NATIONAL ELECTROSTATICS CORP.

Instruction Manual No. 2HT066180 for
Operation and Service of

VOLTAGE STABILIZER
2HA066180

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SHP

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TABLE OF CONTENTS

I. GENERAL DESCRIPTION

A. Introduction

The Voltage Stabilizer regulates the terminal voltage of 1 MV thru 4 MV single-ended or tandem particle accelerators. The Stabilizer uses a closed loop control system which monitors the terminal voltage and together with an error correction signal derived from the terminal voltage ripple, maintains a constant terminal voltage. The Voltage Stabilizer is the central component of the Terminal Voltage Stabilization System. The external electronics units include:

a) Corona Probe Controller
b) Generating Voltmeter (GVM) Amplifier
c) Charging Controller (if used)
d) Capacitor Pick-Off (CPO) Amplifier

These external units are covered in separate documents.

This manual is divided into six sections. Section I, B contains a discussion of the principles of operation and Section II lists the unit specifications. Section III contains installation and tuning information. Each Voltage Stabilizer must be set up and tuned to the particular machine during installation. Refer to Section III, B for details. Section IV contains operating information including front panel controls, operating instructions and operation notes. Section V has a detailed discussion of the electrical circuits and unit calibration information. Lastly, Section VI contains the Voltage Stabilizer documentation.

B. Theory of Operation

The Voltage Stabilizer, together with the remotely controlled auxiliary units, regulate the terminal voltage of single-ended or tandem accelerators. The stabilizer has a closed loop control system which monitors the terminal voltage and together with the terminal voltage ripple error correction signal, adjusts the corona probe current to maintain a constant terminal voltage. For the following discussion, refer to Figure 1-1, the Voltage Stabilizer Block Diagram for a functional layout of the control system.

The Corona Probe Controller regulates corona probe current and controls the corona probe position. Together with the corona probe, they act as the terminal voltage shunt regulator element in the Voltage Stabilizer system. The balance between charging current(s) and the various load currents (beam current, accelerating tube grading current, and corona probe current) determines the absolute terminal voltage. For a constant charging current, increasing the corona probe current decreases the terminal voltage and decreasing the corona probe current increases the terminal voltage. The corona probe is connected to the plate, or anode, of a high voltage vacuum tube inside the Corona Probe Controller. The tube acts as a variable resistor and regulates corona probe current by changing the corona probe voltage. The tube resistance is in turn governed by the tube grid to cathode voltage. The Corona Probe Controller accepts a current programming signal from the Voltage Stabilizer and adjusts the tube grid voltage as required to match the corona probe current to the current programming signal from the Voltage Stabilizer.

The Corona Probe Controller high voltage vacuum tube operates over a relatively limited dynamic plate voltage range of 30 KVDC maximum. To use the controller over the wide range of operating terminal voltages, the corona probe is moved in towards the terminal for low voltage operation or out away from the terminal for high voltage operation. The Voltage Stabilizer has a probe position control switch to change the probe position. In addition, the Voltage Stabilizer unit has two meters to monitor the Corona Probe Controller condition. The first meter displays corona probe current or corona probe position. The second meter displays the vacuum tube grid voltage and is used to verify that the tube is operating within its active range.

The Voltage Stabilizer uses the GVM control mode which compares the terminal voltage reading from the GVM Amplifier to the front panel Terminal Voltage knob setting and regulates terminal voltage by keeping the two equal. In addition, high frequency signal information generated by the two CPO plates and amplified by the CPO Amplifier is added to the error correction signal. This signal amplitude is then regulated by the front panel Control Gain knob setting. The error correction signal is combined with the front panel Bias Current knob setting and the resulting composite signal programs the Corona Probe current. The current control signal consists of a "DC" (quiescent) current level and an "AC" error correction signal.

The GVM (Generating Voltmeter), together with the GVM Amplifier measure terminal voltage. The rotating vane GVM produces an AC current signal which is instrumented and converted by the GVM Amplifier. The amplifier produces a DC output voltage directly proportional to terminal voltage. A 2:1 adjustment range potentiometer provides for absolute GVM calibration. The GVM signal is then compared to the front panel Terminal Voltage (reference) knob setting. The GVM control error signal (GVM-T.V.) passes through a gain adjustment stage (GVM Gain) and on to the CPO control section, where the high frequency CPO signal is added to the low frequency GVM control error signal. The "crossover" frequency is controlled by the GVM/CPO Crossover Frequency adjustment. If the terminal voltage is too high, a positive GVM error correction signal is added to the Corona Probe bias current which increases the probe current and reduces the terminal voltage. If the terminal voltage is too low, the Corona Probe current is reduced and the terminal voltage increases.

The two CPO (Capacitor Pick-Off) plates together with the CPO Amplifier measure terminal voltage ripple, and are used both in generating the high frequency information for the probe current control error signal, as well as for diagnostic purposes. The CPO acts as a capacitive voltage divider between the terminal and the accelerator tank. The CPO Amplifier instruments and amplifies the two CPO signals. The Voltage Stabilizer buffers the two CPO signals and routes them to a

CPO monitor as well as adds them together. This signal is also available at the CPO Monitor and is useful for initial set-up of the Voltage Stabilizer. The CPO signal then combines with the GVM control error signal in a voltage controlled low-pass/high-pass filter.

The Voltage Stabilizer proportional O/UVP (Over/Under Voltage Protection) circuitry protects the accelerator from excessively high terminal voltages as well as providing an indicator of other potential problems in the machine. The two set point adjustments set the percent overvoltage and percent undervoltage limits, both with ranges of zero to 50 percent. If the terminal voltage rises to a fixed percentage above the front panel terminal voltage knob setting, then the O/UVP circuit toggles. Sparking or similar problems may cause the terminal voltage to decrease below the desired operating voltage. If this decrease in voltage falls to a fixed percentage below the front panel terminal voltage knob setting, the O/UVP will once again toggle. Under normal operating conditions, the charging voltage control signal passes unaffected from the Charging Controller, thru the Voltage Stabilizer and on to the Charging Power Supply. However, when the O/UVP circuit trips, the Voltage Stabilizer disconnects the charging voltage control signal from the Charging Controller, and instead connects a low, preset default charging level. By reducing the charging control signal to a low value, the terminal voltage is reduced to a safe level.

II. SPECIFICATIONS

Maximum Terminal Voltage Range:	1 MV thru 4 MV accelerators
Over/Under Voltage Protection:	Separate, proportional controls, 0 to 50 percent, user settable local or remote (local controls on rear panel)
Internal User Settable Parameters:	Local or remote controllable (local controls on top panel) a) GVM Control Gain b) CPO Control Gain c) GVM/CPO Crossover Frequency d) O/UVP Default Charging e) GVM Calibration, 2:1 Range
Size:	Standard rack mount unit, 19.0 in wide by 7.0 in high by 16.0 in deep
AC Power Input:	110 to 125 VAC or 220 to 250 VAC 45 VA max., 47-63 Hz
AC Power Fusing:	3/8 Ampere 3 AG Slo-Blo at 120 VAC 3/16 Ampere 3 AG Slo-Blo at 240 VAC
24 VDC Power Fusing:	1/2 Ampere 3 AG
Status (On/Off) Controls:	24 VDC Nominal outputs, voltage applied to energize external units. a) GVM Amplifier b) CPO Amplifier c) Corona Probe Controller
Probe Position Controls:	24 VDC Nominal outputs, local or remote controllable a) Drive enable (NOP/ENABLE), voltage applied to enable probe movement. b) Drive direction (Out/In), voltage applied to drive probe in.
GVM Amplifier Status Control Interlock:	External contact closure required to energize unit.

Status (On/Off) Reads:	External contact closure required to indicate power is on. a) GVM Amplifier b) CPO Amplifier c) Corona Probe Controller
Status (On/Off) Remote AC Power Enable Control:	24 VDC Nominal input, voltage applied to switch AC power to controller
Over/Under Voltage Protection Remote Controls:	24 VDC Nominal input a) O/UVP Enable (Momentarily apply input to enable protection) b) O/UVP Disable (Momentarily remove input to disable protection)
Status (On/Off) Remote Reads:	Contact closure exists when condition is true. a) External components AC power On b) O/UVP Enable c) O/UVP Tripped
Analog Inputs:	All inputs are differential, differential input impedance is 4 megohms, common mode compliance is ±13 VDC.

Signal	Range	Corresponding Scale
a) GVM Voltage	0 to +5 VDC to 0 to +10 VDC	0 to Full Scale Terminal Voltage
b) Probe Current	0 to +10 VDC	0 to 200 µA
c) Probe Position	0 to +10 VDC	Out to In Position
d) Grid Voltage	0 to +10 VDC	0 to -25 VDC
e) CPO Channel A	0 to ±10 VAC	0 to ±5.0 KV of Terminal Ripple
f) CPO Channel B	0 to ±10 VAC	0 to ±5.0 KV of Terminal Ripple

Analog Outputs: All outputs are single-ended, output impedance is 1.5K ohms or less

Signal	Range	Corresponding Scale
a) Corona Probe Current Control	0 to +10 VDC	0 to +200 μA
b) GVM Voltage Monitor	0 to +8 VDC	0 to +2 MV (1 MV and 2 MV machines)
	0 to +8 VDC	0 to +4 MV (3 MV and 4 MV machines)
c) Probe Current Monitor	0 to +10 VDC	0 to +200 μA
d) Probe Position Monitor	0 to +10 VDC	Out to In Position
e) CPO Sum Monitor	0 to ±10 VAC	0 to ±500 V of terminal ripple
f) CP01 Monitor	0 to ±10 VAC	0 to ±5.0 KV of terminal ripple
g) CP02 Monitor	0 to ±10 VAC	0 to ±5.0 KV of terminal ripple
h) Grid Voltage Monitor	0 to +10 VDC	0 to -25 VDC of grid voltage
i) GVM-TV Error Monitor	0 to ±10 VDC	0 to ±100 KV of terminal voltage error (1 MV and 2 MV machines)
	0 to ±10 VDC	0 to ±200 KV of terminal voltage error (3 MV and 4 MV machines)

Remote Voltage Control Inputs: All inputs are single-ended, input impedance is 100K ohms or greater

Signal	Range	Corresponding Scale
a) Terminal Voltage	0 to +8 VDC	0 to +2 MV (1 MV and 2 MV machines)
	0 to +8 VDC	0 to +4 MV (3 MV and 4 MV machines)
b) Control Gain	0 to +10 VDC	0 to MAX
c) Bias Current	0 to +10 VDC	0 to +100 μA DC
d) GVM Gain	0 to +10 VDC	0 to MAX
e) CPO Gain	0 to +10 VDC	0 to MAX
f) Crossover Frequency	0 to +10 VDC	0.28 to 89 Hz (logarithmic)
g) OVP Trip Setpoint	0 to +10 VDC	0 to 50% above terminal voltage
h) UVP Trip Setpoint	0 to +10 VDC	0 to 50% below terminal voltage

III. INSTALLATION

A. Installation and Connections

The Voltage Stabilizer should be installed at the accelerator control console and is intended to mount in a standard 19 inch equipment rack. Using the appropriate connectors and cables, make connection to the unit as follows.

1. AC Power

The Voltage Stabilizer can be operated from either 120 VAC or 240 VAC (50 or 60 Hz) power. AC power input voltage selection is made using the rear panel power receptacle (PR1). The present AC line voltage strapping is indicated by a white dot on the power receptacle cover. To restrap the unit for a different voltage, remove the power receptacle cover, remove the AC line voltage selection P.C. board and reinstall it for the desired operating voltage. The unit requires a 3/8 Ampere 3AG Slo-Blo fuse for 120 VAC operation and a 3/16 Ampere 3AG Slo-Blo fuse for 240 VAC operation. Install the appropriate fuse in the fuse holder and reinstall the power receptacle cover. Connect the unit to a grounded 50 or 60 Hz service circuit. The AC power cord has the following color code.

Power Cord Wire Color	Function
Black	Hot (Line)
White	Neutral
Green	Ground

WARNING: Do not operate Voltage Stabilizer without a good external ground attached to rear panel ground stud.

2. Corona Probe Controller

Two cables interconnect between the Voltage Stabilizer and the Corona Probe Controller (ref. 2HA058290). The Position Control connector (J6) contains the probe motor drive functions and the Current Control connector(J7) contains the corona triode and status control functions. Both Voltage Stabilizer connectors have a 1 to 1 pin correspondence with the mating Corona Probe Controller connectors.

a. Position Control Connector (J6)

Connect the Voltage Stabilizer to the Corona Probe Controller using a suitable #24 AWG three-twisted pair shielded cable (Belden No. 9503 or equivalent). The 9 Pin "D" connector has the following pin assignments.

Position Control Connector - J6		Function
Pin 1	Pair	Drive Enable +24 VDC Output
Pin 6		Circuit Common
Pin 2	Pair	Drive Direction +24 VDC Output
Pin 7		Circuit Common
Pin 4	Pair	Probe Position Read (+) Input
Pin 9		Probe Position Read (-) Input
Pin 5	Shield	Chassis Ground

b. Current Control Connector (J7)

Connect the Voltage Stabilizer to the Corona Probe Controller using a suitable #24 AWG five twisted-pair shielded cable (Belden No. 9505 or equivalent). The 15 pin "D" connector has the following pin assignments.

Current Control Connector - J7		Function
Pin 1	Pair	Probe Current Control Output
Pin 9		Circuit Common
Pin 2	Pair	Probe Current Read (+) Input
Pin 10		Probe Current Read (-) Input
Pin 3	Pair	Tube Grid Voltage Read (+) Input
Pin 11		Tube Grid Voltage Read (-) Input
Pin 6	Pair	Status Control +24 VDC Output
Pin 14		Circuit Common
Pin 7	Pair	Status Read Output
Pin 15		Circuit Common
Pin 8	Shield	Chassis Ground

3. GVM Amplifier

Two connectors are associated with the GVM (Generating Voltmeter) Amplifier. The GVM Amplifier connector (J3) goes to the amplifier and the GVM Interlock connector (J9) connects to an external interlocking device (if used).

a. GVM Amplifier Connector (J3)

Connect the Voltage Stabilizer to the GVM Amplifier (ref. 2HA058092, 3) using a suitable #24 AWG three twisted-pair shielded cable (Belden No. 9503 or equivalent). The Voltage Stabilizer connector pinout has a 1 to 1 correspondence with the amplifier. The 9 pin "D" connector has the following pin assignments.

GVM Amplifier Connector - J3		Function
Pin 1	) Pair	GVM (+) Input
Pin 6	)	GVM (-) Input
Pin 3	) Pair	Status Control +24 VDC Output
Pin 8	)	Circuit Common
Pin 4	) Pair	Status Read Output
Pin 9	)	Circuit Common
Pin 5	Shield	Chassis Ground

b. GVM Interlock Connector (J9)

The GVM Amplifier status (On/Off) control may be interlocked to an external device. Typically, the unit is interlocked to a sensor on the accelerator tank to inhibit GVM motor power when the tank is under vacuum. A contact closure (i.e., a short circuit) is required between pins J9-1 and J9-2 to energize the GVM Amplifier. Connect the Voltage Stabilizer to the external interlock device using a suitable #24 AWG twisted-pair shielded cable (Belden No. 9501 or equivalent). If an external interlock is not used, jumper pins J9-1 and J9-2 together at the connector. The three pin connector has the following pin assignments.

GVM Interlock Connector - J9		Function
Pin 1	)	GVM Interlock
	) Pair	
Pin 2	)	GVM Interlock
Pin 3	Shield	Chassis Ground

4. CPO Amplifier

Four connectors are associated with the CPO (Capacitor Pick-Off) Amplifier. The CPO Amplifier connector (J2) goes to the amplifier and the three CPO monitor connectors (J10, J11, J12) connect to an oscilloscope for CPO display.

a. CPO Amplifier Connector (J2)

Connect the Voltage Stabilizer to the CPO Amplifier (ref. 2HA058082, 3) using a suitable #24 AWG four twisted-pair shielded cable (Belden No. 9504 or equivalent). The TPS connector pinout has a 1 to 1 correspondence with the amplifier. The 9 pin "D" connector has the following pin assignments.

CPO Amplifier Connector - J2		Function
Pin 1	)	CPO Channel A (+) Input
	) Pair	
Pin 6	)	CPO Channel A (-) Input
Pin 2	)	CPO Channel B (+) Input
	) Pair	
Pin 7	)	CPO Channel B (-) Input
Pin 3	)	Status Control +24 VDC Output
	) Pair	
Pin 8	)	Circuit Common
Pin 4	)	Status Read Output
	) Pair	
Pin 9	)	Circuit Common
Pin 5	Shield	Chassis Ground

b. CPO Monitor Connectors (J10, J11, J12)

The CPO signals from the individual CPO's are available at the CPO Monitor BNC connectors J11(CP01) and J12(CP02). The buffered, combined CPO signal is available at the CPO Sum Monitor BNC connector (J10). Connect the Voltage Stabilizer to an oscilloscope using RG-58 (or equivalent) coaxial cable.

NOTE: The Voltage Stabilizer buffers each CPO channel, adds the two channels together and then multiplies the combined signal by a factor of five. For a 2 channel CPO Amplifier calibrated to produce 1 Volt output per 500 Volts of terminal voltage ripple, the CPO Sum Monitor signal level is 1 Volt per 50 Volts of terminal ripple. The individual CPO Monitor signal levels are 1 Volt per 500 Volts of terminal voltage ripple. If only one CPO is used, the oscilloscope monitor level is 1 Volt per 100 Volts of terminal ripple.

5. Charging Control Connector (J4)

The Voltage Stabilizer O/UVP (Over/Under Voltage Protection) circuitry interfaces to the charging system at the charging control connector (J4). The proportional O/UVP circuitry protects the accelerator from excessively high terminal voltage as well as providing an indicator of other potential problems in the machine. If the terminal voltage rises to a fixed percentage above the front panel terminal voltage knob setting, the O/UVP circuit toggles. If the terminal voltage should fall to a fixed percentage below the front panel terminal voltage knob setting, perhaps due to sparking, the O/UVP circuitry will once again toggle. When the O/UVP circuit trips, the Voltage Stabilizer takes charging control away from the Charging Controller and charging reverts to a low, preset default value. Under normal operating conditions, the Charging voltage control signal (0 to +10 VDC) passes unaffected from the Charging Controller, thru the Voltage Stabilizer, back to the Charging Controller and on to the charging power supply. However, when the O/UVP circuit trips, the Voltage Stabilizer disconnects the charging control signal from the Charging Controller and instead connects a low, preset DC voltage to the charging power supply input. In this way, the terminal voltage is reduced to a safe level.

Connect the Voltage Stabilizer to the Charging Controller (Ref. 2HA058060, 1, 2, 3 and 2HA058150, 1) using a suitable #24 AWG three twisted-pair shielded cable (Belden No. 9503 or equivalent). The Voltage Stabilizer connector pinout has a 1 to 1 correspondence with the Charging Controller. The 9 pin “D" connector has the following pin assignments.

Charging Control Connector - J4		Function
Pin 1	Pair	Charging Control Input
Pin 6		Charging Controller Return
Pin 2	Pair	+10 VDC Input
Pin 7		Charging Controller Return
Pin 3	Pair	Charging Control Output
Pin 8		Charging Controller Return
Pin 5	Shield	Chassis Ground

Note: The Voltage Stabilizer may be used with a "nonstandard" charging controller and still maintain the O/UVP feature. A normally closed relay contact is available at the Charging Control connector pins J4-1 and J4-3. If the standard 0 to +10 VDC charging control signals are not used, this relay contact may be used to interrupt the charging power supply control signal (or turn off the charging chain) when the O/UVP circuit trips. In addition, a normally open relay contact is available at the Voltage/Status Read connector pins J15-9 and J15-22. Depending on the application, either of these contacts may be used to inhibit the charging system. If the Voltage Stabilizer is connected this way, then the Default Charging potentiometer is not used.

6. Remote Connections

The Voltage Stabilizer has three remote rear panel connectors. The connectors are provided to allow remote monitoring and/or control of the Voltage Stabilizer, depending upon the application. The Voltage/Status read connector (J15) contains data logging signals. The voltage control and status control connectors, J13 and J14 respectively, contain process control signals and are used to remotely control the Voltage Stabilizer. No connections are required to J15 for normal (local) Voltage Stabilizer operation. However, if remote control of the Voltage Stabilizer is not desired, Jumper connectors must be installed in J13 and J14 for normal local control.

a. Voltage Stabilizer Voltage/Status Read (J15)

Eight Voltage Stabilizer voltage/status signals are available at the voltage/status read connector. The signals are:

(1) GVM-TV Error
(2) GVM Voltage
(3) Corona Probe Position
(4) Corona Probe Current
(5) Grid Voltage
(6) O/UVP Status (tripped)
(7) O/UVP Status (enabled)
(8) CPO Amp/Corona Probe Controller/GVM Amp Power Status

The GVM-TV error signal is the difference between the GVM voltage (i.e., Terminal Voltage) and the front panel terminal voltage knob setting (GVM - T.V.). For 1 MV and 2 MV machines, the output voltage is 1 volt per 10 KV of GVM error. For 3 MV and 4 MV machines, the output voltage is 1 volt per 20 KV of GVM error. In both cases, the maximum output is ±10 volts. The GVM voltage signal provides a 0 to +8 VDC output for monitoring terminal voltage. For 1 MV and 2 MV machines, +8 VDC corresponds to 2 MV (i.e., 1 V per 250 KV). For 3 MV and 4 MV machines, +8 VDC corresponds to 4 MV (i.e., 1 V per 500 KV). The Corona Probe position and current signals provide 0 to 10 VDC outputs for monitoring the corona probe. For the probe current monitor +10 VDC corresponds to +200 μA. For the probe position monitor, 0 VDC corresponds to maximum "OUT" position and +10 VDC corresponds to maximum "IN" position. The grid voltage signal provides a 0 to +10 VDC for monitoring the corona triode (tube) grid voltage. A +10 VDC signal corresponds to -25 V of triode grid voltage. The O/UVP status (tripped) and O/UVP status (enabled) signals provide contact closures (i.e., a short circuit) for monitoring the voltage stabilizer status. A contact closure exists when the O/UVP circuitry is enabled and a separate contact closure exists when the O/UVP has been tripped.

The power status signal provides three series connected contact closures for monitoring the power status of the CPO Amp, Corona Probe Controller and GVM Amp. A contact closure exists when power is supplied to its corresponding component (i.e., CPO Amp, Probe Controller, GVM Amp). With all three contacts closed, a signal is passed to the remote controller indicating power supplied to all three components. Should any one or more components lose power, the signal will not be passed. The Voltage Stabilizer front panel would have to be checked to see which specific component(s) have lost power.

Using an appropriate shielded cable, make connections to the voltage/status read connector as required. The 25 pin "D" connector has the following pin assignments.

Voltage Stabilizer
Connector - J15

Pin 1	)		GVM-TV error output
	)	Pair	
Pin 14	)		Circuit common
Pin 2	)		GVM voltage output
	)	Pair	
Pin 15	)		Circuit common
Pin 5	)		Corona probe position output
	)	Pair	
Pin 18	)		Circuit common
Pin 6	)		Corona probe current output
	)	Pair	
Pin 19	)		Circuit common
Pin 7	)		Grid voltage output
	)	Pair	
Pin 20	)		Circuit common
Pin 9	)		Over/Under Voltage Protection
	)	Pair	status (tripped)
Pin 22	)		Over/Under Voltage Protection status (tripped)
Pin 10	)		Over/Under Voltage Protection
	)	Pair	status (enabled)
Pin 23	)		Over/Under Voltage Protection status (enabled)
Pin 11	)		Power status
	)	Pair	
Pin 24	)		Power status
Pin 13		Shield	Chassis ground

b. Voltage Control (J13)

Eight voltage control remote signals are available at the voltage control connector. The signals are:

(1) Control Gain
(2) Bias Current
(3) Undervoltage Protection (UVP) Trip Setpoint
(4) Overvoltage Protection (OVP) Trip Setpoint
(5) Crossover Frequency
(6) Terminal Voltage
(7) CPO Gain
(8) GVM Gain

The Terminal Voltage signal requires 0-10 VDC to remotely set the terminal voltage level. The Terminal Voltage setting is compared to the terminal voltage reading of the GVM producing a GVM error signal. The GVM gain signal requires 0-10 VDC to regulate the amplitude of the GVM error signal. The CPO signal is used in generating the high frequency information for the probe current control error signal. The CPO gain signal requires 0-10 VDC to regulate the amplitude of the CPO signal. The CPO signal and a GVM error signal are combined in a voltage controlled low-pass/high-pass filter producing a GVM error correction signal. The Crossover Frequency signal requires 0-10 VDC to control the "crossover" point. The control gain signal requires 0-10 VDC to regulate the amplitude of the GVM error correction signal. The Bias Current signal requires 0-10 VDC to set the Bias Current level which the GVM error correction signal is combined with to produce the Corona Probe Current correction signal. The Undervoltage and Overvoltage Protection Trip Setpoint signals each require a separate 0-10 VDC to remotely set their respective trip points.

NOTE: Either a remote control connection or a local jumper connection is required at J13 for proper operation of the Voltage Stabilizer (Ref. Dwg.: 2HS066100).

Using an appropriate shielded cable and/or jumper wires, make connections to the Voltage Control connector as required. The 37 pin "D" connector has the following pin assignments. If the remote control connection is not used, the corresponding local jumper must be installed for proper operation.

Voltage Control
Connector - J13

Local Jumper		Remote Connection		
Pin 1)		Pin 1)		Control Gain voltage control input
)		)	Pair	
)	Jmp	Pin 20)		Circuit common
)				
Pin 2)				Control Gain voltage control potentiometer
Pin 21)		Pin 21)		Bias Current voltage control input
)		)	Pair	
)	Jmp	Pin 3)		Circuit common
)				
Pin 22)				Bias Current voltage control potentiometer
Pin 24)		Pin 24)		Undervoltage protection trip setpoint
)		)	Pair	input
)	Jmp	Pin 6)		Circuit common
)				
Pin 25)				Undervoltage protection trip setpoint potentiometer

Pin 27)		Pin 27	)	Overvoltage protection trip setpoint input
)			) Pair	
) Jmp		Pin 9	)	Circuit common
)				
Pin 28)				Overvoltage protection trip setpoint potentiometer
Pin 10)		Pin 10	)	Crossover Frequency voltage control
)			) Pair	input
) Jmp		Pin 29	)	Circuit common
)				
Pin 11)				Crossover Frequency voltage control potentiometer
Pin 30)		Pin 30	)	Terminal Voltage control input
)			) Pair	
) Jmp		Pin 12	)	Circuit common
)				
Pin 31)				Terminal Voltage control potentiometer
Pin 13)		Pin 13	)	CPO Gain Voltage control input
)			) Pair	
) Jmp		Pin 32	)	Circuit common
)				
Pin 14)				CPO Gain voltage control potentiometer
Pin 33)		Pin 33	)	GVM Gain voltage control input
)			) Pair	
) Jmp		Pin 15	)	Circuit common
)				
Pin 34)				GVM Gain voltage control potentiometer
		Pin 19	Shield	Chassis ground

c. Status Control (J14)

Five status control remote signals are available at the Status Control connector. The signals are:

(1) Power ON/OFF
(2) Probe position NOP/ENABLE
(3) Probe Position OUT/IN
(4) Over/Under Voltage Protection ENABLE
(5) Over/Under Voltage Protection DISABLE/RESET

With the Local/Remote switch (located on the rear panel of the Voltage Stabilizer) set to remote, the Power ON/OFF signal requires +24 VDC to supply AC power to the Voltage Stabilizer. The probe position NOP/ENABLE signal requires +24 VDC to enable the corona probe position control (or 0 VDC for NOP state). With the Corona Probe Position Control enabled, the probe position OUT/IN signal requires either 0 VDC or +24 VDC to move the Corona Probe OUT or IN respectively. The Over/Under Voltage Protection Enable signal requires a momentary +24 VDC which latches the O/UVP circuitry in the enabled state. The Over/Under Voltage Protection Disable/Reset signal requires a constant +24 VDC to maintain the O/UVP circuitry in the enabled state. Once the O/UVP circuitry has been tripped, the Disable/Reset signal must be interrupted (i.e., 0 VDC) to reset or disable the O/UVP circuitry.

NOTE: Either a remote control connection or a local jumper connection is required at J14 for proper operation of the Voltage Stabilizer (Ref. Dwg.: 2HS066100).

Using an appropriate shielded cable and/or jumper wires, make connections to the status control connector as required. The 25 Pin "D" connector has the following pin assignments. If the remote control connection is not used, the corresponding local jumper must be installed for proper operation.

Status Control
Connector - J14

Local Jumper	Remote Connection		Function
	Pin 1)		Voltage Stabilizer power ON/OFF
	)	Pair	Control input
	Pin 14)		Voltage Stabilizer power ON/OFF
			Control return (isolated)
Pin 2)			Over/Under Voltage Protection
) Jmp			Enable control switch
Pin 15)	Pin 15)		Over/Under Voltage Protection
	)	Pair	Enable control input
	Pin 3)		Circuit common
Pin 16)			Over/Under Voltage Protection
) Jmp			Disable/Reset control switch
Pin 4)	Pin 4)		Over/Under Voltage Protection
	)	Pair	Disable/Reset control input
	Pin 17)		Circuit common
Pin 8)			Corona Probe position
) Jmp			NOP/ENABLE control switch
Pin 21)	Pin 21)		Corona Probe Position
	)	Pair	NOP/ENABLE control input
	Pin 9)		Circuit common
Pin 22)			Corona Probe Position OUT/IN
) Jmp			control switch
Pin 10)	Pin 10)		Corona Probe position OUT/IN
	)	Pair	control input
	Pin 23)		Circuit common
	Pin 13	Shield	Chassis ground

B. Setup and System Tuning

The Voltage Stabilizer is intended to operate on 1 MV thru 4 MV singled-ended or tandem accelerators. Each controller must be set up and tuned to the particular machine during installation. The set-up procedure consists of two parts. The first part involves setting internal switches to configure the unit for the appropriate terminal voltage. The second part consists of adjusting potentiometers to calibrate the GVM, set the GVM and CPO control gains and crossover frequency adjustment, and set the Over/Under Voltage Protection. Each step is detailed below. It is easier to use local control mode to set up the Voltage Stabilizer. However, remote control mode may also be used.

1. Switch Settings

Three P.C. board mounted switches inside the Voltage Stabilizer configure the unit for 1 MV, 2 MV, 3 MV or 4 MV operation. The first two switches are on the GVM Isolation P.C. board. The Meter Select switch (S1) configures the front panel Terminal Voltage meter for 1 MV/2 MV operation or 3 MV/4 MV operation and the Gain switch (S2) sets the GVM isolation amplifier sensitivity. Both switches must be set prior to GVM calibration. The third switch is on the GVM Control P.C. board. The Gain switch (S1) sets the front panel Terminal Voltage knob gain to calibrate the digital knob setting to the digital meter reading.

Remove the Voltage Stabilizer top cover. Using Table 3-1 below as a guide, set the three P.C. board switches to configure the Voltage Stabilizer for the appropriate terminal voltage. Refer to Figure 3-1, the Voltage Stabilizer Setup Diagram for switch location information.

Terminal Voltage Configuration	GVM Isolation P.C. Bd.		GVM Control P.C. Bd.
	Switch S1 Meter Select	Switch S2 Gain	Switch S1 Gain
1 MV	2 MV	LO	HI
1.7 MV, 2 MV	2 MV	HI	HI
3 MV	4 MV	LO	LO
4 MV	4 MV	HI	HI

Table 3-1: P.C. Board Switch Settings

2. GVM Calibration

The GVM signal sensitivity varies with the application. The Voltage Stabilizer system uses two separate gain adjustment stages to calibrate the GVM. The first stage is in the GVM Amplifier. The amplifier has internal switches to set the approximate overall gain within a two to one range. The amplifier is adjusted to provide between +5 VDC and +10 VDC (7.5 VDC nominal) output at rated terminal voltage. The Voltage Stabilizer has a two to one adjustment range potentiometer for "fine" calibrating the GVM.

To calibrate the GVM, first set up the GVM Amplifier. Refer to the GVM Amplifier Instruction Manual for information. Once the amplifier has been adjusted, "fine" calibrate the GVM at the Voltage Stabilizer. To verify that the GVM Amplifier has been set up correctly, the amplifier output voltage is available in the Voltage Stabilizer on the GVM Isolation P.C. board (PCB 6) at TP1(+) and TP4(-). See drawing No. 8-6-5809 for test point locations. The voltage at TP1 should be between +5 VDC and +10 VDC at rated terminal voltage. With the machine running at a known terminal voltage (as determined by an independent test), adjust the GVM Calibration potentiometer (R10) for the correct front panel Terminal Voltage meter reading. Refer to Figure 3-1, the Voltage Stabilizer Setup Diagram for potentiometer location information.

3. CPO Calibration

The CPO signal sensitivity varies with the application. The CPO Amplifier should be calibrated prior to any Voltage Stabilizer CPO control mode adjustments. Refer to the CPO Amplifier Instruction Manual for calibration information. Typically, each CPO channel is calibrated for 1 Volt output per 500 Volts of terminal voltage ripple.

NOTE: The Voltage Stabilizer buffers each channel, adds the two channels together and then multiplies the combined signal by a factor of five. For a 2 channel CPO amplifier calibrated to provide 1 Volt per 500 Volts of terminal voltage ripple, the oscilloscope monitor signal level is 1 Volt per 50 Volts of terminal ripple. If only one CPO is used, the oscilloscope monitor signal level is 1 Volt per 100 Volts of terminal ripple.

4. GVM Control Adjustments

GVM adjustments are required to optimize the control system for maximum regulation and stability. Three adjustments are involved. The GVM Gain potentiometer sets the closed loop control low frequency gain, the CPO Gain potentiometer sets the closed loop control high frequency CPO signal gain and the GVM/CPO Crossover Frequency control potentiometer sets the center cut-off frequency, above which the GVM control error signal is rolled off at -20 dB/decade and below which the CPO error correction signal is rolled off at 20 dB/decade.

The GVM Gain potentiometer, as well as the CPO Gain potentiometer, are regulated by the front panel Control Gain knob which is "downstream" in the control system. The tuning procedure involves matching the GVM control system to the machine such that the Control Gain and CPO Gain knobs have the widest effective range and highest possible gain.

The GVM and CPO gains should be set so that oscillation occurs at a control gain knob setting (front panel) of about 9. Oscillation is indicated on the front of the Voltage Stabilizer by erratic corona probe current and/or terminal voltage. In addition, there are other means of determining machine stability. The CPO monitors terminal voltage ripple and hence system regulation. Displaying the CPO signal on an oscilloscope is an excellent way to "fine tune" the Voltage Stabilizer for optimum performance. The Voltage Stabilizer rear panel voltage/status read connector provides a GVM control error signal output which is also useful in system tuning. The error signal is steady when the system is regulating and oscillatory when the system is oscillating. Refer to the installation section for error signal connector information.

For the following three adjustments, typical potentiometer wiper voltages are given as an aid to system tuning. The potentiometers are:

(1) GVM Gain (R6)
(2) CPO Gain (R7)
(3) GVM/CPO Crossover Frequency (R8)

They have +10 VDC between the outer clockwise (+) and counter clockwise (-) terminals. The potentiometer center wiper voltage varies from 0 VDC to +10 VDC (with respect to the counter-clockwise terminal) as the potentiometer rotates from counter-clockwise to clockwise. The potentiometer wiper voltages may be monitored with a high impedance voltmeter, and used as a guide for system tuning.

Run the accelerator at about one half the rated terminal voltage without Voltage Stabilizer control. Refer to the operation section (page 4.6) for details. Preset the GVM Gain potentiometer (R6) and CPO gain potentiometer (R7) fully counter-clockwise and the crossover frequency potentiometer (R8) midrange (+5 VDC). Refer to Figure 3-1, the Voltage Stabilizer setup diagram, for potentiometer location. Set the front panel control gain knob (R1) to 9 and the CPO gain potentiometer (R7) fully clockwise. Set the front panel terminal voltage knob (R2) to match the terminal voltage meter reading. It is very helpful to monitor the CPO signal with an oscilloscope to precisely optimize the stabilization characteristics of the Voltage Stabilizer system. The scale factor at the CPO monitor connector (J10) is 1 Volt per 50 Volts of terminal voltage ripple (or 1 Volt per 100 Volts of ripple).

Slowly turn both the GVM gain potentiometer (R6) and the CPO gain potentiometer (R7) clockwise until the Voltage Stabilizer system controls. Continue to turn both potentiometers clockwise in tandem until the Voltage Stabilizer just starts to oscillate or until both potentiometers are at midrange (+5 VDC). At this point an iterative "fine" tuning of the GVM gain potentiometer (R6), CPO gain potentiometer (R7) and Crossover frequency potentiometer (R8) is necessary to optimize the regulation of the Voltage Stabilizer. While monitoring the CPO oscilloscope display, set the GVM gain potentiometer (R6) at the point where the terminal voltage ripple is minimized and non-oscillatory. Repeat this procedure for the CPO gain potentiometer (R7) and then for the Crossover Frequency potentiometer (R8), each time minimizing the terminal voltage ripple displayed on the oscilloscope. Since these adjustments are interactive, additional "fine" tuning of R6, R7 and R8 may be necessary to achieve minimum terminal voltage ripple. As a guide, typical GVM gain and CPO gain potentiometer wiper voltages are in the range of +2.5 VDC to +7.5 VDC. Typical Crossover frequency potentiometer wiper voltage is in the range of +4.5 VDC to +6.5 VDC.

5. Over/Under Voltage Protection Calibration

The Voltage Stabilizer proportional O/UVP (Over/Under Voltage Protection) circuit protects the accelerator from excessively high voltage, as well as other potential problems indicated by sudden decreases in voltage. If the terminal voltage rises to a fixed percentage above the terminal voltage knob setting, the O/UVP circuit toggles. Likewise, when the terminal voltage falls to a separately fixed percentage below the terminal voltage knob setting, the O/UVP circuit toggles. In either case, when it trips, the Voltage Stabilizer takes charging control away from the (normally active) Charging Controller and charging reverts to a low default value. Three adjustments are required to set up the O/UVP. The trip set point potentiometers (R4) and (R5) control the percent overvoltage and percent under voltage limits respectively. The default charging potentiometer (R9) sets the charging level once the O/UVP circuit has tripped.

For the following adjustments, typical potentiometer wiper voltages are given. The trip set point potentiometers and the default charging potentiometer have +10 VDC between the outer clockwise (+) and counter-clockwise (-) terminals. The center wiper voltage varies from 0 VDC to +10 VDC (with respect to the counter-clockwise terminal) as the potentiometer rotates from counter-clockwise to clockwise. The potentiometer center wiper voltages should be monitored with a high impedance voltmeter and used to set the O/UVP.

a. Trip Setpoint Adjustments

The two trip setpoint potentiometers (R4) and (R5) are located on the rear panel of the Voltage Stabilizer (Ref. Fig. 4-2). They set the percent overvoltage and percent undervoltage limits respectively and both have a range of 0 percent (counter-clockwise) to 50 percent (clockwise). Typically, the overvoltage limit is set between 5 and 10 percent. The undervoltage limit will depend on how large of a spark will be allowed in the machine before the UVP circuit is tripped. A higher percent UVP limit will allow a larger spark before tripping. Using a voltmeter to measure the wiper voltages, set the overvoltage and undervoltage trip points for the desired limits. Wiper voltage scale factors are 1 Volt for each 5 percent over or under voltage.

b. Default Charging Adjustment

The default charging potentiometer (R9) sets the charging level once the O/UVP circuit has tripped. In order to set the potentiometer, the O/UVP circuit must be intentionally tripped. First, preset the potentiometer fully counterclockwise. To trip the O/UVP, turn the front panel terminal voltage knob to zero, enable the O/UVP, and use the charging controller to obtain voltage on the terminal. Once the O/UVP has tripped, adjust the default charging potentiometer for the desired charging level. Typically, the potentiometer is set so that the terminal charges to about 10 percent of the rated terminal voltage (without beam). This, in effect, turns down the charging to a safe value without letting the terminal charge negative. As a guide, typical default charging wiper voltages are in the range of +0.5 VDC to +1 VDC.

IV. OPERATION

A. Front and Rear Panel Controls and Indicators

The functions of the Voltage Stabilizer front and rear panel controls and indicators are described below. Refer to Figure 4-1 and 4-2 for layout of front and rear panels and location of each control and indicator.

1. Power Section

a. Power Switch

The switch controls AC power to the Voltage Stabilizer and also controls status (On/Off) control power to the remotely controlled auxiliary units (GVM Amp, CPO Amp and Corona Probe Controller) when the Voltage Stabilizer is in local control mode.

b. Power ON LED

The indicator is "ON" when the Voltage Stabilizer unit is energized.

c. Power Status LEDs

GVM - The indicator is "ON" when the GVM Amplifier is energized. The GVM Amplifier may be interlocked to an external device. When the interlock is tripped, the GVM power LED will not light.

CPO - The indicator is "ON" when the CPO Amplifier is energized.

Probe - The indicator is "ON" when the Corona Probe Controller is energized.

2. Remote/Local Control Section

a. Remote/Local Control Switch. (Fig. 4-2)

The Voltage Stabilizer unit may be either locally controlled or remotely controlled. The switch, found on the rear panel, selects the Stabilizer's method of control. When remote control is selected, the power switch (1a) must be switched "on”. The Power On LED (1b) will not be "ON" until the remote control unit energizes the Voltage Stabilizer unit.

b. Remote Control LED

The indicator is "ON" when two conditions are both met:

(1) Remote/Local switch (2a) is set to remote and;

(2) The remote control unit energizes the Voltage Stabilizer

3. GVM Control Section

a. Control Gain Knob

The knob sets the Voltage Stabilizer closed loop control system gain. Specifically, it controls the amplitude of the error correction signal that is combined with the corona probe "DC" bias level to form the Corona

Probe current control signal. This is an overall system gain knob that adjusts the gain of the low frequency signal (GVM-T.V.) as well as the gain of the high frequency CPO signal. When the knob is set to zero, the Voltage Stabilizer does not regulate terminal voltage. If the knob is set too high, the control system may oscillate (under certain conditions).

b. Terminal Voltage Knob

The knob sets the desired terminal voltage. That is, the control is the reference voltage to which the GVM voltage is compared. Turn the knob clockwise to the desired Terminal Voltage setting indicated on the knob digital reading. The Terminal Voltage knob is a 50 turn knob with each turn corresponding to 100 KV. The 4 digit knob reading corresponds to the terminal voltage in DC Megavolts with an implied decimal point between the first and second digit. NOTE: The digital knob reading is intended for coarse adjustment only. There may be a discrepancy between the digital knob setting and the digital meter reading by several places in the least significant digit.

c. Terminal Voltage Meter

The digital panel meter displays terminal voltage in DC Megavolts. The four digit display (X.XXX MV) has ±1 KV resolution.

4. Corona Probe Section

   a. Bias Current Knob

      The knob sets the "DC" (quiescent) Corona Probe current level. The control range is 0 to +100 µADC. The knob operates independently from the Control Gain knob setting and is active whenever the Voltage Stabilizer unit is "ON”.

   b. Position In/Out Switch

      The switch changes the corona probe position. Normally, it is in the center off position. Momentarily pushing the switch up moves the probe in (towards the terminal) and pushing the switch down moves the probe out.

   c. Grid Voltage Meter

      The meter displays the corona triode (tube) grid voltage. The display range is 0 to -25 VDC. The meter is used to verify that the triode is operating within its active region.

d. Current/Position Meter and Switch

The meter displays both Corona Probe current and Corona Probe position. When the meter select switch is up, the meter displays probe current over a 0 to +200 μADC range. The display indicates actual probe current and will give an upscale reading only when the corona triode is biased in its active region by properly adjusting the probe position. With the switch down, the meter displays probe position in (arbitrary) relative position units. 0 corresponds to maximum "out" position and 200 corresponds to maximum "in" position.

5. Over/Under Voltage Protection Section

The Over/Under Voltage Protection circuitry protects the accelerator from excessively high voltage, as well as other potential problems indicated by sudden decreases in voltage. If the terminal voltage rises to a fixed percentage above the terminal voltage knob setting or falls to a separate fixed percentage below the terminal voltage knob setting, then the over/under voltage protection circuit toggles. When it trips, the Voltage Stabilizer takes charging control away from the Charging Controller and charging reverts to a low, preset default value.

a. Enable/Disable - Reset Switch

The switch enables and disables the over/under voltage protection circuitry. It also resets the O/UVP circuit if it has been tripped. Normally, the switch is in the center position. Momentarily pushing the switch up enables the O/UVP while momentarily pushing the switch down disables the O/UVP. If the O/UVP circuit trips, momentarily pushing the switch down will reset the circuit but not enable it. After reset, the switch must be momentarily pushed up to re-enable the O/UVP circuit.

b. Tripped LED

The indicator is "ON" whenever the Over/Under Voltage Protection circuit has tripped.

c. Enabled LED

The indicator is “ON" whenever the Over/Under Voltage Protection circuit has been enabled.

d. Overvoltage Trip Setpoint Knob (Fig. 4-2)

The knob sets the percent overvoltage trip point. The trip point range is 0 to 50 percent over the terminal voltage knob setting (3b).

e. Undervoltage Trip Setpoint Knob (Fig. 4-2)

The knob sets the percent undervoltage trip point. The trip point range is 0 to 50 percent under the terminal voltage knob setting (3b).

B. Operating Instructions

The Voltage Stabilizer operation is straight-forward. First, obtain the desired operating terminal voltage without Voltage Stabilizer control and adjust the Corona Probe. Then, stabilize the terminal voltage using GVM control and inject a beam thru the accelerator and around the analyzing magnet. Each operation is detailed below.

1. Initial Machine Voltage

a. Set the front panel controls as follows:

POWER	ON (Note that the power LED's come on)
OVERVOLTAGE PROTECTION	ENABLE
CONTROL GAIN	Zero
TERMINAL VOLTAGE	Desired Terminal Voltage
BIAS CURRENT	Zero
PROBE POSITION	Out to zero (or leave at present position if operating at the same terminal voltage as previous operation).

b. On the Charging Controller, preset the Charging Voltage control up about 5 percent, turn on the charging chain(s), and slowly increase the Charging Voltage control until the desired terminal voltage is reached.

2. Corona Probe Adjustment

   a. Set the Bias Current knob for the desired probe current. The bias current should be set at least as high as the expected beam current. Typically, 30 μA is a good value. When running higher beam currents, increase the bias current.

   b. Adjust the probe position in or out as required until the Probe Current meter matches the Bias Current knob setting, and the Grid Voltage meter reads about -10 VDC (-8 to -12 V is OK). The correct probe position will vary with terminal voltage. Move the probe in for low terminal voltage operation and out for high voltage operation. Also, once the Probe Current meter matches the Bias Current knob setting, moving the probe in decreases the grid voltage (meter moves right) and moving the probe out increases the grid voltage (meter moves left).

   c. On the Charging Controller, increase the Charging Voltage control until the terminal voltage comes back up to the desired operating voltage. This makes up for the current drawn by the Corona Probe. "Fine" tune the probe position if necessary.

3. GVM Control

   a. With the terminal at approximately the right voltage and the Corona Probe adjusted, turn up the Control Gain knob to its optimum setting.

   b. “Fine” tune the Terminal Voltage knob for the desired voltage.

4. Beam Transport

   a. With the machine in GVM control, inject the beam thru (or out of) the accelerator, around the analyzing magnet and onto the high energy Faraday cup. Note that the probe current goes down to compensate for the increased beam loading.

   b. On the Charging Controller, increase the Charging Voltage control until the Probe Current meter again matches the Bias Current knob setting. Alternately, when running high beam currents with limited extra charging current available, the Bias Current knob can be turned down to match the Probe Current meter. Either way, match the probe current to the bias current.

C. Operation Notes

1. Over/Under Voltage Protection

In general the Over/Under Voltage Protection should be enabled. One cause of accelerator overvoltage is the sudden loss of beam current. When this happens, the terminal voltage rises abruptly. If the transition is fast enough, GVM control may not be able to compensate for it. When the terminal voltage rises to a fixed percentage above the terminal voltage knob setting, the Over/Under Voltage Protection circuit trips and turns down the charging. One cause of accelerator undervoltage is sparking within the machine. When this happens, the terminal voltage drops off sharply. When the terminal voltage falls to a fixed percentage below the terminal voltage knob setting, the Over/Under Voltage Protection circuit trips and turns down the charging once again.

2. Changing Operating Voltage

Adjust the terminal voltage using the Terminal Voltage knob. Readjust the Corona Probe position and current for the new operating voltage. When making a large change in terminal voltage, it may be necessary to adjust the Corona Probe in steps along the way.

3. System Stability and Oscillation

The Control Gain knob regulates the Voltage Stabilizer closed loop control system gain. If the system oscillates, turn the Control Gain knob down until the oscillation stops and then back up again. System stability may vary depending on the operating terminal voltage.

If the controller just does not regulate at all, check the terminal voltage polarity. The GVM is inherently polarity insensitive and measures magnitude only. The accelerator can be charged negatively and Recondition the accelerating tube. This can happen when the charging chain(s) are turned on while the Charging Voltage control is set to zero. Always turn up the Charging Voltage control a little before starting the chain(s). As a last resort, verify that the charging chain(s) are running in the correct rotation to charge the terminal positively.

4. Charging Current Test

A charging current test can be useful in determining the overall charging system performance. The Voltage Stabilizer can be used to draw over 200 μA of Corona Probe current. To do this, the controller must be intentionally misadjusted. Set the Bias Current knob to 100, the Terminal Voltage knob to zero and the Control Gain knob to 10. The controller will try to draw about 225 μA of probe current. The actual probe current will be determined by the Corona Probe position and the available charging current.

V. ELECTRICAL DESCRIPTION

A. Circuit Description

The Voltage Stabilizer circuitry is divided into five major subsections. They are:

(1) AC Power
(2) DC Power
(3) Input Isolation
(4) Control
(5) Over/Under Voltage Protection

Each section is described below. For the following discussion, refer first to the main Voltage Stabilizer schematic (Dwg. No. 2HS066100) and subsequently to the individual P.C. board schematics as needed.

1. AC Power

AC Power enters the Voltage Stabilizer unit at the rear panel power receptacle (PR1). Power passes thru the main power fuse (F1, part of the power receptacle), thru the line filter (FL1), thru the front panel power switch (S1), thru the Power Relay P.C. board (PCB 16), thru the remote/local switch (S5), and back to the power receptacle. The remote/local switch (S5) determines what path the power will take thru PCB16. The power receptacle internally connects the dual primary transformer windings in series for 240 VAC operation or in parallel for 120 VAC operation. When the power is applied, AC line voltage is applied to the primaries of the two power supply P.C. board transformers (PCB1, PCB2) and also to the primary of transformer T1. T1 provides 120 VAC power to the front panel terminal voltage meter (M1).

2. DC Power

The voltage stabilizer uses three P.C. board power supplies to produce the required ±15 VDC, +24 VDC and +10 VDC necessary to power the electronics. The power supply circuit commons (common No. 1, 2 and 3) are separated from each other, except for their common connection to chassis ground.

a. Multi-Voltage Power Supply (PCB1) REF: 2HS015340

Transformer T1 steps down the AC line voltage, which is then bridge rectified and filtered to produce unregulated ±24 VDC. IC1 and IC2 produce regulated +15 VDC and -15 VDC respectively. IC3 produces +5 VDC which is used, along with R4, to power the front panel power indicator LED (CR1). IC4 provides a precision +10 VDC reference voltage. Potentiometer R1 is the +10 VDC adjustment. The P.C. board supplies thru the Energy/Voltage Stabilizer Backplane P.C. board (PCB3) ±15 VDC to the Isolation, Control and Over/Under Voltage Protection P.C. boards, and unregulated +24 VDC to the +10 VDC power supply P.C. board (PCB14). In addition, the P.C. board supplies and ultrastable +10 VDC reference voltage to the front panel terminal voltage potentiometer (R2).

b. 24 VDC Power Supply (PCB2) REF: 2HS058340

Transformer T1 steps down the AC line voltage, which is then bridge rectified and filtered to produce unregulated +24 VDC. The +24 VDC output passes thru the rear panel "24 V" fuse (F2, 1/2A) and back to the P.C. board for distribution to the various loads. The P.C. board supplies +24 VDC by direct connection to power the remote LED, probe position switch S3 and the over/under voltage protection enable/disable (reset) switch S2. The board supplies +24 VDC thru the Energy/Voltage Stabilizer Backplane (PCB3) to power the remotely controlled auxiliary units status (On/Off) control relays. Finally, the board supplies +24 VDC thru the power relay P.C. board (PCB16) to power the remote auxiliary units status (on/off) LED's.

c. +10 VDC Power Supply (PCB14) REF: 2HS058380

The Multi-Voltage power supply (PCB1) supplies unregulated +24 VDC thru the Energy/Voltage Stabilizer Backplane (PCB3) P.C. board to the +10 VDC power supply P.C. board (PCB14). IC1 provides a regulated +10 VDC output voltage. Potentiometer R2 is the +10 VDC adjustment. The P.C. board supplies +10 VDC thru PCB3 to the front panel potentiometers R1 and R3, rear panel potentiometers R4 and R5 and the side panel (internal) potentiometers R6, R7, R8.

3. Isolation Circuits

The Voltage Stabilizer has three input signal isolation P.C. boards. The circuits differentially buffer the various analog input signals, and hence improve the "signal to noise" ratio by minimizing "ground loop" effects.

a. Tri-Isolation (PCB4) REF: 2HS058360

The Tri-isolation P.C. board buffers the Corona Probe Controller monitor signals. The three signals are the tube grid voltage, the probe current and the probe position reads. The grid voltage monitor (0 to +10 VDC) enters the P.C. board from the Energy/Voltage Stabilizer Backplane (PCB3) at edge connector pins 19(+) and 22(-). IC1A, IC1B and the associated components comprise a unity gain differential voltage buffer. For a +10 VDC input, the output of IC1B (at Pin 1) is +10 VDC. The probe current and the probe position reads (both 0 to +10 VDC) are buffered in the same fashion by IC2 and IC4 and by IC3 and IC5 respectively. The three buffered signals are routed thru PCB3 to the front panel probe meters (M2 and M3) for display. In addition, the three signals are routed thru PCB3 to the rear panel remote voltage/status read connector (J15) for data logging.

b. Quad Isolator (PCB5) REF: 2HS058350

The Quad Isolation P.C. board buffers the CPO (Capacitor Pick-off) monitors. The CPO amplifier channels (Channel A and Channel B.) are adjusted to produce 1 Volt output per 500 Volts of terminal voltage ripple. On the Quad Isolation P.C. Board, the two CPO amplifier signals are differentially buffered by IC1 and IC2. IC5 then sums the two channels together and, at the same time multiplies the channels by five. The buffered CPO signals (at IC1B pin 1, IC2B pin 2 and IC5B pin 7) are routed thru the Energy/Voltage Stabilizer Backplane P.C. Board (PCB3) to the rear panel CPO monitor connecters, (J12) and (J10) respectively for connection to an oscilloscope. (J11) and (J12) have signal levels of 1 Volt per 500 Volts of terminal voltage ripple while (J10) has a signal level of 1 Volt per 50 Volts of terminal voltage ripple if two CPO's are used. The summed CPO signal at IC5B pin 7 is also routed to PCB12, to be incorporated in the CPO control portion of the probe current control circuitry.

c. GVM Isolation (PCB6) REF: 2HS058370

The GVM Isolation P.C. board buffers the GVM (Generating Voltmeter) signal, provides for GVM calibration, and drives the front panel terminal voltage meter (M1).

The GVM Amplifier has internal switches to adjust the approximate overall gain and is set up to produce between +5 VDC and +10 VDC output at rated terminal voltage. At the Voltage Stabilizer, the GVM signal enters the GVM Isolation Board thru the Energy/Voltage Stabilizer Backplane P.C. board (PCB3) at edge connector pins 7(+) and 5(-). IC1A, IC1B, IC2, and the associated components differentially buffer the GVM input signal. The CMR (common mode rejection) potentiometer (R9) and the offset potentiometer (R13) trim the amplifier for optimum performance. The voltage at TP1 (with respect to circuit common at TP4) is the buffered GVM signal.

The side panel GVM Calibration potentiometer (R10), together with the Gain switch (S2), set the absolute GVM calibration. The GVM Calibration potentiometer, along with R7, provide a greater than 2 to 1 attenuation range for the buffered GVM signal. The attenuated GVM voltage at the potentiometer wiper is fed to the input of IC3. The Gain switch in turn controls the amplifier (IC3) gain. When the Gain switch is set Lo, the amplifier gain is 1.0 and when the switch is set Hi, the gain is 1.66. For 1 MV and 3 MV machines, the Gain switch is set Lo and for 2 MV and 4 MV machines, the switch is set Hi. Depending on the rated terminal voltage, the GVM Calibration potentiometer is set one of two ways. For 1 MV and 2 MV machines, the potentiometer is adjusted to produce +8 VDC at TP3 when the terminal voltage is at 2 MV (i.e. 250 KV per Volt). For 3 MV and 4 MV machines, the potentiometer is adjusted to produce +8 VDC at TP3 when the terminal voltage is at 4 MV (i.e. 500 KV per Volt). The calibrated GVM voltage (at TP3) is then routed to the GVM Control P.C. board (PCB10) and also to the rear panel Voltage/Status Read connector (J15) thru the Energy/Voltage Stabilizer backplane P.C. board (PCB3) for data logging.

The GVM isolation P.C. board also drives the front panel terminal voltage meter. The calibrated GVM voltage (at TP3) is attenuated thru the switch selectable resistive divider network R16 thru R20, and then routed thru the Energy/Voltage Stabilizer Backplane P.C. board (PCB3) to the terminal voltage meter input. When the voltage at TP3 is +8 VDC and the Meter Select switch (S1) is set to the 4 MV position, the 4 MV Calibration potentiometer (R18) is set to produce +0.4 VDC at edge connector pin 21 (the meter input). When the switch is set to the 2 MV position, the 2 MV Calibration Potentiometer (R17) is set to produce +0.2 VDC at pin 21. The meter itself accepts a 0 to +2 VDC full scale input. However, the meter's displayed decimal point is shifted one place to the right by the decimal point selection Jumper at J11-N and J11-P. In this way, a 0 to +0.4 VDC meter input voltage is displayed as a 0 to +4 MV terminal voltage reading.

4. Control Circuits

The Voltage Stabilizer has three control P.C. boards. The GVM control P.C. board (PCB10) generates the closed loop control system error correction signal. The CPO Control - GVM P.C. board (PCB12) accepts the GVM-T.V. error correction signal and the buffered CPO error correction signal, and outputs a composite signal. The GVM-T.V. signal forms the low frequency portion of the error correction signal, whereas the CPO signal comprises the high frequency portion. The probe control P.C. board (PCB7) adds in the "DC" bias current and outputs the composite signal to the corona probe controller.

a. GVM Control (PCB10)

The GVM control P.C. board compares the GVM voltage to the front panel terminal voltage knob setting, and generates three error signals. One signal is used by the O/UVP circuit. The second is routed thru PCB3 to the rear panel connector (J15) for data logging. The third is the GVM control error correction signal, which is routed through an adjustable gain block controlled by the GVM gain potentiometer.

The front panel Terminal Voltage potentiometer (R2) wiper voltage enters the board, thru the Energy/Voltage Stabilizer Backplane P.C. board (PCB3), at edge connector pin 9 and is buffered by IC1. The Gain switch (S1) controls the amplifier (IC1) gain, and hence the Terminal

Voltage knob gain. With the Gain switch set Lo, the voltage at TP1 is 0.2 Volts per turn of the Terminal Voltage knob (100 KV). With the switch set Hi, the voltage at TP1 is 0.4 Volts per turn of the Terminal Voltage knob (100 KV). The GVM voltage enters the board at edge connector pin 7 (TP2). For 1 MV and 2 MV machines, the GVM voltage is 1 Volt per 250 KV and for 3 MV and 4 MV machines, the GVM voltage is 1 Volt per 500 KV. IC2 subtracts the terminal reference voltage (T.V. at TP1) from the GVM voltage (at TP2). The GVM error signal (GVM-T.V. at TP3) has two scale factors. For 1 MV and 2 MV machines, the voltage at TP3 is 1 Volt per 125 KV of GVM error. For 3 MV and 4 MV machines, the voltage at TP3 is 1 Volt per 250 KV of error. The Offset potentiometer (R3) and the CMR potentiometer (R11) trim the difference amplifier (IC2) for best performance. Both the terminal reference voltage (T.V. at TP1) and the GVM error signal (GVM-T.V. at TP3) are routed to the Over/Under Voltage Protection P.C. board (PCB8).

The GVM error signal at TP3 is then amplified by IC3. The amplified GVM error signal (GVM-T.V. at TP4) has a scale factor of 1 Volt per 10 KV (for 1 MV and 2 MV machines) or a scale factor of 1 Volt per 20 KV (for 3 MV and 4 MV machines). The amplified GVM error signal (at TP4) is routed to the rear panel voltage/status read connector (J15).

On the P.C. board, the GVM error signal at TP4 also feeds the "Y" input of IC4. IC4 is a multi-purpose analog multiplier/divider circuit. As configured with the "Z" terminal (pin 1) tied to the output (OUT at pin 2), the transfer function is:

$$OUT = \frac{(X1-X2) \times (Y1-Y2)}{10}$$

where all variables represent voltages in Volts. The side panel GVM Gain potentiometer (R6) wiper voltage feeds the "X" input of IC4 (0 to +10 VDC). As configured, the IC is a voltage controlled gain block whose output is proportional to the GVM error voltage, and also to the GVM Gain potentiometer setting. The Offset potentiometer (R18) trims the multiplier for minimum offset voltage. The output of IC4 (TP5) feeds amplifier IC5, which inverts the output error signal. The output of IC5 (at TP6) is inverted and amplified by IC6, and the resulting signal (at TP7) is the GVM control system error signal. When the terminal voltage is higher than the Terminal Voltage knob setting, the GVM error signal is positive, and when the terminal voltage is lower, the GVM error signal is negative. The GVM error signal is then routed to the CPO Control-GVM P.C. board (PCB12).

b. CPO Control - GVM (PCB12) REF: 2HS047570

The CPO Control-GVM P.C. Board accepts the GVM-T.V. error correction signal from the GVM control P.C. board (PCB10) and the buffered CPO error correction signal from the Quad Isolator P.C. board (PCB5). The CPO Signal is routed through an adjustable gain block controlled by the CPO gain potentiometer (R7). This CPO error correction signal is applied to a voltage controlled, first order high-pass filter, while the GVM-T.V. error correction signal is applied to a voltage controlled, first order low-pass filter. The same tracking, center cut-off frequency is used for each filter and is adjustable via the GVM/CPO Crossover Frequency potentiometer. The combined GVM/CPO error correction signal is then routed to the Probe Control P.C. board (PCB7).

The buffered CPO signal enters the board at edge connector pin 8, and feeds the "X" input of IC2. The side panel CPO Gain potentiometer (R7) wiper voltage feeds the "Y” input of IC2 (0 to +10 VDC). Analog multiplier IC2 is configured as a voltage controlled gain block, whose output (at TP1) is proportional to the CPO signal voltage at IC2, pin 7, and also to the CPO Gain potentiometer setting. The Offset potentiometer (R102) trims the multiplier for minimum offset voltage.

IC3, IC6, R22-R26, and C18 form a transconductance controlled, first order lowpass/high-pass filter, with separate low-pass and high-pass inputs and a single output. The heart of the filter is IC6, an Operational Transconductance Amplifier (OTA), which has a high output impedance and a transconductance directly proportional to the amplifier bias current applied to IC6, pin 5. It forms the variable resistor in the low-pass/high-pass filter circuit, and by varying the amplifier bias current, control of the crossover frequency is achieved across two and one-half decades. The GVM-T.V. error correction signal is applied to the low frequency input of the filter at edge connector pin 2, while the CPO error correction signal (at TP1) is applied to the high frequency input. A probe current control error signal leaves the board at edge connector pin 3, composed of GVM-T.V. low frequency information and CPO high frequency information. The Crossover Frequency potentiometer sets the center cut-off frequency, above which the GVM control error signal is rolled off at -20 dB/decade and below which the CPO error correction signal is rolled off at 20 dB/decade.

IC4, IC5, CR4, CR5, R103-R105, and associated components form an exponential current driver, which is applied to IC6, pin 5. The side panel Crossover Frequency potentiometer (R8) wiper voltage enters the board at edge connector pin 1 (0 to +10 VDC). Using the exponential forward voltage versus forward current characteristics of low leakage diode CR5, an exponential increasing current is derived through R22 for a linear increasing voltage at edge connector pin 1. Diode CR4 is included at the positive input of IC4 to provide temperature compensation for CR5. Three adjustments are required to correlate the 0 to +10 VDC input at pin 1 (to generate the appropriate bias current required at ICE, pin 5) to give control of the crossover frequency across two and one-half decades. They are the Gain potentiometer (R103), the Exponential potentiometer (R104), and the Zero potentiometer (R105). Together they establish the upper and lower bounds, as well as the best exponential control for the circuit. Table 5-1 gives the Crossover Frequency potentiometer wiper voltage versus the crossover frequency of the combination low-pass/high-pass filter circuit.

Crossover Frequency Voltage (Volts)	Crossover Frequency (Hz)
0	0.28
1	0.32
2	0.47
3	0.89
4	2.1
5	5
6	11
7	22
8	38
9	61
10	89

Table 5-1: Voltage Controlled Crossover Frequency Circuit: Crossover Frequency Voltage Versus Crossover Frequency

c. Probe Control (PCB7) REF: 2HS066110

The Probe Control P.C. board accepts the GVM/CPO error correction signal from the CPO control - GVM P.C. board (PCB12) and routes the signal through an adjustable gain block controlled by the front panel control gain knob. The DC bias current is then added to the signal creating the corona current control signal. The corona current control signal is then buffered and routed off the board, through the Energy/Voltage Stabilizer Backplane P.C. board (PCB3) and to the rear panel Corona Probe Current Controller connector (J7).

The GVM/CPO error correction signal enters the board at edge connector pin 14 and is inverted by IC1. The error correction signal (at TP1) feeds the "X" input of IC2. The front panel Control Gain potentiometer (R1) wiper voltage feeds the "Y" input of IC2 (0 to +10 VDC). As configured, the analog multiplier (IC2) is a voltage controlled gain block, whose output (at TP2) is proportional to the error correction voltage, and also to the Control Gain knob setting. The Offset potentiometer (R9) trims the multiplier for minimum offset voltage. IC3 inverts and adds the gain controlled error correction signal to the front panel Bias Current potentiometer (R2) wiper voltage (0 to +10 VDC). The combined signal at the output of IC3 (pin 6) is then inverted by IC4 and current amplifier IC5. The 0 to +10 VDC output of IC5 (at TP3) is the Corona Probe Controller current control signal and has a range corresponding to 0 to +200 μA. The control signal is routed to the rear panel Current Control connector (J7).

5. Over/Under Voltage Protection (PCB8) REF: 2HS66090

The Voltage Stabilizer proportional O/UVP (Over/Under Voltage Protection) circuitry protects the accelerator from excessively high terminal voltage as well as potential problems indicated by very low terminal voltage. If the terminal voltage rises to a fixed percentage above the front panel terminal voltage knob setting, or if it drops to a fixed percentage below the setting, the O/UVP circuit toggles. When it trips, the Voltage Stabilizer takes charging control away from the normally active Charging Controller and charging reverts to a low, preset default valve.

IC1, IC3 and associated components comprise a voltage controlled variable gain block, which amplifies the GVM-T.V. error signal inversely proportional to the terminal voltage knob setting. The constant ratio GVM-T.V. error signal is effectively divided by the terminal voltage setting, so that the magnitude of the GVM error is a constant percentage relative to the total voltage.

The terminal voltage reference (T.V.) enters the P.C. board at edge connector Pin 4, and feeds the input of IC1A. The 0 to +8 VDC signal has a scale factor of 1 volt per 250 kV (for 1 MV and 2 MV machines), or a scale factor of 1 Volt per 500 kV (for 3 MV and 4 MV machines). IC1A and IC1B clamp the input voltage to a minimum of +0.25 VDC. The minimum T.V. potentiometer (R101) sets the minimum voltage at TP1. The clipped terminal voltage reference signal at TP1 (+0.25 VDC to +8 VDC) feeds the "X1" input of IC3. The GVM-T.V. error signal enters the P.C. board at edge connector Pin 2. The error signal feeds the "Z2" input of IC3, and has the same scale factor as the terminal voltage reference (T.V.) signal. The output of IC3 (out at TP3) is fed back to the "Y" input. As configured, IC3 is a voltage controlled divider and has a transfer function:

$$\text{Out} = \frac{10 \times Z}{X} = \frac{10 \times (\text{GVM-TV})}{\text{T.V.}}$$

Where all variables represent voltages in Volts. The voltage at TP3 is the amplified GVM-T.V. error signal. The following potentiometers are used to trim the divider for best linear performance: scale factor adjust (R105), Xo adjust (R102), Yo adjust (R103), and Zo adjust (R104).

The rear panel Overvoltage Protection (OVP) Setpoint potentiometer (R4) wiper voltage enters the P.C. board at edge connector pin 1, and feeds the negative input of comparitor IC4A (0 to +10 VDC). The rear panel Under Voltage Protection (UVP) Setpoint potentiometer (R5) wiper voltage enters the P.C. board at edge connector pin 3, and feeds the positive input of comparitor IC4B (0 to +10 VDC). The amplified GVM-T.V. error signal (at TP3) feeds the positive input of IC4A and the negative input of IC4B. Under normal operating conditions, the outputs of IC4A and IC4B are negative (-15 VDC). When the GVM-T.V. error signal (at TP3) is greater than the OVP setpoint or is lower than the UVP setpoint, the output of IC4A or IC4B respectively will go high (+15 VDC). This turns on transistor Q1 and relay K1. When this happens, relay contact K1A closes and, with the O/UVP enabled, relay K2 turns on tripping the O/UVP. Relay contact K2A ensures that the O/UVP stays tripped until relay K2 is manually turned off with the front panel Enable/Disable (Reset) switch (S2).

Under normal operating conditions, the Charging Controller charging voltage control signal (0 to +10 VDC) passes from the Charging Controller, thru the normally closed relay contact K2B, back to the Charging Controller and on to the charging power supply. When the O/UVP trips, relay contact K2B disconnects the normally active charging voltage control signal from the Charging Controller and switches in its place the side panel default charging potentiometer (R9) wiper voltage. The potentiometer is set so that charging reverts to a safe (low) value when the O/UVP trips.

The O/UVP P.C. board also allows for remote enabled and tripped status reads. When the O/UVP is enabled with the front panel Enable/Disable (Reset) switch (S2), relay K3 is turned on, and relay contact K3A closes ensuring that the O/UVP stays enabled until tripped. Relay contact K3B also closes communicating to a remote device, connected through rear panel voltage/status read connector (J15), that the O/UVP has been enabled. When the O/UVP trips, relay K2 is turned on closing relay contact K2C and opening relay contact K2D. A contact closure at K2C alerts a remote device, thru (J15), that the O/UVP has been tripped. While a contact opening at K2D disconnects the front panel "Enabled" LED, it does not effect the enabled information going to the remote device.

B. Calibration

The Voltage Stabilizer has several internal calibrations. All the adjustments are performed at the factory, and need not be readjusted unless the integrated circuit(s) specifically associated with the adjustment have been damaged and replaced. A thorough understanding of the Voltage Stabilizer electronic circuits is implied, and only qualified persons should attempt the adjustments.

Calibration Notes:

1. Allow 10 minutes "warm-up" time so that the integrated circuits reach thermal stability.

2. All the "card cage" P.C. boards have either edge connector pin 22 or pin 10 UP. All the P.C. board "component" sides are to the RIGHT, when viewed from the front of the unit, with the boards installed. When necessary, use the 10 pin or 22 pin right angle extender boards to gain access to the individual test points and/or adjustments.
3. For some of the adjustments below, 0 to +10 VDC bench power supplies are required to simulate external inputs. Make connections to the Voltage Stabilizer unit as required to simulate the inputs.
4. For some of the adjustments below, it is necessary to change one or more of the side panel "setup" potentiometer settings. If the Voltage Stabilizer has already been set up for a particular machine, record the various potentiometer wiper voltages before making any changes, and then return the potentiometers to their original settings once the calibrations have been made. Refer to the Installation section (Setup and System Tuning, page 3.18) for more information.

1. Multi-Voltage Power Supply (PCB1) Calibration
   a. +10 VDC Calibration

      Measure the voltage between the front panel Terminal Voltage potentiometer (R2) clockwise(+) and counterclockwise(-) terminals. On the P.C. board, adjust the +10 VDC potentiometer (R1) for +10.000 VDC (+/-0.002 V).

2. +10 VDC Power Supply (PCB14) Calibration

   a. Measure the voltage between the edge connector pins J30-4(+) and J30-3(-). Adjust the +10 VDC potentiometer (R2) for +10.000 VDC (+/-0.005 V).

3. GVM Isolation (PCB6) Calibration

   Note: On PCB6, circuit common is at TP4. All test point voltage readings are with respect to circuit common (TP4).

   a. Offset Calibration

      Jumper together the GVM inputs at J22-7 and J22-5 and short the inputs to circuit common at J22-1. Measure the voltage at TP2. Adjust the Offset potentiometer (R13) for 0.000 VDC (+/-0.001 V) at TP1.

   b. CMR Calibration

      Jumper together the GVM inputs at J22-7 and J22-5. Apply +10.0 VDC (+/-0.1 V) to the GVM inputs with respect to circuit common at J22-1(-). Measure the voltage at TP1. Adjust the CMR potentiometer (R9) for 0.000 VDC (+/-0.001 V) at TP1.

   c. Terminal Voltage Meter Calibration

      Note: For GVM calibration, refer to the Installation section (Setup and System Tuning).

Simulate a GVM input at J3-1(+) and J3-6(-). Adjust the external supply for +8.000 VDC (+/-0.001 V) at TP3. Set the Meter Select switch (S1) to the 4 MV position. Adjust the 4 MV Calibration Potentiometer (R18) for a reading of 4.000 MV on the front panel Terminal Voltage meter. Set the meter select switch to the 2 MV position. Adjust the 2 MV calibration potentiometer (R17) for a reading of 2.000 MV on the front panel terminal voltage meter.

4. GVM Control (PCB10) Calibration

Note: On PCB10, circuit common is at edge connector pin 4. Unless noted, test point voltage readings are with respect to circuit common (J26-4).

a. IC1 Offset Calibration

Set the Gain switch (S1) to the HI position. Install connector jumper 2XL100132 at J13. Jumper together the GVM inputs at J3-1 and J3-6. Measure the voltage at TP2. It should be 0.000 VDC (+/-0.001 V) with the GVM inputs shorted. Set the front panel Terminal Voltage knob fully counterclockwise (zero). Measure the voltage at TP4. Adjust the Offset Potentiometer (R3) for 0.000 VDC (+/-0.001 V) at TP4.

b. CMR Calibration

Set the Gain switch (S1) to the LO position. Simulate a GVM input at J3-1(+) and J3-6(-). Adjust the external supply for +8.0 VDC (+/-0.1 V) at TP2. Adjust the front panel Terminal Voltage knob for about +8.0 VDC at TP1. Connect a voltmeter between TP1 and TP2 (not circuit common). Fine tune the Terminal Voltage knob for 0.000 VDC (+/-0.001 V) between TP1 and TP2. Measure the voltage at TP4. Adjust the CMR potentiometer (R1) for 0.000 VDC (+/-0.001 V) at TP4.

c. IC4 Offset Calibration

Set the front panel terminal voltage knob fully counterclockwise (zero). Obtain 0.000 VDC (+/-0.001 V) at TP4 (see step 4a above). Turn the side panel GVM gain potentiometer (R6) fully counterclockwise. Measure the voltage at TP7. Adjust the offset potentiometer (R18) for 0.000 VDC (+/-0.005 V) at TP7.

5. CPO Control-GVM (PCB12) Calibration

Connector jumper 2XL100132 should be installed at J13.

Note: On PCB12, circuit common is at edge connector pin 5. Unless noted, test point voltage readings are with respect to circuit common (J28-5).

a. IC2 Offset Calibration

Short the “CPO x Gain” input at J28-8 to circuit common at J28-5 and set the side panel CPO gain potentiometer (R7) fully counterclockwise. Measure the voltage at TP2. Adjust the offset potentiometer (R102) for 0.000 VDC (+/-0.001 V) at TP1.

b. Initial Exponential Calibration

Set the side panel crossover frequency potentiometer (R8) fully counterclockwise. Measure the voltage at TP2. Adjust the exponential potentiometer (R104) for -0.36 VDC (+/-0.01 V) at TP2.

c. Initial Gain Calibration

Set the side panel crossover frequency potentiometer (R8) fully clockwise. Measure the voltage at TP2. Adjust the gain potentiometer (R103) for -0.66 VDC (+/-0.01 V) at TP2.

d. Zero Calibration

Set the side panel crossover frequency potentiometer (R8) fully counterclockwise. Measure the voltage between TP3(+) and TP4(-) (not circuit common). Adjust the zero potentiometer (R105) for 0.033 VDC (+/-0.005 V) between TP3(+) and TP4(-).

e. Gain Calibration

Set the side panel crossover frequency potentiometer (R8) fully clockwise. Measure the voltage between TP3(+) and TP4(-) (not circuit common). Adjust the gain potentiometer (R103) for 10.50 VDC (+/-0.05 V) between TP3(+) and TP4(-).

f. Exponential Calibration

Set the side panel crossover frequency potentiometer (R8) midrange so that 5.000 VDC (+/-0.001 V) is at J28-1(+) and J28-5(-). Measure the voltage between TP3(+) and TP4(-). Adjust the exponential potentiometer (R104) for 0.59 VDC (+/-0.03 V) between TP3(+) and TP4(-).

g. Iterative Calibration

Repeat the Zero calibration (step 6d), the Gain calibration (step 6e), and the Exponential calibration (step 6f) at least once until no further adjustment is required.

6. Probe Control (PCB7) Calibration

Preset potentiometer (R9) to the center of its rotation. Connector jumper 2XL100132 should be installed at J13.

NOTE: On PCB7, circuit common is at edge connector pin 3. All test point voltage readings are with respect to circuit common (J23-3).

a. Offset Calibration

Set the front panel terminal voltage knob (R2) fully counterclockwise. Jumper J23-14 and circuit common J23-3 together. Set both front panel knobs, Control Gain and Bias Current, fully counterclockwise. Adjust the offset potentiometer (R9) for 0.000 VDC (+/-0.001 V) at TP3. Remove the jumper.

7. Over/Under Voltage Protection (PCB8) Calibration

Preset the five potentiometers (R101-R105) to the center of their rotation. Install jumper connector 2XL100132 at J13.

NOTE: On PCB8, circuit common is at edge connector pin 7. All test point voltage readings are with respect to circuit common (J24-7).

a. Set the front panel terminal voltage knob (R2) fully counterclockwise. Measure the voltage at TP1. Adjust the minimum terminal voltage potentiometer (R101) for +0.250 VDC (+/-0.001 V) at TP1.

b. R102-R105 Calibration

Step 1 - Set the front panel Terminal Voltage knob (R2) fully counterclockwise. Jumper J24-7 and J24-2 together. Measure the voltage at TP3. Adjust the Zo potentiometer (R104) for 0.000 VDC (+/-0.005 V) at TP3. Remove the jumper from J24-2 and J24-7.

Step 2 - Apply a DC input voltage to J3-1(+) and J3-6(-) so that the voltage measured at J24-2(+) is +0.250 VDC (+/-0.001 V). Jumper J24-4 to J24-7 and adjust the Xo potentiometer (R102) for 10.000 VDC (+/-0.005 V) at TP3.

Step 3 - Reverse the voltage at J3 to get -0.250 VDC (+/-0.001 V) at J24-2. Measure the voltage at TP3. The voltage at TP3 should be equal to that measured in Step 2 but opposite in sign. If the two levels are not equal, repeat Steps 2 and 3 adjusting R102 (Xo potentiometer) until both readings are as close to +/-10.00 VDC (+/-0.10 V) as possible. Remove the jumper from J24-4 to J24-7.

Step 4 - Set the front panel Terminal Voltage knob (R2) to obtain 8.000 VDC (+/-0.001 V) at J24-4(+). Adjust the input voltage at J3 for 0.000 VDC (+/-0.001 V) at J24-2(+). Measure the voltage at TP3. Adjust the Yo potentiometer (R103) for 0.000 VDC (+/-0.005 V) at TP3.

Step 5 - Measure the voltage at J24-2. Set the input voltage at J3 for 8.000 VDC (+/-0.001 V) at J24-2(+). Measure the voltage at TP3. Adjust the scale factor potentiometer (R105) for 10.000 VDC (+/-0.005 V) at TP3.

Step 6 - Set the input voltage at J3 for -8.000 VDC (+/-0.001 V) at J24-2. Measure the voltage at TP3. If the voltage level is not the same as measured at TP3 in Step 5, except sign, repeat Steps 5 and 6, adjusting R105 (scale factor potentiometer) until both readings are as close to +/-10.000 VDC (+/-0.050 V) as possible.

Step 7 - Set the front panel Terminal Voltage knob (R2) fully counterclockwise. Set the input voltage at J3 for 0.000 VDC (+/-0.001 V) at J24-2. Jumper J24-7 to J24-2. Measure the voltage at TP3. Adjust the Zo potentiometer (R104) for 0.000 VDC (+/-0.005 V) at TP3. Remove the jumper at J24-7 to J24-2.

Step 8 - Set the input voltage at J3 for 0.250 VDC (+/-0.001 V) at J24-2(+). Jumper J24-4 to J24-7. Measure the voltage at TP3. Adjust the Xo potentiometer (R102) for 10.000 VDC (+/-0.005 V) at TP3.

Step 9 - Reverse the input voltage at J3 to get -0.250 VDC (+/-0.001 V) at J24-2. Measure the voltage at TP3. If the voltage level is not the same as measured at TP3 in Step 8 (except sign), repeat steps 8 and 9, adjusting R102 (Xo potentiometer) until both readings are as close to +/-10.000 VDC (+/-0.050 V) as possible.

Step 10 - Repeat Step 8 adjusting Zo potentiometer (R104).

Step 11 - Repeat Step 9 adjusting Zo potentiometer (R104).

Remove the DC input voltage at J3 and the jumper at J24-4 to J24-7.

VI. DOCUMENTATION

Figure 1-1 Voltage Stabilizer Block Diagram	Drawing No. 2HM066180
Figure 3-1 Voltage Stabilizer Setup	Drawing No. 2HM066181
Figure 4-1 Voltage Stabilizer Front Panel	Drawing No. 2HM066182
Figure 4-2 Voltage Stabilizer Rear Panel	Drawing No. 2HM066183
Voltage Stabilizer, w/CPO Control-Assembly	Drawing No. 2HA066180 Parts List No. 2HA066180
Voltage Stabilizer, w/CPO Control-Schematic	Drawing No. 2HS066100
Multi-Voltage 350 mA DC Power Module P.C. Board	Drawing No. 2HR009010 Parts List No. 2HR009012
Multi-Voltage 350 mA DC Power Module Schematic	Drawing No. 2HS015340
24 Volt Power Supply- P.C. Board	Drawing No. 2HR058060 Parts List No. 2HR058061
24 Volt Power Supply- Schematic	Drawing No. 2HS058340
10 Volt Power Supply- P.C. Board	Drawing No . 2HR058100 Parts List No. 2HR058100
10 Volt Power Supply- Schematic	Drawing No. 2HS058380
Quad Isolator- P.C. Board	Drawing No. 2HR058070 Parts List No. 2HR058071
Quad Isolator- Schematic	Drawing No. 2HS058350
Tri Isolator- P.C. Board	Drawing No. 2HR058080 Parts List No. 2HR058080
Tri Isolator- Schematic	Drawing No. 2HS058360
GVM Isolation- P.C. Board	Drawing No. 2HR058090 Parts List No. 2HR058092
GVM Isolation- P.C. Board	Schematic 2HS058370

GVM Control- P.C. Board	Drawing No. 2HR058110 Parts List No. 2HR058112
GVM Control- Schematic	Drawing No. 2HS058400
Probe Control- P.C. Board	Drawing No. 2HR066030 Parts List No. 2HR066030
Probe Control- Schematic	Drawing No. 2HS066110
CPO Control- P.C. Board	Drawing No. 2HR047080 Parts List No. 2HR047081
CPO Control- Schematic	Drawing No. 2HS047570
Energy/Voltage Stabilizer Backplane - P.C. Board	Drawing No. 2HR066000 Parts List No. 2HR066001
Energy/Voltage Stabilizer Backplane - Schematic	Drawing No. 2HS066070
Over/Under Voltage Protection - P.C. Board	Drawing No. 2HR066020 Parts List No. 2HR066020
Over/Under Voltage Protection - Schematic	Drawing No. 2HS066090
Power Relay- P.C. Board	Drawing No. 2HR066010 Parts List No. 2HR066011
Power Relay- Schematic	Drawing No. 2HS066080