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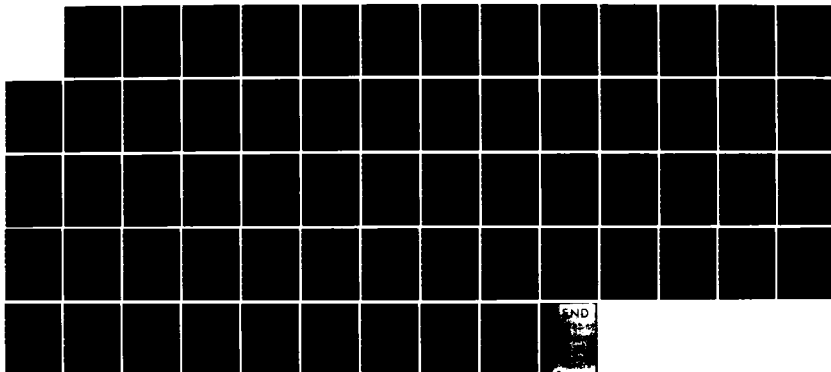
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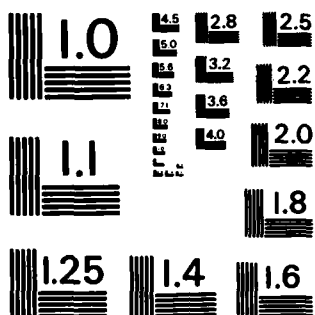
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AFGL-TR-84-0228

THE DESIGN OF AN ION/NEUTRAL MASS SPECTROMETER
TO BE USED IN THE SHUTTLE ENVIRONMENT

Charles J. Risicato

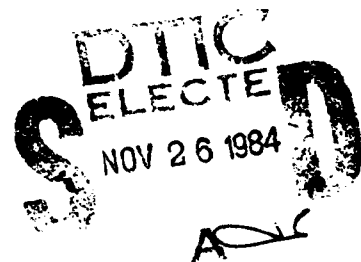
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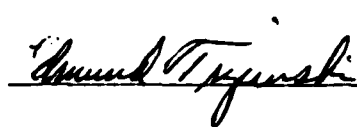
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AIR FORCE GEOPHYSICS LABORATORIES
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This technical report has been reviewed and is approved for publication.



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FOR THE COMMANDER



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Ionospheric Physics Division

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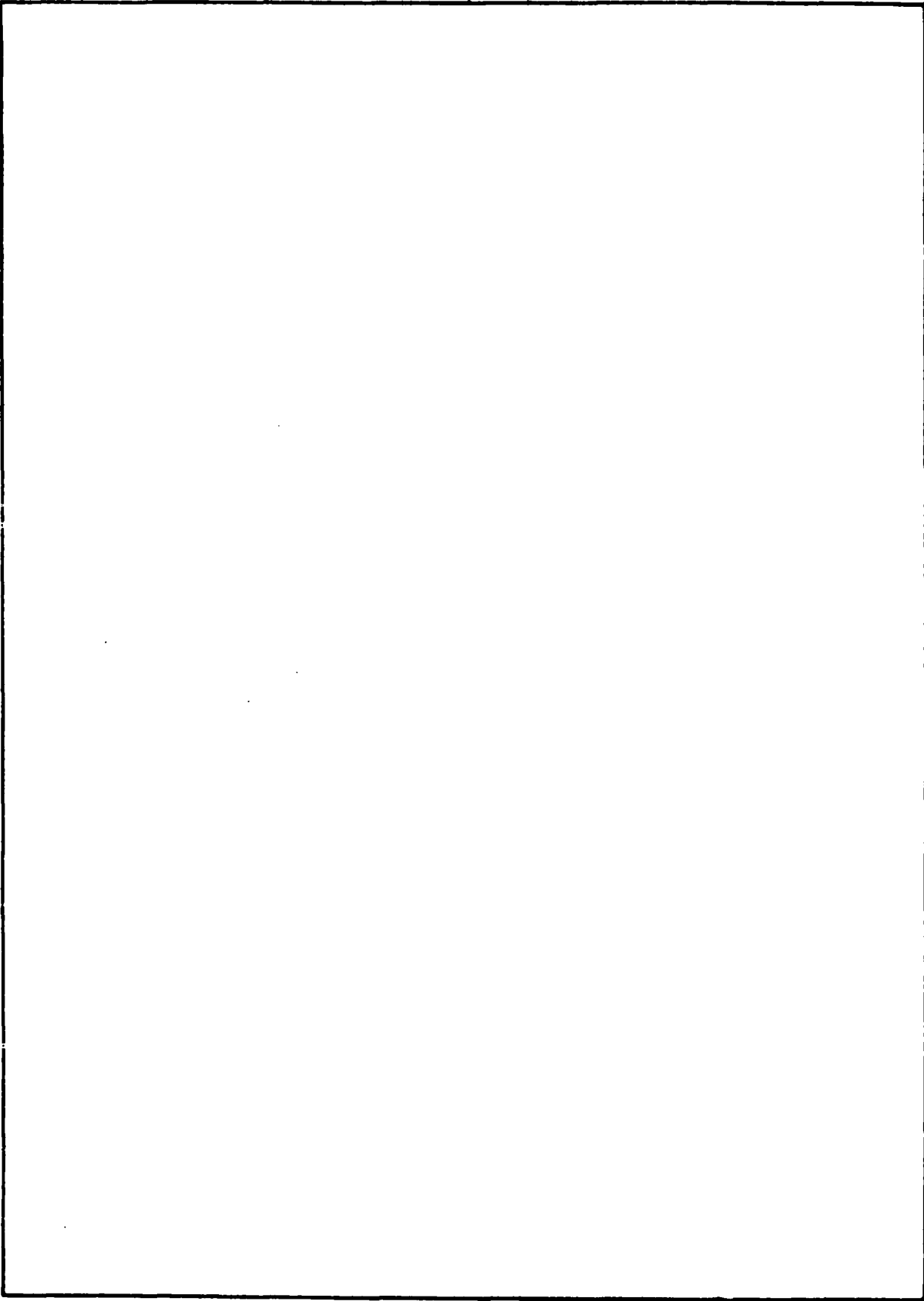
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I. INTRODUCTION

The objective of this contract is to Design and Fabricate a Quadrupole Mass Spectrometer to be used for studying the contaminants in the orbital shuttle environment.

In addition to sampling masses in the 1 AMU to 70 AMU range the instrument will attempt to measure vehicle to plasma potential and bias the quadrupole in such a way as to cancel the effects of the spacecraft charging.

The instrument will also have an ionization source to provide for neutral particle measurements.

A portable console will be fabricated to be used during vacuum and environmental testing and will provide telemetry power and monitor functions normally provided by the spacecraft during flight.

II INSTRUMENT DESCRIPTION

The electronics portion of this mass spectrometer consists of the following subassemblies:

1. DC Sweep Generator
2. DC Sweep and Bias Amplifier
3. RF Oscillator
4. Multiplier Logarithmic Electrometer
5. Auxilliary Circuits
 - 1a. Two Power Converters
 - 2a. Emission Regulator
 - 3a. Aperture Logarithmic Electrometer
 - 4a. Ground Reference Logic
 - 5a. High Voltage Interface
6. Test Console

2.1 DC Sweep Generator

The DC Sweep Generator shown in Drawing C-3093 produces the waveform which is used to control rod bias in both dynamic and static modes. A static mode being one which is entirely devoted to one particular mass.

The waveform is generated as counter U5 scans the prompts at a rate of 10 milliseconds per step. The prompts have been preprogrammed and sequentially outputs a ten bit code to the digital-to-analog converter.

Each mode may have 2^6 or 64 different analog levels as determined by addresses A0 to A5 on prompts U6 and U9.

If it is desirable to sit on one mass for the entire mode, then each of the 64 words in that mode will contain the same output codes.

The microcontroller in the ground reference logic (D-4002) may select one of 32 possible scan formats. These formats are selected by way of A6 to A10 on the memory chips U6 and U9. The microcontroller has a feedback line from counter U5(C3093) which will change logic level whenever the scan counter, counts from its final output (63) back to the first output (00).

There are six extra bits available from U9. One of these bits is used to control a total ions mode, (bit D2 of U9). Another of these bits is used to control the retard bias mode (bit D1 of U9).

The output from D/A circuit U7 and U11 is used to drive the DC Sweep Amplifier and the RF oscillator (Drawing C-3092).

2.2 DC Sweep And Bias Amplifier

The DC Sweep Amplifier supplies equal but opposite polarity voltages to the quadrupole rods. The voltage amplitude depends on the particular mass to be focussed and must be maintained at a fixed ratio relative to the peak RF amplitude in order to obtain good mass resolution.

The amplifiers, U5 and U6, shown in Drawing C-3092, are a hybrid high voltage operational amplifier manufactured by Burr Brown (Model 3582J). The circuit is a linear amplifier capable of sweeping from 0 to ± 80 volts relative to the rod bias of -15 volts or +2 volts with respect to vehicle potential.

The pre-amps, U2 and U3, are a low drift version of the 741 type op amp (Burr Brown Model 3510). An op amp U2 is used to drive the main amplifier (U5 and U6). Op amp U3 controls the output amplitude of the RF oscillator.

Output of the DC sweep is supplied to telemetry in a 0 to 5 volt level by way of op amp U7 (Drawing C-3092). The output of U7 is isolated from signal ground through isolation amp U12 (Drawing C-3093).

Analog Switch U1 is a dual TTL input analog switch made by Siliconix (type DG200). In the total ions mode, the switch disconnects the sweep generator from the DC sweep amplifier. When it is desired to retard the bias, the switch puts a -15V input in amplifier U4 (Burr Brown 3581). The output of this amplifier is used as the voltage reference for the aperture electrometer. It is also used by the DC sweep amplifier to adjust for the changes in bias.

2.3 RF Oscillator

The RF oscillator (Drawing C-857) consists of two sections, the oscillator proper, and the control and monitor section.

The oscillator is a tuned secondary, Hartley oscillator with the frequency being determined by the inductance of the secondary winding and the rod capacitance. The secondary is split and capacitively coupled so that a $\pm$ DC voltage can also be applied to the rods.

The amplitude and power to the oscillator is controlled by the base drive of transistors Q1 and Q2. A servo loop consisting of amplifiers U1, U2 and U3 maintain the peak RF amplitude at a fixed ratio relative to the DC. The output of a control winding is peak detected by U3 and summed into the input of U1 which in turn supplies the base drive of transistors Q1 and Q2. Ferrite beads are used in the oscillator base drive windings and in the control winding to suppress parasitic oscillations. The predominant parasitic is usually about twenty mega hertz for this particular layout.

The oscillator coil is wound on a one inch diameter hollow cylinder of Aluminum oxide and has a turns ratio of 1,2,2,1 in the primary and a 104 turn center tap secondary.

The frequency of oscillation is fixed at about 3.5 mega-hertz and the amplitude varies from 0 to 600 volts peak to peak. The oscillator coil is mounted in a shielded cavity and isolated from the rest of the circuits to minimize RF interference.

2.4 Multiplier Logarithmic Electrometer

The schematic for the multiplier logarithmic electrometer used to measure the spectra data, is shown on Drawing C-3088. The amplifier has a logarithmic transfer characteristic and provides an output voltage of zero to five volts for an input current of 500 picoamps to 5 microamps.

The amplifier is designed around a very high input impedance (10^{15} ohms) integrated operational amplifier. This design uses the Analog Devices AD515K amplifier and is designated U1 on Drawing C-3088.

The logarithmic characteristic is obtained from the relationship between the collector current and the emitter-base voltage of standard junction transistors.

The base emitter voltage changes approximately 60 millivolts for every decade change of input current at 25°C. The 60 millivolts is amplified by use

of a β network consisting of R2, R4 and S1 so that the output presented to telemetry is 1 volt per decade.

The transistor Q1 is a dual NPN in the same T0-5 can. A dual transistor is used to compensate for the change in the base emitter voltage with temperature. The compensation is accomplished by holding the collector current in the transistor on the right hand side at a constant value. The change in V_{be} with temperature is approximately 2 millivolts per degree centigrade. If the right hand side tracks the left hand side, a $\frac{\Delta V}{\Delta T}$ change will appear at the common emitter point and not at the output.

To prevent latch-up from opposite polarity inputs (spikes, transients, etc.) the amplifier has a reverse polarity limiter. Transistor Q3 will conduct and prevent the amplifier from going into an 'open loop' state in the event of a positive input current.

The electrometer has a buffer amplifier to provide a TM compatible output and provide isolation from long lines.

2.5 Auxiliary Circuits

The auxiliary or support circuits are:

- (a) Power Converters (2)
- (b) Emission Regulator
- (c) Aperture Electrometer
- (d) Ground Reference Logic
- (e) High Voltage Interface

2.5.1 Power Converters

There are two similar power converters shown on Drawings C-3091 and C-3090. Converter C-3090 provides the power for telemetry buffers the microcomputer and the bias amplifiers. Converter C-3091 supplies the power for all of the floating assembly including the RF oscillator.

The converters use a transformer designed around a ferrite core and driven by a fixed frequency oscillator. A buffer U3 is necessary between the oscillator U1 (C-3090) and the FET drivers Q1 and Q2 because of the input capacitance C_{gs} .

Without the buffer, the transistors Q1 and Q2 have a tendency to heat up because of the slower turn on/turn off times. A switching regulator designed with U7 and U2 increases the overall efficiency over the input voltage variation of +26 volts +32 volts.

One winding on the main power converter supplies power and synchronization to the floating converter and insulation to withstand 3000 volts was required to isolate it from the rest of the transformer.

2.5.2 Emission Regulator

The Emission Regulator circuit, Drawing C-4003, is designed to regulate anode current and bias the filament and grids to their specified voltage. A switching regulator is used in the pre regulator circuit. This pre regulator is designed around National's LHM605 Hybrid Switching Regulator. The output supplies the voltage into T1 of the emission regulator power converter.

The converter supplies power to the Filament of the emission regulator. The transformer used in the converter is designed around a ferrite core and driven by the oscillator on the main power converter. This is done to keep the two DC to DC converters, synchronous.

Anode current is monitored by operational amplifier U4 and U6. Amplifier U4 is wired in a current to voltage converter configuration and feeds optical isolator U5. This optical isolator feeds back to the pre regulator to adjust the pre regulator voltage in a way that the anode current remains constant. Amplifier U6 amplifies the voltage across current resistor R20. This signal is conditioned to a 0 to 5V level and sent to TM.

Two other parameters that are monitored and sent to TM are emitted current and filament bias. Emitted current is conditioned and amplified by two operational amplifiers contained in U7. Filament bias is monitored by U3.

The emission regulator is enabled by the signal Mode II, from the ground reference logic. This signal is isolated from power return through optical isolator U8 (GE MCA255).

2.5.3 Aperture Logarithmic Electrometer

The aperture electrometer is used to measure ion particle densities and neutral pressure. This information will be used to correlate with the spectra output data.

The operation of the aperture electrometer (Drawing C-3089) is similar to the previously mentioned multiplier electrometer. One change is in the logging transistor type used. Another is the reverse polarity limiter.

To prevent latch-up from opposite polarity spikes, diode CR3 will conduct and prevent the amplifier from going into an open loop state in the event of a negative input current.

2.5.4 Ground Reference Logic

The ground reference logic is designed around an eight bit integrated microcomputer which is

a generic product of the Motorola 6800 micro-processor family.

The 68705 (U3 of D-4002) has three digital I/O ports and one analog multiplexed port.

The three digital ports are assigned to:

- (1) Accept commands during testing and flight.
- (2) Select a sweep mode by controlling the memory in the DC sweep generator circuit.
- (3) Set the spectrometer bias level by way of U8, U12 and U13 on D-4002.

The digital ports are programmed to be either input or output during a cold start initialization. The commands are inputted to the microcomputer on Pins 9, 10 and 11 with a command of 111 serving as a reset in case of computer hang up.

After a command has been accepted from the spacecraft, the microcomputer will refer to a look up table which has been burned into its monitor ROM and proceed to execute that particular subroutine.

The commands are latched until a new command is sent which eliminates the need for handshaking and allows for a simple polling subroutine to detect a change in the command word status.

Pins 25 to 29 are programmed to be outputs and control the floating memory bank, by way of opto isolators U1, U2 and U3 on C-3093.

This output could be considered a page register with each page containing a different quadrupole rod sweep mode.

Pins 33 to 39 are used to generate the spectrometer bias. The spectrometer bias is generated by applying a digital word to U8 which sets an analog level between 0 and +10 volts. The D/A output is then amplified by way of U16, U15 for the lower voltage mode or by way of U17 and the Venus High Voltage Supply for the high voltage mode.

The low voltage mode has two parts: A 0 to 10 volt sweep and a +10 volt to +100 volt sweep. The high voltage sweep is used for the region of +100 volts to +2000 volts.

Two analog switches are used to change the gain and offset of the amplifiers and are controlled by digital bits A5 and A6.

A high voltage relay K6 of D-4002 is used to output the bias voltage to the floating section. The relay is rated for 8000 volts and is manufactured by the Kilovac Corporation. The relay position is controlled by a bit A6 from the microcomputer.

The microcomputer uses one port for interfacing with analog voltages. A built in multiplexer and A/D converter allow for several analog voltages.

2.5.5 High Voltage Interface

The high voltage interface between the floating spectrometer and the spacecraft ground reference, includes power, digital and analog signals.

The power interface is a transformer winding which is insulated to withstand greater than 3000 volts of stress. The digital interface is Darlington Opto Isolators such as the Hewlett Packard HP2730 which require relatively low input currents, and are driven from the buffered output port of the microcomputer.

The analog signals coming back from the floating spectrometer are the aperture electrometer the DC monitor and the RF monitor.

The isolation amplifier used for the analog signals, is an Analog Device AD294. The amplifier fits into the standard 40 pin package profile and is rated for 4000 volts.

The amplifier uses the chopper transformer method of isolation to couple signals back to telemetry ground referenced circuits.

New opto isolated analog integrated circuits are available but none have a high voltage specification good enough to be used in this instrument.

2.6 Test Console

A test console is supplied with the mass spectrometer experiment to allow for field test without the need of a large number of test instruments.

The test console will supply the power and timing functions and display mode and data signals received from the experiment.

Auxiliary jacks are available to allow for more precise measurements of each parameter.

VPMS
C-211

P1	Spectra Log Elect.	DEM-9S
1	+15V	TP2
2	-15V	TP4
3		
4	Multiplier Elect. Monitor out	J3-45; J10-10; P23-6
5		
6		
7		
8		
9	Signal RTN $\frac{1}{=}$	TP7

VPMS
C-211

J2	Main Power Converter	C-4010	2DA31S
1	+30V	J4-1	
2	+15V	TP2	
3	+5V	TP3	
4	-15V	TP4	
5	-90V	J4-5	
6	-125V	J3-12	
7			
8	+125V	J3-10	
9			
10	+28V H.V. Supply	J10-44	
11	+28V Supply	LF1-2	
12	+28V Supply	LF1-2	
13			
14			
15			
16			
17			
18			
19			
20	PS Pre Reg	J4-16	
21	+28V H.V. RTN	VEN3	
22	Pwr RTN	TP5	
23	PWR RTN	TP5	
24	Signal RTN	TP7	
25	Signal RTN	TP7	
26	Temperature Monitor	J3-41	
27			
28			
29			
30	SYNC A	J4-51	
31	SYNC B	J4-52	

VPMS
C-211

J3	Ground Reference Logic	C-4012	2DB52P
1	HV Bias Monitor Out	J10-11; P23-5	
2	HV Control Signal	VEN 2	
3	HV Output - Low Range	HVR-5	
4	HV Relay - Control	HVR-2	
5	HV CMD Out	J4-8	
6			
7	+28V HV Bias Supply - In	J10-46	
8	+28V HV Bias Supply - Out	VEN-1	
9			
10	+125V	J2-8	
11			
12	-125V	J2-6	
13			
14	-15V	TP4	
15	+5V	TP3	
16	+15V	TP2	
17			
18			
19			
20	EXT Clock	J10-51	
21	Sweep Clock	J7-20	
22	End of Mass Scan	J7-21	
23	Mode II Select	J4-28	
24	CMD Reset	J10-5	
25			
26	HV Bias Off	J10-7	

J3	Ground Reference Logic	Page 2
27	HV Bias On	J10-6
28	CMD D	J4-8; J10-20
29	CMD C	J10-19
30	CMD B	J10-4
31	CMD A	J10-3
32	CMD RTN	TP6
33	CMD RTN	TP6
34	Signal RTN	TP7
35	Signal RTN	TP7
36		
37		
38		
39	Mult. HV Stat In	J4-26
40	Mult HV Mon In	J4-15
41	Temperature Mon In	J2-27
42	Filament Bias Mon In	J4-30
43	PS. Pre Reg Mon In	J4-32
44	MUX Mon Out	J10-8; P23-8
45	Multiplier Elect Mon In	J10-10; P1-4; P23-6
46	MUX SYNC	
47		
48	B4	J7-31
49	B3	J7-30
50	B2	J7-29
51	B1	J7-28
52	B0	J7-27

VPMS
C-211

J4	Emission Regulator	2DB52S
1	+30V	J2-1
2	+15V	TP2
3		
4	-15V	TP4
5	-90V	J2-5
6		
7		
8	HV CMD In	J7-18
9		
10	+5V	TP3
11		
12		
13		
14	Mult HV RTN (Velonex)	
15	Mult HV Mon	J3-40
16	Pre Reg PS	J2-20
17		
18	Signal RTN	TP7
19	Signal RTN	TP7
20	Power RTN	TP5
21		
22	CMD RTN	TP6
23		
24	Mult HV On	J10-22
25	Mult HV Off	J10-23
26	Mult HV Status	J3-39

J4	Emission Regulator	Page 2
27	+28 HV Supply In	J10-45
28	Mode II Select	J3-23
29	Anode CUR Mon Out	J10-26; P23-10
30	Filament Bias Mon Out	J3-42
31	Emission Mon Out	J10-27; P23-9
32	PS Preg Mon Out	J3-43
33		
34		
35		
36	+28V Battery (Int LCK)	J10-48
37	Anode	
38	Filament	
39	Filament Bias	
40	Filament Holder	
41	F1	
42	F2	
43	F3	
44	Box	
45	Box Bottom	
46	G2	
47	G3	
48		
49		
50		
51	SYNC A	J2-30
52	SYNC B	J2-31

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J5 Sweep & Bias Amp Floating Converter C-4011 2DA31 Floating

1	DC Mon Out	J6-10
2	Total Ions	J6-9
3	Ret ARD Ions	J6-8
4	RF Control	J9-8
5	RF Sweep	J6-6
6	-40V F	J6-5
7	-15V F	J6-4
8	+5V F	J6-3
9	+15V F	J6-2
10	+28V F	J6-1
11	FPB	J14-B
12		
13	FPA	J14-A
14		
15		
16		
17	Comm Q	P8-7
18		
19	-15V F ²	P8-4
20		
21	+15V F ²	P8-3
22		
23		
24	-DC	J9-4
25		
26	+DC	J9-3
27		
28		
29		
30	Floating RTN	HVR3

VPMS
C-211

J6	DC Sweep Generator	2DA31	Floating
1	+28V F		J5-10
2	+15V F		J5-9
3	+5V F		J5-8
4	-15V F		J5-7
5	-40V F		J5-6
6	RF Sweep		J5-5
7			
8	Retard Ions		J5-3
9	Total Ions		J5-2
10	DC Mon In		J5-1
11	+15V F		P8-1
12			
13	-15V F		P8-2
14			
15			
16			
17	+28V RF Supply		J9-7
18			
19	G4		
20			
21	G6		
22			
23	Floating RTN		HVR3
24			
25			
26			
27	Aperature Mon In		P8-5
28			
29	RF Mon In		J9-9
30			
31	Spare Mon In		NC

VPMS
C-211

J7 DC Sweep Generator 2DA-31P

1		
2	+15V	TP2
3	+5V	TP3
4	-15V	TP4
5		
6		
7		
8		
9		
10		
11	Signal RTN	TP7
12	Signal RTN	TP7
13	CMD RTN	TP6
14	CMD RTN	TP6
15	RF on	J10-38
16	RF off	J10-39
17	RF Stats on	J10-52
18	HV CMD	J3-5; J4-8
19		
20	Sweep Clock	J3-21
21	End of Mass Scan	J3-22
22	RF Mon out	J10-24; P23-12
23	No Mon out	J10-25; P23-11
24	Aperature Mon out	J10-13; P23-7
25	Spare Mon out	
26		
27	B0	J3-52
28	B1	J3-51
29	B2	J3-50
30	B3	J3-49
31	B4	J3-48

VPMS
C-211

P8	Grid Aperature Elect.	DEM-9S	Floating
1	+15F	J6-11	
2	-15F	J6-13	
3	+15F2	J5-21	
4	-15F2	J5-19	
5	Grid Aperature Mon out	J6-27	
6	Floating RTN	HVR-3	
7	Comm Q	J5-17	
8	+15F	J9-1	
9	-15F	J9-2	

VPMS
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J9	RF Oscillator	DEM-9S	Floating
1	+15VF	P8-8	
2	-15VF	P8-9	
3	+DC	J5-26	
4	-DC	J5-24	
5			
6	Floating RTN	HVR-3	
7	RF Supply	J6-17	
8	RF Control in	J5-4	
9	RF Amplitude Mon out	J6-29	

VPMS
C-211

J10	External Signals	2D-5 S
1	+28V	LF1-1
2	+28V	LF1-1
3	CMD a	J3-31
4	CMD b	J3-30
5	CMD Reset	J3-24
6	HV Bias on	J3-27
7	HV Bias off	J3-26
8	Mux Mon Tm	P23-16
9	Grid Aper Mon Tm	P23-15
10	Multiplier Mon Tm	P23-14
11	Vehicle Pot. Mon. Tm	P23-13
12	Mux Mon GSE	J3-44 P23-8
13	Grid Aper Mon GSE	J7-24 P23-7
14	Multiplier Mon GSE	J3-45 P23-6
15	Vehicle Pot Mon GSE	J3-1 P23-5
16	Sig. RTN GSE	TP-7
17		
18	PWR RTN	TP-5
19	CMD c	J3-29
20	CMD d (H.V. CMD)	J3-28
21		
22	Mult HV on	J4-24
23	Mult HV off	J4-25
24	RF Amplitude Mon Tm	J7-22 P23-12
25	DC Amplifier Mon Tm	J7-23 P23-11

J10

External Signals

page 2

26	Collected Current	Tm	J4-29	P23-10
27	Emitted Current	Tm	J4-31	P23-9
28	RF Amplitude Mon	GSE	P23-4	
29	DC Amplifier Mon	GSE	P23-3	
30	Collected Current	GSE	P23-2	
31	Emitted Current	GSE	P23-1	
32	Sig. RTN	GSE	TP-7	
33				
34	PWR RTN		TP-5	
35	CMD RTN		TP-6	
36	CMD RTN		TP-6	
37				
38	RF on		J7-15	
39	RF off		J7-16	
40	Sig. RTN	Tm	TP-7	
41	Sig. RTN	Tm	TP-7	
42				
43				
44	HV +28V Supply out		J2-10	
45	Multiplier +28V Supply in		J4-27	
46	HV Bias +28V Supply in		J3-7	
47	ER +28V Supply out		LF1-2	
48	ER +28V Supply in		J4-36	
49	RF Interlock out		J7-9	
50	RF Interlock in		J7-10	
51	Ext Clk GSE		J3-20	
52	RF Status GSE		J7-17	

VPMS
C-211

P10	External Signals	2D52P
1	+28V	J13-1
2	+28V	J13-2
3	CMD a	J13-3
4	CMD b	J13-4
5	CMD RESET	J13-7
6	HV Bias on	J13-11
7	HV Bias off	J13-23
8	Mux Mon Tm	J12-4
9	Grid Aper Mon Tm	J12-3
10	Multiplier Mon Tm	J12-2
11	Vehicle Pot Mon Tm	J12-1
12	Mux Mon GSE	J11-13
13	Grid Aper Mon GSE	J11-12
14	Multiplier Mon GSE	J11-11
15	Vehicle Pot Mon GSE	J11-10
16	Signal RTN GSE	J11-9
17		
18	PWR RTN	J13-14
19	CMD c	J13-5
20	CMD d (H.V. CMD)	J16-6
21		
22	Mult HV on	J13-12
23	Mult HV off	J13-23
24	RF Amplitude Mon Tm	J12-12
25	DC Amp Mon Tm	J12-11
26	Collected Current Tm	J12-10

P10	External Signals	page 2
27	Emitted Current Tm	J12-9
28	RF Amplitude Mon GSE	J11-25
29	DC Amplitude Mon GSE	J11-24
30	Collected Current GSE	J11-23
31	Emitted Current GSE	J11-22
32	Signal RTN GSE	J11-21
33		
34	PWR RTN	J13-15
35	CMD RTN	J13-16
36	CMD RTN	J13-17
37		
38	RF on	J13-13
39	RF off	J13-25
40	Signal RTN Tm	J12-6
41	Signal RTN Tm	J12-14
42		
43		
44	HV +28V Supply out	J11-7
45	Mult +28V Supply in	J11-6
46	HV Bias +28V Supply in	J11-19
47	E.R. +28V Supply out	J11-5
48	E.R. +28V Supply in	J11-18
49	RF Interlock out	J11-1
50	RF Interlock in	J11-14
51	Ext Clk	J11-15; J12 15
52	RF Status	

VPMS
C-211

J11	GSE & Interlocks	DBH 25
1	RF Interlock 12	P10-49
2		
3		
4		
5	Emission Reg Interlock 12	P10-47
6	HV Interlock 13	P10-45
7	HV Interlock 23	P10-44
8		
9	Signal RTN	P10-16
10	Vehicle Potential Mon	P10-15
11	Mult. Elect Mon	P10-14
12	Grid Aper Mon	P10-13
13	Mux Mon	P10-12
14	RF Interlock 22	P10-50
15	Ext Clk	J12-15; P10-51
16		
17		
18	Emission Reg Interlock 22	P10-48
19	HV Interlock 33	P10-46
20		
21	Sig RTN	P10-32
22	Ion Source Emitted Current Mon	P10-31
23	Ion Source Collected Current Mon	P10-30
24	DC Amplifier Mon	P10-29
25	RF Amplitude Mon	P10-28

VPMS
C-211

J12 Telemetry DAH 15

1	Vehicle Potential Mon	P10-11
2	Mult Elect Mon	P10-10
3	Grid Aper Mon	P10-9
4	Mux Mon	P10-8
5		
6	Signal RTN	P10-40
7		
8		
9	Ion Source Emitted Current	P10-27
10	Ion Source Collected Current	P10-26
11	DC Amplifier Mon	P10-25
12	RF Amplitude Mon	P10-24
13		
14	Signal RTN	P10-41
15	Ext Clk	J11-15; P10-51

VPMS
C-211

J13	Power and Commands	DBH 25
1	+28V	P10-1
2	+28V	P10-2
3	CMD a	P10-3
4	CMD b	P10-4
5	CMD c	P10-19
6	CMD d	P10-20
7	CMD RESET	P10-5
8		
9		
10		
11	HV Bias on	P10-6
12	Mult HV on	P10-22
13	RF on	P10-38
14	PWR RTN	P10-18
15	PWR RTN	P10-34
16	CMD RTN	P10-35
17	CMD RTN	P10-36
18		
19		
20		
21		
22		
23	HV Bias off	P10-7
24	Mult HV off	P10-23
25	RF off	P10-39

VPMS
C-211

P14	Floating Power	JF2S
A	FPA	J5 -13
B	FPB	J5 -11

VPMS
C-211

P15 Vehicle Potential JF1P1S

A HV Bias (Floating RTN) HVR-3
B

OTHER COMPONENTS & CONNECTIONS

PWR TIE POINTS

TP-2	+15V
TP-3	+5V
TP-4	-15V
TP-5	PWR RTN
TP-6	CMD RTN
TP-7	Sig RTN

VELONEX

Velo-1	HV Output
Velo-2	+28V Supply
Velo-3	PWR RTN
Velo-4	HV RTN

HV RELAY

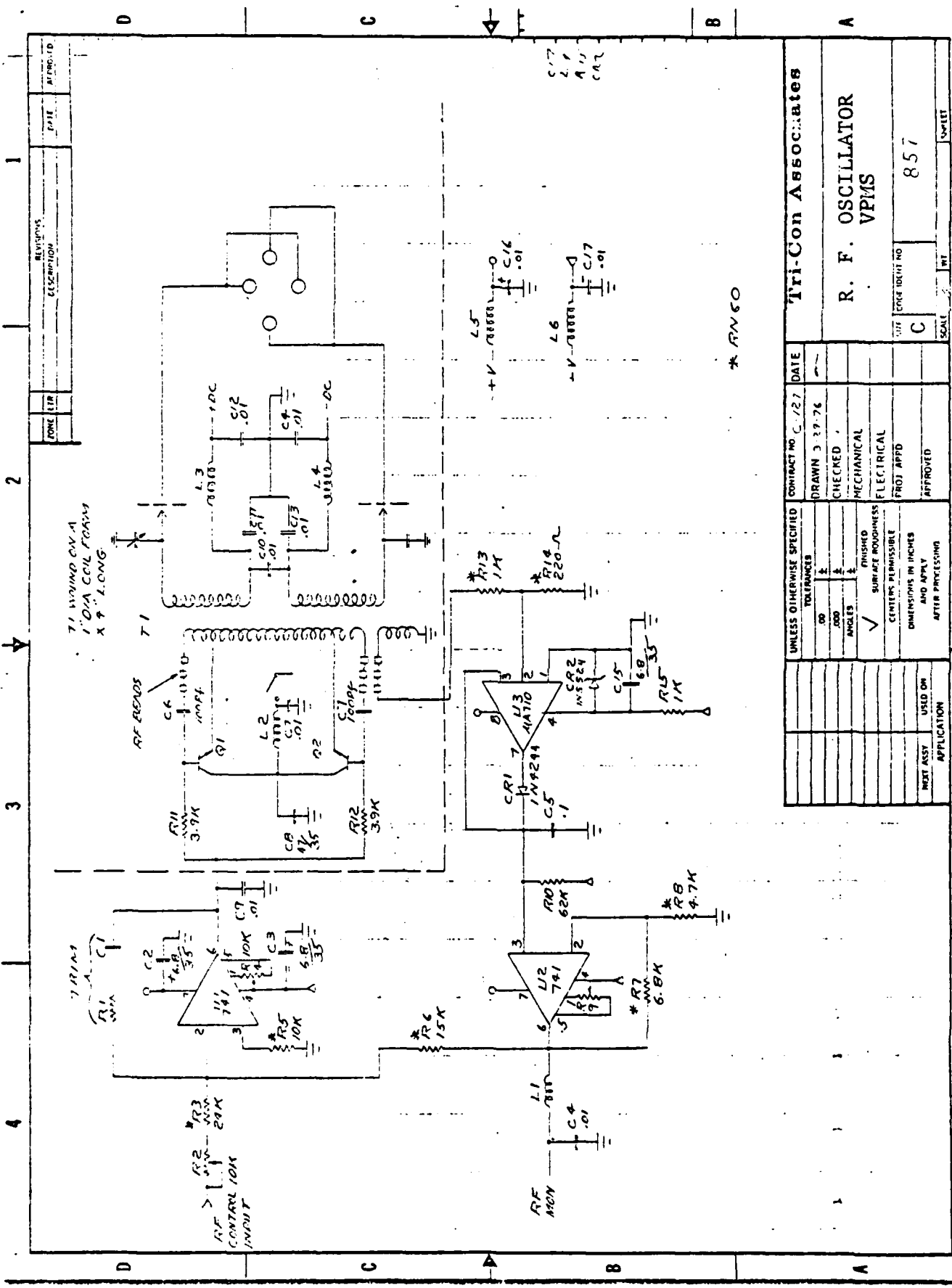
HVR-1 (+) Coil
HVR-2 (-) Coil
HVR-3 Common
HVR-4 N.O.
HVR-5 N.C.

VENUS P.S.

Ven-1	+28V
Ven-2	Volt Adj
Ven-3	+28V RTN
Ven-4	Chassis
Ven-5	Test out
Ven-6	HV Output

FILTERS

LF1-1	+28V Line Filter input
LF1-2	+28V Line Filter output
LF2-1	PWR RTN Line Filter input
LF2-2	PWR RTN Line Filter output

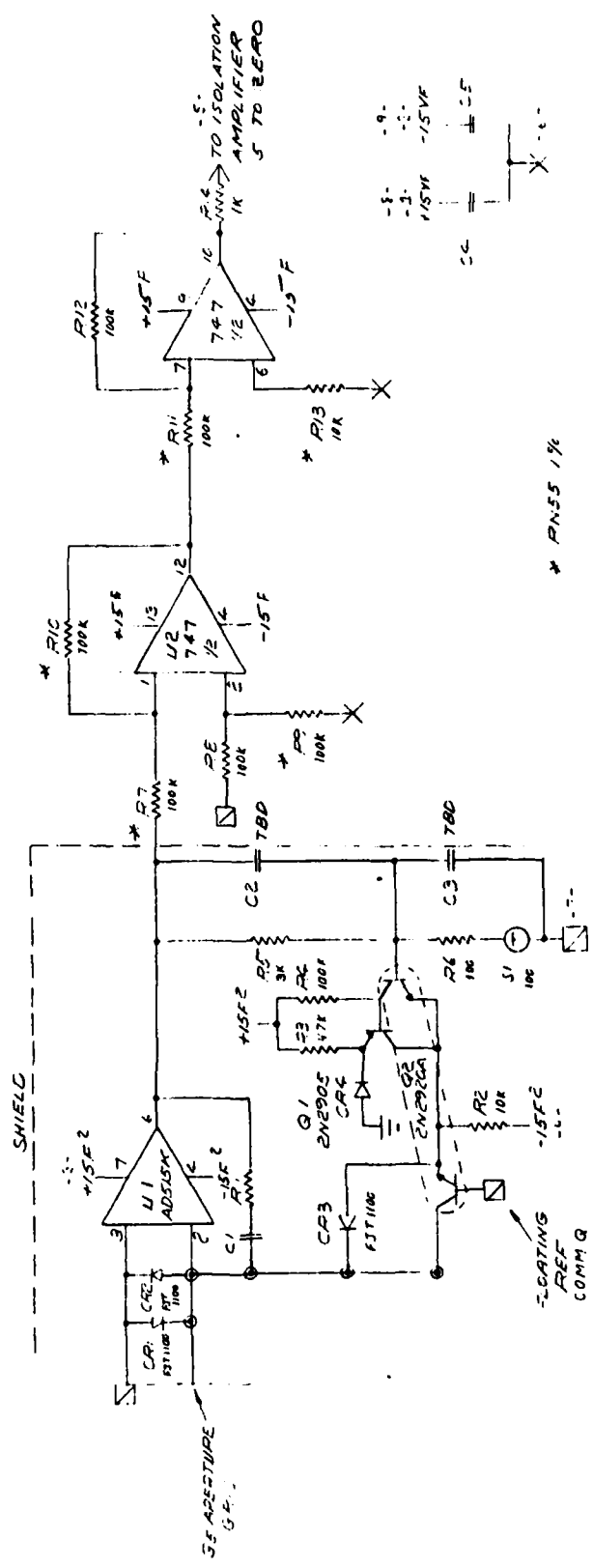


Tri-Con Associates		DATE	CONTRACT NO.
R. F. OSCILLATOR VPMS		3-27-76	C-127
DRAWN		CHECKED	MECHANICAL
ELECTRICAL		PROJ. APPD	APPROVED
SCALE		1/8"	1/16"
C		857	



1 2 3 4

REVISIONS		DATE	APPROVED
ZONE	LTR		
DESCRIPTION			



LAYOUT C-9020

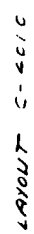
Tri-Con Associates		DATE	4/2/82
CONTRACT NO. 211		DRAWN BY: J. J. Z.	
UNLESS OTHERWISE SPECIFIED		CHECKED	
TOLERANCES		MECHANICAL	
.00		ELECTRICAL	
.000		PROJ. APPD	
.001		APPROVED	
ANGLES			
✓ SURFACE ROUGHNESS			
CENTERS PERMISSIBLE			
DIMENSIONS IN INCHES			
AND APPLY			
AFTER PROCESSING			
NOT ASSY	USED OR	APPLICATION	

APERTURE ELECT
VPMS

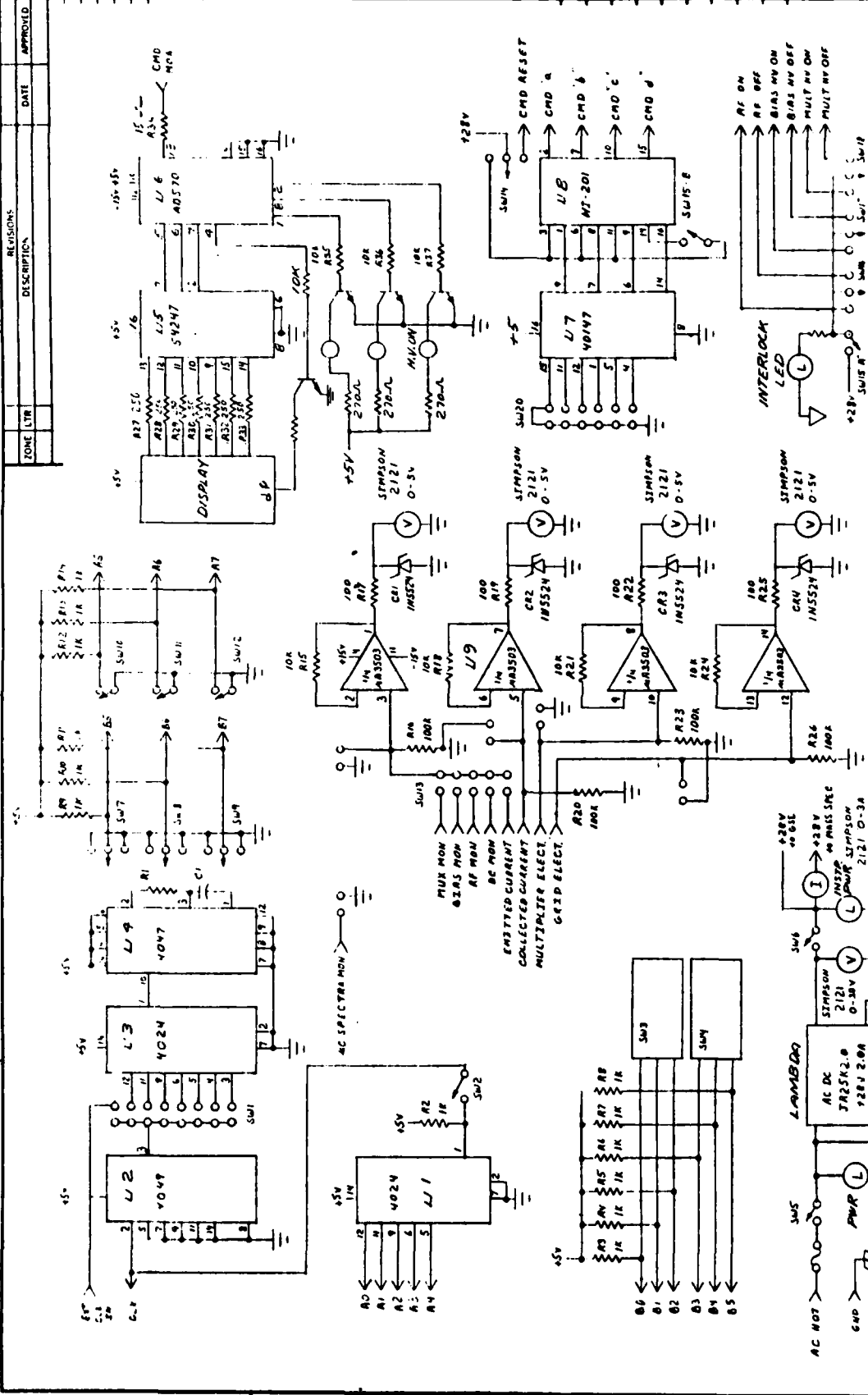
C-3089

SCALE

SHEET



ZONE	LTR	REVISIONS	DATE	APPROVED
		DESCRIPTION		



Tri-Con Associates		DATE	3-20-64
GSE VPMS		CONTRACT NO.	C-211
C-4016		DRAWN	C.B.
C		CHECKED	
C		MECHANICAL	
C		ELECTRICAL	
C		PROJ. APPD	
C		APPROVED	
C		UNLESS OTHERWISE SPECIFIED	
C		TOLERANCES	
C		ANGLES	
C		FINISHED SURFACE ROUGHNESS	
C		CENTERS PERMISSIBLE	
C		DIMENSIONS IN INCHES	
C		AND APPLY AFTER PROCESSING	
C		APPLICATION	
C		USED ON	
C		NOT ASSY	

	title	'VPM6 microcontroller program'		
	subtitle	'system equates, i/o'		
0000	DATA_A	equ	000h	: I/O data ports - port A
0001	DATA_B	equ	001h	: - port B
0002	DATA_C	equ	002h	: - port C
0003	DATA_D	equ	003h	: - port D
0004	DDR_A	equ	004h	: Data direction registers - port A
0005	DDR_B	equ	005h	: - port B
0006	DDR_C	equ	006h	: - port C
0008	TDR	equ	008h	: Timer data register
0009	TCR	equ	009h	: Timer control register
000F	MR	equ	00Fh	: Miscellaneous register
000B	PCR	equ	00Bh	: Program control register
				: *** DO NOT ALTER ***
000E	ADR	equ	00Eh	: A/D control register
000F	ARR	equ	00Fh	: A/D result register

	substitute			'system equate, raw'
0010	COUNT	equ	0010h	: Storage for time delay loop
0011	SECTEMP	equ	0011h	: Storage for segment select subroutine
0012	BIPS	equ	0012h	: Vehicle potential

```

      subtitle      'Jump Table'
;*****
; Jump table
;
;      used to allow easy repositioning of the program modules.
;
;      Format:
;
;      jmp  MODULE_NAME      : Jump to a sweep routine
;      db   ROM_SEGMENT_NUMBER : Rom segment to be used by routine
;                               : Uses 2 contiguous segments
;
;
;      org  0080h            : Must be the start of this table
;
; JPTB:
0080 00 01 19      jmp  NOCMD      : Command 0 - No command
0083 00 00 00      db   000h        : Rom segment 0 = idle state
;
0084 00 04 00      jmp  MODE_1      : Command 1 - Mode 1
0087 00 00 00      db   001h        : Segments 1, 2, 3, 4, 5, 6 (Only 3 are used)
;
0088 00 04 02      jmp  MODE_1A     : Command 2 - Mode 1A
008B 00 00 00      db   007h        : Segment 7, 8 (Only 1 is used)
;
008C 00 01 19      jmp  NOTIMP      : Command 3 - Not implemented
008F 00 00 00      db   000h        :
;
0090 00 05 00      jmp  MODE_11     : Command 4 - Mode 2
0093 00 00 00      db   000h        : Segment 9, 10 (Only 1 is used)
;
0094 00 01 19      jmp  NOTIMP      : Command 5 - Not implemented
0097 00 00 00      db   000h        :
;
0098 00 01 19      jmp  NOTIMP      : Command 6 - Not implemented
009B 00 00 00      db   000h        :
;
009C 00 00 00      db   000h,000h,000h : Command 7 - HARDWARE RESET
009F 00 00 00      db   000h        :

```

```

      subtitle      'Initialization & Command Monitor'
;*****
; initialization & Command Monitor
;
;      Executed upon hardware reset
;

```

```

      org      0100h
INIT:
0102 4F      clr      a
0103 37 00    sta      $DATA_A      ; Initial data for output ports
0105 37 01    sta      $DATA_B      :
0106 37 05    sta      $DDR_C      ; Now setup data direction and control reg's
0107 37 0E    sta      $ACR      :
0109 43      com      a      :
010A 37 04    sta      $DDR_A      :
010C 37 05    sta      $DDR_B      :
010E 45 07    lda      #007h      :
0110 37 04    sta      $MR      :
0112 46 40    lda      #240h      :
0114 37 09    sta      $TCR      :
0116 0D 01 03  rmo      $RDCMD      :

```

ADTMR:

RDCMD:

```

0117 36 10    lds      $DATA_C      ; Get command
0119 0D 0E 00  rsr      WAIT100    ; debounce for relay's
011E 36 0E    cds      $DATA_C      ; G. same command?
0120 26 1F    bne      RDCMD      ; no, go back and read again
0122 40      lsl      a      :
0123 40      lsl      a      :
0124 36 02    add      #IMPTB
0125 37      tax
0127 3D      rsr      [x]
0128 46 00    lda      00h      ; Set to idle sweep
012A 0D 0E 00  rsr      SEGMENT    :
012D 26 0A    bne      RDCMD      ; Reread command and execute indefinitely

```

```

      00000000      'Subroutines'
*****
: Subroutines
:
:   SEGMENT:  -- Select desired row segment
:               Entry:  X = jump table pointer used to enter sweep
:               Exit:   None
:               Uses:   a, flags
:
:   SWEEP:    -- Sweep quadrangle
:               Entry:  None
:               Exit:   None
:               Uses:   None
:
:   SWEEP_WB: -- Sweep quadrangle with +2v retarding voltage
:               Entry:  None
:               Exit:   None
:               Uses:   None
:
:   WAIT100  -- 100 mSec. time delay
:               Entry:  None
:               Exit:   None
:               Uses:   a, flags, $0010h
:
:

```

```

*****
: SEGMENT
:
        org     0200h
SEGMENT:
0000 27          sta     $SECTEMP      : Save segment number
0001 00 00      ora     #00h         : Set clock control bit to prohibit change
0002 04 00      and     $DATA_B      : Take present seg. # and clear necessary bits
0003 00 00      ora     $SECTEMP      : then set necessary bits
0004 07 00      sta     $DATA_B      : Store the new segment address
0005 01          rfe                 :

*****
: SWEEP_WRT A SWEEP
:
        org     0210h
SWEEP_WRT:
0010 10 00      bset     4,$DATA_B    : Apply retarding voltage
SWEEP:
: we must be sure a full sweep has occurred
: If EDMS is high
: Then wait for it to go low then high
: If EDMS is low
: Then wait for it to go high then low
:
0011 00 00 00      brset   7,$DATA_0,SET2 : branch if EDMS is high
:
: To get here, EDMS must be low.
:
0012 00 00 00      CLR1: brclr   7,$DATA_0,CLR1 : wait for EDMS to go high
0013 00 00 00      SET1: brset   7,$DATA_0,SET1 : wait for EDMS to go low
0014 00 00      ora     CLR1         : Continue
:
: To get here, EDMS must be high.
:
0015 00 00 00      SET2: brset   7,$DATA_0,SET2 : wait for EDMS to go low
0016 00 00 00      CLR2: brclr   7,$DATA_0,CLR2 : wait for EDMS to go high
: Continue with sweep subroutine
:
0017          EDV1:
0018 10 00      brclr   4,$DATA_0      : Disable +2v retarding voltage
0019 01          rfe                 : (doesn't matter if it was turned on or not)

```

00000000

WAIT100

Delay = 10 - (1000 * VRL) / 1000
VRL = 1 (Delay * 1000) / 1000

0004	VRL	MOV	0040	: 100 decimal for a 10 sec. delay.
				: (real) delay is 100.000 msec.
	0008			
0010	40 04	lda	VRL	: 1 : compute delay from above formula
0012	07 10	sta	\$COUNT	: 4 :
0014	40 05	lda	#0-00	: 2 : set inner timing loop to 1.00 msec.
0016	44	dec	a	: 3 : inner timing loop
0017	07 F0	bne	WAIT2	: 3 :
0019	0A 10	dec	\$COUNT	: 5 : Outer timing loop
001B	06 F7	bne	WAIT1	: 3 :
001D	81	rcs		: 6 :

```

      subtitle      'Mode 1 Sweep Module'
;*****
; Mode 1 Sweep Module
;
; Entry:  x = jump table pointer used to get here
; Exit:   None
; Uses:   a, flags
;
;
; THRESHOLD equ    085h      ; Minimum reading to determine vehicle potential
;                          ; (this is just a dummy value)
;
; org      0400h
;
; MODE_1:
;
; 0400 26 03      lca      0x.13      ; Get segment # out of table
; 0402 0D 02 00  lsr      S037BNT    ; Select rom segment
;
; AD_RESET:
;
; 042E 4F        slr      a          ; Reset A/D
; 0430 87 0E      sta      $PCR      ;
;
; AD_STATUS:
;
; 0440 26 0E      lca      $PCR      ;
; 0442 24 4C      cpl      AD_STATUS ; Br if the A/D conversion is not complete
; 0444 26 0F      lca      $ADR      ; Read A/D
; 0446 A1 65      cmc      #THRESHOLD ;
; 0448 23 09      cls      BIAS_FOLDN ; Br if reading has fallen to threshold
; 044A 26 00      lca      $DATA_A    ; else, increase HV bias and take another
; 044C 4C        inc      a          ; sample
; 044E A4 7F      and      07Fh      ; we must make sure we don't turn on mode 2
; 0450 87 06      sta      $DATA_A    ;
; 0452 0E 2D      ora      AD_RESET  ;
;
; BIAS_FOLDN:
;
; 0453 26 06      lca      $DATA_A    ; Get value of HV bias
;
; Adjust HV Bias if necessary
;
; 0455 87 06      sta      $DATA_A    ; Set adjusted HV bias
; 0457 27 00      sta      $0_A0      ; Save for more elaborate routines
; 0459 3C 01      inc      $DATA_B    ; Set rom segment for next sweep type
; 045B 0D 22 00  lsr      SWEEP      ; Sweep quadrapole
; 045D 1D 00 00  lsr      SWEEP_WR    ; Sweep quad w/ +2v retard
; 045F 3C 01      inc      $DATA_B    ; Set rom segment for next sweep type
; 0461 27 00      sta      SWEEP      ; Sweep quad
; 0463 1D 00 00  lsr      SWEEP_WR    ; Sweep quad w/ +2v retard
; 0465 87 00      sta      WTS

```

```

        subtitle      'Mode 1A sweep module'
;*****
; Mode 1A sweep module
;
;      Entry:  x = jump table pointer used to get here
;      Exit:   none
;      Uses:   a, flags
;
;
;      org      0482h
MODE_1A:
0482  E6 0C      lda     ldx,3      ; Get segment # from table
0483  CD 02 00   jsr     SEGMENT    ; Select row segment
0486  CD 02 12   jsr     SWEEP      ; Sweep quadrupole
0489  CD 02 10   jsr     SWEEP_W3   ; Sweep quad w/ +2v retard
048C  B1                rts

```

substitute 'Mode 2 sweep module'

; Mode 2 sweep module

;

; Entry: x = jump table pointer used to get here

; Exit: None

; Uses: a.flags

;

org 0580h

MODE_II:

0580	E6 23	lda	[x],3	: Get segment # from table
0582	CD 02 00	jsr	SEGMENT	: Select rom segment
0585	18 00	bset	7,\$DATA_A	: Set up mode 2
0588	CD 42 12	jsr	SWEEP	: Sweep quadrupole
058B	CD 02 10	jsr	SWEEP_WR	: Sweep quad w/ +2v retard
058E	81	rts		:

```

        subtitle      'Interrupt service'
;*****
; Interrupt service routines
;
;   This is a dummy routine just in case a stray interrupt occurs
;

```

```

        org          0FD0h
INT_SERVICE:
        rti           ; Safety precaution

```

```
0FD0 82
```

```

        subtitle      'Interrupt vectors'
;*****
; Interrupt vectors
;
;
;

```

```

        org          0FF8h
INT_VECTORS:
        dw           INT_SERVICE ; Timer on INT2 (external)
        dw           INT_SERVICE ; INT (external)
        dw           INT_SERVICE ; SWI
        dw           INT       ; HARDWARE RESET

```

```

0FF8 0F 32
0FFC 0F 32
0FFC 0F 32
0FFE 2. 00

```

```
end
```

END

FILMED

12-84

DTIC