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PS 5010 PROGRAMMABLE POWER SUPPLY

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

Serial Number ____________

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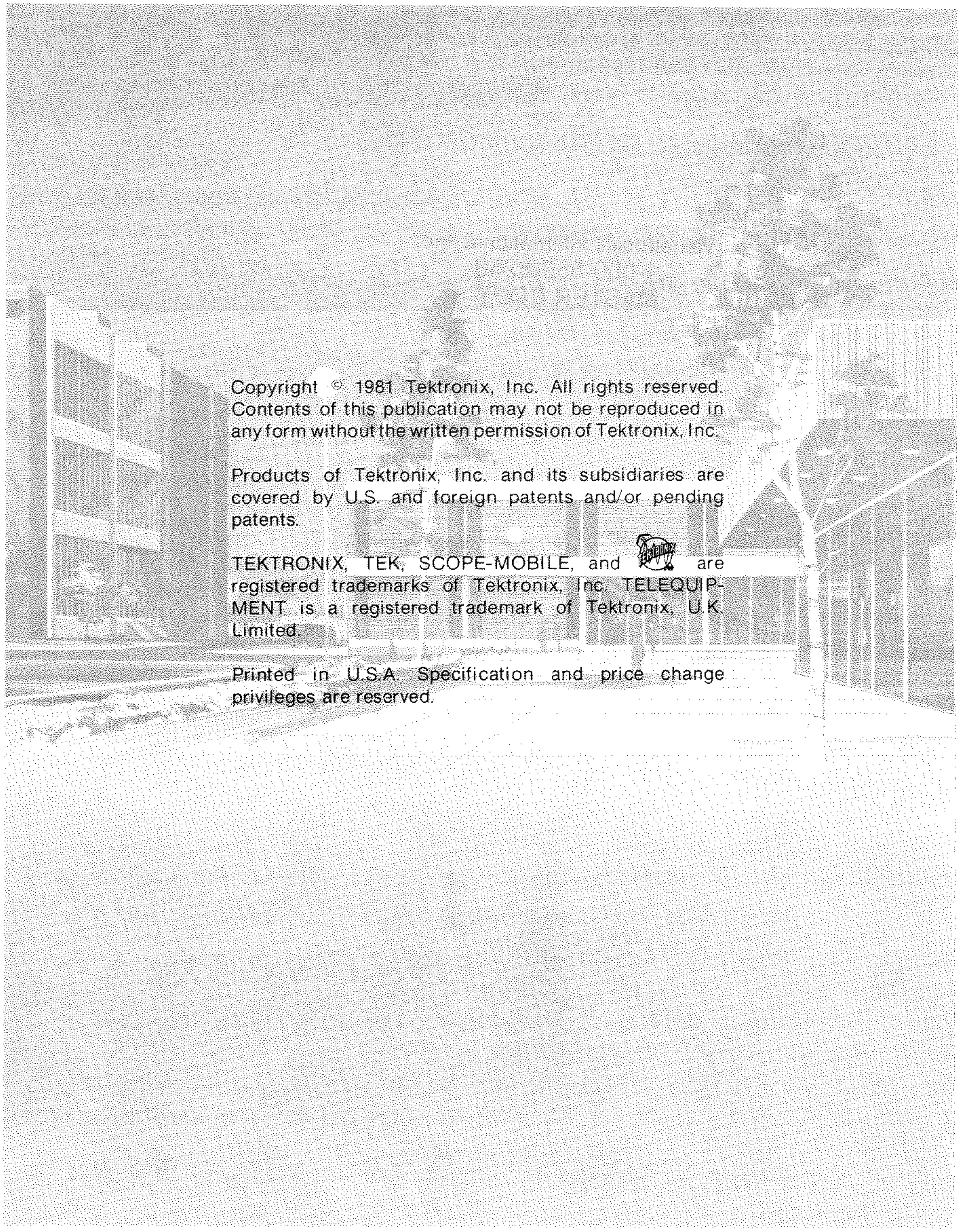


OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual

⚠ This symbol indictes where applicable cautionary or other information is to be found.

As Marked on Equipment

⚡ DANGER — High voltage.

⏚ Protective ground (earth) terminal.

⚠ ATTENTION — refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power module power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the parts list for your product.

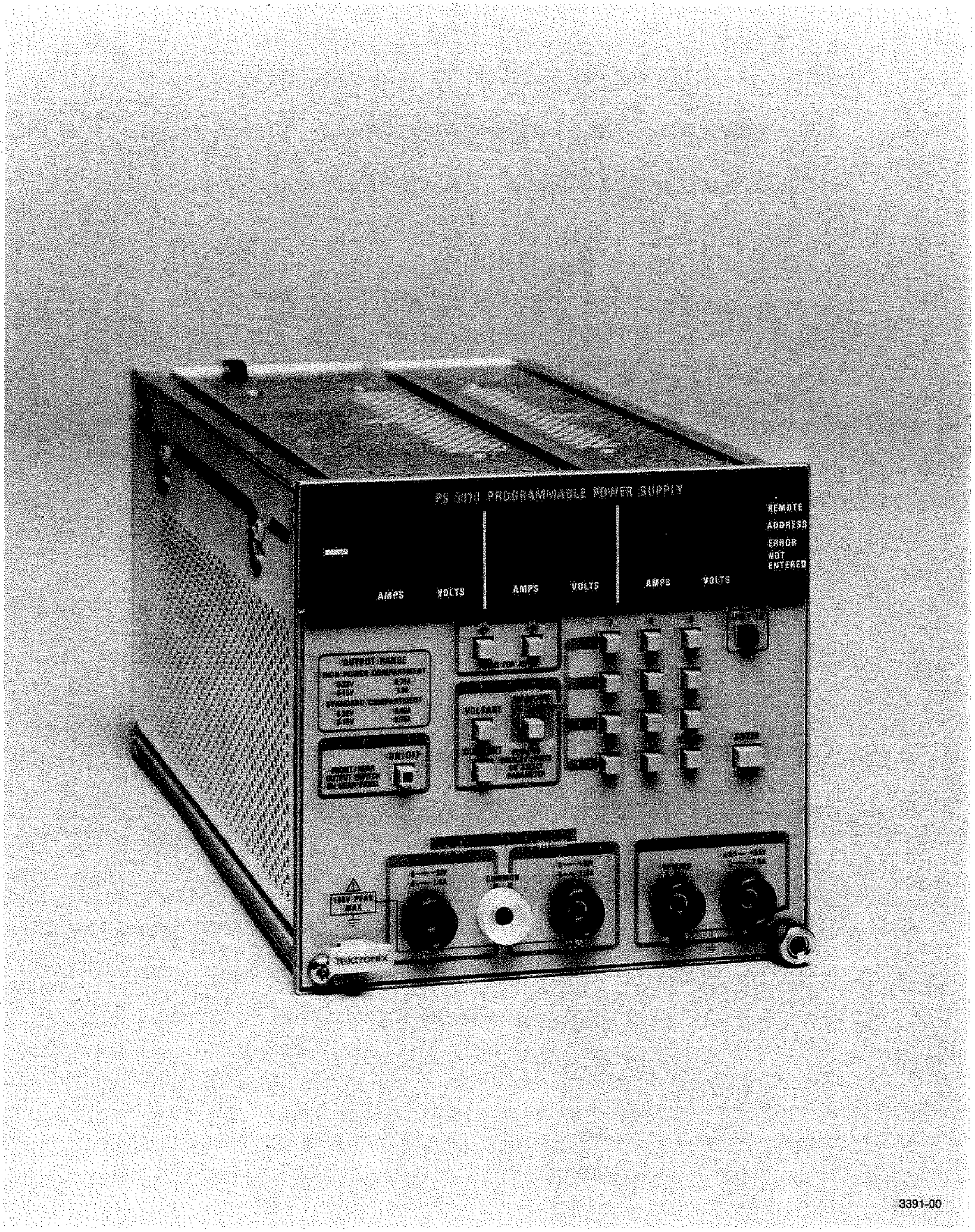
Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.



3391-00

PS 5010 Programmable Power Supply

SPECIFICATION

Introduction

This PS 5010 Programmable Power Supply provides a floating dual supply and a ground referenced logic supply. Each supply has independent constant voltage or constant current modes with automatic crossover.

The floating supply provides 0 to +32 Vdc and 0 to −32 Vdc, both with respect to a common front panel terminal. All floating supply terminals may be elevated above ground to a maximum 150 V peak. Voltages from 0 to 64 V are available across the dual supply terminals. When the PS 5010 is installed in a TM 5000 series power module with one high power compartment, currents to 750 mA (from 0 to 32 V) and 1.6 A (from 0 to 15 V) are available. When the PS 5010 is installed in two low power compartments of the TM 5000 series power module, currents to 400 mA (from 0 to 32 V) and 750 mA (from 0 to 15 V) are available. The floating supplies are programmable in increments of 10 mV from 0 to 10.0 V and in increments of 100 mV from 10.1 V to 32.0 V. The current is programmed in 50 mA increments from 50 mA to 1.6 A.

The logic supply provides 4.5 Vdc to 5.5 Vdc at currents to 3 A. The logic supply is programmable in increments of 10 mV from 4.50 V to 5.50 V and in current increments of 100 mA over a range of 100 mA to 3.0 A.

The front panel LED display is divided into three sections. Each section indicates the programmed currrent or voltage for one supply. Each display contains a three digit segmented numeric LED display and two separate LEDs. These LEDs are located at the bottom of the numeric displays. They indicate whether voltage or current is being displayed.

In the operating mode, the displays show the true output voltage in constant voltage mode or current in the constant current mode. Since the display parameter changes with the automatic crossover the displays always indicate the true output values.

Complete information for programming the PS 5010 via the GPIB is found in the Programming section of this manual. A sample program is provided in the Programming section to verify the operation of the instrument on the GPIB.

NOTE

The PS 5010 operates only in a TM 5000 series power module.

IEEE 488 (GPIB) Function Capability

The PS 5010 is programmable via the digital interface specified in IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation". In this manual, the interface is commonly called the General Purpose Interface Bus (GPIB).

The IEEE Standard indentifies the interface function repertoire of an instrument on the GPIB in terms of interface function subsets. The subsets are defined in the standard. The subsets that apply to the PS 5010 are listed in Table 1-1.

Table 1-1
IEEE 488-1978
INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete.
Acceptor Handshake	AH1	Complete.
Basic Talker	T6	Responds to Serial Poll.
Basic Listener	L4	Unlisten if My Talk Address (MTA) is received.
Service Request	SR1	Complete.
Remote-Local	RL1	Complete.
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete
Device Trigger	DT1	Complete.
Controller	C0	No controller function.

Performance Conditions

The electrical characteristics in this specification are valid only if the PS 5010 has been adjusted at an ambient temperature between +20°C and +30°C. The instrument must be in a noncondensing environment whose limits are described under the environmental part. Allow twenty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in a high humidity (condensing) environment. Any conditions that are unique to a particular characteristic are expressly stated as part of that characteristic.

The electrical and environmental performance limits, together with their related validation procedures, comprise a complete statement of the electrical and environmental performance of a calibrated instrument.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in the Calibration section of this manual. Items listed in the Supplemental Information column are not verified in this manual.

Table 1-2
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
POSITIVE and NEGATIVE FLOATING SUPPLIES		
Configuration		Dual floating supplies with shared common terminal. Independent constant voltage or constant current modes with automatic crossover.
Constant voltage mode		
Range		
Positive supply	0 to +32.0 V	
Negative supply	0 to −32.0 V	
Step size (resolution)	10 mV ±10 mV to 10.0 V	Typically 10 mV ±2 mV at 20°C to 30°C.
	100 mV ±40 mV above 10.1 V	Typically 100 mV ±10 mV at 20°C to 30°C.
Overall accuracy (total effect)	±(0.5% +20 mV)	Measured at front panel output terminals.
Source effect (line regulation)	(0.01% +2 mV)	
Load effect (load regulation)	10 mV for a 1 A change in load current	
	1 mV when using rear interface output connections with remote sensing.	Maximum allowable combined voltage drop in output leads is 500 mV. This may be less when output conditions exceed 14.5 V and 1.3 A at low line. Maximum allowable combined sense line resistance is 400 mΩ.
Drift		Typically <(0.1% +2 mV) for 8 hours.
Temperature coefficient		Typically <(0.01% + 0.1 mV)/°C
PARD (ripple and noise)	10 mV peak-to-peak, 1 mV rms	20 Hz to 20 MHz measured at front panel.
Load transient recovery	500 μs to recover within 20 mV of nominal value	For a 1A change measured at the front panel.

Table 1-2 (cont)

Characteristics	Performance Requirements		Supplemental Information
POSITIVE and NEGATIVE FLOATING SUPPLIES (cont)			
Voltage change response time	**No load**	**Max load**	
Up	1 ms	1 ms	
Down	20 ms	1 ms	
Constant current mode			
Range			
High power compartment	50 mA to 0.750 A (1.60 A at 15 V and below)		
Standard compartment	50 mA to 400 mA (0.750 A at 15 V and below)		
Step size (resolution)	50 mA ±15 mA		
Overall accuracy	±(5% + 20 mA)		
Source effect (line regulation)	1 mA		
Load effect (load regulation)	10 mA		Output impedance is typically 5 kΩ shunted by 10 μF.
Drift			Typically <(0.5% + 5 mA) for 8 hours.
Temperature coefficient			Typically <(0.1% + 1 mA)/°C
PARD (ripple and noise)	10 mA peak-to-peak, 5 mA rms		20 Hz to 20 MHz measured at front panel output terminals.
Current change response time			
Up	20 ms		
Down	20 ms		
Isolation voltage (maximum allowable voltage on any terminal with respect to ground)			
Front panel operation			150 V peak
Rear interface operation			42 V peak
Typical shunting capacitance between floating supplies and ground			0.015 μF
Output on-off response time			Typically 12 ms
Programming Time			
GET time			
Without output on-off change			10 ms typical
With output on-off change			30 ms typical

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
LOGIC SUPPLY		
Configuration		Single supply with negative terminal internally connected to chassis ground. Constant voltage mode with current limit and automatic crossover. Foldback current limiting starts below 4.5 V.
Constant voltage mode		
Voltage range	4.50 to 5.50 V	Ground referenced
Voltage step size	10 mV ±10 mV	
Overall accuracy	±50 mV	
Source effect (line regulation)	1 mV	
Load effect (load regulation)	10 mV for a 1 A change in load current	
	1 mV when using rear interface output with remote sensing	Maximum allowable combined voltage drop in output leads is 500 mV. Maximum allowable combined sense line resistance is 400 mΩ.
Drift		Typically <5 mV/hour
Temperature coefficient		Typically 500 μV/°C
PARD (ripple and noise)	10 mV peak to peak, 2 mV rms	20 Hz to 20 MHz measured at front panel output terminals.
Transient recovery	500 μs to within 20 mV of nominal value.	
Current limit		
Range	100 mA to 3.0 A	Foldback characteristic below 4.5 V. Maximum short circuit output current is <1.5 A.
Step size	100 mA ±30 mA	
Accuracy	±(5% + 20 mA)	
Scaled current out (rear interface only)		
Scale factor	10 mA = 1 mV ±(2% + 2 mV)	Not ground referenced. Requires two terminal measurement.
Output impedance		1kΩ
Programming time		
GET time		
Without output on-off change		3 ms typical
With output on-off change		35 ms typical
Overvoltage protection		SCR crowbar. Typically trips at 6 V to 7 V.

Table 1-2 (cont)

Characteristics	Description
MISCELLANEOUS	
Fuse Data	
25 Vac input from power module	2 ea 2.5 A medium blow, 3 AG, 125 V 2 ea 1.6 A, slow blow, 3 AG, 250 V
+26 Vdc from power module	1 A, fast blow, 3 AG, 250 V
−26 Vdc from power module	1 A, fast blow, 3 AG, 250 V
+8 Vdc from power module	6 A, fast blow, 3 AG, 250 V
Logic supply output	6 A, fast blow, 3 Ag, 250 V
Power consumption	250 VA maximum in high power compartment, 200 VA in standard compartment
Calibration interval	1000 hours or 6 months whichever occurs first
Warm-up time	20 minutes

Table 1-3
ENVIRONMENTAL CHARACTERISTICS[a]

Characteristics	Description	
Temperature		Meets MIL-T-28800B, class 5.
Operating	0°C to +50°C	
Nonoperating	−55°C to +75°C	
Humidity	95% RH, 0°C to 30°C 75% RH, to 40°C 45% RH, to 50°C	Exceeds MIL-T-28800B, class 5.
Altitude		Exceeds MIL-T-28800B, class 5.
Operating	4.6 Km (15,000 ft)	
Nonoperating	15 Km (50,000 ft)	
Vibration	0.38 mm (0.015 in) peak to peak, 5 Hz to 55 Hz, 75 minutes.	Meets MIL-T-28800B, class 5, when installed in qualified power modules.[b]
Shock	30 g's (1/2 sine) 11 ms duration, 3 shocks in each direction[d] along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5, when installed in qualified power modules.[b]
Bench handling[c]	12 drops from 45°, 4 inches or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5, when installed in qualified power modules.[b]
Transportation[c]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC[e]	Within limits of F.C.C. Regulations, Part 15, Subpart J, Class A; VDE 0871; and MIL-461A tests RE01, RE02, CE01, CE03, RS01, RS03, CS01, and CS02.	
Electrical discharge	15 kV maximum charge applied to instrument case.	

[a] With power module.
[b] Refer to TM 5000 power module specifications.
[c] Without power module.
[d] Requires retainer clip in plug-in exit direction.
[e] System performance subject to exceptions of power module or other individual plug-ins.

Table 1-4
PHYSICAL CHARACTERISTICS

Characteristics	Description
Maximum overall dimensions	
Height	126.0 mm (4.96 in)
Width	134.47 mm (5.29 in)
Length	285.37 mm (11.24 in)
Net weight	≈27 kg (6 lbs)
Finish	Laminated polycarbonate front panel with anodized aluminum chassis.
Enclosure type and style per MIL-T-28800B	
Type	III
Style	E (style F in rackmount power modules)

OPERATING INSTRUCTIONS

Preparation For Use

The PS 5010 is calibrated and ready to use when received. The PS 5010 operates in any two adjacent compartments of a TM 5000 series power module. The PS 5010 is preset to GPIB address 22 with an EOI message terminator. The address may be verified by pressing the INST ID button on the front panel. A decimal appears after the address in the display if the terminator is LF-EOI. If other values are required they may be set by qualified service personnel as described in the Maintenance section of this manual.

CAUTION

To prevent damage to the PS 5010, turn the power module off before installing or removing the plug-in from the power module. Do not use excessive force to install or remove.

Refer to Fig. 2-1 for the following instructions. Align the PS 5010 chassis with the upper and lower guides of the selected power module compartments. Push the PS 5010 into the mainframe and press firmly to seat the rear connectors in their respective jacks at the rear of the power module. Connect the power cord to the power source and turn on the power module POWER switch.

Repackaging Information

If this instrument is to be shipped to a Tektronix Service center for service or repair, attach a tag showing owner (with address) and the name of an individual to contact. Include the complete instrument serial number and a description of the service required.

Save and reuse the package in which the instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

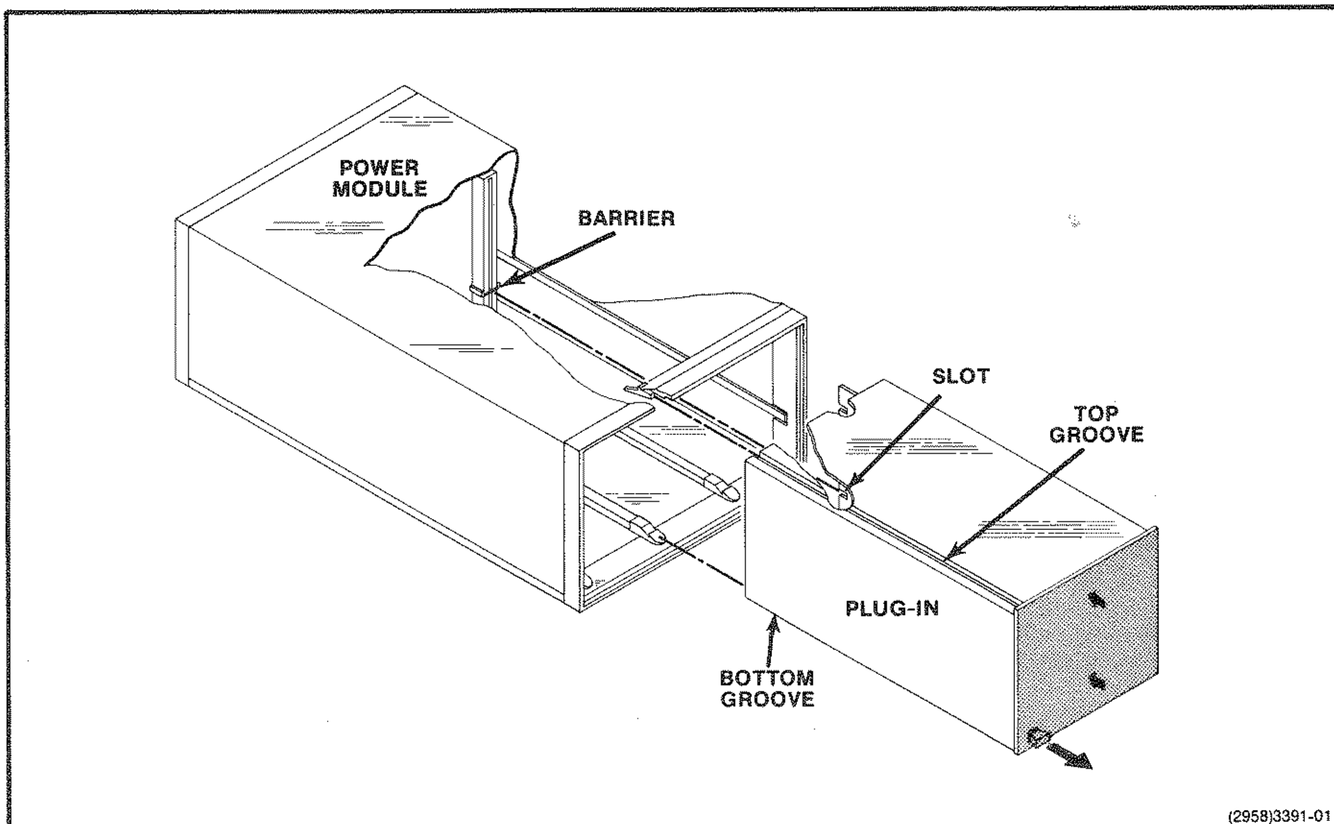


Fig. 2-1. Installation and removal.

1. Obtain a corrugated carton having inside dimensions of no less than six inches more than the instrument dimensions; this will allow for cushioning. Use a carton having a test strength of at least 200 pounds.

2. Surround the instrument with protective polyethylene sheeting.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing three inches on all sides.

4. Seal carton with tape or industrial staples.

Power Up Conditions (Self Test)

At power up, the PS 5010 microprocessor performs a diagnostic routine to check the functionality of the ROM and RAM. If no internal error is found, the instrument enters the Local State (LOCS) with default settings as shown in Table 2-1. The SRQ line on the GPIB is also asserted.

Table 2-1
POWER ON SETTINGS

The instrument goes to the following settings at power on and when the INIT command is executed.

Function	Condition
Positive supply voltage	0.0 Volts
Positive supply current	0.4 Amps
Negative supply voltage	0.0 Volts
Negative supply current	0.4 Amps
Logic supply voltage	5.0 Volts
Logic supply current	1.0 Amps
Floating supply output	OFF
Logic supply output	OFF
Positive regulation interrupt	OFF
Negative regulation interrupt	OFF
Logic regulation interrupt	OFF
Request for service	ON
User request	OFF
Device trigger	OFF

If an internal error is found, an error code is displayed in the front-panel readout. See Table 2-2 for error codes.

Table 2-2
FRONT PANEL ERROR CODES

Error	Code
System error	302
Math pack error	303
System RAM error	340
System RAM error (low nibble)	341
C000 ROM placement error	372
D000 ROM placement error	373
E000 ROM placement error	374
F000 ROM placement error	375
C000 ROM checksum error	392
D000 ROM checksum error	393
E000 ROM checksum error	394
F000 ROM checksum error	395
Signature analysis mode	521
Calibration Mode	CAL

If one of these codes appears on the display during power up or operation, turn the power module off and on. If the error repeats, a qualified service person should refer to the procedure in the Troubleshooting part of the Maintenance section of this manual.

NOTE

IEEE Standard 488-1978 states that a complete system on the GPIB must be operated with power applied to at least one more than half the devices in the system. Powering up a device while the system is running may cause faulty operation.

To remove the PS 5010 from the power module, pull the release latch located on the lower left hand corner of the front panel.

Controls, Connectors and Indicators

All controls, connectors and indicators (except for the rear interface connector and the output selector switch) required for operation of the PS 5010 are located on the front panel. The following information along with Fig. 2-2 provides a description of front panel controls, connectors and indicators.

There are two modes of front panel operation for the PS 5010. These are the entry and operating modes. The voltage and current limits can be examined and changed in the entry mode. In the operating mode these values can be examined but not changed. The operating mode is the normal functional mode. All of the displays are bright in this mode. Supply parameter changes are made in the entry

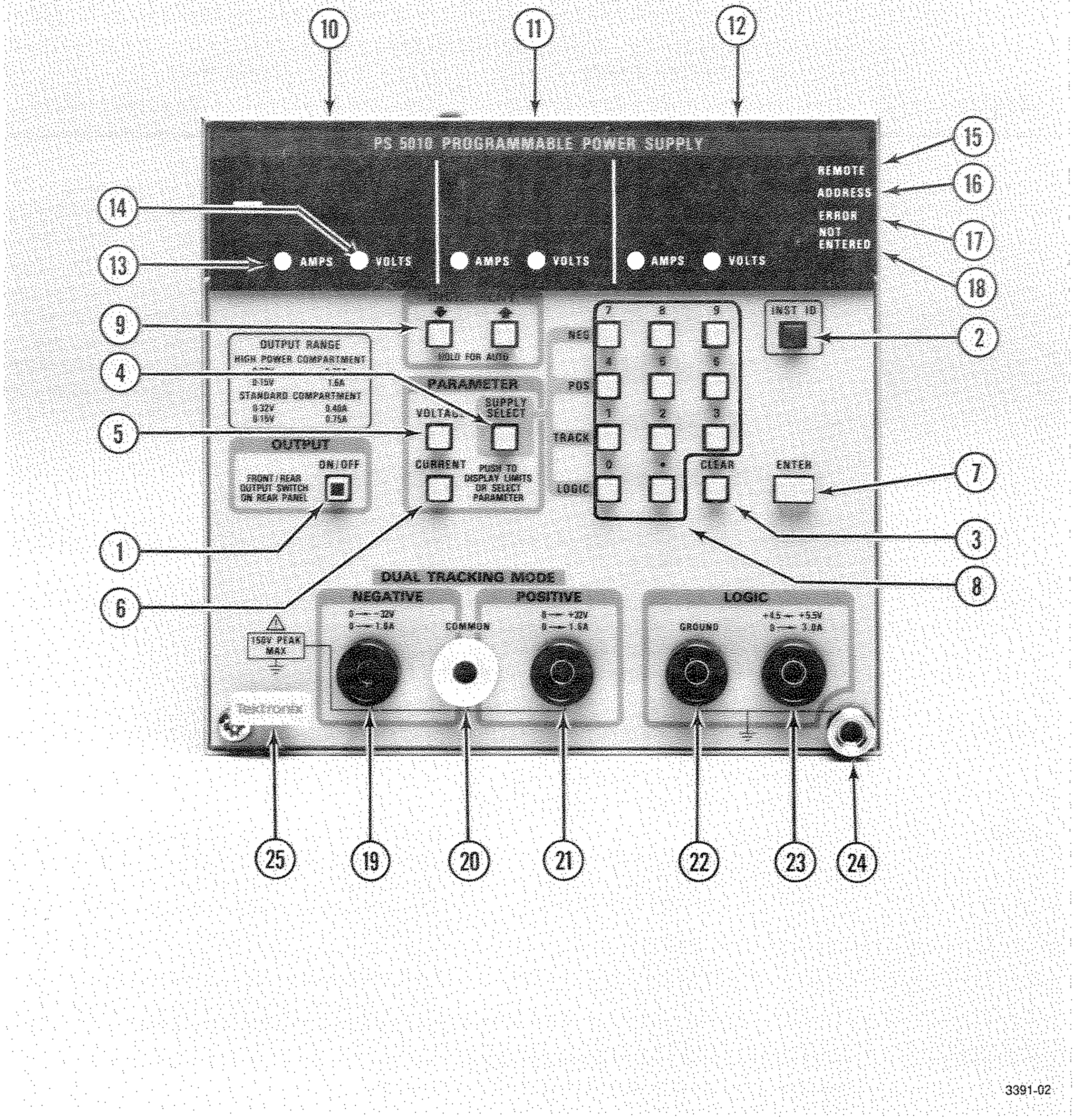


Fig. 2-2. Front panel controls and connectors.

mode. the display for the entry supply is bright with the other displays dim. Figure 2-3 graphically illustrates the entry mode.

When the VOLTS or AMPS LED is steadily on the parameter value in the display is the actual value outputed by the supply. A flashing VOLTS or AMPS LED indicates that the displayed parameter is not the true value of the output because the supply is not operating in this regulation mode.

In the operating mode, the displayed parameter automatically switches with regulation mode changes (the display indicates volts in the constant voltage mode and amperes in the constant current mode). The display blanks out (both VOLTS and AMPS LEDs off) when the supply is neither in constant voltage or current mode. This occurs when the logic supply folds back or when any supply is driven into an overvoltage situation from an external source.

	Operating Mode	Entry Mode
(1) OUTPUT	Turns output on or off. LED in pushbutton indicates output on. Functional in any keystroke sequence.	Turns output on or off. LED in pushbutton indicates output on. Functional in any keystroke sequence.
(2) INST ID	Displays instruments primary address while pressed. Asserts SRQ on GPIB if USER REQUEST is enabled. Functional in any keystroke sequence.	Displays instruments primary address while pressed. Asserts SRQ on GPIB if USER REQUEST is enabled. Functional in any keystroke sequence.
(3) CLEAR	Cancels SUPPLY SELECT keystroke.	The display of the supply in the entry mode returns to the previous entry if the ERROR light or NOT ENTERED light is flashing. This key is the only method to release the keyboard for other functions if the ERROR light is flashing. This key places the front panel into the operating mode if neither light is flashing.
(4) SUPPLY SELECT	Pressing this button places a supply in the entry mode. This must be followed with either NEG, POS, TRACK, or LOGIC. This button is nonfunctional if the NOT ENTERED or ERROR lights are flashing.	Changes entry mode from one supply to any other supply. This is also a two keystroke function, the supply selected is the other keystroke. This button is nonfunctional if the NOT ENTERED or ERROR lights are flashing.
(5) VOLTAGE	Pressing this button displays the voltage limit of all three supplies. When this button is released, the display is returned to the voltage or current limit each supply is operating under.	Places only the display of the selected supply into the voltage entry mode.
(6) CURRENT	Pressing this button displays the current limit of all three supplies. When this button is released, the display returns to the voltage or current limit each supply is operating under.	Places only the display of the selected supply into the current entry mode.
(7) ENTER	Nonfunctional.	A change in the voltage or current (except via the INCREMENT pushbuttons) must be completed with this button. Press the desired voltage or current pushbuttons and then the ENTER button to implement the value selected. The display indicates failure to enter by flashing the NOT ENTERED light. When entering current in the positive or negative supplies an automatic roundoff occurs if the current is not in 50 mA increments.
(8) 0 through 9 and period	Button 0, 1, 4, and 7 are functional to select supplies or tracking mode only after SUPPLY SELECT is pushed.	Numeric key pad for entering voltages and currents.

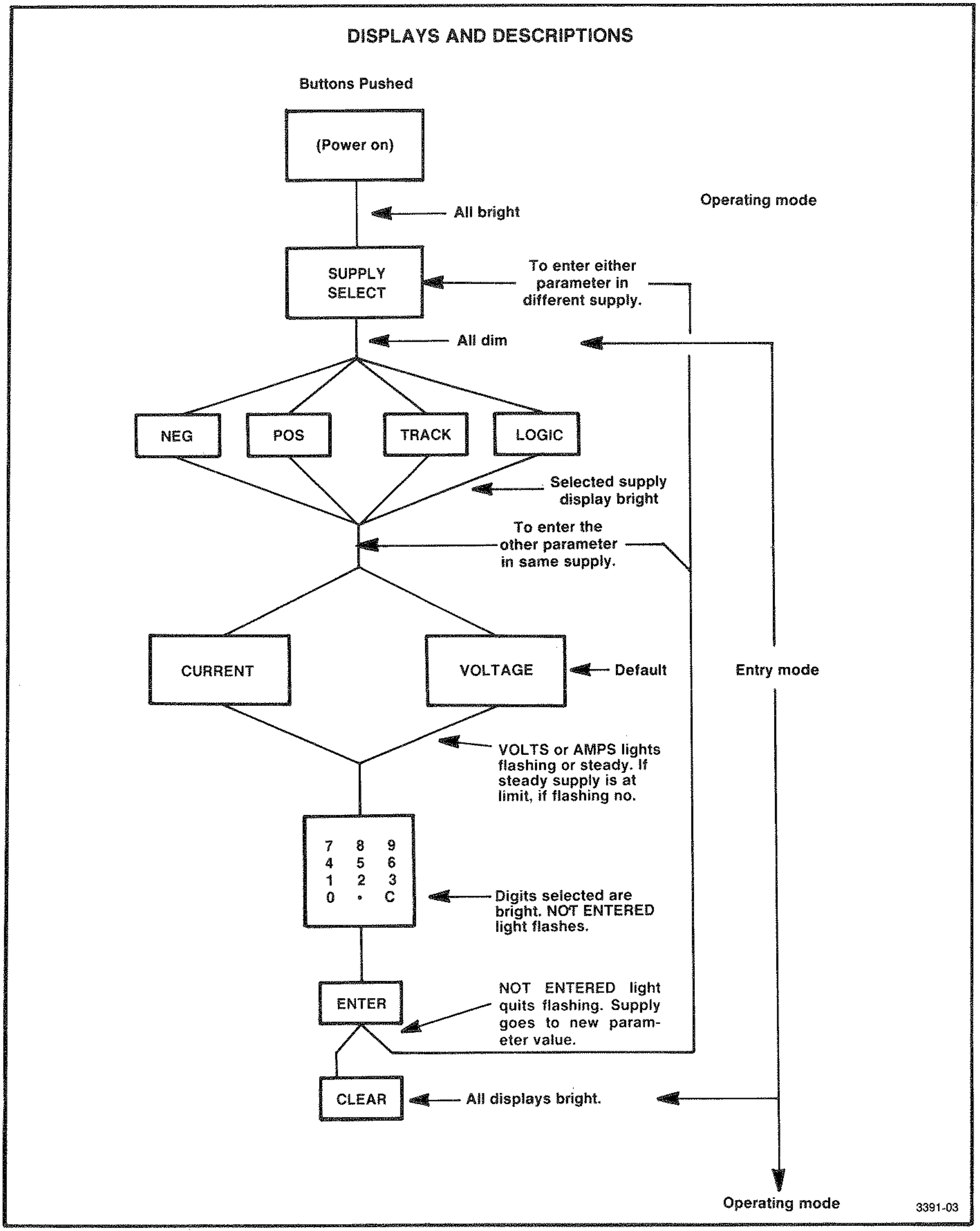


Fig. 2-3. Sequence of events used to enter a parameter into a supply.

	Operating Mode (cont)	Entry Mode (cont)
(9) INCREMENT	Nonfunctional.	Increases or decreases the voltage or current (whichever is programmed) by the smallest step possible. Holding these buttons in increases or decreases the voltage automatically at an increasing rate up to the supply limits. This is an automatic enter function. This pushbutton is nonfunctional if the NOT ENTERED or ERROR lights are flashing. In the track mode both supplies increment by the least significant digit of the highest display. Incrementing occurs until either supply reaches its maximum or minimum allowable value.
(10) Negative supply display	Normally indicates output parameter value. A blank display occurs when the supply is neither in the constant current or constant voltage mode. This may be caused by driving the supply into an overvoltage situation from an external source.	A bright display indicates the parameter value being entered. The remaining dim displays function the same as in the operating mode.
(11) Postive supply display	Normally indicates output parameter value. A blank display occurs when the supply is neither in the constant current or constant voltage mode. This may be caused by driving the supply into an overvoltage situation from an external source.	A bright display indicates the parameter value being entered. The remaining dim displays function the same as in the operating mode.
(12) Logic supply display	Normally indicates output parameter value. A blank display occurs when the supply is neither in the constant current or constant voltage mode. This happens when the output is foldback current limited or driven into overvoltage by an external source.	A bright display indicates the parameter value being entered. The remaining dim displays function the same as in the operating mode.
(13) AMPS	When illuminated, indicates the displayed paramter is amperes. A flashing AMPs LED occurs when the supply is not in constant current mode while the current button is pressed.	When illuminated, indicates the displayed parameter is amperes. A flashing LED indicates the value displayed is not the present value of the output. For example, this LED will flash while entering the amperage of a supply which is in voltage limit.
(14) VOLTS	When illuminated, indicates the displayed parameter is voltage. A flashing VOLTS LED occurs when the supply is not in constant current mode while the current button is pressed.	When illuminated, indicates the displayed parameter is voltage. A flashing LED indicates the value displayed is not the present value of the output. For example, this LED will flash while entering the voltage of a supply which is in current limit. This button is nonfunctional if the NOT ENTERED or ERROR lights are flashing.

(15) REMOTE — Illuminated when instrument is in remote state (controller programmable) via GPIB.

This does not apply to either entry or operating mode.

(16) ADDRESS — Indicates the instrument is addressed by a controller as a talker or listener via GPIB.

(17) ERROR — Illuminated when an attempt is made to enter an out-of-range value from the numerical keyboard.

(18) NOT ENTERED — Indicates value in intensified display(s) is not entered.

(19) NEGATIVE supply output terminal

(20) Floating supply common terminal

Operating Mode (cont)

(21) POSITIVE supply output terminal

(22) LOGIC supply ground (chassis ground) terminal

(23) LOGIC supply positive output terminal

(24) Ground binding post

(25) Plug-in release latch

Entry Mode (cont)

OPERATING CONSIDERATIONS

Auto Crossover

The floating supplies are the automatic crossover type. Under normal conditions, the supply operates in one of two modes: constant voltage or constant current. In the constant voltage mode, decreasing the load impedance increases the output current until the programmed current limit is reached. Further reduction in load impedance puts the supply in constant current mode. As the load impedance continues to decrease, the output current remains constant and the output voltage decreases.

The opposite is true with increasing load impedance. The supply provides constant current until the voltage reaches the programmed voltage limit. Further increase in load impedance puts the supply in the constant voltage mode. See Fig. 2-4.

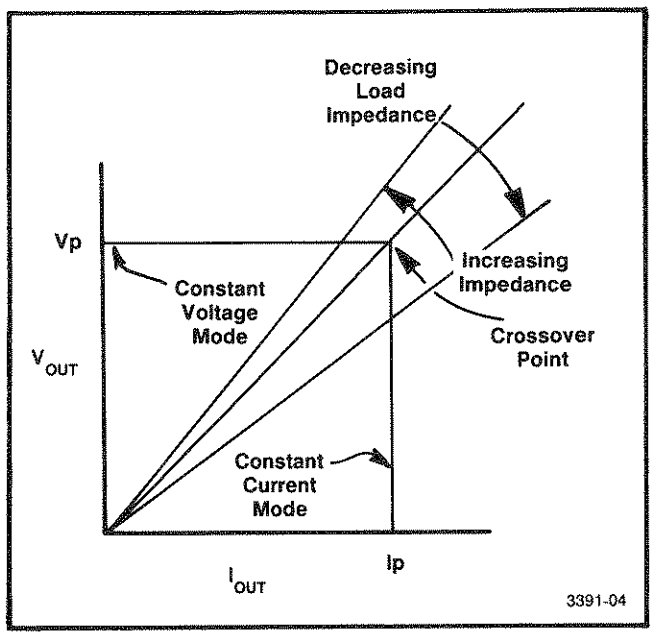


Fig. 2-4. Load lines for individual load impedances.

Logic Supply Foldback Current Limit

The logic supply regulator employs foldback current limiting. This term refers to current limit which is a function of the output voltage. The specified output voltage range of the logic supply is 4.5 V to 5.5 V. As long as the output voltage remains in the specified range, the supply operates in a constant voltage, constant current automatic crossover mode. For voltages under approximately 4 V, the maximum current limit becomes a linearly proportional function of output voltage. The current limit folds back to approximately 1 A with zero output voltage (short circuit). When the logic supply is in foldback mode, neither the current loop nor the voltage loop are balanced. The front panel will display this (blank in operating mode). See Fig. 2-5.

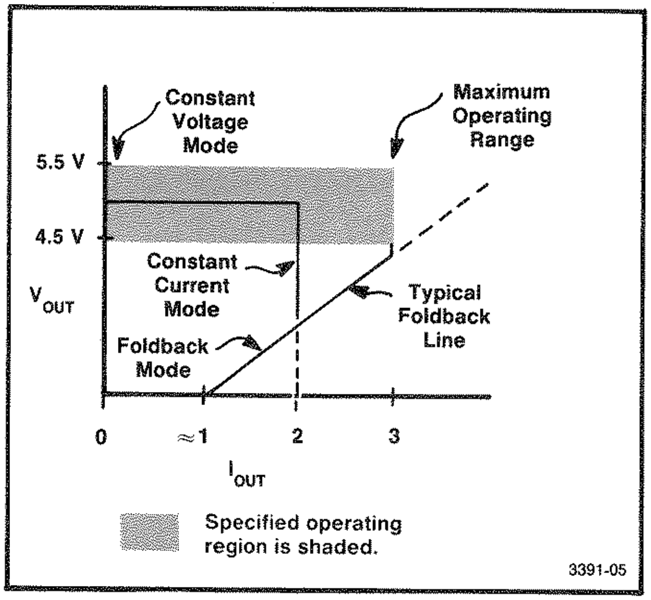


Fig. 2-5. Graph of output characteristics for logic supply.

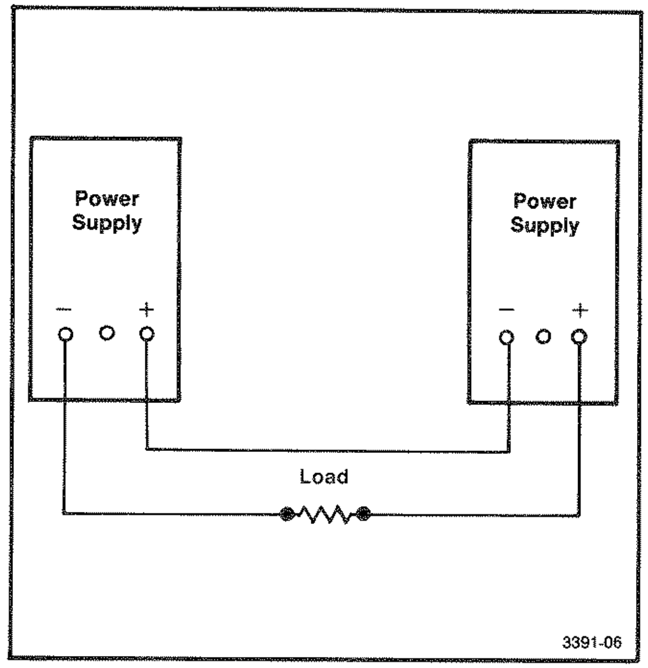


Fig. 2-6. Supplies series connected.

Series-Connected Supplies

The outputs of two or more PS 5010s can be connected in series as shown in Fig. 2-6 to obtain an output voltage equal to the sum of the output voltages from each supply. Each supply must be programmed individually to obtain the desired output voltage.

NOTE

The PS 5010 has internal diodes connected across the output to protect the series-connected supplies against reverse polarity if the load is shorted, or one of the supplies is not on.

Parallel-Connected Supplies

The output of two or more PS 5010s can be connected in parallel as shown in Fig. 2-7 to obtain an output current equal to the sum of the output currents from each supply. Each supply must be programmed individually to obtain the desired output current.

NOTE

The + and − supplies are internally connected in series. Therefore, the + and − supplies cannot be externally connected in parallel to obtain an output current equal to the sum of the currents from each supply.

Both supplies should be programmed to the same voltage. When operating, the display of one supply may blank out, indicating that it is out of regulation. This happens when the supply is driven into overvoltage by the other supply. If the load current increases enough, one supply will go into the constant current mode, and the other in constant voltage mode.

Reverse Voltage Loading

If the polarity across the output of a supply is reversed, a protection diode across the output forward biases, limiting this excursion to the forward voltage drop of the diode. This can occur when a supply is connected in series with another supply and one of two supplies current limit. The diode clamp protects the output transistors from over dissipation and the output capacitors from polarity reversal.

CAUTION

To prevent instrument damage current must be limited to 3 A or less when the polarity is reversed.

Reverse Current Loading

In some bias supply and digital circuitry applications the load may behave as a current source for part of the operating cycle. Since the output circuit of a series regulated sup-

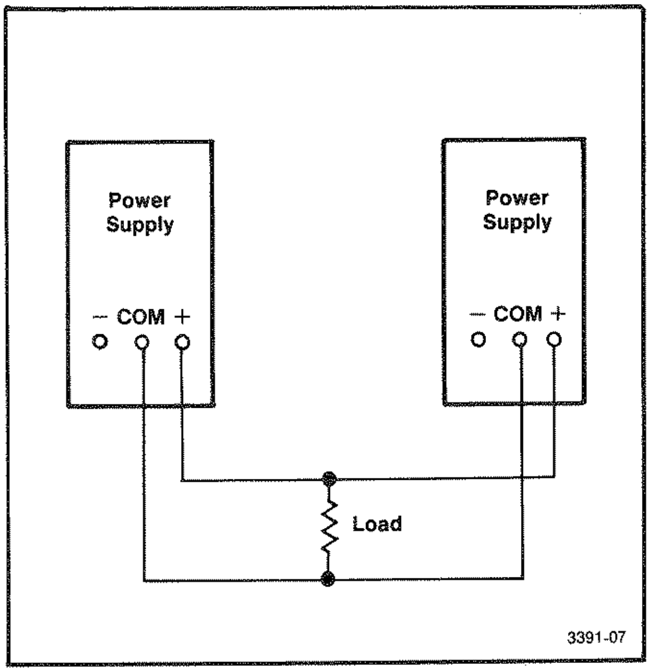


Fig. 2-7. Supplies parallel connected.

ply is unidirectional, current will not pass in the opposite direction except through undesirable paths. The internal reverse current diodes conduct only when the PS 5010 terminal voltage reverses. Connecting a shunt resistor (R_S) as shown in Fig. 2-8 provides an external reverse current path so the power supply always sources current.

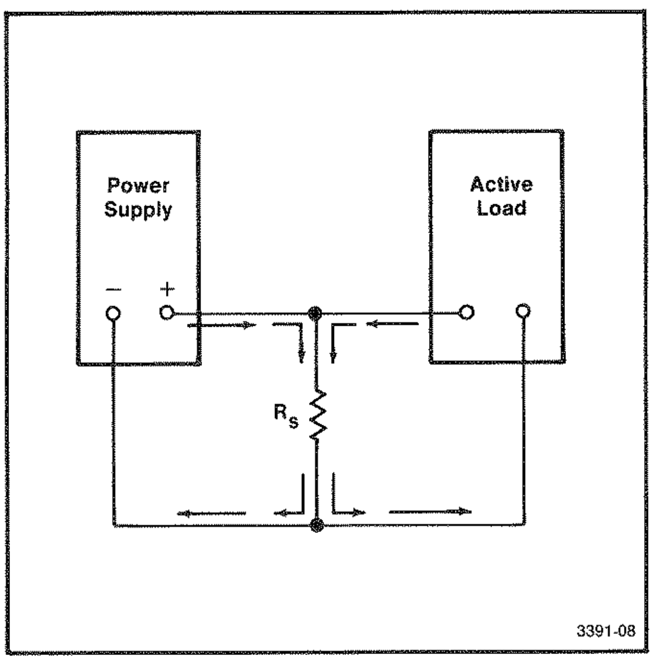


Fig. 2-8. Reverse-current shunt (R_S) with active load.

Overvoltage

CAUTION

Do not externally apply a voltage greater than the maximum rated output voltage of the supply across the output terminals.

Component failure in the PS 5010 can result in floating supply output voltages that exceed the normal range. This can cause load damage if external protection is not provided.

The logic supply output is overvoltage protected by a SCR crowbar connected to the supply input. The trip voltage is approximately 6.2 V. If an internal supply failure or externally applied voltage exceeds this limit, the SCR fires, pulling down the mainframe supplies. This in turn opens the output relays to protect the load and supply from damage.

Load and Monitor Connections

A common source of voltage error is improper connection of loads and monitoring instruments to a power supply output. When using front panel terminals, the sense lines are internally connected. See Fig. 2-9. This maintains load regulation at the terminal. Any lead impedance results in voltage drop at the load. Monitoring of supply output or verification of specifications must be at the output terminal. If one supply output is used to power several loads, each

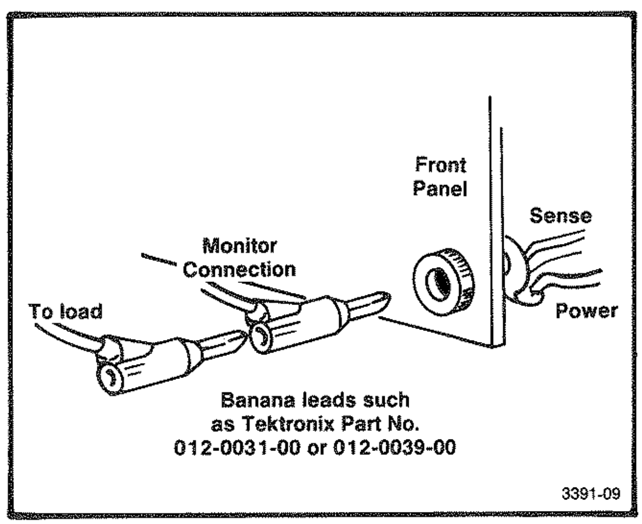


Fig. 2-9. Proper connection of load and monitor test leads to minimize voltage reading error.

load must have its own pair of leads connected as shown in Fig. 2-10. Usually, the load regulation degradation caused by voltage drop in the output leads is insignificant. If it is not, remote sense can be utilized via the rear interface.

Rear Interface Outputs

The logic supply and floating supply outputs and their associated remote sensing lines are available through the rear interface. The logic supply output is available simultaneously at the front panel and rear interface. The sense lines are clamped to the front panel terminals with 1 kΩ resistors. This impedance is large enough so that the lines can be easily pulled to the potential at the remote load. The three floating supply output terminals, and the three associated sense lines are switched to the front panel or rear interface by S1500 which is accessible from the rear panel of the instrument. When using rear interface outputs, remote sense must be used.

Increasing the length of the output leads adds series inductance to the output. This increases the ac impedance which degrades the load transient response. The effect can be minimized by placing a capacitor with good high frequency characteristics directly across the point of load. Larger capacitor values will improve transient resonse in the constant voltage mode, but greatly reduce the response characteristics in the constant current mode. Since this capacitor will temporarily supply large currents into a rapidly decreasing load impedance, delicate load components may be damaged from current supplied by this capacitor before the power supply has time to current limit.

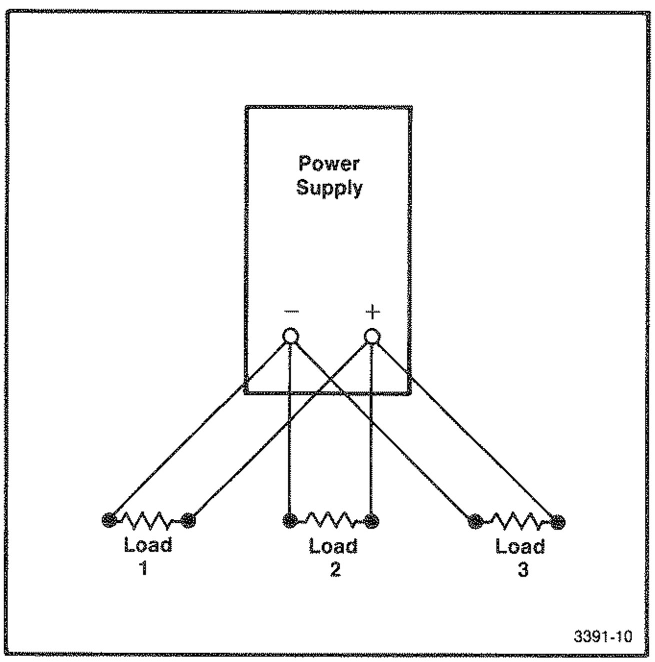


Fig. 2-10. Multiple load connections.

If the output of a supply with remote sensing utilized must be switched, the switch must interrupt both the output leads and the sense leads. It is desirable to open the sense leads first, and close them last. This is done internally when using the OUTPUT ON-OFF button.

Remote Sense

Remote sensing means acquiring voltage feedback from the point of load, rather than from the output terminals. This improves load regulation by allowing the supply to compensate for voltage drop in the power leads. Remote sensing involves only the voltage loop; it has no effect on constant current operation. Since utilization of remote sensing involves bringing the feedback path outside the power supply, precautions must be observed to avoid introducing voltage errors, noise or instability into the voltage loop. See Fig. 2-11.

The power leads to the load should be large enough to minimize the voltage drop. Each sense line is diode clamped to its respective output. This prevents uncontrolled regulator response should the sense lines be inadvertently left unconnected. These diodes limit the amount of load lead drop which the supply can correct for. The load regulation specification for the PS 5010 is valid for a 500 mV maximum combined voltage drop in both load leads. While the current drawn through the sense lines is small, it is not totally insignificant. This current produces a voltage drop in the sense line which may introduce error. Again, a condition for load regulation specification is a maximum combined sense line impedance of 400 mΩ.

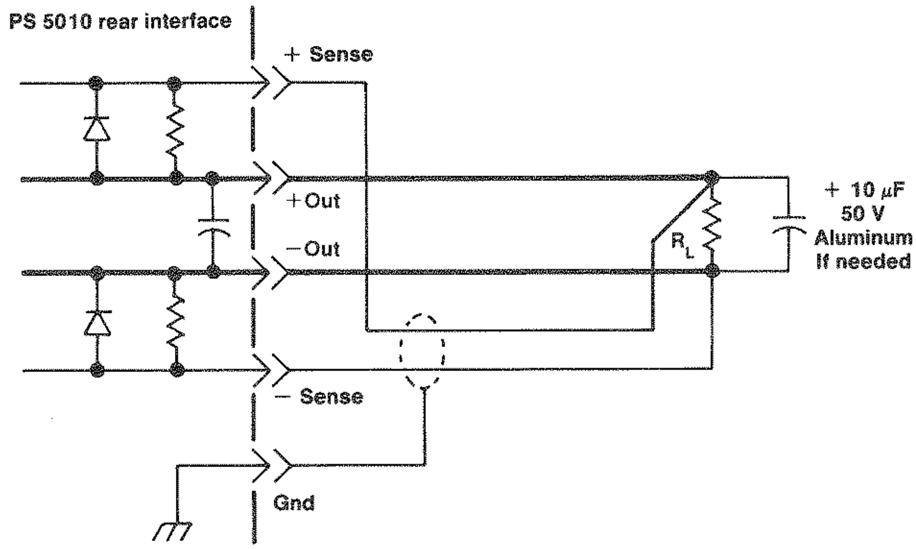
The sense lines should be shielded to avoid noise and power line frequency pick up which might be amplified in the voltage loop and appear in the output. The shield should be connected to chassis ground at the power supply end only.

Logic Supply Ground Loops

The common output terminal of the logic supply is internally connected to chassis ground. If this terminal is also connected to earth ground at the point of load, a ground loop results. If this situation cannot be avoided, it is recommended that the logic supply ground lead be as large a conductor as practical. this insures that return currents will flow primarily through this lead rather than undesirable paths.

Floating Supply Elevation

The floating supply can be operated with any of the three output termiansl grounded or connect to an elevated potential. When operated at an elevated potential, the maximum voltage allowable on any front panel floating supply output terminal with respect to ground is 150 V peak. For example, if the supplies are operated at ±30 V, the common terminal



Observe sense lead polarity when connecting leads to load. Also see material under heading Floating Limitations in this section. Connection information can be found in Rear Interface part of Maintenance section (Section 6) and in the power module manual.

Fig. 2-11. Typical application utilizing remote sensing.

could be floated to any potential between plus and minus 120 Vdc or peak ac with respect to chasis (earth) ground. The maximum allowable voltage on any rear interface output or sense terminal is 60 Vdc or 42 Vac peak with respect to ground.

CAUTION

When any of the floating supply output terminals are elevated with respect to ground, shorting a remaining terminal to ground will apply the elevating potential across the supply. If the elevating potential is of opposite polarity or exceeds the rated output of the supply severe damage to the PS 5010 may result.

When floating this supply with an ac potential, there is an inherent capacitance to chassis ground. This capacitance is distributed to all output terminals and has a value of approximately 0.015 µF.

PROGRAMMING

Introduction

This section of the manual provides information for programming the PS 5010 by remote control via the digital interface. In this manual the digital interface is called the IEEE-488 General Purpose Interface Bus (GPIB). The following information assumes the reader is knowledgeable in GPIB communications and has some exposure to programming controllers. Communication via the GPIB is specified and described in the IEEE Standard 488-1978, Standard Digital Interface for Programmable Instrumentation[1]. TM 5000 instruments are designed to communicate with any GPIB-compatible controller that sends and receives ASCII messages (commands) over the GPIB. These commands program the instrument or request information from the instrument.

Commands for TM 5000 programmable instruments are designed for compatabilty among instrument types. The same command is used in different instruments to control similar functions. In addition, commands are specified in mnemonics related to the functions they implement. For example, the command INIT initializes instrument settings to their power-up states. For further ease of programming, command mnemonics match those on the front panel.

Instrument commands are presented in three formats:

- A front panel illustration — showing command relationships to front panel operation. See Fig. 3-1.
- Functional Command List — A list divided into functional groups with brief descriptions.
- Detailed Command List — An alphabetical listing of commands with complete descriptions.

[1]Published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY, 10017

TM 5000 programmable instruments connect to the GPIB through a TM 5000 power module. Refer to the Operating Instructions section of this manual for information on installing the instrument in the power module. Also review this section to become familiar with front-panel and internally selectable instrument functions.

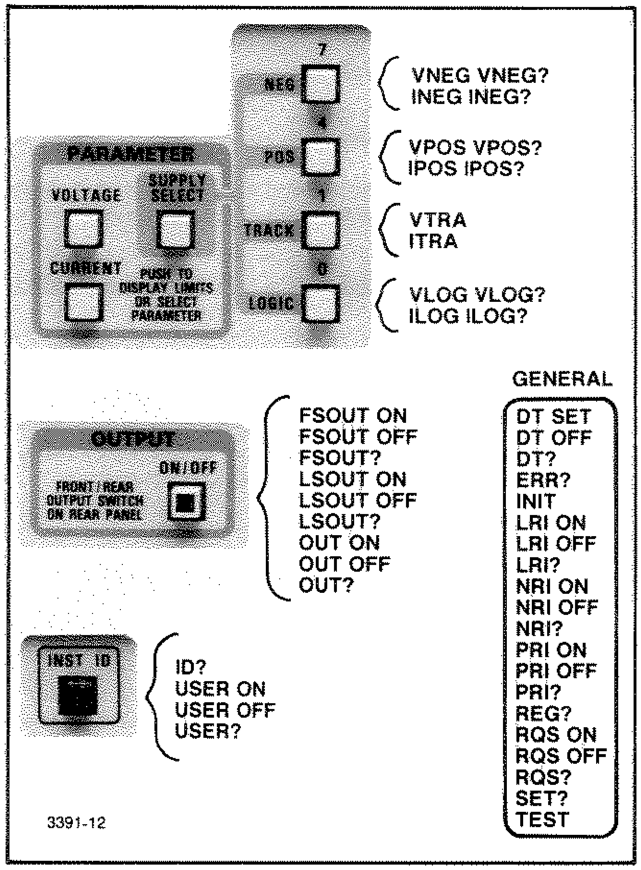


Fig. 3-1. Bus commands and relationships to the front panel.

The GPIB primary address for this instrument may be internally changed by qualified service personnel. The PS 5010 is shipped with the address set to decimal 22. The message terminator may also be internally selected by qualified service personnel. Message terminators are discussed in Messages and Communication Protocol (in this section). TM 5000 instruments are shipped with this terminator set to EOI ONLY. Refer qualified service personnel to the Maintenance section of this manual for locations and setting information. Pressing the INST ID button causes the instrument to display its selected GPIB primary address; the far right decimal point lights if the selected message terminator is LF/EOI.

COMMANDS

The instrument is controlled by the front panel or via commands received from the controller. These commands are of three types:

Setting commands — control instrument settings
Query-output commands — ask for data
Operational commands — cause a particular action

The instrument responds to and executes all commands when in the remote state. When in the local state, *setting* and *operational commands* generate errors since instrument function are under front panel control; only *query-output commands* are executed.

Each command begins with a header — a word that describes the function implemented. Many commands require an argument following the header — a word or number which specifies the desired state for the function.

FUNCTIONAL COMMAND LIST

Instrument Commands

ILOGIC—Sets logic supply current limit.
ILOGIC?—Returns logic supply current limit.
VLOGIC—Sets logic supply voltage limit.
VLOGIC?—Returns logic supply voltage limit.
INEGATIVE—Sets negative supply current limit.
INEGATIVE?—Returns negative current limit.
VNEGATIVE—Sets negative voltage limit.
VNEGATIVE?—Returns negative voltage limit.
IPOSITIVE—Sets positive current limit.
IPOSITIVE?—Returns positive current limit.
VPOSITIVE—Sets positive voltage limit.
VPOSITIVE?—Returns positive voltage limit.
ITRACK—Sets positive and negative current limits.
VTRACK—Sets positive and negative voltage limits.

Input/Output Commands

OUT ON—Connects supplies to output terminals.
OUT OFF—Disconnects supplies from output terminals.
OUTPUT?—Returns FSOUT and LSOUT ON or OFF.
FSOUTPUT ON—Connects the floating supplies to the output terminals.
FSOUTPUT OFF—Disconnects the floating supplies from the output terminals.
FSOUTPUT?—Returns FSOUT ON or OFF.
LSOUTPUT ON—Connects the logic supply to the output terminals.
LSOUTPUT OFF—Disconnects the logic supply from the output terminals.
LSOUTPUT?—Returns LSOUT ON or OFF.

Instrument Status Commands

REGULATION?—Returns regulation status of all supplies.
LRI ON—Enables logic supply regulation interrupt.
LRI OFF—Disables logic supply regulation interrupt.
LRI?—Returns LRI ON or LRI OFF.
NRI ON—Enables negative supply regulation interrupt.
NRI OFF—Disables negative supply regulation interrupt.
NRI?—Returns NRI ON or NRI OFF.
PRI ON—Enables positive supply regulation interrupt.
PRI OFF—Disables positive supply regulation interrupt.
PRI?—Returns PRI ON or PRI OFF.
RQS ON—Enables generation of service requests.
RQS OFF—Disables generation of service requests.
RQS?—Returns RQS ON or OFF.
USEREQ ON—Enables SRQ when ID button is pushed.
USEREQ OFF—Disables SRQ when ID button is pushed.
USEREQ?—Returns USER ON or OFF.

System Commands

DT SET—Updates hardware after <GET>.
DT OFF—Updates hardware without <GET> message.
DT?—Returns DT SET or OFF.
ERROR?—Returns error code.
ID?—Returns instrument identification and firmware version.
INIT—Initializes instrument settings.
SET?—Returns instrument settings.
TEST—Returns 0 or ROM error code.

DETAILED COMMAND LIST

DT (device trigger)

Type:

Setting or query

Setting syntax:

DT SET
DT OFF

Examples:

DT SET
DT OFF

Query syntax:

DT?

Query response:

DT SET;
DT OFF;

Discussion:

This command causes the instrument to wait for the <GET> (group execute trigger) interface message before updating the hardware to new settings. The OFF argument permits hardware updating without the <GET> message.

ERROR?

Type:

Query

Query syntax:

ERR:

Query ERROR? response:

ERR 103;
ERR 204;

Discussion:

This command returns an error code for the most recent error reported via serial poll. When the error status reporting is disabled (RQS OFF) this command returns the highest priority condition pending. The condition is cleared and not reported again.

FSOUTPUT

Type:

Setting or query

Setting syntax:

FSOUT ON
FSOUT OFF

Examples:

FSOUT ON
FSOUTPUT OFF

Query syntax:

FSOUT?

Query response:

FSOUT ON;
FSOUT OFF;

Discussion:

This command connects or disconnects both floating supplies to or from their respective output terminals. Some protective components remain connected to the output terminals. Refer to schematics 11 and 12 for components that remain connected.

ID?

Type:

Query

Query syntax:

ID?

Query response:

ID TEK/PS5010,V79.1,FXX;

Discussion:

XX indicates the firmware version number.

ILOGIC

Type:

Setting or query

Setting syntax:

ILOG <number>

Examples:

ILOG 2.8
ILOG .1
ILOGIC 2

Query syntax:

ILOG?

Query response examples:

ILOGIC 1.6;
ILOGIC 2;

Discussion:

This command sets the logic supply current limit to the value specified. The units are amperes for both the setting and query versions. The range is 0.10 A to 3.0 A and the resolution is 100 mA.

INEGATIVE

Type:

Setting or query

Setting syntax:

INEG <number>

Examples:

INEG 1.45
INEG 1
INEGATIVE .3

Query syntax:

INEG?

Query response examples:

INEG 1.1;
INEG .750;

Discussion:

This command sets the negative supply current limit to the absolute value specified. The units for the setting and query versions are amperes. The range is 0.050 A to 0.750 A (1.6 A at 15 V and below) in the high power compartment and 0.050 A to 0.40 A (0.75 A at 15 V and below) in the standard compartment. The resolution is 0.050 A.

INIT

Type:

Operational

Operational syntax:

INIT

Discussion:

This command changes instrument settings to the power-on state. These settings are shown in Table 3-3 in this section.

IPOSITIVE

Type:

Setting or query

Setting syntax:

IPOS <number>

Examples:

IPOS .45
IPOS 1
IPOSITIVE 0.3

Query syntax:

IPOS?

Query response examples:

IPOS 1.1;
IPOS .750;

Discussion:

This command sets the positive supply current limit to the value specified. Units for the setting and query versions are in amperes. The range is 0.05 A to 0.750 A (1.6 A at 15 V and below) in the high power compartment and 0.05 A to 0.40 A (0.75 A at 15 V and below) in the standard compartment. The resolution is 0.05 A.

ITRACK

Type:

Setting

Setting syntax:

ITRA <number>

Examples:

ITRA 0.45
ITRA 1.0
ITRACK .3

Discussion:

This command sets the magnitude of both floating supplies to the absolute value specified. Units are amperes. The range is 0.05 A to 0.750 A (1.6 A at 15 V and below) in the high power compartment and 0.05 A to 0.40 A (0.75 A at 15 V and below) in the standard compartment. The resolution is 0.05 A.

LLSET

Type:

Setting or query

Setting syntax:

LLSET <binary block>

Query syntax:

LLSET?

Query response:

LLSET <binary block>;

Discussion:

The setting command changes all instrument settings to the states as specified in the binary block argument. Use this command for rapid transfer of settings. The binary block is generated by the instrument and is not intended to be generated or modified by the user. The query returns all instrument settings in low level (binary) format.

The binary block format consists of the percent (%) sign (decimal 37) followed by a two byte binary count, the data bytes and finally the checksum. The two byte binary count (integer, most significant bit first) specifies the number of data bytes plus the checksum byte. The checksum is the 2's complement of the modulo 256 sum of the preceding binary data bytes and the binary count bytes. The checksum does not include the % sign.

LRI

Type:

Setting or query

Setting syntax:

LRI ON
LRI OFF

Examples:

LRI ON
LRI OFF

Query syntax:

LRI?

Query response:

LRI ON;
LRI OFF;

Discussion:

This command enables the logic supply regulation interrupt. SRQ is asserted when the logic supply changes between any two of the three regulated modes. These modes are constant voltage, constant current and unregulated. The device dependent serial poll status byte indicates which supply caused the SRQ and the mode changed to. See Table 3-1.

The status message returned (with RQS asserted), as a result of enabling the LRI interrupt, does not necessarily show the instruments present status. It shows the status which was latched at the time the interrupt occurred. Use the command REG? to determine present status.

LSOUTPUT

Type:

Setting or query

Setting syntax:

LSOUT ON
LSOUT OFF

Examples:

LSOUT ON
LSOUT OFF

Query syntax:

LSOUT?

Query response:

LSOUT ON;
LSOUT OFF;

Discussion:

This command connects or disconnects the logic supply to its positive output terminal. Some protective components remain connected to the output terminals. Refer to schematic 8 for components that remain connected.

NRI

Type:

Setting or query

Setting syntax:

NRI ON
NRI OFF

Examples:

NRI ON
NRI OFF

Query syntax:

NRI?

Query response:

NRI ON;
NRI OFF;

Discussion:

This command enables the negative supply regulation interrupt. SRQ is asserted when the negative supply changes between any two of the three modes. These modes are constant voltage, constant current and unregulated. The device dependent serial poll status byte indicates the supply causing the SRQ and the mode changed to. See Table 3-1.

The status message returned (with RQS asserted), as a result of enabling the NRI interrupt, does not necessarily show the instruments present status. Instead, it shows the status which was latched at the time the interrupt occurred. Use the command REG? to determine present status.

OUTPUT

Type:

Setting or query

Setting syntax:

OUT ON
OUT OFF

Examples:

OUT ON
OUTPUT OFF

Query syntax:

OUT?

Query response examples:

FSOUT ON; LSOUT OFF;
FSOUT OFF; LSOUT ON;

Discussion:

This command connects or disconnects all supplies to or from their respective output terminals. Some protective components remain connected to the output terminals. Refer to schematics 8, 11, and 12 for components that remain connected.

PRI

Type:

Setting or query

Setting syntax:

PRI ON
PRI OFF

Examples:

PRI ON
PRI OFF

Query syntax:

PRI?

Query response:

PRI ON;
PRI OFF;

Discussion:

This command enables the positive supply regulation interrupt. SRQ is asserted when the positive supply changes between any two of the three modes. These modes are constant voltage, constant current and unregulated. The device dependent serial poll status byte indicates the supply causing the SRQ and the mode changed to. See Table 3-1.

The status message returned (with RQS asserted), as a result of enabling the PRI interrupt, does not necessarily show the instruments present status. Instead, it shows the status which was latched at the time the interrupt occurred. Use the command REG? to determine present status.

REGULATION?

Type:

Query

Query syntax:

REG?
REGULATION?

Query response:

REG <number>,<number>,<number>

Discussion:

This command provides a means of determining the regulation status of the three supplies. The three numbers returned apply to the negative, positive, and logic supplies in that order. The numbers returned mean: (1) supply is in constant voltage mode, (2) supply is in constant current mode, (3) supply is unregulated.

RQS

Type:

Setting or query

Setting syntax:

RQS ON
RQS OFF

Examples:

RQS ON
RQS OFF

Query syntax:

RQS?

Query response:

RQS ON;
RQS OFF;

Discussion:

This command enables the instrument to generate service requests. The OFF version of the command disables all service requests.

SET?

Type:

Query

Query syntax:

SET?

Query response example:

VNEG 0.0;INEG 0.4;VPOS 0.0;IPOS 0.4;VLOG 5.0;
ILOG 1.0; FSOUT OFF;LS OUT OFF;NRI OFF;PRI OFF;
LRI OFF; DT OFF;USER OFF;RQS ON;

Discussion:

Returns values for all instrument states as shown in example.

TEST

Type:

Output

Output syntax:

TEST

Discussion:

This command returns 0 or the error code corresponding to the ROM in which the checksum error was found. See Table 3-2.

USEREQ

Type:

Setting or query

Setting syntax:

USER ON
USER OFF
USEREQ ON
USEREQ OFF

Query syntax:

USER?
USEREQ?

Query response:

USER ON;
USER OFF;

Discussion:

Enables SRQ when INST ID front panel button is pressed.

VLOGIC

Type:

Setting or query

Setting syntax:

VLOG <number>
VLOGIC <number>

Examples:

VLOG 5
VLOGIC 4.97

Query syntax:

VLOG?
VLOGIC?

Query response example:

VLOGIC 5.1;

Discussion:

This command sets the logic supply voltage limit to the value specified. The units are volts for both the setting and query versions. The range is 4.5 V to 5.5 V and the resolution is 0.010 V.

VNEGATIVE

Type:

Setting or query

Setting syntax:

VNEG 26.7
VNEGATIVE −3.5

Query syntax:

VNEG?
VNEGATIVE?

Query response example:

VNEG 23.2;
VNEG 1.0;

Discussion:

This command sets the negative floating supply voltage limit to the value specified. The units are volts for both the setting and query versions. The range is 0 to −32 V and the resolution is 0.010 V to 10 V and 0.10 V above 10.1 V.

VPOSITIVE

Type:

Setting or query

Setting syntax:

VPOS <number>
VPOSITIVE <number>

Query syntax:

VPOS?
VPOSITIVE?

Query response example:

VPOS 1.0;
VPOS 29.7;

Discussion:

This command sets the positive floating supply voltage limit to the value specified. The units are volts for both the setting and query versions. The range is 0 V to +32 V and the resolution is 0.01 V to 10 V and 0.10 V above 10.1 V.

VTRACK

Type:

Setting

Setting syntax:

VTRA <number>
VTRACK <number>

Examples:

VTRA 25.3
VTRA 5.02
VTRACK 2

Discussion:

This command sets the voltage magnitude of both floating supplies to the absolute value specified. Units are volts. The range is 0 V to 32 V and the resolution is 0.01 V to 10 V and 0.10 V above 10.0 V.

MESSAGES AND COMMUNICATION PROTOCOL

Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Messages consisting of multiple commands must have the commands separated by semicolons. A semicolon at the end of a message is optional. For example, each line below is a message.

INIT
TEST;INIT;RQS ON;USER OFF;ID?;SET?
TEST;

Message Terminator

Messages may be terminated with EOI or the ASCII line feed (LF) character. Some controllers assert EOI concurrently with the last data byte; others use only the LF character as a terminator. The instrument can be internally set to accept either terminator. With EOI ONLY selected as the terminator, the instrument interprets a data byte received with EOI asserted as the end of the input message; it also asserts EOI concurrently with the last byte of the output message. With the LF/EOI setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message; it transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages. Refer service personnel to the Maintenance section of the manual for information on setting the message terminator. TM 5000 instruments are shipped with EOI ONLY selected.

Formatting A Message

Commands sent to TM 5000 instruments must have the proper format (syntax) to be understood; however, this format is flexible in that many variations are acceptable. The following describes this format and the acceptable variations.

The instruments expect all commands to be encoded in ASCII; however, they accept both upper and lower case ASCII characters. All data output is in upper case. See Fig. 3-2.

As previously discussed, a command consists of a header followed, if necessary, by arguments. A command with arguments must have a header delimiter which is the space character SP between the header and the argument. The space character $_{SP}$, carriage return $_{CR}$, and line feed $_{LF}$ are shown as subscripts in the following examples.

$RQS_{SP}ON$

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode) are added between the header delimiter and the argument, they are ignored by the instrument.

Example 1: $RQS_{SP}ON;$
Example 2: $RQS_{SP\ SP}$ ON;
Example 3: $RQS_{SP\ CR\ LF\ SP\ SP}ON$

In general, these formatting characters are ignored after any delimiter and the beginning and end of a message.

$_{SP}RQS_{SP}ON;_{CR\ LF}$
$_{SP}USER_{SP}OFF$

In the command list, some headers and arguments are listed in two forms, a full-length version and an abbreviated version. The instrument accepts any header or argument containing at least the characters listed in the short form; any characters added to the abbreviated version must be those given in the full-length version. For documentation of programs, the user may add alpha characters to the full-length version. Alpha characters may also be added to query header, provided the question mark is at the end.

USER?
USERE?
USEREQ?
USEREQUEST?

Multiple arguments are separated by a comma; however, the instrument will also accept a space or spaces as a delimiter.

2.3
$2_{SP}3$
$2,_{SP}3$

NOTE

In the last example, the space is treated as a format character because it follows the comma (the argument delimiter).

Number Formats

The instrument accepts the following kinds of numbers for any of the numeric arguments.

- Signed or unsigned integers (including +0 and −0). Unsigned integers are interpreted as positive. Examples: +1, 2, −1, −10.

ASCII & IEEE 488 (GPIB) CODE CHART

B7 B6 B5 BITS B4	B3	B2	B1	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
				CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
Ø	Ø	Ø	Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 ` 60 (96)	160 p 70 (112)
Ø	Ø	Ø	1	1 GTL SOH 1 (1)	21 LLO DC1 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø	Ø	1	Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø	Ø	1	1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø	1	Ø	Ø	4 SDC EOT 4 (4)	24 DCL DC4 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø	1	Ø	1	5 PPC ENQ 5 (5)	25 PPU NAK 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø	1	1	Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø	1	1	1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1	Ø	Ø	Ø	10 GET BS 8 (8)	30 SPE CAN 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1	Ø	Ø	1	11 TCT HT 9 (9)	31 SPD EM 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1	Ø	1	Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1	Ø	1	1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1	1	Ø	Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \\ 5C (92)	154 l 6C (108)	174 | 7C (124)
1	1	Ø	1	15 CR D (13)	35 GS 1D (29)	55 – 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1	1	1	Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 Λ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1	1	1	1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 UNL ? 3F (63)	117 O 4F (79)	137 UNT _ 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS

UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART

octal — 25	PPU — GPIB code	
	NAK — ASCII character	
hex — 15	(21) — decimal	

3391-13

Fig. 3-2. ASCII and IEEE 488 (GPIB) Code Chart.

- Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted to be positive. Examples: −3.2, +5.0, .2.

- Floating point numbers expressed in scientific notation. Examples: +1.0E−2, 1.47E1, 1.E−2, 0.01E+0.

Rounding of Numeric Arguments

The instrument rounds numeric arguments to the nearest unit of resolution and then checks for out-of-range conditions.

Message Protocol

As the instrument receives a message it is stored in the Input Buffer, processed, and executed. Processing a message consists of decoding commands, detecting delimiters, and checking syntax. For *setting commands*, the instrument then stores the indicated changes in the Pending Settings Buffer. If an error is detected during processing the instrument asserts SRQ, ignores the remainder of the message, and resets the Pending Settings Buffer. Resetting the Pending Settings Buffer avoids undesirable states which could occur if some *setting commands* are executed while others in the same message are not.

Executing a message consists of performing the actions specified by its command(s). For *setting commands*, this involves updating the instrument settings and recording these updates in the Current Settings Buffer. The *setting commands* are executed in groups — that is, a series of *setting commands* is processed and recorded in the Pending Settings Buffer before execution takes place. This allows the user to specify a new instrument state without having to consider whether a particular sequence would be valid. Execution of the settings occurs when the instrument processes the message terminator, a *query-output command*, or an *operational command* in a message. The normal execution of settings is modified by the DT SETTINGS command.

When the instrument processes a *query-output command* in a message, it executes any preceding *setting commands* to update the state of the instrument. It then executes the *query-output command* by retrieving the appropriate data and putting it in the Output Buffer. Then, processing and execution continue for the remainder of the message. The data are sent to the controller when the instrument is made a talker.

When the instrument processes an *operational command* in a message, it executes any preceding *setting commands* before executing the *operational command.*

Multiple Messages

The Input Buffer has finite capacity and a single message may be long enough to fill it. In this case, a portion of the message is processed before the instrument accepts additional input. During command processing the instrument holds off additional data (by asserting NRFD) until space is available in the buffer.

When space is available, the instrument can accept a second message before the first has been processed. However, it holds off additional messages with NRFD until it completes processing the first.

After the instrument executes a *query-output command* in a message, it holds the response in its Output Buffer until the controller makes the instrument a talker. If the instrument receives a new message before all of the output from the previous message is read it clears the Output Buffer before executing the new message. This prevents the controller from getting unwanted data from old messages.

One other situation may cause the instrument to delete output. The execution of a long message might cause both the Input and Output Buffers to become full. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated; but the controller cannot read the data because it is waiting to finish sending its message. Because the instruments Input Buffer is full and it is holding off the rest of the controllers message with NRFD, the system is hung up with the controller and instrument waiting for each other. When the instrument detects this condition, it generates an error, asserts SRQ and deletes the data in the Output Buffer. This action allows the controller to transmit the rest of the message and informs the controller that the message was executed and that the output was deleted.

A TM 5000 instrument can be made a talker without having received a message which specifies what it should output. In this case, acquisition instruments (counters and multimeters) return a measurement if one is ready. If no measurement is ready, they return a single byte message with all bits equal to 1 (with message terminator); other TM 5000 instruments will return only this message.

INSTRUMENT RESPONSE TO IEEE-488 INTERFACE MESSAGES

Interface messages and their effects on the instruments interface functions are defined in IEEE Standard 488-1978. Abbreviations from the standard are used in this discussion which describe the effects of interface messages on instrument operation.

Bus interface control messages are sent as low level commands through the use of WBYTE controller commands. For the following commands A = 32 plus the instrument address and B = 64 plus the instrument address.

Listen	WBYTE @ A:
Unlisten	WBYTE @ 63:
Talk	WBYTE @ B:
Untalk	WBYTE @ 95:
Untalk-unlisten	WBYTE @ 63, 95:
Device clear (DCL)	WBYTE @ 20
Selective device clear (SDC)	WBYTE @ A, 4:
Go to local (GTL)	WBYTE @ A, 1:
Remote with lockout	WBYTE @ A, 17, 63:
Local lockout of all instruments	WBYTE @ 17:
Group execute trigger (GET)	WBYTE @ A, 8:

These commands are for the TEKTRONIX 4050-Series controllers and representative for other controllers.

UNL—Unlisten
UNT—Untalk

When the UNL command is received, the instruments listener function goes to its idle state (unaddressed). In the idle state, the instrument will not accept instrument commands from the GPIB.

The talker function goes to its idle state when the instrument receives the UNT command. In this state, the instrument cannot output data via the GPIB.

The ADDRESSED light is off when both the talker and listener functions are idle. If the instrument is either talk addressed or listen addressed, the light is on.

IFC—Interface Clear

This uniline message has the same affect as both the UNT and UNL messages. The front panel ADDRESSED light is off.

DCL—Device Clear

The Device Clear message reinitializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexecuted settings in the Pending Settings Buffer. Also cleared are any errors or events waiting to be reported, except the power-on event. If the SRQ line is asserted for any reason other than power-on when DCL is received, the SRQ is unasserted.

SDC—Selected Device Clear

This message performs the same function as DCL; however, only instruments that are listen addressed respond to SDC.

GET—Group Execute Trigger

The instrument responds to GET only if it is listen addressed and the instruments device trigger function has been enabled by the Device Trigger command (DT). The GET message is ignored and an SRQ generated if the DT function is disabled (DT OFF), the instrument is in the local state, or if a message is being processed when GET is received.

SPE—Serial Poll Enable
SPD—Serial Poll Disable

The SPE message enables the instrument to output serial poll status bytes when it is talk addressed. The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA—My Listen Address
MTA—My Talk Address

The primary listen and talk addresses are established by the instruments GPIB address (internally set). The current setting of the GPIB address is displayed on the front panel when the ID button is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is illuminated.

LLO—Local Lockout

In response to LLO, the instrument goes to a lockout state—from LOCS to LWLS or from REMS to RWLS.

REN—Remote Enable

If REN is true, the instrument goes to a remote state (from LOCS to REMS or from LWLS to RWLS) when its listen address is received. REN false causes a transition from any state to LOCS; the instrument stays in LOCS as long as REN is false.

A REN transition may occur after message processing has begun. In this case execution of the message being processed is not affected by a transition.

GTL—Go To Local

Only instruments that are listen addressed respond to GTL by going to a local state. Remote-to-local transitions caused by GTL do not affect the execution of the message being processed when GTL was received.

Remote-Local Operation

The preceding discussion of interface messages describes the state transitions caused by GTL and REN. Most front panel controls cause a transition from REMS to LOCS by asserting a message called return-to-local (*rtl*). This transition may occur during message execution; but in contrast to GTL and REN transitions, a transition initiated by *rtl* does affect message execution. In this case, the instrument generates an error if there are any unexecuted setting or operational commands. Front panel controls that only change the display (like ID) do not affect the remote-local states — only front panel controls that change settings assert *rtl*. The *rtl* message remains asserted while multiple keystroke settings are entered; and it is unasserted after the execution of the settings. Since *rtl* prevents transitions to REMS, the instrument unasserts *rtl* if a multiple button sequence is not completed in a reasonable length of time (approximately 5 to 10 seconds).

The instrument maintains a record of its settings in the Current Settings Buffer and new settings from the front panel or the controller update these recorded settings. In addition, the front panel is updated to reflect setting changes due to commands. Instrument settings are unaffected by transitions between the four remote-local states. The REMOTE indicator is illuminated when the instrument is in REMS or RWLS.

Local State (LOCS)

In LOCS, instrument settings are controlled by the operator via front panel pushbuttons. When in LOCS, only bus commands that do not change instrument settings are executed (*query-output commands*); all other bus commands (*setting* and *operational*) generate an error since their functions are under front panel control.

Local With Lockout State (LWLS)

The instrument operates the same as it does in LOCS, except that *rtl* will not inhibit a transition to remote.

Remote State (REMS)

In this state, the instrument executes all instrument commands. For commands having front panel indicators, the front panel is updated when the commands are executed.

Remote With Lockout State (RWLS)

Instrument operation is identical to REMS operation except that the *rtl* message is ignored.

STATUS AND ERROR REPORTING

Through the Service Request function (defined in the IEEE-488 Standard), the instrument may alert the controller that it needs service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request the controller performs a Serial Poll; in response the instrument returns a Status Byte (STB) which indicates whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Fig. 3-3. When data bit 8 is set, the STB conveys Device Status information which is indicated by bits 1 through 4.

Because the STB conveys limited information about an event, the events are divided into classes; the Status Byte reports the class. The classes of events are defined as follows:

COMMAND ERROR Indicates the instrument has received a command which it cannot understand.

EXECUTION ERROR Indicates that the instrument has received a command that it cannot execute. This is caused by arguments out of range or settings that conflict.

INTERNAL ERROR Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

SYSTEM EVENTS Events that are common to instruments in a system (e.g., Power on, User Request, etc.).

EXECUTION WARNING The instrument is operating but the user should be aware of potential problems.

DEVICE STATUS Device dependent events.

The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB) the controller may request the additional information by sending an error query (ERR?). In response, the instrument returns a code which defines the event. These codes are described in Table 3-1.

Table 3-3
STATUS BYTE BITS DEFINITION

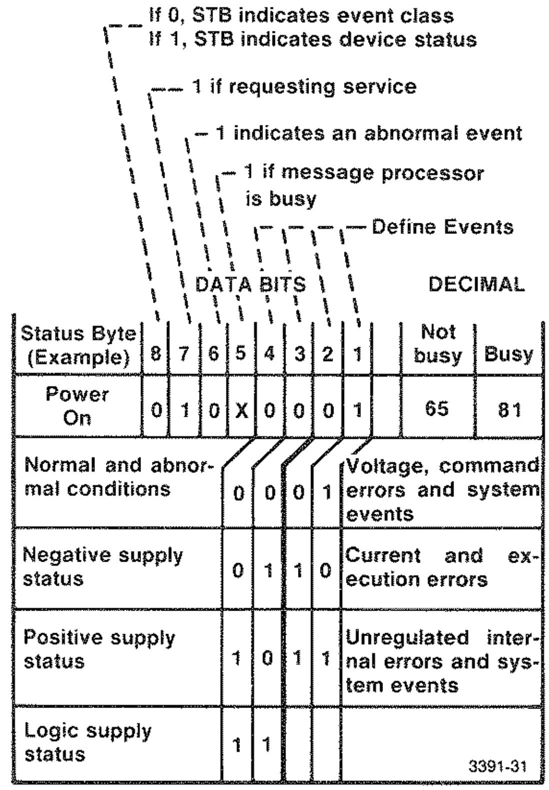


Fig. 3-3. Definition of status bytes.

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Table 3-1

ERROR QUERY AND STATUS INFORMATION

Abnormal Conditions

Event	Bus response to ERR?	Response to serial poll[a]
Command Errors		
Command header error	101	97 or 113
Header delimiter error	102	97 or 113
Command argument error	103	97 or 113
Argument delimiter error	104	97 or 113
Missing argument	106	97 or 113
Invalid message unit delimiter	107	97 or 113
Binary block checksum error	108	97 or 113
binary block byte counter error	109	97 or 113
Execution Errors		
Command not executable in local mode	201	98 or 114
Returned to local, new settings pending lost	202	98 or 114
I/O buffers full, output dumped	203	98 or 114
Settings conflicts	204	98 or 114
Argument out of range	205	98 or 114
Group execute trigger ignored	206	98 or 114
Internal Errors		
System error	302	99 or 115
Math pack error	303	99 or 115

Normal Conditions

Event	Bus response to ERR?	Response to serial poll[a]
System Events		
Power on	401	65 or 81
User request	403	67 or 83
Device Dependent Events		
Negative supply goes to constant voltage mode	721	197 or 213
Negative supply goes to constant current mode	722	198 or 214
Negative supply goes to unregulated mode	723	199 or 215
Positive supply goes to constant voltage mode	724	201 or 217
Positive supply goes to constant current mode	725	202 or 218
Positive supply goes to unregulated mode	726	203 or 219
Logic supply goes to constant voltage mode	727	205 or 221
Logic supply goes to constant current mode	728	206 or 222
Logic supply goes to unregulated mode	729	207 or 223

[a]If the message processor is busy, the instrument returns the higher decimal number.

Table 3-2

FRONT PANEL ERROR CODES

Displayed	Abnormal Events
302	System error
303	Math pack error
340	System RAM error
341	System RAM error (low nibble)
372	C000 ROM placement error
373	D000 ROM placement error
374	E000 ROM placement error
375	F000 ROM placement error
392	C000 ROM checksum error
393	D000 ROM checksum error
394	E000 ROM checksum error
395	F000 ROM checksum error
521	Signature analysis mode

If there is more than one event to be reported, the instrument continues to assert SRQ until it reports all events. Each event is automatically cleared when it is reported via Serial Poll. The Device Clear (DCL) interface message may be used to clear all events except Power on.

Commands are provided to control the reporting of some individual events and to disable all service requests. For example, the User Request command (USEREQ) provides individual control over the reporting of the user request event which occurs when the front panel ID button is pushed. The Request for Service command (RQS) controls whether the instrument reports any events with SRQ.

RQS OFF inhibits all SRQs so in this mode the ERR? query allows the controller to find out about events without first performing a Serial Poll. With RQS OFF, the controller may send the ERR? query at any time and the instrument returns an event waiting to be reported. The controller can clear all events by sending the error query until a zero (0) code is returned, or clear all events except Power-on through the DCL interface message.

With RQS OFF the controller may perform a Serial Poll, but the Status Byte only contains Device Dependent Status information. With RQS ON, the STB contains the class of the event and a subsequent error reported in the STB.

Power Up (Initial) Conditions

During power up, the PS 5010 microprocessor performs a diagnostic routine (self test) to check the functionality of the ROM and RAM. If no error is found, the instrument enters the Local State (LOCS) with the default settings as listed in Table 3-3. The SRQ line on the GPIB is also asserted.

Table 3-3

POWER ON SETTINGS

The instrument goes to the following settings at power on and when the INIT command is executed. Characters in parenthesis are not entered as part of the argument.

Header	Argument
VPOSitive	0.0 (V)
IPOSitive	0.4 (A)
VNEGative	0.0 (V)
INEGative	0.4 (A)
VLOGic	5.0 (V)
ILOGic	1.0 (A)
FSOUTput	OFF
LSOUTput	OFF
PRI	OFF
NRI	OFF
LRI	OFF
RQS	ON
USEReq	OFF
DT	OFF

If an internal error is found, an error code is displayed in the front-panel readout. See Table 3-2 for error codes.

APPLICATIONS

Talker Listener Program For 4050 Series Controllers

This sample program allows sending the listed commands and receiving the data generated.

```
100 REM PS5010 TALKER/LISTENER PROGRAM
110 REM PS5010 PRIMARY ADDRESS = 22
120 INIT
130 ON SRQ THEN 240
140 DIM A$(200)
150 PRINT "ENTER MESSAGE(S): ";
160 INPUT C$
170 PRINT @22:C$
180 REM CHECK FOR QUERIES
190 IF POS(C$,"?",1)=0 THEN 150
200 REM INPUT FROM DEVICE
210 INPUT @22:A$
220 PRINT A$
230 GO TO 150
240 REM SERIAL POLL ROUTINE
250 POLL X,Y;22
260 PRINT "STATUS BYTE: ";Y
270 RETURN
```

4050 Series Talker Listener Program Description

This program must be typed into the 4050 series controller before the PS 5010 is powered up. The PS 5010 asserts SRQ on power up. The program will clear the SRQ by polling the instrument before proceeding. The program starts with two remark statements, one titling the program and the other listing the instruments factory set primary address, 22. Line 130 allows a transfer to line 240. Upon an SRQ interrupt, lines 250 and 260 clear the serial poll and print a status byte. The condition that generated the SRQ can be determined by reviewing Table 3-1. Statement 140 dimensions A character string (A$). The default length for A$ in the 4050 series is 72 characters (1 line). Line 150 prompts the user for a message (command or query). The message entered is assigned to C$. C$ is sent to the PS 5010 by the print statement at line 170. If the message is a settings command, the front panel displays change to reflect the value sent. Statement 180 is a remark statement. Statement 190 checks C$ for a question mark. If a question mark is included in C$, the message contained a query. The program moves on to statement 200, 210 and 220 which will input the response to the query from the PS 5010 and print it on the computer screen.

Talker Listener Program For the 4041 Controller

This sample program allows sending the listed commands and receiving the data generated.

```
90 REM PS5010 TALKER/LISTENER PROGRAM
95 REM PS5010 PRIMARY ADDRESS = 22
100 OPEN #1:"GPIB(PRI=22,EOM=<>):"
110 ON SRQ THEN GOSUB 240
115 ENABLE SRQ
120 DIM A$ TO (200)
130 PRINT "ENTER COMMAND(S) / QUERY "
140 INPUT C$
145 IF C$="EX"THEN GOTO 230
150 PRINT #1:C$
160 REM CHECK FOR QUERIES
170 IF POS(C$,"?",1)=0 THEN GOTO 130
190 REM INPUT FROM DEVICE
200 INPUT #1:A$
210 PRINT A$
220 GOTO 130
230 STOP
240 POLL SB,P,S,22
250 PRINT "SRQ SEEN, STATUS BYTE:",SB
260 RETURN
```

Sample Program

This program illustrates how the PS 5010 can be used to learn front panel settings. The program varies these settings by a selected percentage using only the INST ID button, which operates as a user interrupt.

Line 110 tells the controller the location of the poll routine.

Line 150 tells the PS 5010 that the INST ID button is to be used as a user interrupt.

Lines 290 and 300 are examples of commands assigning instrument settings to variables.

Line 390 shows the use of an arithmetic variable as a command argument.

Lines 450 through 530 are the SRQ service routine to do a poll, print out the POLL status and the error query response.

Line 470 checks if the SRQ was generated by the INST ID button. If so, control returns to the main program.

```
100 REM High level learn and tolerance change program
110 ON SRQ THEN 450
120 DELETE F$,C,D,F,P,S,T
130 REM     Default address for the PS5010
140 P=22
150 PRINT @P:"USER ON"
160 PAGE
170 PRINT
180 PRINT "    This program allows you to manually set up the PS5010  "
190 PRINT "    front panel and then change the floating supply voltages"
200 PRINT "    by plus and minus a selectable percentage, by using the"
210 PRINT "    INST ID button as a user interrupt."
220 PRINT
230 PRINT "    Enter percent tolerance change, then RETURN. ";
240 INPUT T
250 PRINT
260 PRINT "    Set up front panel for initial settings, then press "
270 PRINT "    PS5010 INST ID button."
280 WAIT
290 PRINT @P:"VNEG?;VPOS?"
300 INPUT @P:A,B
310 LET F=1+T/100
320 PRINT
330 PRINT "    Plus ";T;" percent tolerance."
340 PRINT @P:"VNEG ";A*F;";VPOS ";B*F
350 WAIT
360 LET F=1-T/100
370 PRINT
380 PRINT "    Minus ";T;" percent tolerance."
390 PRINT @P:"VNEG ";A*F;";VPOS ";B*F
400 WAIT
410 PRINT
420 PRINT "    Returned to initial settings."
430 PRINT @P:"VNEG ";A;";VPOS ";B
440 GO TO 220
450 REM                         SRQ Service routine
460 POLL D,S;P
470 IF S=67 OR S=83 THEN 540
480 PRINT
490 PRINT "SRQ serviced @ address ";P
500 PRINT "     POLL status returned: ";S
510 PRINT @P:"ERR?;"
520 INPUT @P:F$
530 PRINT "     Error Query response: ";F$
540 RETURN
```

The POLL Statement and Clearing SRQ

The POLL statement causes the BASIC interpreter in the 4050 series controllers to serially poll each peripheral device on the General Purpose Interface Bus (GPIB) and determine which device is requesting service. When the device is found, the device sends its status byte to the BASIC interpreter over the GPIB.

The POLL statement is normally executed in response to a service request from a peripheral device on the GPIB. Two numeric variables are specified as parameters in the POLL statement followed by a series of I/O addresses. The BASIC interpreter polls the first I/O address in the list, then the second I/O address, then the third, and so on, until the device requesting service is found. It is imperative that the I/O address of the device requesting service is in the list, or program execution is halted.

The PS 5010 asserts SRQ during power up or power down. The power up SRQ must be cleared before continuing.

```
POLL A,B;22
```

This statement shows a method of clearing the service request. The variables A and B in this example may be any undefined variables. Following the variables is the semicolon delimiter and the alpha character defined in the first line as the instruments primary address. The devices position in the list is assigned to the first variable specified in the POLL statement. The status word from the device is then sent over the GPIB and assigned to the second variable specified in the POLL statement.

Using Low Level Settings

```
P=22
DIM A(26)
PRINT @P:"LLSET?"
WBYTE @64+P:
RBYTE A
WBYTE @32+P:A
```

The above program lines retrieve the PS 5010 settings in low level binary format and return them at a later time. Transferring settings in a low level binary format requires considerably less bus time. The first statement assigns the PS 5010 factory set address to the undefined variable P. The next dimensions A to 26 characters. The low level settings query command is then sent to the PS 5010. The fourth statement makes the PS 5010 a talker and the following line reads the binary block into the computer memory. The last statement recovers the low level settings from the computer memory and sends them back to the PS 5010. For a definition of the binary block argument see the description for the LLSET command in this section. Further discussion of RBYTE and WBYTE may be found elsewhere in this section and in the computer programming manual.

Program Delays

The PS 5010 delays status reporting, via SRQ after changes in voltage, current or output, to allow instrument stabilization. If interrupts to detect changes in status are desired, a 100 ms delay must be inserted in the program after each change to insure the PS 5010 has sufficient time to report.

Information Available

Additional assistance in developing specific application oriented software is available in the following Tektronix manuals.

(1) 070-3985-00—GPIB Programming Guide. This manual is specifically written for applications of this instrument in IEEE-488 systems. It contains programming instructions, tips and some specific example programs.

(2) 070-2270-00—4051 GPIB Hardware Support Manual. This manual gives an indepth discussion of IEEE-488 bus operation, explanations of bus timing details and early bus interface circuitry.

(3) 070-2058-01—Programming In BASIC

(4) 070-2059-01—Graphic Programming In BASIC

(5) 51/00-700 4/0—4050 Series Programming Tips

(6) 070-2380-01—4907 File Manager Operators manual

(7) 070-2128-00—4924 Users manual

(8) 070-1940-01—4050 Series Graphic System Operators manual

(9) 070-2056-01—4050 Series Graphic System Reference manual

(10) 070-3918-00—4041 Operators manual

(11) 061-2546-00—4041 Programming Reference manual