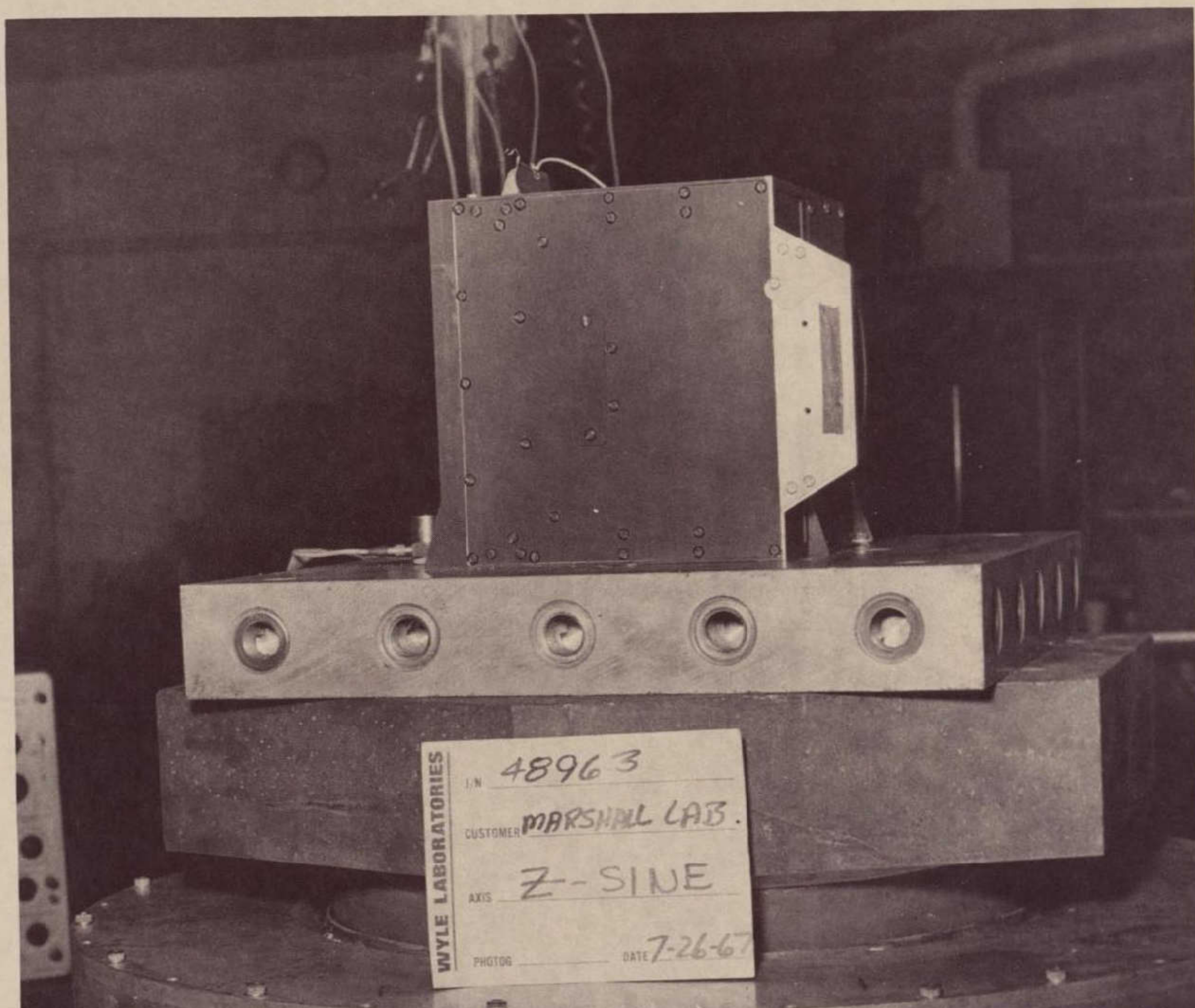
PHOTOGRAPH NO. 1

X AXIS SINUSOIDAL VIBRATION TEST SETUP



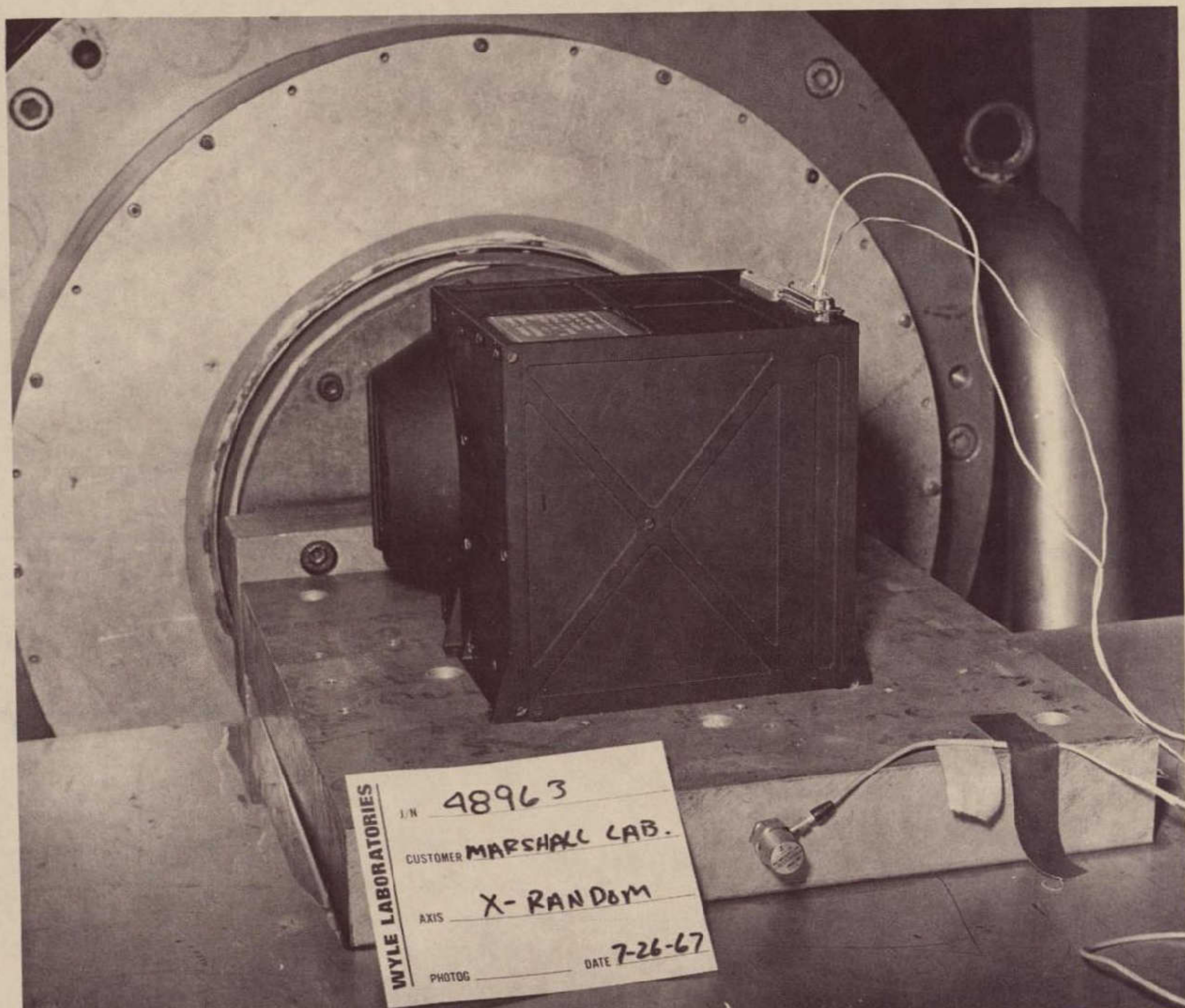
PHOTOGRAPH NO. 2

Y AXIS SINUSOIDAL VIBRATION TEST SETUP



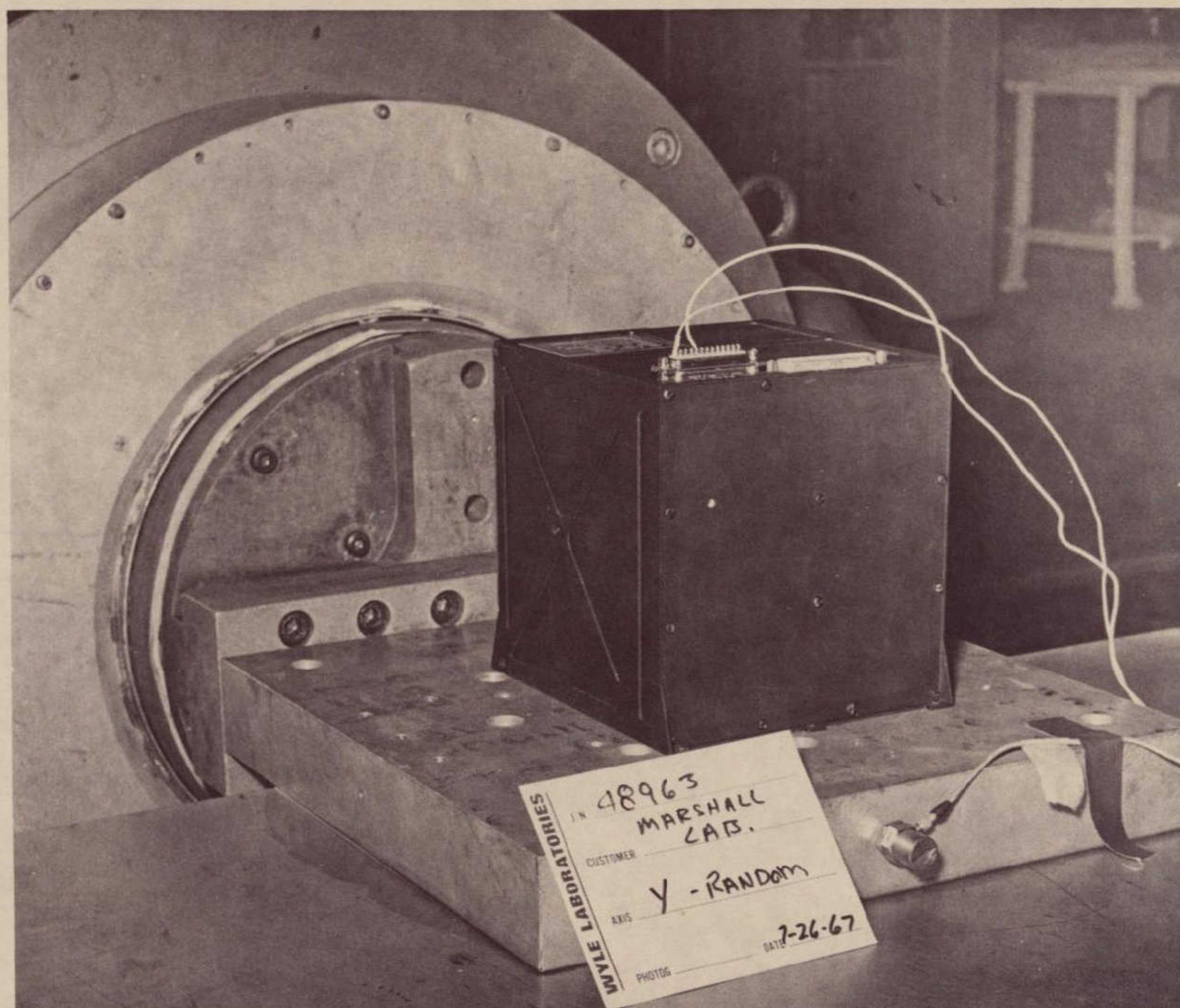
PHOTOGRAPH NO. 3

Z AXIS SINUSOIDAL VIBRATION TEST SETUP



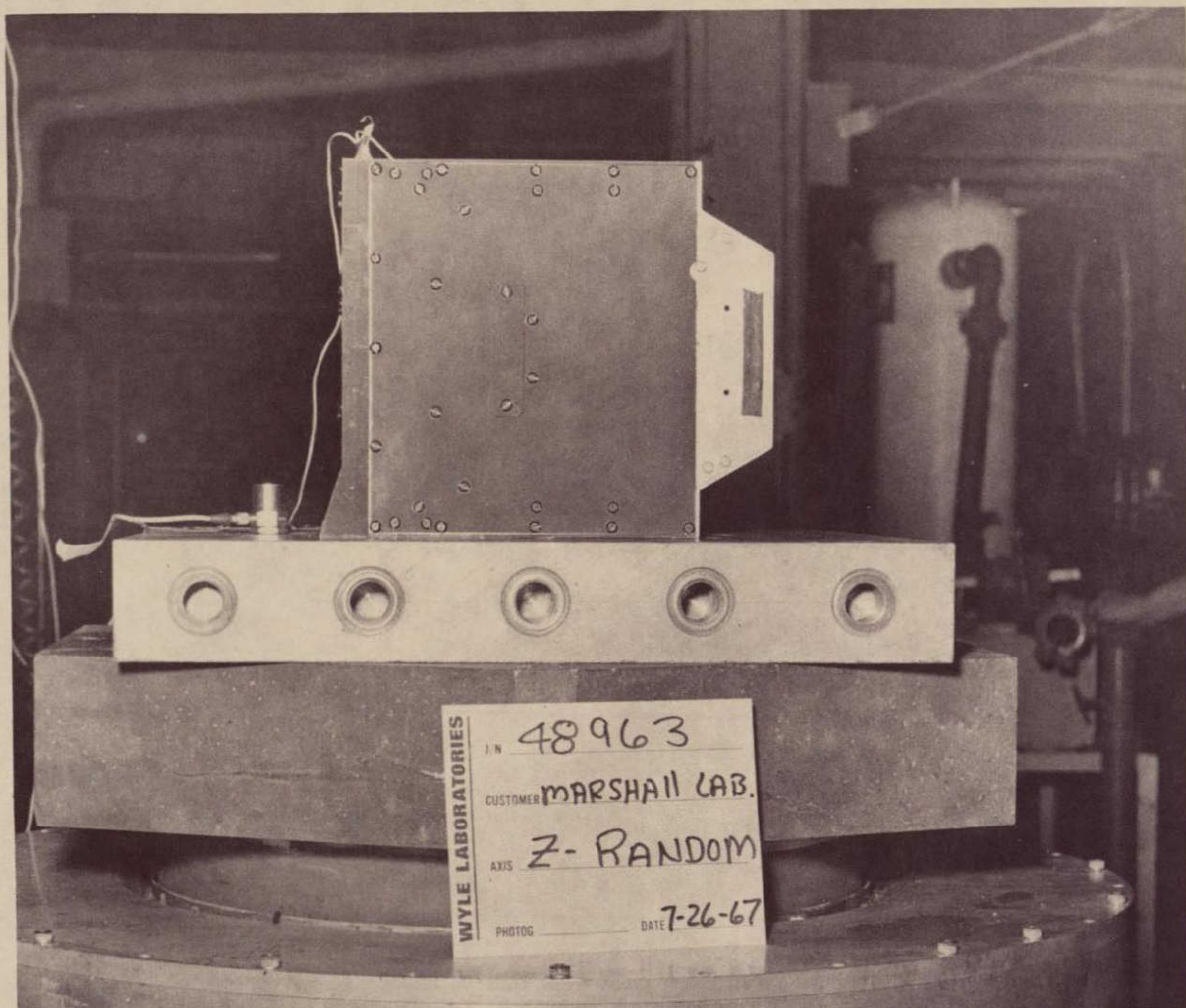
PHOTOGRAPH NO. 4

X AXIS RANDOM VIBRATION TEST SETUP



PHOTOGRAPH NO. 5

Y AXIS RANDOM VIBRATION TEST SETUP



PHOTOGRAPH NO. 6

Z AXIS RANDOM VIBRATION TEST SETUP

APPENDIX III

FAILURE REPORTS

[1] Name of experiment ARC Plasma Probe - Pioneer C & D [2] Unit No. 8C05-2 [3] Date of failure 24 Sept. 1967

[4] Description of failure. Amplifier No. 2 indicated a high flux level upon change of suppression voltage. [5] Operating hours at failure, total. unknown

[6] Operating conditions contingent to failure Instrument had been delivered to Ames Research Center after completion of flight acceptance testing. Instrument was undergoing observatory level testing at TRW Systems in preparation for solar-vac when failure occurred.

[7] Other instruments/experiments operating with experiment at time of failure: Unknown

[8] Signature of Operating Engineer: Rene Evelyn-Veere

[9] Description of failure: (Exact circuit, module, part, etc.) Dismantling the instrument disclosed a loose piece of RTV in the target area of the No. 2 amplifier.

[10] Cause of failure: Workmanship

[11] Corrective action taken: The optics assembly was removed, dismantled, cleaned and reassembled.

[12] Failure classification: a. Part component [ ] b. Design defect [ ] c. Workmanship [x]

[13] Alterations required on other units: Yes [ ] No [x] [14] Suggested alterations: None

[15] Log entry made: (Initials) Rene Evelyn-Veere Date.

ORIGINAL PIONEER PROJECT OFFICE
Green: Experimenter
Canary Accompanies experiment for rework and is retained by person doing rework
Pink Returned to P P O after rework with all entries
Goldenrod: (Hardcopy) Accompanies experiment and acts as a route sheet or traveler

Signed: Eric Azari
Title: Program Manager

[1] Name of experiment: ARC Plasma Probe - Pioneer C & D [2] Unit No 8C05-2 [3] Date of failure: 28 July 1967

[4] Description of failure: Improper electron mode data format at low data bit rate. [5] Operating hours at failure; total 80

[6] Operating conditions contingent to failure: Instrument had completed low temperature thermal-vac and gone onto high temperature thermal-vac when failure occurred.

[7] Other instruments/experiments operating with experiment at time of failure. Normal Plasma Probe ground support equipment plus isolation transformer and type 535 Oscilloscope (Tektronix).

[8] Signature of Operating Engineer: R Kobayashi
Robert Kobayashi

[9] Description of failure: (Exact circuit, module, part, etc.) During a retest at Marshall Laboratories the problems were defined as two (2) separate cases. (1) temperature problem, during electron mode in LBR, the data format is not proper in that 15 frames are appearing instead of 10. Also 6 words of frame 01 or 02 are present. (2) Spin Rate Problem. The first line of frame 01 during electron mode is all zeros dependent on spin rate between 56 to 58 RPM at 64 Bit Rate. In dismantling the experiment and electrically testing it the problem was located in the Buffer Storage Blivet. The Flip/Flop generating inhibit read signal was toggling on set-reset change without clock pulse being present. Two (2) resistors and a capacitor were installed in module Z21 and Z27 respectively in the Buffer Storage Blivet to load down the set reset lines to 1.6 volts. A redundant signal was located in the logic blivet module Z37. The MFS + HBR on pin 6 was eliminated.

[10] Cause of failure: Design Defect

[11] Corrective action taken: The instrument was modified as described in section 9 of this report by design changes.

[12] Failure classification: a. Part component [ ] b. Design defect [1-2] c. Workmanship [ ]

[13] Alterations required on other units: Yes [X] No [ ] [14] Suggested alterations: Incorporate design changes

[15] Log entry made: (Initials) R Kobayashi Date: 10/12/67
Robert Kobayashi, Program Engineer

ORIGINAL PIONEER PROJECT OFFICE
Green: Experimenter
Canary: Accompanies experiment for rework and is retained by person doing rework
Pink: Returned to P P O after rework with all entries
Goldenrod (Hardcopy) Accompanies experiment and acts as a route sheet or traveler

Signed: E. Azari
E. Azari
Title: Program Manager

PROJECT PIONEER AMES RESEARCH CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Name of experiment: ARC Plasma Probe - Pioneer C & D Unit No 8C05-2 Date of failure 22 July 1967

Description of failure: Excessive noise within amplifier No. 2 Operating hours at failure, total. 37

Operating conditions conducive to failure: Instrument had successfully completed flight acceptance sine vibration in the "X" axis. Failure was noticed during operational test after completing "Y" axis sine vibration.

Other instruments/experiments operating with experiment at time of failure: Normal Plasma Probe ground support equipment plus isolation transformer and type 535 Oscilloscope (Tektronix).

Signature of Operating Engineer. [signature]
Robert Kobayashi

Description of failure: (Exact circuit, module, part, etc.) Dismantling and electrically testing the instrument disclosed the following discrepancies - (1) Excessive noise existed within amplifier No. 2 as a result of a degraded front end assembly.

Cause of failure: Component breakdown.

Corrective action taken. To expedite the corrective action, flight unit 2 amplifier No. 2 was installed in the flight one instrument as a replacement for the failed flight unit 1 amplifier. The flight unit one amplifier will be reworked for the flight 2 instrument.

Failure classification: a. Part component [1] b. Design defect [ ] c. Workmanship [ ]

Alterations required on other units. Yes [ ] No [X] Suggested alterations: None

Log entry made: (Initials) [initials] Date: 7/7/67
Robert Kobayashi, Program Engineer

ORIGINAL. PIONEER PROJECT OFFICE
Green Experimenter
Canary Accompanies experiment for rework and is retained by person doing rework
Pink Returned to P P O after rework with all entries
Goldenrod (Hardcopy) Accompanies experiment and acts as a route sheet or traveler

Signed: [signature]
Title:
D. L. Chinburg, Program Manager

APPENDIX IV

TEST DATA

TEST REPORT

REPORT NO. 48963

OUR JOB. NO 489[illegible]

YOUR P. O. NO 21881

CONTRACT NAS 2-3374

YLE LABORATORIES/ El Segundo, California • EA 2-1763 • OR 8 4251 • TWX 213-322-5415 • Cable WYLAB

MARSHALL LABORATORIES
3530 TORRANCE BLVD.
TORRANCE, CALIFORNIA

35 PAGE REPORT

DATE 31 AUGUST 1967

ACCEPTANCE TEST

ON

ONE ARC PLASMA PROBE (F/U1)

PART NUMBER 544100-101

SERIAL NUMBER 8C05-2

MODEL ML-304-1

FOR

MARSHALL LABORATORIES

TATE OF CALIFORNIA }
OUNTY OF LOS ANGELES } ss

B. M. BLEAK, being duly sworn, deposes and says: That the information contained in this report is the result of complete and carefully conducted tests and is to the best of his knowledge true and correct in all respects

B. M. Bleak

SUBSCRIBED and sworn to before me this 31 day of AUGUST, 19 67

Notary Public in and for the County of Los Angeles, State of California

My Commission expires 20 JULY, 19 70

TEST BY ELECTRONICS DEPARTMENT

TEST WITNESS

DCAS-QAR VERIFICATION

QUALITY CONTROL APPROVAL

WYLE LABORATORIES

DATA SHEET

Test Title: VIBRATION

Customer: MARSHALL LABS. | Job No: 48963
Part No: 544100-101 | Date Test Started: 7/22/67
S/N: 8C05-2 | Date Test Completed: 7/22/67
Spec: MARSHALL LAB. T.P. S-96276 N/C | Amb Temp: 72°F
Para: 13.9 & 13.11 | Photo: N/A
Test Med: N/A
Specimen Temp: AMB.

Specimen: ARC PLASMA PROBE F/U1 ckt 9/14/67

PERFORM SINE AND RANDOM VIBRATION IN EACH OF THREE AXES AS OUTLINED BELOW:—

SINE:— SWEEP FROM 10 to 2000 @ 2 OCT./MIN.

AXIS			
X-X, Y-Y	10-50 HZ	@	5g
	50-2000 HZ	@	14g
Z-Z (THRUST)	10-50 HZ	@	5g
	50-100 HZ	@	29g
	100-250 HZ	@	14g
	250-500 HZ	@	5g
	500-2000 HZ	@	14g

RANDOM:— ALL 3 AXES FOR 2 MIN./AXIS

20 - 2000 HZ @ 0.032 g^2/HZ

8.0 GRMS

Specimen Meets Spec Requirements YES ☑ NO ☐

Tested By: Hutchinson
Witness: ______ Date: ______
Sheet No: 2 of 4
Approved: R. Baum Date: 7-24-67

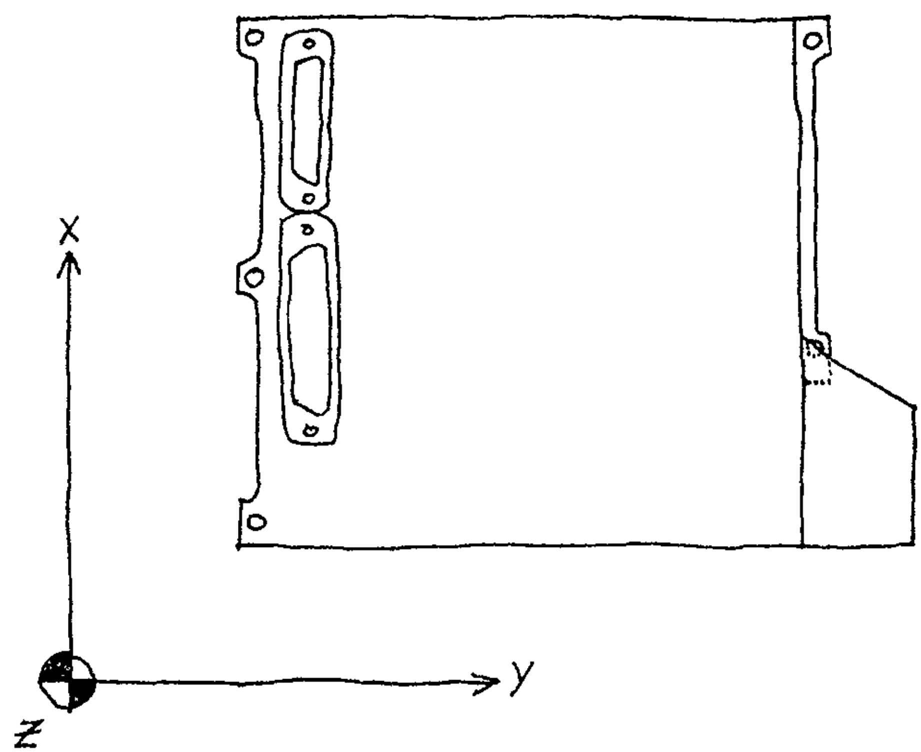
W 614 A

WYLE LABORATORIES

DATA SHEET

CUSTOMER MARSHALL LABS.
Test Title VIBRATION
Specimen ARC PLASMA F/ut PROBE 9/10/67 Job No. 48963
S/N 8C05-2
Part No 544100-101 Date 7/22/67

AXES DEFINITION:—



DYNAMICS SECTION
VIBRATION TEST DATA SHEET
SINE VIBRATION

Job No. 48963
Sheet 4 of 4
I D No. N/A

Date	Time	Axis	Temp (°F)	Sinusoidal Freq. (CPS)	Disp. ("DA)	Accel. (±G)	Test Time (Min.)	Comments	Name
							2.687 MIN.	TEST REQUIREMENT	
7/22/67	1615	X	AMB.	10-50	—	5		SWEEP COMPLETED — FREQ AND	
	1619			50-2000	—	14	3'43"	VOLTAGE RECORDED ON VISICORDER.	
									TCA
7/22	1750	Y	AMB.	10-50	—	5		SWEEP COMPLETED — FREQ. AND	
	1754			50-2000	—	14	3'40"	VOLTAGE RECORDED ON VISICORDER.	
									TCA

REPORT NO 48963
PAGE NO 12

W589 Q. C. Form Approval

Signed: R Biller

DYNAMICS SECTION
VIBRATION TEST DATA SHEET

JOB NO. [illegible]
SHEET 1 OF 1
I D No. ____

DATE	TIME	AXIS	TEMP (°F)	SINUSOIDAL FREQ. (CPS)	SINUSOIDAL DISP. ("DA)	SINUSOIDAL ACCEL. (±G)	TEST TIME (MIN)	COMMENTS	NAME
7/26			Amb.					TEST REQUIREMENT	
7/26	1010	Y	Amb.	10-50	–	5		SWEEP COMPLETED. VOLTAGE RECORDED	
	1014			50-2000	–	14	3'45"	ON VISICORDER.	J.m.
7/26	1307	Z	Amb.	10-50	–	5		SWEEP COMPLETED. VOLTAGE RECORDED	
				50-100	–	21		ON VISICORDER.	J.m.
	1311			100-250	–	14			
				250-500	–	5			
				500-2000	–	14	3'47"		

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PAGE NO 13

11589 Q. C. Form Approval [illegible]

SIGNED: R. [illegible]

DYNAMICS SEC[redacted]N
VIBRATION TEST DATA SHEET

JOB No. 40 [redacted]
SHEET 1 OF 1
I D No. —

DATE	TIME	AXIS	TEMP (°F)	RANDOM FREQ. (CPS)	RANDOM PSD (G^2/CPS)	RANDOM ACCEL (GRMS)	TEST TIME (MIN)	COMMENTS	NAME
7/26		XYZ	Amb.	20-2000	.032	8.0	2	TEST REQUIREMENT	
7/26	1452	Z	Amb.	20-2000	.032	8.0		RUN COMPLETED. NO APPARENT	
	1454						2'	DAMAGE.	V.M.
7/26	1658	Y	Amb.	20-2000	.032	8.0		RUN COMPLETED. NO APPARENT	
	1700						2'	DAMAGE.	V.M.
7/26	1815	X	Amb.	20-2000	.032	8.0		RUN COMPLETED.	
	1817						2'		V.M.

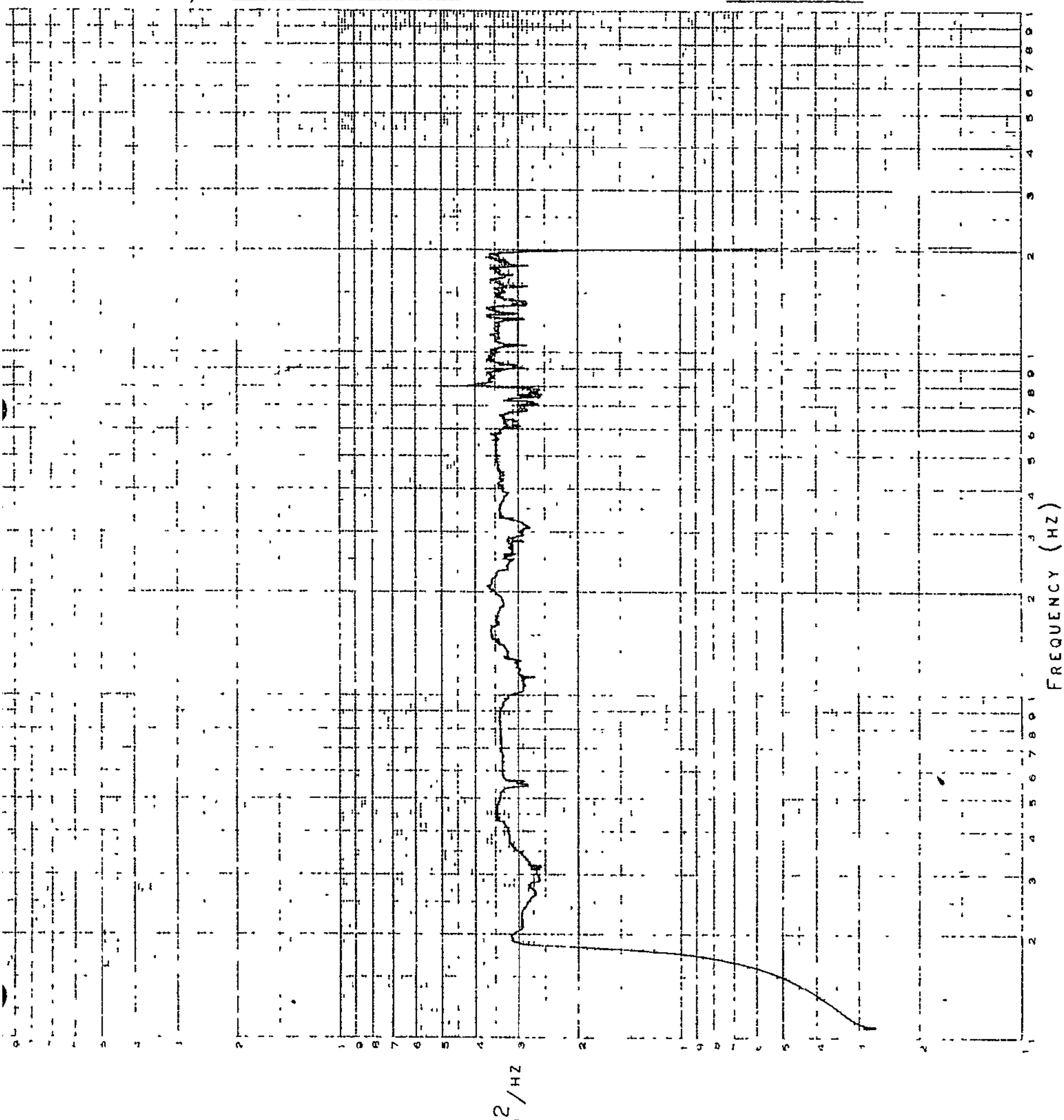
SIGNED: F. Green

W603R

JOB NUMBER 48963 DATE 7-26-67

P/N 544100-101 AXIS X

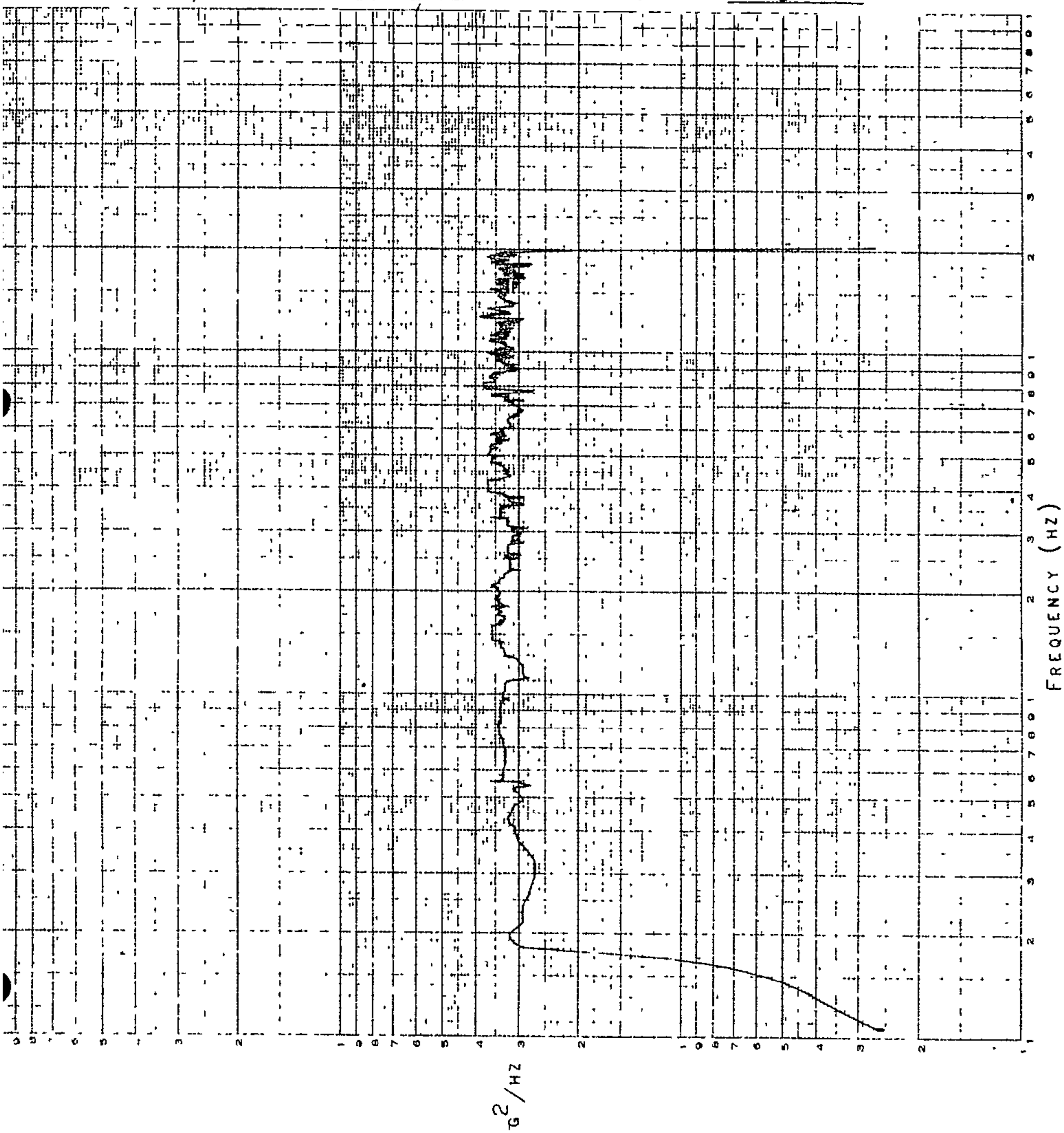
S/N 8C05-2 TOTAL GRMS 8.0



JOB NUMBER 48963 DATE 7-26-67

P/N 544100-101 AXIS Y

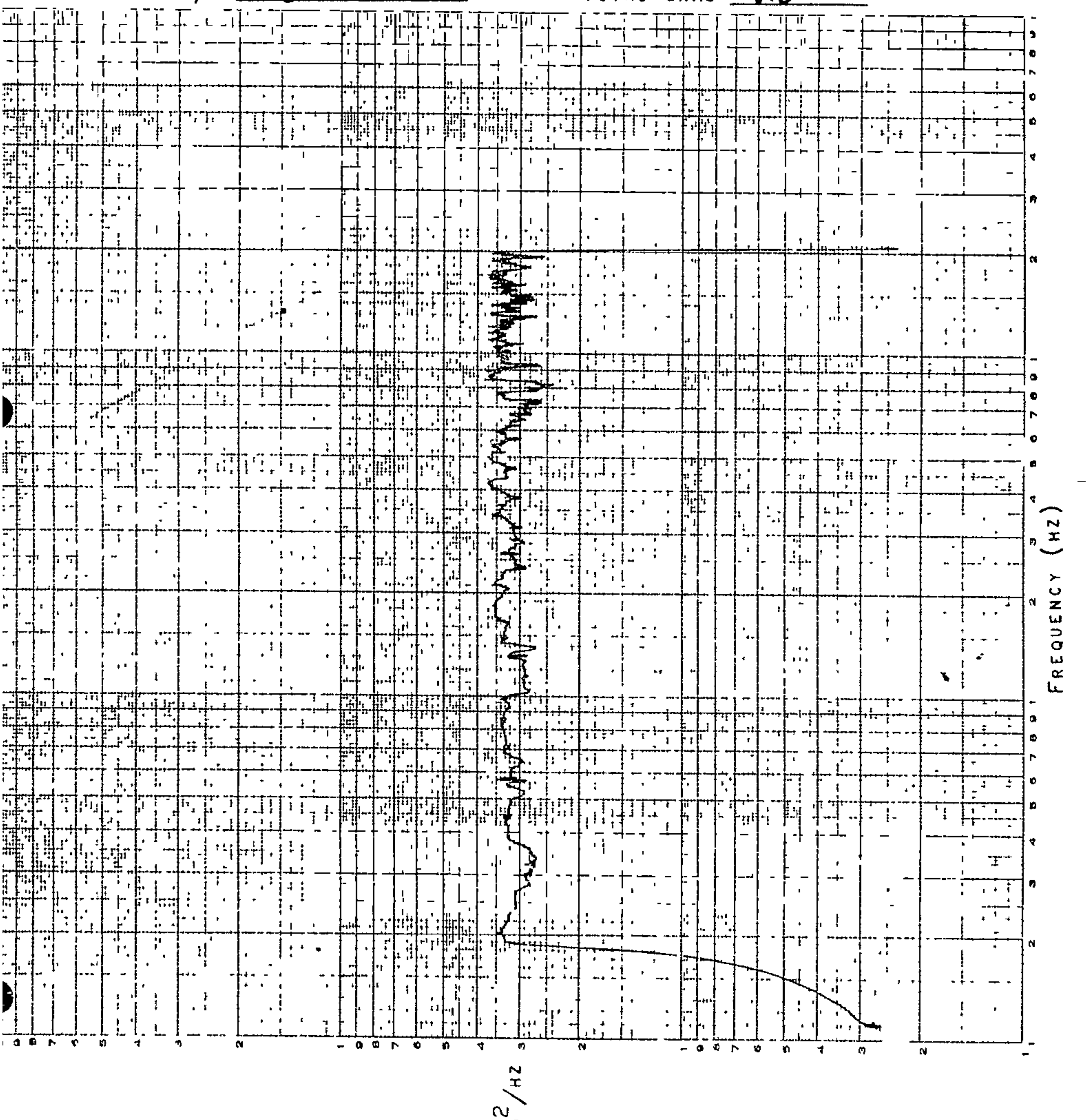
S/N 8C05-2 TOTAL GRMS 8.0



JOB NUMBER 48963 DATE 7-26-67

P/N 544100-101 AXIS Z

S/N 8C05-2 TOTAL GRMS 8.0



DYNAMICS SECT
VIBRATION TEST DATA SHEET

JOB NO. ______
SHEET 1 OF 1
I D No P/N 544100-101

DATE	TIME	AXIS	TEMP (°F)	RANDOM FREQ. (CPS)	RANDOM PSD (G^2/CPS)	RANDOM ACCEL (GRMS)	TEST TIME (MIN)	COMMENTS	NAME
		XYZ	AMB.	20-2000	0.015	5.5	2	TEST REQUIREMENT	
8/4/67	1605	X	AMB.	20-2000	0.015	5.4		BARE FIXTURE EQUALIZATION	
	1608						3.14	RUN COMPLETED.	JCR
8/4	1617	X	AMB.	20-2000	0.015			S/N 8C05-2	
	1619					5.4	2	RUN COMPLETED.	JCR
8/4	1646	Y	AMB.	20-2000	0.015			S/N 8C05-2	
	1648					5.4	2	RUN COMPLETED.	JCR
8/4	1715	Z	AMB.	20-2000	0.015			S/N 8C05-2	
	1719					5.4	2	Run Completed	R.B.

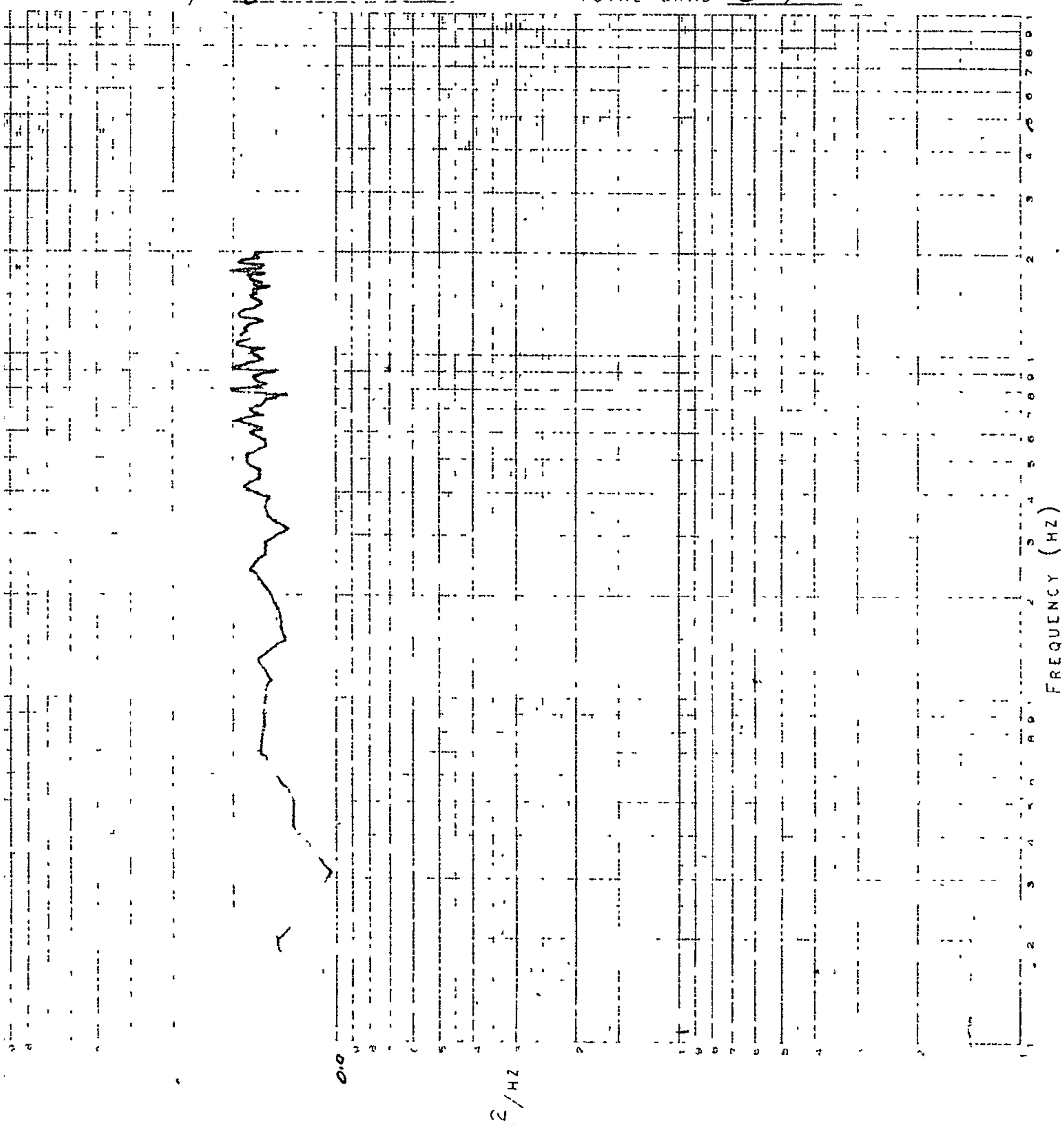
SIGNED: R Bell

W603R

JOB NUMBER 48963 DATE 8/4/67

P/N 544-100-101 AXIS X

S/N 8C05-2 TOTAL GRMS 6.4



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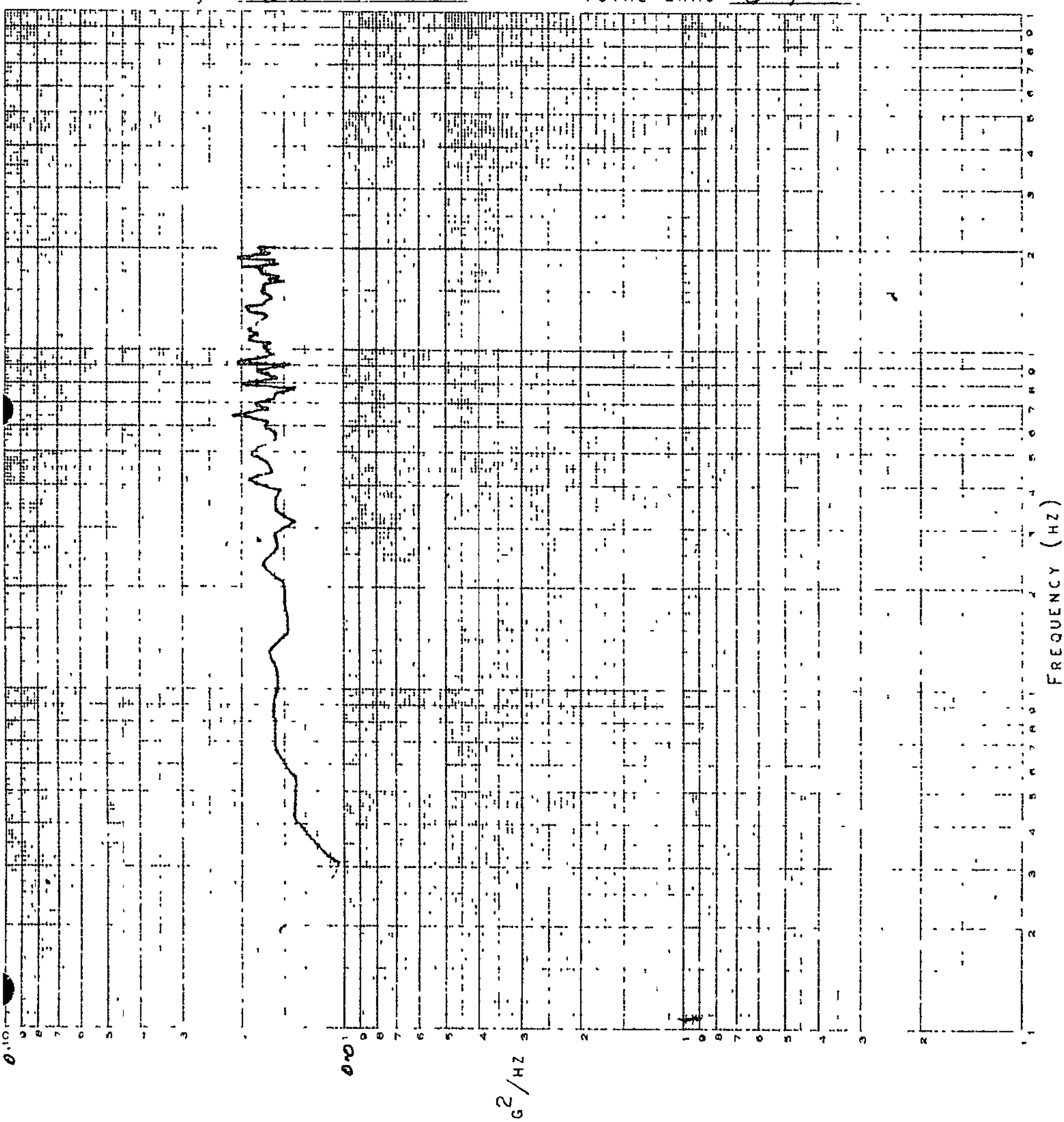
PAGE NUMBER 20

JOB NUMBER 48963 DATE 8/4/67

P/N 544100-101 AXIS Y

S/N 8C05-2 TOTAL GRMS 5.4



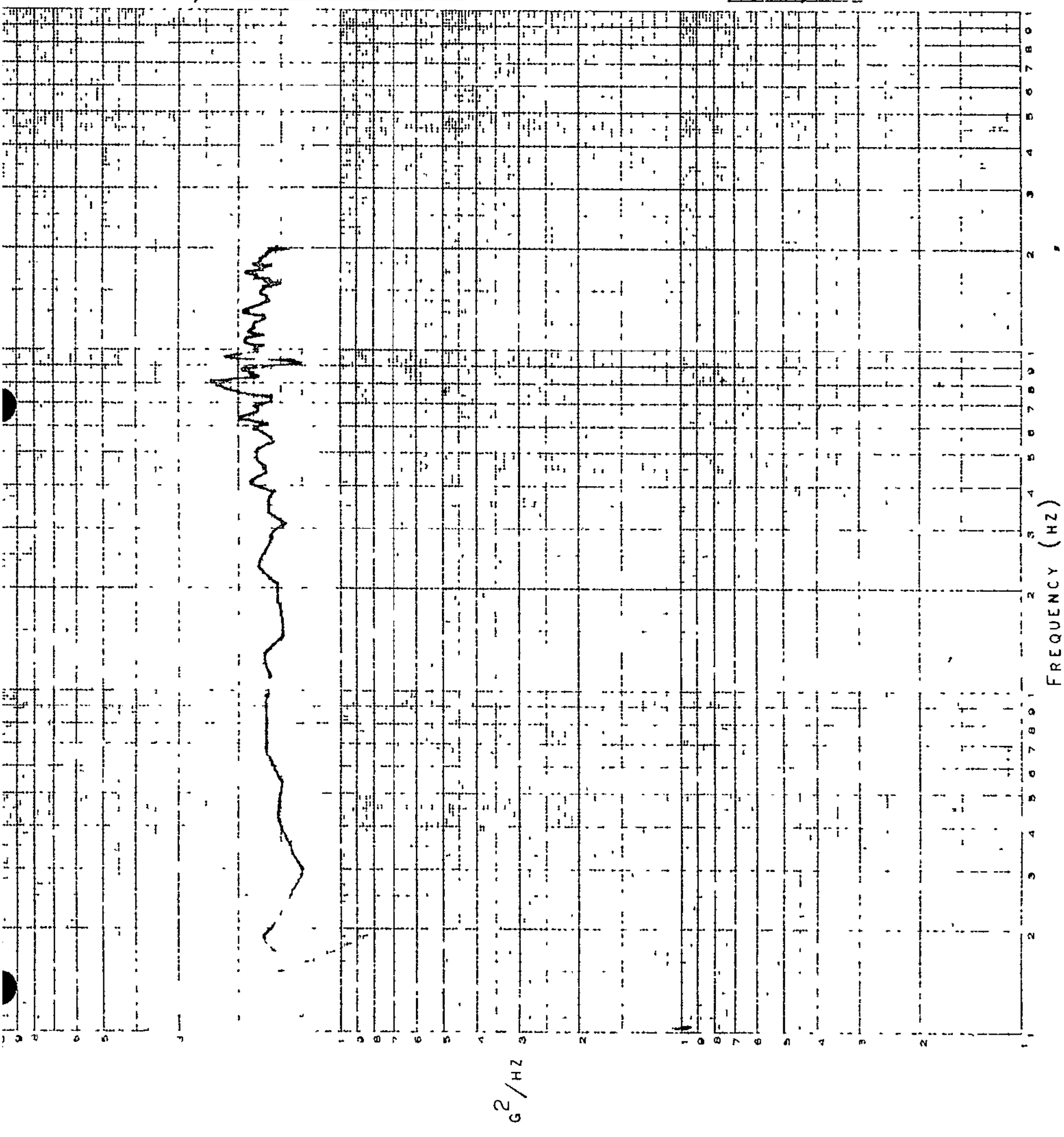
REPORT NUMBER 48963

PAGE NUMBER 21

JOB NUMBER 48963 DATE 8-4-67

P/N 544100-101 AXIS Z

S/N 8C05-Z TOTAL GRMS 5.4



WYLE LABORATORIES

DATA SHEET

Test Title THERMAL VACUUM

Customer Marshall Labs.

Job No 48963

Date Test Started 7-26-67

Date Test Completed 7-28-67

Part No 544100-101

S/N 8C05-2

Amb Temp 72 ± 15 F

Spec MARSHALL SPEC TPS-46276

Photo No

Para

Test Med Temp. Vacuum

Specimen Temp See Below

Specimen Plasma Probe

The Test Specimen Was Installed In A Temp. Controlled Vacuum Chamber At Room Ambient Conditions. Provisions Were Made For Normal Operation Of The Specimen. The Specimen Was Subjected To The Following Test Conditions

1. Chamber Pressure: Reduced To 1×10^{-5} mm Hg (Or Less) And Maintained At That Pressure During The Entire Test.

2. Chamber Temp. Reduced To 14 F And Maintained At 14 F For A Period Of 24 Hours

3. a. Chamber Temp. Increased From 14 F To 116 F And Maintained At 116 F For 8.17 Hrs. Of The 24 Hour Test Period.
   b. Specimen Temp. Maintained At 120 F For A Period Of 8.17 Hrs. The Customer Requested The Test To Stop Due To Specimen Trouble.

Test Results: Visual Examination Revealed No Evidence Of Damage Or Deterioration To The Specimen.

Tested By Bill Redwine

Specimen Meets Spec Requirements YES ☐ NO ☐ N.A.

Witness ______ Date ______

Sheet No 1 of 2

Q. C. Form Approval [signature]

Approved [signature] Date 8-10-67

W 614 A

WYLE LABORATORIES

DATA SHEET

Test Title Thermal Vacuum

Customer Marshall Lab.

Part No 544100-101

S/N 8605-2

Spec MARSHALL SPEC. TP S-46276

Para —

Specimen Plasma Probe

Job No 48963

Date Test Started 8-4-67

Date Test Completed 8-5-67

Amb Temp 77 ± 15 F

Photo No

Test Med Temp. Vacuum

Specimen Temp See Below

The Test Specimen Was Installed In A Temperature Controlled Vacuum Chamber At Room Ambient Conditions. Provisions Were Made For Normal Operation Of The Specimen. The Specimen Was Subjected To The Test As Follows.

Step 1. The Chamber Pressure Was Reduced To 1×10^{-5} mm Hg (Or Less) And Maintained At 1×10^{-5} mm Hg During The Entire Test.

2. The Specimen Plate Temp. Was Reduced To 14 F And Maintained At 14 F For A Period Of 10.0 Hours.

3. The Specimen Plate Temp. Was Increased To 120 F And Maintained At 120 F For A Period Of 10.30 Hours.

Test Results:
Visual Examination Revealed No Evidence Of Damage Or Deterioration To The Specimen From This Test.

Specimen Meets Spec Requirements YES ☑ NO ☐

Q. C. Form Approval

Tested By Bill Redmine

Witness — Date —

Sheet No 1 of 2

Approved [signature] Date 8-10-67

W 614 A

WYLE LABORATORIES

SPECIMEN ARC PLASMA PROBE
CUSTOMER MARSHALL LABS.
PART NO. 544100-101
S/N 8C05-2

JOB NO. 48963
DATE 7/22/67
TEST BY [signature]
WITNESS

TEST: VIBRATION

EQUIPMENT	MANUFACTURER	MODEL NO.	SERIAL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY
POWER AMP.	LING	175/240	—	175 KVA	6374	N/A	N/A.	N/A
VIBRATION EXCITER	LING	B300	—	8,000 lbs.-SINE	6811	N/A	N/A	N/A
SERVO	B&K	1018	—	5-10,000 HZ	6271	5/10/67	8/10/67	±1%
TIMER	STANDARD	—	—	1 HOUR	6835	4/10/67	10/10/67	±.1 SEC.
TIMER	STANDARD	—	—	1 HOUR	6389	4/10/67	10/10/67	±.1 SEC.
RANDOM CONSOLE	LING	ASDE 80	—	85 CHANNELS	6812	PRIOR to TEST		N/A
RMS METER	B&K	2416	—	1000 VAC	6823	5/28/67	8/28/67	±3%
CHARGE AMP.	UNHOLTZ-DICKIE	8PMCV	—	1,000 g	4530	2/13/67	8/13/67	±2% F.S.
ACCEL.	ENDEVCO	2272	NG62	1,000 g	30527	7/12/67	10/18/67	±5%
VISICORDER	HONEYWELL	1108	—	8 INCH 24 CHANNEL	4380	6/5/67	9/5/67	

W64C

SHEET 4 OF

WYLE LABORATORIES

SPECIMEN Plasma Probe
CUSTOMER Marshall Lab.
PART NO. 544100-101
S/N 8005-2
TEST: Thermal Vacuum

JOB NO. 48963
DATE 8-5-67
TEST BY Bill Redwine
WITNESS

EQUIPMENT	MANUFACTURER	MODEL NO.	SERIAL NO.	RANGE	WYLE NO.	CALIBRATION LAST	CALIBRATION DUE	ACCY
Vacuum Chamber	CVC	Special	1381	—	6863	10-15-66	10-15-67	—
Ion. Gauge	CVC	GIC-100	110.41	10^{-3} To 10^{-12} Torr	6862	10-15-66	10-15-67†	MFG Spec
Temp. Recorder	Minn. Honeywell	4153X60P8 W7-2	583403	-100 To 300 F	3186	7-7-67	10-7-67†	0.5% Span
Temp. Control Recorder	Minn. Honeywell	By152C(35) P(830)W791	665970	-150 To 250 F	5578	7-31-67	10-31-67†	0.5% Span

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W 814 C

Q. C. Form Approval [signature]

SHEET 2 OF 2

WYLE LABORATORIES

SPECIMEN Plasma Probe
CUSTOMER Marshall Labs.
PART NO. 544100-101
S/N 8C05-2
TEST: Temp. Vacuum

JOB NO. 48963
DATE 2-28-67
TEST BY Bill Redwine
WITNESS

EQUIPMENT	MANUFACTURER	MODEL No.	SERIAL No.	RANGE	WYLE No.	CALIBRATION		ACCY
						LAST	DUE	
Vacuum Chamber	CVC	Special	1381	—	6863	—	—	—
Ion Gauge	CVC	GIC-100	11041	10^{-3} To 10^{-12} Torr	6862	10-15-66	10-15-67	MFG Spec
Temp. Recorder Controller	Minn. Honeywell	152C15-PSH 226-111-21	N112657001	-200 To 200 F	6402	7-26-67	10-26-67	± 0.5%
Temp. Recorder	Minn-Honeywell	153X60 P8 W7-31	683403	-100 To 300 F	3186	7-7-67	10-7-67	± 0.5% Span

W 614 C

Q. C. Form Approval [illegible]

SHEET 2 OF 2

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PAGE NO. 26

NOTICE OF DEVIATION

TEST REPORT NO	48963 PAGE 27
WYLE JOB NO	48963
NOD NO	1
PO NO	21881
DATE	22 JULY 1967
GOV T CONT NO	NAS 2-3374

WYLE LABORATORIES

TO MARSHALL LABS

ATTN MR. CHINBURG

PART NAME ARC PLASMA PROBE- F/U1

PART NO 544100-101 SERIAL NO 8C05-2

TEST VIBRATION

SPECIFICATION MARSHALL LABS 546276 PARAGRAPH NO 13.9

NOTIFICATION MADE TO MR. FANTASKI DCAS – QAR REQUIRED

DATE 7-22-67 BY T. ATCHISON VIA VERBAL

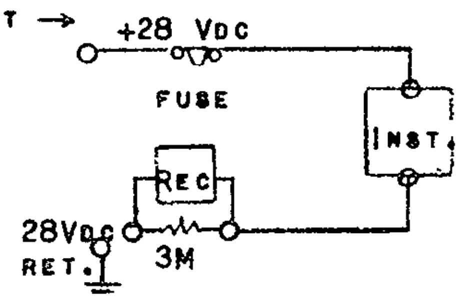
SPECIFICATION REQUIREMENTS

A) 13.9: THE TEST CONFIGURATION SHALL BE AS SHOWN IN FIGURE 3 OF THE SPECIFICATION.

B) 13.9: THE SENSITIVITY OF THE RECORDER SHALL BE ADJUSTED TO PROVIDE AT LEAST ONE VOLT/INCH SENSITIVITY FROM FULL SCALE DEFLECTION AT 28 VDC......

DESCRIPTION OF DEVIATION

A) TEST CONFIGURATION WAS AS SHOWN AT RIGHT →



B) RECORDER SENSITIVITY WAS 7 VDC/INCH

SPECIMEN DISPOSITION CONTINUE TESTING

COMMENTS RECOMMENDATIONS

TEST WITNESS

REPRESENTING

TEST ENGINEER R. J. FANTASKI

DEPT MANAGER T. PFENNING

QUALITY CONTROL

DISTRIBUTION
ORIGINAL QUALITY CONTROL
3 COPIES CUSTOMER
1 COPY JOB CONTROL
1 COPY WHITE FOLDER
1 COPY GREEN FOLDER
1 COPY CONTRACTS
1 COPIES DCAS — QAR

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NOTICE OF DEVIATION

TEST REPORT NO	48963 PAGE 28
WYLE JOB NO	48963
NOD NO	2
PO NO	21881
DATE	22 JULY 1967
GOV'T CONT NO	NAS 2-3374

WYLE LABORATORIES

TO MARSHALL LABS.

ATTN MR. CHINBURG

PART NAME ARC PLASMA PROBE F/U1

PART NO 544100-101 SERIAL NO 8C05-2

TEST SINUSOIDAL VIBRATION

SPECIFICATION MARSHALL LABS 546276 PARAGRAPH NO 13.9 AND 13.11

NOTIFICATION MADE TO MR. FANTASKI DCAS — QAR REQUIRED

DATE 7-22-67 BY T. ATCHISON VIA VERBAL

SPECIFICATION REQUIREMENTS

SINUSOIDAL VIBRATION AS PER PARAGRAPH 13.9
RANDOM VIBRATION AS PER PARAGRAPH 13.11

DESCRIPTION OF DEVIATION

AFTER THE "Y" AXIS SINE SWEEP THE CUSTOMER FOUND THAT THE SPECIMEN WAS NOT OPERATING PROPERLY.

SPECIMEN DISPOSITION RETURN TO MARSHALL LABS. FOR FAILURE ANALYSIS.

COMMENTS - RECOMMENDATIONS

TEST WITNESS

REPRESENTING

TEST ENGINEER R. J. FANTASKI

DEPT MANAGER T. PFENNING

QUALITY CONTROL

DISTRIBUTION
ORIGINAL QUALITY CONTROL
3 COPIES CUSTOMER
1 COPY JOB CONTROL
1 COPY WHITE FOLDER
1 COPY GREEN FOLDER
1 COPY CONTRACTS
1 COPIES DCAS — QAR

WL-109A

NOTICE OF DEVIATION

TEST REPORT NO	48963 PAGE 29
WYLE JOB NO	48963
NOD NO	3
PO NO	21881
DATE	7/28/67
GOV'T CONT NO	NAS 2-3374

WYLE LABORATORIES

TO MARSHALL LABS

ATTN MR. CHINBURG

PART NAME ARC PLASMA PROBE F/U1

PART NO 544100-101 SERIAL NO 8C05-2

TEST THERMAL VACUUM

SPECIFICATION MARSHALL LABS S-46276 PARAGRAPH NO 3.14

NOTIFICATION MADE TO MR. CHINBURG DCAS — QAR REQUIRED

DATE 7/28/67 BY M. BOSKOVICH VIA VERBAL

SPECIFICATION REQUIREMENTS

MAINTAIN 120F AT 1×10^{-5} TORR OR LESS FOR 24 HOURS.

DESCRIPTION OF DEVIATION

AFTER MAINTAINING 120F FOR 8 HOURS AND 11 MINUTES THE CUSTOMER REQUESTED TO STOP THE TEST DUE TO PROBLEMS WITH THE TEST SPECIMEN.

SPECIMEN DISPOSITION DISCONTINUE TESTING

COMMENTS RECOMMENDATIONS

TEST WITNESS

REPRESENTING

TEST ENGINEER M Boskovich
M. BOSKOVICH

DEPT MANAGER A. R. LASKY

QUALITY CONTROL [illegible]

DISTRIBUTION
ORIGINAL QUALITY CONTROL
3 COPIES CUSTOMER
1 COPY JOB CONTROL
1 COPY WHITE FOLDER
1 COPY GREEN FOLDER
1 COPY CONTRACTS
1 COPIES DCAS — QAR

WL-109A

APPENDIX D

Memory Specification

I Memory System Electrical Specification

General System Requirements

Capacity: 768 bits (16 x 48 Y)

15 x 44 is sufficient to fulfill the requirements of data storage. The additional 4 Y lines, and 1 X line may be considered spares (the spare X line is not connected).

Cycle Time. Minimum time between Read/Write commands 22.5 microseconds. The maximum write rate is 20 KC. The maximum read rate is 512 cycles.

Operating Mode. Sequential Interlace.

The write cycle is interlaced with the read cycle. Information is written into and read out of memory sequentially. Any arbitrary read address can follow any write address and vice versa.

Operating Temperature Range. $-15^{o}C$ to $55^{o}C$

Total Average Power. Less than 120 milliwatts at the maximum interlaced read and write duty cycles. Write duty cycle 1.7×10^{-3}. Read duty cycle 1.5×10^{-3}.

Interface Requirements

Supply Voltages

$+12$ v $\pm$ .6v @ 2.7 ma average
$+6$ v $\pm$ .006v @ 7.5 ma average
$+3$ v $\pm$ .06 v @ 1.7 ma average
-6 v $\pm$ .006v @ 2.9 ma average
$+24$ v $\pm$ .048v @ 2.9 ma average

Input Signals

General

The interface circuits shall be of the RCTL type.

The limits on the static signal levels shall be +0.22 volts maximum at the lower level and +2.0 volts minimum at the upper level. Signal levels are positive true.

Refer to the read and write timing diagrams for the voltage level references required in interpreting times given in this section.

Data

Data is available on 9 lines.

Each data line is loaded with 20K Ω ± 10% to +6 volts at the memory.

Each data line must be settled before the initiation of a write command, and can not change until 5 microseconds after the termination of the write command.

X Read or Write Address

Five address bits are available on 20 lines.

Each line is loaded with a minimum of 5K Ω ± 10% to +6 volts at the memory.

Each address line must be settled before the initiation of a command, and cannot change until 5 microseconds after the termination of the command.

Y Read or Write Address

Seven address bits are available on 28 lines. An additional term is available on 2 lines.

Each line is loaded with a minimum of 5K Ω ± 10% to +6 volts at the memory.

Each address line must be settled before the initiation of a command, and cannot change until 5 microseconds after the termination of the command.

Write Command

During the application of this signal the information present on the data input lines is written into the memory

The write command line is loaded with 10K Ω ± 10% minimum to +6 volts at the memory.

The rise and fall times shall be less than 1 microsecond.

The command duration shall be 11 microseconds ± 2 microseconds, measured at the 50% points.

Read Command

During the application of this signal the information stored in memory is read out on the data output line.

The read command line is loaded with 10K Ω ± 10% minimum to +6 volts at the memory.

The rise and fall times shall be less than 1 microsecond.

The command duration shall be 11 microseconds ± 2 microseconds, measured at the 50% points.

Shift Frame I. D

This signal is used to trigger the memory output one-shot when frame information is entered. Frame information shall not occur at the same time as the read command (shift pulse).

This line is loaded with 20K Ω ± 10% minimum to +6 volts at the memory.

The rise time (positive excursion) shall be 2 microseconds maximum, measured from 10% to 90%.

The fall time (negative excursion) shall be 0.5 microseconds maximum, measured from 10% to 90%

The width shall be 6 microseconds ± 3 microseconds, measured 50% to 50%.

I. D. Data

This signal is the I. D data level.

The I. D. data line shall be settled prior to and cannot change during the shift Frame I. D. signal.

Data Output Signal

General

The presence of a signal represents a "1" read from memory of a "1" in the frame I. D. The absence of a signal represents a "0". This signal occurs with a maximum of 6.5 microseconds delay relative to the initiation of Read Command (Shift Pulse) or a "1" in the Frame I. D

Levels

Signal Levels are positive true. The limits on the static signal levels shall be +0.2 volts maximum at the lower level and +10 volts ± 1 volt at the upper level.

Type Storage: Ferrite core, coincident current.

Loads

The external load shall be 3.9 K $\Omega \pm$ 1% in parallel with 300 pf maximum to ground.

Timing

The rise time (positive excursion) shall be 1 microseconds maximum, measured 10% to 90%.

The fall time (negative excursion) shall be 3 microseconds, maximum, measured 10% to 90%.

The signal duration shall be 7 microseconds $\pm$ 3 microseconds, measured 50% to 50%.

II Core Memory Plane Specification

The contents of this section are excerpts from Marshall Laboratories Specification S46017A, and are included here for information only.

A. The dynamic electrical tests on the core plane shall be performed at three temperatures. $-15^{\circ}C \pm 1^{\circ}C$; $25^{\circ}C \pm 1^{\circ}C$; $55^{\circ}C \pm 1^{\circ}C$.

B. The information shall be written into the elements of the plane after the plane temperature has stabilized in each case. The information will then be read out, and the sense line output will be monitored for conformance to the Acceptable Characteristics specified in (F).

C. Data patterns to be used shall include the worse case pattern, worse case pattern complement, all "1"s pattern, and any other applicable pattern. In each case a pattern will be written into the plane in some order (as a function of position), and will be readout in the same order.

D Input Current Characteristics (quantities specified apply at all temperatures except as notes).

Full Select Amplitude = $I_x + I_y$ = 490 ma - turns @ $-15^{\circ}C$

= 400 ma - turns @ $+25^{\circ}C$

= 330 ma - turns @ $+55^{\circ}C$

($\pm$ 3% tolerances are allowed at all temperatures)

Disturb Ratio $\frac{I_X}{I_X + I_Y} = 0.5 \pm 0.03$

Pulse Widths 4 microseconds minimum coincidence of Ix and Iy is required

Rise and Fall Times linear 0.1 microseconds $\pm$ 0.05 microseoncds

Delay Time Between 1/2 select currents during read out shall be 1.5 microseconds $\pm$ 0.05 microseconds (10% to 10% times). Iy follows Ix

E. Sense Line Termination = 30 Ω resistive load

F. Acceptable Output Characteristics

Quantities specified apply at all temperatures and for all possible data patterns unless otherwise noted.

"1" Amplitude 40 mv @ $-15^{\circ}C$

45 mv @ $+25^{\circ}C$

40 mv @ $+55^{\circ}C$

"1" Peaking Time = 1.0 microsecond $\pm$ 0.3 microseconds.

"1" Switching Time = 2.8 microseconds ± 0.7 microseconds.

Note: "1" Peaking and switching times are to be measured from the 10% level of Iy.

"0" Amplitude 10 mv, decayed to 3 mv maximum in 1 microsecond maximum relative to the 10% point of Iy.

Signal to Noise Ratio 10/1 at "1" peaking time

Common Mode Voltage 400 mv at any time during the read cycle.

G. Vendor data sheets containing driver characteristics and performance data obtained during the performance of the dynamic electrical tests outlined in this section shall be supplied with each delivered unit. In addition, test setups and test procedures utilized for the performance of the dynamic electrical tests outlined shall be subject to Company approval.

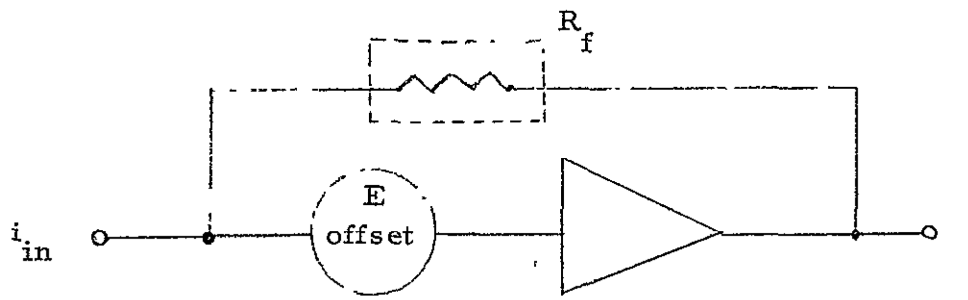
APPENDIX E

Instrument Circuit Worst Case Analysis

I Electrometer Amplifier

Electrometer

The worst case offset in the Electrometer that is due to shock, vibration, aging, power supply drift, target leakage and initial set-up error can be assumed to be 100 millivolts as referred to the input control grid.



The offset is the voltage required at the input control grid to cause an output of zero. The general relationship of the controlling parameters of the output voltage can be expressed as:

$$E = f\,(I_{in},\ R_f,\ I_L,\ E_{sq},\ E_{Ps},\ E_{FIL},\ R_a \ldots R_i,\ Q_a \ldots Q_i)$$

where

I_{in} is the input signal current

I_L is the input leakage current

R_f is the feedback resistor

E_{sq} is the screen grid potential

E_{ps} is the power supply potential

E_{FIL} is the filament potential

$R_a \ldots R_i$ are various resistors in the circuit

$Q_a \ldots Q_i$ are various transistors in the ciruit

and where $\frac{E_o}{in}$ dn represents the change in the output due to a change in source parameter (n).

In general any change as E_{FIL} or E_{ps} that occurs in the amplifier appears as a shift in the virtual ground potential at the control grid. Changes in the feedback resistor appear as change in sensitivity and not as an offset. Leakage current appears as a potential across the feedback resistor. The output voltage can be expressed as

$$E_o = I_{in} R_f + I_L R_f + E \text{ offset}$$

where $I_{in} R_f$ is the signal term and $I_L R_f + E$ offset is the error term.

In order to achieve maximum performance, especially where lower current ranges are to be detected, the total error should not be larger than the minimum desirable signal. The total error can be substantially reduced, if not altogether cancelled, by inserting a cancelling signal somewhere in the overall loop. The method used to insert a cancelling signal into the loop is to control the bias on the screen grid potential. The amount of control necessary to cancel the worst case error which was assumed to be $\pm$ 100 millivolts at the screen grid is determined by the ratio of the screen grid transconductance to the control grid transconductance. This ratio has been empirically derived by laboratory measurements to be 1:1.6. The total worst case Electrometer error referred to the screen grid could be as high as 160 millivolts. The degree to which the offset must be cancelled is determined by the accuracy to which the required offset can be generated, metered and stored. The system specification requires a worst case offset of $\pm$ 1 x 10^{-14} amps and a drift rate not more than 1 x 10^{-14} amps between stabilization cycles. This is a maximum interval of 50 seconds. Referred to the screen grid, the specification requires a generation and metering accuracy of 2.4 x 10^{-4} volts and storage drift of 2.54 x 10^{-4} volts for the 50 seconds interval. The tolerable storage drift can be expressed as fractional time decay. For the worst case the total error is 160 x 10^{-3} volts, the frist is 2.54 x 10^{-4} in 50 seconds. This amounts to 3 x 10^{-5} per second which is equivalent to 3 x 10^{4} time constant.

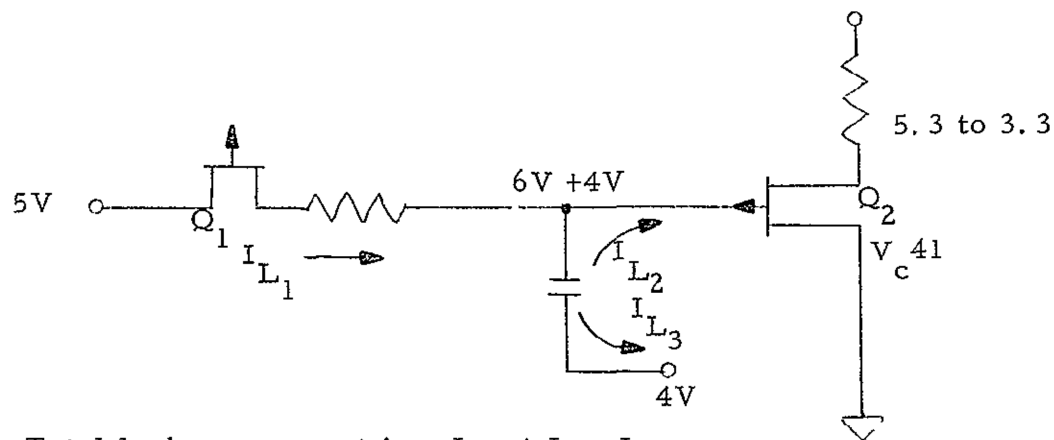
I Stabilization Storage

The worst case condition occurs when the stored stabilization error is a maximum at high temperature.

Under the operating condition

$$V_{error} = 2V \ (V_{GQ_2} = 6V)$$

Q_1 and Q_2 are selected for leakage currents (I_L and I_{L2}) of less than 5×10^{-12} amps at 55°C C is chosen for a leakage current (I_{L3}) of less than 2×10^{-10} at 55°C at 2V.



Total leakage current is $I_{C_1} + I_{C_3} - I_{L_2}$

for worst case condition let $I_{L_2} = 0$

$I_{L\ Total} = 2.05 \times 10^{-10}$ amps.

$$\frac{dV}{dt} = \frac{I}{C}$$

$$\frac{dV_{error}}{dt} = \frac{I_{C\ Total}}{C} =$$

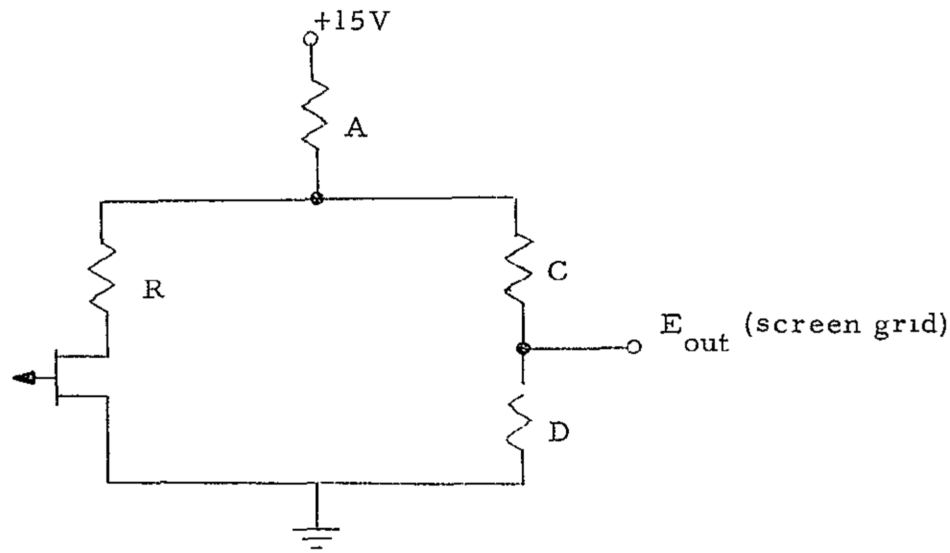
$$\frac{2.05 \times 10^{-10}}{6.8 \times 10^{5}} = 3 \times 10^{-5} \text{ volts/sec.}$$

Since the capacitor is a polarized type and the error can be either polarity a nominal +1V corresponds to zero error and 2 volts and 0 volts correspond to maximum error. The fraction error drift

$$\frac{1}{V_{error}} \cdot \frac{dV_{error}}{dt} = \frac{1}{1V} \times 3 \times 10^{-5} \frac{\text{volts}}{\text{sec.}} = 3 \times 10^{-5} \text{ sec.}$$

The 3×10^{-5} second fractional error drift rate meets the system specification.

screen grid bias circuit



The requirements for the nominal conditions are as follows.

$$E_{in} = 5V, \quad E_{out} = 7.5V$$

where E_{in} = 4V Fixed bias + 1V stored voltage

for worst case condition

$$\text{store} = \pm 1V$$

$$E_{out} = \pm 160 \times 10^{-3} \text{ volts}$$

That is

$$\frac{\Delta E_{out}}{\Delta E_{in}} = .16$$

E_{out} can be expressed as.

$$E_o = (E_{in} - V_{GS}) \frac{\frac{A(B+C)}{A+(B+C)}}{R + \frac{A(B+C)}{A+(B+C)}} \times \frac{C}{B+C} + 15V \frac{\frac{R(B+C)}{R+(B+C)}}{A+R(B+C)} \times \frac{C}{B+C}$$

Let $$\alpha = \frac{\frac{A(B+C)}{A+(B+C)}}{R + \frac{A(B+C)}{A+(B+C)}}$$

$$\beta = \frac{C}{B+C}$$

$$\gamma = \frac{\frac{R(B+C)}{R+(B+C)}}{A+\frac{R(B+C)}{R+(B+C)}}$$

$$D = B + C$$

Normalize by R = 1

$$E_o = (E_{in} - V_{GS}) \qquad + 15V$$

$$\frac{dE_o}{dE_{in}} = .16 = \alpha\beta$$

or $$\frac{E_o}{\alpha\beta} = (E_{in} - V_{GS}) + 15V \frac{\gamma}{\alpha}$$

$E_o = 7.5$ volts

$E_{in} = 5$ volts

$V_{GS} = 0.7$ volts

therefore: $$\frac{\frac{E_o}{\alpha\beta} - E_{in} + V_{GS}}{15} = \frac{\gamma}{\alpha}$$

or $$\frac{\frac{7.5}{.16} - 5 + 0.7}{15} = \frac{\gamma}{\alpha}$$

$$\frac{\gamma}{\alpha} = 2.85$$

and $$\alpha = \frac{\frac{AD}{A + D}}{1 + \frac{AD}{A + D}}$$

or $$\alpha = \frac{AD}{A + D + AD}$$ and dividing by D

$$\alpha = \frac{A}{1 + A\,\frac{(D+1)}{D}}$$

$$\gamma = \frac{\frac{D}{1 + D}}{A + \frac{D}{1+ D}}$$

$$\frac{\gamma}{\alpha} = \frac{\frac{D}{1 + D}}{A + \frac{D}{1 + D}} \quad X \quad \frac{1 + A\,\frac{(D+1)}{D}}{A}$$

By rearranging and cancelling out like terms

$$\frac{\gamma}{\alpha} = \frac{1}{A}$$

or $$A = \frac{1}{2.85} = 0.352$$

$$\alpha = \frac{A}{1 + \frac{A(D+1)}{D}} \qquad \text{or} \quad A = \quad + A \quad \frac{(D+1)}{D}$$

$$\frac{D+1}{D} = \frac{A - \alpha}{A\alpha} \qquad \text{By rearranging terms}$$

$$\frac{1}{D} = \frac{1}{\alpha} - \frac{1}{A} - 1$$

the value $\frac{1}{\alpha}$ could be calculated from $\alpha\beta = .16$

or $$\alpha = \frac{.16}{\beta} \quad \text{or} \quad \frac{1}{\alpha} = \frac{1 \times \beta}{} = 6.2\beta$$

$$\frac{1}{D} = 6.2\beta - \frac{1}{A} - 1$$

but $$\frac{1}{D} = 6.2\beta - \frac{1}{.352} - 1$$

or $$\frac{1}{D} = 6.2\beta - 3.85$$

$$D = B + C$$

$$\beta = \frac{C}{B + C}$$

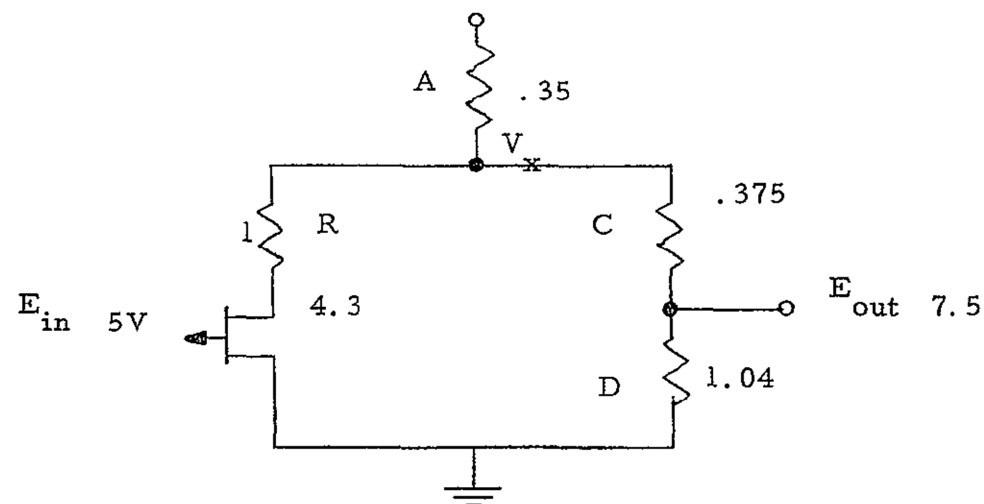
or $$1 = 6.2C - 3.85\ (B + C)$$

therefore $$C = \frac{3.85\ B + 1}{2.35}$$

let $B = \frac{3}{8} = 3.75$

then $C = 1.04$

for maximum temperature stability, the FET should have an $I_D = 25$ microamperes.



where $V_X = 7.5 \frac{1.04 + .375}{1.04} = 10.2$ volts

$V_R = 10.2 + .7 - 5 = 5.9V \quad R = \frac{5.9V}{25 \times 10^{-6}} = 236K$

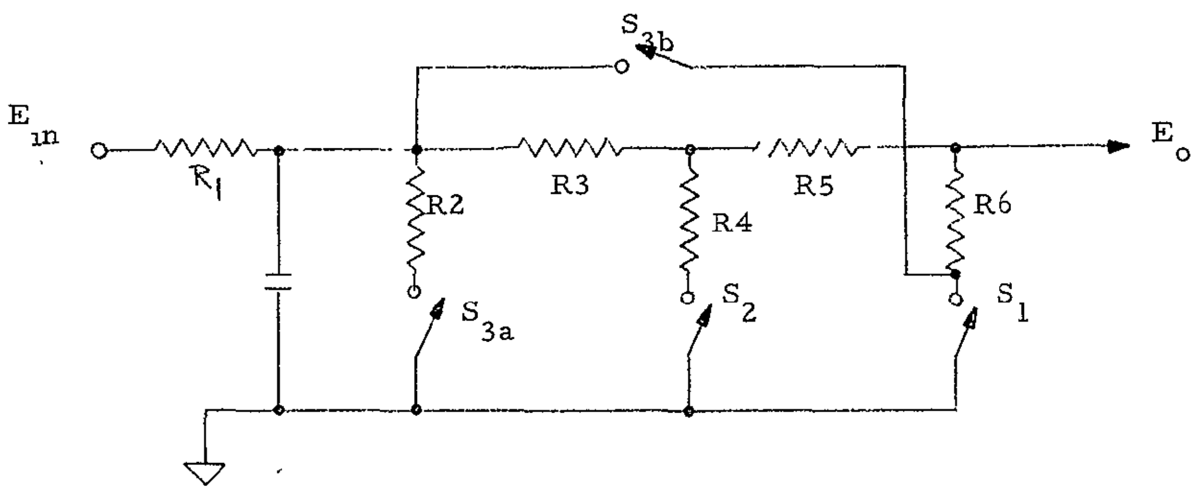
for 1% Value

R = 243K

A = 84.5K

B = 90.9K

C = 200K + Select (series)



EQUIVALENT CIRCUIT, ATTENUATOR

FIGURE 28

There are 3 regions of attenuation; 1/15, 1/7, and 2/3. In Region I, S_1 is closed, S_2 is open, S_3 is open. The output is determined by the ratio

$$\frac{E_{out}}{E_{in}} = \frac{R_6}{R_1 + R_3 + R_5 + R_6}$$

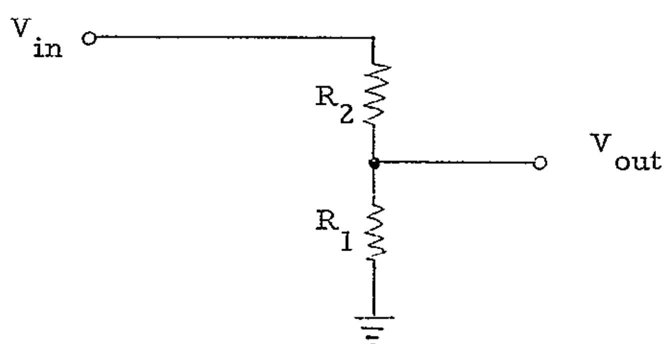
In Region II, S_1 is open, S_2 is closed, S_3 is open. The output is determined by the ratio

$$\frac{E_{out}}{E_{in}} = \frac{R_4}{R_1 + R_3 + R_4}$$

In Region III, S_1 is open, S_2 is open, S_3 is closed. The output is determined by the ratio

$$\frac{E_{out}}{F_{in}} = \frac{R_2}{R_2 + R_1}$$

The worst case analysis for a divider network can be represented in the following manner.



$$\frac{V_{out}}{V_{in}} = a = \frac{R_1}{R_1 + R_2}$$

$$\frac{\Delta a}{a} = \frac{R_1}{a} \cdot \frac{\partial a}{R_1} \cdot \frac{\Delta R_1}{R_1} + \frac{R_2}{a} \cdot \frac{\partial a}{R_2} \cdot \frac{\Delta R_2}{R_2}$$

$$\frac{\partial a}{\partial R_1} = \frac{R_2}{(R_1 + R_2)^2} = \frac{1}{R_1} \; a. \; (1-a) = \frac{a(1-a)}{R_1}$$

$$\frac{\partial a}{R_2} = \frac{-R_1}{(R_1 + R_2)^2} = \frac{-1}{R_2} \; a. \; (1-a) = \frac{-a(1-a)}{R_2}$$

$$\frac{\Delta a}{a} = \frac{R_1}{a} \; \frac{a(1-a)}{R_1} \cdot \frac{\Delta R_1}{R_1} - \frac{R_2}{a} \cdot \frac{a(1-a)}{R_2} \cdot \frac{\Delta R_2}{R_2}$$

$$\frac{\Delta a}{a} = (1-a) \left[\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} \right]$$

Worst case will occur when

$$\frac{\Delta R_1}{R_1} = \frac{\Delta R}{R}$$

$$\frac{\Delta R_2}{R_2} = -\frac{\Delta R}{R}$$

$$\frac{\Delta a}{a} = (1-a) \left[\frac{\Delta R}{R} + \frac{\Delta R}{R} \right]$$

$$\frac{\Delta a}{a} = 2(1-a) \left(\frac{\Delta R}{R} \right)$$

Maximum error for Region I

$$\frac{E_o}{E_{in}} = a = \frac{1}{15}$$

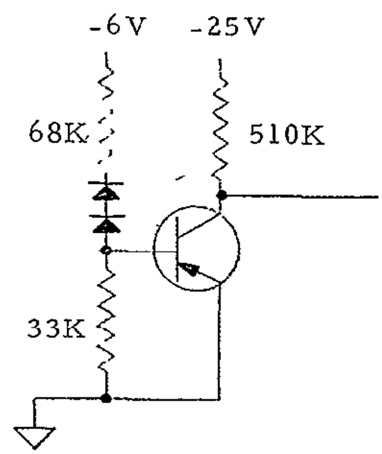
$$\% \text{ error} = 2\,(1-a) \left(\frac{\Delta R}{R} \right)$$

Assume $\qquad\qquad \frac{\Delta R}{R} = 0.65\%$

Error = 2 (1-1/15) (.65%) = 1.2%

By the same analysis, maximum error in Region II = 1.1% and maximum error in Region III = 0.43%.

Worst case design considerations include turn "On" and "Off" of transistors. Major considerations are I_{CBO}, collector leakage current at high temperature and h_{fe}, forward DC current gain at low temperatures. In the Attenuator circuit (Figure 4.1.5-1) all three transistors (Q_1, Q_2 and Q_3) act as switches. Worst case analysis of one should apply to the remaining.



From the electrical characteristics charts, the following parameters are known.

$\overline{I_{CBO}} = 0.01 \times 10^{-6}$ amp at 25°C and $V_{CB} = 50V$

$\overline{I_{CBO}} = 10 \times 10^{-6}$ amp at 150°C and $V_{CB} = 50$ V

h_{fe} = min. 100. Maximum 300 at I_c = 150 m ADC

V_{CE} = 10 VDC and 25°C

From the I_{CBO} vs T graph I_{CBO} maximum at 100°C is seen to be 680 μa. For worst case 680 x 2 = 1360 μa will flow through R_2, developing an IR drop of $33 \times 10^3 \times 1.360 \times 10^{-6}$ = .045 volts or 45 mv which is not high enough to overcome V_{BE} and turn "On" transistor Q_1.

From the current gain versus collector current graph β min. is obtained to be 44. Worst case application would be

$$\frac{44}{2} = 22.$$

Collector current for transistor Q_1 while in saturation is

$$\frac{-25 + 0.2}{510K} = 50 \ \mu a$$

Therefore required base current to turn "On" transistor Q_1 would be

$$\frac{50 \mu a}{22} \cong 2 \ \mu a$$

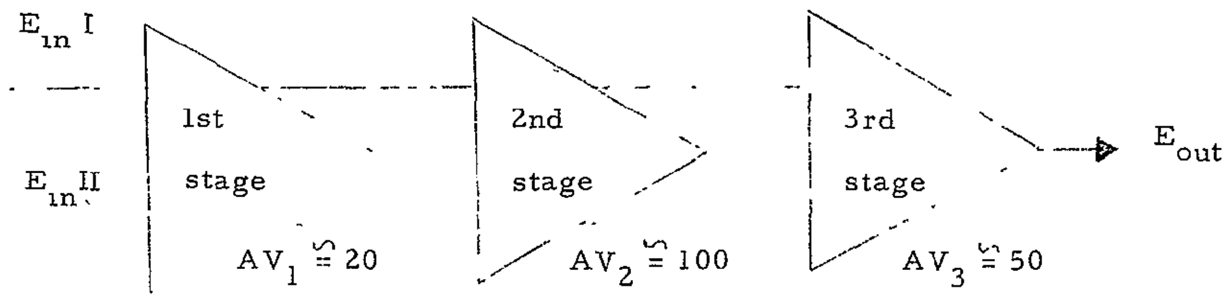
The base current is computed to be

$$I_B = \frac{6.0V-(.8 + .8 + .8)}{68K} = \frac{3.6}{68K} = 53 \ \mu a$$

and proves to be adequately sufficient to turn transistor Q_1 "On".

Worst case considerations apply also to the N Channel FET transistors Q_5 and Q_6 which act as switches. For turn "On" the potential applied to the gate should be as close to zero as possible. In this case, since the gates are tied to the collector of Q_1, the potential applied to the gates will be (a) the supply potential -25V for turn "Off" and (b) the saturation potential V_{CE} sat. of Q_1 for turn "On" of Q_5 and Q_6. Worst case V_{CE} sat. of Q_1 and worst case V_p (pinch off voltage) for Q_5 and Q_6 are considered simultaneously. From the electrical characteristics charts at -55°C V_{CE} sat. of transistor Q_1 is determined to be 0.1V and from the electrical characteristics charts of Q_5 and Q_5 worst case V_p is determined to be about 0.5 volts. Since the potential applied to gates of Q_5 and Q_6 is less than worst case pinch off voltage, this assures turn "On" of Q_5 and Q_6.

<u>Comparators</u>



$$\text{Total Gain} = AV_1 \cdot AV_2 \cdot AV_3$$

$$= 20 \times 100 \times 50.0$$

$$= 1 \times 10^5$$

E_o for logic change = 1 volt maximum

E_{in} for logic change $= \frac{1}{1 \times 10^5} =$ 10 microvolt

If $AV = \infty$, then $\Delta E_{in} = -10$ microvolt

If AV changes by 50%, ΔE_{in} would have to be 20 microvolts to produce a 1 volt output.

The worst case error for open loop gain refered to the input is:

$$\Delta E_{in} = \pm 15 \text{ microvolts}$$

There are four major sources of temperature dependent errors: the input differential stage mismatch input error, drain current mismatch due to changes in the drain resistors, the input error of the second stage and common mode error of the input gate to source voltage.

(a) Input differential mismatch error. For the particular FET transistor used, 2N3954,

$$\Delta V_{in} \text{ Diff.} < 10 \text{ microvolts}/C^{o}$$

(b) Drain current - Drain resistor

$$\frac{\Delta R}{R_D} < 50 \text{ ppm}/C^{o}$$

$$\frac{\Delta R}{R_D} = \frac{\Delta I}{I}$$

$$\Delta V_{in} = \frac{\Delta I_D}{gm}$$

$$\Delta V_{in} = \frac{\frac{\Delta R}{R}}{gm} I$$

But. $$\frac{\Delta R}{R} = 5 \times 10^{-5}/^{o}C$$

I_D in this design $= 2 \times 10^{-4}$, gm for a 2N3954 $= 7 \times 10^{-4}$ mhos

therefore. $$\Delta V_{in} = \frac{\pm 5 \times 10^{-5}/^{o}C \times 2 \times 10^{-4}}{7 \times 10^{-4}}$$

or. $$\Delta V_{in}/R_D = \pm 14 \times 10^{-6} \text{ volts}/^{o}C$$

(c) Second stage mismatch

$$\Delta V_{BE} = 3\mu v/{}^{\circ}C$$

$$\Delta V_{in}\Big|_{2nd\ stage} = \frac{\Delta V_{BE}}{AV_1}$$

or $$\Delta V_{in}\Big|_{2nd\ stage} = \frac{3\mu v/{}^{\circ}C}{20} = 0.015 \text{ microvolt}/{}^{\circ}C$$

(d) Common mode due to input gate to source voltage

$$V_{GS} < 1mv/{}^{\circ}C$$

$$\frac{\Delta V_{in}}{V_{GS}} = \frac{AV_{on}}{AV_{off}}$$

$$\Delta V_{in} = \frac{4}{1 \times 10^5} \times 1mv/{}^{\circ}C$$

$$= 0.04 \text{ microvolt}/{}^{\circ}C$$

Total error due to temperature

$$V_{in}\Big|_{T}^{T_C} = \sum V_{in}\Big|_{T}$$

$$= (10 + 14 + 0.015 + 0.04) \text{ microvolt}/{}^{\circ}C$$

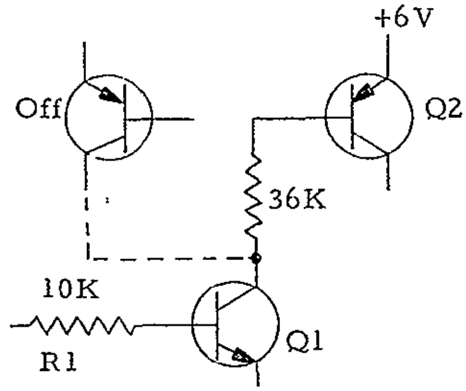
$$= 24 \text{ microvolt}/{}^{\circ}C$$

$$\Delta T = \pm 30^{\circ}$$

$$\Delta V_{in}\Big|_{T} = .7 \text{ millivolts}$$

Reference Drivers

For analysis purposes, the reference driver circuit can be represented by the following circuit that permits "On", "Off" analysis of Q1.



Q_1 "Off"

If V_{in} maximum is less than V_{BEQ_1} required for I_c Q_1 of $\approx$100 microamps, Q_1 will stay "Off". The worst case occurs at the highest temperature of interest (55°C).

$$\text{at } 55^\circ\text{C} \quad V_{BE}\Big|_{I_c = 100\mu a} > 0.45 \text{ volts}$$

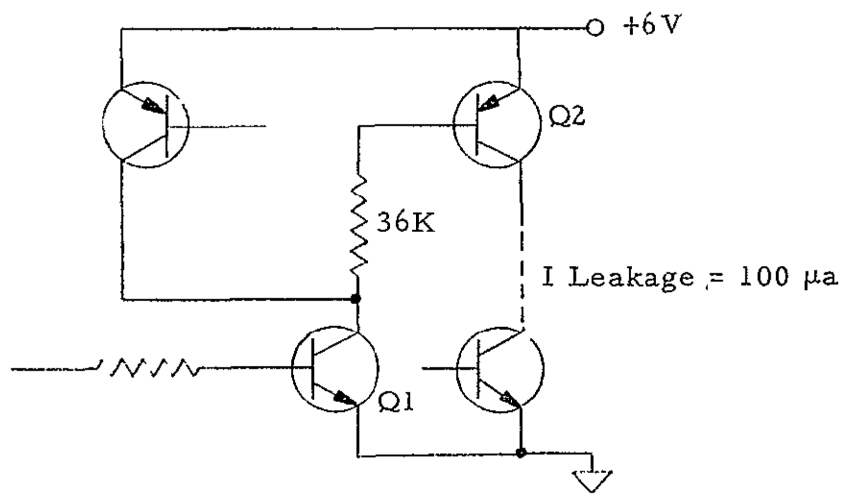
As indicated in the transistor characteristic charts:

$$V_{in\,max.} \text{ (Worst case)} = .3V$$

The worst case margin then becomes.

$$0.45 - 0.30 = 0.15 \text{ volts}$$

To investigate "On", "Off" conditions for Q_2 we refer to the circuit below



Q_2 "On"

Assuming V_{besat} = .9V (at lowest temperature)

$Q_{1\,sat}$ max. was shown to be 0.040V

$$I_{bQ_2\,min.} = \frac{6 -.09 - 0.040}{36K \times 1.15 \text{ derated}} = 120 \text{ micro amps}$$

$$I_{cQ_2\,max.} = 300\mu a + 100\mu a = 400\mu a$$

Q_1 "On" V_{in} is the output of the PWM programmer and as such appears at the emitter follower of a SN5112 bistable multivibrator.

$$V_{in}^{+} \text{ Min.} = 1.5V \text{ at } 125^{\circ}C$$

$$V_{in}^{+} \text{ Min.} = 1.6V \text{ at } -55^{\circ}C$$

I_{bQ_1} Min. assuming $V_{beQ1} = 0.8$ volts (worst case at low temperature)

$$I_{b\,min.} = \frac{1.6 - 0.8}{10K \,.\, 1.15 \text{Derated}} = 70 \text{ micro amps}$$

I_{cQ_1} Max. assuming $V_{CE\ Sat} = 0$

$$V_{beQ_2} = 0$$

$$I_{c\ max.} = \frac{6V}{36K \times 0.85 \text{ Derated}} + 150 = 350 \text{ micro amps}$$

$$\beta_f \text{ min. } Q_1 = \frac{I_{c\,max.}}{I_{b\,max.}} = \frac{350}{70} = 5$$

$$\beta_{f\ min.} = 5$$

Q_1 is selected for

$$V_{CE\,Sat} < 20\text{mv at } \beta_f = 5,\ I_c = 300\ \mu a$$

Allowing $V_{CE\,Sat}$ to vary from "0" to x2

$$\Delta V_{CE\,Sat}\Big|_{aging} = \pm 20\text{mv}$$

This will appear as a percent error of

$$\% V_{Ref.} = \frac{\Delta V_{CE\,Sat}}{6V} = \pm \frac{20}{6000} \times 1000$$

$$= .3\%$$

$$\beta_f = \frac{I_{c\,max.}}{I_{b\,min.}} = \frac{400}{120} = 3.3$$

$$\beta_f \quad \text{worst case} = 3.3$$

Q_2 is selected for

$$V_{CE\,sat} < 20\text{mv at } \beta_f = 5 \quad I_c = 300\,\mu a$$

allowing $V_{CE\,sat}$ to vary from 0 to x 2

$$\Delta V_{CE\,sat}\Big|_{aging} = \pm 20 \text{ mv}$$

This appears as a percent error of

$$\%\ V_{Ref.} = \frac{\Delta V_{CE\,sat}}{6V} = \frac{20}{6000} \times 100$$

$$= 0.3\%$$

<u>Q_2 "Off"</u>

Q_2 is "Off" implies

$$I_c < 100 \text{ microamps}$$

$V_{BE(\text{worst case for } I_c = 100\mu a)} = .5V$

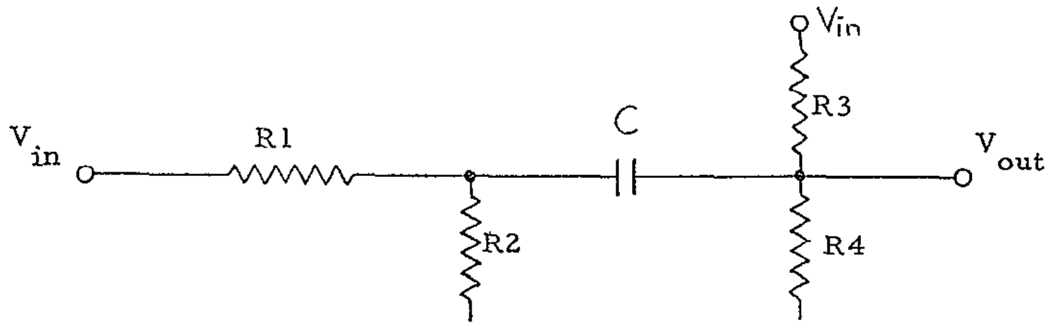
V_{BE} applied max. $= V_{CE\,sat}\ Q_3$ max.

V_{BE} applied max. $= 0.040V$

Worst case "Off" margin = 0.46V

Reference Generator

Worst case accuracy as a function of component aging and temperature is determined by



use of the model represented above.

$$V_{out} = f(V_{in_1}, V_{in_2}, R_1, R_2, R_3, R_4, C)$$

V_{out} is a function of the two input voltages, resistors and capacitors. Any changes in the voltages, resistors or capacitors which are due to aging and temperature will be statistically independent. Therefore, the root mean error of V_{out} expressed as fraction change will be

$$\frac{\overline{\Delta V_{out}}}{V_{out}} = \left\{ \left[\frac{\Delta V_{in\,I}}{V_{in}} \cdot \frac{V_{inI}}{V_{out}} \cdot \frac{\partial V_{out}}{\partial V_{in1}} \right]^2 + \left[\frac{\Delta V_{in2}}{V_{in2}} \cdot \frac{V_{in2}}{V_{out}} \cdot \frac{\partial V_{out}}{\partial V_{in2}} \right]^2 \right.$$

$$+ \left[\frac{\Delta R_1}{R_1} \cdot \frac{R_1}{V_{out}} \cdot \frac{\partial V_{out}}{\partial R_1} \right]^2 + \left[\frac{\Delta R_4}{R_4} \cdot \frac{R_4}{V_{out}} \cdot \frac{\partial V_{out}}{\partial R_4} \right]^2$$

$$+ \left[\frac{\Delta C}{C} \cdot \frac{C}{V_{out}} \cdot \frac{\partial V_{out}}{\partial C} \right]^2$$

The initial step is independent of the value of the capacity. That is,

$$\left. \frac{\partial V_{out}}{\partial C} \right|_{T=0} = 0$$

Also for $T = 0$

$$\frac{V_{inI}}{V_{out}} \cdot \frac{\partial V_{out}}{\partial V_{inI}} < 1$$

$$\frac{V_{in2}}{V_{out}} \cdot \frac{\partial V_{out}}{\partial V_{in2}} < 1$$

$$\frac{R_1}{V_{out}} \cdot \frac{\partial V_{out}}{\partial R_1} < 1$$

$$\frac{R_4}{V_{out}} \cdot \frac{\partial V_{out}}{\partial R_4} < 1$$

The initial error can then be represented by

$$\frac{\overline{\Delta V_{out}}}{V_{out}} < \sqrt{\left(\frac{\Delta V_{inI}}{V_{inI}}\right)^2 + \left(\frac{\Delta V_{in2}}{V_{in2}}\right)^2 + \left(\frac{\Delta R_1}{R_1}\right)^2 + \ldots + \left(\frac{\Delta R_4}{R_4}\right)^2}$$

All resistors RNXXC have "C" characteristics and as such have temperature characteristics less than 50 parts per million per degree centigrade (p. p. m/$^\circ$C). The total temperature change is $\pm$ 30°. Therefore the change in resistance due to temperature is

$$\frac{\Delta R}{R} = 50 \times 10^{-6} \times 30 = 1.5 \times 10^{-3}$$

or

$$\frac{\Delta R}{R} \% = 0.15$$

Total effect of time on the resistors is assumed to cause a worst case change of 0.5%. The total error in any resistor (assuming worst case and add both effects) in

$$0.15 + 0.5 = 0.65\%$$

The worst case analysis of the reference drivers indicated a worst case error of 0.3%. The drivers provide V_{inI} and V_{in2}.

The total worst case initial error is

$$\left.\frac{\Delta V_{out}}{V_{out}}\right|_{To} (\%) < \sqrt{(.3)^2 + (.3)^2 + 4\,(.65)^2}$$

$$\frac{\Delta V_{out}}{V_{out}} < 1.4\%$$

This percent error is equivalent to a digital output of

$$10\% = 1 \text{ Bit}$$

$$\left.\text{Error}\right|_{To} < .14 \text{ Bits}$$

Error as a function of time.

The time dependent error is a function of the constant error (γ) which is in the expression $R_T C$ where R_T is the equivalent resistance.

The total error in R_T can be found in a similar manner to the initial error. However, the percent error in total resistance is always less than the maximum error of any resistor.

$$\frac{\Delta R_T}{R_T} \ (\%) < .65\%$$

All Effects

The error in capacitance is composed of temperature and aging effects. The T.C of the capacitor is 150 ppm/^{o}C. This yields a total error due to the temperature range of 0.45%. The long term aging effect should produce a worst case error of about 0.5%. The total capacitor error (assuming worst case and adding the errors) is 0.95%.

$$\frac{\Delta C}{C} \ (\%) < .95\%$$

All Effects

Since there is only one capacitor and one main resistor that determine time constant, the total worst case error will be

$$\frac{\Delta \gamma}{\gamma} \ (\%) < \frac{\Delta R}{R} + \frac{\Delta C}{C}$$

$$< 0.95\% + 0.5\%$$

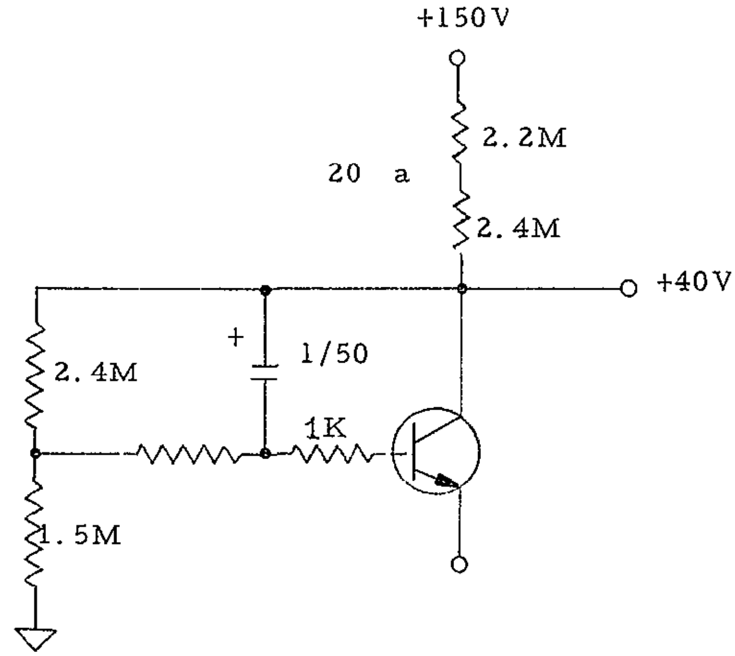
$$< 1.45\%$$

The error in time constant (γ) is equivalent to an error in time. The number of bits is directly related to time. The system error in bits is therefore in bits per bit. The largest time interval for a reference voltage step is 44 bits. The time dependent worst case error is

$$\text{Error}\Big|_{\substack{\text{Max.} \\ T = 44 \text{ bits}}} < .62 \text{ Bits}$$

<u>Suppression Circuit</u>

+40 Volts supply:



All resistors are BB's, therefore

$$40V = 15\ (1 + \frac{2.5\ (1 \pm .15)}{1.5\ (1 \pm .15)}$$

$$40V = 15 + (25\ {}^{+8.4}_{-6.2})$$

$$40 = 15 + 25 + 8.4 = 48.4V \quad \text{or}$$

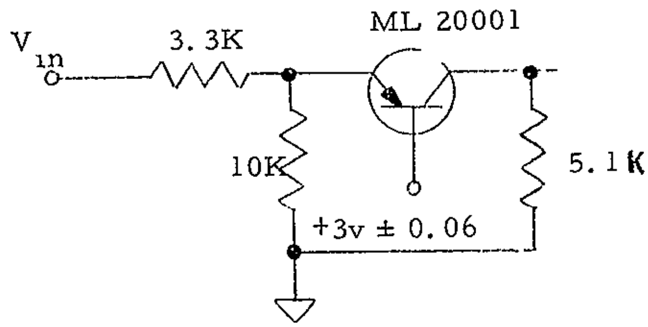
$$40 - 15 + 25 - 6.2 = 33.8V$$

II Buffer Logic

Timing and Control

Interface

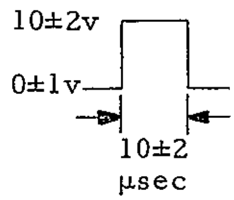
Calibration command at SMCC



β min $\approx$ 50

V_{eb} = -5v

Pc = 0.7w @25°C



Specified Zin > 1K

Actual Zin > 3K

Worst Case Turn on:

$V_b = +3.06v$

$V_{in} = +8v$

$I_{in} = \dfrac{8 - 3.12}{3.3x10^3 x1.05} = \dfrac{4.88}{3.46}$ ma $\approx$ 1.4 ma

$I_e = 1.4 - \dfrac{3.12}{10x10^3 x.95} = 1.4 - .3 = 1.1$ ma.

$I_c = \approx 1.1$ ma.

If E_o min = +2v,

$$I_o \text{ avail.} = 1.1 - \frac{2}{5.1K} = 0.7 \text{ ma.}$$

Worst Case Turn Off:

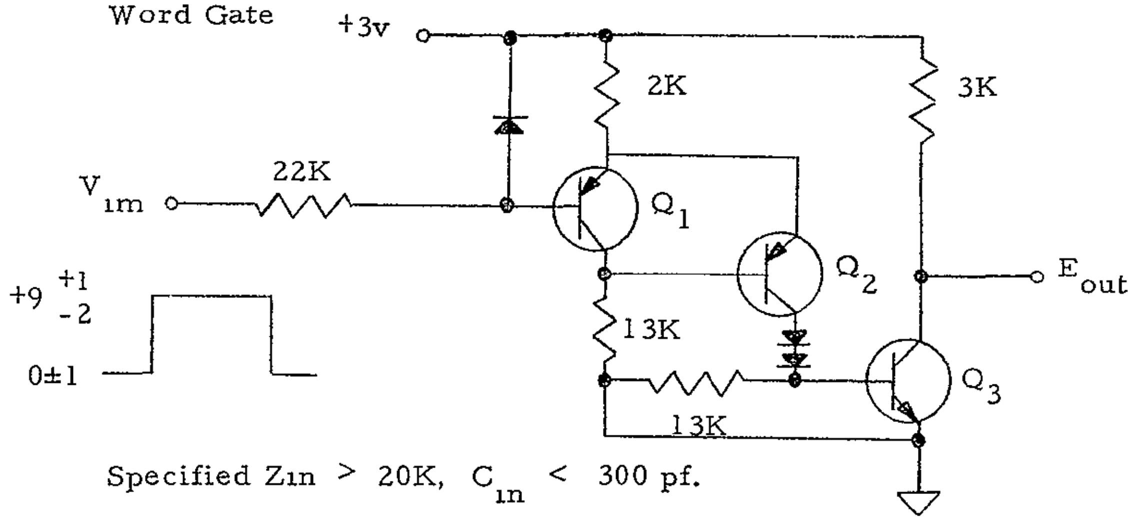
$$E_{in} = +1v$$

$$V_b = +2.96v$$

$$V_e = \frac{10}{13.3} \times 1 \approx +0.7v$$

$$V_{eb} = 0.7 - 2.96 = -2.2v$$

Word Gate



Specified Zin > 20K, C_{in} < 300 pf.

Actual Zin > 22K, C_{in} - negligible.

With V_{in} = 0, allow Q1 to saturate at 0.2v

$$\therefore I_e = I_c = \frac{3 - 0.2}{15K} \approx 190 \ \mu a$$

Q2 and Q3 are cutoff

$E_o \approx +3v$

With V_{in} = +9v

Q1 is cutoff with V_b = +3.6v

Q2 will saturate at 0.2v

$\therefore \quad I_{e2} = I_{c2} = 190\ \mu a$

V_e of Q1 = $3 - (2\times10^3 \times .19\times10^{-3}) = 3 - 0.38 = 2.6v$

$\therefore \quad V_{eb} = 2.6 - 3.6 = -1v$

$I_{b3} = .19 - \frac{.6}{13} \approx 0.14$ ma

If βmin of Q3 = 20:

$I_{c3} = 20 \times .14 = 2.8$ ma.

Allowing E_o (Lo) to be +0.3 max.

I_L avail. = $2.8 - \frac{2.7}{3K} = 1.9$ ma.

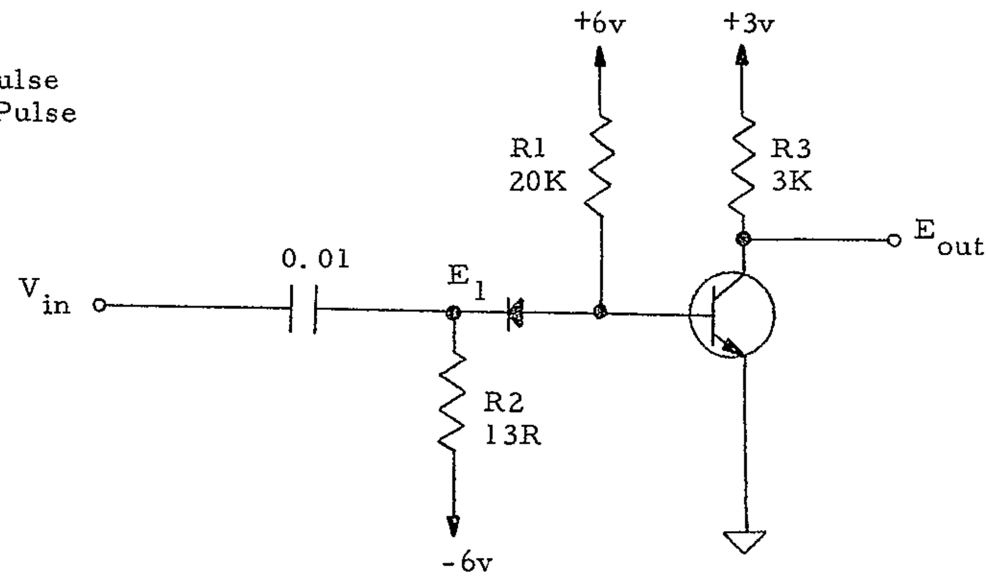
Assume $C_r \approx 50$ pf

$$t_f = \frac{\Delta V \times C}{I} = \frac{2.7\times50\times10^{-12}}{1.9\times10^{-3}} \approx 70 \text{ nsec.}$$

$$t_r = (10\text{-}90) = 2.2 \times 3 \times 10^3 \times 50 \times 10^{-12} = 330 \text{ nsec.}$$

Because of the large input voltage swing, the trigger level stability is insignificant.

Sun Pulse
Shift Pulse
16 KC



Worst Case Off Bias:

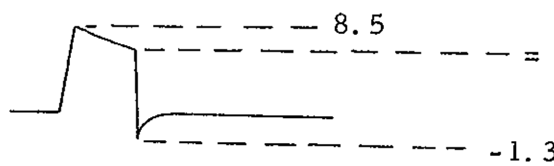
$$R1 = 19.5K$$
$$R2 = 13.6K$$
$$V_b = -6v + \left(\frac{12-0.6}{33.1K}\right) 13.6K + 0.6$$
$$= -6 + 4.6 + 0.6 = -0.8v$$

Worst Case Turn On:

$$V_{in} = +8.5v, \quad t_{(on)} = 18\ \mu sec$$

$$RC\ min = 100\ \mu sec$$

E_1



$$= 8.5\left(\epsilon^{\frac{-18}{108}}\right) = 7.2\ v$$

$$I_b = \frac{6 - 0.7}{20K} = .26\ ma$$

If β_{min} = 20

I_{cmin} = $20 \times .26 = 5.2$ ma.

If $E_o(Lo)max$ = $+0.3v$

$$I_{R3} = \frac{3.0 - 0.3}{3K} = .9 \text{ ma.}$$

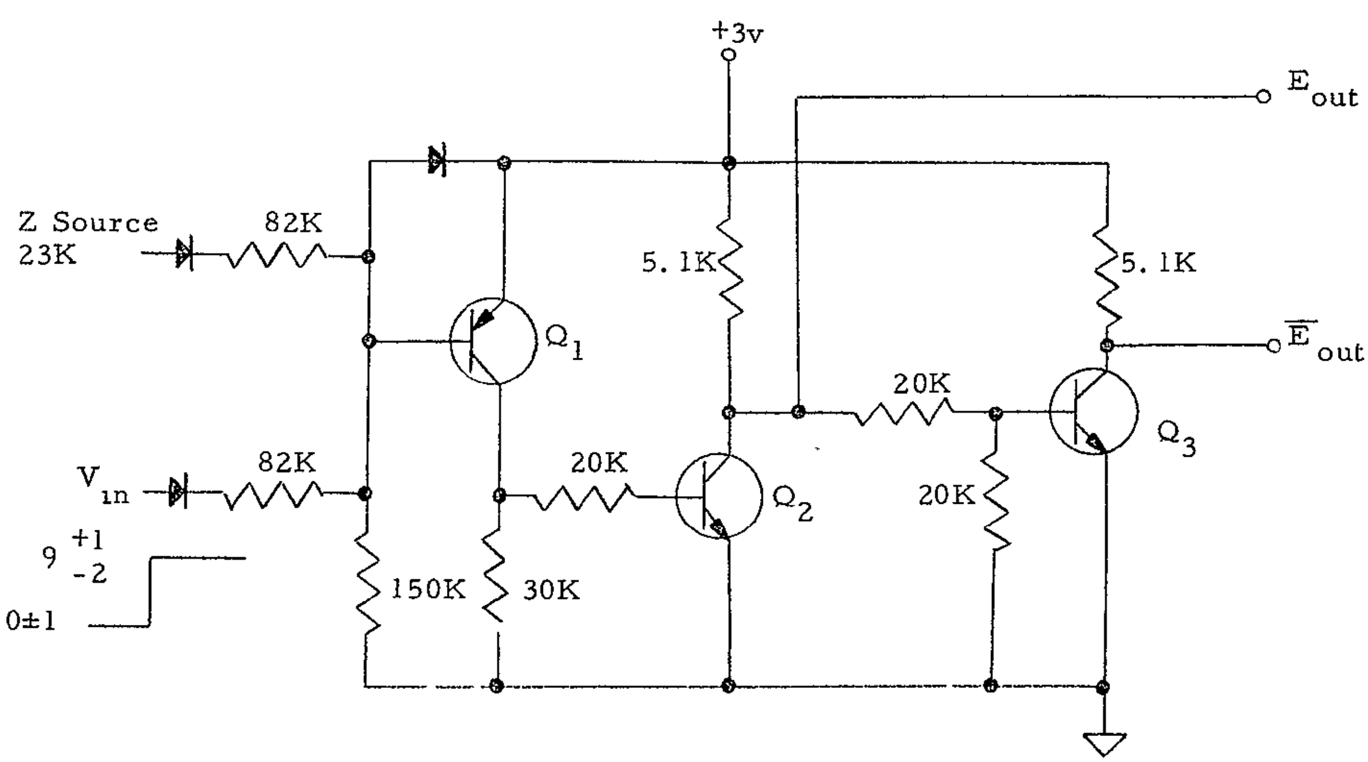
$I_{L\ avail.}$ = $5.2 - .9 = 4.3$ ma.

Assume C_L = 50 pf.

$$tf = \frac{2.7 \times 50 \times 10^{-12}}{4.3 \times 10^{-3}} \approx 30 \text{ nsec.}$$

$$t_r\ (10\text{-}90) = 2.2 \times 3 \times 10^{3} \times 50 \times 10^{-12} = 330 \text{ nsec.}$$

D-C Interface



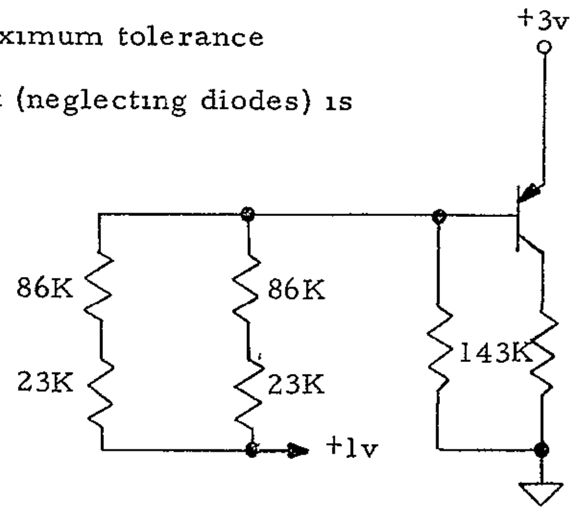
With both V_{in} down

Worst Case Q1 turn on

$V1 \quad = \quad +1.0v$ (No Load)

Input R, s at maximum tolerance

Equivalent input (neglecting diodes) is



$V_b \quad = \quad 2.3v$

$I_{in} \quad = \quad \frac{2.3}{54K} = 43\ \mu a$

$I_b \quad = \quad 43\ \mu a - \frac{2.3}{143K} = 27\ \mu a$

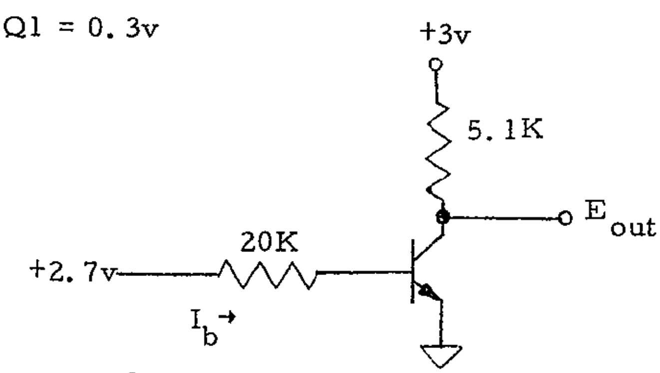
If β min $= 100$

$I_c \quad = \quad 100 \times 27\ \mu a = 2.7$ ma.

(Sufficient to saturate Q1)

If V_{ce} sat. of Q1 = 0.3v

Q2 input is



$I_b = \frac{2}{20K} = 0.1$ ma

β min of Q2 = 20

$I_{c2\ min}$ = 2 ma

(Sufficient to saturate Q2)

$\therefore$ E_o(lo)max. = +0.3v

Q3 will be biased off

$\therefore$ $\overline{E_o}$ (hi) min = +2v

$I_{L\ avail.} = \frac{3-2}{5.1K} \approx 0.2$ ma

With either V_{in} up, Q1 will be biased off.

Q2 will be biased off

For E_o (hi) min = +2v

$I_{in3} = \frac{2 - 0.7}{20K} = 65\ \mu a$

$I_{L\ avail} = 200 - 65 = 135\ \mu a.$

$I_{b3} = 65 - \frac{.7}{20K} = 30\ \mu a.$

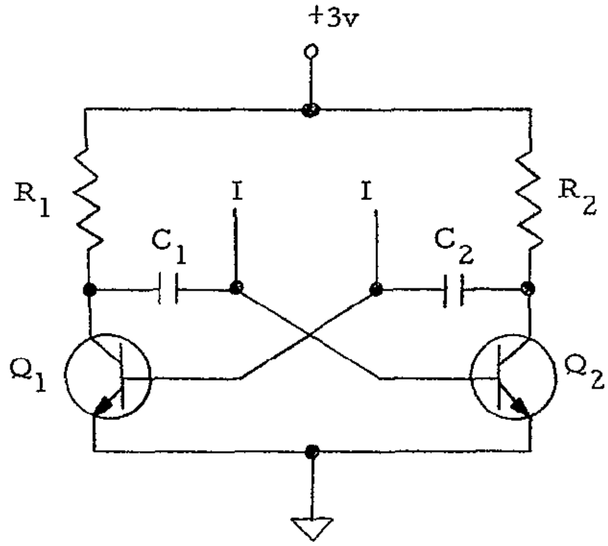
If $\beta 3$ min = 20

$I_{c3} = 20 \times 30\ \mu a = 0.6$ ma.

For $\overline{E_o}$(lo) max. = 0.3v

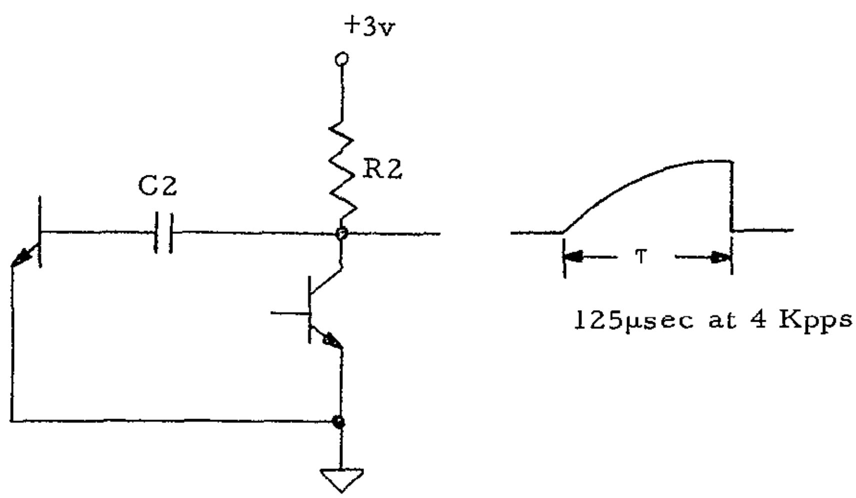
$I_{L\ avail} = 0.6 - \frac{3.0 - 0.3}{5.1K} = 70\ \mu a$

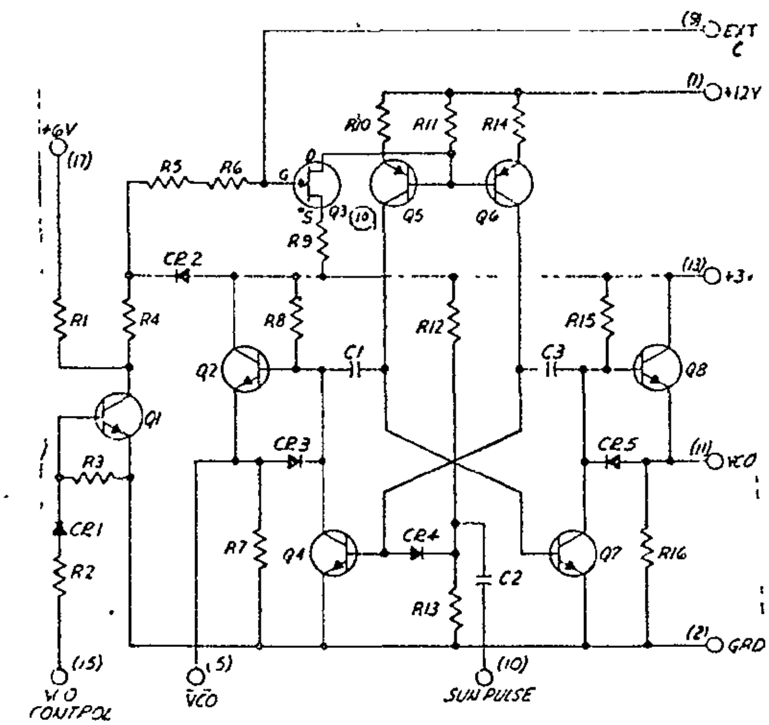
VCO



The oscillator is an astable multivibrator with a symmetrical output. The "off" period of each transistor is set by controlled charge currents to the cross-coupling capacitors.

The mean frequency is 2048 pps corresponding to a 60 ppm Sun Pulse. The minimum and maximum frequencies are 1024 and 4096 pps.





ELECTRONIC SCHEMATIC
VCO

At the maximum frequency, the capacitor recovery time must be 125 µsec.

$$\tau = 125 \times 10^{-6}$$

Make $R2C2 = \frac{\tau}{5} = 25\ \mu sec$

Make $C2 = 1000\ pf$

$$\therefore R2 = \frac{25 \times 10^{-6}}{10^{-9}} = 25K$$

use 24K

The collector is connected to an emitter follower so that the loading is insignificant. The emitter follower is loaded with one IC gate.

To saturate Q2,

$$I_c = \frac{2.7}{24K} = 0.11\ ma.$$

For a frequency of 1K pps, $\tau = 500\ \mu sec$. C2 must be discharged at a rate that will hold off Q1 for 500 µsec.

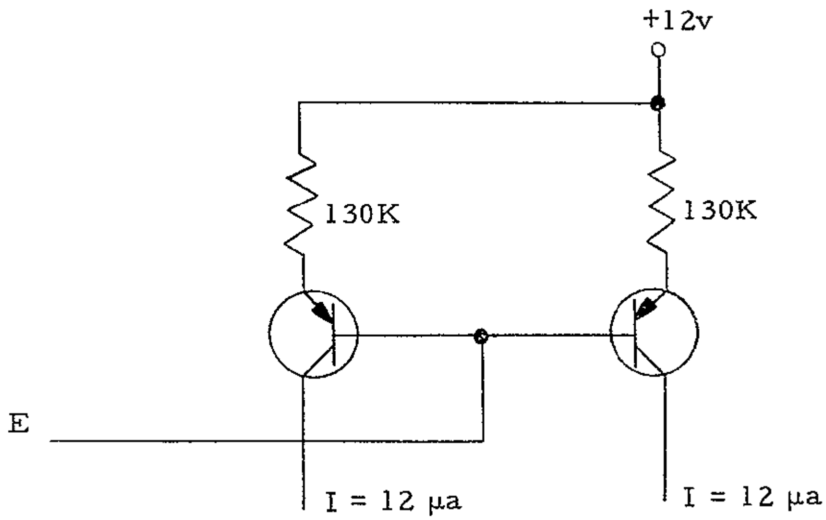
$$\therefore i = \frac{\Delta VXC}{\tau} = \frac{3 \times 10^{-9}}{500 \times 10^{-6}} = 6\ \mu a$$

$\beta\ min = 40$

$I_{cmin} = 40 \times 6\ \mu a = 0.24\ ma.$

The frequency control current must vary thus:

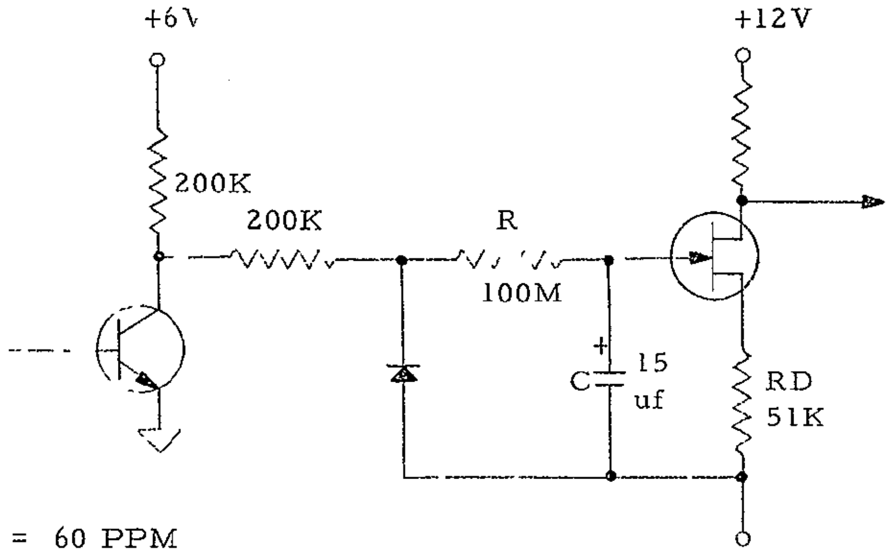
1Kpps = 6 μa
2Kpps = 12 μa
4Kpps = 24 μa



Assume I is negligible

$$\frac{12 - (E+0.7)}{130K} = 12\ \mu a$$

E = + 9.74v @ 12μa
E = +10.52v @ 6μa
E = +8.18v @ 24μa



At Sun Pulse $=$ 60 PPM

$E = 9.74v$

$E_{(51K)} = 12 - 9.74 = 2.26v$

$I_D = \frac{2.26}{51K} = 44\ \mu a.$

The FET is selected for $V_p = 1.0$ to $1.2v$.

It has been determined experimentally that for $V_p = 1.0v$.

$V_{GS} \approx .9v$ for $I_D = 45\ \mu a.$

E across R_D must equal 2.26v and also is $= V_C + V_{GS}$.

$\therefore\ V_C = E_{RD} - V_{GS} = 2.26 - .9 = 1.36v$

The VCO control voltage will turn "off" the bi-polar transistor if the oscillator frequency is low, and "on" if the frequency is high. If the transistor is off, V_C increases, increasing I_D. If it is on, V_C decreases, decreasing I_D.

The filter time constant is,

$$RC = 102 \times 10^6 \times 15 \times 10^{-6} \approx 1500 \text{ seconds.}$$

The leakage current of the capacitor is specified to be 4 nanoamps maximum at 140°F with $V_C = 2$ v.

This makes $R_{Leak} = \dfrac{2}{4 \times 10^{-9}} = 500$ Meg

When the bi-polar transistor is on, the 100 Meg resistor is essentially in parallel with the leakage resistor. This gives a discharge time constant of approximately 1200 seconds.

The gain of the system can be calculated:

$$\frac{\Delta F}{\Delta V_C} = \frac{2 \text{ KC} - 1 \text{ KC}}{10.52 - 9.74} = \frac{1 \text{ KC}}{>80 \text{ mv.}} = \frac{1.28 \text{ cycles}}{\text{mv.}}$$

where $\Delta V_C = \Delta E$.

Assume the frequency is 2 KC at the time of a Sun Pulse and the bi-polar transistor turns on.

$$\Delta V_C = V_C - V_C \left(\epsilon^{-\frac{1}{1200}} \right)$$

$$\Delta V_C = 1.13 \text{ mv}$$

$$\therefore \Delta F = \Delta V_C \times \text{Gain} \times 1 \text{ sec}$$

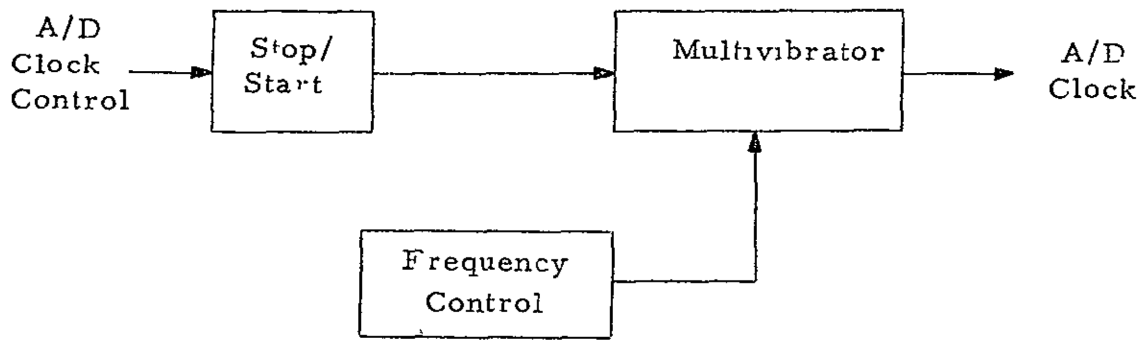
$$= \frac{1.13 \text{ mv}}{\text{sec}} \times \frac{1.28 \text{ cycles}}{\text{mv}} \times 1 \text{ sec.}$$

$$\Delta F = 1.4 \text{ cycles in one second.}$$

At this time, the control flip flop will turn off the bi-polar transistor causing the oscillator frequency to increase at approximately the same rate

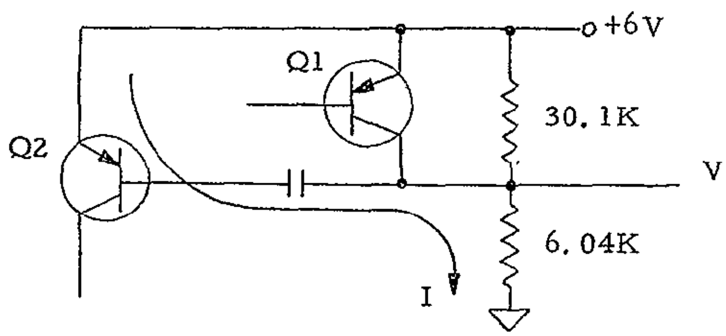
The frequency error of 1.4 cycles/second represents the time of about 10% of 1 sector.

A/D Clock



The A/D clock oscillator is an astable multivibrator whose output is a 4 μsec pulse at a rate of 81.92 K pps. The repetition rate is controlled to within 0.4%.

The stop/start circuit provides a delay of 8 μsec between the "start" command and the first clock pulse.



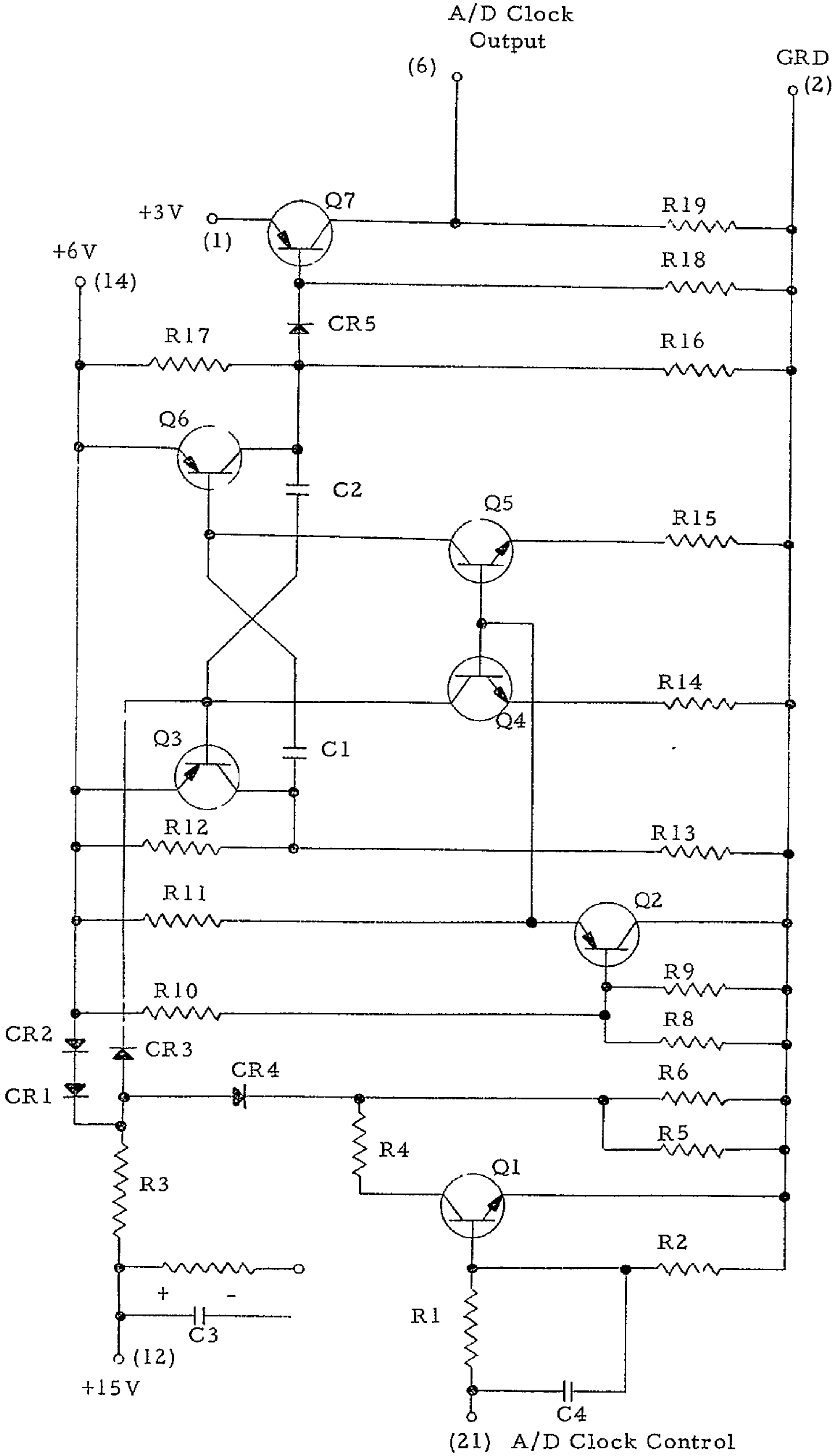
The sketch shows the deviation of the output voltage V of the multivibrator. With the transistor Q_1 saturated,

$$V \approx 5.5v$$

With the transistor Q_1 biased off,

$$V \approx \frac{6x6}{36} = 1v$$

$$\therefore \Delta V \approx 4.5v$$



Electronic Schematic
A/D Clock

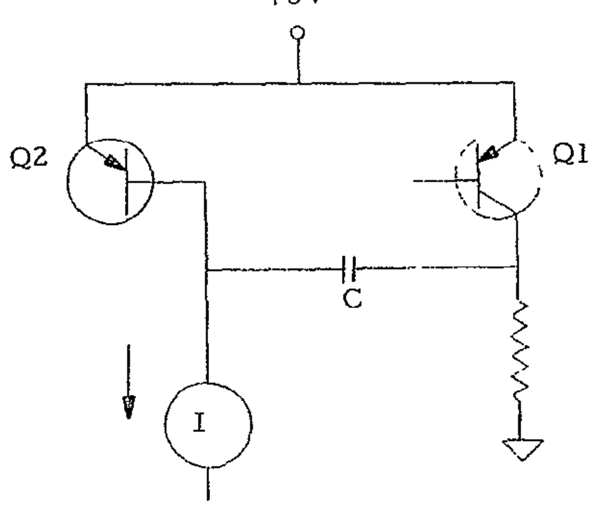
When the transistor Q_1 turns off, the fall time of V is:

$$t_f\,(10\text{-}90) = 2.2\ RC$$

$$= 2.2 \times 5 \times 10^{3} \times 160 \times 10^{-12}$$

$$= 1.7\ \mu sec$$

$$\text{where } R = 30K \parallel 6K$$



When Q1 conducts, the base of Q2 is driven 4.5v positive. The discharge of C is controlled by current source I. To hold Q2 off for 8 μsec.

$$I = \frac{\Delta VC}{t} = \frac{4.5 \times 160 \times 10^{-12}}{8 \times 10^{-6}}$$

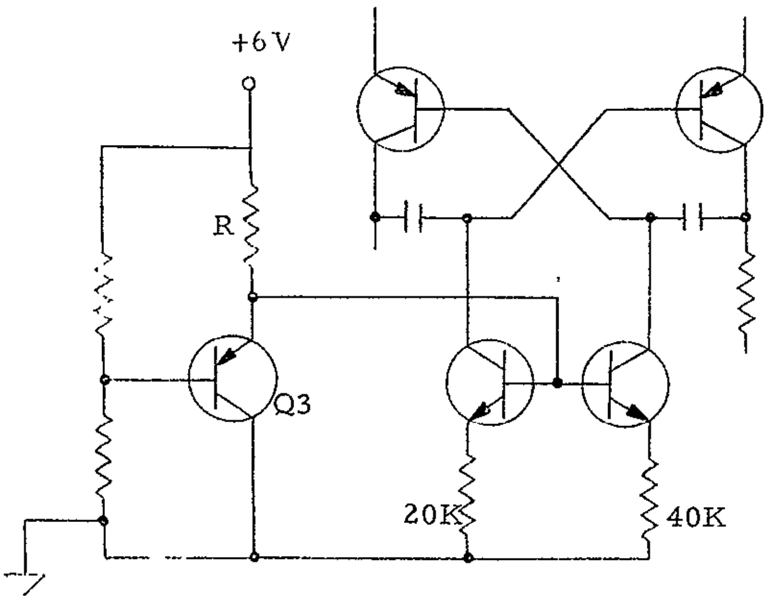
$$= 90\ \mu a.$$

On the next alternation, Q1 is held off for 4 μsec. The current source for this side delivers 180 μa.

A collector current of 1 ma is required to saturate Q1 or Q2. With the current source supply I_b on, the required β is:

$$\beta = \frac{I_c}{I_b} = \frac{1.0}{.09} \approx 11$$

At low temperature and allowing for aging, the min. β of the 2N869A is 20.



The resistances of the voltage divider are selected so that V_b will produce the proper oscillator frequency.

The temperature dependent ΔV_{be} of the current source is cancelled by the ΔV_{be} of Q3. The resistor R is selected to adjust the emitter current of Q3 so that the ΔV_{be} of the two transistor types is matched and frequency drift over the temperature range is ± 0.3%.

EFFECTS OF CLOCK INSTABILITY ON SYSTEM ACCURACY

At the time an A/D conversion is made for flux or Hi voltage, a burst of 128 clock pulses is generated. This is sufficient to exactly fill a 7 stage register.

The 128 pulses occupy a time slot of 1561.6 μsec. If the instrument is calibrated at this frequency, a pulse width of 1561.6 μsec indicates 0 volts or 0 flux.

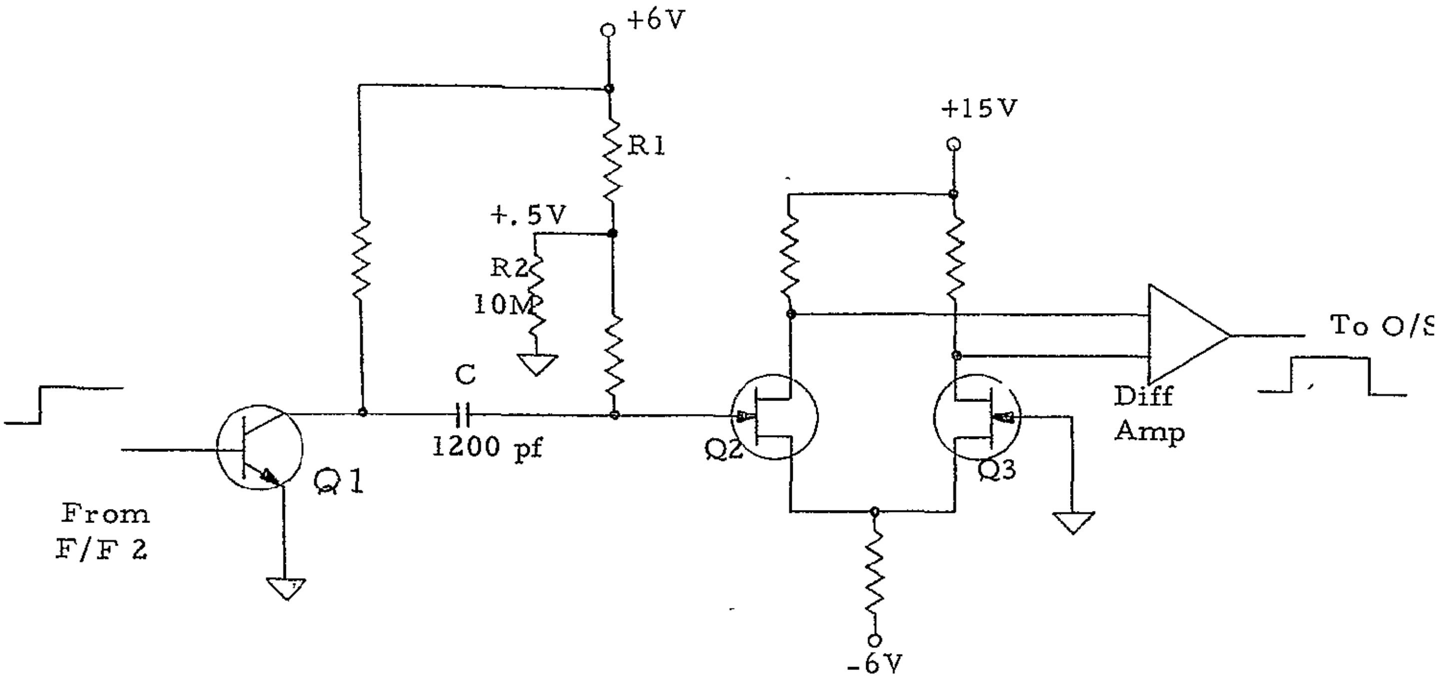
Now, if the frequency decreases by 1% to 82.11 KC, only 126.72 pulses will enter the register for a pulse width of 1561.6 μsec. This is an insignificant error of 1.28 bits. For a pulse of one-half full scale width, the error is 0.64 bits.

Because of the more complex PWM technique used for flux measurement, the A/D error is reduced by 1/3 to 0.42 bits for full scale pulse width.

The above analysis is made on the basis of 1% instability, whereas the maximum instability is 0.3%.

$$\text{Design Margin} = \frac{1.0}{0.3} = 3\ 3$$

The important function is the delay circuit whose schematic is presented below.



Normally, Q1 is cutoff and its collector voltage is about +6v. The voltage divider between +6v and ground holds the gate of Q2 at +0.5v. With the gate of Q3 held at ground, Q3 is cutoff and Q2 is conducting. When the base of Q1 goes positive its collector goes to ground and the gate of Q2 goes to about -5.5v. This cuts off Q2 and allows Q3 to conduct.

C discharges through R2 until the gate of Q2 reaches 0v, then Q2 conducts again.

Analytically, the time constant is 12 msec and with the +0.5v bias, Q2 is biased off for 30 msec. To compensate for this, along with component and voltage tolerances, R is selected so that the output pulse width is 32 ± 0.1 msec.

Using the nominal values introduced above,

$$5.5 = 6 \times \epsilon^{-\frac{t}{12 \times 10^{-3}}}$$

$$\epsilon^{-\frac{t}{12 \times 10^{-3}}} = .083$$

$$\frac{t}{12 \times 10^{-3}} = 2.5$$

$$t = 30 \text{ msec.}$$

The specified capacitor has a maximum T. C of +165 PPM/$^{\circ}$C

$$\therefore \quad \Delta C \text{ max.} = 7 \text{ pf.}$$

The specified resistor has a maximum T. C of ± 500 PPM/$^{\circ}$C.

$$\therefore \quad \Delta R \text{ max.} = 175\text{K}$$

$$R' = 10.17 \text{ M}$$

$$C' = 1207 \text{ pf}$$

$$R'C' = 12.27 \text{ msec.}$$

and,

$$t' = 2.5 \times 12.27 \times 10^{-3}$$

$$= 30.6 \text{ msec.}$$

therefore,

$$\% \text{ change} = \frac{0.6}{30} = 2\%$$

$$\text{Allowed change} = 3.2\%$$

$$\text{Design Margin} = \frac{3.2}{2} = 1.6$$

The slope of the discharge curve at 32 msec is determined,

$$e_o = -6\,\epsilon^{\frac{-32}{12 \times 10^{-3}}}$$

$$\frac{d\,e_o}{dt} = (-6)\left(-\frac{1}{12 \times 10^{-3}}\right)\epsilon^{\frac{-32}{12 \times 10^{-3}}}$$

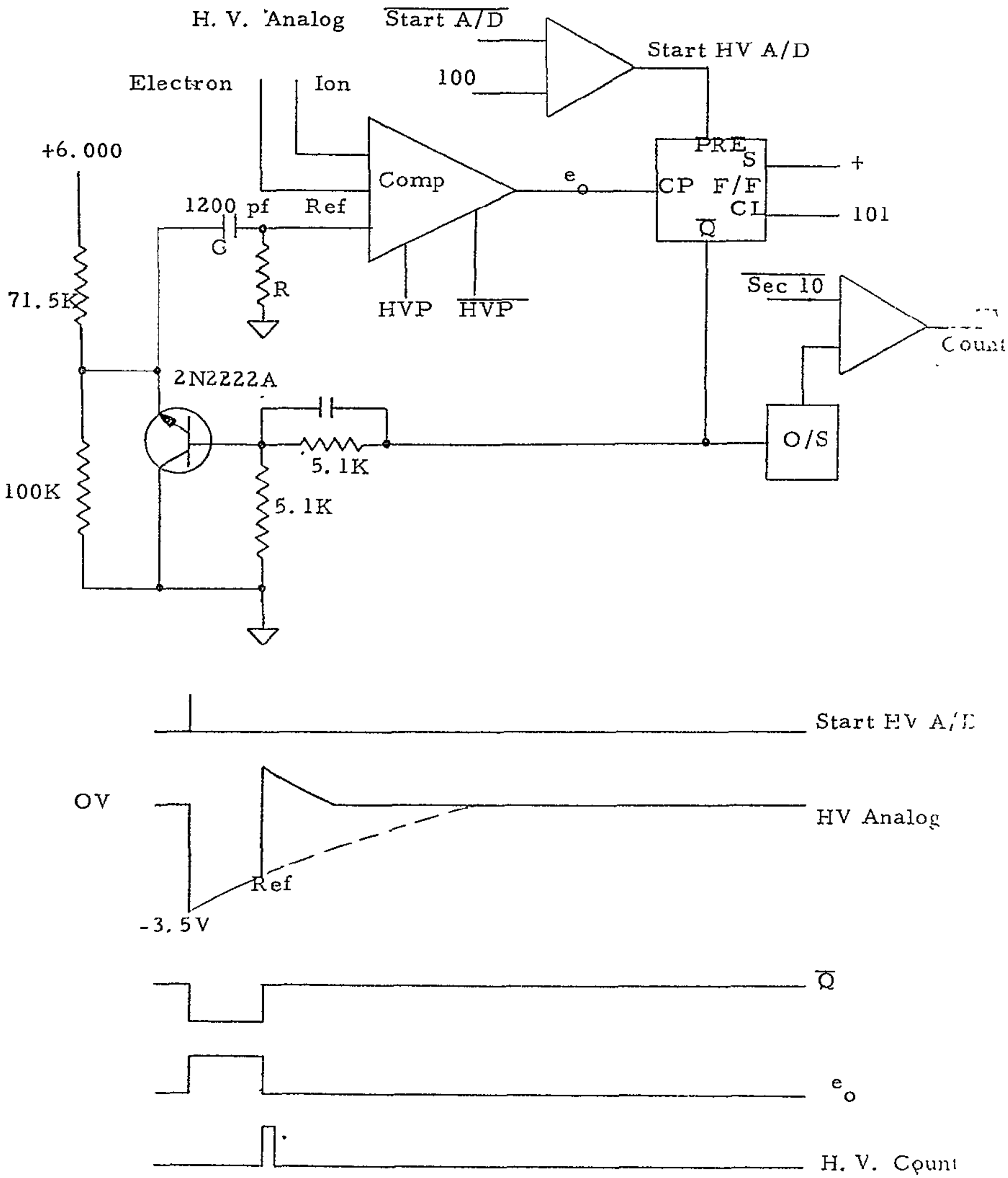
$$= .5\text{v/msec} \times .074 = 37\text{mv/msec.}$$

$V_{GS1} - V_{GS2}$ of the FET's can change by 0.5 mv when temperature is changed from 25°C to 65° C. Thus, the switching time of the FET's can by,

$$\frac{.5 \text{ mv}}{37. \text{ mv/msec}} = .013 \text{ msec}$$

which is insignificant.

High Voltage A/D



The RC time constant is selected such that with a 42 mv input to the comparator, the H. V. count pulse will allow 124 of the 128 A/D clock pulses into the digital register. This is equivalent to a time duration between start A/D and H. V. count of.

$$t = 124 \times 12.2 \text{ usec.} = 1493 \text{ usec.}$$

with

$$.042 = 3.500\, e^{-\frac{1493 \times 10^{-6}}{RC}}$$

$$RC = 340 \times 10^{-6} \text{ sec.}$$

Selecting $C = 1200$ pf

(Ceramic with TC = 25 ppm/$^{\circ}$C)

$$R = 280K$$

(RN60E, with TC = 25 ppm/$^{\circ}$C)

$$\Delta T = 35^{\circ}C$$

$$\Delta C = 10 \text{ pf}$$

$$\Delta R = 245 \text{ ohms}$$

$$\text{with } RC = \frac{t}{L_n \frac{3500}{42}}$$

$$RC + \Delta RC = \frac{t + \Delta t}{L_n \frac{3500}{42}}$$

$$L_n = \frac{3500}{42} = 4.4$$

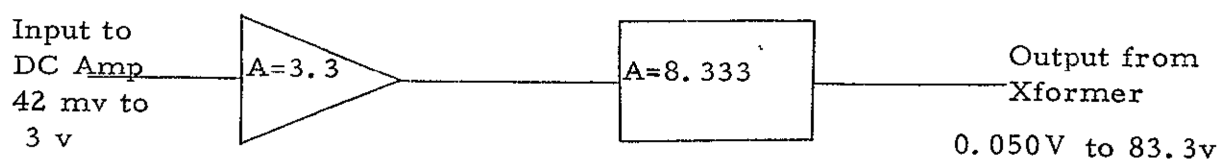
Therefore:

$$4.4\,(340 \times 10^{-6} + 2450 \times 10^{-12}) = t + \Delta t$$

$$t = .01 \text{ usec.}$$

III High Voltage Power Supply

D.C. Amp and Chopper



Input Drift = 0.3 mv, Output Drift = 0.3 x 3.3 x 8.3 = 8.33 mv

$$\% \text{ drift } \frac{8.33}{1166} = 0.7\%$$

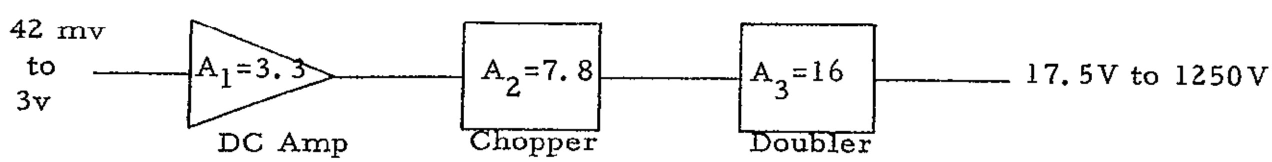
Maximum input drift for an output drift of 5%

$$\Delta E_o = 5 \times 10^{-2} \times 1.166 = 58 \text{ mv}$$

$$\Delta E_{in} = \frac{\Delta E_o}{A_T} = \frac{58 \text{ mv}}{3.33 \times 8.33} = 2.1 \text{ mv}$$

Maximum drift refer to input is 2.1 mv.

D.C. Amp, Chopper & Doubler



Input Drift = 0.3 mv (input amp only)

Output Drift = 0.3 x 3.3 x 7.8 x 16 = 123 mv

$$\% \text{ drift} = \frac{0.123}{17.5} = 0.7\%$$

Therefore, the best possible stability for the system is 0.7%.

Maximum input drift for an output drift of 5% is

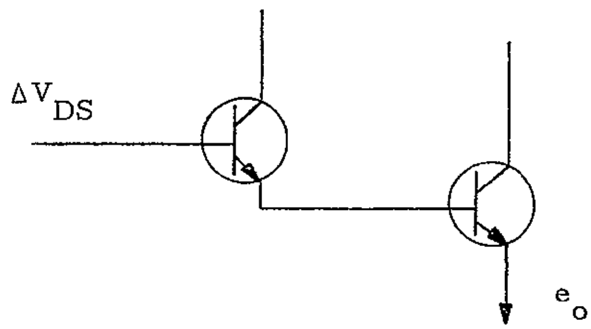
$$\Delta E_o = 5 \times 10^{-2} \times 17.5 = 435 \text{ mv}$$

$$\Delta E_{in} = \frac{\Delta E_o}{A_1 A_2 A_3} = \frac{435}{3.3 \times 7.8 \times 16} = 1.06 \text{ mv}$$

Therefore, the maximum drift of the system refer to input is 1.06 mv.

Amplifier Drift

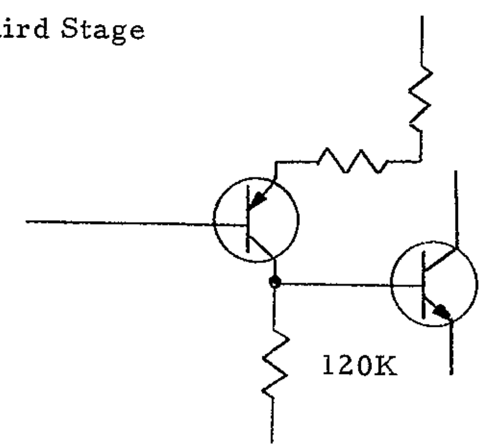
a) Output Stage



ΔV_{BE} $(-15^{\circ}C + 60^{\circ}C) = 150$ millivolts

ΔV_{DS} $= 2 \times 150 = 300$ millivolts

b) Third Stage



at output drift is

$$\Delta V_{DS} + (\Delta R_L \times \Delta T \times I_c) + \quad I_c$$

$300 + 28 + 360 = 688.0$ mv

Gain of third stage:

$$A \cong 2 \frac{R_L}{r_{ea} + R_{EE} + r_{eb}} \qquad R_{EE} \cong 1.5K$$

$$r_{ea} = \frac{26 \times 10^{-3}}{144 \times 10^{-6}} = 180\Omega$$

$$r_{eb} = \frac{26 \times 10^{-3}}{59 \times 10^{-6}} = 440\Omega$$

$$R_L = R_c \,||\, R_{in}$$

$$R_{in} >> R_c$$

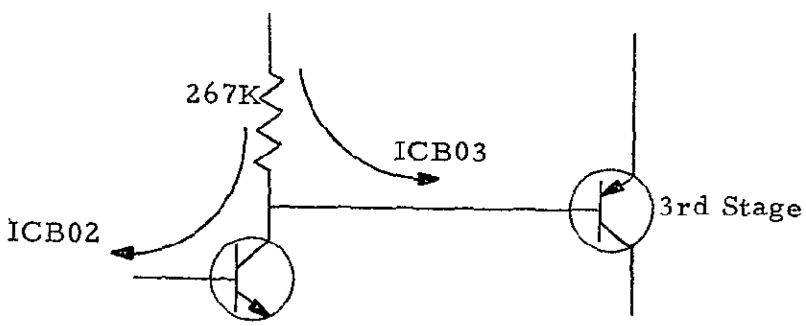
$$R_L = R_c$$

$$A = \frac{2 \times 120 \times 10^3}{180 + 1.5K + 440} = 121$$

Drift of third stage:

$$\Delta V_{3S} = \frac{\text{output drift}}{\text{gain}} = \frac{688}{121} = 5.7 \text{ mv}$$

Second stage or input to third stage.



Drift due to V_{BE3a}

$$\Delta V_{BE} = 150 \text{ millivolts}$$

$$\Delta \left| V_{BE3a} - V_{BE3b} \right| < 15 \text{ millivolts}$$

Drift due to I_{CBO}

$$\Delta I_{CBO} = 3 \mu a$$

$$\Delta V_{ICBO} = 267 \times 10^{3} \times 3 \times 10^{-6} = 800 \text{ millivolts}$$

Resistor will be within 2%.

$$\Delta V_{ICBO} = 800 \times 0.02 = 16 \text{ mv}$$

Drift due to resistor

$$V_R = 2.5 \text{ volts}$$

$$\Delta V_R = 2.5V \times \Delta T \times 50\text{ppm}/C^{o}$$

$$\Delta V_R = 2.5V \times 75 \times 50 \times 10^{-6} = 9.4 \text{ millivolts}$$

RMS Total $V = 13.8$ mv

RMS total refer to input of gain of second stage

$$A = \frac{2 R_L}{r_{e1} + r_{e2}}$$

$$r_{e1} = r_{e2} \cong \frac{26 \times 10^{-3}}{I_B} = \frac{26 \times 10^{-3}}{10 \mu a} = 2.6K$$

$$R_L = R_C \parallel R_{in3}$$

$$R_{in3} \approx \beta R_E = 100 \times 9K = 900K$$

$$R_L = \frac{267 \times 900}{1167} \cong 210K$$

$$A = \frac{2 \times 210}{5.2} = 81$$

$$\text{Input drift} = \frac{13.8 \text{ mv}}{81} = 172 \text{ microvolts}$$

First stage or input of second stage

$$\Delta V_{BE} = 5 \times 10^{-6} \times 75 = 375 \text{ microvolts}$$

Drift due to drain resistor

$$V_{RD} = .2 \times 29.4 \times 10^{3} = 5.9 \text{ volts}$$

$$\Delta V_{RD} = 5.9 \times 75 \times 50 \times 10^{-6} = 22 \text{ mv}$$

Resistance tolerance is 2%

$$\Delta V_{RD} = \frac{22 \times 2}{100} \approx 440 \text{ microvolts}$$

Total RMS signal output drift

$$V_{DS2} = 495 \text{ microvolts}$$

$$V_{DS1} = \frac{495}{20} = 24.7 \text{ microvolts}$$

Total input drift = 750 + 25 = 775 microvolts

$$\therefore \% \text{ drift} = \frac{0.775}{42} = 1.85\%$$

Doubler Gate and Doubler Chain

The following factors dictate the size of the doubler capacitor:

1. Ripple Output

2. Response Time (Step time)

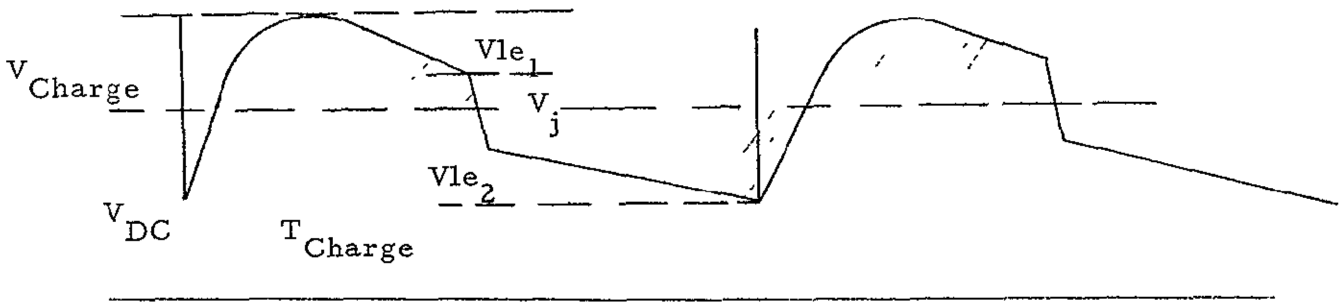
3. Output Voltage required

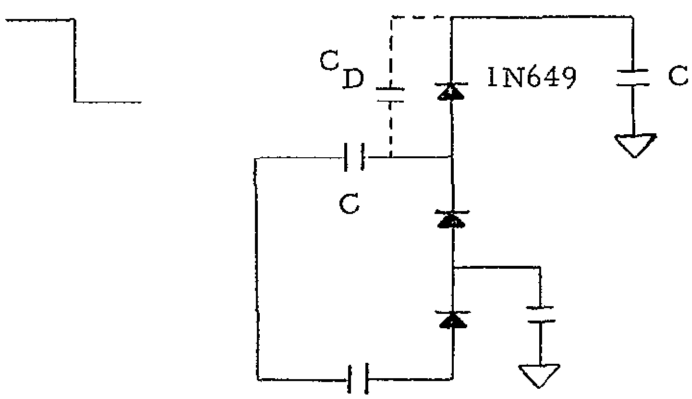
(Factors 1 and 3 are related)

Ripple is less than 1%.

$$\text{Maximum ripple } V_r = \frac{1 \times 1250}{10} = 12.5 \text{ volts}$$

The output ripple waveform is shown below.





V_J shown in the ripple output is due to the capacitance of the 1N649 diode as shown in figure above. This occurs during the negative transition of the input from the transformer.

$$V_J = \frac{\frac{CC_D}{C+C_D} E}{\frac{CC_D}{C+C_D} + C} \qquad \text{where } C >> C_D$$

$$V_j = \frac{C_D}{C} E$$

$C_{D\,max} = 10$ pf and $V_j = 2$ volts $E = 157V$

$$C = \frac{EC_D}{V_j} = \frac{157}{2} \times 10^{-12} = 780 \times 10^{-12} \text{ farads}$$

This is a rough calculation since C_D will decrease as E increases. For worst case consideration assume C = 400 pf. The analysis follows

$$V_{le_2} = \frac{IT}{C}$$

I = I leak (See leakage & Load path)

I = 12.4 microamp

T = 60 microseconds

$$V_{le_2} = \frac{12.4 \times 10^{-6} \times 60 \times 10^{-6}}{400 \times 10^{-12}} = 1.8V$$

also $$V_{le_1} = V_{le_2}$$

or $$V_{le_1} \quad 1.8 \text{ volts}$$

Assume the charge time of the capacitor is 20 microseconds and the discharge time for V_{le_1} is 40 microseconds.

$$V_{le_1} \quad \frac{12.4 \times 10^{-6} \times 40 \times 10^{-6}}{400 \times 10^{-12}} = 1.24 \text{ volts}$$

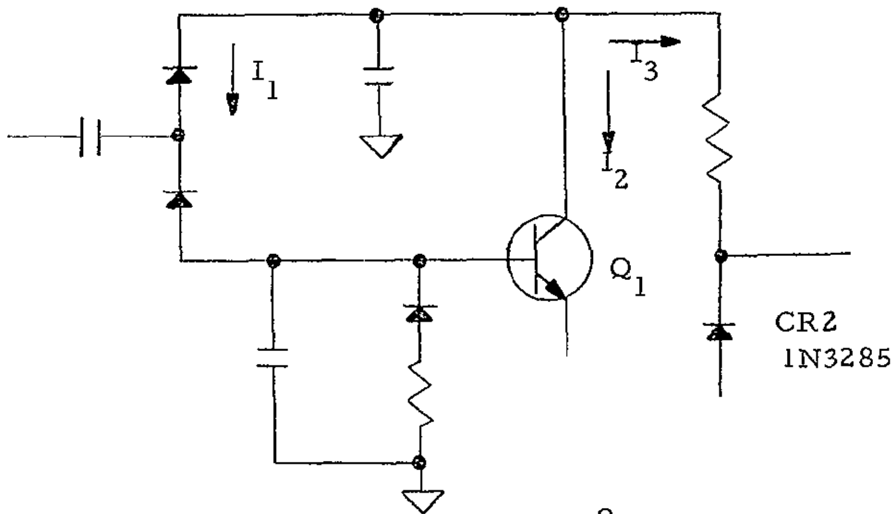
$$V_J = \frac{C_D}{C} E = \frac{5 \times 10^{-12}}{400 \times 10^{-12}} \times 157 = 2V$$

or $$V_{charge} = V_{le_1} + V_{le_2} + V_J = 1.2V + 1.8V + 2 = 5V$$

$$I_{charge} = \frac{CV}{T} = \frac{4 \times 10^{-10} \times 5V}{20 \times 10^{-6}} = 100 \text{ microamps}$$

The above ripple analysis shows that a 400 pf doubler capacitor will be large enough to supply voltage with ripple less than 1%.

Load and leakage path on output capacitor:



I_{CER} = 50 nanoamps at 400V and 25°C

The 2N3439 transistors are selected such that:

I_{CER} at 1 Meg =< 100 nanoamps at 400 V and 25°C

Therefore I_{CER} = 3.2 microamps at 60°C

I_{CER} will be less than 3.2 microamps because.

V_{CE} = 156 volts

i_1 = leakage current of a 1N649 diode and is less than 2 microamps

i_3 = leakage current of a 1N3285 diode and is less than 1 microamp.

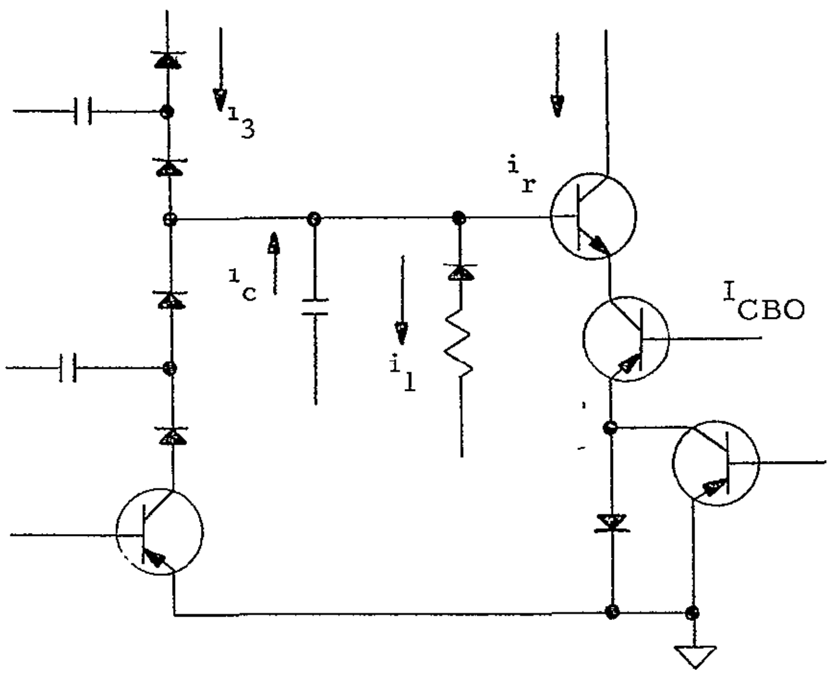
Total leakage current.

$$i_T = i_1 + e_2 + e_3 = 2 + 3.2 + 1 = 6.2 \text{ microamps}$$

allowing a design margin of 2

$$i_T = 6.4 \text{ microamps} \times 2 = 12.8 \text{ mircoamps}$$

First doubler leak path.



$i_1 = i_3$ $\quad$ $i_c = i_2$ $\quad$ $i_2 = 3.2$ microamps

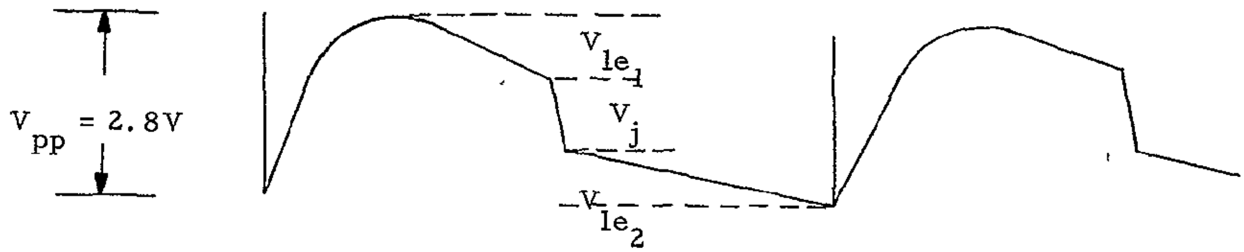
$$V_{le_2} = \frac{IT}{C} = \frac{3.2 \times 10^{-6} \times 60 \times 10^{-6}}{400 \times 10^{-12}} = 0.48\text{V}$$

$$V_{le_1} = \frac{3.2 \times 10^{-6} \times 40 \times 10^{-6}}{400 \times 10^{-12}} = 0.32\text{V}$$

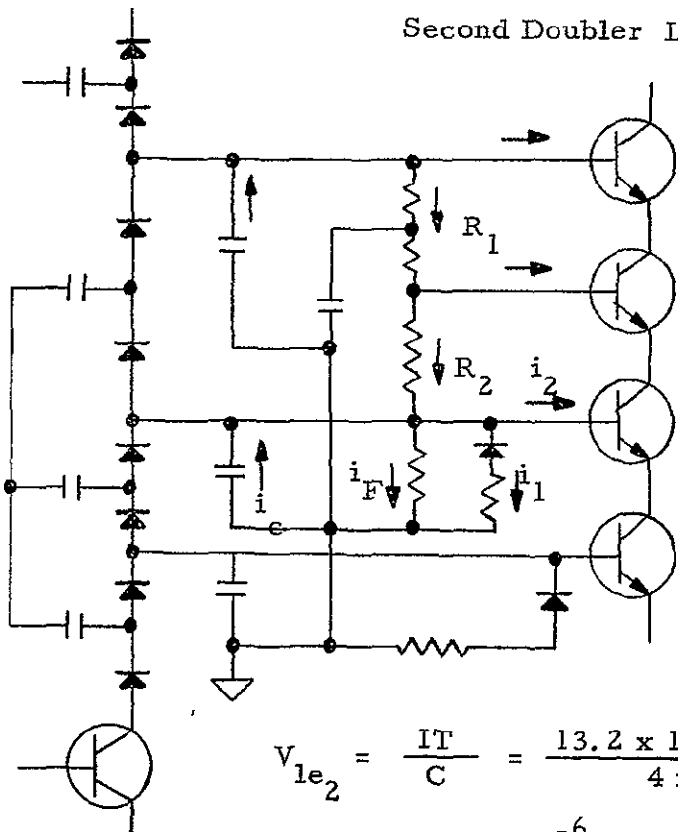
$$V_j = \frac{5 \times 156}{400} = 2\text{V}$$

$$V_{pp} = 2.8\text{V}$$

Referring back to ripple output wave we have



Second Doubler Leak Paths



$R_F = 30$ Meg

$R_1 = 66$ Meg $= R_2$

$IF = \dfrac{312}{30} = 10\ \mu a$

$IR_2 = \dfrac{78}{66} = 1.2\ \mu a$

$iR_2 = 1i$

$iC = iF + i2$

$iC = 13.2\ \mu a$

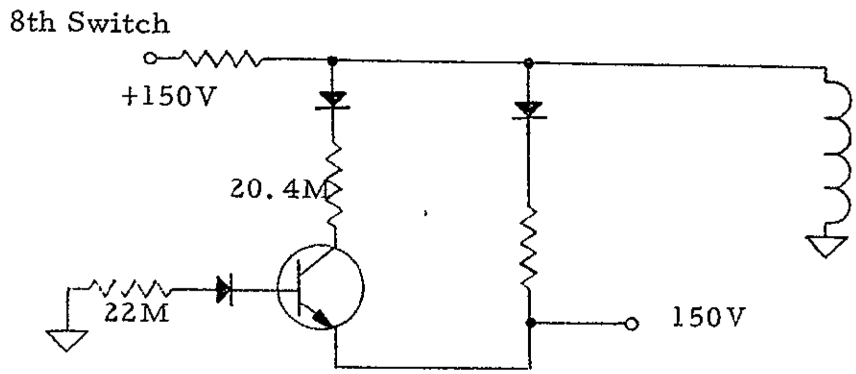
$$V_{le_2} = \frac{IT}{C} = \frac{13.2 \times 10^{-6} \times 60 \times 10^{-6}}{4 \times 10\text{-}10} = 2V$$

$$V_{le_1} = \frac{13.2 \times 10^{-6} \times 40 \times 10^{-6}}{4 \times 10^{-10}} = 1.3V$$

$V_j = 2V$

$V_{pp} = V_{le_1} + V_{le_2} + V_j = 5.3V$

Dump Switch



Maximum I_c occurs when $E_o \cong 0$ $\quad I_{c\,max.} = \frac{-150-1}{18M} = 8.3$ microamperes

let R_b = 22M and derate by $\pm$ 10%

$$I_{B\,min.} = \frac{148V}{24M} = 6.3\ \mu a$$

$$I_{B\,max.} = \frac{149}{20M} = 7.5\ \mu a$$

$$I_{E\,max.} = I_{c\,max.} + I_{B\,max.}$$

$$= 8.3 + 7.5 = 15.8\ \mu a$$

The forced beta is equal to

$$\beta_F = \frac{I_{c\,max.}}{I_{B\,max.}} = \frac{8.3}{6.3} = 1.3$$

All transistors are selected with $\beta > 6$ therefore allowing a reduction of 50% over temperature and worst case consideration. β min. = 3.

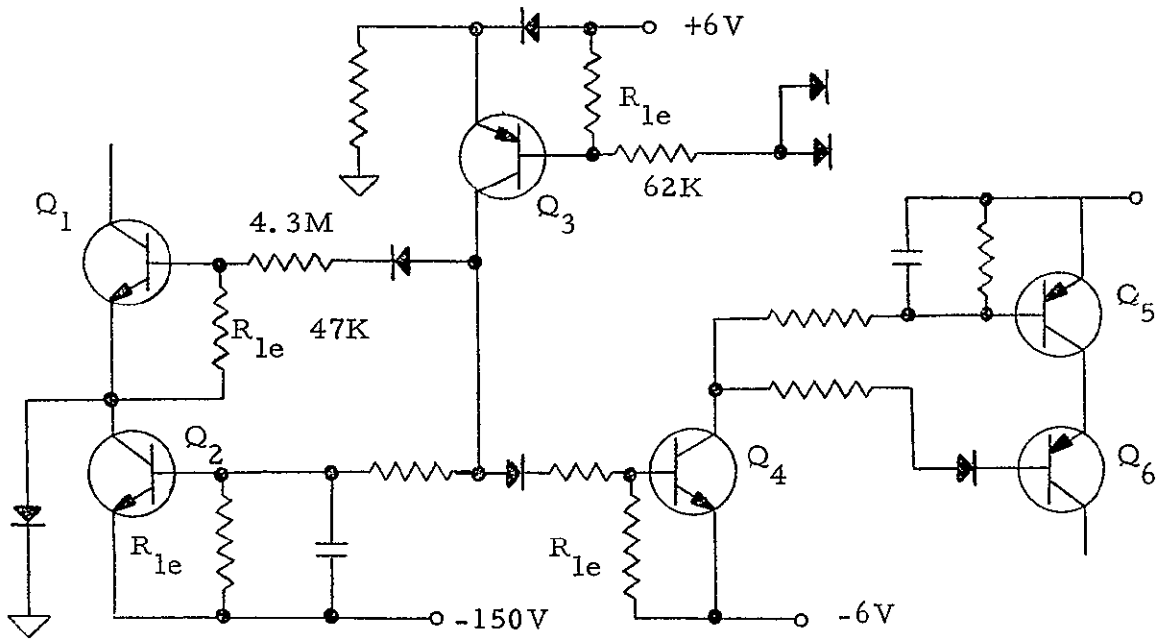
$$\text{Design margin} = \frac{3}{1.3} = 2.3$$

By applying the reasoning above to all dump switches, the results tabulated in table below are obtained.

SUMMARY OF WORST CASE BIASING OF DUMP SW

SW	I_c max. µa	I_B max µa	I_B min. µa	I_E max. µa	B_F	B	B at -15^{o}	Design Margin
8	8.3	7.5	6.3	15.8	1.3	6	3	2.3
7	15.8	8.3	6.7	24.1	2.3	10	5	2.2
6	24.1	9.4	7.4	33.5	3.2	12	6	1.9
5	33.5	9.9	8.2	43.4	4.1	15	7.5	1.8
4	43.4	11.4	10.0	54.8	3.9	16	8	2.0
3	54.8	14.9	12.3	69.7	4.5	18	9	2.0
2	69.7	16.4	13.4	86.1	5.2	20	10	1.9
1	86.1	22.0	18.00	108.1	4.7	22	11	2.3

Dump Gate



A change of $\pm$ 10% is assumed for all resistors and the $\pm$ 150 volts supply.

$$I_{B_1} \text{ max.} = \frac{165 - 0.5 - 0.5 - 0.5 + 6}{3.9\text{M}} - \frac{.6}{47\text{K}}$$

$$I_{B_1} \text{ max.} = 41 - 14 = 27 \ \mu\text{a}$$

$$I_{B_1} \text{ max.} = \frac{135 - 0.6 - 0.6 - 0.6 + 6}{4.7\text{M}} - \frac{.6}{47\text{K}}$$

$$I_{B_1} \text{ min.} = 29.6 - 14 = 15.6 \ \mu\text{a}$$

From worst case calculation of dump circuitry $I_{C_1 \text{ max}}$ was found to be 86.1 μa.

Therefore $$\beta_F = \frac{I_{C_1} \text{ max.}}{I_{B_1} \text{ min.}} = \frac{86.1}{15.6} = 5.5$$

Choose transistor with a β min of 11 which yields a design margin of

$$\frac{11}{5.5} = 2$$

$$\overline{I_{C2}} = \overline{I_{C1}} + \overline{I_{RB1}}$$

$$= 86 + 41 = 127 \ \mu a$$

$$I_{RB2} = \frac{135 - .6 - .6 + 6}{4.7} = 29.6 \ \mu a$$

$$I_{R\,1e} = 14 \ \mu a$$

$$I_{B2\,min.} = 29.6 - 14 = 15.6$$

$$\beta \ \text{min. at } 100^{o} > 30$$

$$\beta \ \text{min. at } -15^{o} > 15$$

$$\beta_F = \frac{127}{15.6} = 8.1$$

$$\text{Design Margin} = \frac{\beta \ \text{min.}}{\beta_F} = \frac{15}{8.1} = 1.85$$

6.1.7.2.1 Leakage Analysis

$$I_{CBO} = 3.2 \ \ a \ \ \text{at } 60^{o}C$$

$$V_{BE} = 3.2 \times 56K = 180 \text{ millivolts}$$

Assuming for worst case transistor turn "On" $V_{BE} = 0.4$ volts

$$\text{Design Margin} = \frac{.4}{.18} = 2.2$$

$$I_{C4} \text{ max.} = 82\ \mu a$$

$$I_{RB4} = \frac{6 + 6 - 0.6 - 0.6 - 0.6 - 0.3}{220K} = 45 \mu a$$

$$I_{R1\,e} = 14\ \mu a$$

$$I_{B4 \text{ min.}} = 45 - 14 = 31\ \mu a$$

$$\beta_F = \frac{82}{31} = 2.6$$

$$\beta_{\text{min.}} \text{ at } -15^{\circ}C = 11$$

$$\text{Design Margin} = \frac{11}{2.6} = 4.2$$

$$I_{RB4 \text{ max.}} = 52\ \mu a$$

$$I_{C3 \text{ max.}} = 82 + 52 = 134 \mu a$$

$$I_{RB3 \text{ min.}} = \frac{6 - 0.6 - 0.6 - 0.6}{68K} = 62\ \mu a$$

$$I_{R1e} = \frac{1.2}{47K} = 26\ \mu a$$

$$I_{B3 \text{ min.}} = 62 - 26 = 36\ \mu a$$

$$\beta_F = \frac{134}{36} = 3.7$$

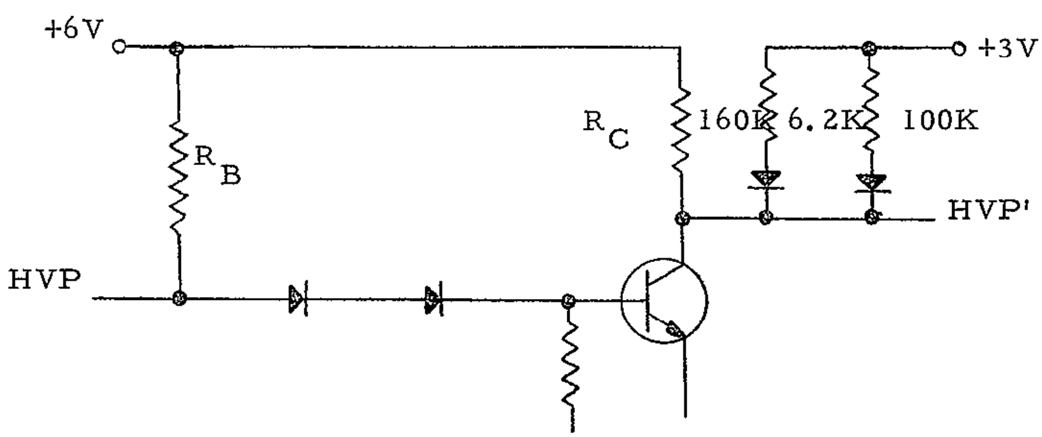
$$\beta_{\text{min.}} \text{ at } -15^{\circ} = 15$$

$$\text{Design Margin} = \frac{15}{3.7} = 4$$

Control Logic

The HVP interface converts the low level HVP signal into high level $\overline{HVP}'$ and $\overline{HVP}'$ signals. The HVZ interface converts the low level $\overline{HVZ}$ signal into high level HVZ' and $\overline{HVZ}'$ signals.

Interface Gating



The only source current needed is for RC. Given I_{CBO} =0.4 μa maximum.

$$\Delta V_{RC} \text{ due to } I_{CBO} = 1\text{V max. worst case}$$

$$R_C = \frac{1}{0.4 \times 10^{-6}} = 2.5 \text{ Meg.}$$

$$\text{if } R_C = 160\text{K}$$

$$V_{RC} \text{ due to } I_{CBO} = 16. \times 10^{5} \times 0.4 \times 10^{-6} = .064 \text{ V}$$

$$I_{C\ Total} = \frac{6}{1.6 \times 10^{5}} + \frac{2.4}{6.2 \times 10^{3}} + \frac{2.4}{1 \times 10^{5}}$$

$$I_{C\ Total} = 37.5\,\mu a + 388\,\mu a + 24\,\mu a = 450\,\mu a$$

$$\text{If } \beta = 60$$

Then $$I_B = \frac{450\,\mu a}{60} = 7.5\ \mu a$$

$$R_{1e} = 160K$$

$$V_{BE\ max.} = 0.75 \text{ volts}$$

$$I_{R1e} = \frac{0.75}{160} = 4.7\ \mu a$$

$$I_{RB} = 7.5 + 4.7 = 12.2\ \mu a$$

$$R_B = \frac{6 - 2}{12.2} \cong 300K$$

IV Low Voltage Power Supply

Preregulator

See Figure 4.14.1-1

The +28 volts spacecraft fluctuations are +5V and -4V. For an input power of less than 3.5 watts,

at 28V $\quad I_{max} = \frac{3.0}{28} = 107$ ma

at 28 + 5 = 33V $\quad I_{max} = \frac{3.0}{33} = 91$ ma

at 28 - 4 = 24V $\quad I_{max} = \frac{3.0}{24} = 125$ ma

The regulating transistor 2N1486 is mounted on a hook-up board and is in thermal contact with the power supply housing for a more effective heat dissipation.

β min. of 2N1486 at 5°F and 125 ma is = 60 For worst case design derate by 50% But the characteristic curves for this particular transistor show β does not vary with temperature below $\beta = 60$. β worst case = 60.

$$I_{cmax.}\, 2N1486 = I_{max.} = 125 \text{ ma}$$

$$I_{B\,max.}\, 2N1486 = \frac{125 \text{ ma}}{60} = 2.08 \text{ ma}$$

Q_1 and Q_2 are ML002 transistors with β min. = 160 and with 50% derating for worst case, then

$$\beta \min Q_1,\ Q_2 = 80$$

$$I_{E1} = I_B\, 2N1486 = 2 \text{ ma}$$

$$I_{B1} = \frac{I_{E1}}{\beta + 1} = \frac{2\text{ma}}{80} = 25\ \mu\text{a}$$

Worst case I_{B1} = 25 microamps.

By increasing the gain of the d-c amplifier, a tight regulation and ripple free output is obtained. This however, causes high frequency oscillation. These oscillations are eliminated by limiting the high frequency response of the amplifier by including a large capacitor across the output.

At this time let us analyze the comparison element of the preregulator, the differential amplifier. Again refer to Figure 4.14.1-1.

CR3 is a zener diode, FCT 1121 and has a TC at 100 microamps of $\pm$ 0.001%/$^\circ$C (temperature range -55°C to 100°C) and V_{CR3} = 6.7V nominal at output = 23.5 volts.

$$R_7 = \frac{V_{out} - V_{CR3}}{IR_7} = \frac{V_{out} - V_{CR3}}{ICR_3}$$

$$R_7 = \frac{23.5 - 6.7}{100\mu a} = \frac{16.8 \text{ volts}}{100\mu a}$$

$$R_7 = 168K$$

since $$V_BQ_{3A} = 6.7 \text{ volts}$$

then $$V_EQ_{3A} = 6.7 - .7 = 6V$$

Let $$I_CQ_{3A} = I_cQ_{3B} = 10\ \mu a$$

$$I_E = I_CQ_{3B} + I_cQ_{3B} = 10 + 10 = 20\ \mu a$$

$$R_6 = \frac{V_EQ_3}{I_EQ_3} = \frac{6 \text{ volts}}{20\mu a} = 300K$$

since $$V_BQ_{3A} = 6.7 \text{ V}$$

and I_BQ_{3A} is relatively small,

then $$\frac{R_{10}}{R_{10} + (R_{11} + R_{12})} = \frac{V_BQ_{3A}}{V_{out}} = \frac{6.7V}{23.5V}$$

Let $IR10 = IR7 = 100\ \mu a$

Then $IR10 = \dfrac{V_{out}}{R_{10} + (R_{11} + R_{12})} = \dfrac{23.5V}{R_{10} + (R_{11} + R_{12})}$

therefore $R_{10} + (R_{11} + R_{12}) = \dfrac{23.5V}{100\mu a} = 235K$

Let $R_{10} = 168K$

Then $(R_{11} + R_{12}) = 235K - 168K = 67K$

$V_E Q_{3B} = 6$ volts

Let $V_{CE} Q_{3B} = \dfrac{V_{out} - V_E Q_{3B}}{2}$

$= \dfrac{23.5 - 6}{2} = \dfrac{17.5}{2} = 8.75V$

$V_C Q_{3B} = V_E + V_{CE} = 6 + 8.75 = 14.75$ volts

$$R_8 = \frac{V_{out} - V_C Q_{3B}}{IR_8} = \frac{23.5 - 14\ 75}{10\mu a}$$

$$R_8 = \frac{8.75}{10\ \mu a} = 875K$$

For a balanced amplifier

$$R_8 = R_5 = 875K$$

Let $I_C Q_2 = 100\ \mu a$

Then $IR_3 = 100\mu a + 25\mu a = 125\mu a$

$VR_3 = 34V - 25.2 - 8.8V$

$R_3 = \dfrac{8.8V}{125\mu a} = 80K$

Chopper

A. For T_1

Use magnetics incorporated core.

50153 - ID

$A = 0.038\ cm^2$

$l = 3.49\ cm$

$\beta = 8500$ gauss

and frequency 5000 Hz

$$N_p = \frac{4}{4 \times \beta \times f \times A}$$

$\beta = 8500$ gauss $= 8500 \times 10^{-8}$ weber

$$N_p = \frac{23.5 \times 10^8}{4 \times 8500 \times 5000 \times 0.038} = 360 \text{ turns}$$

let $V_S = 4.5$ volts, then

$$\frac{N_p}{N_S} = \frac{V_c}{V_S}$$

$$N_S = \frac{N_p V_S}{V_c} = 360 \ \frac{4.5}{23.5} = 70 \text{ turns or } 35 \text{ turns } (3\text{-}4,\ 4\text{-}5)$$

$$I_m = \frac{\cdot\ Hl}{0.4\pi N_p} = \frac{0.08 \times 3.49}{1.26 \times 360} = .61 \text{ ma}$$

Q_2 and Q_3 are NPN power transistor 2N1482 and $I_{c\,max.}$ at 23.5 volts is equal to about 500 ma. Worst case β is about the same as β min. for this particular transistor.

$$I_B = \frac{500}{70} = 7.15 \text{ ma}$$

$$V_{R6} = I_{R6} \cdot R_6 = V_S - V_{BE}$$

$$V_S - V_{BE} = 2.3 - 1.1 = 1.2V$$

$$R_6 = \frac{1.2V}{7.15 \text{ ma}} = \frac{1.2 \times 10^3}{7.15} = 200 \text{ ohms}$$

$$R_4 + R_5 = \frac{V_c}{I_p}$$

$$I_p = I_m + I_B \frac{N_S}{N_p}$$

$$= 0.61 \text{ ma} + 7.15 \text{ ma } \frac{35}{360}$$

$$= 0.61 \text{ ma} + \ 715 \text{ ma} = 1.325 \text{ ma}$$

$$R_4 + R_5 = \frac{23.5\ V}{1.325 \times 10^{-3}} = 17 \times 10^3 \text{ ohms}$$

or

$$R_4 = R_5 = 8K\,\Omega$$

B For T_2

Use magnetics incorporated

core 50007 - IR

$A = 227$

$l = 6.48$

$\beta = 7500/2 = 3750$

$f = 5000$

$v = 23.5$

$H = 0.1$

$$N_p = \frac{47.0 \times 10^8}{4 \times 3750 \times 5000 \times 227} = 376 \text{ turns}$$

or 138 turns (4-5, 5-6)

$$I_{max} = \frac{Hl}{.4\pi N} = \frac{0\ 1 \times 6.48}{1.26 \times 376} = 1.85 \text{ ma}$$

The required potential for the post regulators is derived from the following.

$$E_o + \Delta V_R + V_D + V_{wIR}$$

The drop across the winding V_{wIR} will be an estimate

For the +12 volt post regulator

$$12 + 1 + 0.7 + 0.1 = 13.95$$

N_S for +12V post regulator is

$$\frac{23.5}{13.95} = \frac{276}{N_S}$$

where $N_S = 166$ turns

or 83 turns (23-24, 24-25)

For the +6 volts post regulator

$$6 + 1 + 0.85 + 0.1 = 7.95$$

N_S for +6V post regulator is

$$\frac{23.5}{7.95} = \frac{276}{N_S}$$

Where N_S = 94 turns or 47 turns (12-13, 13-14)

The turn ratio for remaining windings are computed in the same manner

When the preregulator voltage starts to rise to 15 volts, the starting network is going to turn On the inverter. Q_1 is an ML 20001 transistor, it requires a base current of 7 15 ma to fully turn "On" Q_2, or $I_B Q_2 = 7.15$ ma. This means that initially I_{R19} is about 7.15 ma.

$$15V - V_{CE}Q_1 - V_{BE}Q_2 = I_{R8} \; R_8$$

or

$$R_8 = \frac{15V - 0.4 - 1.1}{I_{R8}} = \frac{13.5}{I_{R8}}$$

and for the 7.15 ma required, then

$$R_8 = \frac{13\ 5}{7.15\text{ma}} \cong 2K$$

Post Regulator

a) + 6 Volts post regulator (Figure 4.14.3-1)

$$I_cQ_1 = 20 \text{ ma}$$

β min of $Q_1 = 90$ $\quad\quad$ Q_1 = 2N2222 or = ML000

$$\text{worst case } \beta = \frac{\beta \text{ min}}{2} = \frac{90}{2} = 45$$

$$I_{BQ_1} = \frac{I_CQ_1}{45} = \frac{20 \times 10^{-3}}{45} = 0.45 \text{ ma}$$

$$I_EQ_2 = I_BQ_1 = 0.45 \text{ ma}$$

$$I_CQ_2 = I_EQ_2 = 0.45 \text{ ma}$$

β min of $Q_2 = 160$ $\quad\quad$ Q_2 = 2N2484 = ML002

$$\text{worst case } \beta\ Q_2 = 160/2 = 80$$

$$I_BQ_2 = \frac{0.45 \text{ ma}}{80} \doteq 5\ \mu a$$

let $\quad I_CQ_{3A} = I_CQ_{3B} = 45\ \mu a$

$$I_{R2} = I_BQ_2 + I_CQ_{3A}$$

$$= 5\ \mu a + 45\,\mu a = 50\ \mu a$$

$$V_CQ_{3A} = 6V + V_{BEQ_1} + V_{BEQ_2}$$

$$V_CQ_{3A} = 6V + 0.7 + 0\ 7 = 7.4 \text{ volts}$$

$$R_2 = \frac{15 - 7.4}{50 \times 10^{-6}} = \frac{7.6 \times 10^6}{50} = 150K$$

Also

$$IR_1 = I_CQ_2 = 0.45 \text{ ma}$$

let $V_{CE}Q_2 = \dfrac{15 - 6 - 1}{2} = 4$ volts

then $V_CQ_2 = 6 + 1 + 4 = 11$ volts

or $R_1 = \dfrac{15 - 11}{0\ 45 \times 10^{-3}} = \dfrac{4 \times 10^3}{.45} = 10K$

and let $160\,\mu a$ through CR1 and R8 + R11 with $100\ \mu a$ thru CR1

$$R_5 = \frac{15 - 6.7}{160 \times 10^{-6}} = \frac{8.3}{160} = 52K$$

$$R_8 + R_7 + R_6 = \frac{6.7V}{60 \times 10^{-6}} = 111K$$

$$V_BQ_{4A} = \frac{6V}{60 \times 10^{-6}} = 100K$$

let $R_6 = 100K$ and $R_7 + R_8 = 11K$

also since $IR_3 = 90\,\mu a$

$$V_E Q_{3A} = V_B Q_{3A} - V_{BE} Q_{3A}$$

$$V_E Q_{3A} = 6 - 0.7 = 5.3 \text{ V}$$

$$R_3 = \frac{5.3\text{V}}{90 \times 10^{-6}} = 55\text{K}$$

b) -6 volts post regulator (Figure 4.14.3-2)

$$I_C Q_1 = 20 \text{ ma}$$

β min Q_1 = 100 $\qquad\qquad$ Q_1 = 2N2907A = ML001

$$\beta \text{ worst case} = \frac{\beta \text{ min}}{2} = \frac{100}{2} = 50$$

$$I_B Q_1 = \frac{20\text{ma}}{50} = .4 \text{ ma}$$

$$I_B Q_1 = I_E Q_2 = I_C Q_2$$

β worst case = Q_2 = 50 $\qquad\qquad$ $Q_2 = Q_1$

$$I_B Q_2 = \frac{.4\text{ma}}{50} = 8 \ \mu\text{a}$$

Since the output voltage and current are equivalent to that of the +6 volts post regulator, the worst case design follows the same reasoning as before with the exception of the V_{cc} supply for Q_2 and Q_3 which is now -25 volts

$$I_{R2} = 45\mu\text{a} + 8 \ \mu\text{a} = 53\mu\text{a}$$

$$V_C Q_{3A} = 7.4 \text{ volts}$$

$$R_2 = \frac{25 - 7\ 4}{53 \times 10^{-6}} = \frac{17.6}{53 \times 10^{-6}} = 350K$$

and $$R_1 = \frac{25 - 11}{.4 \times 10^{-3}} = \frac{14}{.4 \times 10^{-3}} = \frac{140 \times 10^3}{4} = 35K$$

let 180 μa through for CR1 and $R_8 + R_7 + R_6$ with ICR1 = 100 μa.

$$R_6 = \frac{6V}{80\mu a} = 75K$$

$$R_7 + R_8 + 75K = \frac{6\ 7V}{80\ \mu a}$$

$$R_7 + R_8 + 75K = 83K$$

where $$R_7 + R_8 = 83 - 75 = 8K$$

The design of remaining post regulators is similar to the ± 6 volt post regulator.

APPENDIX F

Reliability Analysis

RELIABILITY ANALYSIS
ARC PLASMA PROBE - PIONEER C & D

December 1965

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Program Manager

INTRODUCTION

This report is submitted as a partial fulfillment of the NASA/ARC Contract (NAS 2-3374) to Marshall Laboratories.

During this analysis it was assumed that all components were serially arranged for worst case conditions. Failure rates used were based on a high reliability component derating of 10% at a temperature of 50° C and the confidence level of 60%.

ABSTRACT

A preliminary reliability study was conducted to determine the relative probability of success of the ARC Plasma Probe Experiment - Pioneer C & D Spacecraft. The early design probability of success is 488 for a period of 10,000 hours or a meantime between failure (MTBF) of 1.59 year.

TEXT

Factors taken into consideration for this analysis are the length of operating time desired, the environments in which the instrument must operate, and the reliability design goal.

Since each component will be subjected to extensive burn-in and screening tests, the only failure that may be experienced will be essentially constant. That is, any failure occurring after infant mortality and before normal wear out.

When failures occur at a constant rate, the failure follows an exponential distribution. Therefore, the following expression from the Poisson distribution was used to show a close approximation of the probability of no failure in the given time:

$$P_s = e^{-\lambda t}$$

where P_s is the probability of survival without failure. The λ is the effective failure rate per 10^9 hours and t is the operating time in hours to the first failure.

Since this instrument contains a large number of components arranged serially, the following expression was used for the total failure rate:

$$\lambda = \Sigma \lambda_1 n_1$$

where $\lambda 1$ is the individual failure rate of a particular component and n_1 is the number of times that component appears in the system.

The meantime between failure (MTBF) of the system can be expressed:

$$\text{MTBF} = \frac{1}{\lambda} = \frac{1}{\Sigma n_1 \cdot \lambda_1}$$

An initial search was conducted to establish a realistic component failure rate (λ_1) to be used in the analysis. Failure rate tables considered included

1. The Merit Index of Proven Parts and Sources from the National Aeronautics and Space Administration.

2. The failure rates developed by Rome Air Development Center.

3. Military Standardization Handbook 217 dated August 8, 1962.

4. The failure rates established in the Thompson-Ramo-Wooldridge Reliability Handbook.

The data used to establish the failure rate values in the TRW Reliability Handbook come from the Minuteman Program, the various OGO Spacecraft, the Vela Nuclear Detector Spacecraft, and the Titan Guidance Computer.

Considering the Component Evaluation and Quality Assurance Programs in effect at Marshall Laboratories and the fact that the TRW failure rates are established for aerospace equipment under conditions similar to those of the subject space instrument, the same tables are therefore most applicable and have been used in the following preliminary design reliability calculations.

Calculations

The following calculations are based on an estimate of the total number of components used in the instrument, serially arranged, under 10% stress, at 50° C and a confidence level of 60%.

Given

	λ_1	$\cdot\ n_1$	$= (\lambda 1 \cdot n1)$
Transistors	$20 \cdot 10^{-9}$	354	7,080
Diodes	$6 \cdot 10^{-9}$	503	1,518
Integrated Circuits	$160 \cdot 10^{-9}$	379	60,640
Resistors	$2 \cdot 10^{-9}$	898	1,796
Capacitors	$3 \cdot 10^{-9}$	336	1,002

Therefore $\lambda = \Sigma \lambda_1 \cdot n_1 = 72,036$

and $\lambda = 72,036$ failures per 10^{-9} hours.

The MTBF $= \dfrac{1}{\lambda} = \dfrac{1}{72,036 \cdot 10^{-9}} = 13.85 \cdot 10^3$ hours or 1.59 years

The $P_s = e^{-\lambda t} = e^{-.720} = .488$ or 48.8%

The following calculations show the reliability of each particular section of the instrument with worst case (Ps1) and best case (Ps2) figures.

Low Voltage Power Supply Ps1 (worst & best not shown here because actual rates used)

$\Sigma\, n1\, \lambda 1 = 4280 \cdot 10^{-9}$

MTBF = 234.10^3 hours = 26.6 year

$Ps = e^{-(4.28.10^{-6}) \cdot (10^{+4})} = e^{-.0428} = 0.958$

Electrometer Amplifiers (3) Ps2 (worst & best not shown here because actual rates used)

$\Sigma\, n1\, \lambda = 3432 \cdot 10^{-9}$

MTBF $= 292.10^{-3}$ hr

$Ps = e^{-(343.10^{-6}) \cdot (10^4)} = e^{-.0343} = .967$

Timing and Control P_{s3}

$\Sigma_1 n_1 \lambda_1 = WC = 22,762 \cdot 10^{-9}$

$\Sigma_2 n_2 \lambda_2 = BC = 16,713.10^{-9}$

$MTBF_1 = \frac{1.10^9}{22,762} = 44 \; .10^3$ hrs

$MTBF_2 = \frac{1.10^9}{16,713} = 60 \; .10^3$ hrs

$P_{s1} = e^{-(22.162.10^{-6})\;(10^4)} = e^{-.2276} = .796$

$P_{s2} = e^{-(16.713.10^{-6})\;(10^4)} = e^{-.1671} = .846$

Sector Programmer P_{s4}

$\Sigma_1 n_1 \cdot \lambda_1 = WC = 11,086 \cdot 10^{-9}$

$\Sigma_2 n_2 \cdot \lambda_2 = BC = 8,161 \cdot 10^{-9}$

$MTBF_1 = \frac{1.10^9}{11,086} = 90.10^3$ hrs

$MTBF_2 = \frac{1.10^9}{8,161} = 123.10^3$ hrs

$P_{s1} = e^{-(11.086.10^{-6})\;(10^4)} = e^{-.1108} = .895$

$P_{s2} = e^{-(8.161.10^{-6})\;(10^4)} = e^{-.0816} = .9215$

Target Programmer P_{s5}

$\Sigma_1 n_1 \cdot \lambda_1 = WC = 1,010\ 10^{-9}$

$\Sigma_2 n_2 \cdot \lambda_2 = BC = 730 \cdot 10^{-9}$

$MTBF_1 = \frac{1.10^9}{1,010} = 99 \cdot 10^3$ hrs

$MTBF_2 = \frac{1.10^9}{730} = 137\ 10^3$ hrs

$P_{s1} = e^{-(1.010.10^{-6})(10^4)} = e^{-.010} = .990$

$P_{s2} = e^{-(.730.10^{-6})(10^4)} = e^{-.0073} \doteq > .990$

A/D Connector P_{s6}

$\Sigma_1 n_1 \cdot \lambda_1 = WC = 21,324 \cdot 10^{-9}$

$\Sigma_2 n_2\ \lambda_2 = BC = 15,864 \cdot 10^{-9}$

$MTBF_1 = \frac{1.10^9}{21,324} = 46 \cdot 10^3$ hrs

$MTBF_2 = \frac{1.10^9}{15,864} = 63 \cdot 10^3$ hrs

$P_{s1} = e^{-(21.324.10^{-6})(10^4)} = e^{-.2132} = .808$

$P_{s2} = e^{-(15.864.10^{-6})(10^4)} = e^{-.1586} = .859$

Compression and Pulse Width Modulations P_{s7}

$\Sigma\, n_1 \lambda_1 = 5212 \cdot 10^{-9}$

$MTBF = 102 \cdot 10^3$ hrs

$P_s = e^{-(5.21 \cdot 10^{-6})(10^4)} = e^{-.0521} = .949$

High Voltage Power Supply P_{s8}

$\Sigma\, n_1 \lambda_1 =$ worst case $5220 \cdot 10^{-9}$

$\Sigma\, n_2 \lambda_2 =$ best case $4540 \cdot 10^{-9}$

$MTBF_1 = \frac{1}{5220} = 192 \cdot 10^3$ hrs

$MTBF_2 = \frac{1}{4540} = 220 \cdot 10^3$ hrs

$P_{s1} = e^{-(5.22 \cdot 10^{-6})(10^4)}$

$P_{s1} = e^{-(522)} = .9492$

$P_{s2} = e^{-(4.54 \cdot 10^{-6})(10^4)}$

$P_{s2} = e^{-(0454)} = .9560$

High Voltage Programmer $P_{s\,9}$

$$\Sigma_1 = n_1 \cdot \lambda_1 = WC = 7035 \cdot 10^{-9}$$

$$\Sigma_2 = n_2 \cdot \lambda_2 = BC = 7900\ 10^{-9}$$

$$MTBF_1 = \frac{1 \cdot 10^9}{7035} = 136 \cdot 10^3 \text{ hrs}$$

$$MTBF_2 = \frac{1.10^9}{7900} = 127 \cdot 10^3 \text{ hrs}$$

$$P_{s1} = e^{-(7.03.10^{-6})(10^4)} = e^{-.0703} = .932$$

$$P_{s2} = e^{-(7.90\ 10^{-6})(10^4)} = e^{-.079} = .924$$

Suppressor Programmer P_{s10}

$$\Sigma_1 = WC = 1170 \cdot 10^{-9}$$

$$\Sigma_2 = BC = 845 \cdot 10^{-9}$$

$$MTBF_1 = \frac{1\ 10^9}{1170} = 855 \cdot 10^3 \text{ hrs}$$

$$MTBF_2 = \frac{1\ 10^9}{845} = 118 \cdot 10^3 \text{ hrs}$$

$$P_{s1} = e^{-(1.170.10^{-6})(10^4)} = e^{-.0117} = .988$$

$$P_{s2} = e^{-(855.10^{-6})(10^4)} = e^{-.0085} = >.990$$

Buffer Storage P_{s11}

$$\Sigma_1 n_1 \cdot \lambda_1 = WC = 35,976 \cdot 10^{-9}$$

$$\Sigma_2 n_2 \cdot \lambda_2 = BC = 22,256 \cdot 10^{-9}$$

$$MTBF_1 = \frac{1.10^9}{35,976} = 28 \cdot 10^3 \text{ hrs}$$

$$MTBF_2 = \frac{1\ 10^9}{22,256} = 45 \cdot 10^3 \text{ hrs}$$

$$P_{s1} = e^{-(65.976.10^{-6})(10^4)} = e^{-.3597} = .699$$

$$P_{s2} = e^{-(22.256.10^{-6})(10^4)} = e^{-.2225} = .802$$

In Flight Calibrator P_{s12}

$$\Sigma n_1 \lambda_1 = WC = 1356 \cdot 10^{-9}$$

$$\Sigma n_2 \lambda_2 = BC = 838 \cdot 10^{-9}$$

$$MTBF_1 = \frac{1\ 10^9}{1356} = 740 \cdot 10^3 \text{ hrs}$$

$$MTBF_2 = \frac{1\ 10^9}{838} = 1195 \cdot 10^3 \text{ hrs}$$

$$P_{s1} = e^{-(1.35.10^{-6})(10^4)} = e^{-.0135} == .9861$$

$$P_{s2} = e^{-(838\ 10^{-6})(10^4)} = e^{-.0083} = > .990$$

Temperature Sensor P_{s13}

$$\Sigma n_1\lambda_1 = WC = 360\cdot 10^{-9}$$

$$\Sigma n_2\lambda_2 = BC = 328\cdot 10^{-9}$$

$$MTBF_1 = \frac{1\cdot 10^9}{360} \quad 2,780\cdot 10^3 \text{ hrs}$$

$$MTBF_2 = \frac{1.10^9}{328} \quad 3,030\cdot 10^3 \text{ hrs}$$

$$P_{s1} = e^{-(360.10^{-6})(10^4)} = e^{-.0036} = >.990$$

$$P_{s2} = e^{-(328.10^{-6})(10^4)} = e^{-.0033} = >.990$$

APPENDIX G

Mechanical
Stress Analysis

STRESS ANALYSIS

1.0 INTRODUCTION

This document defines the results of a mathematical analysis of the ARC Plasma Probe ML 304-1 packaging design undertaken to demonstrate compliance to the environmental conditions imposed by ARC Specification A-10202.

2.0 CONCLUSIONS

The instrument has been shown by this analysis to meet the requirements of the environmental conditions of Qualification Testing. A factor of safety of 2.0 is required for satisfactory compliance of the instrument. As noted in Table I, the lowest factor of safety was determined to be 2.5. The analysis is based on 50g shock environment with an amplification factor of 1.75, or 30g vibration level with an amplification factor of 3. The corresponding loadings are listed in Table II.

TABLE I

SUMMARY OF RESULTS

Reference Paragraph	Member	Loading	Axis	Safety Factor
3.3.1.2	Attachment Screws	Tension resulting from Sinusoidal Vibration	Thrust	3.1
3.3.1.3	Attachment Screws	Resistance to tipping-shock	Lateral	2.8
3.3.1.3	Attachment Screws	Maximum Tensile stress of screws - shock	Lateral	2.7
3.3.1.3	Mounting Feet	Maximum shear stress of screws - shock	Lateral	2.5
3.3.2.1	Housing Side Panels	Tension resulting from shock	Lateral	12.7
3.3.2.2	Housing Corners	Compression resulting shock	Lateral	9.1
3.3.2.3	Housing Corners	Buckling-Shock	Lateral	10.9

TABLE II

EQUIVALENT ENVIRONMENTAL LOADING

Environ-mental Condition	Axis (see Fig.1)	Applied Level	Ampli-fication Factor	Inertia Force Level	Equiv. Applied Load (pounds)
Shock (3.1.3)	X, Y & Z	50g	1.75	87.5g	569
Random Vibration (3.1.2	X, Y & Z	(.07g 2/cps)	3.0	34g	221
Sinuoidal Vibration (3.1.1)	Y & Z X	20g 30g	3.0 3.0	60g 90g	390 585
Continuous Acceleration (3.1.4)	20^o to X	48g	1.0	48g	312

X ~ Thrust Axis

Y & Z ~ Lateral Axis

3.0 ANALYSIS

The analysis consists of first evaluating the loads corresponding to the many environmental conditions and thereby establishing the most severe requirements. Second, the stresses in the instrument structure, caused by these loads are calculated.

3.1 Specified Environment

Environmental conditions are given in ARC Specification A-10202. The conditions which impose stresses in the instrument structure are principally:

(a) Sinusoidal Vibration (paragraph B2.1.6.3.2)

(b) Random Vibration (B2.1.6.3.2)

(c) Shock (B2.1.6.3.4)

(d) Steady State Acceleration (B2.1.6.3.3)

3.1.1 Sinusoidal Vibration

Sinusoidal Vibration is specified as follows for the qualification test.

Vibration Axis	Frequency Range (cps)		Test Duration (min.)	Acceleration 0-peak
Thrust (X -X)	10 - 50		1.17	7.5
	50 - 100		.5	30
	100 - 250		.65	20
	250 - 500		.50	7.5
	500 - 2000		1.0	21
		Total	3.82	
Lateral Y -Y & Z -Z	10 - 50		1.17	7.5
	50 - 2000		2.65	20.0
		Total	3.82 Each Axis	

Axes are shown on Figure 1.

3.1.2 Random Vibration

Random Vibration is applied as follows for qualification testing.

Vibration Axis	Frequency Range	PSD Level g 2/cps	Acceleration g (rms)
X, Y & Z	20 - 2000	0.07	11.8

Peak g = 3 times g(rms)

3.1.3 Shock

Shock is specified as follows for qualification testing.

Axes	Level	Duration
X, Y & Z	50	6 ms

3.1.4 Steady State Acceleration

Steady state acceleration is specified as follows for qualification.

48 g at an angle 20^{o} to vertical axis for 3 min.

3.1.5 Acceptance Testing

It should be noted that each unit shipped to the customer must pass acceptance tests similar to the above except that the g levels will be approximately 65% to 75% of the values listed above. Therefore, the unit

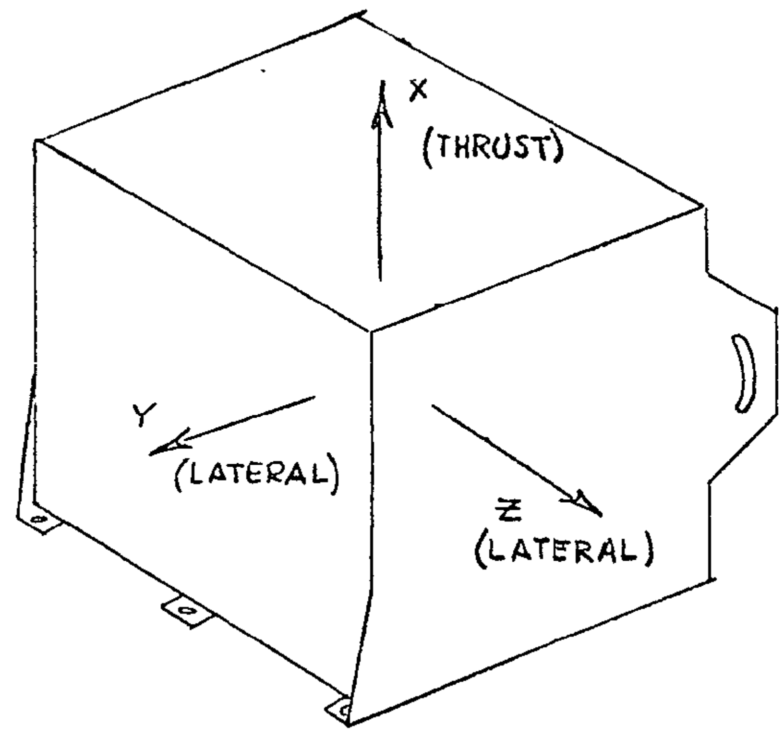


FIGURE 1. AXIS ALIGNMENT

will withstand the environmental conditions expected during launch and flight based upon the results calculated upon qualification test levels.

3.2 Load Determination

Inertial loads are induced in the instrument as the result of subjecting it to qualification test environments:

(a) Sinusoidal Vibration

(b) Random Vibration

(c) Shock

(d) Steady State Acceleration

The inertial loads are applied to the instrument parts in proportion to their individual weights, and in a direction opposite to the instantaneous, local acceleration.

The total force corresponding to the environments (a), (b), (c) and (d) is calculated in terms of acceleration, g. Table II shows loads and g levels corresponding to the environmental factors as computed below.

3.2.1 Sinusoidal Vibration Loads

The sinusoidal test requirements vary with the test axis. The thrust axis has a different requirement from the lateral axes.

For the thrust axis, the worst case would be a resonance between 50 and 100 cps where an input of 30 g and an amplification factor of three would require the structure to withstand a loading of 90 g.

For the lateral axes, a resonance between 50 and 2000 cps would have a loading of 60 g due to an amplification factor of three and an input of 20 g.

These values of g load, amplification factor and the equivalent total force acting a 6.5 pound instrument are listed in Table II.

3.2.2 Random Vibration Loads

The amplification of any small part of the experiment may vary over a wide range, from about 2/1 to 20/1. The amplification of the unit as a whole should be low, around 3/1 as far as the primary structural portion requirements for carrying the entire load is concerned. Random vibration loads are computed on the basis of the following equation:

$$g_r = 3\sqrt{\frac{\pi}{2} f Q Z} \qquad \text{(Reference, Page 25, Eq. 32)}$$

Note: The 3 is for peak g_r which is specified as three times the rms g level

f = frequency in cps
Q = Amplification factor
Z = Power spectral density g 2/cps

This indicates that g_r is frequency dependent. The resonant frequency is not known but a safe assumption would be to place it no higher than 400 cps for the overall structure.

$$\text{Then:} \quad g_r = 3\sqrt{\frac{\pi}{2} fQZ}$$

$$g_r = 3\sqrt{\frac{\pi}{2} (400)(3)(.07)}$$

$$g_r = 3\sqrt{132}$$

$$g_r = 34 \text{ g peak}$$

This value applies to all three (3) axes since the test requirements do not change with the axis chosen for the random vibration test. The value is listed in Table II.

3.2.3 Shock Induced Loading

The maximum inertia load corresponding a shock applied to a sprung mass system often exceeds the level of the applied shock. In the worst case, for a half-sine pulse the maximum amplification factor is 1.75. (Ref 1, Chapter 23, ppg. 11 thru 14 and 21 thru 23). Therefore, the maximum g level corresponding to the 50 g shock pulse is:

$$S = 50 \text{ g} \times 1.75 = 87.5 \text{ g}$$

This value is listed in Table II.

3.2.4 Steady State Acceleration Loading

The loading induced by steady state acceleration is the same as specified, namely 48 g, inasmuch as there is no amplification involved. This value is listed in Table II.

3.3 Stress Calculations

The basic structure is substantially a thin wall box with reinforced edges, and loaded from within by its "contents". Inertia loads resulting from shock and vibration environments are effectively applied throughout the instrument according to the weight/acceleration distribution.

Loads are assumed to be carried from the contents of the box through side panels to the base and then through mounting feet and screws to the spacecraft structure.

Side Panels are treated as buckled webs supporting diagonal tension.

Forces are transmitted from the instrument base to the vehicle structure by tension and shear of the mounting screws and by contact force, and friction force of the mounting feet.

The analysis treats primarily, strength of the side panels and the mounting feet and screws.

Natural frequency of various members is also computed.

3.3.1 Instrument Attachment Stress Calculations

The unit is attached to the spacecraft by (5) 6-32 screws. For the present purpose it is assumed that the screws are installed to 10 inch pounds torque and further that the material is equivalent to titanium (eg. Ti - 8 Al - Mo - 1 V) with a yield strength of 120,000 psi: (Ref. 4, pg 51, table I).

3.3.1.1 The clamping force of the screws may then be found from:

$$P_s = \frac{T_s}{KD} \quad \text{(Ref. 3, pg 19, Eq. 3)}$$

$T_s \sim$ torque (10 inch pounds)

$D \sim$ nominal screw diameter (.138 inch)

$K \sim$ torque coefficient (.2) (Ref 3, pg. 20)

$$P_s = \frac{10}{(.2)(.138)}$$

$$P_s = 362 \text{ lbs.}$$

The axial tensile stress, σ_t, in a 6-32 screw with 362 pounds axial load is:

$$\sigma_t = \frac{P_s}{A}$$

where $A \sim$ stress area of screw (.00909 inches squared per Ref. 3, pg. 17, Table II).

therefore $$\sigma_t = \frac{362}{.00909}$$

$$\sigma_t = 40,000 \text{ psi}$$

Clamping force and clamping stress are used in the subsequent sections for further calculations.

3.3.1.2 Thrust load Screw Strength

The maximum inertia load applied to the units along the thrust axis is listed on Table II as that resulting from sinusoidal vibration, namely 585 pounds. This force is applied, effectively, through the CG. Inasmuch as the CG of the instrument mass very nearly coincides with a vertical line through the center of the bolt pattern, the load is divided almost equally among the mounting screws. The load per screw is therefore:

$$P_T = \frac{585}{5} = 117 \text{ pounds}$$

Stress, σsc, in the screw is:

$$\sigma sc = \frac{Pt}{A} \qquad \text{(observe alignment)}$$

$$\sigma sc = \frac{117}{.00909}$$

$$\sigma sc = 12,900 \text{ psi}$$

Initial tightening produces 40,000 psi stress, consequently the safety factor keeping the joint from opening is:

$$S.F. = \frac{40,000}{12,900}$$

$$S.F. = 3.1$$

This value is listed in Table I.

3.3.1.3 Lateral Load Screw Strength

When the input shock is along either of the lateral axes, the screws are subjected to both shear and tensile loads.

<u>Tension Load</u>

The screws are in tension under lateral shock loading. The worst case is when the load tends to pivot about the edge that has three mounting screws and the other two must react to the load.

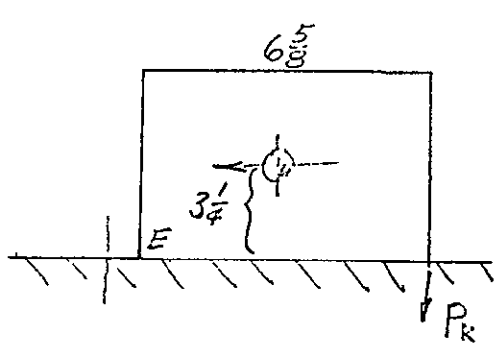


Figure 2.

$$\Sigma M_E = 0 \text{ (Equilibrium of moments about edge, E)}$$

$$(6.5 \text{ pounds}) (87.5 \text{ g}) (3\ 1/4 \text{ inch}) -$$
$$(6\ 5/8 \text{ inch}) \ (2) \ P_R = 0$$

$$P_R = \frac{6.5\ (87.5)(3\ 1/4)}{(6\ 5/8)\ (2)}$$

$$P_R = 140 \text{ lbs.}$$

The screw tensile stress required is:

$$\sigma_R' = \frac{140}{.00909}$$

$$\sigma_R' = 15,400 \text{ psi}$$

which again is less than 40,000 psi (screw preload stress). The safety factor preventing the joint opening is then:

$$S.\ F. = \frac{40,000}{15,400} = 2.8$$

This value is entered in Table I.

Shear Stress

The shear load for both axes is the same if the center of gravity of the unit coincides with the centroid of the mounting screw pattern. Maximum lateral g loads are found in Table II. The shear load induced in each screw by lateral shock is:

$$P_L = \frac{87.5\ (6.5)}{5}$$

$$P_L = 114 \text{ pounds/screw}$$

The corresponding shear stress is:

$$S_S = \frac{114}{.00909}$$

$$S_S = 12,500 \text{ psi}$$

This value if shear stress is used below along with the axial tensile stress to determine if maximum combined stresses.

Combined Stresses

The maximum shear and tensile stresses in the screws are computed on the basis of combined stress. The values of shear stress, computed above, and screw clamping tension, computed in Section 3.3.1.1, are used to compute the maximum tensile and shear stresses to which the screws are subjected. Values of shear and clamping tension are combined as indicated in Reference 5, (pg. 90, Table II, Case 3) to provide values of maximum stresses. Thus, the maximum tensile stress, σ_n, is:

$$\sigma_n = 1/2\, \sigma_t + \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + S_S^{\ 2}}$$

$\sigma_t \sim$ axial tensile stress (40,000 psi)

$S_S \sim$ shear stress (12,500 psi)

$$\sigma_n = \frac{40,000}{2} + \sqrt{\left(\frac{40,000}{2}\right)^2 + (12,500)^2}$$

$$= 20,000 + \sqrt{4 \times 10^8 + 1.56 \times 10^8}$$

$$= 20,000 + \sqrt{5.56 \times 10^8}$$

$$= 20,000 + 23,600$$

$$\sigma_n = 43,600 \text{ psi}$$

The safety factor corresponding to 43,600 is:

$$\text{S.F.} = \frac{120,000}{43,600} = 2.75$$

This value is listed in Table I.

Similarly, the maximum shear stress, S_P, is:

$$S_P = \sqrt{\left(\frac{\sigma_t}{2}\right)^2 + S_S^{\ 2}}$$

$$= \sqrt{\left(\frac{40,000}{2}\right)^2 + (12,500)^2}$$

$$= \sqrt{4. \times 10^8 + 1.56 \times 10^8}$$

$$= \sqrt{5.56 \times 10^8}$$

$$S_P = 23,600 \text{ psi}$$

Inasmuch as shear strength of metals is characteristically greater than half the tensile strength, the yield strength in shear may conservatively be figured as 60,000 psi. The corresponding safety factor is :

$$\text{S.F.} = \frac{60,000}{23,600} = 2.54$$

Which is listed in Table I.

Shear Tear-Out Calculations

The screws tend to pull out through the mounting feet as the result of lateral shock. Figure 3 illustrates the critical areas involved:

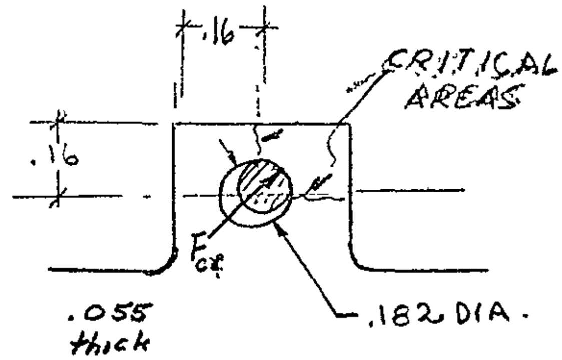


Figure 3

Relative motion is resisted by (1) friction forces between instrument mounting feet and mounting shelf (2) friction forces between instrument mounting feet and the underside of the screw head, and (3) by bearing of the screw on the hole. It is the force exerted by the screw on the hole that produces the stresses tending to tear along the critical areas.

The friction force is computed on the basis of a coefficient of friction, μ, which is taken conservatively as 0.2. The friction force, F_f, then is found from the familiar relation:

$$F_f = \mu N \text{ (for each friction surface)}$$

where N ~ normal force.

The normal force is equal to the clamping force of the screw, 362 pounds, as obtained in 3.3.1.1. Thus, for two friction surfaces:

$$2F_f = (2)\ (.2)\ (362)$$

$$2F_f = 144 \text{ pounds}$$

The strength of the critical areas loaded in shear is the allowable stress times the area.

The allowable shear stress is taken as half the tensile yield strength. For Magnesium ZK 60 A-T5, the minimum tensile yield strength is given in Reference 4, (pg 41, Table II) as 38,000 psi. Half of 38,000 psi is the shear yield strength S_m = 19,000 psi.

The critical area is taken from Figure 3:

$$A_{cr} = \left[(.16 + .16) - .182\right](.055)$$

$$= (.138)(.055)$$

$$= .0076 \text{ inch}^2$$

The maximum force, F_{cr}, allowable on the critical areas is:

$$F_{cr} = S_m A_{cr}$$

$$= (19,000)(.0076)$$

$$= 144 \text{ pounds}$$

Combining the hole strength with the friction force gives the resisting force, F_m, available at each hole:

$$F_m = F_{cr} + F_f$$

$$= 144 + 144$$

$$F_m = 288 \text{ pounds}$$

Table II shows maximum laterally applied load is 569 pounds. Of this, each screw bears shearing force, F_{al}:

$$F_{al} = \frac{569}{5}$$

$$F_{al} = 114 \text{ pounds}$$

The safety factor, therefore, associated with pullout strength is:

$$S.F. = \frac{288}{144}$$

$$S.F. = 2.52$$

This value is listed in Table I.

Note that when the pullout tendency exists on holes along one side of the instrument, the forces on the opposite set of holes are in the other direction relative to the foot thereby preventing possible tear out failure.

3.3.2 Housing Load Calculations

Inertia loads, generated throughout the instrument are carried to the mounting feet primarily through the housing.

The housing's strength derives principally from the side panels. Each panel develops high strength in diagonal tension after buckling, as discussed in Reference 6.

Since the wall thickness is determined by fabrication and handling requirements, it has been shown considerably stronger than necessary for environmental exposure. Consequently an exact analysis has not been attempted here.

For the purpose of the present approximations, the housing is treated as a thin walled box. Loads are transferred from the contents to the "front" edges of the side panels as indicated by the distributed force, P, in Figure 4a, through the front panel and the contents themselves. The applied loads are inertial and are assumed to be uniformly distributed throughout the box representing the housing. This loading condition corresponds to uniform weight distribution and uniform instantaneous local acceleration and is used here as an approximation of actual conditions.

The above loading produces uniform, linearly distributed force, P, which is reacted by diagonal tension, T, in the side panels and which in turn introduces vertical compression in the corners, C, as indicated in the free body diagram of a portion of the front edge, Figure 4b.

Figure 4c, illustrates the forces acting on an element of the reinforced corner. Applying static equilibrium requirements to this element yields force and stress relations among T, P, and C:

where $P \sim$ load per inch of height

$C \sim$ compressive force in edge

$T \sim$ tensile stress in side panel

$\Sigma F_H = 0$ (Equilibrium of horizontal force components)

$$P_{dx} = t\ T \cos\theta\ dx$$

$$P = t\ T \cos\theta$$

where $t \sim$ side panel thickness (.015 inches)

$\theta \sim$ direction of tensile stress T taken as parallel to diagonal (45^o with edges).

$x \sim$ distance from top of box along front edge

Again referring to Figure 4c:

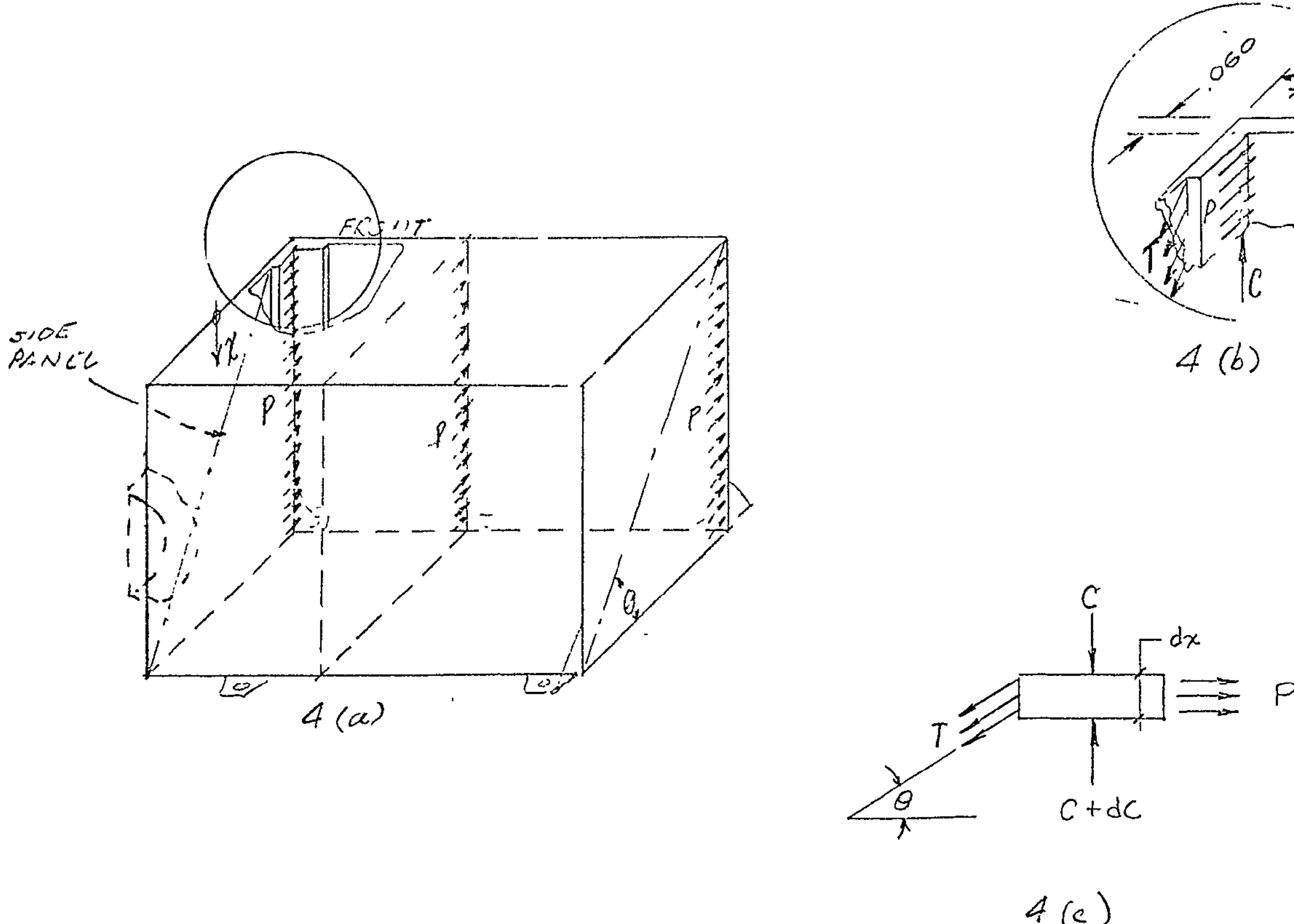

FRONT
SIDE PANEL
P
P
P
θ
4 (a)
.060
.38 TYP
P
T
C
4 (b)
C
dx
P
T
θ
C + dC
4 (c)

FIGURE 4

$\Sigma f_v = 0$ (Equilibrium of vertical force components)

$$(C + dC) - C = t\,T \sin\theta\, dx$$

$$dC = t\,T \sin\theta\, dx$$

$$C_{mx} = \int_0^{C_{mx}} dC = t\,T \sin\theta \int_0^h dx$$

$$C_{mx} = t\,T\,h \sin\theta$$

where $h \sim$ height of side panel (6 inch)

$C_{mx} \sim$ compressive load at bottom of front edge. (pounds)

Combining (1) and (2) yields an expression of C_{mx} in terms of loading P and the geometry:

$$C_{mx} = h\,P \tan\theta \qquad (3)$$

Load carrying capacity may be limited by either (1) tensile stress, T, in the side panel or (2) by compressive stress resulting from C_{mx} at the base of the corner or by (3) buckling of the corner post as a column.

Since all corners and panels are similar, the strength of a typical corner is figured.

3.3.2.1 Tensile Stress Limit in Typical Panel

Tensile stress is limited by the yield strength of the magnesium side panel, 38,000 psi. The tensile stress developed in a panel is given by equation (1), rearranged:

$$T = \frac{P}{t \cos\theta}$$

where P is at most one third of the total lateral inertia load (since at least three panels provide reaction) divided by the height h, of the equivalent box. P is computed first. 569 pounds load is used as the maximum lateral force given in Table II.

$$P = \frac{569}{(3)(6)}$$

$$P = 31.6 \text{ pounds/inch}$$

Knowing the value of P, the tension, T, in the side panel is then:

$$T = \frac{(31.6)}{(.015)(.707)}$$

$$T = 2980 \text{ psi}$$

The safety factor corresponding to tension, T, in the side panels is therefore:

$$S.F. = \frac{38,000}{2,980} = 12.7$$

This value is listed in Table I.

3.3.2.2 Compression Stress Limit of Typical Loaded Housing Edge

Maximum compressive stress results from C_{mx} and occurs at the bottom of the corner post. It is equal to:

$$\sigma_c = \frac{C_{mx}}{A_c}$$

Where A_c is area of the reinforced corner:

$$A_c = (.38)(2)(.06) \quad \text{(See Figure 4b)}$$

$$A_c = .0456 \text{ inches}^2$$

and C_{mx} is given by equation (3):

$$C_{mx} = h\, P \tan\theta$$

$$= (6)(31.6)$$

$$C_{mx} = 190 \text{ pounds}$$

and, therefore:

$$\sigma_c = \frac{190}{.0456}$$

$$\sigma_c = 4170 \text{ psi}$$

The corresponding safety factor is:

$$S.F. = \frac{38,000}{4,170} = 9.1$$

This value is listed in Table I.

3.3.2.3 Stability of Housing Edge as a Column

Corner stability in compression is considered next. The force tending to buckle the corner area is C_{mx}. It is distributed along the front reinforced edge. The corner area approximates a column with built in ends owing to the constraining effect of the top and bottom intersecting edges. A conservative stability estimate results from taking the maximum compressive force, C_{mx}, which in fact exists only at the bottom and considering it to be applied at the top. Reference 5 (page 305, Case 5) provides a basis for computing the buckling strength of such an element. The cross section of the column is an equal leg, 90° angle, .060 inch thick with legs of .38 inch length. The dimensions are shown in Figure 4. The expression for critical load is:

$$P_{cr} = \frac{4 \pi^2 EI}{h^2}$$

where, E modulus of elesticity (6.5×10^{-6} psi)

I moment of inertia of the angle (2.92×10^{-4} inch ^{4}).

h height of box (6 inches)

$$P_{cr} = \frac{(4)\ (9.86)\ (6.5 \times 10^6)\ (2.92 \times 10^{-4})}{36}$$

$$P_{cr} = 2080 \text{ pounds}$$

The corresponding factor of safety is therefore, at least:

$$S.F. = \frac{P_{cr}}{C_{mx}}$$

$$= \frac{2080}{190}$$

$$S.F. = 10.9$$

This value is listed in Table I.

3.4 Natural Frequencies of Structural Members

Calculations were made to determine the resonant frequency of various structural members of the instrument. The equation used is:

$$f_n = 9600 \frac{Kh}{b^2}$$

where: f_n = natural bending frequency (fundamental mode) cps

b = side length (short dimension) inches

a = side length (long dimension) inches

h = plate thickness

The method and equations are taken from Reference 7, Pgs, 139-141.

Back Surface, Center Web and Front Plate

Note: Effect of center screw is neglected in back. Lexan and power supply in front also neglected.

$$a = 6.5$$

$$b = 6$$

All sides clamped - Figure D(Reference 7)

$$\frac{b}{a} = \frac{5}{6.5} = .77$$

$$K = 27$$

$$f_n = 9600 \frac{Kh}{b}$$

Assume $h = .040$

$$f_n = \frac{9600\ (27)\ (.04)}{5^2}$$

$$f_n = 415 \text{ cps}$$

Side Areas

One is 3-1/2" x 5", and the other is 3" x 5".

Assume $a = 5$

$$b = 3$$

$$\frac{b}{a} = \frac{3}{5}$$

$$f_n = 9600 \frac{Kh}{b^2} \qquad \text{where } K = 26$$

$$f_n = \frac{9600\ (26)\ (.04)}{3^2}$$

$$f_n = 1110 \text{ cps}$$

$a = 5$

$b = 3.5$

$\frac{b}{a} = \frac{3.5}{5} = .7$

$f_n = 9600 \frac{Kh}{b^2}$ where $K = 27$

$= \frac{9600 (27) (.04)}{3.5^2}$

$= 844$ cps

Harness Cover Effects of Screw and Stiffener Neglected.

$a = 6.510$

$b = 6.250$

$h = 0.040$

$\frac{b}{a} = \frac{6.250}{6.510} = .96$

$f_n = \frac{9600 \; Kh}{b^2}$ where $K = 14.26$ (edges simply supported)

$= \frac{9600 (14.26) (.04)}{6.250^2}$

$f_n = 140$ cps

Resonant frequency of the Front Cover

Resonant frequency of the front cover is computed using the Rayleigh Method as discussed in Reference 8 (pgs 63 & 89). Static deflection is from Reference 5 (pg. 203 case 37).

Assume cover is 6.5' x 6.0' and 0.040' thick magnesium. Assume the suspended parts weigh 1/2 pound and are a point load at the center.

$$y_{max} = \frac{0.203 \; Wb^2 \; (m^2-1)}{m^2 Et^3 \; (1+ 0.462 \; ^4)}$$

$W = 1/2$ lb.

$b = 6''$

$a = 6.5''$

$\alpha = \frac{b}{a}$

$$\alpha = \frac{6}{6.5} = 0.925$$

$$t = 0.040''$$

$$m = \frac{1}{\gamma} = \frac{1}{0.3} = 3.33$$

$$m^2 = 11.1$$

$$E = 6.5 \times 10^6$$

$$y_{max} = \frac{0.203\ (0.5)\ (6)^2\ (11.1 - 1)}{11.1\ (6.5)\ 10^6\ (0.04)^3 \left[1 + 0.462\ (0.732)\right]}$$

$$= \frac{-0.203\ (0.5)\ (.36)\ (10-1)}{11.1\ (6.5)\ 10^6\ (64)\ 10^{-6} \left[1.\ \ 338\right]}$$

$$y_{max} = -0.00597$$

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{y_{max}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{386}{0.00597}}$$

$$f = \frac{1}{2\pi}\sqrt{64800}$$

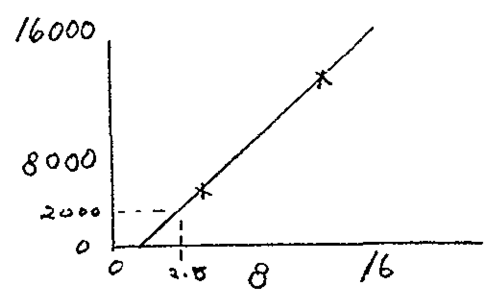
$$f = \frac{254}{2\pi}$$

$$f = 40.4 \text{ cps}$$

Note: No credit given to stiffening of the Lexan.

Resonant Frequency of Foamed Blivet

<u>Effect of Foam</u>



X are catalog data for Eco-Foam. It is proposed to use the foam at a density of 2 to 3 lbs/ft.^{3} for which modulus of elasticity data is not included in the catalog.

Assume foam is 0.55 thick

$$y_{max} = \frac{-0.0284 \; wb^{4}}{Et^{3} \; (1 + 1.056^{5})}$$

Et^3 is essentially a moment of inertia type term. Since this now becomes a composite type of section an equivalent moment of inertia term must be found

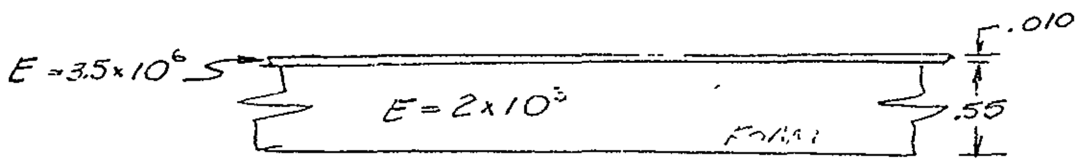


FIGURE 5

If no bond exists between the foam and the epoxy-glass, the Et^3 products become additive.

$$y_{max} = \frac{-0.0284 \; wb^{4}}{\left[E_1 t_1^{3} + E_2 t_2^{3}\right] \; (1 + 1.056^{5})}$$

See Paragraph where resonant frequency without foam is calculated.

$w = 0.0113$

$\alpha = 0.719$

$b = 2.3$

$\alpha^5 = 2.3$

$$y_{max} = \frac{-0.0284 \; (0.0113) \; (2.3)^4}{\left[(3.5 \times 10^6) \; (0.01)^3 + (2 \times 10^3) \; (0.55)^3\right]\left[1 + 1.056 \; (0.192)\right]}$$

$$= \frac{-0.0284 \; (0.0113) \; (2.3)^4}{[3.5 + 332] \; [1.203]}$$

$$= \frac{-0.0284 \; (0.0113) \; (28)}{(335.5) \; (1.203)}$$

$$y_{max} = 2.24 \times 10^{-5}$$

The resonant frequency

$$f_n = \frac{1}{2\pi}\sqrt{\frac{g}{\Delta}}$$

$$f_n = \frac{1}{2\pi}\sqrt{\frac{386}{2.24 \times 10^{-5}}}$$

$$f_n = \frac{1}{2\pi}\sqrt{17.25 \times 10^{6}}$$

$$f_n = \frac{10^3}{2\pi} \quad (4.15)$$

$$f_n = 661 \text{ cps}$$

APPENDIX IV

HEAT TRANSFER ANALYSIS

1.0 INTRODUCTION

The ARC Plasma Probe shall have adequate heat transfer characteristics such that the internal and external heat load is dissipated within the requirements of the instrument specification after launch. The following calculations show that the instrument does satisfy the requirements. Refer to NASA/ARC Interface Specifications PC-121.00 and PC-121.01 and Marshall Laboratories TN 3000.368.

2.0 HEAT TRANSFER CRITERIA

The experiment is mounted on a shelf which is maintained at 60°F ± 30°F. Radiation existing within the space probe will be to and from surfaces at 60°F ± 30°F. The emittance of these surfaces in the infrared range is 0.5.

The experiment will have a small portion exposed to the sun's energy. The heat received is listed below (assumes perfect black body):

Table I

Sun Thermal Heat

Distance from the sun, A.U.	Energy gains and losses. Watts per square inch of opening.
0.8	0.188
1.0	0.0305
1.2	-0.055

Note: Positive numbers indicate net flow of energy into spacecraft.

The allowable heat load on the mounting shelf shall be the algebraic sum of the internally generated energy of the experiment and the net absorbed external energy and shall be:

1. Not less than -1.0 watts per instrument, or

2. Not greater than 0.2 watts per square inch of the instrument mounting area.

The maximum allowable instrument internal power dissipation is 3 watts with the instrument mounting area of 44 inches ^{2} and the instrument area exposed to incoming radiation being 8.4 inches ^{2}

3 0 CALCULATIONS

Using the known heat transfer requirements and expected thermal loading, the following tabular calculations were made to ascertain the heat loading upon the instrument shelf.

Heat in or out from sun watts	Internal Power Dissipation Watts	Σ	$\frac{\text{Watts}}{\text{Inches}^2} = \Sigma/44$
0.188 (8.4)= +1.58	3.4	+4.98	0.114
0.0305 (8.4)=+0.256	3.4	+3.656	0.083
-0.055 (8.4)=-0.462	3.4	+2.938	0.0667

Table II

Heat Transfer Calculations

4.0 CONCLUSIONS

It should be noted that in the heat transfer calculations, an emittance of 1 was assumed for the surface receiving heat from the sun. This is a worst case for both the plus and minus conditions. Since the calculated values are well within the specification requirement ($\Sigma > -1.0$ watts; $\frac{\Sigma}{A} < 0.2$ watts/in^2) no special efforts to control the emittance of the surfaces should be required.

APPENDIX H

Shroud Heating Analysis

SHROUD HEATING ANALYSIS

3.0 DISCUSSION AND CALCULATIONS

3.1 Purpose

The objective of these calculations is to determine if any portion of the experiment will be damaged from "shroud" heating during launch. In this experiment of the most temperature sensitive element may be permanently damaged if a temperature of +85°C (+185°F) is exceeded.

3.2 Shroud Temperature Curve

The heat comes in the form of radiation from the shroud (it is assumed that because of altitude, convection may be neglected). The time temperature history of the shroud in the region of this experiment is plotted in Figure 1.

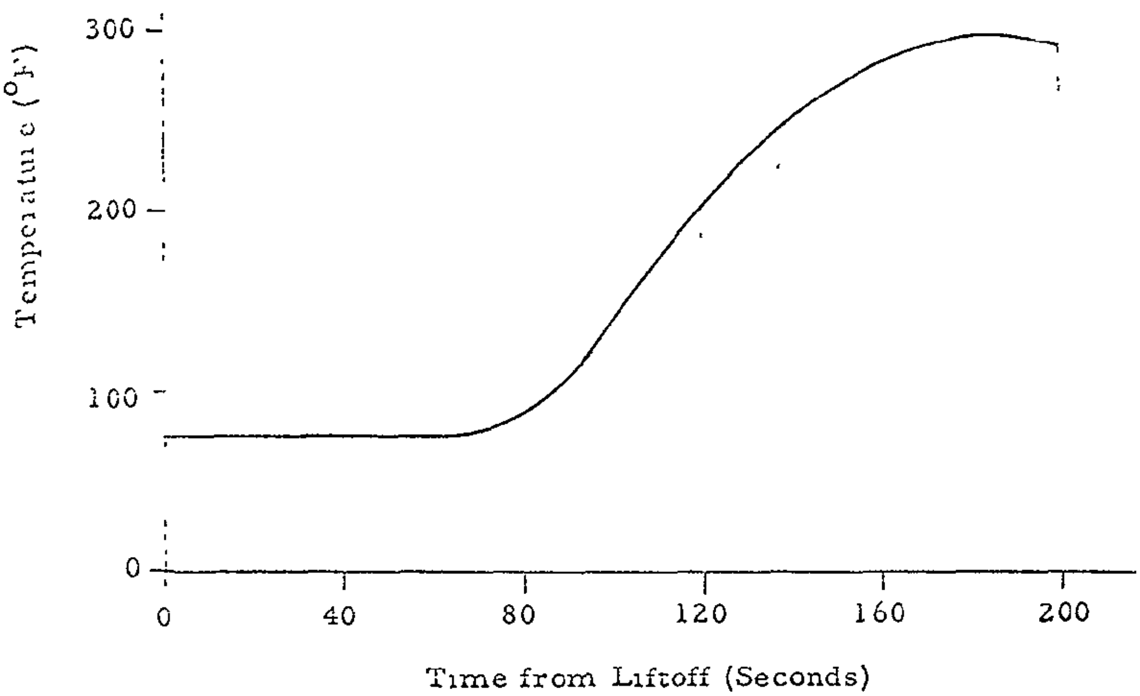


Figure 1. Shroud Temperature Curve

3.3 Area Exposed to Shroud Radiatic

The experiment is mounted with ly a small area exposed to the shroud radiation, the rest being shielded by the spacrcraft's outer skin. It is assumed that a 1/2 inch clearance exists between the experiment and the skin.

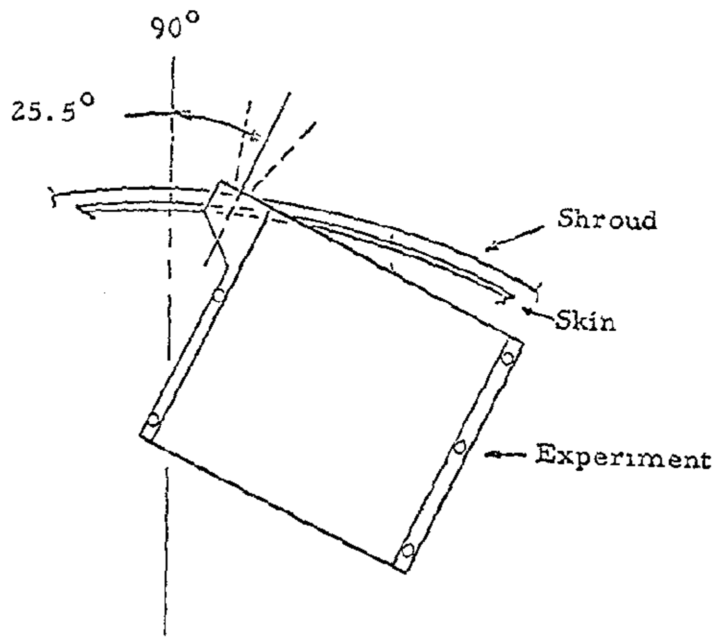


Figure 2. Instrument Mounting

3.4 Area Receiving Radiation

The area being calculated perpendicul - to the radiation with the 25 1/2° taken into account and based upo. .ne dimensions of drawing 51448.

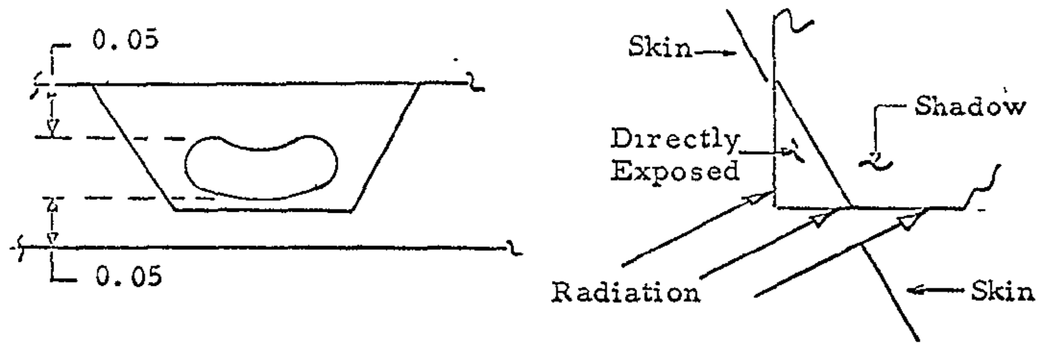


Figure 3. Area Receiving Radiation

$$\text{Area} = \left(1.22 \times 3.12\right) + 2\left(\frac{1.22}{2}\right)(0.75)$$

$$+ \pi (1.56)\ (0.75)$$

$$= 3.8 + 0.915 + 3.67$$

$$= 8.385 \text{ inches}^2$$

$$= 0.0583 \text{ feet}^2$$

3.5 Approximation Criteria

The safeness of the design will be proven if it can be shown that the hottest spot in the experiment, which must be the surface receiving the radiation from the shroud, is always below the critical temperature of +85°C (+185°F).

Certainly a worst case would be : he highest shroud temperature ($+295^{\circ}F$) was a steady state condition and if e heat sink (mounting shelf) was at its highest temperature ($+90^{\circ}F$) and if al e heat received had to be conducted to the shelf through the housing (. wing 51148). The thermal conduction of the inner portions of the experiment and the thermal inertia of the entire experiment would be neglected. This approach will be used as the approximation.

3.6 Thermal Conductive Path Calculations

The following calculations were made to find the "thermal resistance" of the conductive paths of the instrument to dissipate the shroud heating radiation:

Thru Cover - Material AZ 31B - H24 sheet 0.040 inch thick.
Plated on both sides with 0.001 inch thick copper
0.001 inch thick silver
0.00005 inch thick gold

mean path length 4.5 inches (scaled from
mean path width 3.3 inchs drawing 51148)

Thru Housing -

mean path length 3 inches
mean path width 6.5 inches
mean path thickness 0.020 inch

Thermal Conductivity (k) (P.A.-1, Ref.)

Magnesium	92	$BTU/Hr\ Ft^2\ (^{\circ}F/Ft)$
Silver	238	
Copper	224	
Gold	169	

$$q = \frac{-kA \Delta T}{L} \quad \text{or}$$

$$q = \frac{\Delta T}{\left(\frac{L}{kA}\right)}$$

where $\frac{L}{kA}$ ca be thought of as an analogous thermal resistance.

In this problem, the "thermal resistances" will be evaluated and then treated as a series-parallel circuit where the resistances of the cover will be in parallel with each other (base metal plus plating) and will be in series with the housing.

Cover

Magnesium -

$$\text{Area} = \frac{0.040 \times 3.3 \text{ Ft}^2}{12^2}$$

$$\text{Length} = \frac{4.5}{12}$$

$$\frac{L}{kA} = \frac{4.5}{12} \frac{(12^2)}{(0.040)(3.3)(92)}$$

$$\frac{L}{kA} = 4.46$$

Copper -

$$\text{Area} = \frac{(0.001)(3.3)}{12^2}$$

$$\text{Length} = \frac{4.5}{12}$$

$$\frac{L}{kA} = \frac{4.5}{12} \frac{(12^2)}{(0.002)(3.3)(224)}$$

$$\frac{L}{kA} = 36.5$$

Silver -

$$\text{Area} = \frac{(0.001)(3.3)}{12^2}$$

$$\text{Length} = \frac{4.5}{12}$$

$$\frac{L}{kA} = \frac{4.5 \, (12^2)}{12\,(0.002)\,(3.3)\,(238)}$$

$$\frac{L}{kA} = 34.3$$

<u>Total Resistance for the Cover</u>

$$\frac{1}{R\ \text{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \qquad \text{or}$$

$$\frac{1}{R\ \text{Total}} = \frac{1}{4.46} + \frac{1}{36.5} + \frac{1}{34.5}$$

$$\frac{1}{\frac{L}{kA}} = 0.224 + 0.0274 + 0.029$$

$$\frac{1}{\frac{L}{kA}} = 0.2804$$

$$\frac{L}{kA}\ \underset{\text{Cover}}{\text{Total}} = 3.57$$

Resistance for the Housing

Magnesium -

$$\frac{L}{kA} = \frac{3 \quad \left(12^2\right)}{12\ (0.020)\ (6.5)\ (92)}$$

$$\frac{L}{kA} = 3.01$$

Copper -

$$\frac{L}{kA} = \frac{3 \quad \left(12^2\right)}{12\ (0.001)\ (6.5)\ (224)}$$

$$\frac{L}{kA} = 24.7$$

Silver -

$$\frac{L}{kA} = \frac{3 \quad \left(12^2\right)}{12\ (0.001)\ (65.)\ (238)}$$

$$\frac{L}{kA} = 23.3$$

$$\frac{1}{\frac{L}{kA}_{\text{Total Housing}}} = \frac{1}{3.01} + \frac{1}{24.7} + \frac{1}{23.3}$$

$$= 0.332 + 0.0405 + 0.043$$

$$= 0.415$$

$$= 2.41$$

<u>Resistance for the Housing and Cover in Series</u>

$$\frac{L}{kA}_{Total} = 2.41 + 3.[illegible] = 5.98$$

3.7 Heat Balance Calculations

A heat balance will now be established by assuming a temperature for the cover, calculating the radiant energy received at that temperature and also calculating the heat conducted to the mounting shelf from the cover at that same temperature.

$$q = \frac{T_2 - T_3}{\frac{L}{kA}} \qquad \text{Conduction}$$

$$q = (A)(\sigma)(F_{AE})(T_1^4 - T_2^4) \qquad \text{Radiation}$$

A = Area (Ft^2)

F_{AE} = Shape and Emissivity Factor

σ = Stefan-Boltzman Constant

$\sigma = 0.173 \times 10^{-8}$ BTU/Hr Ft^2 ^oR

q = Heat Transfer Rate $\frac{BTU}{Hr}$

To find F_{AE}, assume the emissivity of both surfaces ≈ 0.9 and treat as essentially two parallel surfaces.

$$F_{AE} = \frac{1}{\frac{1}{E_1} + \frac{1}{E_2} - 1}$$

$$F_{AE} = \frac{1}{\frac{1}{0.9} + \frac{1}{0.9} \quad -1}$$

$$F_{AE} = \frac{1}{1.11 + 1.11 \quad -1}$$

$$F_{AE} = \frac{1}{1.22}$$

$$F_{AE} = 0.82$$

$$q = A \left(F_{AE}\right)\left(T_1^4 - T_2^4\right)$$

$$q = (0.0583)\,(0.173 \times 10^{-8})\,(0.82)\,(T_1^4 - T_2^4)$$

$$\text{for } T_1 = 295^{\circ}F = 755^{\circ}R$$

$$q = 8.3 \times 10^{-11} \left(3{,}200 \times 10^{8} - T_2^4\right)$$

T_2 °F	T_2 °R	T_2^4	3200×10^8 $-T_2^4$	q (BTU/Hr)
90°	550	900×10^8	2.30×10^{11}	19.1
110°	570	1050×10^8	2.15×10^{11}	17.8
130°	590	1250×10^8	1.95×10^{11}	16.2
150°	610	1400×10^8	1.80×10^{11}	14.9
170°	630	1550×10^8	1.65×10^{11}	13.7
190°	650	1800×10^8	1.40×10^{11}	11.6

TABLE I

Radiation Tabulations

$$q = \frac{T_2 - T_3}{\frac{L}{kA}} \qquad \text{Conduction}$$

$$q = \frac{T_2 - T_3}{5.98}$$

$$q = \frac{T_2 - 90}{5.98}$$

T_2 °F	$T_2 - 90$	$\frac{T_2 - 90}{5.98} = q$ (Conduction)
90	0	0
110	20	3.35
130	40	6.70
150	60	10.05
170	80	13.40
190	100	16.75
210	120	20.10
230	140	23.40

TABLE II

Conduction Tabulations

A plot was made from the conduction and radiation calculations to ascertain the maximum equilibrium temperature at which the instrument would be subjected to during launch. See Figure 4.

From the plot of conduction and radiation, the maximum equilibrium temperature is + 170°F. This is below the temperature (+185°F) at which various components used in the instrument would start to be affected by the aerodynamic heating during launch of the space vehicle and, therefore, no additional testing is required to ascertain the instrument's ability to withstand the shroud heating effects.

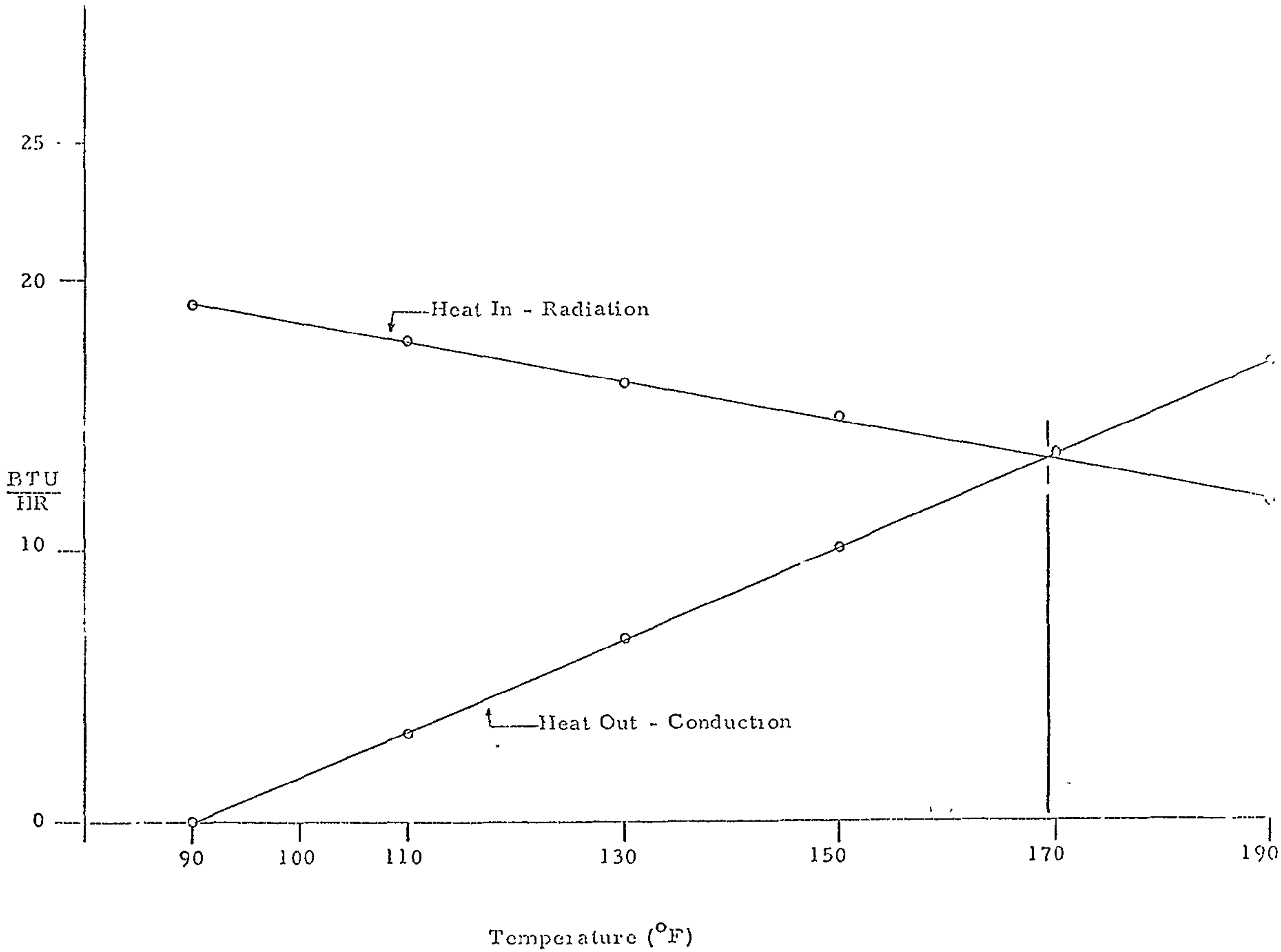


Figure 4 Heat Balance

APPENDIX I

GSE Circuit Analysis

Integrated circuits are used extensively in the GSE to improve system reliability. Marshall Laboratories standard modules are used for oscillators, drivers, interface circuits, and other special purpose applications for which there are no integrated circuits readily available.

Individual integrated circuit flip flops are used for all flip flop applications in the Simulator unit. These devices are Texas Instrument Corp., 7300 Series networks which have the following basic characteristics:

Power Supply	-	3 to 4 v dc
Maximum Toggle Rate	-	4 mhz
Fan out	-	10
Noise Margin	-	300 mv
Output Impedance	-	50 ohms
Average Power Dissipation	-	40 mw

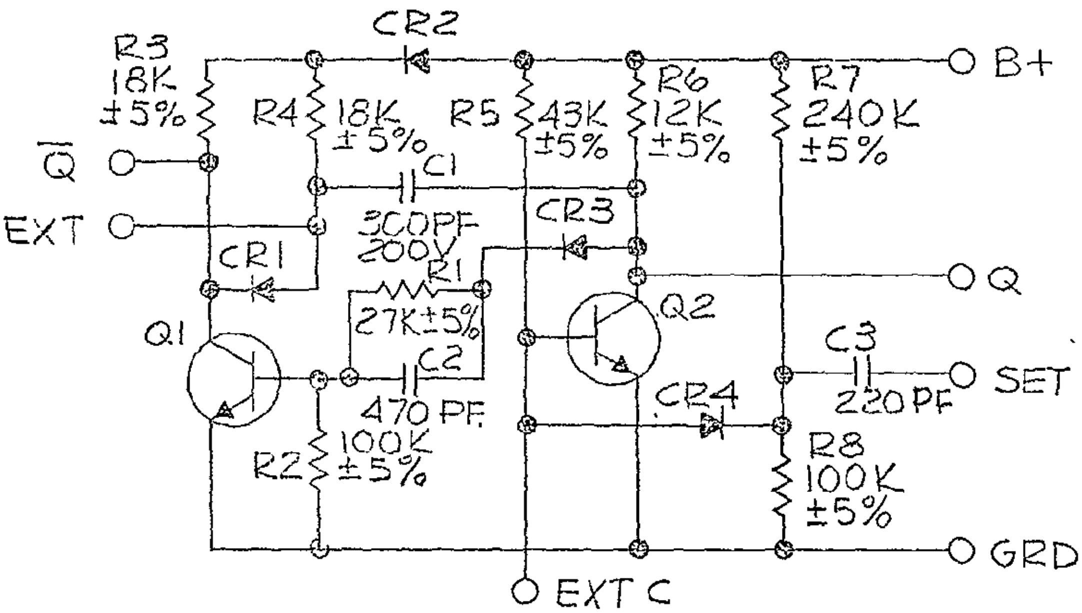
The monitor and control unit utilizes a family of integrated circuit boards manufactured by the Computer Logic Corporation. These boards utilize modified Fairchild logic flip-flops and Texas Instrument 7300 Series gates. The flip-flops have the following basic characteristics:

Power Supply	-	4.0 V $\pm$ 0.2 V
Maximum Toggle Rate	-	2.0 mhz
Fan out	-	30
Noise Margin	-	1.2 V
Output Impedance	-	120 ohms
Average Power Dissipation	-	132 mw

Since all integrated circuits used are standard, off-the-shelf purchased components, no detailed circuit analysis will be performed on these elements. Worst - worst case (worst case tolerances with end-of-life values imposed) analysis for each of the ML designed modules used in the GSE is provided in the following paragraphs.

WORST CASE ANALYSIS FOR W4193 ONE SHOT MODULE

Schematic W4193 Module



One Shot Circuit

All diodes are TI 01295.

For Q_1 and Q_2 $h_{ft\ min}$ = 5 (for worst, worst case = .5)

$B_T = 6$ volts

$I_{C1} = 6/18 \times 10^3 = 334\ \mu a$ $\quad I_{B1} = \frac{334}{25} = 13.3\ \mu a$

Turn on: $\frac{V_{T\ min} - V_{BE\ max}}{R_2\ (1 + \gamma)} - \frac{V_{BE\ max} - V_b\ (1 + v)}{R_1\ (1 \quad \gamma)} \quad I_{B1}$

Turn off: $\frac{V_{CO} - V_b\ (1 - v)}{R_1\ (1 + \gamma)} - \frac{V_{\ max} - V_{CO}}{R_2\ (1 - \gamma)} \quad I_{CBO}$

Turn on (Q_1) $\frac{V_{T\ min} - V_{BE\ max}}{R_2\ (1 + \gamma)} - \frac{V_{BE\ max} - V_b\ (1 + v)}{R_1\ (1 + \gamma)} \quad I_{B1}$

$$= \frac{4 - 0.8}{100\ (1.1) \times 10^3} - \frac{0.8 - 8\ (1.1)}{27\ (0.9) \times 10^3} \geq I_{B1}$$

$$= \frac{3.2}{110 \times 10^3} + \frac{(-5.4)}{24.3 \times 10^3} \geq I_{B1}$$

$$= 29\ \mu a + 195\ \mu a \geq 13.3\ \mu a$$

or $\underline{254\ \mu a \geq 13.3\ \mu a}$

Turn on: (Q_2)

$$\frac{4 - 0.8}{43\ (1.1) \times 10^3} - \frac{0.8 - 6\ (1.1)}{\infty} \geq I_{B2}$$

$$= \frac{3.2}{47.3 \times 10^3} - 0 \geq I_{B2}$$

$$= 68\ \mu a \geq I_{B1}$$

$$I_{C(Q_2)} = 6/12 = 500\ \mu a$$

$$\therefore I_{B2} = \frac{500}{25} = 20\ \mu a$$

$\underline{68\ \mu a \geq 20\ \mu a}$

Turn Off: (Q_1)

$$\frac{V_{CO} - V_b\ (1 - v)}{R_1\ (1 + \gamma)} - \frac{V_{F\ max} - V_{CO}}{R_2\ (1 + v)} \geq I_{CBO}$$

$$= \frac{1 - 6\ (0.9)}{27\ (1.1) \times 10^3} - 0 \geq I_{CBO}$$

$$= \frac{-4.4}{29.7 \times 10^3} \geq I_{CBO}$$

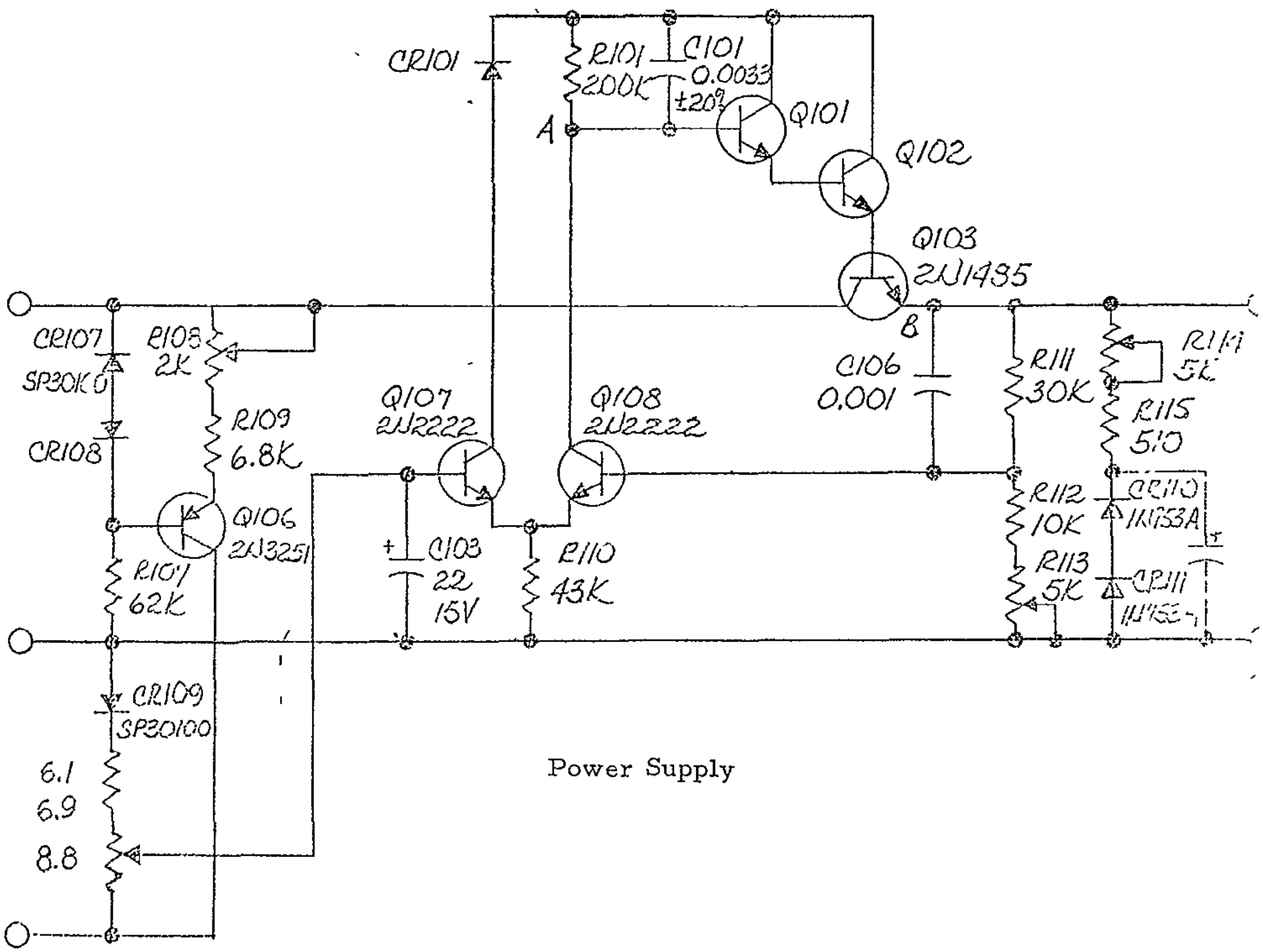
$$= -150\ \mu a \geq I_{CBO}$$

$$I_{CBO} = 10\ \mu a$$

$\underline{150\ \mu a \geq 10\ \mu a}$

WORST CASE ANALYSIS FOR GSE SIMULATOR POWER SUPPLY

Marshall Laboratory Drawing No. 544901

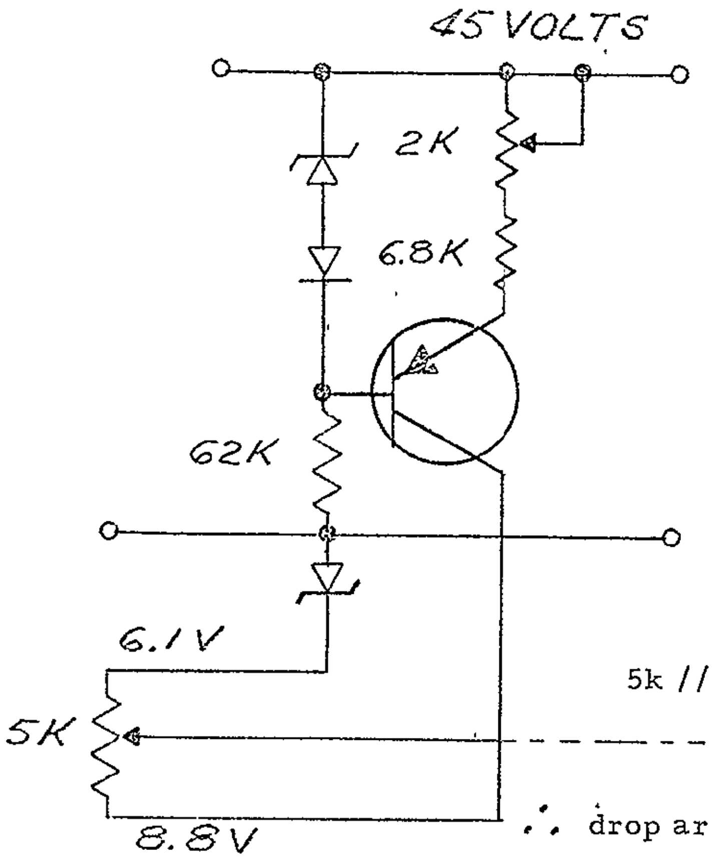


Power Supply

$$\text{Voltage at base} = \frac{18}{297}\ 40 = 2.4 \text{ volts}$$

$$\text{Current in base} = \frac{1.8}{79\text{ k}} \quad \frac{40}{29.7\text{k}} = \frac{1.8 \times 1.34 \text{ ma}}{79} = 30\ \mu\text{a}$$

$$I_C = 80 \times 30 = 2400 \times 10^{-6} = \underline{2.4 \text{ ma}}$$



$45 - 9 = 36V$

$I_C = \frac{36}{8.8} = 4$ ma

Voltage at Y = 45-6.5 = 38.5 volts

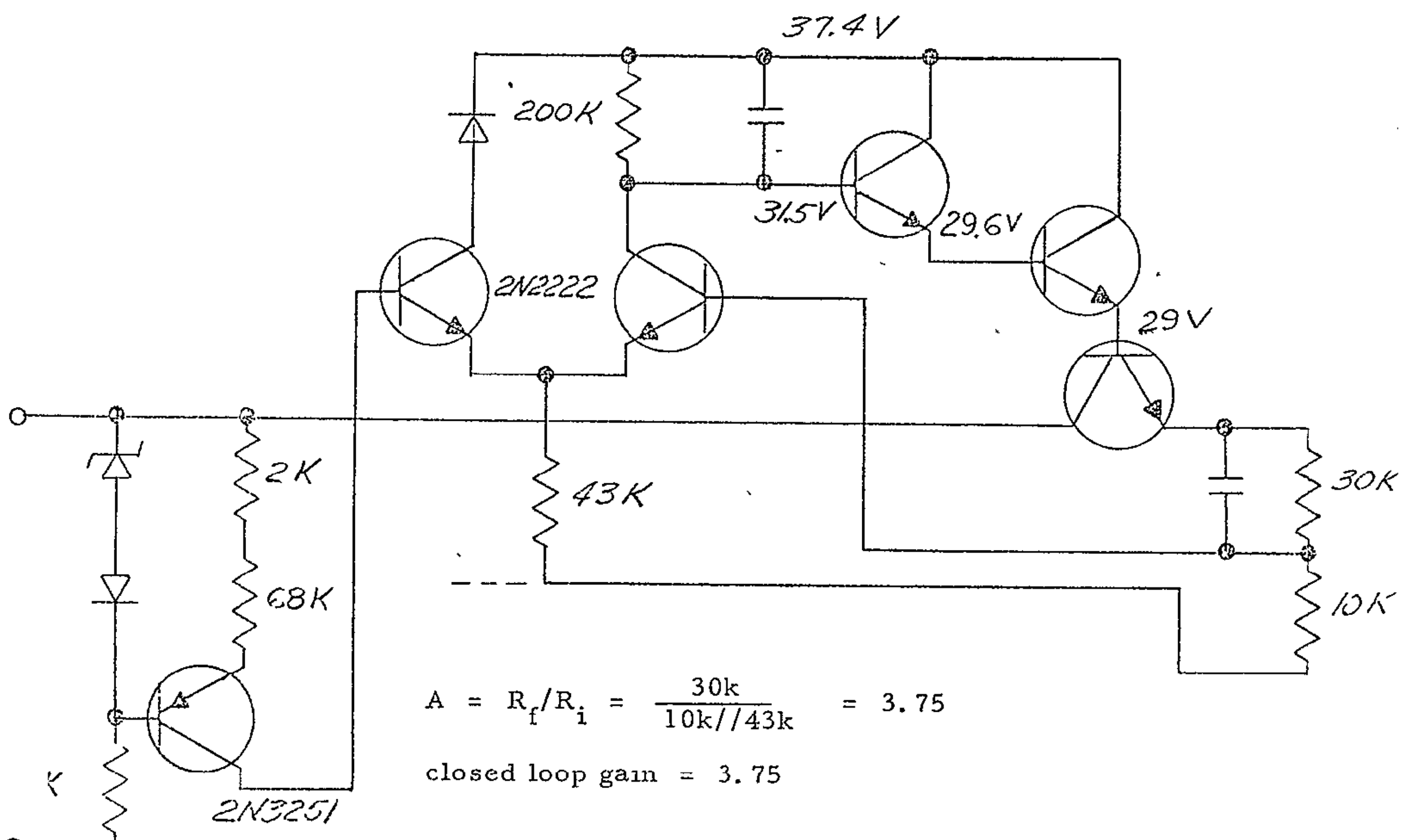
Voltage at Z = 37.9 volts

$I_E = \frac{45 - 37.9}{6.8k} = \frac{7.1}{6.8k} = 1$ ma

5k // 43k = .90 ma through 5k Pot

$\frac{5k43}{48} = 2.45$ k

$\therefore$ drop areas resistor = 2.45 x 1 ma = 2.45v + 6.1 = 8.55



$A = R_f/R_i = \frac{30k}{10k//43k} = 3.75$

closed loop gain = 3.75

As first approximation:

current through 10 Ω = 150 ma

current through base of 2N1485 = $\frac{150}{50}$ = 3 ma

current through the base of Q_1 = $\frac{3 \text{ ma}}{60}$ = 50 ma

voltage at base = 8.2 x 3 = 24.6 volts

Current through emmitter = $\frac{6}{43 \times 10^3}$ = 1.4×10^{-4}

= 140 μa

This current is equally divided between emitter legs of the two diff-amp transistors.

Therefore current through each leg = 70 μa

Voltage drop across 200 k = $2 \times 10^5 \times 7 \times 10^{-5}$
= 14 volts

Voltage at point A = 38-14 = 24 volts

V_{BE} drops across Darlington pair: 1.2 volts (for both transistors).

∴ Base drive = 30.6 - 1.4 = 29.2 volts

∴ Voltage at B = 29 volts

Maximum V_{BE} drop of Q_3 and Q_4 = 0.90 volts

Minimum β = 15

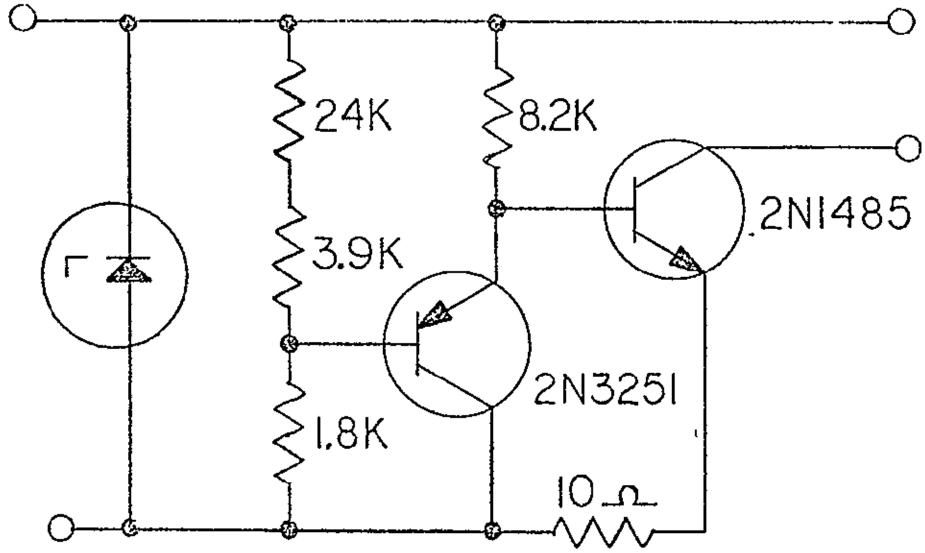
Maximum V_{BE} of Q_1 and Q_2 = 1.3 volts

Minimum V_{be} of Q_5 = 1 volts at I_B = 20 ma

6.9 - 1.3 = $\frac{5.6}{43}$ = 130 ma

∴ current through each emitter leg of Q_1 and Q_2 = $\frac{130}{2}$ = 65 μa

Voltage drop across 200k = 200 x 65 = 13.0 volts.



$$5.8 \times \frac{1.8}{5.7} = 1.8 \text{ v}$$

$I = 5.8/5.8 = 1 \text{ ma}$

Assume $B = 60$ in worst case

Worst case I_C (when transistor is saturated)

$I_C = 40/8.2 = 5 \text{ ma}$

$$I_B = \frac{5 \text{ ma}}{50} = 100 \ \mu a$$

$V_1 = 1.8 \text{ v}$

$V_2 = 1.8 + .8 = 2.6 \text{ volts}$

$2.6 = 0.8 + IR$

$IR = 1.8 \text{ volts}$

$1.8 = 10 I$

$I = 180 \ \mu a$

Voltage at output = 44.6 = 13 = 31.6 volts.

Voltage drop across Q_3 and Q_4 = .9 x 2 = 1.8

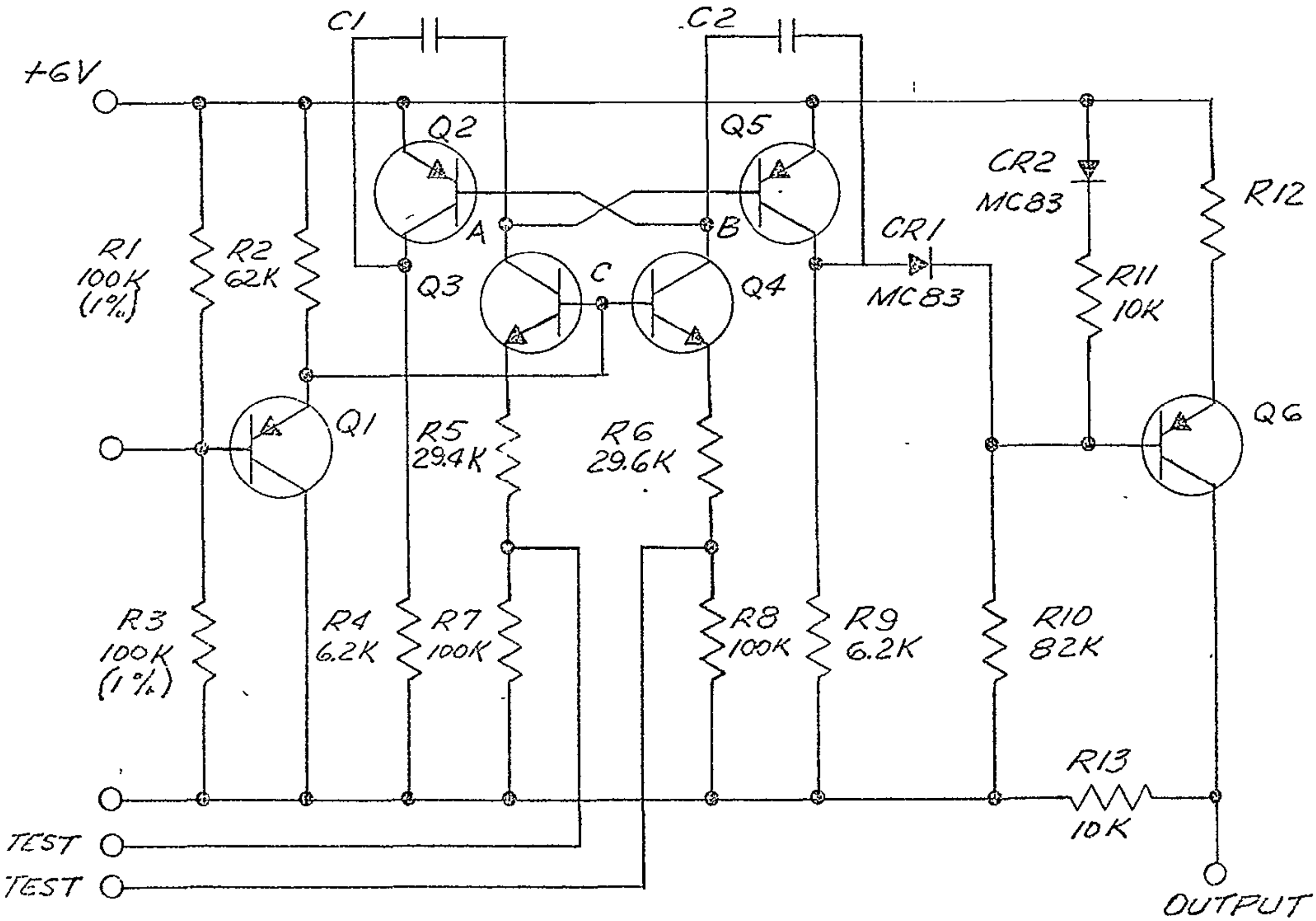
Voltage at base of Q_5 = 31.6 - 1.8 = 29.6

Voltage at B = 29.6 - 1 = <u>28.6 V</u>

Current at base of Q_5 = $(65 \times 10^{-6})(15)^2$

+ <u>14.8 ma</u>

WORSE CASE DESIGN ANALYSIS FOR W4209 OSCILLATOR MODULE



Electronic Schematic Oscillator

Voltage at Point A = 3 volts

Voltage at Point B = 3.60 volts

$$I_C = \frac{6.0 - 3.6}{62 \times 10^3} = \frac{2.4}{62 \times 10^3} = 0.38 \text{ ma}$$

$$I_B = \frac{0.38}{80} \approx 5 \ \mu a$$

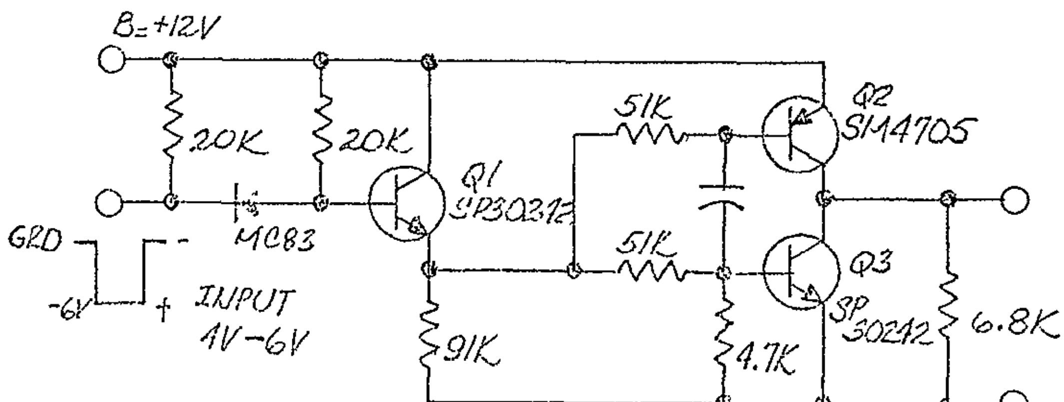
Reference voltage at C = 3.8 volts

Therefore the voltage at the base of Q_3 and Q_4 is 3.8V.

Q_2 and Q_5 act as the switching elements for charging capacitors C_1 and C_2 on alternate cycles. Q_3 and Q_4 form the constant current paths for discharging capacitors C_1 and C_2. With 3.8v at bases of Q_3 and Q_4, the capacitor discharge current is determined by $\frac{V_B - V_{BE}}{R_k}$ or $\frac{3.2 - .8}{129.4 \text{ k}} = .023$ ma. Assurance C_2 is initially charged to 2 V_{cc} volts (Q_2 is Off, Q_5 is On). C_2 will discharge through Q_4 until point B (Q_2 base reaches 5.2 volts ($V_{cc} - V_{be}$). At this point Q_2 will turn on, causing a step impulse to 12 v through C_1 to Point A to cutoff Q_5. With Q_5 off Q_2On, capacitor C_1 will discharge through Q_3 until it reaches 5.2 volts to turn Q_5On, Q_2 Off, thus creating the oscillitory condition of the circuit. The period of oscillation is determined by $t = \frac{V_C}{i}$

where i = constant and V = $2V_{cc}$ ($V_{cc} - V_{be}$). For 1638 cps, t = 30 µsec, V = 6.8 volts: $C = \frac{t/n\,i}{V} = 270$ pf.

WORST CASE ANALYSIS OF W4203 DRIVER MODULE



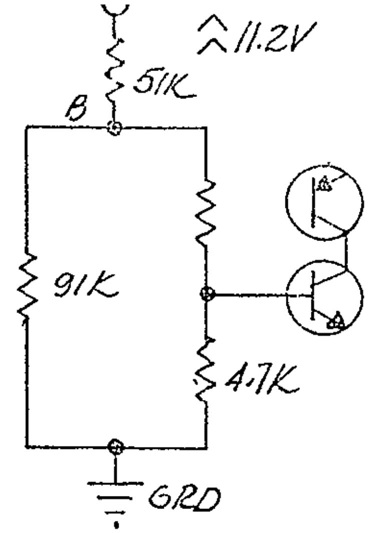
SP 242

Max V_{BE} = 0.8v

H_{fe} = 25 - 200

$V_{CE(Sat)}$ = 0.2v

With ground or negative voltage input, Q_1 goes off, Q_2 is on, Q_3 is off at the output we get a 12 volts signal. When input signal is positive, Q_1 and Q_3 are on, Q_2 is off and output is at ground.



91//55.7 = 35K

voltage at B

$$\frac{35}{86} \times 11.2 = 4.55\text{v}$$

voltage at C

$$\frac{4.7}{55.6} \times 4.55 = 0.385 \text{ volts}$$

Turn on for Q_3

$$\frac{0.385\text{v} - .8}{4.7\ (1.1)\ \text{k}} - \frac{0.8 - 12\ (1.1)}{57\ (0.9)\ \text{k}} \geq I_{B1}$$

$$\frac{-0.42}{5.17\text{k}} + \frac{12.4}{46.3\text{k}} \geq I_{B1}$$

$$-.008 + .275 \geq I_{B1}$$

$$0.267 \text{ ma} \geq 0.2 \text{ ma}$$

Turn on for Q_1:

$$\frac{4 - 0.80}{22} + \frac{12.4}{18} \geq I_{B1}$$

$$\frac{3.2}{22} + \frac{12.4}{18} \geq .2 \text{ ma}$$

$$0.145 + 0.695 \geq .2 \text{ma}$$

$$0.840 \geq 0.2 \text{ ma}$$

Turn off condition S

$$\frac{V_{CO} - V_b\ (1-b)}{R_1\ (1+\gamma)} - \frac{V_{F\ max} - V_{CO}}{R_2\ (1+\gamma)} \geq I_{CBO}$$

$$\frac{1 - 10.8}{22} - \frac{(-2) - 1}{18} \geq I_{CO}$$

$$\frac{-9.8}{22} + \frac{3}{18} \geq I_{CO}$$

$$-.445 \text{ ma} + .166 \geq I_{CO}$$

$$.28 \text{ ma} \geq 10 \text{ ma}$$

Turn off condition S:

For Q_1

$$\frac{V_{CO} - V_b (1 - b)}{R_1 (1 + \gamma)} - \frac{V_{F\,max} - V_{CO}}{R_2 (1 + \gamma)} \geq I_{CBO}$$

$$\frac{1 - 10.8}{22} - \frac{(-2) - 1}{18} \geq I_{CO}$$

$$\frac{-9.8}{22} + \frac{3}{18} \geq I_{CO}$$

$$-.445 \text{ ma} + .116 \geq I_{CO}$$

$$\underline{.28 \text{ ,a} \geq 10\ \mu a}$$

For Q_3

$$\frac{-9.8}{56} + \frac{3}{42} \geq I_{CBO}$$

$$-.175 + .72 \geq 10\ \mu a$$

$$-.54 \geq 10\ \mu a$$

Turn off for Q_2

$$\frac{V_{CO} - V_b (1 - \gamma)}{R_1 (1 + \gamma)} - \frac{V_{F\,max} - V_{CO}}{(1 + \gamma)} \geq I_{CBO}$$

$$\frac{1 - 0}{0} - \frac{11.8 - 1}{84 \text{ k}} \geq 10\ \mu a$$

$$128\ \mu a \geq 10\ \mu a$$

Turn on for Q_2

$$\frac{V_{T\,min} - V_{RE\,max}}{R_2\,(1 + \gamma)} - \frac{V_{RE\,max} - V_b(1 + v)}{R_1\,(1 + \gamma)} \quad I_{b1}$$

$$I_C = \frac{11.8}{6.8k} = 1.7\text{ ma}$$

$$I_{b1} = \frac{1.7}{20} = 85\ \mu a$$

$$\frac{11.8 = .8}{57k} - \frac{.8 - 0}{0} \geq 85\ \mu a$$

$$194\ \mu a \geq 85\ \mu a$$

RELIABILITY ANALYSIS

Specification A10202 requirements related to GSE reliability are as follows:

Paragraph B1.2.2.1 - Temperature The GSE shall be designed to operate continuously over a temperature range of at least 50°F to 100°F.

Paragraph B1.2.3.4 - Lifetime The GSE shall have as a design goal an operating life of 20,000 hours with reasonable service and parts replacement and shall have an overall possible lifetime of 10 years.

Paragraph B1.2.3.5 - Duty Cycle GSE shall be capable of continuous operation for 1000 hours within the anticipated ground environments allowing for battery charging only.

The following is a tabulation of the number of components used in the GSE with the associated failure rates for appropriate stress levels used in the design.

Item	Item Description	Total Used	Failure Rate/Item	N. F.
1.	JK Flip Flops (IC)	129	.01%/1000 hrs.	0.0129
2.	Gates (IC)	57	.01%/1000 hrs.	0.0057
3.	Clock Drivers (IC)	8	.01%/1000 hrs.	0.0008
4.	One Shot	17		
	* Transistors (7)	34	.01%/1000 hrs.	0.0034
	* Resistors (7)	119	.0012%/100 hrs.	0.00142
	* Capacitors (3)	51	.008%/1000 hrs.	0.00024
			.0014%/1000 hrs	0.00002
5.	Drivers	8		
	* Transistors (3)	24	.01%/1000 hrs.	0.10024
	* Resistors (7)	56	.0012%/1000 hrs.	0.0067
	* Capacitors (1)	8	.001%/1000 hrs	0.0008
6.	Oscillator	1		
	* Transistor (6)	6	.01%/1000 hrs.	0.0006
	* Resistors (12)	12	.0012%/1000 hrs.	0.00010
	* Capacitors (2)	2	.001%/100 hrs.	0.00002
7.	Power Supply	1		
	* Transistors (8)	8	.01%/1000 hrs.	0.0008
	* Resistors (18)	18	.0012%/1000 hrs.	0.0021
	* Capacitors (6)	6	.001%/1000 hrs	0.00006
	* Diodes (12)	12		

Total Failure Rate 0.03849/1000 hrs.

* Number in parenthesis gives number of components/modules.

On the basis of this data, the total GSE system failure rate is calculated to be .03849 per 1000 hours. Since MTBF is the reciprocal of failure rate, the system MTBF = 26,000 hours.

The probability of survival for the specified 1000 hour period of operatio is $P_s = e^{-t/T}$

$$= e^{-1000/26,000} = e^{-.0385}$$

$$P_s = 96.2\%$$

These calculations indicate that the GSE design will meet the 20,000 hour lifetime goal with a minimum of parts replacement and will operate for the 1000 hour specified no failure period with .962 probability