Instruction Manual

Tektronix

PS 5004
Precision Power Supply

070-4442-00

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing service.

Please check for change information at the rear of this manual.

First Printing: January 1984
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Instrument Serial Numbers

Each instrument manufactured by Tektronix has a serial number on a panel insert or tag, or stamped on the chassis. The first letter in the serial number designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B010000	Tektronix, Inc., Beaverton, Oregon, USA
E200000	Tektronix United Kingdom, Ltd., London
J300000	Sony/Tektronix, Japan
H700000	Tektronix Holland, NV, Heerenveen, The Netherlands

Instruments manufactured for Tektronix by external vendors outside the United States are assigned a two digit alpha code to identify the country of manufacture (e.g., JP for Japan, HK for Hong Kong, IL for Israel, etc.).

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

Printed in U.S.A.

WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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TABLE OF CONTENTS

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

TABLE OF CONTENTS (cont)

LIST OF ILLUSTRATIONS

LIST OF TABLES

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 indicates 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.

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

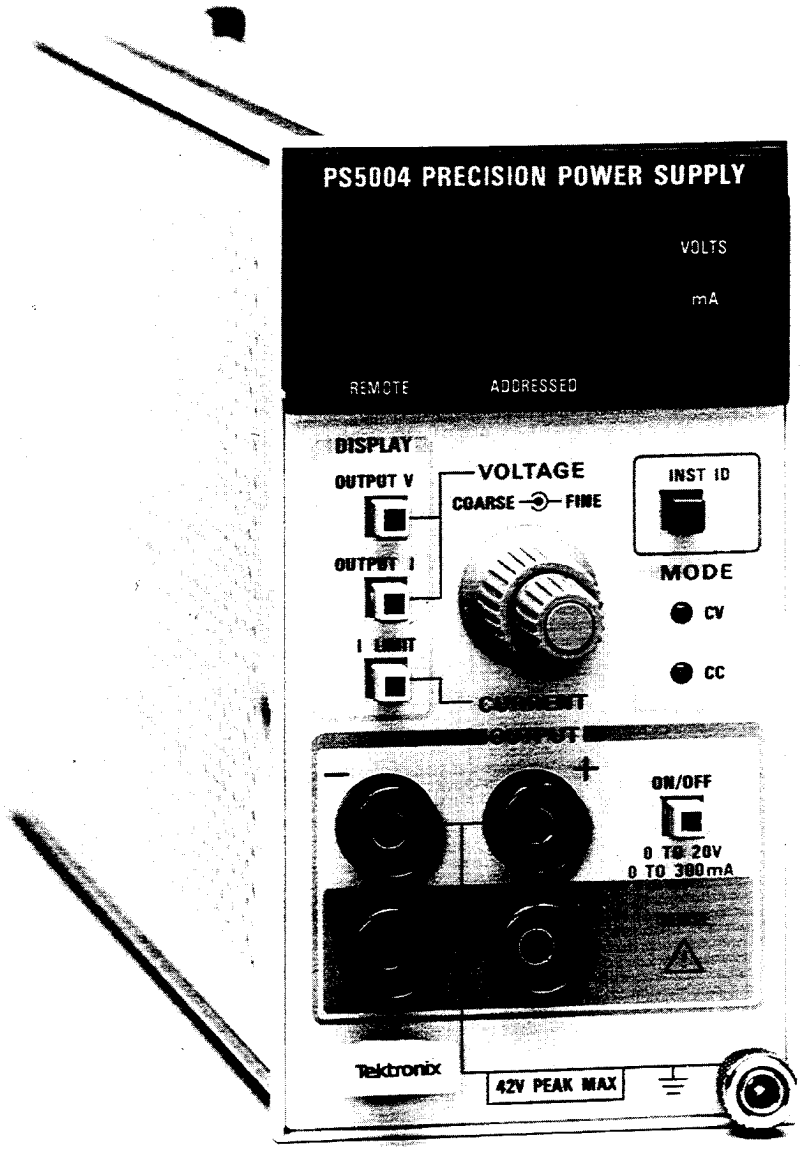
Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate in 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.



4442-01

PS 5004 Precision Power Supply

SPECIFICATIONS

Instrument Description

The PS 5004 is a one-wide precision power supply useable in TM 5000-Series power modules. It is not compatible with TM 500 power modules. The instrument is GPIB compatible. The unit provides voltages from 0 V to +20 V over a current range from 0 to 300 mA. The unit operates in the constant voltage or constant current mode. A 4 1/2 digit dvm measures the output voltage, output current, or the current limit. The voltage sense terminals are provided on the front panel. Internal straps select either front panel or rear interface output. The unit is shipped with front panel output.

Standard Accessories

The following items are shipped with the PS 5004.

1 Instruction Manual
1 Reference Guide
1 Instrument Interfacing Guide

IEEE 488 (GPIB) Functions

The PS 5004 can be remotely programmed via the digital interface specified in IEEE Standard 488-1978, IEEE Standard Digital Interface for Programmable Instrumentation. In this manual, the digital interface is called the General Purpose Interface Bus (GPIB).

The IEEE standard identifies 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 5004 are listed in Table 1-1.

NOTE

Refer to IEEE Standard 488-1978 for more detailed information. The standard is published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

Performance Conditions

The electrical characteristics in this specification are valid only if the PS 5004 has been adjusted at an ambient temperature between +21°C and +25°C. The instrument must be in a non-condensing 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 1-1
IEEE 488 INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete capability.
Acceptor Handshake	AH1	Complete capability.
Basic Talker	T6	Responds to Serial Poll, Untalks if My Listen Address (MLA) is received.
Basic Listener	L4	Unlistens if My Talk Address (MTA) is received.
Service Request	SR1	Complete capability.
Remote-Local	RL1	Complete capability.
Function		
Parallel Poll	PPO	Does not respond to Parallel Poll.
Device Clear	DC1	Complete capability.
Device Trigger	DT1	Complete capability.
Controller Function	CO	No controller function.
Electrical Interface	E2	Three-state drivers.

Table 1-2
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
Constant Voltage Mode		
NOTE *Unless otherwise noted, all constant voltage specifications are valid for Iout <(I limit - 10 mA), measured at the remote sensing points with ≤1 Ω output lead resistance and ≤5 Ω Sense lead resistance. These specifications are also valid when measuring the voltage at the output terminals with remote sensing disconnected, if Iout ≤ 100 mA.*		
Range	0 V to 20.0000 V in 0.5 mV steps	
Overall Accuracy (Total Effect)	±(0.01% + 2 mV) from +15°C to +30°C, derating to ±(0.035% +3 mV) at 0°C and +50°C	
Source Effect	≤ 0.5 mV	
Load Effect	≤ 1 mV	
Step Size Accuracy (15°C to +30°C)	0.5 mV ±0.2 mV	
PARD	≤ 1 mV p-p 10 Hz to 1 MHz (< 3 mV p-p 10 Hz to 5 MHz)	Measured at front panel terminals without using Remote Sense
Load Transient Recovery	< 200 μs to recover within 5.0 mV of final value from a 100 mA load change	Without external energy storage components
Typical voltage change processing times to start of output change. (For total response time, add slew rates listed below) From <DT> command From <FVOLTS> command From <VOLTAGE> command	 1.5 ms 7.5 ms 27 ms	
Typical output slew rates Risetime (incr voltage) Falltime (decr voltage)	 4 ms 1 ms + 1.6 ms/V	
Constant Current Mode		
Range	10 mA – 305.0 mA in 2.5 mA steps	
Overall Accuracy	±(2% + 5 mA)	

Table 1-2 (cont)

Characteristics	Performance Requirement	Supplemental Information
	Digital Meter	
Configuration		True 4 1/2 digit free running voltmeter. Meter can be selected by front panel controls or via IEEE 488 bus to monitor output voltage, current, or current limit setting. Measurements are displayed on the front panel and are available over the IEEE 488 bus.
Resolution	1 mV or 0.1 mA	
Accuracy Output Voltage Output Current Current Limit	 ±(0.15% + 6 mV) ±(1.5% + 1 mA) ±(1.5% + 5 mA)	
Reading Rate		Approximately 5 per second

Table 1-3
MISCELLANEOUS

Characteristics	Performance Requirement	Supplemental Information
Isolation Voltage (Maximum allowable voltage between any output or sense terminal and chassis ground)	42 V peak ac + dc	
Typical shunting capacitance distributed between supply and chassis ground	0.035 μF	
Warm-up Time	20 minutes, 60 minutes after removal from a condensing environment.	
Recommended Calibration Interval	2000 hours or 1 year.	
Power Consumption		35 W maximum
Fuse Data 25 Vac power winding P1010-13A&B 25 Vac control winding P1010-1A&B +8.0 V P1010-2 +26 V P1010-8 Output		 1.6 A slow, 3 AG, 125 V 0.5 A slow, 3 AG, 125 V 1.6 A slow, 3 AG, 125 V 0.5 A fast, 3 AG, 125 V 1.0 A fast, 3 AG, 125 V

Table 1-4
ENVIRONMENTAL[a]

Characteristics		Description
Temperature		Meets MIL-T- 28800C, class 5.
Operating	0°C to +50°C	
Nonoperating	−40°C to +75°C	
ENGINEERING REFERENCE INFORMATION		
The test procedures conform to MIL-T-28800C specified in paragraph 6.4.7.1.		
Humidity	95% RH, 0°C to 30°C 75% RH, to 40°C 45% RH, to 50°C	Meets MIL-T-28800C, class 5
ENGINEERING REFERENCE INFORMATION		
Test procedures conform to MIL-T-28800C specified in paragraph 6.4.7.1		
Altitude		Exceeds MIL-T-28800C, class 5.
Operating	4.6 km (15,000 ft)	
Nonoperating	15 km (50,000 ft)	
ENGINEERING REFERENCE INFORMATION		
Test procedures conform to MIL-STD-810C Method 500.1, Procedure I, as specified in paragraph 4.5.5.2 of MIL-T-28800C.		
Vibration[c]	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.	Meets MIL-T-28800C, class 5, when installed in qualified power modules.[b]
ENGINEERING REFERENCE INFORMATION		
Test procedures conform to MIL-STD-80C, Method 514, Procedure X specified in paragraph 4.5.5.3.1 of MIL-T 228800C, class 3. Plug-ins must be operating on flexible extender cables outside of power module.		
Shock[c]	30 g's (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800C, class 5, when installed in qualified power modules.[b]
ENGINEERING REFERENCE INFORMATION		
Test procedures conform to MIL-STD-810C, Method 516, Procedure I as specified in paragraph 4.5.5.4.1 of MIL-T-28800C, class I-VI. Test to 50 g's (1/2 sine) without power module.		
Bench Handling (Plug-in only)	12 drops from 45, 4" or equilibrium, whichever occurs first.	Meets MIL-T-228800C, class 5.
ENGINEERING REFERENCE INFORMATION		
The test procedures conform to MIL-STD-810C, Method 516, Procedure V, modified as specified in paragraph 4.5.5.4.3 of MIL-T-28800C.		
Packaged Product Vibration and Shock (Plug-in only)	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	

Table 1-4 (cont)

Characteristics		Description
ENGINEERING REFERENCE INFORMATION		
Test to Tektronix Standard 062-2858-00, Section 9.		
Electromagnetic Interference	Within limits of F.C.C. Regulations, Part 15, Subpart J, Class A; and MIL-STD-461B (April 1, 1980) class B.	
ENGINEERING REFERENCE INFORMATION		
Test to Tektronix Standard 062-2866-00 and F.C.C. Regulations, Part 15, Subpart J, Class A. Unused Plug-in compartments must be covered with a blank plug-in. Dress power cord for worst case validated emanations.		
Electromagnetic Susceptibility	Meets MIL-STD-461B (April 1, 1980) class B with either output terminal grounded.	
ENGINEERING REFERENCE INFORMATION		
Test to Tektronix Standard 062-2866-00. CS02 and CS06 tests require strapping power module chassis to ground.		
Electrostatic Immunity	At least 15 kV discharge from 500 pF in series with 100 ohms to instrument case or any front panel connector without damage or permanent performance degradation.	
ENGINEERING REFERENCE INFORMATION		
Test to Tektronix Standard 062-2862-00. Changes of instrument state that require power off-on recycling to clear, or that create potentially hazardous or damaging output signals are considered test failures.		

[a]**With TM 5000-Series power module. System performance subject to exceptions of power module or other individual plug-ins.**

[b]**Refer to TM 5000 power module specifications.**

[c]**Requires power module retainer bar or clip.**

Table 1-5
PHYSICAL

Characteristics	Description
Finish	Chassis: Chromate conversion coated aluminum Front subpanel: Molded polycarbonate Front panel: 0.010" thick polycarbonate sheet with pressure sensitive adhesive.
Net Weight	2.0 lb (0.92 kg)
Enclosure Type and Style per MIL-T-2800B Type	 III
Style Overall dimensions (nom.) Height Width Length	E (Style F in rackmount power module) 126.0 mm (4.96 in) 66.8 mm (2.63 in) 296.6 mm (11.68 in)

OPERATING INSTRUCTIONS

Preparation For Use

The PS 5004 is calibrated and ready for use when received. It operates in any compartment of a TM 5000-Series power module. See the power module instruction manual for line voltage requirements and power module operation. Figure 2-1 shows the PS 5004 installation and removal procedure.

CAUTION

Turn the power module off before inserting or removing the PS 5004. Failure to do so may damage the plug-in circuitry. Do not use excessive force to install or remove the instrument from the power module. Insertion or removal of any TM 5000-Series instrument into a power module connected to a GPIB system, in operation, may cause errors in the system (even with the power module off).

Check to see that plastic barriers on the interconnecting jacks of the selected power module compartment match the cutouts in the PS 5004 circuit board edge connector. If they don't match, investigate the reason before installing the PS 5004. When the units are properly matched, align the PS 5004 chassis with the upper and lower guides of the selected compartment. Press the PS 5004 in, to firmly seat the circuit boards in the interconnecting sockets.

To remove the PS 5004, pull the release latch (located in the lower left corner) until the interconnecting sockets disengage and the PS 5004 slides out.

Repackaging Information

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing the owner (with address) and the name of an individual at your firm that can be contacted. Include the com-

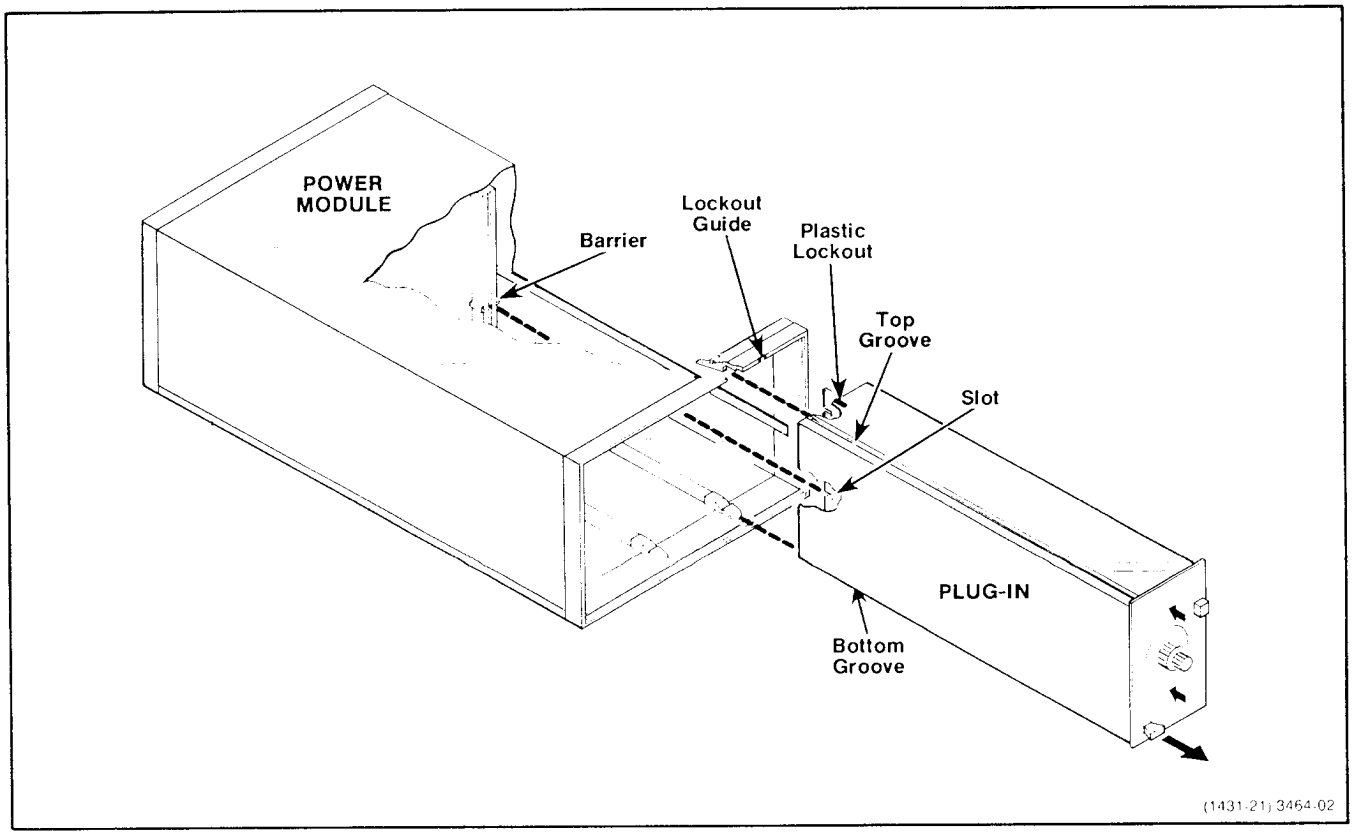


Fig. 2-1. Plug-in installation and removal.

plete instrument serial number and a description of the service required.

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

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing three inches of dunnage or urethane foam between carton and instrument on all sides. Seal the carton with shipping tape or an industrial stapler.

The carton test strength for this instrument is 200 pounds per square inch.

Front Panel Controls, Connectors, and Indicators

All controls, connectors and indicators required for manual operation of the PS 5004 are located on the front panel. Fig. 2-2 provides a brief description of all front panel controls, connectors, and indicators.

NOTE

Refer to the Maintenance section of this manual for Rear Interface Connector information.

(1) VOLTS

Indicates that the displayed units are volts.

(2) mA

Indicates that the displayed units are milliamperes.

(3) ADDRESSED

Illuminated when the PS 5004 is being addressed via the GPIB.

(4) INSTRUMENT ID

Displays the PS 5004 GPIB address. Also initiates SRQ if User Request is on.

(5) CV MODE

Illuminated when the instrument is in Constant Voltage mode.

(6) CC MODE

Illuminated when the instrument is in Constant Current mode.

(7) ON/OFF

Toggles the output on or off. Illuminated when the output is on.

(8) POSITIVE OUTPUT CONNECTOR

(9) POSITIVE SENSE CONNECTOR

(10) CHASSIS GROUND BINDING POST

(11) INSTRUMENT LATCH

(12) NEGATIVE SENSE CONNECTOR

(13) NEGATIVE OUTPUT CONNECTOR

(14) DISPLAY I LIMIT

Press to measure and display current limit. Illuminated when current limit is being displayed. Current limit may only be adjusted in this mode.

(15) DISPLAY OUTPUT CURRENT

Press to measure and display the output current. Illuminated when output current is being displayed. Voltage limit may be adjusted while in this mode.

(16) DISPLAY OUTPUT VOLTAGE

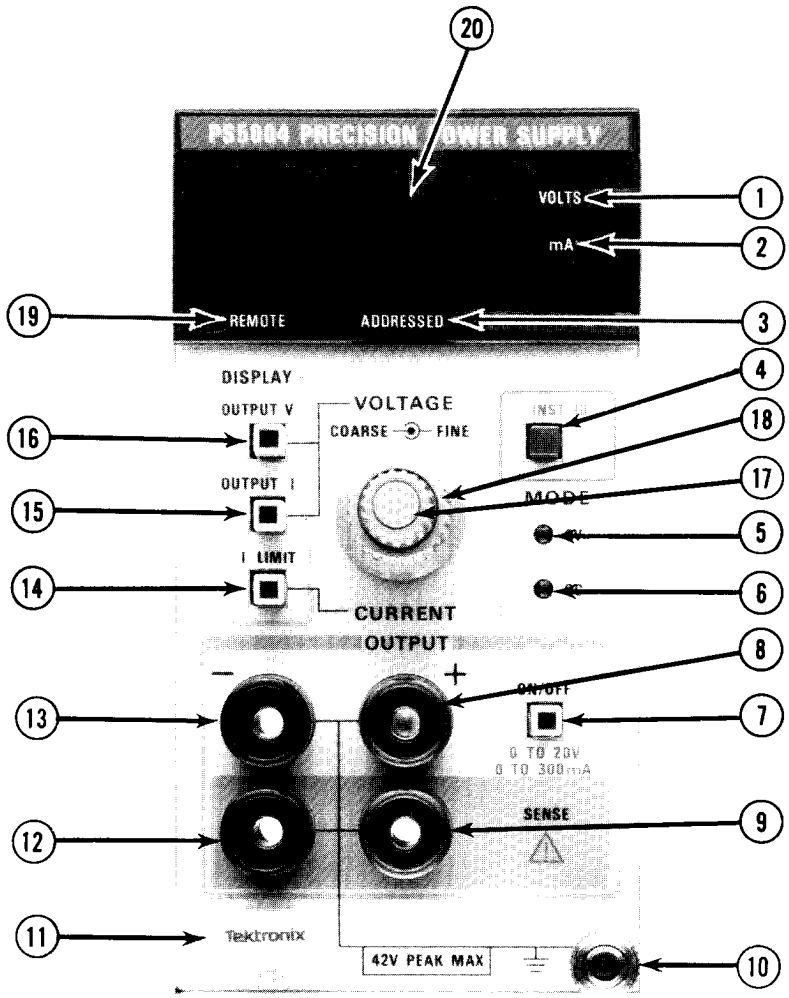
Press to measure and display output voltage. Illuminated when displaying output voltage. Voltage limit may be adjusted while in this mode.

(17) COARSE

Provides coarse voltage limit or fine current limit adjustment. Parameter is selected by DISPLAY button.

(18) FINE

Provides fine voltage or current adjustment. Parameter is selected by the DISPLAY buttons.



4442-02

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

(19) REMOTE

Illuminated when the instrument is in remote state via GPIB.

(20) 4.5 DIGIT DIGITAL METER DISPLAY

Provides readings from the Digital Meter. Parameter measured is selected by the DISPLAY buttons. Readings are updated 5 times a second.

OPERATORS FAMILIARIZATION

General Operating Information

With the PS 5004 properly installed in the power module, allow twenty minutes warmup time for operation to specified accuracy; 60 minutes after storage in or exposure to a high humidity (condensing) environment.

Power Up Conditions and Self Test

Check that the PS 5004 is fully inserted in the power module. Turn on the power module. Upon power up, the PS 5004 performs a diagnostic routine 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 shown in Table 2-1. The SRQ line on the bus is also asserted. Also, during the self test sequence, all of the segments in the display are illuminated. The individual LEDs are hardware driven and their illumination state during power up is unpredictable.

NOTE

The PS 5004 can be operated via the front panel or by commands sent over the GPIB by a suitable controller. This section discusses front panel operation. See the programming section of this manual for instrument operation via the GPIB.

Front panel error codes are listed in Table 2-2. If one of these codes appears on the display after power up, turn the power module off and on. If the error condition persists, a qualified service person should refer to the troubleshooting procedure in the Maintenance section of this manual.

Table 2-1
POWER UP SETTINGS

The instrument assumes these default settings at power up and when the INIT command is executed.

Header	Argument
Voltage	0.0000 V
Current	100.0 mA
Output	Off
Display	Voltage
Voltage Regulation Intertrupt	Off
Current Regulation Interrupt	Off
Unregulated Interrupt	Off
Device Trigger	Off
User Request	Off
Request for Service	Off

Table 2-2
Front Panel Error Codes

Error	Code
System RAM Error (high nibble)	40
System RAM Error (low nibble)	41
ROM Checksum Error	92
Signature Analysis Mode	S.A.
Calibration Mode	C1,C2, or C3

Setting Current and Voltage Limits

The PS 5004 voltage and current limits are set from the front panel using the dual concentric rotary encoder. This control operates like a conventional potentiometer except it does not have end stops. The parameter, set by the rotary encoder, is selected by the Display buttons. Voltage limit can be adjusted when the Display is set for Output V or Output I. Current limit can only be adjusted when Display is set for I Limit. Note the Display function is programmable over the GPIB; any change made by a running program may effect the parameter currently being adjusted with the encoder.
Voltage limit adjusts in either coarse or fine increments. The COARSE knob increments or decrements the voltage limit in 100.0 mV steps. The FINE knob step size is 500 μV. The display resolution, in volts, is 1 mV.

Either knob will increment or decrement the current limit in 2.5 mA steps.

Note that the display is a real digital meter measuring the parameter determined by the Display buttons (not the digital value of the parameter stored in the microcomputer).

Display Selection

The digital meter in the PS 5004 measures output voltage, output current, or the current limit setting. The parameter, being measured, is determined by the Display buttons and shown by the illumination of the appropriate Display button. After a change is made in the Display parameter (either from the front panel or under program control), the digital meter will require approximately two readings to stabilize to the new value.

Output Connections

The output of the PS 5004 can be connected in either a 2-wire or 4-wire configuration. Both front panel and rear interface outputs incorporate remote sense capability. Remote sensing is a method used to compensate for the voltage drop that occurs in the output leads caused by the load current. The amount of voltage drop is proportional to load current drawn. When the PS 5004 is used as a precision reference, with the load current small, the lead loss error may be so small that remote sensing is not required.

In either 2-wire or 4-wire systems, the load is driven by the output terminals. These are the upper two output jacks on the front panel, or rear interface pins 22A (positive) and 21A&B (negative). The Sense inputs are buffered internally in the PS 5004. Both front panel and rear interface sense inputs are internally clamped to the respective output terminals with 5000 ohm resistors. This allows the sense input terminals to be left unconnected, without external strapping, when using the PS 5004 in a 2-wire configuration. Refer to Fig. 2-3 for both 2-wire and 4-wire output configurations. For more information on the proper use of remote sense, refer to Remote Sense Operation, in this section.

The front panel output and sense connectors are the insulated shoulder banana jack type. All front panel connections should be made only with standard banana plugs.

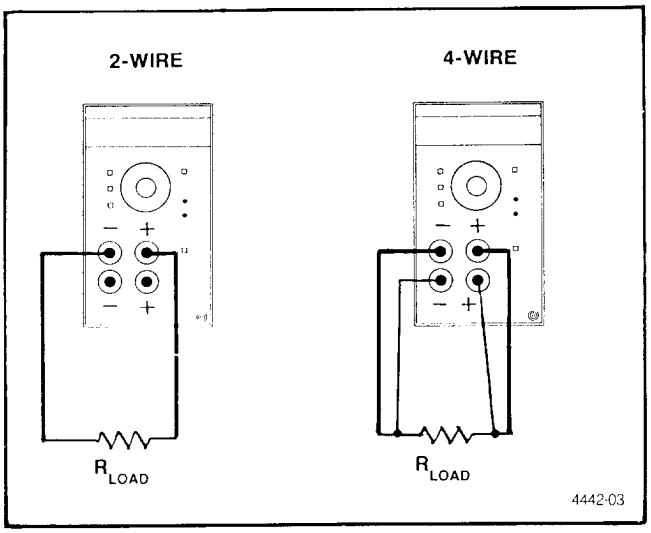


Fig. 2-3. 2-wire and 4-wire connections.

Remote Sense Operation

Remote sensing refers to acquiring voltage feedback from the point of load, rather than from the front panel output terminals. This improves load regulation by allowing the power supply to compensate for the voltage drop in the output power leads. Remote sensing involves only the voltage loop; it has no effect on the current loop during 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 error, noise, or instability into the voltage loop. Refer to Fig. 2-4.

The output lead path resistance should be low enough to minimize the voltage drop that remote sensing compensates for. The PS 5004 contains clamp diodes between the outputs and their respective sense line to protect the supply from damage, if the sense leads are accidentally misconnected or shorted. These diodes limit the amount of drop that the sense compensates for. The PS 5004 is specified to meet full accuracy with up to 1 ohm of resistance in each

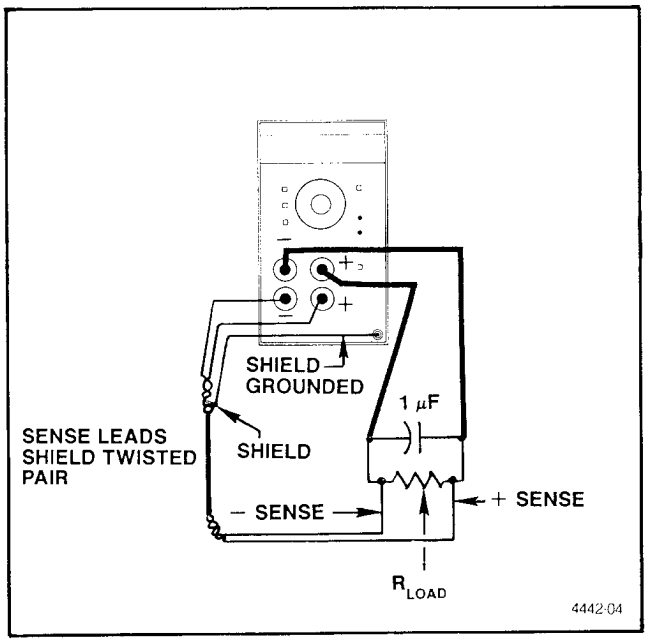


Fig. 2-4. Typical 4-wire system.

output lead path. The sense leads should also be low resistance. Any resistance in the sense path forms a voltage divider with the 5000 ohm resister that clamps the sense lead to its output terminal. While the PS 5004 is specified to full accuracy with up to 5 ohms in each sense lead, the load effect improves linearly as a function of sense lead resistance. See Fig 2-5 for an example.

Any thermocouple, relay contact, or other potentials introduced in the sense leads introduces an error equal to the sum of these potentials in the output. A good practice is to make both the positive and negative sense paths identical, and physically close to each other to minimize differential thermal gradiants. If all junctions between different metals are in the same direction and close to the same temperature, the differential voltage error will cancel out.

Any differential noise or hum induced into the sense leads will be amplified by the error amplifier and show up at the output. Therefore, it is very important to adequately shield the sense lines from noise and line frequency hum pick up. It is recommended to connect the sense leads to the load point with a shielded twisted pair. The shield should be connected to a good ground at either the load end or to the ground lug on the PS 5004 front panel, but not both.

Since the sense leads provide feedback to the voltage loop, the introduction of any significant phase lead or lag will effect the PS 5004 stability. This results in either poor transient recovery or oscillation. A major cause for this phase shift is mutual inductance between either the sense leads or between the sense and output leads.

NOTE

Never coil excess sense leads or allow unshielded sense leads to run along output leads for any great distance.

If the output and the sense leads are going to be switched external to the PS 5004, as in a multiplexed system, it is imperative the sense contacts be closed after, and opened before the output contacts. Failure to do this causes load current to be drawn from the sense leads, causing the output terminal voltage to rise above the nominal value. While the PS 5004 is protected from damage in this situtation, the excessive voltage may damage the load. If the application does not guarantee switching in this order, the output of the PS 5004 should be turned off (either from the front panel, or under program control), prior to allowing the external switching to take place.

The internal circuitry of the PS 5004 is protected from damage when the sense leads are shorted, or connected to the wrong output terminal. However, the power supply output returns to a voltage approximately 6 volts higher than the nominal value. Such overvoltage conditions may damage the load. It is good practice to make changes to the sense wiring only when the power is off.

Noise Suppression

At the output terminals, the PS 5004 looks like a very low impedance voltage source with a reasonably high bandwidth. Any inductance present in the output leads increases this impedance, particularly at higher bandwidths. Since some inductance will always be present in the output leads, it is necessary to bypass the higher frequency noise components at the load point for any application sensitive to this noise. This is accomplished by installing a high quality capacitor with low effective series resistance and inductance across the load. Values from one to several microfarads are very effective in this application.

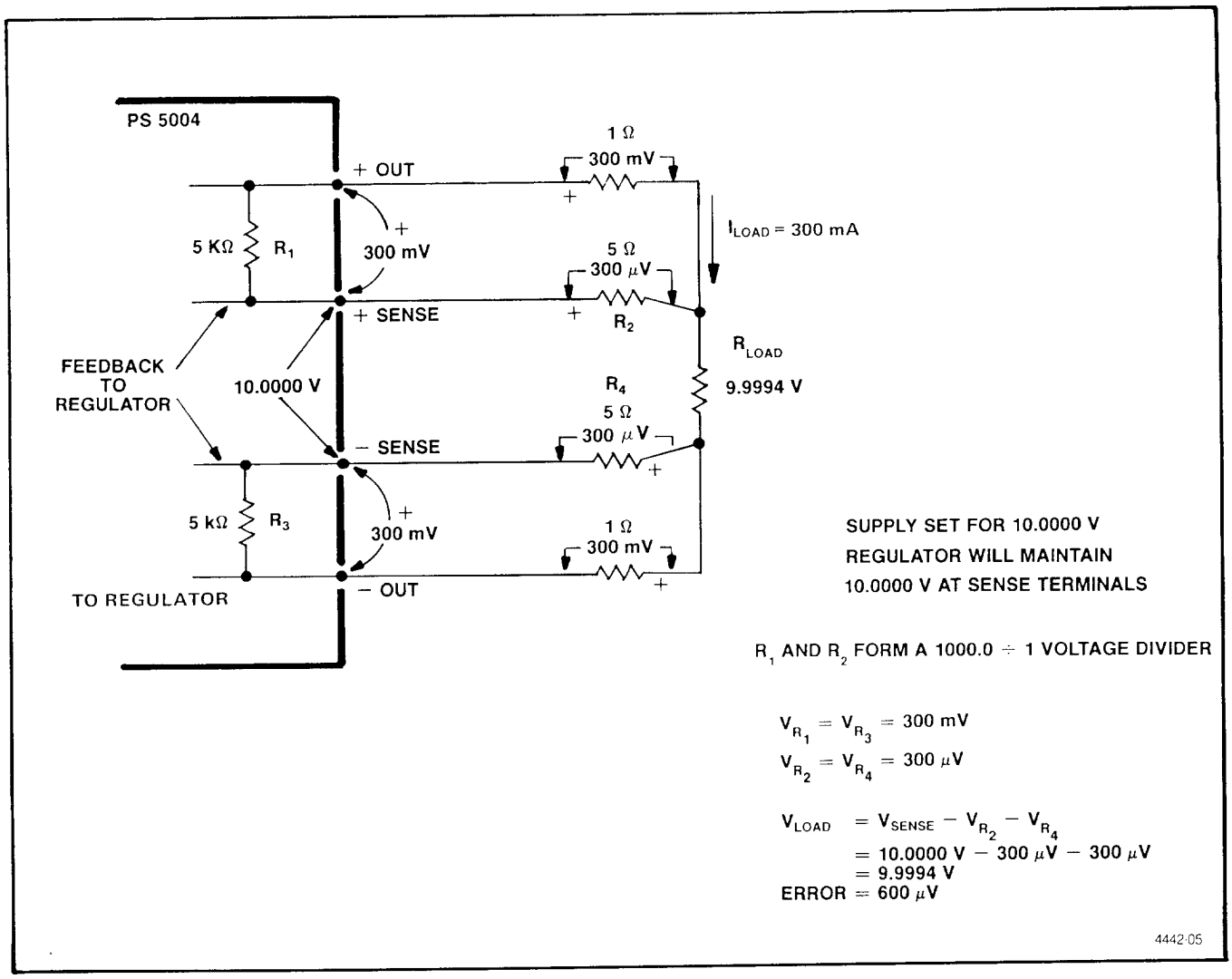


Fig. 2-5. Example of error introduced by excessive sense lead resistance.

OPERATING CONSIDERATIONS

Auto Crossover

The PS 5004 is the auto crossover type. Under normal conditions, the supply operates in one of two modes: Constant Voltage, or Constant Current (see Fig. 2-6). In the Constant Voltage mode, decreasing the load impedance increases the output current until the current limit setting is reached. Any further reduction of load reduction in load impedance puts the supply into Constant Current mode. As the load impedance continues to decrease, the output voltage decreases while the output current remains constant. The opposite is true with increasing load impedance. The supply provides a constant current until the voltage reaches the voltage limit setting. Further increases in load impedance puts the supply in Constant Voltage mode.

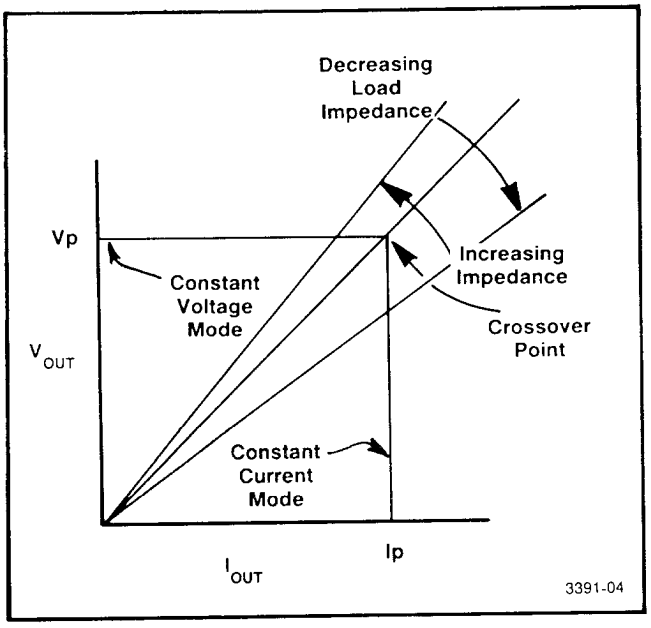


Fig. 2-6. Load lines for individual load impedances.

Supply Elevation

The PS 5004 may be operated with either the positive or negative output terminal grounded or elevated to another potential. The intent of the floating output is to break ground loops in a system by not allowing any ground return path at the supply. When operating with an output terminal at an elevated potential, the maximum voltage allowable on any terminal is 42 volts peak with respect to chassis (earth) ground. If the output is tied to ground at some point in the system, it is imperative the output terminal (not the sense terminal) be grounded. Because the sense terminals are buffered and have very high input impedance, grounding either sense terminal induces severe line frequency hum into the power supply output.

CAUTION

If either of the PS 5004 output terminals is elevated, (with respect to ground) shorting the remaining output terminal or either of the sense terminals to ground applies the elevating potential across the power supply internal circuitry. This could result in severe damage to the PS 5004.

Series Connected Supplies

The outputs of more than one PS 5004 may be connected in series (as shown in Fig. 2-7) to obtain an output voltage equal to the sum of the programmed voltages for each supply. Programming each supply (individually) is necessary to obtain the desired output voltage. When using remote sense, connect the sense terminals in series, as was done with the output terminals.

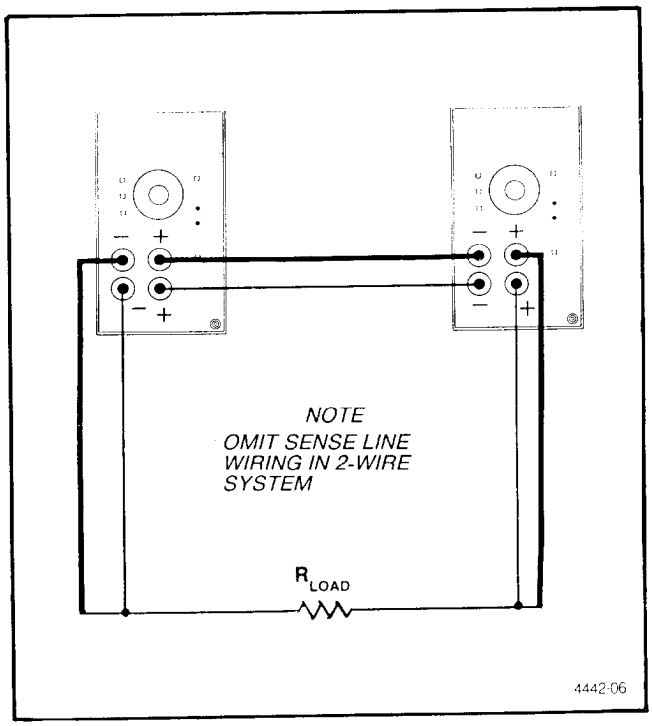


Fig. 2-7. Series connected supplies.

Note

The PS 5004 has internal diodes connected across the output to protect the series connected supplies from reverse polarity if the load is shorted, or one of the supplies is not turned on.

Parallel Connected Supplies

The output of two or more PS 5004s can be connected in parallel (see Fig. 2-8) to obtain a higher output current than allowed from the use of one PS 5004. To lower the output noise, each supply is set to the same voltage. The output current, being delivered to the load, is the sum of the currents indicated by a digital multimeter (set to display output current). If remote sense is being used, the sense terminals on the PS 5004s are connected in parallel as was done with the output leads. When operating with a load current that is less than any of the current limit settings, one of the PS 5004s may be overvoltaged and operating in unregulated mode. When load current increases to the point that the PS 5004 with lower voltage goes into Constant Current mode, the remaining supply (supplies) goes into Constant Voltage mode. If monitoring the current regulation status over GPIB is desired, monitor only the supply operating at the lowest output voltage. Voltage regulation status cannot be monitored when using parallel connected supplies.

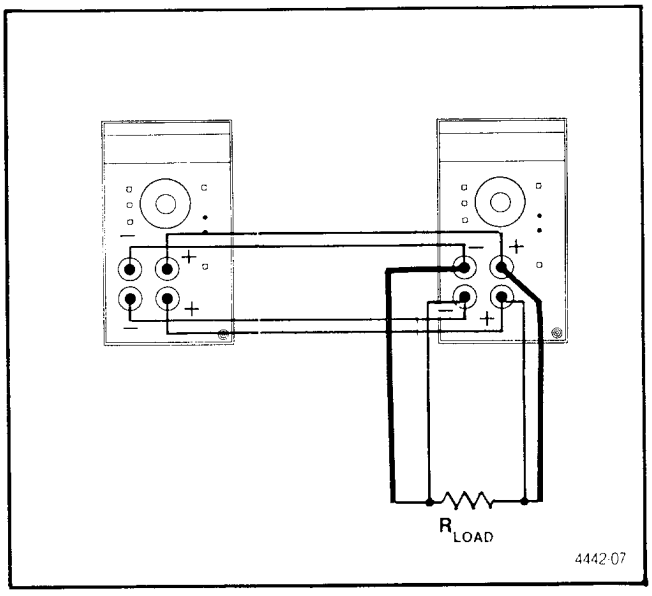


Fig. 2-8. Parallel connected supplies.

Reverse Voltage Loading

If the polarity across the output of the PS 5004 is reversed, an internal protection diode forward biases, limiting this excursion to the forward voltage drop of the diode. This situtation can occur when a supply, connected in series with another supply, goes into current limit. The protection diode protects the output transistors from over dissipation.

CAUTION

If the current flowing through a reverse voltage loaded PS 5004 exceeds 1 ampere, a protection fuse will open in the output circuit. Further operation of the PS 5004 will not be possible until this fuse is replaced.

Reverse Current Loading

In some bias supply applications, the load may act as a current source during part of the operating cycle. Since the PS 5004 is a unipolar power supply, current will not pass throught the supply in the reverse direction. The internal reverse protection diode only conducts when the output voltage polarity reverses. Connecting a shunt resistor as shown in Fig. 2-9 provides an external reverse current path and the power supply always sources current.

Overvoltage

CAUTION

Under no circumstances may a voltage of greater value than the maximum rated output voltage of the PS 5004 be placed across the output terminals.

Component failure in the PS 5004, or TM 5000 power module (or both) may result from voltages greater than the maximum output (20 volts) being placed across the PS 5004 output.

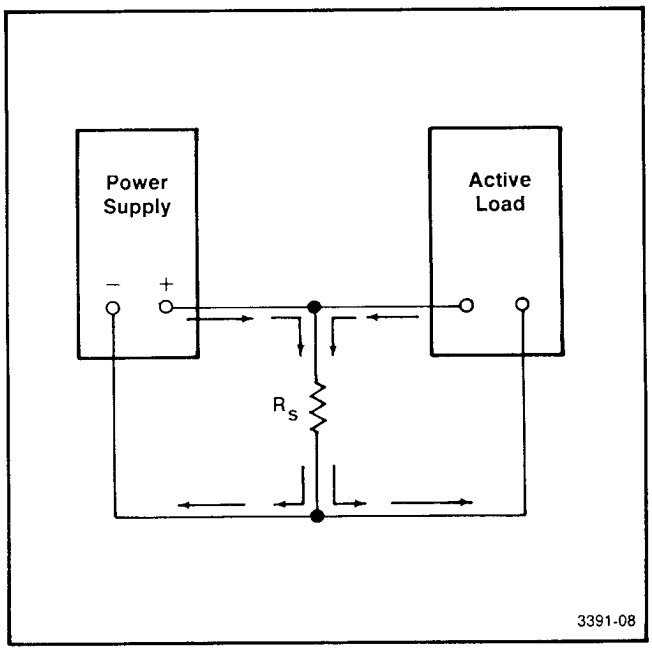


Fig. 2-9. Reverse-current shunt (Rs) with active load.

PROGRAMMING

Introduction

This section of the manual provides information for programming the PS 5004 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 for the instrument.

Commands for TM 5000 programmable instruments are designed for compatibility 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.

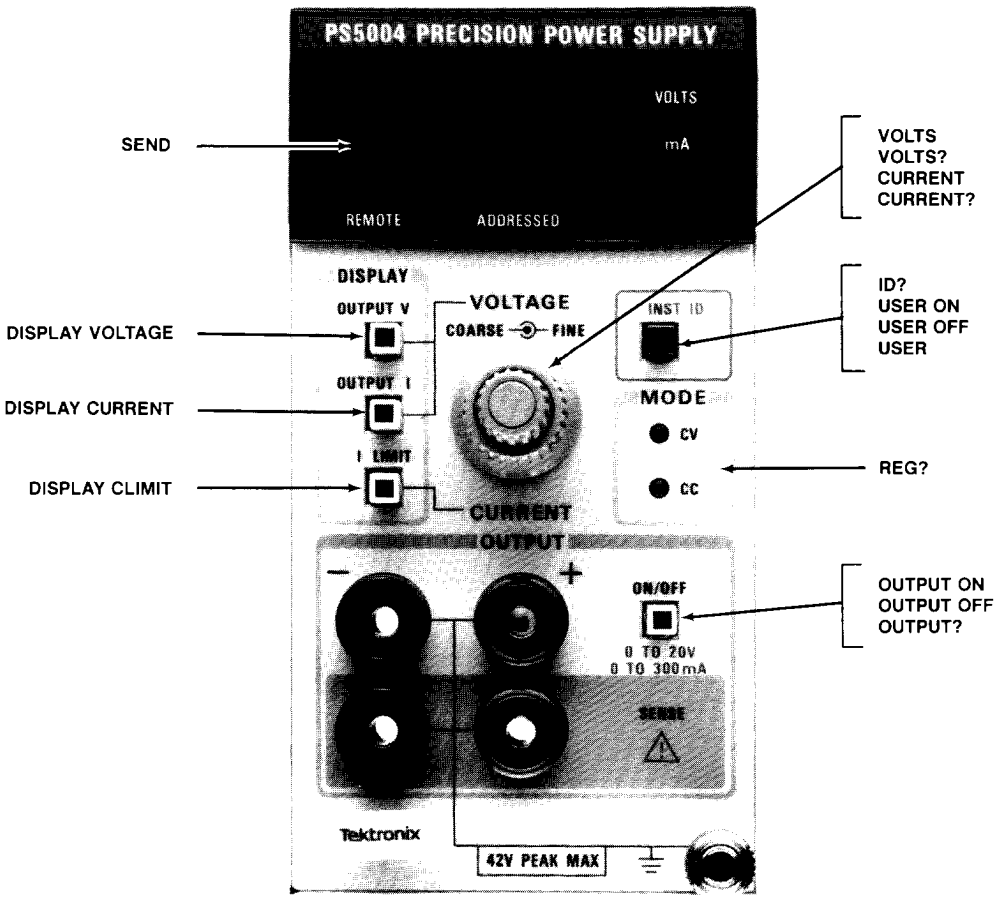
Functional Command List—A list divided into functional groups with brief descriptions.

Detailed Command List—An alphabetical listing of commands with complete descriptions.

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 selectable instrument functions.

The IEEE-488 bus primary address for the PS 5004 is selectable from the back of the instrument, when it is removed from the power module. The PS 5004 is shipped with the address set to decimal 21. The message terminator is also selectable from the back of the instrument, when it is removed from the power module. (Message terminators are described in this section, in the portion entitled Messages and Communications Protocol.) TM 5000 instruments are shipped with this terminator set to EOI ONLY. Pressing the INST ID front panel push button causes the PS 5004 to display its selected IEEE-488 bus primary address; the right-hand decimal point lights if the selected message terminator is LF/EOI.

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



GENERAL

CRI ON	DT ON
CRI OFF	DT OFF
CRI?	DT?
VRI ON	RQS ON
VRI OFF	RQS OFF
VRI?	RQS?
URI ON	USER ON
URI OFF	USER OFF
URI?	USER?
TEST	ERROR?
SET?	EVENT?
INIT	LL SET
HELP?	LL SET?
F	
F?	

4442-08

Fig. 3-1. Instrument commands and relationship to front panel controls.

COMMANDS

The commands for the PS 5004 can be classified in three categories:

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. The instrument is in the remote state when addressed over the GPIB. In the local state, setting and operational commands generate errors as the instrument is under front panel control. Only query-output commands are executed in this mode.

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 specifying the desired state.

See the material under the Message and Communication Protocal heading following the individual commands in this section for more information on sending commands.

FUNCTIONAL COMMAND LIST

Instrument Commands

CRi ON—Enables the current regulation interrupt.

CRi OFf—Disables the current regulation interrupt.

CUrrent—Sets the supply current limit.

CUrrent?—Returns the preset current limit.

DIsplay Voltage—Sets the display to voltage.

DIsplay CUrrent—Sets the display to current.

DIsplay CLimit—Sets the display to current limit.

DIsplay?—Returns the present display argument.

DT Set—Enables the device trigger.

DT ON—Enables the device trigger.

DT OFf—Disables the device trigger.

DT?—Returns the state of the device trigger.

ERRMsg?—Returns the event code and description.

ERRor?—Returns error code for most recent event reported by SRQ.

EVent?—Returns error code for most recent event reported by SRQ.

Fvolts—Sets voltage using binary argument.

Fvolts?—Returns voltage setting in binary format.

Help?—Lists all settable and query arguments.

ID?—Returns instrument identification and firmware version.

INit—Sets instrument to initial (power on) settings.

LIset—Sets instrument to settings specified in binary argument.

LIset—Returns settings in binary format.

OUTput ON—Turns the output on.

OUTput OFf—Turns the output off.

OUTput?—Returns the state of the output.

REGulation?—Returns the regulation status.

RQs ON—Enables all service requests.

RQs OFf—Disables all service requests.

RQs?—Returns RQS ON or RQS OFF.

SENd—Returns next dvm reading.

SET?—Returns all instrument settings.

Test—Returns the status of the ROM checksum.

URi ON—Enables the unregulated interrupt.

URi OFf—Disables the unregulated interrupt.

URi?—Returns URI ON or URI OFF.

USer ON—Enables the INST ID button.

USer OFf—Disables the INST ID button.

USer?—Returns USER ON or USER OFF.

VOltage—Sets the supply voltage.

VOltage?—Returns the supply voltage limit.

VRi ON—Enables the voltage regulation interrupt.

VRi OFf—Disables the voltage regulation interrupt.

VRi?—Returns VRI ON or VRI OFF.

DETAILED COMMAND LIST

CURRENT REGULATION INTERRUPT

Type:

Setting or query

Setting Syntax:

CRi ON
CRi OFf

Query Syntax:

CRi?

Query Response:

CRI ON;
CRI OFF;

Discussion:

This command enables or disables the current regulation interrupt. The query command determines the state of the current regulation interrupt. SRQ is asserted when the supply changes from either voltage regulation or unregulated state to current regulation. The instrument powers up with CRi OFF.

CURRENT

Type:

Setting or Query

Setting Syntax:

CUrrent <numeric>
CUrrent <numeric>[:mA]

Arguments:

Any value from 10 mA to 305 mA (0.010 A to 0.305 A)

Examples:

CUrrent 10:mA
CUrrent 20E-3
CUrrent .25
CUrrent .3

Query Syntax:

CUrrent?

Query Response:

CURRENT <numeric> E-3;

Discussion:

Sets the supply current limit to the value specified. The query command returns the current limit in Amperes. The argument units are Amperes unless mA are specified. See the examples above for their setting command or query response format. Any value from 10 mA to 305 mA (0.010A to 0.305 mA) is acceptable as an argument. The resolution is 2.5 mA (0.0025 A). The instrument powers up with current set to 100 mA.

DISPLAY

Type:

Setting or query

Setting Syntax:

DIsplay Voltage
DIsplay CUrrent
DIsplay CLimit

Query Syntax:

DIsplay?

Query Response:

DIsplay Voltage;
DIsplay CUrrent;
DIsplay CLimit

Discussion:

Selects the digital meter input source for measuring either output voltage, output current, or current limit. Readings are displayed on the front panel, or available over the bus with the <SEND> command. After a change in display mode, the following two readings will not be used for a <SEND> in order to allow the DM to stabilize.

DEVICE TRIGGER

Type:

Setting or query

Setting Syntax:

DT Set
DT ON
DT OFf

Query Syntax:

DT?

Query Response:

DT ON;
DT OFF;

Discussion:

SET or ON arguments enable and the OFF argument disables the device trigger. The query command determines the state of the DT flag. The instrument does not respond to the Group Execute Trigger <GET> interface message when this command is OFF. The instrument powers up with this command OFF.

DT SET causes instrument to wait for <GET> interface message before updating instrument settings.

ERROR MESSAGE

Type:

Query

Syntax:

ERRMsg?

Response Example:

ERR 401, POWER ON;

Discussion:

This query returns the event code and a brief description of the most recent error code with RQS ON ; with RQS OFF - Highest Priority. The event and error codes are listed elsewhere in this section. See description for ERROR or EVENT command.

ERROR or EVENT

Type:

Query

Syntax:

ERRor?
EVent?

Response Example:

ERR 401;
EVENT 401;

Discussion:

Returns the error code for the most recent event reported by serial poll. When SRQ status reporting is disabled (RQs OFF), this command returns the error code for the highest priority condition pending. This condition is then cleared so that it is not reported again.

FAST VOLTS

Type:

Setting or query

Setting Syntax:

Fvolts <binary block>

Query Syntax:

Fvolts?

Query Response:

F <binary block>;

Discussion:

This command is similar to the LIset command but, only affects or reports the instrument voltage setting as specified in the binary block argument. This command is intended for rapid transfer and execution of voltage settings between the instrument and the controller.

HELP

Type:

Query

Query Syntax:

Help?

Query Response:

HELP CRI, CURRENT, DISPLAY, DT, ERRMSG, ERR, EVENT, F, HELP, ID, INIT, LLSET, OUT, REG, RQS, SEND, SET, TEST, URI, USER, VOLTAGE, VRI;

Discussion:

Returns a list of all settable and query commands for user convenience.

IDENTIFY

Type:

Query

Query Syntax:

ID?

Query Response:

ID <string>;

Discussion:

The string returned consists of: ID TEK/PS5004,V81.1, FX.X; where TEK/PS 5004 is the instrument type, V81.1 is the codes and formats version, X.X is the firmware version number.

INITIALIZE

Type:

Setting

Syntax:

INit

Discussion:

Places all instrument settings to their power-on states. These settings are listed elsewhere in this section.

LOW LEVEL SETTINGS

Type:

Setting or query

Setting Syntax:

LIset <binary block>

Query Syntax:

LIset?

Query Response:

LLSET <binary block>;

Discussion:

This command changes all instrument settings to the states specified in the binary block argument. This command is intended to transfer settings rapidly. The PS 5004 generates the binary block and returns the block to the controller in the LLset query response. The binary block is not intended to be generated or modified by the user. The format of the binary block is not included in this manual. Refer to the Tektronix GPIB Codes, Formats, Conventions and Features Standard for specifications of the binary block format.

OUTPUT

Type:

Setting or query

Setting Syntax:

OUTput ON
OUTput OFf

Query Syntax:

OUTput?

Query Response:

OUTPUT ON;
OUTPUT OFF;

Discussion:

This command sets the output to the state specified in the argument. The query command determines the OUTPUT state.

REGULATION

Type:

Query

Syntax:

REGulation?

Response?

REGULATION <number>;

Discussion:

This command returns the status of the supply. Integers 1,2 or 3 are returned. The integers mean: (1) In voltage regulation (CV) mode, (2) In current (CC) regulation mode and (3) in the unregulated state.

REQUEST FOR SERVICE

Type:

Setting or query

Setting Syntax:

RQs ON
RQs OFf

Query Syntax:

RQs?

Query Response:

RQS ON;
RQS OFF;

Discussion:

This command enables or disables all service requests. The query command determines the state of the RQs interrupt. Other commands affected by this command are CRi, URi, USer and VRi. Refer to the EVent command for a discussion of status reporting with all SRQs disables. The instrument powers up with RQS ON.

SEND

Type:

Setting (output)

Syntax:

SENd

Response Examples:

<voltage> E+0
<current> E-3
<voltage> E+1

Discussion:

When this command is sent the NEXT dvm reading is formatted and outputted to the controller. Successive execution of the SENd command returns the results of successive measurements.

After changes in the display mode, the response to this command is delayed by two measurement cycles to allow the reading to stabilize.

The response is appended in scientific notation.

SET QUERY

Type:

Query

Syntax:

SET?

Response:

VOLTAGE number;
CURRENT number;
OUT OFF or ON;
DISPLAY VOLTAGE or DISPLAY CURRENT or DISPLAY CLIMIT;
VRI OFF or ON;
CRI OFF or ON;
URI OFF or ON;
DT OFF or ON;
USER OFF or ON;
RQS OFF or ON;

Discussion:

This command returns all current instrument settings.

ROM TEST

Type:

Output

Syntax:

Test

Response:

TEST <numeric>

Discussion:

Returns 0 of the ROM test is passed or 394 if the ROM test fails.

UNREGULATED INTERRUPT

Type:

Setting or query

Setting Syntax:

URi ON
URi OFf

Query Syntax:

URi?

Query Response:

URI ON;
URI OFF;

Discussion:

This command enables or disables the unregulated interrupt. The query command determines the state of the URI interrupt. SRQ is asserted when the supply changes from either constant voltage or constant current to unregulated.

The instrument powers up with URi OFF.

USER REQUEST

Type:

Setting or query

Setting Syntax:

USer ON
USer OFf

Query Syntax:

USer?

Query Response:

USER ON;
USER OFF;

Discussion:

This command enables or disables the INST ID front panel push button service request. The query command determines the state of the USER flag. The instrument powers up with USER OFF.

VOLTAGE

Type:

Setting or query

Setting Syntax:

VOltage <numeric>

Arguments:

Any number from 0 to 20.0000

Examples:

VOltage 19.2365
VOltage 0.5 E+1
VOltage 200 E-2

Query Syntax:

VOltage?

Query Response:

VOLTAGE <numeric>;

Discussion:

This command sets or queries the supply voltage limit. The argument (in volts) sets the voltage limit. The resolution is 0.5 mV. The instrument powers up with the voltage set to 0.0000 V.

VOLTAGE REGULATION INTERRUPT

Type:

Setting or query

Setting Syntax:

VRi ON
VRi OFf

Query Syntax:

VRi?

Query Response:

VRI ON;
VRI OFF;

Discussion:

This command enables or disables the voltage regulation interrupt. The query command determines the state of the VRI interrupt. SRQ is asserted when the supply changes from either current regulation or unregulated to voltage regulation. The instrument powers up with VRI OFF.

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;DT 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. This instrument can be internally set to accept either terminator. With EOI ONLY selected as the terminator, the instrument interprets a data byte received 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 as the end of the input message. The PS 5004 transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages.

GPIB Address and Message Terminator Switches

A set of six address and message terminator switches is located on the Programmer board and is accessible through a cutout in the rear panel of the PS 5004. (Simply remove the instrument from Power Module for access.) Five of the switches are user set to select the primary address of the PS 5004. One switch is user set for the instrument to respond to one of two possible message delimiters (LF/EOI, or EOI ONLY) that may be sent over the bus by various controllers. Selection of the primary address bits and message terminator is accomplished as shown in Fig. 3-2. Switches 1 through 5 can be set to any address between 0 and 30. Address 31 effectively takes the PS 5004 off the bus.

All PS 5004 instruments are shipped set to primary address 21 and EOI ONLY.

Formatting A Message

Commands sent to the PS 5004 must have the proper format (syntax) to be understood. This format is flexible and many variations are acceptable. The following describes this format and the acceptable variations.

All commands must be encoded in upper and lower case ASCII. All data output is in upper case.

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

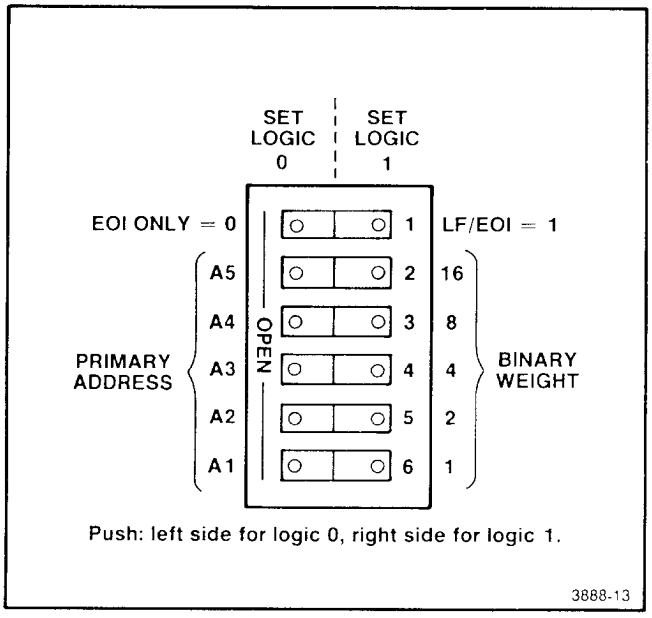


Fig. 3-2. Bus address and message terminator switches.

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

$_{SP}$ RQs_{SP} ON;$_{CR\ LF}$
$_{SP}$ DT_{SP} OFF

In the command list, some letters are capitalized and others are lower case. The capitalized letters are the minimum necessary for command recognition. However, if additional letters are added they must be the same as shown in the header. For documentation of programs, the user may add alpha characters to the full header. Alpha characters may also be added to the query header, provided the question mark is at the end.

EV?
EVe?
EVen?
EVent A?

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 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.

Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as 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 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 rests 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 considering if a particular sequence is valid. Execution of the settings occurs when the instrument processes the message terminator, a *query-output command*, or an *operational command.*

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

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

Multiple Messages

A single message may be long enough to fill the input buffer, and 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 buffer space is available, the instrument accepts a second message before processing the first. However, additional messages are held off with NRFD until the first message is processed completely.

After the instrument executes a *query-output command*, the response holds the output buffer until the instrument becomes a talker. If a new message is received before all of the output from the previous message is read, the output buffer is cleared before executing the new message. This prevents the controller from getting unwanted data from old messages.

Another situation might cause the instrument to delete output. The execution of a long message might fill both the input and output buffers. 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 the remainder of the controllers message is held off by NRFD, the system hangs up. The controller and instrument are 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 allows the controller to transmit the rest of the message and informs the controller that the message was executed and the output was deleted.

The PS 5004 can be made a talker without having received a message that specifies an output. When this occurs, the instrument returns a single byte message with all bits equal to 1 (with message terminator).

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 (MLA)	WBYTE @ A:
UNlisten (UNL)	WBYTE @ 63:
Talk (MTA)	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 (RWLS)	WBYTE @ A, 17, 63:
Local lockout of all instruments (LLO)	WBYTE @ 17:
Group execute trigger (GET)	WBYTE @ A, 8:
Serial Poll Enable (SPE)	WBYTE @ 24:
Serial Poll Disable (SPD)	WBYTE @ 25:

These commands are for the TEKTRONIX 4041 and 4050-Series controllers and representative for other controllers.

UNL - Unlisten
UNT - Untalk

When the PS 5004 receives the UNL command, the listener function goes to the idle state (unaddressed). In the idle state, the PS 5004 does not accept instrument commands from the GPIB.

The talker function goes to the idle state when the PS 5004 receives the UNT command. In this state, the PS 5004 cannot output data via the GPIB.

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

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 re-initializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexpected settings in the pending settings buffer. Also cleared are any errors or events waiting to be reported (except the power-on events). When DCL is received by the PS 5004, an SRQ is unasserted if the SRQ line was asserted for any reason other than power-on.

SDC - Selected Device Clear

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

GET - Group Execute Trigger

The instrument responds to <GET>, only if it is listen-addressed and the instrument device trigger function has been enabled by the Device Trigger command (DT). The <GET> message is ignored and an SRQ is 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 PS 5004 to output serial poll status bytes when it is talk addressed. The SPD message switches the PS 5004 to sending data from the output buffer.

MLA - My Listen Address
MTA - My Talk Address

The primary listen and talk addresses are established by the PS 5004 GPIB address. (Set by switches accessable on the rear panel.) When the PS 5004 is addressed to talk or listen, the front panel ADDRESSED indicator illuminates.

LLO - Local Lockout

In response to LLO, the PS 5004 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. When REN is false, the transition is from any state to LOCS. The PS 5004 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.

GTL - Go To Local

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

Remote-Local Operation

The preceding discussion described the state transitions caused by GTL and REN. All front panel pushbuttons and knobs, except "INST ID" button (which only affects the display), cause a transition from REMS to LOCS by asserting a message called return-to-local (*rtl*). This transition may occur during message execution. In contrast to GTL and REN transitions, a transition initiated by *rtl* does affect message execution. The instrument generates an error if there are any unexecuted setting or operational commands.

The instrument maintains a record of its settings in the current settings buffer. New settings from the front panel or the controller update these 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 REWLS.

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 as their functions are under front panel control.

Local With Lockout State (LWLS)

The instrument operates the same as in LOCS, except *rtl* does 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 the *rtl* message is ignored.

STATUS AND ERROR REPORTING

Through the Service Request function (defined in the IEEE-488 Standard), the instrument alerts 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 if it requested service. The STB also provides a limited amount of information about the request. The format of information encoded in the STB is given in Fig. 3-3. When data bit 8 is set, the STB conveys Device Status information indicated by bits 1 through 4.

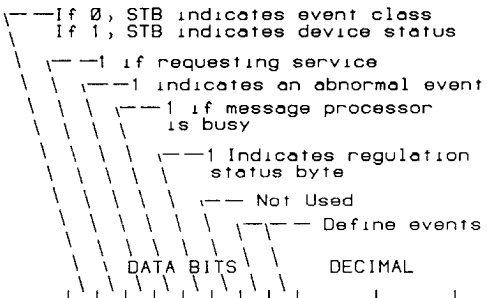
As the STB conveys limited information about an event, the events are divided into classes; the Status Byte reports the class of events. The classes of events are listed as follows:

COMMAND ERROR	Indicates the instrument received a command which it cannot understand.
EXECUTION ERROR	Indicates that the instrument 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.).

INTERNAL WARNINGS — The instrument has detected a problem. The instrument remains operational, but the problem should be corrected.

DEVICE STATUS — Device dependent events.



Status Byte (Example)	8	7	6	5	4	3	2	1	Not busy	Busy
Power On	0	1	0	X	0	0	0	1	65	81
User Request	0	1	0	X	0	0	1	1	67	83
Measurement Timeout	0	1	1	X	0	0	1	1	99	115
Voltage Regulation	1	1	0	X	1	0	0	1	201	217
Current Regulation	1	1	0	X	1	0	1	0	202	218
Unregulated Output	1	1	0	X	1	0	1	1	203	219

4442 09

Fig. 3-3. Definition of STB bit configuration with examples.

The instrument can provide additional information about many of the events, particularly the errors reported in the Error Query. After determining that the instrument requested service (by examining the STB), the controller may request 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.

To report more than one event, the instrument continues to assert SRQ until all events are reported. Each event is cleared when reported, via Serial Poll. The Device Clear (DCL) interface message clears all events except Power On.

Some commands control reporting of certain individual events and disable all service requests. For example, the Request for Service command (RQs) controls the reporting of events with SRQ. The Current Regulation Interrupt (CR) asserts SRQ when the supply changes to current regulation. The Unregulated Interrupt (URi) command asserts SRQ when the supply changes to unregulated.

RQs OFF inhibits all SRQs. In this mode the ERROr? query allows the controller to find out about events without performing a Serial Poll. With RQs OFF, the controller may send the ERROr? query at any time and the instruments

Table 3-1
ERROR QUERY AND STATUS INFORMATION

Event	Bus response to ERR?	Response to serial poll[a]
Abnormal Conditions		
Command Errors		
Command header error	101	97 or 113
Header delimiter error	102	97 or 113
Command argument error	103	97 or 113
Missing argument	106	97 or 113
Invalid message unit delimiter	107	97 or 113
Checksum error	108	97 or 113
Byte count error	109	97 or 113
Execution Errors		
Command not executable in local mode	201	98 or 114
Returned to local, new pending	202	98 or 114
Settings lost		
I/O buffers full, output dumped	203	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
Measurement not complete	311	99 or 115
Normal Conditions		
System Events		
Power on	401	65 or 81
User request	403	67 or 83
Device Dependent Events		
Voltage regulation state	724	201 or 217
Current regulation state	725	202 or 218
Unregulated	725	203 or 219

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

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 can 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 query returns additional information about the previous event reported in the STB.

Power-Up (Initial) Conditions

During power-up, the PS 5004 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 3-2. The SRQ line on the GPIB is asserted.

Table 3-2
POWER ON SETTINGS

The instrument assumes 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
VOltage	0.0000 V
CUrrent	100.0 mA
OUTput	OFf
DIsplay	Voltage
VRi	OFf
CRi	OFf
URi	OFf
DT	OFf
USer	OFf
RQs	ON

If an internal error is found, an error code is displayed in the front-panel readout. See Table 3-1 for error codes.

The POLL Statement and Clearing SRQ

The POLL Statement causes the BASIC interpreter in the 4050-series and 4041 controllers to serially poll each peripheral device on the General Purpose Interface Bus (GPIB) to determine the device 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, the second I/O address, the third, and so on, until the device requesting service is found. Program execution is halted, if the I/O address of the device requesting service is not on the list.

The PS 5004 asserts SRQ during power-up or power-down. The power-up SRQ must be cleared before continuing.

```
POLL A,B;21
```

This statement shows a method of clearing the service request. Two numeric variables A and B are specified. Following the variables is the semicolon delimiter and the instrument address, or the alpha character defined as the instruments primary address. After the device requesting service is found, the devices position in the list is assigned to the first variable. The status word from this device is assigned to the second variable.

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) 070-3917-00 - 4041 System Controller Programmer's Reference manual.

(3) 070-2271-00 - 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.

(4) 070-2058-01 - Programming in BASIC.

(5) 070-2059-01 - Graphic Programming in BASIC.

(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.

(12) 070-4696-00 - 4041 GPIB Programming Guide.

ASCII & IEEE 488 (GPIB) CODE CHART

B4 B3 B2 B1	B7 B6 B5 = 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 ^ 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

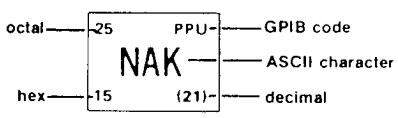
UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART



3391-13

Fig. 3-4. ASCII and IEEE 488 (GPIB) code chart.

PROGRAMMING EXAMPLES

```
100   ! ************************************************************
110   ! *****    TALKER/LISTENER PROGRAM FOR 4052A / PS 5004       ****
120   ! ************************************************************
130   !
140   ! Nov 17, 1983
150   !
160   ! PURPOSE:
170   ! Support operator interaction with the PS 5004 over the GPIB.
180   ! The operator may enter PS 5004 commands and observe the
190   ! results. Service requests, such as for an incorrect command,
200   ! are handled.
210   !
220   ! EQUIPMENT REQUIRED:
230   ! 4052A Controller
240   ! PS 5004 Programmable power supply
250   ! TM 5000 Mainframe
260   !
270   ! VARIABLES USED:
280   ! Ps -- PS 5004 primary address. Assigned a value of 21. Change
290   ! if instrument is set to another address.
300   !
310   ! Com$ -- Commands entered by operator and sent to the PS 5004.
320   !
330   ! Ans$ -- Responses from the PS 5004 to query commands.
340   !
350   ! Stat -- Status byte returned from device requesting service.
360   !
370   ! Dev -- Index to device requesting service.
380   !
390   ! ROUTINE(S) CALLED:
400   ! Serial poll subroutine handles instrument service request.
410   !
420   ! POSSIBLE ERRORS:
430   ! Other instruments on the bus would not be serviced.
440   ! PS 5004 primary address set to a different address.
450   !
460 INIT
470 DIM Ans$(200),Com$(100)  !Handle communication with PS 5004
480 Ps=21  !PS 5004 primary address
490   !
500 ON SRQ THEN 620
505   !
510 PRINT "Enter command/query or RETURN only to end the program ";
520 INPUT Com$
530 IF Com$="" THEN 590
540 PRINT @Ps:Com$  !Send the command
550 IF POS(Com$,"?",1)=0 AND POS(Com$,"SEN",1)=0 THEN 510
560 INPUT @Ps:Ans$
570 PRINT Ans$
580 GO TO 510  !Repeat the process
590 END
600   !
610   ! Serial poll routine
620 POLL Dev,Stat;Ps  !Poll handler
630 PRINT "Status byte ";Stat
640 RETURN
730 END
740   !
750   ! Serial poll handler
760 POLL Dev,Stat;Ps  !Poll handler
770 IF Stat=67 THEN 790  !User interrupt response
780 PRINT "Status byte ";Stat
790 RETURN
```

4442-10

Fig. 3-5. PS 5004 Talker/Listener program (4052A).

```
100   ! ************************************************************************
110   ! *****          TALKER/LISTENER PROGRAM FOR 4041 / PS 5004        *****
120   ! ************************************************************************
130   !
140   ! Nov 17, 1983
150   !
160   ! PURPOSE:
170   ! Support operator interaction with the PS 5004 over the GPIB.
180   ! The operator may enter PS 5004 commands and observe the
190   ! results. Service requests, such as for command errors, are
200   ! handled.
210   !
220   ! EQUIPMENT REQUIRED:
230   ! 4041 Controller
240   ! PS 5004 Programmable power supply
250   ! TM 5000 mainframe
260   !
270   ! VARIABLES USED:
280   ! Ps -- PS 5004 primary address. Assigned to a value of 21. Change
290   ! if instrument is set for a different address.
300   !
310   ! Com$ -- Commands entered by the operator and sent to the PS 5004.
320   !
330   ! Ans$ -- Responses from the PS 5004 to query commands.
340   !
350   ! Stat -- Status byte returned by device requesting service.
360   !
370   ! Dev -- Primary address of device requesting service.
380   !
390   ! ROUTINE(S) CALLED:
400   ! Serial poll subroutine handles instrument service requests.
410   !
420   ! POSSIBLE ERRORS:
430   ! Other instruments on the bus would not be serviced.
440   ! PS 5004 primary address set to a diifferent address.
450   ! GPIB0 is assumed.
460   !
470     Init all
480     Dim ans$ to 200,com$ to 100
490     Ps=21 ! PRIMARY ADDRESS SET FOR 21
500     Open #1:"spib(pri="&str$(ps)&",eom=()):"
510   !
520     On srq then gosub spoll
530     Enable srq
540   !
550     Print "Enter command/query or RETURN only to end the program "
560     Input com$
570     If com$="" then goto 650
580     Print #1:com$
590   ! check for query
600     If pos(com$,"?",1)=0 and pos(com$,"sen",1)=0 then goto 550
610   ! get response from PS 5004
620     Input #1:ans$
630     Print ans$
640     Goto 550
650     Stop
660   !
670 Spoll:     poll stat,dev;ps
680     Print "SRQ occurred, status byte is ";stat
690     Resume
730       Print #1:"OUT OFF" ! Reading complete
740       Next count
750     Stop
760   !
770 Spoll:     poll stat,dev;ps
780     If stat=67 then goto 800
790     Print "SRQ occurred, status byte is ";stat
800     Resume
```

4442-11

Fig. 3-6. PS 5004 Talker/Listener program (4041).

```
100   ! ***************************************************************
110   ! *****          PS 5004 CURRENT LOGGER WITH 4052A          ****
120   ! ***************************************************************
130   !
140   ! Nov 17, 1983
150   !
160   ! PURPOSE:
170   ! Set up the PS 5004 to make ten readings of the output current.
180   ! The operator enters the desired voltage to run the program with.
190   !
200   ! EQUIPMENT REQUIRED:
210   ! 4052A Controller
220   ! PS 5004 Programmable power supply
230   ! TM 5000 Mainframe
240   !
250   ! VARIABLES USED:
260   ! Ps -- PS 5004 primary address. Assigned a value of 21. Change
270   ! if instrument is set to another address.
280   !
290   ! Volt -- Voltage that the PS 5004 will be programmed for.
300   !
310   ! Amp -- The value of current supplied by the PS 5004.
320   !
330   ! Stat -- Status byte returned from device requesting service.
340   !
350   ! Dev -- Index to device requesting service.
360   !
370   ! ROUTINE(S) CALLED:
380   ! Serial poll subroutine handles instrument service request.
390   !
400   ! POSSIBLE ERRORS:
410   ! Other instruments on the bus would not be serviced.
420   ! PS 5004 primary address set to a different address.
430   !
440 INIT
450 PAGE
460   !
470 Ps=21  !PS 5004 primary address
480   !
490 ON SRQ THEN 760
500   !
510 PRINT "       PS 5004 Current Logger"
520 PRINT "Enter the voltage you would like for this test. ";
530 INPUT Volt
540 PRINT @Ps:"init;volt ";Volt;";user on"
550 PRINT
560 PRINT "To take ten current readings, press INST ID for each check."
570 PRINT "The output will be turned on only during the reading."
580 PRINT "The current limit will be 300ma."
590 PRINT @Ps:"cu .3"
600 PRINT "READY"
610   !
620   ! Current measurement loop
630   !
640 FOR Count=1 TO 10
650 WAIT
660 PRINT @Ps:"OUT ON"  !Start the reading
670 CALL "wait",0.5  !Settling time
680 PRINT @Ps:"dis cu;sen"
690 INPUT @Ps:Amp
700 PRINT Count;")     ";Amp
710 PRINT @Ps:"out off"  !Reading complete
720 NEXT Count
```

4442-12

Fig. 3-7. PS 5004 Current Logger program (4052A).

```
100   ! ***************************************************************
110   ! *****            PS 5004 CURRENT LOGGER WITH 4041             *****
120   ! ***************************************************************
130   !
140   ! Nov 17, 1983
150   !
160   ! PURPOSE:
170   ! Set up the PS 5004 to make ten readings of the output
180   ! current drawn by an external load. The operator enters the
190   ! desired voltage to run the program with.
200   !
210   ! EQUIPMENT REQUIRED:
220   ! 4041 Controller
230   ! PS 5004 Programmable power supply
240   ! TM 5000 mainframe
250   !
260   ! VARIABLES USED:
270   ! Ps -- PS 5004 primary address. Assigned to a value of 21. Change
280   ! if instrument is set for a different address.
290   !
300   ! Volt -- Voltage that the PS 5004 will be programmed for.
310   !
320   ! Amp -- The value of the current supplied by the PS 5004
330   !
340   ! Stat -- Status byte returned by device requesting service.
350   !
360   ! Dev -- Primary address of device requesting service.
370   !
380   ! Count -- Measurement loop counter
390   !
400   ! ROUTINE(S) CALLED:
410   ! Serial poll subroutine handles instrument service requests.
420   !
430   ! POSSIBLE ERRORS:
440   ! Other instruments on the bus would not be serviced.
450   ! PS 5004 primary address set to a diifferent address.
460   ! GPIB0 is assumed.
470   !
480     Init all
490     Ps=21 ! PRIMARY ADDRESS SET FOR 21
500     Open #1:"spib(pri="&str$(ps)&",eom=()):"
510   !
520     On srq then gosub spoll
530     Enable srq
540   !
550     Print "PS 5004 Current Logger"
560     Input prompt "Enter the voltage you would like for this test ":volt
570     Print #1:"INIT;VOLT "&str$(volt)&";USER ON"
580     Print
590     Print "To take ten current readings, press INST ID for each"
600     Print "check. The output will be turned on only during the"
610     Print "reading. The current limit will be 300ma."
620     Print #1:"CU .3"
630     Print "READY"
640   !
650   ! Current measurement loop
660   !
670     For count=1 to 10
680       Wait
690       Print #1:"OUT ON" ! Start the reading
700       Wait 0.5 ! Settling time
710       Input #1 prompt "DIS CU;SEN":amp
720       Print count;")    ";amp
```

4442-13

Fig. 3-8. PS 5004 Current Logger program (4041).

Warning

The following servicing instructions are for use only by qualified personnel. To avoid personnel injury, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so. Refer to General Safety Summary and Service Safety Summary prior to performing any service.

THEORY OF OPERATION

BLOCK DIAGRAM DISCUSSION

Introduction

The block diagram shows the four major block elements in the PS 5004 Precision Power Supply. The power rectifier and pre-regulator recieves power from one of the 25 volt AC windings in the power module. This voltage is rectified, filtered, and pre-regulated for use by the precision regulators and output stage. The regulation of the output occurs on the negative lead, as it passes through the series pass stage. The series pass stage is controlled by either the current error amplifier or the voltage error amplifier. An analog OR gate assures that only one (never both), of the error amplifiers is in control of the output at any given time. A pair of balance comparators monitors the output of the error amplifiers to determine the one controlling the output. Information from these comparators is passed to the front panel and the microcomputer for reporting over the bus. A current sampling resistor is in the positive output lead. The current error amp compares the voltage drop across this resistor with a voltage referenced to the positive end of the resistor (to control the output current). The voltage error amp compares the + sense terminal voltage with a reference supply. The negative end of this reference supply "floats" on the − sense terminal. By controlling the output voltage, the voltage error amp keeps the voltage across the sense terminals equal to the reference supply voltage.

A seperate control supply is powered from the remaining 25 volt AC winding in the power module. This supply provides control voltages independent from those produced by the power rectifier section.

A digital meter continually monitors either the output voltage, output current, or the current limit set point. An input selector routes the appropriate signals to the input of the digital meter. The meter output, displayed on the instrument front panel, is also monitored by the microcomputer to transmit over the bus, if requested.

A microcomputer controls the internal operation of the PS 5004. Information for controlling the instrument comes from the front panel or over the GPIB. This information is processed to generate the correct control signals for hardware use. The microcomputer also monitors various hardware inputs, processes them, and outputs the information to the front panel or the GPIB. The microcomputer and some of the control circuits operate from the chassis referenced DC voltage provided by the power module. Since the output of the PS 5004 is floating, some of the interface circuits must isolate the hardware from the microcomputer.

Simplified Schematic Discussion

The power rectifier,filter and pre-regulator provides regulated +12 volts, +8 volts, −25.5 volts and filtered −12 volts to the instrument. These voltages are all referenced to ground 1 ($\downarrow_1$) which, after passing through the current sampling resistor, become the + output. The pre-regulated −25.5 volts is applied to the emitter follower collector serving as the series pass element. From the emitter, the output passes through a relay used for output on-off control, and then to the − output terminal. A set of jumpers (right side cover location) select either front panel output (and sense), or rear interface.

Binary information for the current Digital-to-Analog Converter (DAC) comes from the microcomputer via the optically isolated serial interface. The DAC acts as a digitally programmed current sink. The output current is drawn from a resistor which is tied to the ($\downarrow_1$) end of the current sampling resistor. This creates a voltage drop used as the reference for the current error amp. As the output current increases, the voltage drop across the current sampling resistor becomes greater. As the output current tries to increase over the programmed current limit, the resulting voltage begins to make the current error amp inverting input more negative than the positive input. This causes the error amp output to go more positive which, when coupled through the diode OR gate, makes the output stage base more positive. This action begins turning off the output stage and continues, until the output current is either equal to or less than the programmed output current.

The voltage DAC produces a precision DC voltage of equal magnitude to the programmed output voltage. The negative terminal of this DAC is tied to the − sense terminal. The positive terminal of the voltage DAC is fed to the

inverting input of the voltage error amplifier. The error amp non-inverting input comes from the + sense terminal of the supply. If the output voltage begins to raise higher than the programmed voltage limit, the non-inverting input will begin to raise higher than the reference voltage applied to the inverting input. This action causes the voltage error amp output to become more positive. From the operation of the current error amp, this output, coupled through the diode OR gate, makes the output stage base more positive and therefore lowers the output voltage. The converse holds true when the output voltage becomes too small. If an increasing load causes the output voltage to start to drop, the resulting drop in the + sense lead lowers the non-inverting input more negative than the inverting input of the voltage error amp. This causes the error amp output to become more negative, allowing the output stage to turn on more and thus raise the output voltage.

The balance status comparators monitor the voltage error amp and the current error amp outputs. By checking the voltage of the outputs, the comparator circuit determines which amp is in balance and outputs this information to the microcomputer through opto-isolators, and the front panel indicators (direct).

The output stage is an emitter follower composed of two PNP transistors connected in a Darlington configuration. A constant current sink, connected to the base is used to turn the output stage on. Either of the two error amplifiers supply a current, through the diode OR gate, which turns off the output stage until the amplifier is balanced. The emitter output stage emitter passes through an output relay then to the negative output terminal. The emitter is also the reference point, ground 2 ($\downarrow_2$), for a second set of floating supplies. These supply voltages, +10 V, −15 V, and −21 V, are used to operate the precision voltage DAC.

The voltage DAC operates on a charge pump principal. A precision current source is switched in and out of the summing node of a precision current-to-voltage converter. The current gate is switched on and off with a periodic pulse shaped waveform. The period of the waveform is constant, but the duty factor varies to change the average output voltage. In the PS 5004, two negative current sources are used for coarse and fine voltage setting. The magnitude of the two currents differs by a factor of two hundred. The current gate drive signals are produced by the clock generator in the pulse width control logic. The period of the clocks is a constant 256 microseconds. The on time for each current gate can be varied in one microsecond increments. Each additional microsecond of the fine current gate increments the average output voltage 500 microvolts, (the resolution of the DAC). The binary representation of the output voltage is loaded into the microcomputer clock generator direct as a 16-bit word. The clock generator logic is operated from the microcomputer power supplies, and the output waveforms are isolated in the gate drivers. The current-to-voltage converter output passes through a five pole quasi-elliptical filter that changes the periodic zero-to-full scale voltage input into a DC voltage having the average value of the input. To improve low end linearity, an offset is added to the digital voltage word by the microcomputer. This DC offset is removed by a current sink operating on the filters fixed output impedance. The system zero is nulled out here.

The non-inverting node of the current to voltage converter is connected directly to the PS 5004 − sense terminal. Since this is the reference point for the voltage DAC, the output voltage floats on this point. As previously mentioned, the + sense goes directly into the feedback input of the voltage error amp. Since both sense lines drive only operational amplifier inputs, they draw extremely low current from the output terminals. As shown in the simplified schematic, these sense lines are connected to the output terminals internally with large resistors. Therefore, the supply can be operated with full accuracy at the output terminals with the sense terminals left unconnected.

The digital meter is based around an analog-to-digital converter (ADC) set for two volts full scale. The converter uses a modified dual slope integration method. The three signals controlling the integrator are optically isolated between the analog and digital sections of the converter. The converter can monitor either output voltage, output current, or current limit. An integrated analog switch is used as an input selector. A pair of unity gain buffer amps drive a 10:1 attenuator from the output voltage sense lines to provide the output voltage signal to the ADC. Output current is measured from the voltage drop produced across the same current sampling resistor used by the current error amplifier. Current limit is measured by changing the ADC − input (from the supply output side of the sampling resistor) to the reference input of the current error amplifier. The output of the ADC drives a five digit multiplexed display on the front panel. The multiplexed information is also passed to the microcomputer for generating output messages when queried over the bus.

Microcomputer Block Diagram Discussion

The microcomputer used in the PS 5004 is based on a Motorola 6808 8-bit microprocessor. The 6808 has a 16-bit external address bus that is partially decoded in the address decoder block. The address decoder also contains a RS flip-flop that latches one of the two bits used to perform the display select function. The timing generator gates the various timing signals from the processor to produce Enable, Read Enable, and Write Enable. The data bus passes through a jumper which can be removed for service. The address switch is placed on the bus on the microprocessor side of the jumper. The switch buffer can be enabled by either its address or the RE signal, for use in the forced instruction diagnostic mode.

The operational code for the PS 5004 resides in a 16K word ROM. 1K of RAM is available for variable storage. The GPIB interface is bi-directional to and from the microprocessor. This interface also generates an Interrupt Request used to request service from the microprocessor. In addition to the address switch buffer, the system has three additional 8-bit input ports:

- One port for inputting segment information from the digital meter. The remaining bit is used for the Measure/Zero line from the ADC, which synchronizes the DM reading.
- The second port inputs the digit scan and the display select buttons on the front panel.
- The remaining port handles the four bits from the digital knob on the front panel, along with the Constant Voltage mode and Constant Current mode inputs from the balance comparators. The remaining two bits come from the front panel INST ID and OUTPUT buttons.

An octal buffer is placed on the data bus to drive all output ports. The decoding for all output ports is enabled with Write Enable from the microprocessor. The PS 5004 has four octal latches and a bit addressable octal latch. Two of the octal latches supply the Voltage DAC clock generator circuit with a 16-bit word. The remaining two latches are used to store two digits of segment code which the microcomputer can display on the front panel. This is typically the bus address when the INST ID button is pressed. Each bit in the addressable latch can be written individually. Three of the lines are used for the serial port to the current DAC. Two bits are used for the front panel Addressed LED and the Remote LED. The remaining three lines are used for the output relay drive, display selection, and to mask the Real Time Interrupt.

A Real Time Interrupt generator provides a non-maskable interrupt to the microprocessor every 512 microseconds. This generator is used for some internal timing functions in the instrument.

DETAILED CIRCUIT DESCRIPTION

Microprocessor ◇1

The internal operation of the PS 5004 is controlled by a microcomputer based around the MC6808 microprocessor, U4040. The MC6808 microprocessor is an 8-bit parallel processor with a 16-bit address bus. The eight data lines pass through a jumper, W4030, which can be removed to isolate the kernel from the memory and I/O. A bank of six switches (S4020) and two jumpers drive the data bus on the microprocessor side of the data jumper, when buffer U4020 is enabled. A jumper, J4020, allows this buffer to be enabled either when addressed (in RUN posisition), or on every microprocessor read cycle. Normally, the jumper is in the RUN posisition and the switch register is read on power-up to determine the GPIB bus address. For kernel testing with signature analysis, the jumper is set to FORCE DATA, and data jumper W4030 is removed. This will force whatever instruction that is loaded in the address switch to be executed every fetch cycle.

The microprocessor operates with a 1.0 uS cycle time and generates its own clock from 4.0 MHz crystal Y3030. The microprocessor reset, pin 40, is driven from Power On Reset ($\overline{\text{POR}}$). $\overline{\text{POR}}$ is derived from the power module PWR. R3021 and C3020 filter out any fast noise spikes that could reset the system. Two interrupt lines enter the microprocessor. Non Maskable Interrupt, pin 6, is driven by a Real Time Interrupt generator. The Interrupt Request, pin 4, is driven by the GPIB interface when it requires servicing.

Gates U2040 and U2030 are driven by the microprocessor Enable output, pin 37, (ϕ2 clock); Read/$\overline{\text{Write}}$ pin 34, and Valid Memory Address pin 5 (VMA). These gates generate a Read Enable, $\overline{\text{Write Enable}}$, $\overline{\text{Read}}$/write, and buffered clock for use in the remainder of the instrument.

Address decoding is accomplished by U3041 and U3050. U3041 decoding is qualified with VMA and $\overline{\text{E}}$. U3050 decoding is also gualified with R/$\overline{\text{W}}$. Two of the decoded outputs of U3050 are used to set or clear a RS flip flop, U3052C and U3052D. This flip flop latches the Display Current Limit bit, one of two bits used to drive the display select switch. U4050 is an octal-bit addressable latch driven from data bus line D_7. The Display Vo (output voltage) line is gated with the Display CL (current limit) line in U2030D. When both lines are logic one (an illegal condition for the display select switch), this gate will force an INST ID pushbutton closure. This is done to display an error code on the display. Refer to Table 4-1 and 4-2 for Address Map and I/O Data Bus Assignments respectively.

Table 4-1
I/O ADDRESS MAP

Function	Ckt #	Type	Hex Address	Wrap-around?
(Decoded by U3041 qualified by $\overline{E}$ and VMA)				
RAM	U2042, U2050	Memory	0000-1FFF	Yes
Digit Buffer	U5052	Inp	2000-3FFF	Yes
Segment Buffer	U2090	Inp	4000-5FFF	Yes
Bal Stat Buff	U2092	Inp	6000-7FFF	Yes
GPIB INTERFACE	U2030	In/Out	8000-9FFF	Yes
ADDRESS SWITCH	U4020	Inp	A000-BFFF	Yes
ROM	U3040	Mem Inp	C000-FFFF	No
(Decoded by U3050 qualified by $\overline{E}$, VMA, and WRITE)				
DISPLAY DIG 2	U2080	Out	A000-A3FF	
DISPLAY DIG 3	U2082	Out	A400-A7FF	
VDAC HI ORDER	U2070	Out	AC00-AFFF	
VDAC LO ORDER	U2072	Out	B000-B3FF	
DISP CUR LIM-SET	U3052D	Out	B400-B7FF	
DISP CUR LIM-CLR	U3052C	Out	B800-BBFF	
SIG ANAL-START/STOP	TP4050, TP4052	Out	BC00-BFFF	
Latched by U4050; Qualified with $\overline{E}$, VMA, and WRITE; Written with DB7)				
I DAC DATA	U4060	Out	A800-A87F	
I DAC CLOCK	U4062	Out	A880-A8FF	
I DAC STROBE	U3060	Out	A900-A97F	
$\overline{\text{RTI MASK}}$	U2100	Out	A980-A9FF	
DISP OUT VOLTAGE	U4063	Out	AA00-AA7F	
OUTPUT ON	Q3032	Out	AA80-AAFF	
$\overline{\text{ADDRESS LED}}$	DS2021	Out	AB00-ABFF	
$\overline{\text{REMOTE LED}}$	DS2011	Out	AB80-ABFF	

Table 4-2
I/O DATA BUS ASSIGNMENTS

Digit Input Buffer U2052		Segment Input Buffer U2090	
D_0	DIGIT 1 (LSB)	D_0	$\overline{Sq}$
D_1	DIGIT 2	D_1	$\overline{Sb}$
D_2	DIGIT 3	D_2	$\overline{Sc}$
D_3	DIGIT 4	D_3	$\overline{Sd}$
D_4	DIGIT 5	D_4	$\overline{Se}$
D_5	$\overline{\text{DISPLAY Vo}}$ BUTTON	D_5	$\overline{Sf}$
D_6	$\overline{\text{DISPLAY Io}}$ BUTTON	D_6	$\overline{Sg}$
D_7	$\overline{\text{DISPLAY V1}}$ BUTTON	D_7	MEASURE/$\overline{\text{ZERO}}$
Address Sw Inp Buffer U4020		**Bal Status Input Buffer U2092**	
D_0	LF/LF-EOI	D_0	$\overline{\text{CONSTANT VOLTAGE}}$
D_1	A_{16}	D_1	$\overline{\text{CONSTANT CURRENT}}$
D_2	A_8	D_2	DIGITAL ENCODER COARSE A
D_3	A_4	D_3	DIGITAL ENCODER COARSE B
D_4	A_2	D_4	DIGITAL ENCODER FINE A
D_5	A_1	D_5	DIGITAL ENCODER FINE B
D_6	SIG ANAL-0	D_6	$\overline{\text{OUTPUT ON}}$ BUTTON
D_7	CALIBRATE-0	D_7	INST ID BUTTON

Adrs Disp Regis U2080, U2082		Lo Order Vdac U2072	Hi Order Word Vdac U2070
D_0	$\overline{Sq}$	Direct Map $D_0>B_0$, $D_7>B_7$	Direct Map $D_0>B_0$ $D_7>B_7$
D_1	$\overline{Sb}$		
D_2	$\overline{Sc}$		
D_3	$\overline{Sd}$		
D_4	$\overline{Se}$		
D_5	$\overline{Sf}$		
D_6	$\overline{Sg}$		
D_7	$\overline{Sdp}$		

The system firmware resides in a 16K word ROM, U3040. The ROM address is decoded by gate U2040C. The Output Enable, pin 22, is driven by Read Enable. The RAM is comprised of two 1K by 4-bit static RAM ICs, U2042,and U2050.

Display Input-Output ◇2

The five digit display in the PS 5004 is multiplexed by the Analog-to-Digital converter. The converter outputs the data needed to generate the segments displayed one digit at a time. The corresponding digit strobe line is active during the same time. In order for the microcomputer to acquire a reading from the Digital Meter, it must first detect the rising edge of the Measure/$\overline{\text{Zero}}$ line to determine that a new reading is available. The microprocessor must then detect the segment data from the segment drivers during each valid digit strobe time once for each of the five digits. Five of the eight data bits available on input buffer U2052 are used for the DM digit strobes. The remaining three bits are used to input the Display Select pushbuttons from the front panel. The segment information, along with the Measure/$\overline{\text{Zero}}$ line input through buffer U2090.

The four output latches in the system are buffered from the microprocessor data bus by Write buffer, U2060. Two of the latches, U2080 and U2082, are used to store the segment data needed to generate a two digit number on the display. Normally, this number is the GPIB address and is displayed when the INST ID button is pressed on the front panel. The output lines of these latches are bussed together with the segments from the display driver. Pressing the INST ID button pulls the ID Req low. This signal is inverted by U1060F, and drives gates U3052A, U3052B and open collector inverters U1060A-C. The three Display Blank lines from these inverters disable the seven segment driver, decimal point generator, and – sign logic (all on diagram 3). This action does not disrupt the digit scan, and digit strobes D2 and D3 are fed into gates U3052A and U3052B respectively. When D2 is active, U3052A enables the output of latch U2080 to activate the appropriate segments to display its digit. The same process is performed by U2082 during valid digit strobe D3 time.

GPIB Interface ◇2

The GPIB communications are controlled by U1030, U1020 and U2020. Bi-directional buffers U1020 and U2020 provide drive for U1030, the GPIB interface chip. The IEEE 488-1975/78 standard protocol is handled automatically in both talker and listener modes by U1030. The internal state machine in this IC is clocked by E delayed. This IC operates asynchronously and therefore, guarantees no timing relationships between the GPIB side and microprocessor clock. This instrument is assigned a five bit address to enable talker or listener addressing over the bus, by reading the address set on S4020 (shown on diagram 1) during power up.

Rotary Encoder Interface ◇2

The COARSE and FINE rotary encoders (shown on diagram 7) each have two switches connected to +5 V. As the front panel knobs are rotated, a waveform similar to the one

shown in Fig. 4-1 is generated. The two switches for the COARSE control connect to pins 5 and 11 of U1102B and U1102D respectively. The two switches for the FINE encoder connect to pins 9 and 7 of U1102C and U1102A respectively. RC filters placed on all of the comparator inputs remove noise that might be interpreted as false closures, when the encoder is rotated. As the knobs are turned, the positive terminal of these comparators switch between approximately ground and +2 V. Resistors R2100 and R2110 form a voltage divider from the +5 V supply to generate the comparator threshold voltage. The comparators have open collector outputs. Pull-up resistor R1100 is used to make these outputs TTL compatable. The four output data bits are placed on the input of U2092 and transferred to the data bus, when Select Balance Status is true.

Information from the loop balance status comparators (diagram 5) is used to drive the LEDs in optical isolators U4081 and U4082. The isolators provide ground referenced Constant Voltage and Constant Current signals to input buffer U2092. INST ID from U1060F-10 and the Output On line from the front panel pushbutton, drive the remaining two input lines on this input buffer.

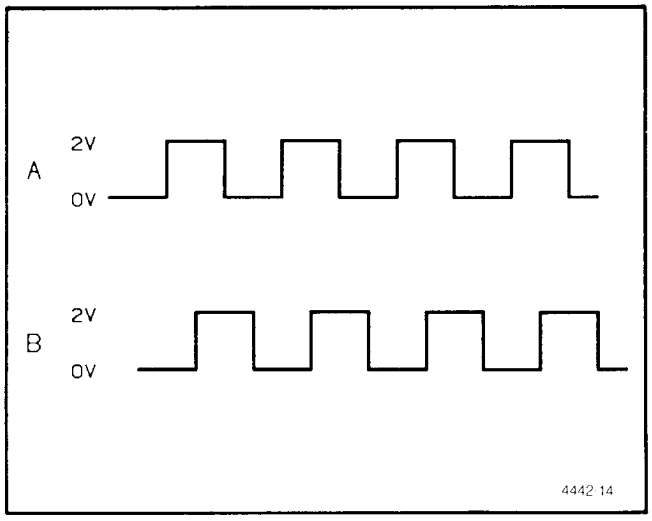


Fig. 4-1. Rotary encoder output (clockwise rotation).

VDAC Current Gate Clock Generator ◇3

The Voltage Digital-to-Analog Converter (DAC) provides the regulator with a reference voltage that has a range of zero to 20.0000 volts. The VDAC resolution is 500 μV. The voltage is programmed by 16 bits loaded in two 8-bit words. The buffered data bus loads the high order word into U2070 and the low order word into U2072. Each of these words determine the duty factor of a current gate. The current gates are used to switch current into the summing node of the current-to-voltage converter. Both current gate waveforms have a constant 256 μS period. The latched digital word determines the on time of the current gate. Each count represents 1 μS of on time. This corresponds to 500 μV in the low order word and 100.0 mV in the high order word. Offsets of 50 counts (25.0 mV) and one count (100.0 mV) are added by the microprocessor to the low order and high order words respectively. Each of the latched words is fed into the B inputs of an eight bit magnitude comparator composed of U3060 and U3070 for the high order, and U3072 and U3080 for the low order. The A inputs of the magnitude comparators are driven by a free running eight bit counter, U3082. The counter is clocked on the falling edge of the 1 MHz E Delayed clock. The high order current gate clock waveform comes out on pin 7 of U3060, and the low order on pin 7 of U3080. During the time when the counter word on the A input is less than the the latched word present on the B input, the comparator output will be a logic one. When the value of the counter word equals the latched word, the output will go to logic zero and remain there until the counter is clocked from 255 (maximum count) to 0. The cycle then repeats itself.

Coarse and Fine Current Gate Drivers ◇3

The current gate waveforms from the comparators are clocked into D flip flops U3090A & B on the rising edge of the 1 MHz E Delayed clock. This removes any glitches in the waveform caused by the ripple-carry stages in the counter and comparators. The flip-flop outputs are fed into the inputs of line drivers U3092A-D. These, in turn, differentially drive the primaries of pulse transformers T3090 and T4090 through RC impedance matching networks R3092, C3092, R3090, and C3093. The pulse transformers provide the isolation between the floating output of the power supply and the digital logic on the Programmer board.

Diode and resistor networks on the secondaries of the transformers clamp and bias the inputs of gates U4090A-D. These gates form a pair of RS flip-flops to reconstruct the current gate clock waveforms from the pulses produced in the transformers. The outputs of the flip-flops are biased and drive the bases of switching transistors Q3110 and Q3100. The base of the coarse gate transistor is clamped to the collector by schottky diode CR4100, which prevents saturation and speeds up recovery when the transistor is turned off. When the switching transistor is turned on, the negative current from the precision current source is diverted from the current-to-voltage converter by the transistor. Therefore, when the switching transistor is on, the current gate is off.

The floating secondary circuitry described above is powered from a supply that tracks the – sense line. A voltage one diode drop lower than the – sense terminal enters the board through J1070-49. Emitter follower, Q2090 provides a second diode drop to generate –1.5 V with respect to – sense. Q2090 is kept on by approximately 20 mA of current that returns to the negative unregulated $\downarrow_2$ supply

through R1034 shown on diagram 6. Voltage regulator U1100 provides +3.5 V relative to − sense.

The Real Time Interrupt Generator and DM Clock ◇3

Two D flip-flops, contained in U2100 comprise the real time interrupt generator. When the $\overline{\text{RTI Mask}}$ signal is high, the output pin 8 of U2100B is a clock with a 512 μS period. When the $\overline{\text{RTI Mask}}$ line goes low, the $\overline{\text{RTI}}$ is disabled (logic one).

The 250 KHz clock for the Digital Meter is tapped from the Q_b line of the binary counter (U3082 pin 4)

Analog-to-Digital Converter ◇4

The Analog-to-Digital Converter (ADC) is based on the Siliconix LD120 analog processor U4091 and the type LD121 digital processor U2092. The analog processor contains an input buffer, integrator, comparator, and an auto-zero amplifier. The digital processor contains the necessary control logic for the analog converter and the buffers, multiplexers, latches, and counters to drive the display circuitry. The three digital control signals between the two ICs are optically isolated, allowing the digital processor to operate at chassis ground. (See Fig 4-2.)

The converter is set up for a 2 V full scale input, with a resolution of 100 μV. Output is a five digit multiplexed BCD used to drive the display and input for the microcomputer. Because of common mode range restrictions, all input voltages are applied to the input terminal inverted. The sign is inverted by logic on the output.

The DM can measure output voltage at the sense terminals, output current, or the current limit setting. The appropriate input signal is connected to the ADC input by analog switch U4081. The digital select inputs for U4081 are optically isolated from their drive logic by U4062 and U4063. See diagram 5 for the input signal paths described below. The voltage signal is buffered from the sense lines by U3061B and U3062B. The − sense voltage is attenuated 10:1 with respect to the + sense by R3075. The output current signal is obtained from the voltage drop across the output current sampling resistor, R4051. Since the value of this resistor is one ohm, output milliamps convert directly to millivolts. To measure current limit, the input of the ADC is moved from the output side of the current sampling resistor to the reference point of the current error amp. Since the error amp shares the same current sampling resistor with the DM, the scaling for current limit at this point is the same 1 mV/mA.

The reference voltage for the ADC is obtained from temperature compensated zener diode VR5071. Trimmer R4073 adjusts the exact voltage to set the full scale equal to 2.0000 volts. The ADC gain is set by the ratio of R4092 to R5091. The ADC operates on a charge-balancing principal. The input voltage is converted to a current that charges integrating capacitor C4092. The converter counts the units of charge needed to keep the integrator output near zero (See Fig. 4-3).

The DM operates with a clock frequency of 250 KHz. A complete conversion cycle requires 49,152 clock pulses. The Auto Zero (A-Z) cycle is 16,384 pulses. The measure zero interval uses 32,768 pulses.

Auto-Zero Period

The ADC system operation during the auto-zero period is shown in Fig. 4-2. In the AZ period, the input buffer is connected to reference ground. The AZ buffer input is connected through R4101 to the integrator output. The measure zero line is logic low. The Up/Down line is toggling at a 50% duty cycle, which results in an average current through R5091 equal to one-half of $V_{ref} \div$ R5091. The dynamics of the system causes the voltage on capacitor, C4101 to attain the value required for the sum of the currents, entering the integrator summing node, to be zero. The AZ voltage on C4101 is approximately −2 V. At the end of the AZ interval, the AZ switch is opened and the AZ buffer will continue to supply the zero correction current to the summing node.

Measure Interval

During the measure interval (see Fig. 4-3), the input buffer is connected to V_{in}. This generates a current into the integrator summing node equal to $V_{in} \div$ R4092. This current causes the integrator output voltage to move from V_{AZ}. The comparator determines the direction (positive or negative) that the integrator output is deviating from V_{AZ}. This information is sent to the digital processor U2092 through opto-isolator U3071. The digital processor attempts to keep the integrator output voltage close to V_{AZ} by adding or subtracting units of charge to integrator capacitor, C4092. The direction of correction charge is transmitted to the analog processor over the Up/Down line. With a unit of charge equal to 14 counts, the net amount of charge for correction is totaled by the BCD counters in the digital processor. The measure interval can only resolve multiples of 14 counts.

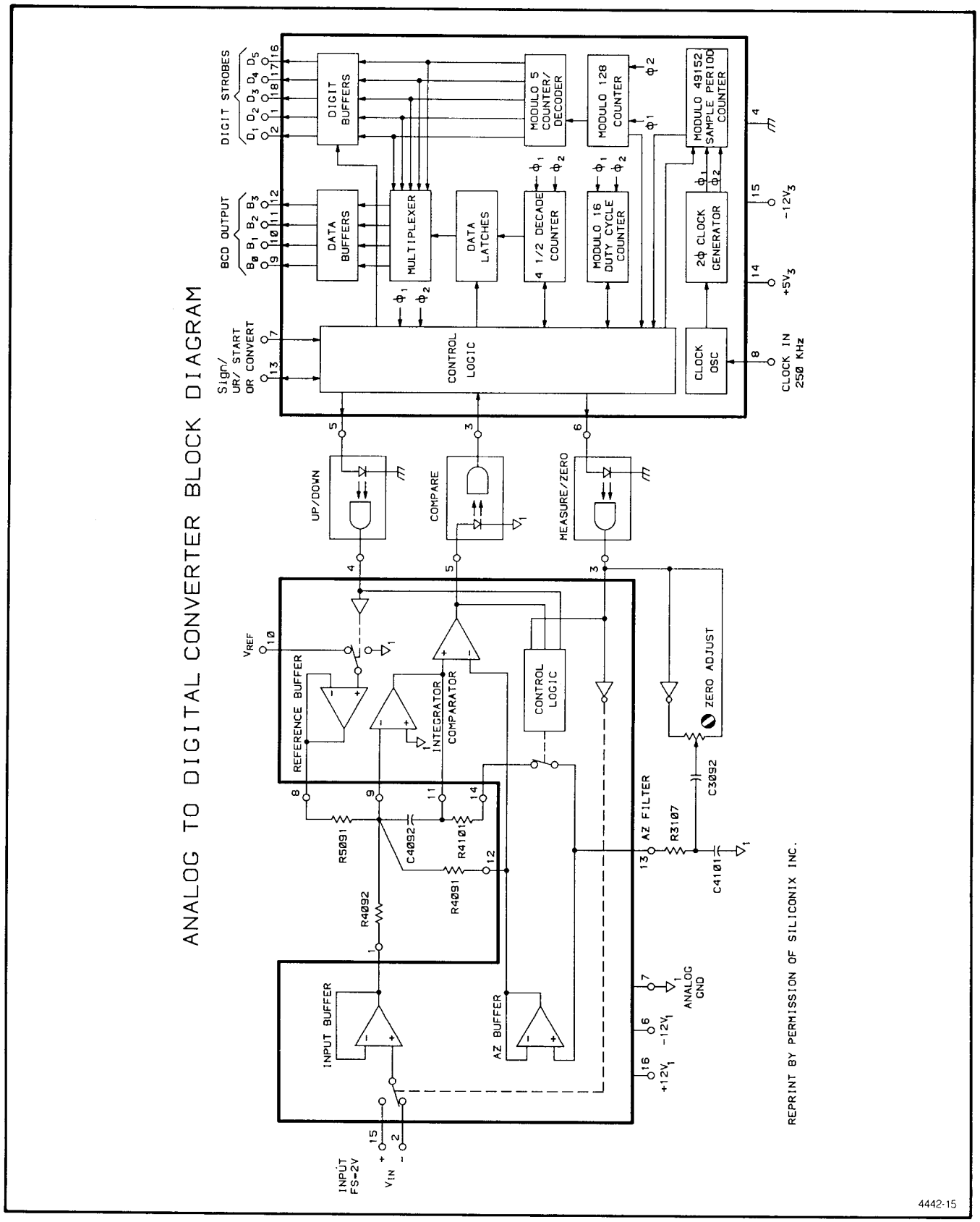


Fig. 4-2. A to D converter block diagram

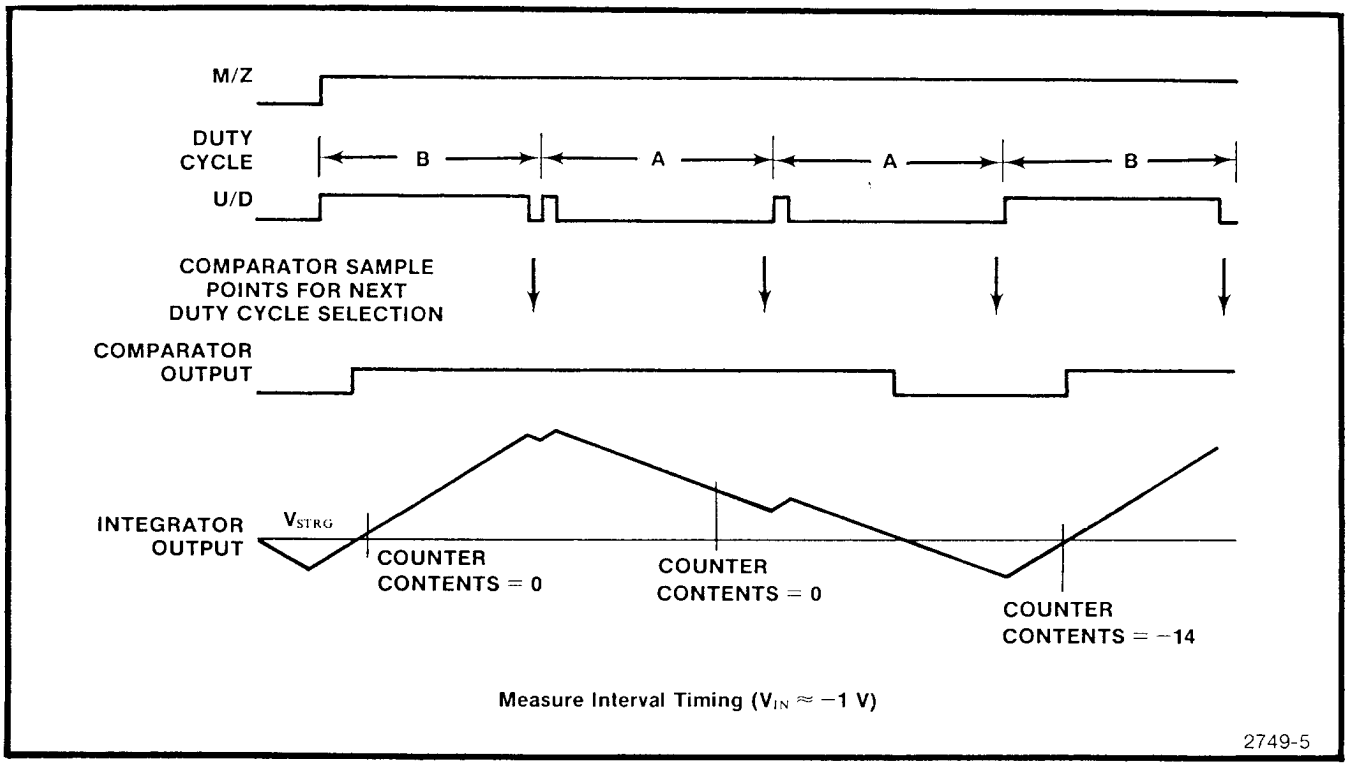


Fig. 4-3. Measure interval timing.

Auto Zero Override Period

The override period immediately follows the measure interval to resolve the last of the measurement. The Auto Zero correction is inhibited until the residual voltage is cancelled on the integrator capacitor. The input buffer now connects to the high quality ground and the C_{AZ} switch is open. The digital processor (U2092) causes the integrator to go positive with respect to the V_{AZ} potential, stopping only when the comparator changes state. The count is in single clock times. (See Fig. 4-4.)

The override period can exist for a maximum of 56 clock cycles into the zero period. Since only 14 of the 16 counts in the U/D waveform (see Fig. 4-5) produce net counts, there are ±28,672 counts maximum out of the measure period of 32,768 clock times available.

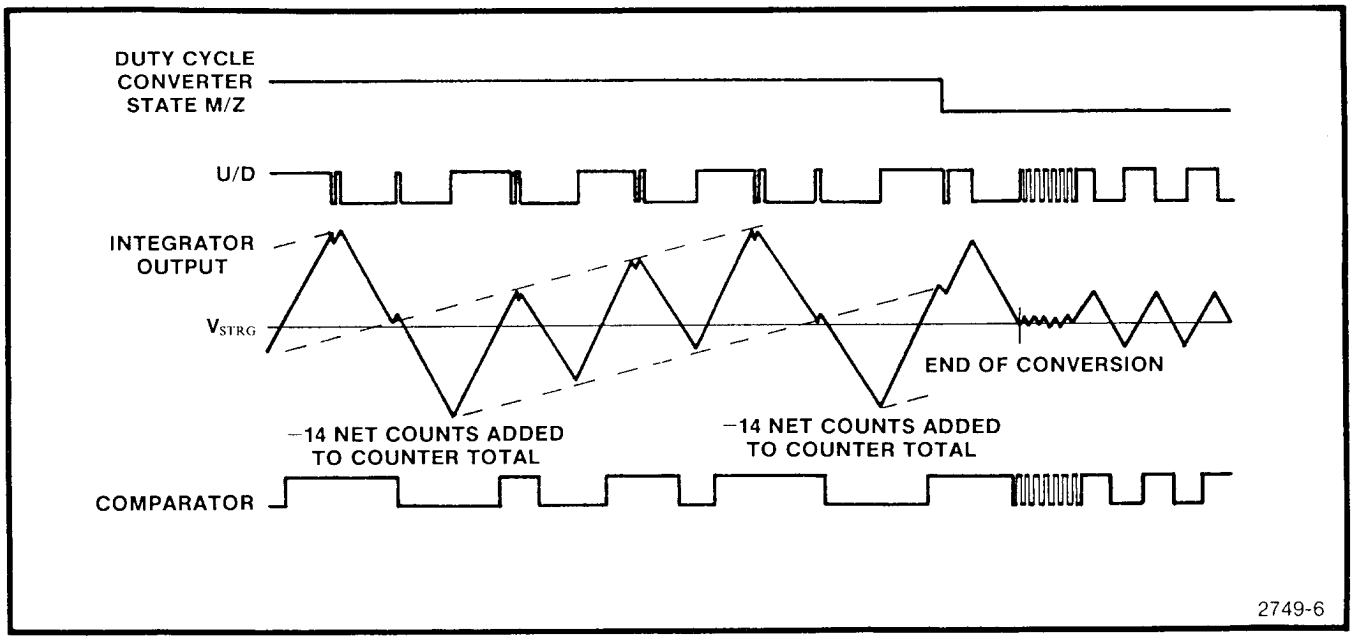


Fig. 4-4. Algorithm waveforms at end-of-measure interval.

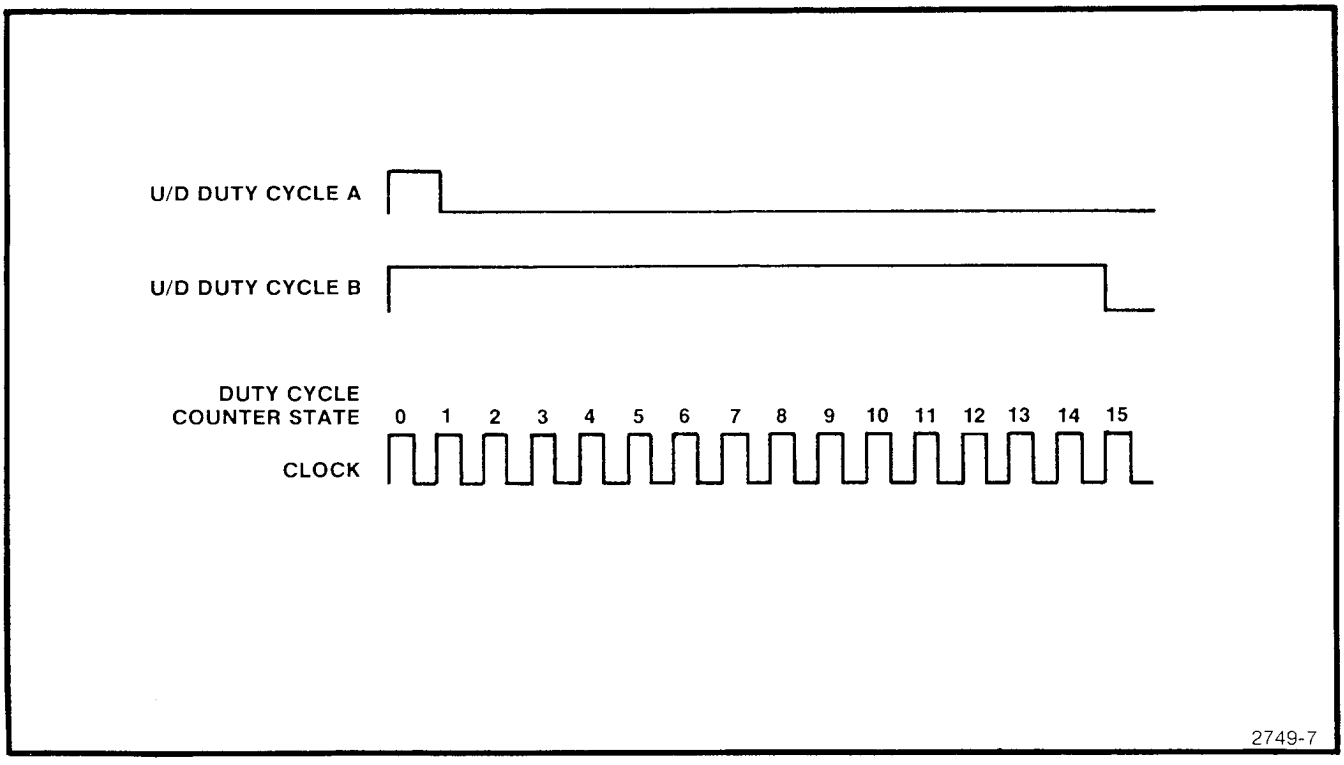


Fig. 4-5. Modulo 16 dual duty cycle counter waveforms.

At the end of the measure period (after the last count cycle has accumulated its counts), the data in the counter is transferred to the data latches. This data is then multiplexed to the BCD outputs through pins 9, 10, 11 and 12 of U2092 at the time the proper digit select line is enabled. (See Fig. 4-6.) The sign information outputs on the sign/overrange/underrange line (U2092 pin 13) during digit D5 time. During digit D4 time, this pin becomes an input and is pulled to a logic one by transistor Q2104. This programs the digital processor not to flash the display on an overrange condition (displaying 20,000 or more counts).

The digit select lines drive inverters U2091A, B, D, E and F which feed the five digit driver transistors Q1101-1103, Q2101, and Q2102. Each driver transistor has a 0.01 uF capacitor connected from base to collector. These capacitors limit the driver slew rates to keep the display multiplex noise out of the power supply output. The seven segment displays are common anode configuration (shown on diagram 7). Each segment's cathode current returns through a current limiting resistor (R1081-R2084), and then flows into the BCD-to-seven segment decoder/driver, U2071. The seven segment lines, Sa through Sg, and decimal point, Sdp, are tapped off between the current limiting resistor, and U2071 to go to the programmer board. These lines are bi-directional and are used to input the DM reading to the microcomputer and for displaying address or error codes on the display. The ripple blanking input, U2071-5 is driven by Q2105 wire-ORed with Q2103. These transistors pull this line to logic zero during D5 digit time, including the slewed falling edge. When U2071 detects BCD zero coming in (while this line is logic zero), it disables its output stage to perform a leading zero suppression. The blanking input, (U2071-4), is pulled low by the Programmer board when it displays an error code or address.

A logic one on sign/OR/UR (U2092-13) during digit D5 time, indicates a positive polarity input into the Vin of the ADC. As previously mentioned, this is a negative polarity in the PS 5004, since all of the voltage inputs have inverted polarity. R2095G pulls the output of gate U2093D to logic high when the sign bit is high during D5 time. This turns on Q2071 which illuminates the segment Sg of the left hand display to indicate a minus sign. A second display $\overline{\text{blank}}$ line from the Programmer board holds open collector gate U2093D low during address or error code displays, to inhibit minus sign generation. The decimal point is displayed to the right of digit D4 when measuring voltage, and to the right of digit D2, when measuring current. Either gate U2093A or U2093B can turn on the decimal point driver, Q2072 during the appropriate digit time. The third $\overline{\text{blank}}$ line from the Programmer board, is used to disable this driver while the Programmer board drives the display.

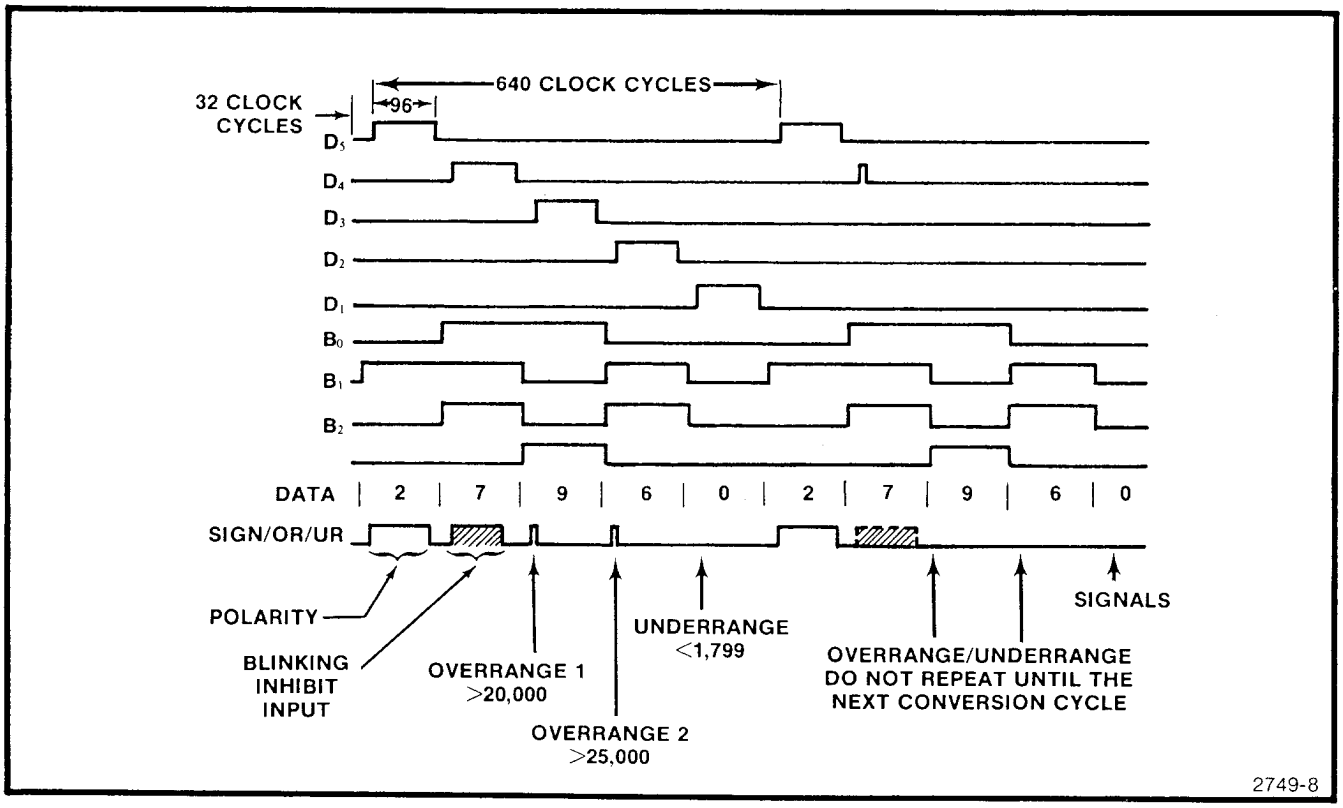


Fig. 4-6. LD121 data output waveforms.

The front panel display select and units LEDs are driven by the Display Vo and Display C1 lines from the Programmer board. Gate U2093C and inverter U2091C drive the Display Io LED when neither the display Vo of C1 LEDs are illuminated.

Output Stage ◇5◇

As mentioned in the block diagram discussion, The PS 5004 regulates the negative terminal with the positive terminal essentially grounded. The output current flows from ground ⏚ 1, through the current sampling resistor, R4051, to the + output terminal. The return path is from the − terminal, through F3041, through output relay K4041. From the relay, current flows through an emitter follower stage, into the pre-regulated −25.5 V_1 supply. The emitter follower is composed of a darlington pair, with Q3052 driving the PNP transistor located in the power module. Q3051 and R3044 form a current source which provides a constant current to pull down the output. This adds to the loop stability and discharges the output capacitors, when a lower voltage is programmed while driving a very small load.

The supply is protected from an externally applied reverse polarity to the outputs by CR3042. If excessive reverse current is applied to the supply output, fuse F3041 will open protecting the etched circuit runs from damage. Capacitors C1052 and C4022 are placed across the output to shunt the high frequency noise components, which are above the voltage error amplifier's bandwidth. Jumpers J4041A-D select either front panel or rear output for the output terminals and remote sense terminals. All four of the jumpers MUST be set for the same output selection.

Output relay K4041 is controlled by two switching transistors, Q3031 and Q3032. Q3031 is driven with Power On Reset to assure that the output is not supplying uncontrolled voltage during power up. Q3032 is driven by an output port on the Programmer board. The relay current is supplied through the Output LED on the front panel from +8 V_3.

A constant current sink connected to the base of the darlington driver, Q3052, acts to turn the output stage fully on. Either of the two error amplifiers supply a current, through the diode OR gate, which turns off the output stage until the amplifier is balanced. The current sink is implemented with a resistor, R5051, which pulls the base drive to a regulated voltage, −15 V_2, referenced to the output emitter. Clamp diode CR3041 protects driver Q3052 from reverse emitter-base breakdown, if the supply is connected to an active load that has a potential greater than the programmed voltage. FET Q3053 limits the current flowing from the voltage error amp output, when this situtation exists. R4053, shunted by C4052, produces a DC level shift in the base voltage, controlled by either error amp. This voltage is approximately 3 volts and is constant, due to the constant current that the controlling error amp is sourcing.

Loop Balance Comparators ◇5◇

The loop balance comparators determine which loop, if either, is controlling the output stage at any given time. The supply is in Constant Voltage mode (CV) when the voltage error amp is balanced, Constant Current mode (CC) when the current error amp is balanced, and unregulated when neither amps are balanced. The latter case occurs, when the output is being pulled up to a higher output voltage then the supply is set for (by an active load). Error amp balance is detected by checking to see if the amp output is up against a supply rail. Each of the two amplifier outputs is connected to a pair of voltage comparators, U4061A-D, one for the positive rail, and one for the negative rail. Threshold voltages are set just outside the worst case legal range of an error amp output, while it is controlling the output stage. The positive and negative comparator outputs for each amp are wire ORed together. Resistors R4062, and R5054 pull the open collector outputs up to ⏚ 1, if the amplifier output is not against a supply rail. This saturates Q5062 (for CV mode) or Q5061 (for CC mode). Current will now flow through the approprate Mode LED on the front panel, and the balance opto-isolator LED (shown on diagram 2).

Current DAC ◇5◇

The DATA, CLOCK, and STROBE lines from the microcomputer are applied to opto-isolators U4060, U4062, and U3060. The output from the opto-isolators drives the emitters of level shifting transistors Q4062, Q4064, and Q4060. The base current for these transistors is provided by Q3060 (with associated components). The output of this emitter follower is ≈2 V. These level shift transistors permit higher speed operation for the transistors in the opto-isolators, as only a small voltage change is required at the collectors of the opto-isolator transistors.

The eight bit Register U4070 is a shift-and-store device. The serial data input is accumulated in time with the clock pulse inputs. When the transfer strobe pulse occurs, the data present in the shift register transfers to the output latch.

Internally, DAC U4080 employs a current reference driving a ladder network. Each bit drives a binary weighted current switch that steers the current into either IO or $\overline{IO}$. The negative current sources (pins 2 and 4) in U4080 are transistor collectors. This gives the IO terminal a voltage compliance of −10 V to +18 V. The reference voltage for U4080 is provided from the +12 V_1 supply through R4081 and from R4074 and R4076. V_{ref} + and − (U4080 pins 14,15) are inputs to an internal op amp used to produce the reference current, and therefore the same potential. The reference current is equal to the current through R4080.

The output of the DAC U4080, draws current through R4052 which produces a voltage drop relative to the current sampling resistor, R4051. This voltage drop is applied to the reference input (non inverting) of the current error amp, U5051. The inverting input is connected, through R5052, to the output end of the current sampling resistor. As the supply output current increases, pin 2 of U5051 goes more negative with respect to ground ⏚ 1. When the current sense voltage across R4051 equals the current DAC voltage at pin 3 of U5051, the output pin 6 begins to go positive. This, coupled through diode OR gate CR4053, begins to turn off the output stage. This action continues until the output current equals (or is less than in Constant Voltage mode) the programmed current limit.

Voltage Error Amp ◇5

Voltage error amp U3062A controls the output stage through diode OR gate CR4052. The inverting input of U3062A is driven by the output of the voltage DAC. VR3061 and CR4061 limit the voltage swing on this input when the PS 5004 is in CC mode. R3060 limits the DAC output current when this clamp is operating. The voltage DAC "floats" on the − sense terminal to provide correction for the voltage drop in the − output lead. The comparison (non-inverting) input of the voltage error amp is driven from the + sense terminal. VR3062 limits the voltage between the + sense line and the + output during fault conditions (misconnected sense terminals). Light bulb DS3051 provides a low resistance in the sense line, unless a fault causes excessive current to flow through VR3062.

The feedback action of the voltage error amp is similar to that of the current loop. If a load change causes the output voltage to drop, the + sense line will begin to go negative with respect to the voltage DAC output. This will lower the error amp output voltage, lowering the control voltage on the output stage. This causes the − output terminal to become more negative with respect to the positive output terminal, hence greater output voltage. This action continues until the output voltage, at the sense terminals, equals the programmed value of the voltage DAC.

Resistor R5023, (R1021 for rear interface operation), clamps the + sense jack to the + output jack. Because voltage error amp, U3062A, and + voltage sense buffer, U3062B are FET input op amps, their input leakage current is extremely small. This allows operation of the PS 5004 with the sense terminals unconnected. When operated in this manner, the output voltage is regulated at the output terminal, not the load point.

Charge Pump Voltage DAC ◇5

As mentioned in the simplified schematic discussion, the reference voltage for the PS 5004 error amp is generated in a DAC, that operates on an integrated, gated charge transfer principle. Four main elements comprise the DAC; a pair of precision constant current sources, variable duty factor current gates (which control the amount of time that the current is transfered), a precision current to voltage converter, and an integrator to filter the chopped voltage into clean DC.

Reference and Current Sources. U2041 is a precision, low drift, voltage reference IC. To minimize the effects of temperature, this IC incorporates a temperature regulated heater which maintains the die at 85°C. The heater is powered from the negative unregulated ⏚ 2 supply. A constant current source, comprised of Q2041, VR2031, R2041 and R2042 eliminates the effects caused by line voltage changes on the dynamic impedance of the reference.

Resistors R1037-R1042 with switch S1041 form a voltage divider to provide a coarse adjustment of the reference voltage. This brings the voltage into the adjust range of Full Scale Adjust, R2043, and Fine Span Adjust, R2044. These two trimmers adjust the level of the precision current sources.

Both current sources have the same topology. Both are negative sources or current sinks. The coarse current source is composed of control amplifier U2051A, FET Q2051, and feedback resistor R2056A. Current enters the drain of Q2051, and exits through the source. The current produces a voltage drop across R2056A. This voltage is compared with the reference voltage by FET input op amp U2051A. The output of the op amp drives the FET gate. By negative feedback action, the op amp controls the conduction of the FET, keeping the voltage on its inputs equal. Since this voltage represents the current flowing through R2056A, the FET sinks a constant current at all times.

The coarse current source operates at approximately −4.0 mA. The fine current source is adjusted to operate exactly 1/200 of the coarse level or −20 μA. Because the accuracy of the PS 5004 is directly influenced by the accuracy of these current sources, the sensitive nodes on the etched circuit board are protected from surface leakage currents by guard runs. These guards are driven to a voltage approximately the same as the node which they are protecting. Any surface leakage will be absorbed into the guard rather than entering the protected node.

Current Gates. The coarse current gate is made up of diodes CR1051 and CR2051, while CR1061 and CR2061 make up the fine current gate. Each gate steers current into the current source from either the current-to-voltage converter or the gate driver transistor (described in current gate drivers, diagram 3). When the coarse driver transistor, Q3110 on Programmer board, turns on (current gate off), it

provides a voltage approximately 3 volts higher than the summing junction of the current-to-voltage converter U2061A. This voltage forward biases CR1051 and raises the voltage on the cathode of CR2051, causing it to back bias. Since CR2051 is now back biased, all current for the current source must be provided by the gate driver transistor. The gate is turned on when Q3110 is turned off. This back biases CR1051 and forward biases CR2051, forcing the current-to-voltage converter to provide current for the current source. The fine current gate operates in the same manner.

Current-to-Voltage Converter. The current-to-voltage converter is formed from FET input operational amplifier U2061A and R2056B. All of the current absorbed by the current sources, when the gates are on, is provided by the output of U2061A through R2056. This current produces a voltage drop across R2056B . U2061A will move its output voltage wherever necessary to keep its summing node, pin 2 equal to its reference node, pin 3. The reference node for the current-to-voltage converter is driven from the − sense line, through output relay K4041. This assures that the DAC output voltage will "float" on the − sense line providing sense correction. The − sense line incorporates the same protection as the + sense line (described in the Voltage Error Amp section). Additional resistor R2051 clamps the sense line to the − output line when the output relay is open.

Integrator-Filter. C1062 forms an integrator with U2061A. This produces a sawtooth waveform output from the current-to-voltage converter rather than a pulse waveform. The amplitude of this waveform is about 3 Volts p-p. U2061B and associated components form a four pole quasi-eliptical filter, tuned to the fundamential frequency components of the current gate waveform. This produces a clean DC output voltage with a level related to the time averaged current flowing from the current-to-voltage converter, while allowing the filter to settle to a new voltage level quickly.

As mentioned in the current gate clock generator discussion, offset counts are added to the digital words that program the voltage DAC to improve low end linearity. This offset is removed by the zero correction circuit. This negative current sink acts on the constant output impedance of the filter to remove the offset voltage. The system output zero is adjusted by R3062. Since this adjustment is effected by the DAC gain (full scale value), the reference for this current source is taken from the wiper of the Full Scale adjustment, providing first order cancellation of this interaction.

Output Supply ◇6◇

This supply provides $+12\ V_1$, $+8\ V_1$, $-12\ V_1$, and $-25.5\ V_1$. 25 VAC from the power module provides voltage for this supply. This AC voltage is rectified by CR2032, filtered by C2022, and passes to solid state regulator U1030. The $+12\ V_1$ output is determined by R1011, R1022, and R1028. The $+8\ V_1$ is derived from the $+12\ V_1$ by solid state regulator U2031.

Power for the negative output supplies is rectified by CR2033 and filtered by C1031 and C1041. R1035 is a bleeder resistor used to discharge the capacitors when power is removed. The -25.5 V is regulated with a descrete regulator. This voltage is referenced to the $+12\ V_1$ by the voltage divider consisting of R1036 and R1033. The tap point if this divider is buffered by emitter follower Q1032. R1032 keeps a quiescent current flowing through Q1032 and provides a minimum load on the $-25.5\ V_1$ supply. The emitter voltage from Q1032 is compared with $\downarrow_1$ in Q1031. The collector of Q1031 controls the darlington driver Q1021. Q1021 then drives the output common emitter stage which is the NPN transistor in the power module. As the load increases on the $-25.5\ V_1$ supply, the voltage begins to go more positive. This raises the voltage on the emitters of Q1032 and Q1321 causing Q1031 to turn on more, raising its collector voltage. This in turn, raises the base voltage on driver Q1021, raising its emitter turns on the output stage more to compensate for the increased load.

$-12\ V_1$ is obtained through emitter follower Q2021. The voltage on this transistor base is set by R1024 and R1023.

Control Supplies ◇6◇

The remaining 25 VAC power module winding supplies voltage for the control supplies that are referenced to the − output. Positive rectification is accomplished by CR4022. The voltage on emitter follower transistor Q4041 is set by an 11 V zener diode, VR4021. $+10\ V_2$ is available at the emitter of Q4041.

Rectification for the negative control supplies is accomplished by CR4021. C1051 provides filtering. Q5041 is the emitter follower transistor for the $-21\ V_2$ supply. The base voltage for this transistor is provided by VR4041, a 22 V zener diode. Relatively constant current for the zener diode over the wide range of unregulated voltages is provided by FET Q5031. $-21\ V_2$ is divided by R4034 and R4033 to drive the base of emitter follower Q5032. Q5032 emitter provides the $-15\ V_2$.

Ground Referenced Supplies ◇6◇

$+8$ V, regulated by the power module switching supply is supplied to regulator U1051. This provides $+5\ V_3$ for the microcomputer, control logic, and DM.

−26 Vdc drops to 12.6 V across VR3021 and R3022 to provide correct base voltage for Q4031. $-12\ V_3$ for the DM is available at Q4031 emitter.

The $\overline{POR}$ line is pulled from TTL logic low to high by the power module, when its DC voltages are regulated. This signal resets the microprocessor, GPIB interface, output relay, and provides a segment test of the DM display. Refer to the power module instruction manual for the specification concerning this signal.

Front Panel ◇7

Each of the five digit displays DS1011-DS1025, have a common anode and individual cathodes for the various segments. The connections to these modules are shown on the diagram.

The COARSE and FINE controls (S302A and B) each provide a two bit gray code for voltage or current change. Zener diodes VR2013-VR2026 are connected to each output line. They clamp any static induced voltages on these lines to prevent it from entering the microcomputer.

The control lines from the front panel pushbuttons are held high at +5 V by R3106. When the pushbuttons are pressed, the lines are grounded (low true).

Also shown on diagram 7 are the connections to the front panel LEDs. The display units LEDs DS1031 and DS1032 are driven through the display select LEDs. Current from the Display Output Voltage LED DS3011, flows throught the Volts LED DS1031. Current to illuminate either the Display Output Current LED DS3013, or Display Current LED DS4014, must also Pass through the mA LED DS1032.

CALIBRATION

PERFORMANCE CHECK

Introduction

This procedure checks the electrical performance requirements as listed in the Specifications section of this manual and may be used in an incoming inspection facility to determine acceptability of performance. If the instrument fails to meet the requirements given in this Performance Check section, the Adjustments Procedure should be performed. Refer to the Parts Location Grid in the pull-out pages for the following Checks and Procedures. Except as noted, this procedure can be performed at any ambient temperature between 0°C to +50°C.

Performance Check Interval

The performance check should be performed at the following intervals:

- At incoming inspection.
- After 2000 hours of operation or every 12 months, if used infrequently.
- After repair or accidental abuse.

Services Available

Tektronix, Inc. provides complete instrument repair facilities at local field service centers and at the factory service center. Contact your local Tektronix Field Office or representative for more information.

Test Equipment Required

The test equipment, or equivalent (except as noted) listed in Table 5-1 is suggested to perform the Performance Check and the Adjustment Procedure in this manual.

Table 5-1
Suggested Test Equipment

Description	Min. Requirements	Example
Power Module		TEKTRONIX TM 5006 or TM 5003
Digital Voltmeter	0..003% accuracy on 200 mV and 20 V DC ranges. 6 1/2 digit.	John Fluke 8505A
Oscilloscope	1 mV/Div. Vertical with 1 MHz and 5 MHz BW limits and delayed sweep time base.	TEKTRONIX 7603 with 7A13, 7A22, and 7B53A.
Square Wave Generator	4 V p-p into 50 Ω with adjustable output offset.	TEKTRONIX FG 501A Function Generator
Variable Line Autotransformer	1000 VA Capability	General Radio Variac W10MT3W
Adapter, bnc female-to-dual banana adapter (2 ea.)		Tektronix Part No. 103-0090-00
Bnc connectors, 50 Ω coaxial cables 42 inch (2 ea.)		Tektronix Part No. 012-0057-01
Bnc TEE connector		Tektronix Part No. 103-0030-00
Adapter, bnc-to-Mini Hook Test Clips		Tektronix Part No. 013-0076-01
6 inch banana-to-banana plug patch cord		Tektronix Part No. 012-0024-00
NPN Transistor	$\beta >$ 50, Pd $>$ 10 W	TIP 29C Tektronix Part No. 151-0464-00
100 Ω Resistor	1/4 W, 5%	Tektronix Part No. 315-0101-00
10 Ω Resistor	10 W, 5%	Tektronix Part No. 308-0175-00
5.1 Ω Resistor (2 ea.)	1/4 W, 5%	Tektronix Part No. 307-0113-00
1.0 Ω Resistor (2 ea.)	1/4 W, 5%	Tektronix Part No. 308-0677-00
Banana plug (4 ea.)	Un-insulated	Tektronix Part No. 134-0013-00
Extender cable		Tektronix Part No. 067-0645-02

Performance Check Steps

1. Check Constant Voltage Range and Overall Accuracy.
2. Check Source Effect.
3. Check Load Effect.
4. Check Step Size Accuracy.
5. Check PARD.
6. Check Load Transient Recovery.
7. Check Constant Current Range and Overall Accuracy.
8. Check Display Current Limit Accuracy.
9. Check Display Output Current Accuracy.
10. Check Display Output Voltage Accuracy.
11. Check GPIB Operation.

PS 5004 Performance Check Summary

Serial Number Date:		Notes:	
STEP #	**CHECK**	**ALLOWABLE LIMITS**	**ACTUAL VALUE**
1. Constant Voltage Range and Accuracy			
	0.0000 V	±2.0 mV (15-30°C) ±3.0 mV (0-50°C)	
	20.0000 V	19.9960 V to 20.0040 V (15-30°C) 19.9900 V to 20.0100 V (0-50°C)	
2. Source Effect			
	10.0000 V	±0.5 mV of nominal line value	
3. Load Effect			
	1.0000 V	±1 mV of unloaded output	
4. Step Size Accuracy (15-30°C only)			
	500 μV	300-700 μV	
5. PARD			
		1 mV p-p 20 Hz to 1 MHz 3 mV p-p 20 Hz to 5 MHz	
6. Load Transient Recovery			
	to 5 mV for 100 mA change	200 μS	
7. Constant Current Range and Accuracy			
	10.0 mA 305.0 mA	4.8-15.2 mA 293.9-316.1 mA	
8. Display Current Limit Accuracy			
		±1.5% + 5 mA of measured current	
9. Display Output Current Accuracy			
		±1.5% + 1 mA of measured current	
10. Display Output Voltage Accuracy			
		±0.15% + 6 mV of measured voltage	

PERFORMANCE CHECK PROCEDURE

1. Check Constant Voltage Range and Overall Accuracy

PS 5004 Control Settings

DISPLAY	OUTPUT V
OUTPUT	Off

a. Connect the digital voltmeter to the PS 5004 output connectors using a bnc cable and dual banana plug-to-bnc adapters. The shield lead connects from the PS 5004 – OUTPUT terminal to the voltmeter Low Input. Connect a patch cord from the – OUTPUT to the front panel ground lug. Connect the voltmeter guard to the Low Input terminal.

b. Set the voltmeter to DC volts, Autoranging, and Internal Triggered.

c. Press the PS 5004 OUTPUT button to turn on the output.

d. CHECK—That the PS 5004 output voltage is 0.0000 V ±3 mV (±2 mV for +15°C to +30°C ambient).

e. Rotate the COARSE knob clockwise until the PS 5004 display indicates no further voltage increase.

f. CHECK—That the PS 5004 output voltage measured on the digital voltmeter is between 19.9960 V and 20.0040 V (+15°to +30°C) or 19.9900 V and 20.0100 V (0°C to +50°C).

g. Leave these connections for the next step.

2. Check Source Effect

a. Rotate the COARSE knob counter clockwise until the digital voltmeter reads 10.0000 V. Use the FINE knob, if necessary, to obtain a closer reading.

b. Determine the power module selected line voltage range.

c. Note the present digital voltmeter reading.

d. Adjust the variable auto transformer for the selected range lower line voltage.

e. Allow the PS 5004 a few moments to thermally stabilize.

f. CHECK—that the output voltage is within 0.5 mV of the previous reading.

g. Adjust the variable auto transformer to the selected range higher line voltage.

h. Allow the PS 5004 a few moments to thermally stabilize.

i. CHECK—that the output voltage is within 0.5 mV of the initial reading.

j. Adjust the variable auto transformer to the selected line voltage range center.

3. Check Load Effect

a. Turn off the PS 5004 OUTPUT.

b. Adjust the output voltage, using the COARSE and FINE knobs, for a display of 1.000 V.

c. Set the DISPLAY to I LIMIT and adjust the COARSE knob for maximum current limit.

d. Set up the test components as shown in Fig. 5-1.

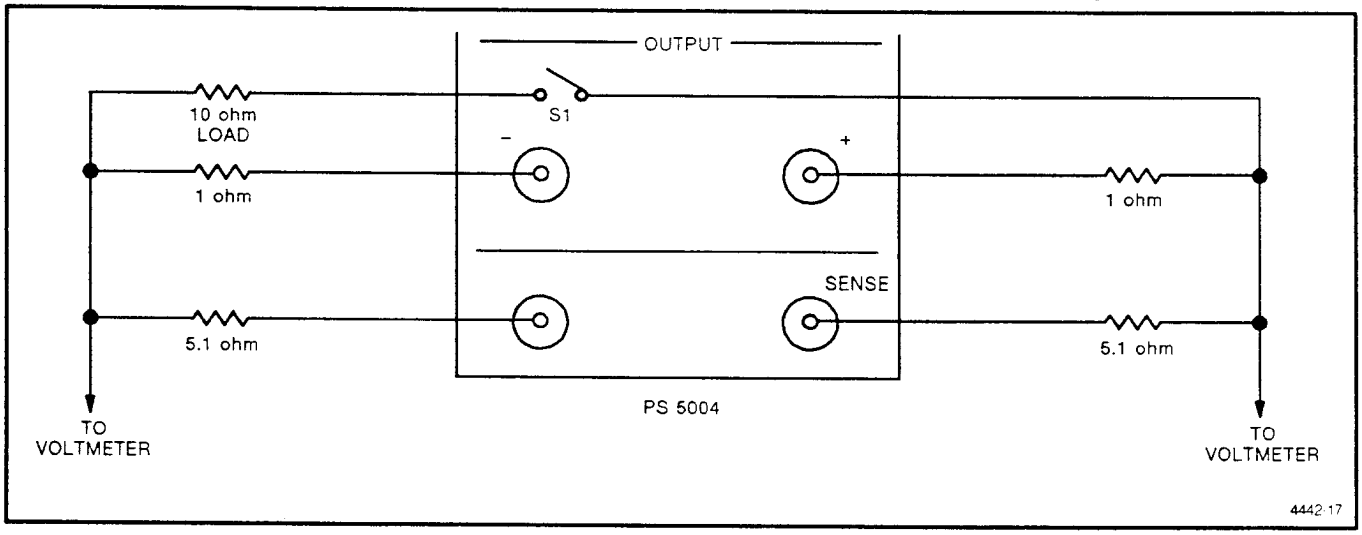


Fig. 5-1. Calibration fixture (passive).

NOTE

Be certain the digital voltmeter monitors the SENSE side of the leads ONLY (not the OUTPUT side).

e. Turn on the PS 5004 OUTPUT.

f. Open the 10 Ω load switch. This can be verified by momentarily setting the DISPLAY to monitor OUTPUT I. The display reads approximately 0 mA when the switch is open.[1] (Display indicates approximately 100 mA if switch is closed.)

g. Note the digital voltmeter reading.

h. Close the 10 Ω load switch. The PS 5004 output display should indicate approximately 100.0 mA.[1]

i. CHECK—that the output voltage at the sense side of the load is within 1.0 mV of the previously recorded reading.

j. Disconnect the test set up.

[1]Actual reading is dependent on PS 5004 DM calibration.

4. Check Step Size Accuracy (applicable in +15°C to +30°C only)

a. Connect the digital voltmeter to the OUTPUT terminals (refer to step 1).

b. Turn on the PS 5004 output.

c. Set the PS 5004 DISPLAY to read OUTPUT V.

d. Rotate the COARSE knob counterclockwise until the output voltage no longer changes. Using ONLY the COARSE knob, adjust the output voltage for a PS 5004 display readout of 100 mV.

e. Note the digital voltmeter reading.

f. Carefully rotate the FINE knob very slowly counterclockwise until the output voltage drops ONLY one step.

g. CHECK—that the reading is 300 μV to 700 μV lower than the previous reading.

h. Disconnect the voltmeter from the PS 5004 OUTPUT.

5. Check PARD (Periodic and Random Deviation)

a. Set the oscilloscope system as follows:

7A22

+ Input	AC Coupled
− Input	Grounded
Volts/Div	0.5 mV
LF −3 dB	DC
HF −3 dB	1 MHz
Position	On Screen

7A13

+ Input	AC Coupled
− Input	Grounded
Volts/Div	1 mV
BW	5 MHz
Position	On Screen

7B53A

Time/Div	5 Seconds
Trigger	
Mode	Auto
Coupling	AC
Source	Internal
Slope	+
Level	Center
Magnifier	X1

7603

Vertical Mode	7A22
Trigger Source	7A22

b. Connect the PS 5004 OUTPUT to the 7A22 + Input using a bnc cable and a bnc-to-banana plug adapter. Do NOT ground the PS 5004 + and − OUTPUT terminals with a separate ground patch cord.

c. Set the PS 5004 output to +12.5 V, ±100 mV.

d. Turn on the PS 5004 OUTPUT.

e. Adjust the oscilloscope intensity until the peaks of the noise envelope become visible.

f. CHECK—that output PARD is less than 1 mV p-p (2 divisions) with 1 MHz Bandwidth limit.

g. Move the bnc cable to the 7A13 + Input.

h. Switch the 7603 Vertical Mode and Trigger Selector to the 7A13.

i. CHECK—that the output PARD is ≤3 mV p-p (3 divisions) with a 5 MHz Bandwidth limit.

j. Remove test connections.

6. Check Load Transient Recovery

a. Set the PS 5004 to 2.000 V, maximum current limit, and OUTPUT OFF.

b. Construct and connect the dynamic load test circuit as shown in Fig. 5-2.

c. Set the oscilloscope system as follows:

7A13

+ Input	DC Coupled
− Input	Vc
Comparison Voltage	0.224 V +
Volts/Div	5 mV
BW	5 MHz
Position	2nd div from top with Identify pushed

7B53A

Time/Div	50 μS
Delay Time/Div	0.5 mS
Trigger	
Mode	Auto
Coupling	AC
Source	Internal
Slope	+
Level	Stable display

d. Set the FG 501A as follows:

Mode	Square Wave
Frequency	500 Hz
Run Mode	Free Run
Variable Symmetry	Off
Attenuator	−20 dB
Offset	Fully CW
Amplitude	Fully CW

e. Set the PS 5004 DISPLAY to OUTPUT I and turn on the OUTPUT.

f. Adjust the output voltage for a display readout of 105.0 mA

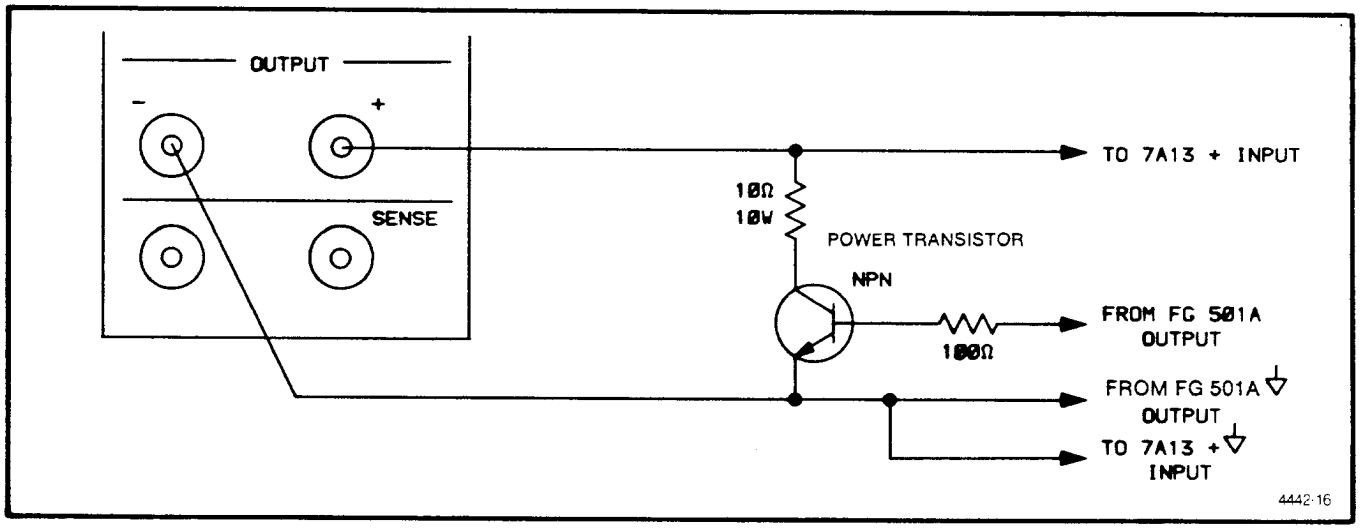


Fig. 5-2. Calibration fixture (active).

g. Using the 7B53A Delay Time Multiplier, position the displayed waveform negative going (load turn on) transition with the sharp edge located on the second graticule division (see Fig. 5-3A).

h. Adjust the 7A13 Comparison Voltage until the displayed waveform stable DC voltage (before the transition) is located on the second vertical graticule division from the top.

i. CHECK—that the recovery time to 5 mV (one vertical division) is less than 200 μS (four divisions).

j. Adjust the 7A13 Comparison Voltage until the displayed waveform stable DC voltage (before the transition) is located on the second vertical graticule division from the bottom.

k. Adjust the 7B53A Delay Time Multiplier to position the waveform positive going (load turn off) transition with the sharp edge located on the second graticule division (see Fig. 5-3B).

l. CHECK—that the recovery time to 5 mV (one vertical division) is less than 200 μS (four divisions).

m. Remove the PS 5004 connections and test circuit.

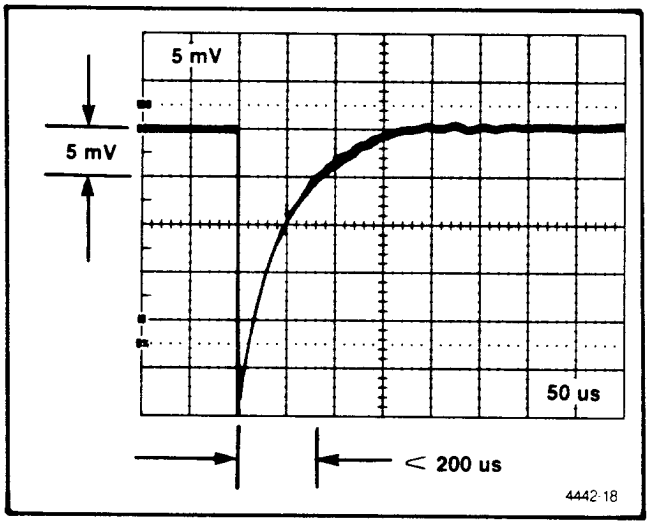


Fig. 5-3A. Load transient recovery waveform (increasing load).

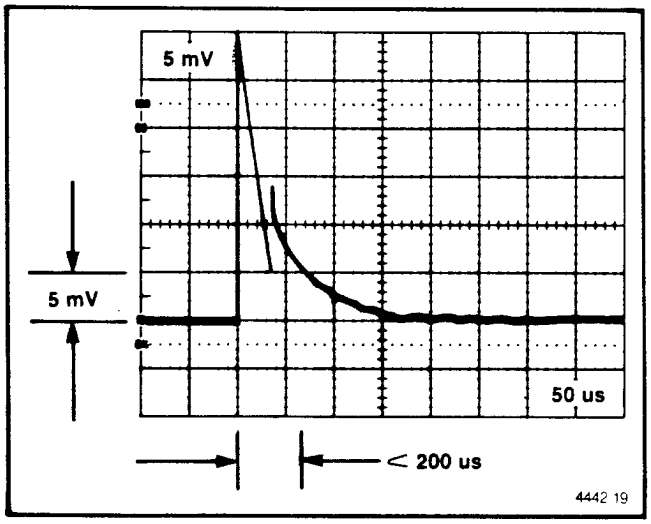


Fig. 5-3B. Load transient recovery waveform (decreasing load).

7. Check Constant Current Range and Accuracy

a. Set the PS 5004 to 1 V ±10 mV output, with the OUTPUT OFF.

b. Set the PS 5004 DISPLAY to I Limit. Set the Current limit to minimum by rotating either knob counterclockwise until the display indicates no further change.

c. Connect the PS 5004 + OUTPUT to the mA Input and the − OUTPUT terminal to the DM 501A Low Input.

d. Set the DM 501A to measure DC Current, using the 2000 mA Range.

e. Turn on the PS 5004 OUTPUT.

f. CHECK—that the DM 501A displayed output current reading is 4.8 mA to 15.2 mA.

g. Rotate either knob on the PS 5004 clockwise until the display indicates no further increase in current limit.

h. CHECK—that the current measured on the DM 501A is 293.2 mA to 316.1 mA.

i. Leave these connections and settings for the next step.

8. Check Digital Meter Current Limit Accuracy

a. Note the DM 501A measured output current reading.

b. CHECK—that the displayed current limit is within ± (1.5% + 5 mA) of the measured output current.

c. Leave these connections and settings for the next step.

9. Check Display Output Current Accuracy

a. Set the PS 5004 DISPLAY to OUTPUT I.

b. Note the DM 501A measured output current reading.

c. CHECK—that the displayed output current is ± (1.5% + 1 mA.) of the measured output current.

d. Turn off the PS 5004 OUTPUT.

10. Check Display Output Voltage Accuracy

a. Connect the PS 5004 OUTPUT to the digital voltmeter Input using a bnc cable and two bnc-to-dual banana plug adapters. The PS 5004 − and voltmeter Low connect to the bnc shield.

b. Set the PS 5004 DISPLAY to OUTPUT V and turn the OUTPUT ON.

c. Set the PS 5004 output voltage to ±10.0 V ±10 mV.

d. Note the digital voltmeter reading.

e. CHECK—that the PS 5004 display is the same as the measured voltage within ± (0.15% + 6 mV).

f. Remove all connections.

11. Check the GPIB Bus through Controller

Refer to the Talker/Listener sample programs in the Programming section of this manual for the following check.

a. Connect the selected controller to the TM 5000-Series power module using a suitable GPIB cable.

b. Run the program and test the PS 5004 by sending various setting and queries commands.

c. CHECK—the controller display for PS 5004 returned query data.

d. Send the PS 5004 a SEND command.

e. CHECK—that the PS 5004 returns the present display reading to the controller.

f. Send the PS 5004 VRI ON and CRI ON commands.

g. Turn on the PS 5004 OUTPUT, and set the Voltage to approximately 1 V.

h. Short the PS 5004 Output using a patch cord.

i. CHECK—that the PS 5004 sent the controller an SRQ. The status byte returned, when polled, is 202 (decimal).

j. Remove the short from the Output.

k. CHECK—that the PS 5004 sent the controller an SRQ. The status byte returned, when polled, is 201 (decimal).

NOTE

In order to send SRQ for current limit and voltage limit, CRI and VRI must be set ON. The status byte will be from the first event which created the SRQ and will remain the same until the PS 5004 is polled. Therefore, it may be necessary to repeat the test until all previous SRQs are cleared.

ADJUSTMENT PROCEDURE

Introduction

This procedure need not be performed unless the instrument fails to meet the performance requirements of the electrical characteristics listed in the Specification section of this manual. To ensure instrument accuracy, perform the adjustment of the instrument every 2000 hours of operation or every 12 months if used infrequently. Adjustment may be required after a repair has been made. If adjustment of internal controls does not bring the instrument performance within the limits listed in the Specification section, troubleshooting is indicated. To insure full accuracy over temperature, adjustments must be made with the instrument operating at an ambient temperature of +21°C to +25°C.

Test Equipment Required

Test equipment used for adjustment of the PS 5004 is listed at the beginning of the Performance Check, in this section.

Preparation

To gain access to the test points and adjustable components, remove the instrument side covers (refer to the Maintenance section for instructions). All adjustments are accessible through the side covers. Refer to Fig. 5-4 for the Main board adjustments and test points locations.

CAUTION

Some areas of the circuit board surface contain precision high impedance circuitry which become exposed when the right side cover is removed. These areas are susceptible to contamination that can cause serious performance degradation to the PS 5004. Avoid touching or exposing the circuit board to other contamination such as Pink Polethylene or other detergent based anti-static materials. If the circuit board becomes contaminated, refer to the cleaning procedures given in the Maintenance section.

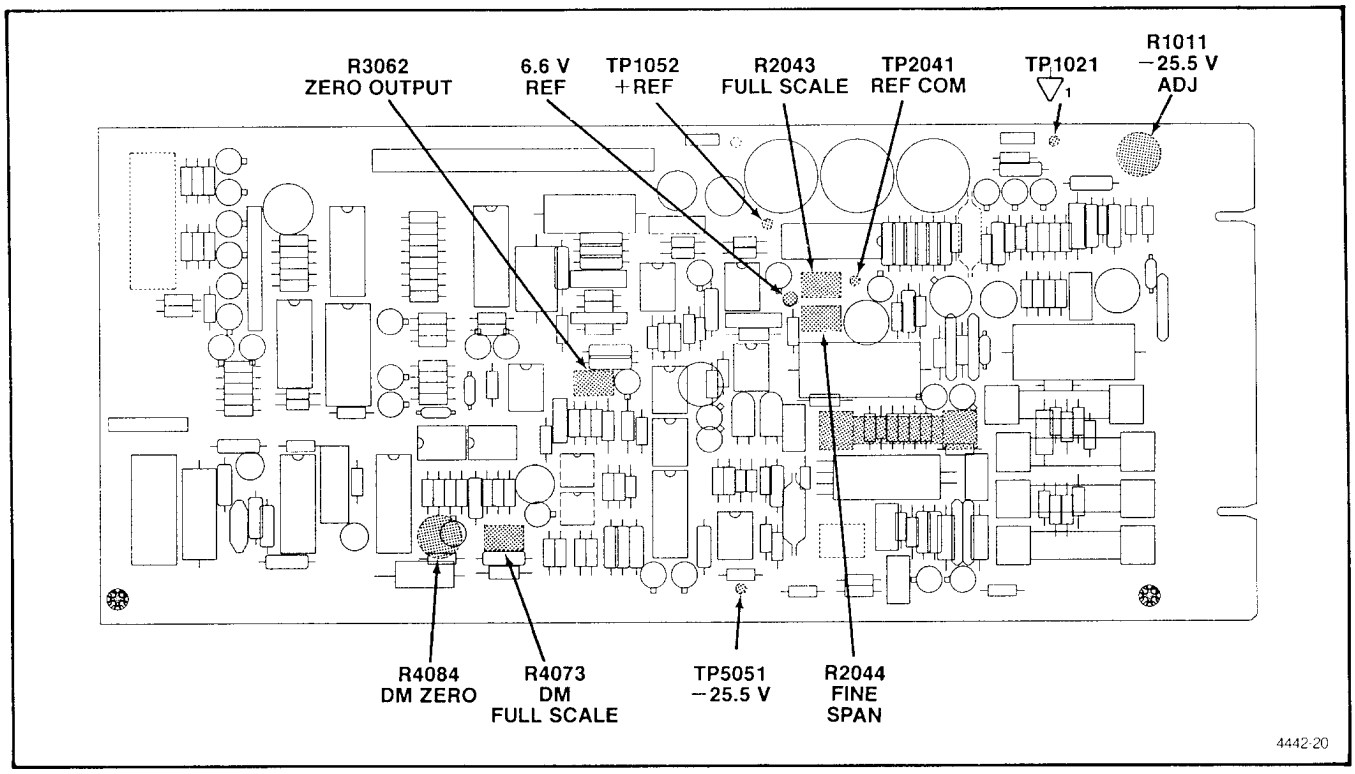


Fig. 5-4. Main board adjustments and test points locations.

Preliminary Procedure

Connect the PS 5004 to the power module via the extender cable. Do not position the PS 5004 in the path of fans, air conditioning ducts, or any other source of air movement that can cool the internal components below their normal operating temperature.

Connect the test equipment and the power module to the variable autotransformer. Select the line voltage range for the power module. Adjust the output voltage of the autotransformer to the range center. Turn on the power module and test equipment and allow at least 30 minutes warm-up time for the PS 5004.

PROCEDURE

1. Coarse Reference Adjust (S1041)

NOTE

Steps 1 and 2 should only be performed if reference IC U2041 has been replaced.

a. Turn the power module power switch off.

b. Remove the Programmer board, using the procedure in the Maintenance section, if it is not already removed.

c. Connect the PS 5004 to the power module using the flexible extender.

d. Carefully place a long, thin, straight screwdriver in the slot of Coarse Reference Adjust Switch, S1041.

e. Connect the negative lead from the digital voltmeter to Ref Common test point, TP2041.

f. Turn on the power module power switch. Allow the PS 5004 internal supplies to stabilize for approximately 10 seconds.

g. Apply the positive voltmeter probe to the 6.6 V test pad.

h. ADJUST—Coarse Reference, S1041, to the switch detent that allows the closest value to the 6.6 V (test pad).

NOTE

Although S1041 has 16 positions, it provides only 8 discrete levels of voltage. Positions 8 – F are duplications of positions 0 – 7.

2. Full Scale (R2043) and Fine Span (R2044) Presets

NOTE

Perform Step 2 only if reference IC, U2041, has been replaced.

a. Move positive voltmeter probe to + Ref Test Point, TP1052.

b. ADJUST—Full Scale Adjust, R2043, for a voltmeter reading of 6.550 V ±5 mV.

c. Move positive voltmeter lead to the wiper of Fine Span Adjust, R2044.

d. ADJUST—Fine Span Adjust, R2044, for a voltmeter reading of 6.550 V ±5 mV.

e. Turn off the power, remove all test connections, and reassemble the instrument.

f. Reconnect the flexible extender to the PS 5004, apply power, and allow at least 30 minutes warm up time.

3. −25.5 V Adjust (R1011)

a. Connect a test cable from the digital voltmeter and attach the positive lead to the −25.5 V test point (TP 5051) and the negative lead to ground[1] (TP 1021).

b. ADJUST— −25.5 V Adjust, R1011, for −25.5 V, ±50 mV.

NOTE

Although the −25.5 V is adjusted to ±50 mV, the drift specification is ±500 mV.

c. Remove all cable connections.

4. Zero Output Adjust (R3062)

a. Connect the PS 5004 OUTPUT to the digital voltmeter input using a bnc cable and a pair of bnc-to-banana plug adapters. The shield side of the bnc is connected to the PS 5004 – OUTPUT terminal, and the voltmeter Low input. The voltmeter guard is driven by the Low input. Connect the patch cable from the PS 5004 – OUTPUT terminal to the ground post connector.

b. Set the voltmeter to DC volts, with Autorange On.

c. Place the Mode Jumper, J4024 (located on the Programmer board) in the CAL position. Refer to the Component Locations pullout pages.

d. Turn the PS 5004 off, then back on.

e. ADJUST—Zero Output Adjust, R3062 for 0.0000 V ±100 μV.

f. Leave the connections for the next step.

5. Full Scale Adjust (R2043)

a. Press and hold the PS 5004 INST ID button (front panel) until the display reads C.2. The display should read approximately 19.000 V when the INST ID button is released.

NOTE

While in the CAL MODE, the PS 5004 will cycle through the three calibration presets, C1 (0.0000 V), C2 (19.0000 V), and C3 (100.0 mV), as long as the INST ID button is depressed. If the PS 5004 display indicates the wrong voltage (one of the other presets) when the INST ID is released, the INST ID was held too long. If this occurs, press the INST ID to repeat the preset cycle.

b. ADJUST—Full Scale Adjust, R2043, for a digital voltmeter reading of 19.0000 V ±100 μV.

c. Leave all connections for the following step.

6. Fine Span Adjust (R2044)

a. Press and hold the INST ID button (front panel) until the display reads C.3. The PS 5004 display should read approximately 0.100 V when the button is released.

b. ADJUST—Fine Span Adjust, R2044, for a digital voltmeter reading of 100.00 mV ±50 μV.

c. INTERACTION—Both Full Scale and Fine Span adjustments interact slightly with the Zero Volts adjustment. Press and hold the INST button until C.1. appears in the display. This programs the output to zero volts. Repeat steps 4, 5 and 6 until voltages measured on the digital voltmeter are within indicated tolerances.

d. Leave connections for the following steps.

7. Full Scale (R2043), Fine Span (R2044), and Zero Output (R3062) Final Adjusts

a. Place the MODE Jumper J4024, (located on the Programmer board) in the RUN position.

b. Turn off the PS 5004, then back on. Do not touch either knob after the instrument powers up.

c. Using ONLY the COARSE knob (front panel), adjust the output voltage for a PS 5004 displayed reading of approximately 0.700 V.[1]

d. Turn the PS 5004 OUTPUT ON.

e. ADJUST—Zero Output Adjust, R3062, for a digital voltmeter reading of 700.00 mV ±50 μV.

f. If the digital voltmeter has a NULL mode, activate it. If not, record the reading for 10 μV resolution.

NOTE

Due to random noise in the system, the last few digits of the voltmeter will not be stable. There can also be short term drift noticeable in the PS 5004 output. Keep in mind that the least significant digit on the 200.0 mV range is 100 nV.

g. Carefully Rotate the FINE knob to decrement the voltage by one step (500 μV).

NOTE

It is important to decrement the output voltage by only one step. This is verified by rotating the FINE knob clockwise one increment, then checking the voltmeter readout for the original output voltage.

[1]**Actual reading is dependent on PS 5004 DM calibration.**

h. ADJUST—Fine Span Adjust, R2044 for a decrease of 500 μV $\pm$10 μV reading from the previous step.

i. Turn off the voltmeter NULL function, if applicable.

j. Rotate the COARSE knob of the PS 5004 clockwise until the display indicates no further increase in output voltage.

k. Using only the COARSE knob, decrement the voltage one step, (100 mV).

l. ADJUST—Full Scale Adjust, R2043, if necessary for an output voltage of 19.9000 V $\pm$50 μV.

m. If an adjustment was made in step 7l, rotate the COARSE knob counterclockwise until no further decrease in output voltage is noted on the PS 5004 display. Repeat steps 7c through 7h once.

n. Leave the connections for the following step.

8. DM Zero Adjust (R4084)

a. Rotate the COARSE knob counterclockwise until no further decrease in voltage is noted on the PS 5004 display.

b. Turn the OUTPUT ON.

c. Rotate the FINE control for the digital voltmeter's closest reading to 20.0 mV.

d. ADJUST—DM Zero Adjust, R4084, for a reading changing between 19 mV and 20 mV in the display. Rotate R4084 slightly clockwise until the reading just stabilizes on 20 mV.

e. Leave connections for the next step.

9. DM Full Scale Adjust (R4073)

a. Rotate the COARSE knob clockwise until there is no further increase in the display reading.

b. ADJUST—DM Full Scale Adjust, R4073, for a displayed reading changing between 19.999 V and 20.000 V. Rotate R4073 slightly clockwise until the reading just stabilizes on 20.000 V.

c. Remove the digital voltmeter connection.

d. Replace the PS 5004 right side cover.

10. I Limit Adjust (R4076)

a. Set the PS 5004 OUTPUT OFF, OUTPUT VOLTAGE to approximately 5 V, and DISPLAY to I LIMIT.[1]

b. Connect the + OUTPUT to the ammeter (DM 501A) mA Input, and the – OUTPUT to the ammeter Low Input.

c. Rotate either knob on the PS 5004 until no further increase in current limit is noted on the display.

d. Set the ammeter to DC mA Function, 2000 mA Range.

e. Turn the PS 5004 OUTPUT ON.

f. ADJUST—I Limit, R4076, (located on the Programmer board) for an ammeter reading of 305.0 mA $\pm$0.1 mA.

g. Remove all PS 5004 connections.

h. Replace the PS 5004 left side cover.

[1]**Actual reading is dependent on PS 5004 DM calibration.**

MAINTENANCE

Introduction

This section of the manual describes on-board jumpers and rear interface information. It also provides general maintenance and troubleshooting information.

CAUTION

To prevent damage to the PS 5004, turn off the power module before installing or removing the instrument. Do not use excessive force to install or remove.

Calibration and Diagnostic Jumper Positions

Two jumpers, located on the lower left corner of the PS 5004 Programmer board, are used to enter special calibration or diagnostics modes, on power up (see Fig. 6-1). Jumper, J4020, places the instrument in Forced Data mode. In this mode, the instruction loaded in the address switch and J4024 will be placed on the data bus during every fetch cycle. Remove the data jumper, W4030 to isolate the data bus from the kernel (see Signature Analysis in this section, for more information).

J4024 provides special modes for calibration without using a GPIB controller and Firmware Signature Analysis. The Force Data jumper, J4020, must be in the RUN mode with data bus jumper W4030 installed before either mode can function.

REAR INTERFACE INFORMATION

Refer to Fig. 6-2 for the Main board assignments and Fig. 6-3 for the GPIB assignments.

Front-Rear Output Selection Jumpers

Connections to output and sense terminals are made at either the front panel or rear interface of the PS 5004. A set of four jumpers, located on the rear of the Main circuit board, are used to select either front or rear interface output. The rear interface + OUT (pin 22A) and + SENSE (pin 23A) signals are switched through on-board jumper straps P4041B (J4041B). The rear interface – OUT (pins 21A,B) and – SENSE (pins 24A,B) signals are switched through on-board jumper straps P4041C (J4041C). Access to the jumpers is obtained by removing the right side cover of the instrument (see Circuit Board Removal). Refer to Fig. 6-5A for location. The PS 5004 is shipped with the jumpers configured for front panel output. To change the output to the rear interface, move all four jumpers to the lower position.

NOTE

For proper regulation and operation, all four PS 5004 output jumpers must be in the same position.

GENERAL MAINTENANCE

Troubleshooting Aids

Diagrams. Complete circuit diagrams are located in the pullout pages in the Diagrams and Circuit Board illustrations section of this manual. The portions of the circuit mounted on the circuit boards is enclosed by a solid line. The circuit number of each component in this instrument is shown on a diagram. See the first page of the Diagrams and Circuit Board Illustrations section for definitions of the symbols and reference designators used on the diagrams.

Circuit Board Illustrations. Circuit board illustrations are provided in conjunction with the circuit diagrams. Each board-mounted component shown on a diagram is also identified on the circuit board illustration by circuit number. A table is provided with each diagram, listing components by assembly and circuit number. The table also lists the component grid locations on both the associated diagram and the circuit board illustrations.

Troubleshooting Equipment

Before using any test equipment to make measurements on static-sensitive components or assemblies, be certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

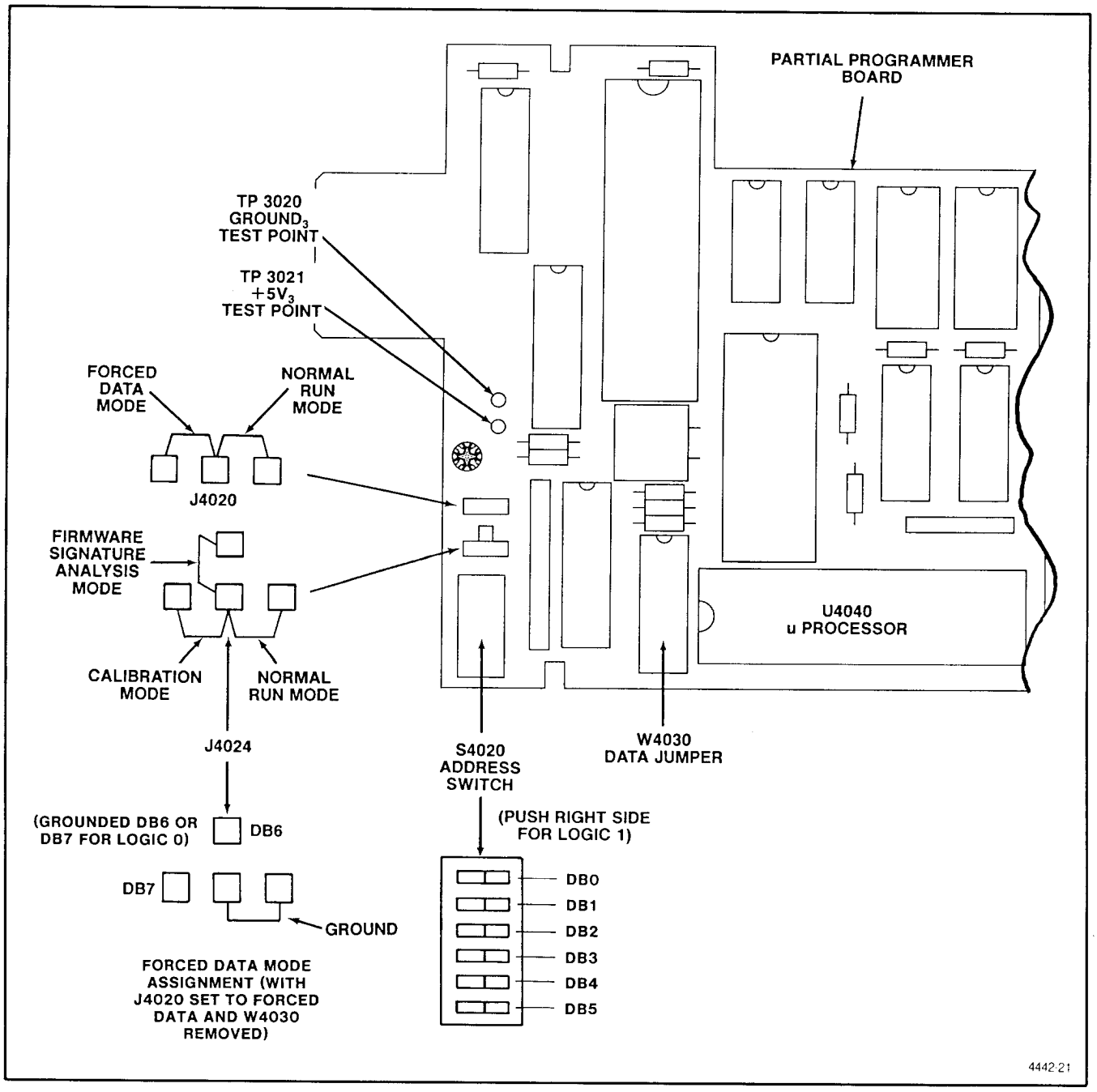


Fig. 6-1. Programmer board jumpers and testpoint locations and positions.

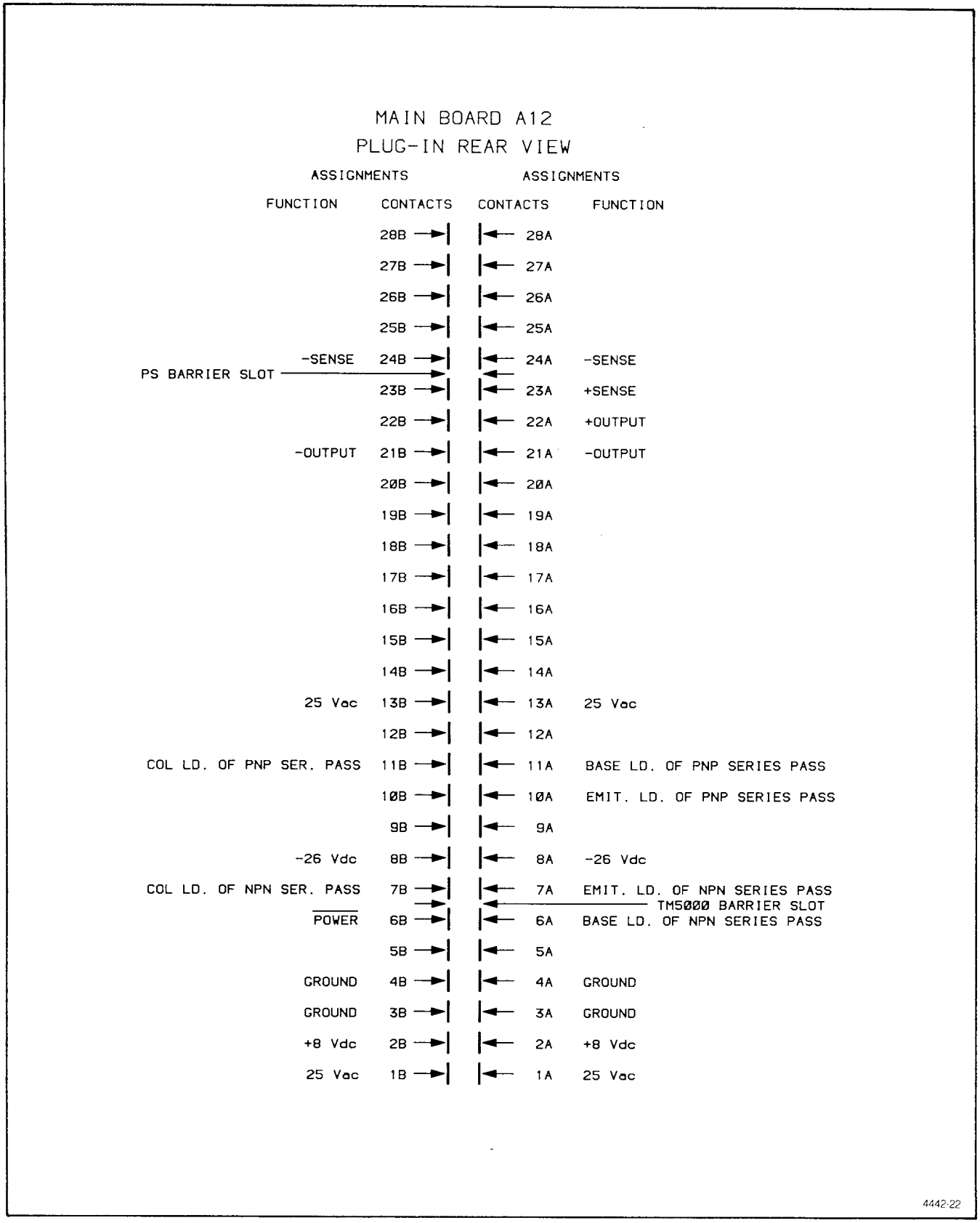


Fig. 6-2. Main board rear interface connector assignments.

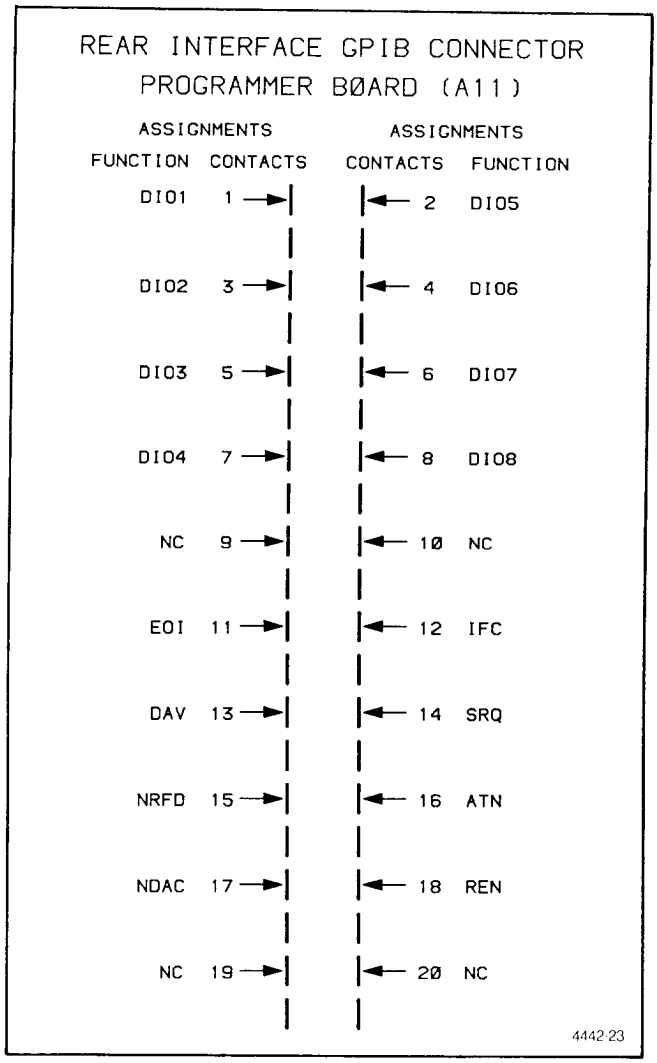


Fig. 6-3. GPIB board rear interface connector assignments.

Static-Sensitive Components

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 6-1 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage:

1. Minimize handling of static-sensitive components.

2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.

3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.

4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5. Keep the component leads shorted together whenever possible.

6. Pick up components by the body, never by the leads.

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only special antistatic suction type or wick type desoldering tools.

Table 6-1
RELATIVE SUSCEPTIBILITY TO STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels[a]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a]**Voltage equivalent for levels: (Voltage discharged from a 100 pF capacitor through a resistance of 100 Ω.)**

1 = 100 to 500 V 4 = 500 V 7 = 400 to 1000 V (est.)
2 = 200 to 500 V 5 = 400 to 600 V 8 = 900 V
3 = 250 V 6 = 600 to 800 V 9 = 1200 V

Obtaining Replacement Parts

Electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, it may be possible to obtain many of the standard electronic components from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., check the Replaceable Electrical Parts list for the proper value, rating, tolerance, and description.

NOTE

When selecting replacement parts, remember that the physical size and shape of a component may affect its performance in the instrument.

Some parts are manufactured or selected by Tektronix, Inc. to satisfy particular requirements or are manufactured for Tektronix, Inc., to our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine the manufacturer, refer to the replaceable parts lists and the Cross Reference Index, Mfr. Code Number to Manufacturer.

When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type (include modification or option number).

2. Instrument serial number.

3. A description of the part (if electrical, include complete circuit number).

4. Tektronix part number.

CIRCUIT BOARD REMOVAL

1. Side Covers Removal

Most PS 5004 maintenance procedures can be performed by removing only the side covers. These covers are secured with quarter-turn fasteners.

Use care in handling the circuit boards, with covers removed. The PS 5004 Main circuit board contains circuitry that is susceptible to performance degradation, caused by circuit board contamination.

CAUTION

Avoid touching etched circuit board surfaces.

The top, bottom and back covers removal are necessary only when the Main circuit board assembly is replaced.

2. Programmer Circuit Board Removal

It is necessary to remove the Programmer board, when accessing the Main board components for servicing or troubleshooting. The Programmer board connects electrically to the Main board through a 50 conductor ribbon cable. This cable has sufficient length to allow PS 5004 operation when using the module extender cable with the Programmer board removed.

Remove the interconnect cable from the top of the circuit board and carefully pull it back, out of the way. Then remove the five board mounting screws.

Use care when lifting the Programmer board front end, to clear the front panel. Slide the board toward the front of the instrument, until the GPIB connector clears the rear cover.

Remove the circuit board and place it on a conductive foam pad (if Main board troubleshooting is not required).

3. Front Panel Latch Removal

Refer to Fig. 6-4 for the following procedure.

Use a small screwdriver to push forward slightly on the rear latch just in front of the spring. Press down on the latch knob to raise the latch knob extension at the point where the two latch pieces engage. While holding the latch knob down, push up on the front panel latch piece at the point of engagement to disengage the two pieces. Then, pull the latch knob out.

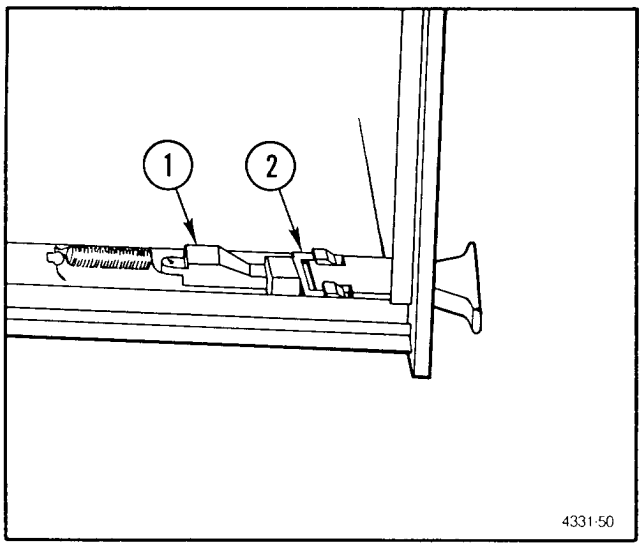


Fig. 6-4. Front panel latch removal.

4. Front Panel Removal

Remove the side covers and front panel latch.

Remove the four mounting screws located on the top and bottom cover. The longer mounting screw passes through the ground post (located in the lower right corner).

Remove the ground post by pulling it straight out.

Grasp the instrument top and bottom covers in one hand and firmly pull the front panel assembly straight out with the other hand.

CAUTION

Pulling the front panel out at an angle can cause damage to the interconnect pins.

During re-assembly (of the front panel), be certain to correctly align the interconnect pins with their respective jacks. Visual inspection of the lower interconnection is possible through the cutout in the lower cover.

5. Front Panel Circuit Board Removal.

Remove the instrument front panel.

Remove both knobs from the rotary encoder.

Remove the four retaining nuts from the the OUTPUT and SENSE connectors.

Remove the three mounting screws from the circuit board.

Carefully lift the circuit board out from the bottom.

When re-assembling the circuit board, do not tighten the three mounting screws because circuit board alignment may be necessary to center the pushbuttons in their cutouts in the front panel. Tighten these screws after making correct board alignment.

6. Main Circuit Board Replacement.

Perform procedures in steps 1 through 5, then remove the screws securing the two regulator ICs to the upper cover (see Fig. 6-5A).

Remove the two posi-drive screws from the rear of the upper cover. It is not necessary to remove the two guide pins from the bottom cover.

Remove the three 4-40 screws which pass through the metal mounting taps to the nylon stand off posts.

Remove the top cover using care not to loosen the insulators for the two regulator ICs.

Remove the remaining self tapping 6-24 screw from the front lower cover. The board assembly can now slide out from the rear cover.

When replacing the Main circuit board with a new assembly, use care to avoid contaminating the board surface. (See warning note under Side Cover Removal) Handle this circuit board by the edges only. Use only the special metalized anti-static shipping bag for storage of the board. Do not allow the Main circuit board to come in contact with Pink Polethylene or other detergent based anti-static protection materials.

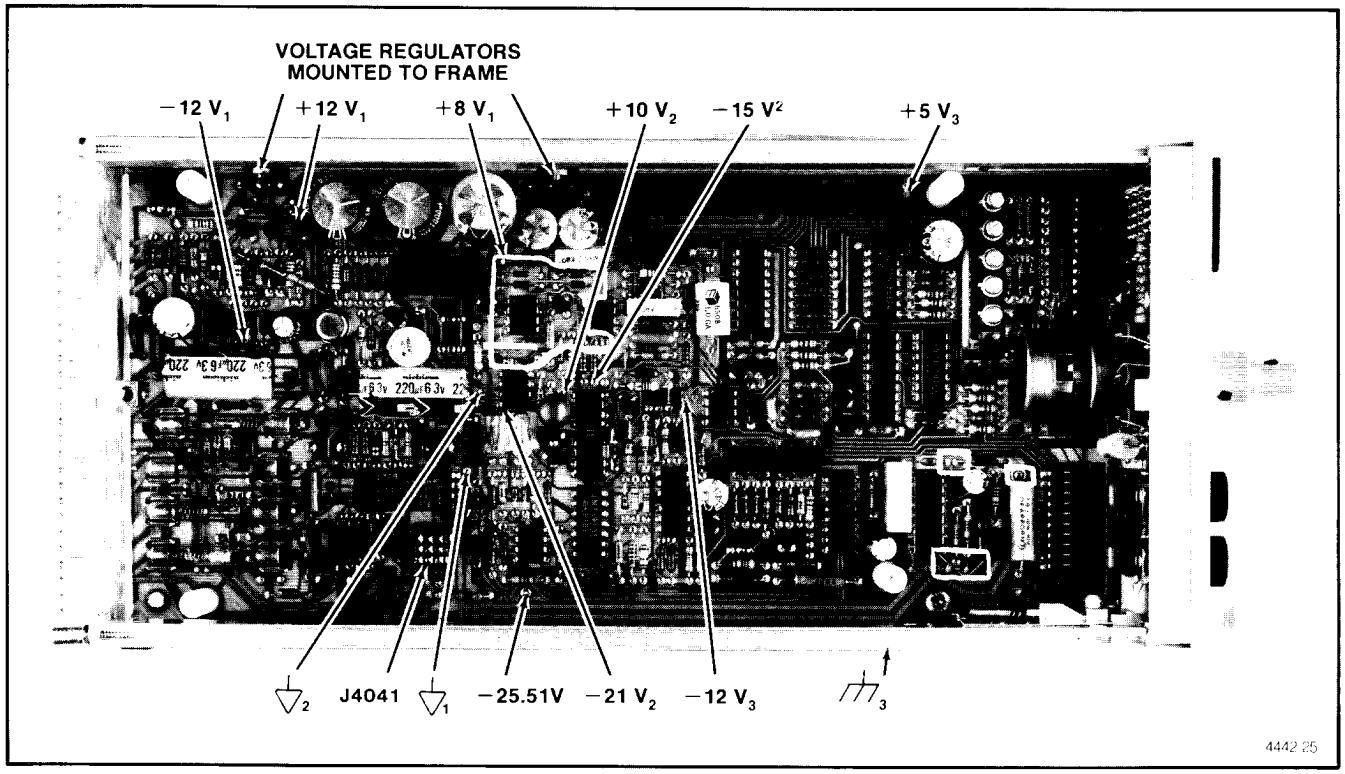


Fig. 6-5A. Main board sensitive circuitry areas (component side), power supply test points, front-rear jumper, and regulator ICs location.

To replace the Main circuit board, reverse the above procedure. Make certain that the insulators are in proper position under the regulator ICs which mount to the upper cover.

Although the replacement circuit board has been tested and calibrated, the interaction between the Main and Programmer circuit boards will necessitate recalibration of the finished instrument. Due to the high accuracy of the PS 5004, it is desirable to operate the instrument for at least 8 hours prior to final calibration when the Main board has been replaced.

Soldering Techniques

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques, which apply to maintenance of any precision electronic equipment, should be used when working on this instrument. Use only 60/40 rosin-core, electronic grade solder. The choice of soldering iron is determined by the repair to be made.

WARNING

The Main and Programmer circuit boards in the PS 5004 are multilayer type with conductive paths laminated between the top and bottom board layers. All soldering on these boards should be done with extreme care to prevent breaking the connections to these conductive paths. Only experienced maintenance personnel should attempt to repair these boards.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best head transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

Semiconductors

To remove in-line integrated circuits use an extracting tool. This tool is available from Tektronix, Inc.; order Tektronix Part Number 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end before the other end.

Exterior Cleaning

Chassis. Accumulated dust on the instrument chassis can be removed using a soft cloth or small brush. Remove dirt that remains, with a soft cloth dampened in a mild detergent and water solution; then remove the detergent with a cloth dampened in clean water. Do not use abrasive cleaners.

Front Panel. Use only a cotton swab or soft cloth, dampened in isopropyl alcohol or water.

CAUTION

To avoid board damage, use only isopropyl alcohol or water. Do not use petroleum based cleansing agents. Before using any other type of cleaner, consult your Tektronix Service Center or representative for information.

Special Cleaning Procedure for Main Circuit Board

Certain areas of the Main circuit board contain precision high impedance circuitry subject to performance degradation if contaminated. Fig. 6-5A and Fig. 6-5B illustrate the sensitive areas on the back and front of the Main board. Significant contamination can occur from touching the board surface, or board contact with Pink Polethylene (or other detergent based anti-static materials), or operation of the PS 5004 for extended periods of time in a dusty atmosphere. The resulting surface leakage can output voltages that are outside the specified accuracy limits, when operating in a high humidity environment.

Cleaning is required if the repairs are made in the sensitive areas of the circuit board.

If the contamination results from accidental contact with the back of the Main board, only the right side cover must be removed to gain access for cleaning. If the PS 5004 interior is excessivly dusty, both sides of the board will require cleaning. In either case, it is not necessary or recommended to remove the Main board from the instrument frame or front panel.

If both sides of the Main board require cleaning, first remove the Programmer board, exposing the Main board. Using low pressure (5 PSI), low velocity air, blow off the loose dirt from both boards.

Clean the component side of the Main board first using clean isopropyl alcohol and a small brush. It is imperative that the contaminated alcohol be rinsed from the areas and not allowed to evaporate (leaving the contaminates). Use an adequate amount of clean alcohol to rinse.

Next, wash the circuit board sensitive areas with de-ionized water to remove any salts which are not soluble in isopropyl alcohol. Again rinse well with more de-ionized water.

Allow the instrument to air dry, or force dry in warm air not over +70°C (+160°F).

CAUTION

Circuit boards and components must be dry before applying power.

TROUBLESHOOTING INFORMATION

Introduction

Troubleshooting information for the PS 5004 includes hardware tests, general troubleshooting information, and signature analysis for selected digital circuits.

If an error code is returned to the controller in response to an ERR? query, refer to the error code definitions in the Programming section of this manual. The only error codes that indicate instrument malfunction are those classified as Internal Errors in the error code list.

HARDWARE TESTS

The hardware is tested by the PS 5004 firmware in two ways:

- Power-on Self Tests
- Test Query

Power-on Self Test

The power-on self tests run each hardware test once. If an error occurs, the PS 5004 front panel display is set to the code of the first error detected. The PS 5004 will perform no other functions if an error occurs.

The tests performed and their corresponding error displays are listed in Table 6-2.

Table 6-2
FRONT PANEL ERROR DISPLAY
POWER-ON SELF TESTS

Tests Performed	Error Display
System RAM error (high nibble)	40
System RAM error (low nibble)	41
ROM checksum error (C000 to FFFF)	92

GENERAL TROUBLESHOOTING INFORMATION

Locating problem areas in the PS 5004 circuits is not difficult. Review the related information in the Detailed Circuit Description as an aid. Some subtle problems can affect non-related circuits.

Refer to the following descriptions and tests as an aid to determine problem areas.

Internal Power Supplies

When a problem occurs, first check the power supplies. Fig. 6-5A indicates the areas, on the Main circuit board, where the various voltages can be measured. Table 6-3 gives the allowable tolerances and ripple for each supply.

Table 6-3
INTERNAL POWER SUPPLY SPECIFICATIONS

NOMINAL	RANGE	PARD pp 5 Mhz
(Output Supplies)		
$+12V_1$	11-13V	50 mV
$+8V_1$	7.5-8.5V	10 mV
$-12V_1$	−11--13.5V	50 mV
$-25.5V_1$	−25--26V adjusted to −25.5 ±50 mV	50 mV
(Control Supply)		
$+10V_2$	+9-11.5V	100 mV
$-15V_2$	−14--16V	50 mV
$-21V_2$	−20--22V	50 mV
(Ground referenced supplies)		
$+8V_3$	Mainframe regulated	
$+5V_3$	4.50-5.30V	50 mV
$-12V_3$	−11--13V	70 mV

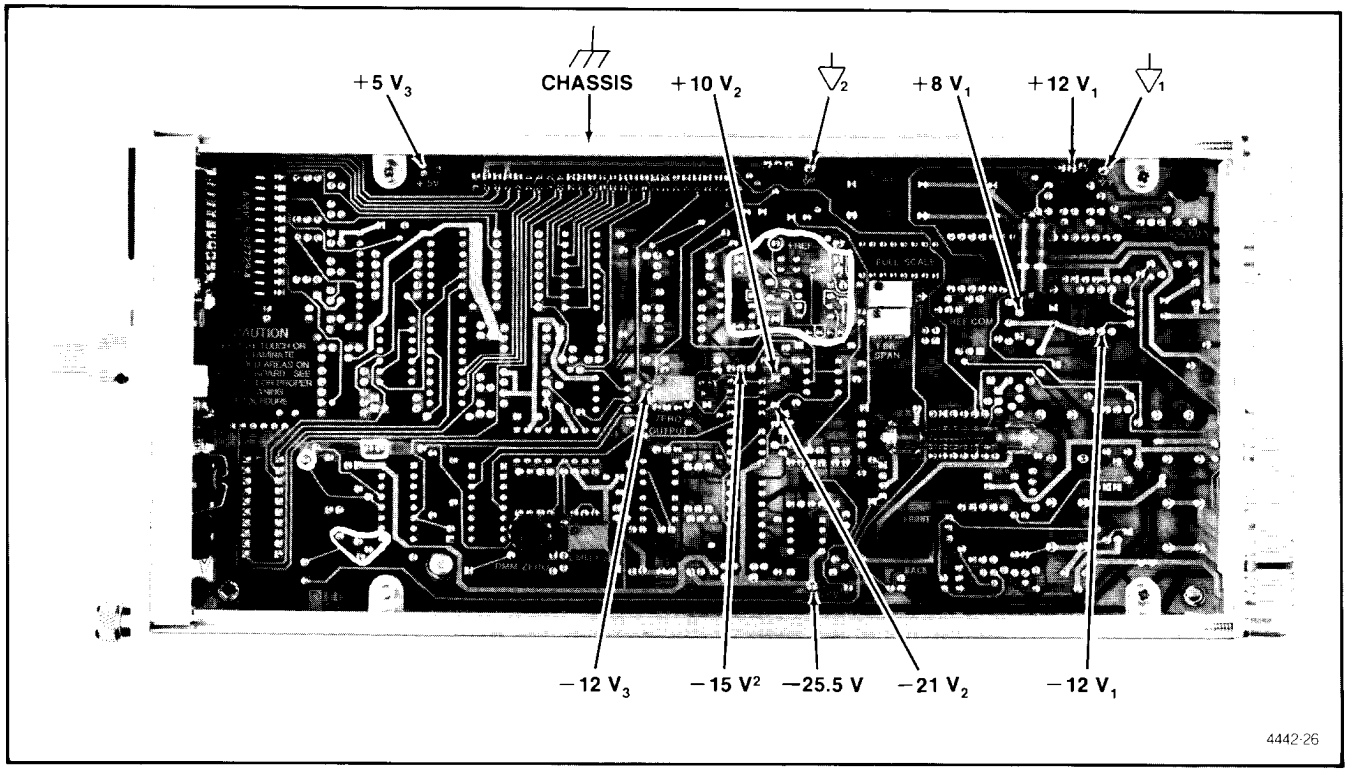


Fig. 6-5B. Main board sensitive circuitry areas (non-component side) and testpoint locations.

Measurements taken from test point indicated in Fig. 6-5A, with OUTPUT off (after 10 minutes warm-up period).

Output Voltage

Poor voltage regulation can result from a disturbance in the sense path. These are moderately high impedance paths and susceptable to line related noise injection from undesirable capacitive coupling. If the output appears to regulate under no load (as indicated by the internal DM), but becomes erratic when the slightest load is driven; suspect an open output fuse or output relay.

Excessive periodic noise in the output, with a frequency of 3.9 KHz, indicates a problem in the Voltage DAC filter. Output voltage that is approximately 123 mV high, indicates a problem in the zero offset correction circuit.

Excessive output voltage drift or inaccuracy with temperature is not necessarily caused by an analog component. Slew rate changes in the Voltage DAC current gates will change the system offset. Check the waveforms in the gate driver circuits with those given in the Diagrams section. A defective schottky diode A11 CR4100 introduces temperature dependence in the switching speed of the coarse current gate drive transistor resulting in an offset drift.

Line ripple in the gate drive floating power supply can cause line noise in the output. Likewise, failure of this supply to track the – sense lead will result in degraded load effect performance.

Output Current

Line related current noise in Constant Current Mode may be caused by excessive ripple in the $+12V_1$ supply, since the current DAC is referenced to this regulated supply. Large differences in output current in CC Mode and current limit, as measured by the internal DM, may be caused by either excessive offset voltage in the current error amp, or leakage in either of the two output capacitors.

Mode Indicators

The three states of the mode indicators can be tested with two banana patch cables and an external power supply.

With the output off, the Constant Voltage (CV) mode LED should be illuminated with any voltage setting. Set the PS 5004 for an output voltage greater than 0.500 volts. Short the output terminals together with a patch cable and turn the output on. The Constant Current (CC) Mode LED is illuminated when the current limit is set to any value in its range.

Set the output voltage for approximately 3 volts and the current to 25 mA. Connect an external power supply, set for approximately 5 volts, to the output terminals making sure that the polarity is the same. With both outputs on, neither the CC or CV Mode LEDs should be illuminated. If there is a failure in either of the mode indicators, check that the corresponding error amp output swing is sufficiently close to the supply voltage. A severe misadjustment in the $-25.5V_1$ supply can result in this swing being insufficient to cross the comparator threshold.

SIGNATURE ANALYSIS

Introduction

Signature analysis provides a simple and direct method of troubleshooting complex digital circuitry to the component level. There are two signature analysis modes available in the PS 5004.

The first is kernel test mode. This mode is used to check the basic processing functions of the instrument. It covers the microprocessor, ROM, data bus, address bus, and address bus decoding.

The second mode executes a routine from the ROM. This mode is referred to as firmware signature analysis, and requires a functional microprocessor, RAM, ROM, address and data bus. These functions are verified during the power-on self test. Refer to the pullout pages in the diagram section for detailed information for each test.

Mode Descriptions

The kernel test mode is implemented by forcing the same instruction on the data bus during each microprocessor read cycle. The instruction used in the PS 5004 is a DEC B (Decrement Accumulator B) which is a Hex 5A. This is accomplished by setting the GPIB address switch , S4020, to load the DEC B instruction on the data bus, and then placing the Run/Force Data jumper, J4020 in the Force Data position. Refer to the Diagrams section in the fold out pages for proper switch and jumper positions.

The following four tests are performed by the kernel test:

1. GPIB address switch, jumper, and buffer test. This test is used if the kernel test or firmware signature analysis modes fail.

2. Address bus and decoder (U3041) test. Use this test when a system error, unknown power-up condition, address bus or address decoding problem is suspected.

3. ROM test. This test is used when a ROM error is reported via front panel error code or a power condition is incorrect. This test verifies that the microprocessor can read the ROM.

4. Balance status input buffer (U2092). Use this test when proper balance SRQs are not reported over the GPIB or the rotary encoder on the front panel does not operate properly.

The Firmware Signature Analysis mode is entered by placing the Run/Force Data jumper (J4020) in the Run position, and the Run/Cal/SA jumper (J4024), in the Signature Analysis position. The PS 5004 now enters the signature analysis mode on power-up. Refer to the pull out pages for jumper positions and more test information.

There are four major tests provided by the firmware signature analysis routine:

1. Power-up/display checks. This test is entered automatically when the instrument is turned on. Initally, a segment test is performed. During this test, the display should indicate 8888.8. The mA, Remote, and Addressed indicators are illuminated. Either the I LIMIT or OUTPUT I display select button is illuminated. Following the segment test, a verification of RAM, ROM, address and data bus including most of the microprocessor will be performed. If a failure is detected in either ROM or RAM, the appropriate error code is displayed (see Table 6-2 for error codes). After sucessful completion of RAM and ROM tests, the routine allows a display test by marching a single segment through the two displays that the microcomputer can write to, (the second and third digit from the right). Finally, the test routine displays a signature analysis in the display and enters a continuous cycle that exercises specific hardware for further testing.

2. Address decoders. Checks U3050 abd U4050.

3. Data Bus and Data Write buffer (U2060) tests.

4. Voltage DAC. Tests the high order and low order latches (U2070 and U2072).

How to Use Signature Analysis

The troubleshooting Chart, Table 6-4, shows the available tests and data covered by each. The tests may be performed in any order as long as the electrical conditions, necessary to perform the test, listed with each procedure are met. The If Failure section indicates suggested action for failures found during the test.

Signature Analysis Tips and Suggestions

Signature analysis is most useful when the particular test objective is understood by the user. A unique feature of signature analysis is the ability to diagnose bus related problems to the component level, which is not always possible with conventional troubleshooting methods.

Component verification is performed by checking all input and output lines. If all of the inputs have a correct signature, but an incorrect signature is present on an output(s), then a component is most likely defective. Some guidelines follow to help maximize the usefulness of this tool.

If all the signatures are found to be incorrect:

1. Check connections and settings. Recheck the instructions for set up.

2. Verify the +5 V signature. If this is incorrect, either the set up is incorrect, or the instrument is not in the proper mode for the test.

3. Check the ground signature. It should be 0000.

4. Check the signature analyzer gate light. It should blink at a steady rate indicating that the analyzer is getting a good start, stop, and clock.

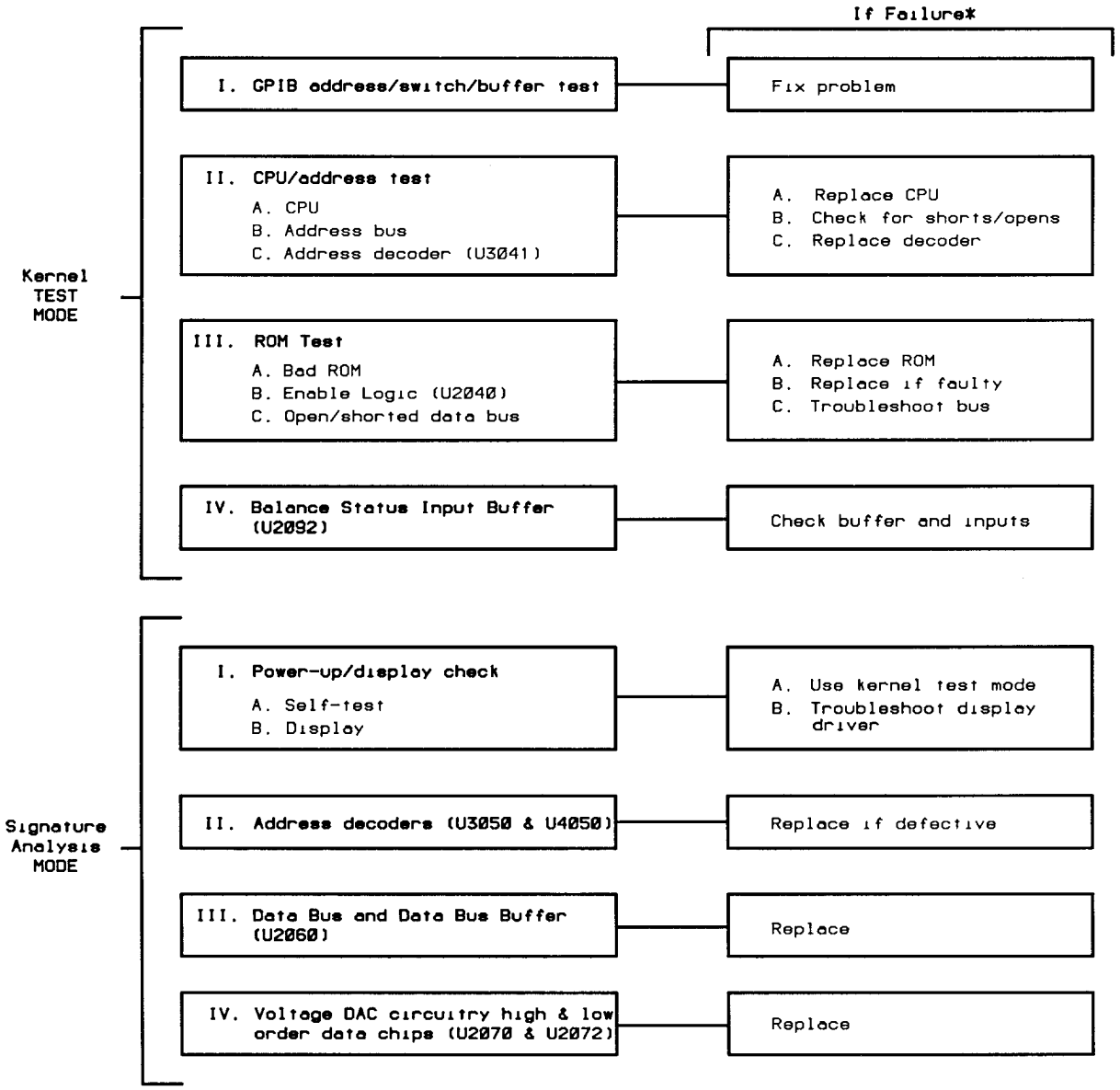
5. Power cycle the instrument. Since the routine is executing a program out of ROM, the program is easily upset by accidental shorting of address or data bus lines.

6. Verify that all of the inputs to the signature are correct. They are:

a. GND—Provides the logic reference for the other inputs.

Table 6-4

TROUBLESHOOTING CHART PS 5004



b. Clock—Synchronizes the analyzer to the circuit being tested. All data is expected to be stable during the selected clock transition.

c. Start/Stop—These signals define the window in which the signature is taken.

7. Note that although the analyzer probe resembles a logic probe, it only has one logic threshold. Therefore, it can not detect illegal logic levels which can be caused by a contention problem.

OPTIONS

There are no options at this time.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

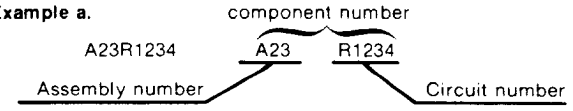
ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

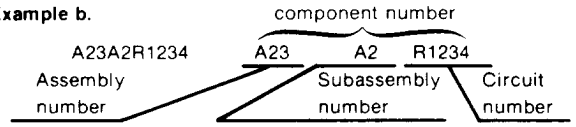
A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:

Example a.



Read: Resistor 1234 of Assembly 23

Example b.



Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00779	AMP INC	2800 FULLING MILL PO BOX 3608	HARRISBURG PA 17105
00853	SANGAMO WESTON INC COMPONENTS DIV	SANGAMO RD PO BOX 128	PICKENS SC 29671-9716
01121	ALLEN-BRADLEY CO	1201 SOUTH 2ND ST	MILWAUKEE WI 53204-2410
01295	TEXAS INSTRUMENTS INC SEMICONDUCTOR GROUP	13500 N CENTRAL EXP PO BOX 655012	DALLAS TX 75265
02111	HAMILTON STANDARD CONTROLS INC SPECTROL DIV	17070 E GALE AVE P O BOX 1220	CITY OF INDUSTRY CA 91749
02735	RCA CORP SOLID STATE DIVISION	ROUTE 202	SOMERVILLE NJ 08876
03508	GENERAL ELECTRIC CO SEMI-CONDUCTOR PRODUCTS DEPT	W GENESEE ST	AUBURN NY 13021
04222	AVX CERAMICS DIV OF AVX CORP	19TH AVE SOUTH P O BOX 867	MYRTLE BEACH SC 29577
04713	MOTOROLA INC SEMICONDUCTOR PRODUCTS SECTOR	5005 E MCDOWELL RD	PHOENIX AZ 85008-4229
05292	ITT COMPONENTS DIV		CLIFTON NJ
05347	ULTRONIX INC	461 N 22ND ST PO BOX 1090	GRAND JUNCTION CO 81502
05397	UNION CARBIDE CORP MATERIALS SYSTEMS DIV	11901 MADISON AVE	CLEVELAND OH 44101
05828	GENERAL INSTRUMENT CORP GOVERNMENT SYSTEMS DIV	600 W JOHN ST	HICKSVILLE NY 11802
06665	PRECISION MONOLITHICS INC SUB OF BOURNS INC	1500 SPACE PARK DR	SANTA CLARA CA 95050
07263	FAIRCHILD SEMICONDUCTOR CORP NORTH AMERICAN SALES SUB OF SCHLUMBERGER LTD MS 118	10400 RIDGEVIEW CT	CUPERTINO CAW CA 95014
07716	TRW INC TRW IRC FIXED RESISTORS/BURLINGTON	2850 MT PLEASANT AVE	BURLINGTON IA 52601
08806	GENERAL ELECTRIC CO MINIATURE LAMP PRODUCTS DEPT	NELA PK	CLEVELAND OH 44112
11236	CTS CORP BERNE DIV THICK FILM PRODUCTS GROUP	406 PARR ROAD	BERNE IN 46711-9506
12954	MICROSEMI CORP - SCOTTSDALE	8700 E THOMAS RD P O BOX 1390	SCOTTSDALE AZ 85252
12969	UNITRODE CORP	5 FORBES RD	LEXINGTON MA 02173-7305
14433	ITT SEMICONDUCTORS DIV		WEST PALM BEACH FL
14752	ELECTRO CUBE INC	1710 S DEL MAR AVE	SAN GABRIEL CA 91776-3825
15238	ITT SEMICONDUCTORS A DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORP	500 BROADWAY P O BOX 168	LAWRENCE MA 01841-3002
15636	ELEC-TROL INC	26477 N GOLDEN VALLEY RD	SAUGUS CA 91350-2621
17856	SILICONIX INC	2201 LAURELWOOD RD	SANTA CLARA CA 95054-1516
18324	SIGNETICS CORP MILITARY PRODUCTS DIV	4130 S MARKET COURT	SACRAMENTO CA 95834-1222
19647	CADDOCK ELECTRONICS INC	1717 CHICAGO AVE	RIVERSIDE CA 92507-2302
19701	MEPCO/CENTRALAB A NORTH AMERICAN PHILIPS CO	P O BOX 760	MINERAL WELLS TX 76067-0760
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS DIV MILITARY PRODUCTS GROUP	515 FISHING CREEK RD	NEW CUMBERLAND PA 17070-3007
24546	CORNING GLASS WORKS	550 HIGH ST	BRADFORD PA 16701-3737
27014	NATIONAL SEMICONDUCTOR CORP	2900 SEMICONDUCTOR DR	SANTA CLARA CA 95051-0606
31433	UNION CARBIDE CORP ELECTRONICS DIV	HWY 276 SE PO BOX 5928	GREENVILLE SC 29606
32997	BOURNS INC TRIMPOT DIV	1200 COLUMBIA AVE	RIVERSIDE CA 92507-2114
34335	A M D ADVANCED MICRO DEVICES	901 THOMPSON PL	SUNNYVALE CA 94086-4518
34630	K AND L/QUARTZTEK INC	3940 W MONTECITO	PHOENIX AZ 85019
50434	HEWLETT-PACKARD CO OPTOELECTRONICS DIV	370 W TRIMBLE RD	SAN JOSE CA 95131

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
50438	HEWLETT-PACKARD CO DATA SYSTEMS DIV	11000 WOLFE RD	CUPERTINO CA 95014-0602
54473	MATSUSHITA ELECTRIC CORP OF AMERICA	ONE PANASONIC WAY PO BOX 1501	SECAUCUS NJ 07094-2917
55680	NICHICON /AMERICA/ CORP	927 E STATE PKY	SCHAUMBURG IL 60195-4526
56289	SPRAGUE ELECTRIC CO WORLD HEADQUARTERS	92 HAYDEN AVE	LEXINGTON MA 02173-7929
57668	R-OHM CORP	16931 MILLIKEN AVE	IRVINE CA 92713
58361	GENERAL INSTRUMENT CORP OPTOELECTRONICS DIV	3400 HILLVIEW AVE	PALO ALTO CA 94304-1319
59660	TUSONIX INC	7741 N BUSINESS PARK DR PO BOX 37144	TUCSON AZ 85740-7144
71400	BUSSMANN DIV OF COOPER INDUSTRIES INC	114 OLD STATE RD PO BOX 14460	ST LOUIS MO 63178
80009	TEKTRONIX INC	14150 SW KARL BRAUM DR PO BOX 500 MS 53-111	BEAVERTON OR 97077
81073	GRAYHILL INC	561 HILLGROVE AVE PO BOX 10373	LA GRANGE IL 60525-5914
91637	DALE ELECTRONICS INC	2064 12TH AVE PO BOX 609	COLUMBUS NE 68601-3632
TK0510	PANASONIC COMPANY DIV OF MATSUSHITA ELECTRIC CORP	ONE PANASONIC WAY	SECAUCUS NJ 07094
TK1483	TEKA PRODUCTS INC	45 SALEM ST	PROVIDENCE RI 02907
TK1727	PHILIPS NEDERLAND BV AFD ELONCO	POSTBUS 90050	5600 PB EINDHOVEN THE NETHERLANDS

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A10	670-0017-00			CIRCUIT BD ASSY:FRONT PANEL	80009	670-0017-00
A11	670-0024-00			CIRCUIT BD ASSY:PROGRAMMER	80009	670-0024-00
A12	670-0025-00	B010100	B010433	CIRCUIT BD ASSY:MAIN	80009	670-0025-00
A12	670-0025-01	B010434		CIRCUIT BD ASSY:MAIN	80009	670-0025-01
A10	670-0017-00			CIRCUIT BD ASSY:FRONT PANEL	80009	670-0017-00
A10C4021	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C4022	285-1056-00			CAP,FXD,PLASTIC:1UF,2%,50V	14752	650B1A105G
A10C4024	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A10C5023	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,25V	31433	C330C105M5R5CA
A10C6024	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,25V	31433	C330C105M5R5CA
A10DS1011	150-1117-00			LAMP,LED RDOUT:RED,7 SEGMENT	58361	FND-360 L10,11
A10DS1012	150-1117-00			LAMP,LED RDOUT:RED,7 SEGMENT	58361	FND-360 L10,11
A10DS1023	150-1117-00			LAMP,LED RDOUT:RED,7 SEGMENT	58361	FND-360 L10,11
A10DS1024	150-1117-00			LAMP,LED RDOUT:RED,7 SEGMENT	58361	FND-360 L10,11
A10DS1025	150-1117-00			LAMP,LED RDOUT:RED,7 SEGMENT	58361	FND-360 L10,11
A10DS1031	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS1032	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS2011	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS2021	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS3011	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS3013	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS3032	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS4014	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS4033	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10DS5035	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A10P1101	131-3059-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR,GOLD PLATED	TK1483	082-3643-SS13
A10P4101	131-3059-00			CONN,RCPT,ELEC:HEADER,1 X 36,0.1 CTR,GOLD PLATED	TK1483	082-3643-SS13
A10R1012	315-0561-00			RES,FXD,FILM:560 OHM,5%,0.25W	19701	5043CX560R0J
A10R1032	315-0681-00			RES,FXD,FILM:680 OHM,5%,0.25W	57668	NTR25J-E680E
A10R2013	315-0681-00			RES,FXD,FILM:680 OHM,5%,0.25W	57668	NTR25J-E680E
A10R2024	315-0561-00			RES,FXD,FILM:560 OHM,5%,0.25W	19701	5043CX560R0J
A10R4020	315-0224-00			RES,FXD,FILM:220K OHM,5%,0.25W	57668	NTR25J-E220K
A10R5023	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A10R6024	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A10S3012	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A10S3013	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A10S3020	311-1632-00			ENCODER,DIGITAL:INCREMENTAL,DUAL CONCENTRIC,75/50 PPR/CH	TK0510	EWT-XKDR04011
A10S3031	263-0019-36	B010100	B011151	SWITCH PB ASSY:MOMENTARY	80009	263-0019-36
A10S3031	263-0114-00	B011152		SWITCH,PB ASSY:MOMENTARY	80009	263-0114-00
A10S4014	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A10S5035	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A10VR2013	152-0195-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	04713	SZ11755RL
A10VR2014	152-0195-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	04713	SZ11755RL
A10VR2025	152-0195-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	04713	SZ11755RL
A10VR2026	152-0195-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	04713	SZ11755RL
A10VR4020	152-0824-00			SEMICOND DVC,DI:BI DIR TRANSIENT SUPPR,SI	04713	TO BE ASSIGNED
A11	670-0024-00			CIRCUIT BD ASSY:PROGRAMMER	80009	670-0024-00
A11C1020	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C1030	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C1090	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C1100	290-0748-00			CAP,FXD,ELCTLT:10UF,+50-20%,25WVDC	54473	ECE-BIEV100S
A11C1110	281-0774-00			CAP,FXD,CER DI:0.022MFD,20%,100V	04222	MA201E223MAA
A11C1112	281-0774-00			CAP,FXD,CER DI:0.022MFD,20%,100V	04222	MA201E223MAA
A11C1114	281-0774-00			CAP,FXD,CER DI:0.022MFD,20%,100V	04222	MA201E223MAA

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A11C2040	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C2110	281-0774-00			CAP,FXD,CER DI:0.022MFD,20%,100V	04222	MA201E223MAA
A11C3020	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A11C3022	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3030	281-0762-00			CAP,FXD,CER DI:27PF,20%,100V	04222	MA101A270MAA
A11C3040	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3060	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3070	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3072	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3082	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3090	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3092	281-0809-00			CAP,FXD,CER DI:200 PF,5%,100V	04222	MA101A201JAA
A11C3093	281-0809-00			CAP,FXD,CER DI:200 PF,5%,100V	04222	MA101A201JAA
A11C3100	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C3101	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4030	281-0762-00			CAP,FXD,CER DI:27PF,20%,100V	04222	MA101A270MAA
A11C4032	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4071	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4075	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4081	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4083	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A11C4084	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A11CR3060	152-0071-00			SEMICOND DVC,DI:SW,GE,15V,40MA,DO-7	15238	G865
A11CR3102	152-0322-00			SEMICOND DVC,DI:SCHOTTKY,SI,15V,DO-35	50434	5082-2672
A11CR3103	152-0322-00			SEMICOND DVC,DI:SCHOTTKY,SI,15V,DO-35	50434	5082-2672
A11CR3104	152-0322-00			SEMICOND DVC,DI:SCHOTTKY,SI,15V,DO-35	50434	5082-2672
A11CR3105	152-0322-00			SEMICOND DVC,DI:SCHOTTKY,SI,15V,DO-35	50434	5082-2672
A11CR4100	152-0322-00			SEMICOND DVC,DI:SCHOTTKY,SI,15V,DO-35	50434	5082-2672
A11J1070	131-2401-00			CONN,RCPT,ELEC:2 X 25,MALE	TK1483	082-2543-SD10
A11J4020	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11J4022	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11J4024	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11P4020	131-0993-00			BUS,CONDUCTOR:SHUNT ASSEMBLY,BLACK	22526	65474-005
A11P4024	131-0993-00			BUS,CONDUCTOR:SHUNT ASSEMBLY,BLACK	22526	65474-005
A11Q2090	151-0302-00			TRANSISTOR:NPN,SI,TO-18	04713	ST899
A11Q3060	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A11Q3100	151-0221-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0221-00
A11Q3110	151-0221-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0221-00
A11Q4060	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A11Q4062	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A11Q4064	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A11R1090	315-0621-00			RES,FXD,FILM:620 OHM,5%,0.25W	57668	NTR25J-E620E
A11R1100	307-0542-00			RES NTWK,FXD,FI:(5)10K OHM,5%,0.125W	01121	106A1030R706A103
A11R1111	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A11R1113	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A11R1115	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A11R2050	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R2100	321-0173-00			RES,FXD,FILM:619 OHM,1%,0.125W,TC=T0	07716	CEAD619R0F
A11R2110	321-0265-00			RES,FXD,FILM:5.62K OHM,1%,0.125W,TC=T0	19701	5043ED5K620F
A11R2111	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A11R3040	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R3050	315-0361-00			RES,FXD,FILM:360 OHM,5%,0.25W	19701	5043CX360R0J
A11R3070	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R3071	315-0752-00			RES,FXD,FILM:7.5K OHM,5%,0.25W	57668	NTR25J-E07K5
A11R3080	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R3081	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R3090	315-0621-00			RES,FXD,FILM:620 OHM,5%,0.25W	57668	NTR25J-E620E
A11R3092	315-0621-00			RES,FXD,FILM:620 OHM,5%,0.25W	57668	NTR25J-E620E

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A11R3100	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A11R3101	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A11R3102	315-0183-00			RES,FXD,FILM:18K OHM,5%,0.25W	19701	5043CX18K00J
A11R3103	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A11R3105	315-0183-00			RES,FXD,FILM:18K OHM,5%,0.25W	19701	5043CX18K00J
A11R3106	315-0183-00			RES,FXD,FILM:18K OHM,5%,0.25W	19701	5043CX18K00J
A11R3107	315-0183-00			RES,FXD,FILM:18K OHM,5%,0.25W	19701	5043CX18K00J
A11R4020	307-0445-00			RES NTWK,FXD,FI:4.7K OHM,20%,(9)RES	32997	4310R-101-472
A11R4050	315-0361-00			RES,FXD,FILM:360 OHM,5%,0.25W	19701	5043CX360R0J
A11R4052	315-0361-00			RES,FXD,FILM:360 OHM,5%,0.25W	19701	5043CX360R0J
A11R4070	315-0561-00			RES,FXD,FILM:560 OHM,5%,0.25W	19701	5043CX560R0J
A11R4071	315-0202-00			RES,FXD,FILM:2K OHM,5%,0.25W	57668	NTR25J-E 2K
A11R4072	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A11R4073	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A11R4074	321-0281-00			RES,FXD,FILM:8.25K OHM,1%,0.125W,TC=T0	19701	5043ED8K250F
A11R4075	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A11R4076	311-1749-00			RES,VAR,NONWW:TRMR,1.5K OHM,0.5W	32997	3352T-1-152
A11R4080	321-0265-00			RES,FXD,FILM:5.62K OHM,1%,0.125W,TC=T0	19701	5043ED5K620F
A11R4081	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A11R4082	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A11R4083	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A11R4090	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A11R4111	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A11R4112	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A11R4113	315-0471-00			RES,FXD,FILM:470 OHM,5%,0.25W	57668	NTR25J-E470E
A11R4114	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A11R4115	315-0471-00			RES,FXD,FILM:470 OHM,5%,0.25W	57668	NTR25J-E470E
A11R4116	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A11S4020	260-2064-00			SWITCH,ROCKER:(6)SPST,125MA,30VDC	81073	76YYXXXS
A11T3090	120-0487-00			XFMR,TOROID:	80009	120-0487-00
A11T4090	120-0487-00			XFMR,TOROID:	80009	120-0487-00
A11TP3020	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A11TP3021	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A11TP4040	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4042	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4050	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4052	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4054	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4056	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11TP4058	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL	22526	48283-036
A11U1020	156-1414-02			MICROCKT,DGTL:OCTAL GPIB BUS XCVR,SCRN	27014	DS75160A N
A11U1030	156-1444-01			MICROCKT,DGTL:NMOS,GPIB INTFC CONTROLLER	01295	TMS9914A (NL
A11U1060	156-0724-02			MICROCKT,DGTL:HEX INV W/OC OUT,SCRN,	01295	SN74LS05NP3
A11U1100	156-0991-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L05ACP
A11U1102	156-0411-02			MICROCKT,LINEAR:QUAD COMPARATOR,SCREENED	04713	LM339JDS
A11U2020	156-1415-01			MICROCKT,DGTL:OCTAL GPIB XCVR-MANAGEMENT	27014	DS75161A NA+
A11U2030	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A11U2040	156-0386-02			MICROCKT,DGTL:TRIPLE 3-INP NAND GATE,SCRN	07263	74LS10PCQR
A11U2042	156-1461-01	B010100	B010587	MICROCKT,DGTL:1024 X 4 SRAM,SCREENED	80009	156-1461-01
A11U2042	156-1461-00	B010588		MICROCKT,DGTL:HMOS,1024 X 4 SRAM	34335	AM91L14EDC/EPC
A11U2050	156-1461-01	B010100	B010587	MICROCKT,DGTL:1024 X 4 SRAM,SCREENED	80009	156-1461-01
A11U2050	156-1461-00	B010588		MICROCKT,DGTL:HMOS,1024 X 4 SRAM	34335	AM91L14EDC/EPC
A11U2052	156-1277-00			MICROCKT,DGTL:LSTTL,3-STATE OCTAL BFR,SCRN	27014	DM81LS95ANA+
A11U2060	156-0956-02			MICROCKT,DGTL:OCTAL BFR W/3 STATE OUT,SCRN	01295	SN74LS244NP3
A11U2070	156-0982-03			MICROCKT,DGTL:OCTAL-D-EDGE TRIG FF,SCRN	01295	SN74LS374N3
A11U2072	156-0982-03			MICROCKT,DGTL:OCTAL-D-EDGE TRIG FF,SCRN	01295	SN74LS374N3
A11U2080	156-0982-03			MICROCKT,DGTL:OCTAL-D-EDGE TRIG FF,SCRN	01295	SN74LS374N3
A11U2082	156-0982-03			MICROCKT,DGTL:OCTAL-D-EDGE TRIG FF,SCRN	01295	SN74LS374N3

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A11U2090	156-1277-00			MICROCKT,DGTL:LSTTL,3-STATE OCTAL BFR,SCRN	27014	DM81LS95ANA+
A11U2092	156-1277-00			MICROCKT,DGTL:LSTTL,3-STATE OCTAL BFR,SCRN	27014	DM81LS95ANA+
A11U2100	156-0388-03			MICROCKT,DGTL:DUAL D FLIP-FLOP,SCRN	01295	SN74LS74ANP3
A11U3040	160-2144-00			MICROCKT,DGTL:16384 X 8 EPROM,PRGM	80009	160-2144-00
A11U3041	156-0469-02			MICROCKT,DGTL:3/8 LINE DCDR,SCRN	01295	SN74LS138NP3
A11U3050	156-0469-02			MICROCKT,DGTL:3/8 LINE DCDR,SCRN	01295	SN74LS138NP3
A11U3052	156-0721-02			MICROCKT,DGTL:QUAD ST 2-INP NAND GATES	18324	N74LS132(NBORFB)
A11U3060	156-0953-02			MICROCKT,DGTL:4 BIT MAGNITUDE CMPRTR,SCRN	01295	SN74LS85NP3
A11U3061	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A11U3070	156-0953-02			MICROCKT,DGTL:4 BIT MAGNITUDE CMPRTR,SCRN	01295	SN74LS85NP3
A11U3072	156-0953-02			MICROCKT,DGTL:4 BIT MAGNITUDE CMPRTR,SCRN	01295	SN74LS85NP3
A11U3080	156-0953-02			MICROCKT,DGTL:4 BIT MAGNITUDE CMPRTR,SCRN	01295	SN74LS85NP3
A11U3082	156-1172-01			MICROCKT,DGTL:DUAL 4 BIT BIN CNTR,SCRN	01295	SN74LS393NP3
A11U3090	156-0388-03			MICROCKT,DGTL:DUAL D FLIP-FLOP,SCRN	01295	SN74LS74ANP3
A11U3092	156-0451-02			MICROCKT,DGTL:QUAD 2-INP NOR BFR,SCREENED	18324	N74128(NB OR FB)
A11U4020	156-1277-00			MICROCKT,DGTL:LSTTL,3-STATE OCTAL BFR,SCRN	27014	DM81LS95ANA+
A11U4030	307-1137-00			RES NTWK,FXD,FI:8,0.005 OHM,+150-50%,0.125W	00779	435704-8
A11U4040	156-1342-01			MICROCKT,DGTL:NMOS,MPU,8-BIT W/CLK	04713	SC67127P
A11U4050	156-0874-02			MICROCKT,DGTL:8 BIT ADDRESSABLE LATCH	04713	SN74LS259NDS
A11U4060	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A11U4062	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A11U4070	156-0796-01			MICROCKT,DGTL:8 STG SHF & STORE BUS RGTR	02735	CD4094BFX
A11U4080	156-1255-01			MICROCKT,LINEAR:D/A CONVERTER,8 BIT,SCRN	06665	DAC080156Q
A11U4081	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A11U4082	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A11U4090	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A11VR1090	152-0757-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,1W,DO-41	04713	1N4735A
A11Y3030	158-0224-00			XTAL UNIT,QTZ:4.0MHZ,0.1%,ANTIRESONANT	34630	ORDER BY DESCR
A12	670-0025-00	B010100	B010433	CIRCUIT BD ASSY:MAIN	80009	670-0025-00
A12	670-0025-01	B010434		CIRCUIT BD ASSY:MAIN	80009	670-0025-01
A12C1021	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C1022	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C1028	281-0813-00			CAP,FXD,CER DI:0.047UF,20%,50V	05397	C412C473M5V2CA
A12C1031	290-0922-00			CAP,FXD,ELCTLT:1000UF,20%,50V	55680	ULB1E102TFAANA
A12C1033	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1041	290-0922-00			CAP,FXD,ELCTLT:1000UF,20%,50V	55680	ULB1E102TFAANA
A12C1051	290-0831-00			CAP,FXD,ELCTLT:470UF,+50-20%,50V	54473	ECE-A1HV471S
A12C1052	290-0768-00			CAP,FXD,ELCTLT:10UF,+50-20%,100WVDC	54473	ECE-A100V10L
A12C1061	290-0770-00			CAP,FXD,ELCTLT:100UF,+50-20%,25VDC	54473	ECE-A25V100L
A12C1062	285-1188-00			CAP,FXD,MTLZD:0.082 UF,5%,100 V	05292	PMT 3R ADVISE
A12C1063	285-0650-00			CAP,FXD,PLASTIC:0.027UF,5%,100V	56289	192P27352M447
A12C1091	290-0770-00			CAP,FXD,ELCTLT:100UF,+50-20%,25VDC	54473	ECE-A25V100L
A12C1101	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1102	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1103	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C1104	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C2011	283-0134-00			CAP,FXD,CER DI:0.47UF,80-20%,50V	05397	C330C474Z5U1CA
A12C2012	283-0068-00			CAP,FXD,CER DI:0.01UF,+100-0%,500V	59660	871-533E103P
A12C2021	290-0846-00			CAP,FXD,ELCTLT:47UF,+75-20%,35V	54473	ECE-A35V47LU
A12C2022	290-0918-00			CAP,FXD,ELCTLT:220UF,+50-20%,63WVDC	55680	TLB1J221TCAANA
A12C2031	290-0779-00			CAP,FXD,ELCTLT:10 UF +50% -10%,50VDC	56289	502D237
A12C2032	283-0134-00			CAP,FXD,CER DI:0.47UF,80-20%,50V	05397	C330C474Z5U1CA
A12C2033	283-0068-00			CAP,FXD,CER DI:0.01UF,+100-0%,500V	59660	871-533E103P
A12C2034	283-0068-00			CAP,FXD,CER DI:0.01UF,+100-0%,500V	59660	871-533E103P
A12C2036	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C2052	281-0765-00			CAP,FXD,CER DI:100PF,5%,100V	04222	MA101A101JAA
A12C2061	285-1188-00			CAP,FXD,MTLZD:0.082 UF,5%,100 V	05292	PMT 3R ADVISE
A12C2062	283-0194-00			CAP,FXD,CER DI:4.7UF,20%,50V	04222	SR505E475MAA

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12C2070	285-1056-00			CAP,FXD,PLASTIC:1UF,2%,50V	14752	650B1A105G
A12C2071	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C2101	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C2102	281-0814-00			CAP,FXD,CER DI:100 PF,10%,100V	04222	MA101A101KAA
A12C2103	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C3020	281-0773-00			CAP,FXD,CER DI:0.01UF,10%,100V	04222	MA201C103KAA
A12C3021	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C3031	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C3041	290-0918-00			CAP,FXD,ELCTLT:220UF,+50-20%,63WVDC	55680	TLB1J221TCAANA
A12C3051	281-0759-00			CAP,FXD,CER DI:22PF,10%,100V	04222	MA101A220KAA
A12C3052	290-0717-00			CAP,FXD,ELCTLT:15UF,20%,50V	56289	196D156X0050PE3
A12C3060	283-0238-00			CAP,FXD,CER DI:0.01UF,10%,50V	04222	SR205C103KAA
A12C3061	283-0238-00			CAP,FXD,CER DI:0.01UF,10%,50V	04222	SR205C103KAA
A12C3071	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,25V	31433	C330C105M5R5CA
A12C3081	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C3082	283-0059-00			CAP,FXD,CER DI:1UF,+80-20%,25V	31433	C330C105M5R5CA
A12C3091	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C3092	281-0791-00			CAP,FXD,CER DI:270PF,10%,100V	04222	MA101C271KAA
A12C4031	283-0068-00			CAP,FXD,CER DI:0.01UF,+100-0%,500V	59660	871-533E103P
A12C4032	283-0068-00			CAP,FXD,CER DI:0.01UF,+100-0%,500V	59660	871-533E103P
A12C4051	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C4052	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C4071	290-0944-00			CAP,FXD,ELCTLT:220UF,+50-20%,10V	55680	ULB1A221TPAANA
A12C4081	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C4082	290-0804-00			CAP,FXD,ELCTLT:10UF,+50-10%,25V	55680	ULB1E100TAAANA
A12C4091	285-1187-00			CAP,FXD,MTLZD:0.47 UF,10%,100 V	05292	PMT 3R .47K 100
A12C4092	283-0660-00			CAP,FXD,MICA DI:510PF,2%,500V	00853	D155F511G0
A12C4093	290-0804-00			CAP,FXD,ELCTLT:10UF,+50-10%,25V	55680	ULB1E100TAAANA
A12C4101	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V	56289	LP66A1A105K
A12C5031	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C5041	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C5042	281-0775-00			CAP,FXD,CER DI:0.1UF,+/-1PF,50V	04222	MA205E104MAA
A12C5081	290-0167-00			CAP,FXD,ELCTLT:10UF,20%,15V	05397	T110B106M015AS
A12CR1031	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR1051	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR1061	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR2032	152-0066-00			SEMICOND DVC,DI:RECT,SI,400V,1A,DO-41	05828	GP10G-020
A12CR2033	152-0066-00			SEMICOND DVC,DI:RECT,SI,400V,1A,DO-41	05828	GP10G-020
A12CR2051	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR2052	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR2062	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR2063	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR3041	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR3042	152-0066-00			SEMICOND DVC,DI:RECT,SI,400V,1A,DO-41	05828	GP10G-020
A12CR3091	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR3092	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR4021	152-0066-00			SEMICOND DVC,DI:RECT,SI,400V,1A,DO-41	05828	GP10G-020
A12CR4022	152-0066-00			SEMICOND DVC,DI:RECT,SI,400V,1A,DO-41	05828	GP10G-020
A12CR4051	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR4052	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR4053	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12CR4061	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	03508	DA2527 (1N4152)
A12DS3051	150-0077-01			LAMP,INCAND:14V,0.08A,#2282D,WIRE LEADS	08806	2162D
A12DS3052	150-0077-01			LAMP,INCAND:14V,0.08A,#2282D,WIRE LEADS	08806	2162D
A12F3021	159-0034-00			FUSE,CARTRIDGE:3AG,1.6A,125V,22SEC	71400	MDL 1 6/10
A12F3022	159-0025-00			FUSE,CARTRIDGE:3AG,0.5A,250V,0.25SEC	71400	AGC-CW-1/2
A12F3041	159-0022-00			FUSE,CARTRIDGE:3AG,1A,250V,FAST BLOW	71400	AGC-CW-1
A12F4021	159-0034-00			FUSE,CARTRIDGE:3AG,1.6A,125V,22SEC	71400	MDL 1 6/10

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12F5021	159-0032-00			FUSE,CARTRIDGE:3AG,0.5A,250V,SLOW BLOW	71400	MDL 1/2
A12J1071	131-2401-00			CONN,RCPT,ELEC:2 X 25,MALE	TK1483	082-2543-SD10
A12J1101	131-3071-00			CONN,RCPT,ELEC:CKT BD,2 X 12,01,CTR	00779	5-87729-4
A12J4041	131-1857-00			TERM SET,PIN:36/0.025 SQ PIN,ON 0.1 CTRS	TK1483	082-3643-SS10
A12J4101	131-2183-00			CONN,RCPT,ELEC:CKT BD,2 X 10 FEM,SIDE ENTR	00779	5-87729-6
A12K4041	148-0134-00			RELAY,REED:2 FORM A,0,25A,200VDC,COIL 5VDC 250 OHM	15636	R8077-1
A12P4041	131-0993-00			BUS,CONDUCTOR:SHUNT ASSEMBLY,BLACK	22526	65474-005
A12Q1021	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q1031	151-0342-00			TRANSISTOR:PNP,SI,TO-92	07263	S035928
A12Q1032	151-0341-00			TRANSISTOR:NPN,SI,TO-106	04713	SPS6919
A12Q1101	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A12Q1102	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A12Q1103	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A12Q2021	151-0462-00			TRANSISTOR:PNP,SI,TO-220	04713	SJE491
A12Q2041	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q2051	151-1025-00			TRANSISTOR:FET,N-CHAN,SI,TO-92	04713	SPF3036
A12Q2052	151-1025-00			TRANSISTOR:FET,N-CHAN,SI,TO-92	04713	SPF3036
A12Q2071	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q2072	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q2081	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q2101	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A12Q2102	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A12Q2103	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q2104	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q2105	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q3031	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q3032	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q3051	151-0462-00			TRANSISTOR:PNP,SI,TO-220	04713	SJE491
A12Q3052	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q3053	151-1004-00			TRANSISTOR:FET,N-CHAN,SI,TO-106	04713	SPF3034
A12Q3061	151-1025-00			TRANSISTOR:FET,N-CHAN,SI,TO-92	04713	SPF3036
A12Q3081	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q3082	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q4031	151-0462-00			TRANSISTOR:PNP,SI,TO-220	04713	SJE491
A12Q4041	151-0464-00			TRANSISTOR:NPN,SI,TO-220	04713	SJE412
A12Q4071	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q4081	151-0342-00			TRANSISTOR:PNP,SI,TO-92	07263	S035928
A12Q5031	151-1006-00			TRANSISTOR:FET,N-CHAN,SI,TO-106	04713	SPF3035
A12Q5032	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A12Q5041	151-0462-00			TRANSISTOR:PNP,SI,TO-220	04713	SJE491
A12Q5061	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12Q5062	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A12R1011	311-1564-00			RES,VAR,NONWW:TRMR,500 OHM,0.5W	32997	3352T-CK5501
A12R1012	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R1021	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R1022	321-0228-00			RES,FXD,FILM:2.32K OHM,1%,0.125W,TC=T0	19701	5043ED2K32F
A12R1023	321-0226-00			RES,FXD,FILM:2.21K OHM,1%,0.125W,TC=T0	01121	RNK2211F
A12R1024	321-0231-00			RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
A12R1025	301-0152-00			RES,FXD,FILM:1.5K OHM,5%,0.5W	19701	5053CX1K500J
A12R1026	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25W	57668	NTR25J-E02K2
A12R1027	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R1028	321-0143-00			RES,FXD,FILM:301 OHM,1%,0.125W,TC=T0	07716	CEAD301R0F
A12R1031	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R1032	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R1033	321-0300-00			RES,FXD,FILM:13.0K OHM,1%,0.125W,TC=T0	07716	CEAD13001F
A12R1034	308-0867-00			RES,FXD,WW:820 OHM,1%,3W	05347	MS3-820R0F
A12R1035	315-0682-00			RES,FXD,FILM:6.8K OHM,5%,0.25W	57668	NTR25J-E06K8

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12R1036	321-0262-00			RES,FXD,FILM:5.23K OHM,1,0.125W,TC=T0	19701	5033ED5K230F
A12R1037	325-0391-00			RES SET,MATCHED:1EA,100 OHM,200 OHM,400 OHM ,6.403K OHM	91637	SPTF-121
A12R1038	----- -----			(PART OF A12R1037)		
A12R1039	315-0361-00			RES,FXD,FILM:360 OHM,5%,0.25W	19701	5043CX360R0J
A12R1041	----- -----			(PART OF A12R1037)		
A12R1042	----- -----			(PART OF A12R1037)		
A12R1043	----- -----			(PART OF A12R1037)		
A12R1061	321-0404-00			RES,FXD,FILM:158K OHM,1%,0.125W,TC=T0	07716	CEAD15802F
A12R1081	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R1082	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R1083	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R1091	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R1101	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R1102	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R2021	315-0561-00			RES,FXD,FILM:560 OHM,5%,0.25W	19701	5043CX560R0J
A12R2022	315-0242-00			RES,FXD,FILM:2.4K OHM,5%,0.25W	57668	NTR25J-E02K4
A12R2023	315-0332-00			RES,FXD,FILM:3.3K OHM,5%,0.25W	57668	NTR25J-E03K3
A12R2041	321-0218-00			RES,FXD,FILM:1.82K OHM,1%,0.125W,TC=T0	19701	5033ED1K82F
A12R2042	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A12R2043	311-1897-00			RES,VAR,NONWW:TRMR,25K OHM,10%,0.5W,LIN	32997	3299W-R27-253
A12R2044	311-1897-00			RES,VAR,NONWW:TRMR,25K OHM,10%,0.5W,LIN	32997	3299W-R27-253
A12R2051	315-0474-00			RES,FXD,FILM:470K OHM,5%,0.25W	19701	5043CX470K0J92U
A12R2052	321-0856-07			RES,FXD,FILM:330K OHM,0.1%,0.125W,TC=T9	19701	5033RE330K0B
A12R2056	307-1155-00			RES NTWK,FXD,FI:1 EA 1.65K OHM,6.4488K OHM, 0.1W EA	19647	T912-225
A12R2061	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R2064	321-1288-01			RES,FXD,FILM:9.88K OHM,0.5%,0.12KW,TC=T0	19701	5033RD9K88D
A12R2065	321-1288-01			RES,FXD,FILM:9.88K OHM,0.5%,0.12KW,TC=T0	19701	5033RD9K88D
A12R2066	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R2067	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R2068	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R2069	321-1693-07			RES,FXD,FILM:46.67K OHM,0.1%,0.125W,T-9	07716	CEAE46671B
A12R2071	321-0193-07			RES,FXD,FILM:1K OHM,0.1%,0.125W,TC=T9	19701	5033RE1K000B
A12R2072	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A12R2073	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R2081	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R2082	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R2083	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R2084	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R2085	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A12R2086	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R2087	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R2088	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R2091	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R2092	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R2093	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R2094	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R2095	307-0675-00			RES NTWK,FXD,FI:9,1K OHM,2%1.25W	11236	750-101-R1K OHM
A12R3021	315-0361-00			RES,FXD,FILM:360 OHM,5%,0.25W	19701	5043CX360R0J
A12R3022	315-0132-00			RES,FXD,FILM:1.3K OHM,5%,0.25W	57668	NTR25J-E01K3
A12R3023	301-0201-00			RES,FXD,FILM:200 OHM,5%,0.5W	19701	5053CX200R0J
A12R3031	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R3041	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R3042	307-0113-00			RES,FXD,CMPSN:5.1 OHM,5%,0.25W	01121	CB51G5
A12R3043	315-0301-00			RES,FXD,FILM:300 OHM,5%,0.25W	57668	NTR25J-E300E
A12R3044	315-0301-00			RES,FXD,FILM:300 OHM,5%,0.25W	57668	NTR25J-E300E
A12R3051	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12R3060	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R3060	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R3061	321-0685-07			RES,FXD,FILM:30K OHM,0.1%,0.125W,TC=T9	07716	CEAE30001B
A12R3062	311-1879-00			RES,VAR,NONWW:TRMR,20K OHM,0.5W	32997	3299W-R27-203
A12R3063	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R3064	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R3071	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R3072	315-0182-00			RES,FXD,FILM:1.8K OHM,5%,0.25W	57668	NTR25J-E1K8
A12R3075	307-0765-00			RES NTWK,FXD,FI:1K OHM & 9K OHM,5% EA,0.1W EA	07716	4168
A12R3081	315-0121-00			RES,FXD,FILM:120 OHM,5%,0.25W	19701	5043CX120R0J
A12R3082	315-0182-00			RES,FXD,FILM:1.8K OHM,5%,0.25W	57668	NTR25J-E1K8
A12R3083	315-0121-00			RES,FXD,FILM:120 OHM,5%,0.25W	19701	5043CX120R0J
A12R3101	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A12R3102	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R3103	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R3104	315-0473-00			RES,FXD,FILM:47K OHM,5%,0.25W	57668	NTR25J-E47K0
A12R3105	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A12R3106	307-0637-00			RES NTWK,FXD,FI:5,2K OHM,2%,0.125W	01121	206A202
A12R3107	321-0275-00			RES,FXD,FILM:7.15K OHM,1%,0.125W,TC=T0	07716	CEAD71500F
A12R4021	315-0242-00			RES,FXD,FILM:2.4K OHM,5%,0.25W	57668	NTR25J-E02K4
A12R4031	301-0391-00			RES,FXD,FILM:390 OHM,5%,0.5W	01121	EB3915
A12R4032	301-0151-00			RES,FXD,FILM:150 OHM,5%,0.5W	TK1727	SFR30 2322-182
A12R4033	321-0195-00			RES,FXD,FILM:1.05K OHM,1%,0.125W,TC=T0	07716	CEAD10500F
A12R4034	321-0237-00			RES,FXD,FILM:2.87K OHM,1%,0.125W,TC=T0	07716	CEAD 28700F
A12R4041	315-0131-00			RES,FXD,FILM:130 OHM,5%,0.25W	19701	5043CX130R0J
A12R4051	308-0799-00			RES,FXD,WW:1 OHM,1%,4W,TC=50 PPM/DEG C	91637	NS21R000F
A12R4052	321-0117-00			RES,FXD,FILM:162 OHM,1%,0.125W,TC=T0	07716	CEAD162R0F
A12R4053	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R4062	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A12R4063	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A12R4071	315-0331-00			RES,FXD,FILM:330 OHM,5%,0.25W	57668	NTR25J-E330E
A12R4072	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R4073	311-1944-00			RES,VAR,NONWW:TRMR,1K OHM,10%,0.5W	02111	64W102T611
A12R4074	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R4075	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A12R4076	321-0177-00			RES,FXD,FILM:681 OHM,1%,0.125W,TC=T0	07716	CEAD681R0F
A12R4081	315-0302-00			RES,FXD,FILM:3K OHM,5%,0.25W	57668	NTR25J-E03K0
A12R4082	315-0302-00			RES,FXD,FILM:3K OHM,5%,0.25W	57668	NTR25J-E03K0
A12R4083	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A12R4084	311-1555-00			RES,VAR,NONWW:TRMR,100K OHM,0.5W	32997	3352T-1-104
A12R4085	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A12R4091	321-0369-00			RES,FXD,FILM:68.1K OHM,1%,0.125W,TC=T0	19701	5043ED68K10F
A12R4092	321-0386-00			RES,FXD,FILM:102K OHM,1%,0.125W,TC=T0	07716	CEAD10202F
A12R4101	321-0335-00	B010100	B010433	RES,FXD,FILM:30.1K OHM,1%,0.125W,TC=T0	57668	RB14FXE30K1
A12R4101	321-0389-00	B010434		RES,FXD,FILM:110K OHM,1%,0.125W,TC=T0	07716	CEAD11002F
A12R5051	315-0432-00			RES,FXD,FILM:4.3K OHM,5%,0.25W	57668	NTR25J-E04K3
A12R5052	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R5053	315-0512-00			RES,FXD,FILM:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A12R5054	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A12R5055	321-0245-00			RES,FXD,FILM:3.48K OHM,1%,0.125W,TC=T0	19701	5033ED3K48F
A12R5061	321-0274-00			RES,FXD,FILM:6.98K OHM,1%,0.125W,TC=T0	19701	5043ED6K980F
A12R5062	321-0297-00			RES,FXD,FILM:12.1K OHM,1%,0.125W,TC=T0	07716	CEAD12101F
A12R5063	321-0231-00			RES,FXD,FILM:2.49K OHM,1%,0.125W,TC=T0	19701	5033ED2K49F
A12R5064	315-0153-00			RES,FXD,FILM:15K OHM,5%,0.25W	19701	5043CX15K00J
A12R5065	315-0153-00			RES,FXD,FILM:15K OHM,5%,0.25W	19701	5043CX15K00J
A12R5071	315-0223-00			RES,FXD,FILM:22K OHM,5%,0.25W	19701	5043CX22K00J92U
A12R5072	315-0153-00			RES,FXD,FILM:15K OHM,5%,0.25W	19701	5043CX15K00J

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12R5073	321-0286-00			RES,FXD,FILM:9.31K OHM,1%,0.125W,TC=T0	19701	5043ED9K310F
A12R5081	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A12R5091	321-0382-07			RES,FXD,FILM:93.1K OHM,0.1%,0.125W,TC=T9	24546	NE55E9312B
A12S1041	260-1777-01			SWITCH,ROTARY:16 POSN,28VDC,100MA	00779	54792-1
A12TP1021	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP1051	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP1052	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP2041	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12TP5051	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A12U1030	156-1161-00			MICROCKT,LINEAR:VOLTAGE REGULATOR,POS,ADJ	12969	UC317T
A12U1051	156-0277-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	LM340T-5.0
A12U2031	156-1244-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L08ACG
A12U2041	156-0783-00			MICROCKT,LINEAR:PRECISION VOLTAGE REFERENCE	27014	LM399
A12U2051	156-1699-00			MICROCKT,LINEAR:DUAL BI-FET,OPNL AMPL	01295	TL288CP
A12U2061	156-1699-00			MICROCKT,LINEAR:DUAL BI-FET,OPNL AMPL	01295	TL288CP
A12U2071	156-1243-01			MICROCKT,DGTL:BCD TO 7-SEG DECODER/DR,SCRN	01295	SN74LS47NP3
A12U2091	156-0724-02			MICROCKT,DGTL:HEX INV W/OC OUT,SCRN,	01295	SN74LS05NP3
A12U2092	156-1305-00			MICROCKT,LINEAR:TTL,4.5 DIGIT A/D CONVERTER	17856	SLD2105
A12U2093	156-0728-02			MICROCKT,DGTL:QUAD 2 INP GATE W/OC OUT,SCRN	01295	SN74LS09NP3
A12U3051	156-1338-02			MICROCKT,LINEAR:OPERATIONAL AMPLIFIER,SCRN	01295	NE5534P3
A12U3061	156-1699-00			MICROCKT,LINEAR:DUAL BI-FET,OPNL AMPL	01295	TL288CP
A12U3062	156-1699-00			MICROCKT,LINEAR:DUAL BI-FET,OPNL AMPL	01295	TL288CP
A12U3071	156-1162-00			CPLR,OPTOELECTR:LED,2500V	50438	6N136
A12U3072	156-1162-00			CPLR,OPTOELECTR:LED,2500V	50438	6N136
A12U3081	156-1162-00			CPLR,OPTOELECTR:LED,2500V	50438	6N136
A12U4061	156-0411-00			MICROCKT,LINEAR:SGL SPLY COMPARATOR	04713	LM339N
A12U4062	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A12U4063	156-0885-00			CPLR,OPTOELECTR:LED,5KV ISOLATION	04713	SOC 123A
A12U4081	156-0514-01			MICROCKT,DGTL:DIFF 4-CHANNEL MUX,SEL	80009	156-0514-01
A12U4091	156-1306-00			MICROCKT,LINEAR:TTL,4.5 DIGIT A/D CONVERTER	17856	SLD2004
A12U5051	156-0067-01			MICROCKT,LINEAR:OPNL AMPL,CHECKED	04713	MC1741CP1DS
A12VR2031	152-0166-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,400MW,DO-7	04713	SZ11738RL
A12VR2051	152-0744-00			SEMICOND DVC,DI:ZEN,SI,3.6V,5%,0.4W,DO-7	15238	IN747ATK
A12VR3021	152-0508-00			SEMICOND DVC,DI:ZEN,SI,12.6V,5%,0.4W,DO-7	04713	SZ13294RL
A12VR3061	152-0166-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,400MW,DO-7	04713	SZ11738RL
A12VR3062	152-0744-00			SEMICOND DVC,DI:ZEN,SI,3.6V,5%,0.4W,DO-7	15238	IN747ATK
A12VR4021	152-0055-00			SEMICOND DVC,DI:ZEN,SI,11V,5%,0.4W,DO-7	14433	Z5407
A12VR4041	152-0281-00			SEMICOND DVC,DI:ZEN,SI,22V,5%,0.4W,DO-7	12954	1N969B/DO-35
A12VR5071	152-0727-00			SEMICOND DVC,DI:ZEN,SI,6.3V 2%,0.4W,DO-7	04713	SZG20246
W500	175-2442-00			CA ASSY,SP,ELEC:50,28 AWG,3.0 L	22526	ORDER BY DESCR

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it is in the low state.

Abbreviations are based on ANSI Y1.1-1972.

Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

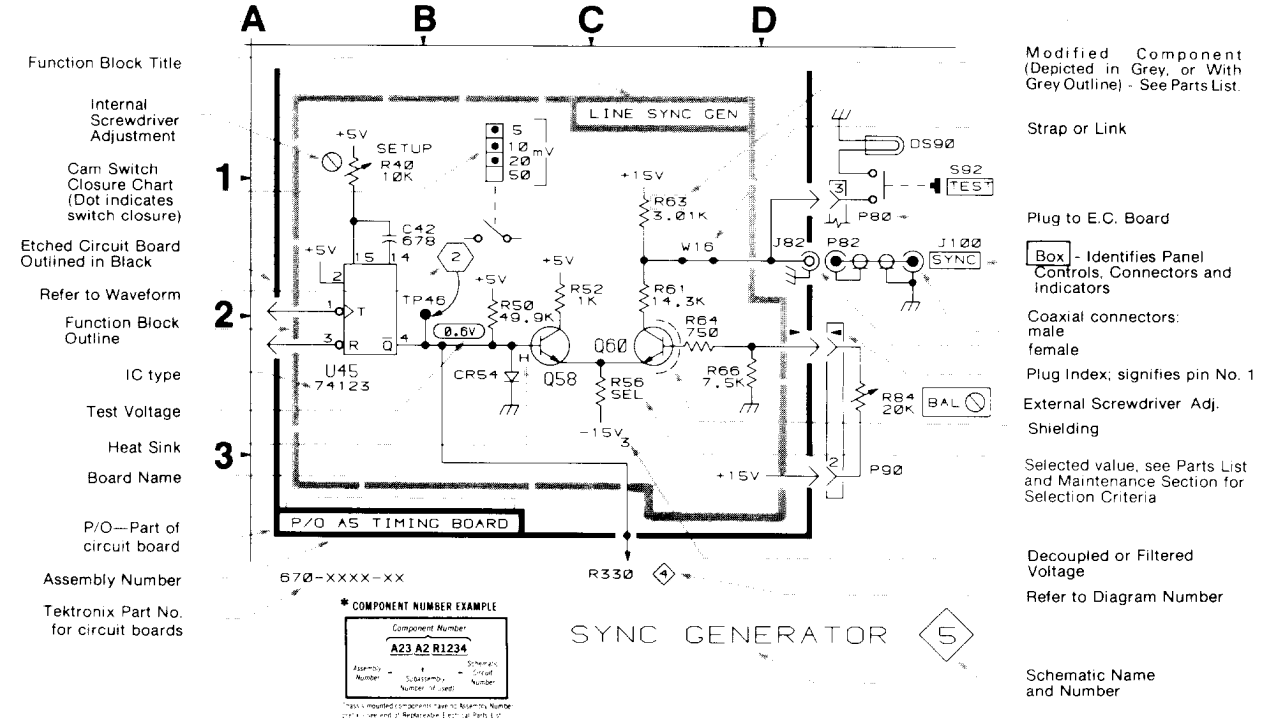
Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors = Ohms (Ω).

The information and special symbols below may appear in this manual.

Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.



REV OCT 1981

(1)

PLEASE INSERT (2) Z-FOLDS

SIMPLIFIED SCHM.

THRU

PRECISION POWER

HERE

SEE SEQUENCE LIST.

TABLE 9-1
COMPONENT REFERENCE CHART

P/O A11 ASSY — **MICROPROCESSOR AND MEMORY** ◇1◇

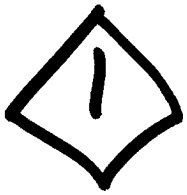
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C2040	G8	D3
C3020	C4	B3
C3030	C5	C3
C3040	G9	D3
C4030	C3	C4
C4032	C2	C4
CR3060	N9	F3
J1070	B5	G1
J1070	O7	G1
J4020	F4	A4
J4024	F3	A4
P1070	B5	G1
P1070	O7	G1
P4020	F4	A4
P4024	F3	A4
R3040	L4	D4
R4020	G1	B4
R4020A	C3	B4
S4020	F1	A4
TP3020	C7	B3
TP3021	C6	B3
TP4040	E4	D4
TP4042	J7	D4
TP4050	L8	E4
TP4052	L8	E4
TP4054	G6	E4
TP4056	L4	E4
TP4058	C5	E4
U1060D	N8	E1
U1060E	N9	E1
U2030A	E7	C2
U2030B	E6	C2
U2030C	F6	C2
U2030D	N8	C2
U2040A	F6	D2
U2040B	F7	D2
U2040C	L4	D2
U2042*	J1	D2
U2050*	L1	E2
U3040	N2	C3
U3041	K5	D3
U3050	J7	E3
U3052C	M8	E3
U3052D	M7	E3
U4020	H1	B4
U4040	D1	D4
U4050	J10	E4
VR1090	C7	I1
W4030	I6	C4
W500	A5	CHASSIS
W500	O7	CHASSIS
Y3030	C4	C3

P/O A11 ASSY also shown on ◇2◇ ◇3◇ ◇5◇

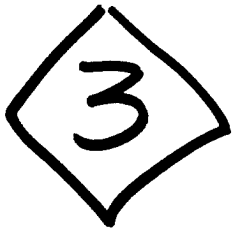
*See Parts List for serial number ranges.

2.

PLEASE INSERT (3) Z-FOLDS



THRU



HERE

SEE SEQ. LIST.

TABLE 9-4
COMPONENT REFERENCE CHART

P/O A12 ASSY — **DIGITAL METER** ◇4◇

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C1091	M2	I1	Q2103	K5	J2	R4075	F3	G4
C1101	M2	J1	Q2104	L7	I3	R4076	D4	G4
C1102	L4	J1	Q2105	K5	J3	R4081	F5	H4
C1103	L3	J2	Q3081	I4	H3	R4082	F5	H4
C1104	L3	J2	Q3082	I5	H3	R4083	F4	H4
C2036	F7	C2	Q4071	G2	G4	R4084	F4	H4
C2071	D7	G2	Q4081	G3	H4	R4085	E3	I4
C2102	L5	J2				R4091	D6	I4
C2103	L5	J2	R1081	N7	H1	R4092	D6	I4
C2101	L2	J2	R1082	N7	H1	R4101	C6	J4
C3071	H6	G3	R1083	N6	H2	R5064	B3	F4
C3081	H4	H3	R1091	K4	I2	R5065	C3	G4
C3082	H1	H3	R1101	L5	J1	R5071	F2	G4
C3091	E7	H3	R1102	L5	J2	R5072	F2	G4
C3092	F4	I3	R2022	E8	B2	R5073	D5	G4
C4071	G3	G4	R2023	F7	B2	R5081	D5	H4
C4081	G4	H4	R2073	L6	G2	R5091	E6	I4
C4082	E4	H4	R2081	N6	H2			
C4091	E2	I4	R2082	N7	H2	U2071	M6	G2
C4092	C6	J4	R2083	N7	H2	U2091A	K2	I2
C4093	E4	I4	R2084	N7	H2	U2091B	K2	I2
C4101	F4	J4	R2085	N7	H2	U2091C	L9	I2
C5081	E5	H5	R2086	I2	H2	U2091D	K3	I2
			R2087	H1	H2	U2091E	K4	I2
CR3091	L8	I3	R2088	H2	H2	U2091F	K4	I2
CR3092	L9	I3	R2091	K4	I2	U2092	J2	H3
			R2092	K2	I2	U2093A	L9	I2
J1071	B1	G1	R2093	K3	I2	U2093B	L8	I2
J1071	B5	G1	R2094	K3	I2	U2093C	L9	I2
J1071	B8	G1	R2095A	L4	I2	U2093D	L8	I2
J1071	O1	G1	R2095B	K4	I2	U3071	G2	G3
J1071	O5	G1	R2095C	L2	I2	U3072	G4	G3
J1071	O8	G1	R2095D	L2	I2	U3081	G5	H3
J1101	O2	J1	R2095E	L3	I2	U4062	B4	F4
J1101	O6	J1	R2095F	L9	I2	U4063	C4	F4
J1101	O9	J1	R2095G	L8	I2	U4081	D1	H4
J4101	O9	J4	R2095H	L8	I2	U4091	E2	I4
			R3071	B4	G3			
P1071	B1	G1	R3072	G2	G3	VR5071	C5	G5
P1071	B5	G1	R3081	H4	H3			
P1071	B8	G1	R3082	H5	H3	W500	A1	CHASSIS
P1071	O1	G1	R3083	H5	H3	W500	A5	CHASSIS
P1071	O5	G1	R3101	K5	I3	W500	A8	CHASSIS
P1071	O8	G1	R3102	K5	I3	W500	O1	CHASSIS
			R3103	K7	I3	W500	O5	CHASSIS
Q1101	M4	J1	R3104	M8	I3	W500	O8	CHASSIS
Q1102	L4	J1	R3105	L9	I3			
Q1103	M2	J1	R3107	F4	I3			
Q2071	N8	G2	R4063	C4	F4			
Q2072	N9	G2	R4071	G2	G3			
Q2081	I2	H2	R4072	F3	G4			
Q2101	M3	J2	R4073	D5	G4			
Q2102	L3	J2	R4074	G4	G4			

P/O A12 ASSY also shown on ◇5◇ ◇6◇ ◇7◇

PLEASE INSERT (1) Z-Fold

~~THRU~~

HERE

TABLE 9-5
COMPONENT REFERENCE CHART

P/O A12 ASSY — **REGULATOR AND OUTPUT** ◇5

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C1052	M5	E1
C1062	H6	F1
C1063	J8	F1
C2011	K6	A2
C2052	H7	F2
C2061	I7	F2
C2062	F5	F2
C2070	K8	G2
C3020	M8	B3
C3051	M8	E3
C3052	H5	E3
C3060	L6	F3
C3061	L2	F3
C4051	H2	E4
C4052	J3	E4
CR1051	G7	E2
CR1061	G6	E2
CR2051	H7	E2
CR2052	H7	E2
CR2062	H6	E2
CR2063	H9	F3
CR3041	J5	D3
CR3042	N5	D3
CR4051	P10	E4
CR4053	I2	E4
CR4052	J2	E4
CR4061	L3	F4
DS3051	M2	E3
DS3052	M6	E3
F3041	N5	C3
J1071	B6	G1
J1071	H2	G1
J1071	N9	G1
J1071	O3	G1
J1071	O10	G1
J4041A	N1	D4
J4041B	N2	D4
J4041C	N6	D4
J4041D	N5	D4
J4101	M3	J4
J4101	O1	J4
J4101	O2	J4
J4101	O3	J4
J4101	O5	J4
J4101	O6	J4
J4101	O9	J4
K4041	P9	D4
K4041S	N5	D4
P1010	K5	A3
P1010	K6	A3
P1010	O2	A3
P1010	O5	A3
P1010	O6	A3
P1071	B6	G1
P1071	H2	G1
P1071	N9	G1
P1071	O3	G1
P1071	O10	G1
P4041A	N1	D4
P4041B	N2	D4
P4041C	N6	D4
P4041D	N5	D4
Q2041	C7	D2
Q2051	G8	E2
Q2052	G10	E2
Q3031	P10	C3
Q3032	P10	C3
Q3051	J5	E3
Q3052	J6	E3
Q3053	J3	E3
Q3061	L10	F3
Q5061	M4	F5
Q5062	M3	F5
R1012	O6	A2
R1021	O2	B1
R1037	C8	C2
R1038	D8	C2
R1041	D8	D2
R1042	D8	D2
R1043	D8	D2
R1061	I6	F2
R2041	C7	D2
R2042	B7	D2
R2043	E8	D2
R2044	E8	D2
R2051	M5	E2
R2052	F10	E2
R2056A	F9	E2
R2056B	H7	E2
R2061	H8	F3
R2063	H9	F3
R2064	I7	F2
R2065	J7	F2
R2066	J7	F2
R2067	J7	F2
R2068	L8	F2
R2069	K10	F3
R2071	K7	G2
R2072	F5	G2
R3031	P10	C3
R3041	P10	D3
R3042	J6	D3
R3043	J5	D3
R3044	J5	D3
R3051	M8	E3
R3060	K6	F3
R3061	L10	F3
R3062	K10	F3
R3063	L2	F3
R3064	L7	F3
R3075	N7	G3
R4051	H1	E4
R4052	H2	E4
R4053	I3	E4
R4062	K4	F4
R5051	J3	D5
R5052	I2	E4
R5053	H2	E4
R5054	K4	E5
R5055	J4	E4
R5061	J3	F4
R5062	J3	F4
R5063	J5	F4
S1041A	D7	D2
S1041B	D7	D2
S1041C	C7	D2
TP1052	F8	E1
TP2041	D8	D2
U2041	B8	D2
U2051A	G8	E2
U2051B	G10	E2
U2061A	I7	F2
U2061B	J7	F2
U3051	M7	E3
U3061A	K10	F3
U3061B	M8	F3
U3062A	K2	F3
U3062B	M7	F3
U4061A	K5	F4
U4061B	K4	F4
U4061C	K3	F4
U4061D	K3	F4
U5051	I3	E4
VR2031	B7	D2
VR2051	L5	E2
VR3061	L3	F3
VR3062	L2	F3
W500	A6	CHASSIS
W500	H3	CHASSIS
W500	N9	CHASSIS
W500	N10	CHASSIS
W500	P3	CHASSIS

P/O A12 ASSY also shown on ◇4 ◇6 ◇7

Continued on following page.

TABLE 9-5 (CONT'D)
COMPONENT REFERENCE CHART

P/O A10 ASSY — **REGULATOR & OUTPUT**

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4021	Q5	A3	P4101	N3	B4
C4022	P3	B3	P4101	P1	B4
C4024	P3	B3	P4101	P2	B4
C5023	P2	A4	P4101	P5	B4
C6024	P6	A4	P4101	P6	B4
DS3032	N3	B2	R4020	Q3	B3
DS4033	N4	B3	R5023	P2	A4
			R6024	P6	A4
J5010	Q5	A4			
J5021	Q1	B4	VR4020	Q3	B3
J6010	Q6	A4			
J6020	Q2	B4			

P/O A10 ASSY also shown on 7

P/O A11 ASSY — **REGULATOR & OUTPUT**

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4071	C2	G4	R4052	C3	E4
C4075	F4	G4	R4070	B2	G4
C4081	F4	H5	R4071	B1	G4
C4083	E3	H4	R4072	D1	G4
C4084	F5	H5	R4073	D1	G4
			R4074	E3	G4
J1070	G2	G1	R4075	D1	G4
			R4076	E4	G4
P1070	G2	G1	R4080	F2	G4
			R4081	F4	H4
Q3060	C2	F3			
Q4060	E2	F4	TP3082	G2	H3
Q4062	D2	F4			
Q4064	D2	F4	U3061	D4	F3
			U4060	D3	F4
R3050	C4	E3	U4062	D3	F4
R3070	F3	G3	U4070	E1	G4
R3071	F3	G3	U4080	F1	H4
R4050	C3	E4			

P/O A11 ASSY also shown on 1 2 3

4.

PLEASE INSERT(4) Z-Folds

5

THRU

PS 5004 FIGS. 9-4, 9-5, 9-6

HERE

SEE SEQ. LIST

(Signature analyzer)

a. Threshold	TTL	
b. START	⌐	Connect to U3041, pin 12
c. STOP	⌐	Connect to U3041, pin 12
d. CLOCK	⌐	Connect to E Delayed test point (TP4054)
e. GND		Connect to ground test point (TP3020)

5. Procedure

a. Turn on the signature analyzer and PS 5004.

b. Verify the +5 V signature. If incorrect, turn the PS 5004 off, then on. If the signature is still incorrect, check steps IV 1 through 4.

c. Check signatures on the data bus as shown:

NOTE

Signatures shown in parenthesis are alternate signatures for each input on the Balance Status Indicator. Each input (except CV and CC) is toggled to its alternate value to assume proper operation.

+5 V	= 1180		
DO	= 0000		CV low (status indicator)
D1	= 1180		CC low (status indicator)
D2	= 0000	(1180)	coarse (rotary encoder)
D3	= 0000	(1180)	coarse (rotary encoder)
D4	= 0000	(1180)	fine (rotary encoder)
D5	= 0000	(1180)	fine (rotary encoder)
D6	= 1180	(0000)	OUTPUT ON (front panel button)
D7	= 0000		ID REQ (front panel button)

To check rotary encoder, turn fine or coarse knob slowly until alternate signature appears.

To check front panel buttons, depress and hold selected button while observing signature analyzer readout.

V ADDRESS DECODERS TEST (FIRMWARE)

1. Purpose

To verify the address decoders operation (U3050, U4050) and part of U3052 (Display CL flip-flop).

2. Equipment Required

a. Signature analyzer.

b. Oscilloscope system.

c. TM 500/5000-Series flexible extender.

d. Register (pull-up) - 10 kΩ, 5%, 1/4 W (Tektronix part no. 315-0103-00).

3. Conditions

a. Requires +5 V and ground to Programmer board and functional microprocessor clock signal (for signature analyzer) from U4040, pin 37.

b. ROM, RAM, address and data busses (with necessary control circuitry) must be functional (verified in POWER-UP SELF TEST in the Maintenance section of this manual).

c. START/STOP test point (TP4050) from U3050, pin 7 must be functional. Check this test point for a .5 μs pulse with 2 kHz repetition rate using the oscilloscope system.

4. Setup

(PS 5004)

a. Turn power off.

b. Set the firmware signature analysis mode as shown in Fig. 9-9.

Continued on following page.

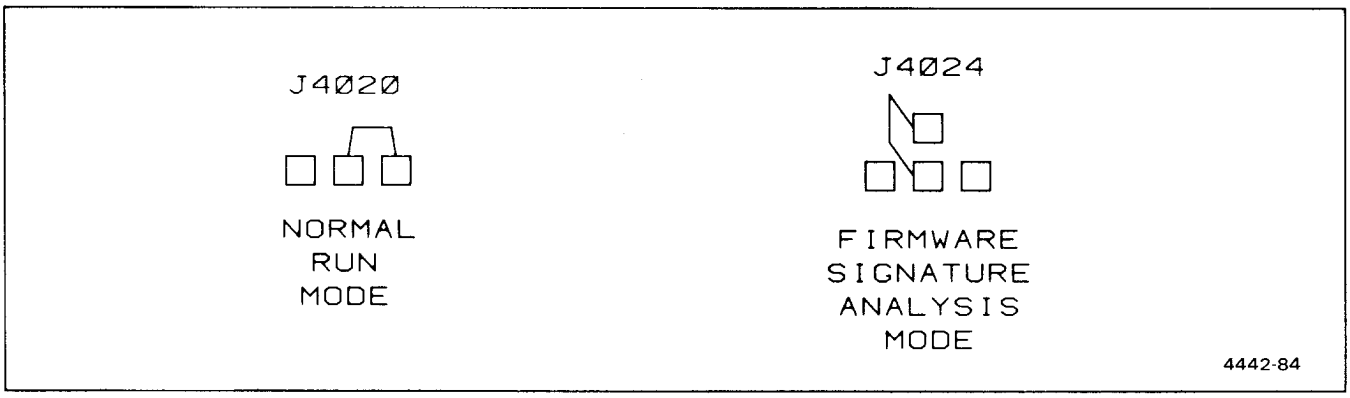


Fig. 9-9. Jumpers positions.

c. Install the Data Bus jumper, W4030 (if not already in position).

(Signature analyzer)

a. Threshold (if available) TTL

b. START — Connect to S/S test point (TP4050)

c. STOP — Connect to S/S test point (TP4052)

d. CLOCK — Connect to E Delayed test point (TP4054)

e. GND — Connect to ground test point (TP3020)

5. Procedure

a. Turn on the signature analyzer and PS 5004.

b. Verify the +5 V signature. If incorrect, turn the PS 5004 off, then on. If the signature is still incorrect, check U3050 (pin 13 is an enable for U4050) then check steps V 1 through 4.

NOTE

Checking U4050 input (pin 13) is optional and requires connecting the 10 kΩ pull-up resistor from the unbuffered side of the data bus (bit 7, W4030 pin 9) to +5 V. Be careful not to short adjoining pins (instrument must be started again).

c. Check the address decoders (U3050, U4050) and the display CL flip-flop (U3052) as shown in Fig. 9-10.

5.

PLEASE INSERT (1) Z-FOLD

PS5004 FIGS. 9-9, 9-10, + 9-11

~~THRU~~

HERE

See SEQ. LIST.

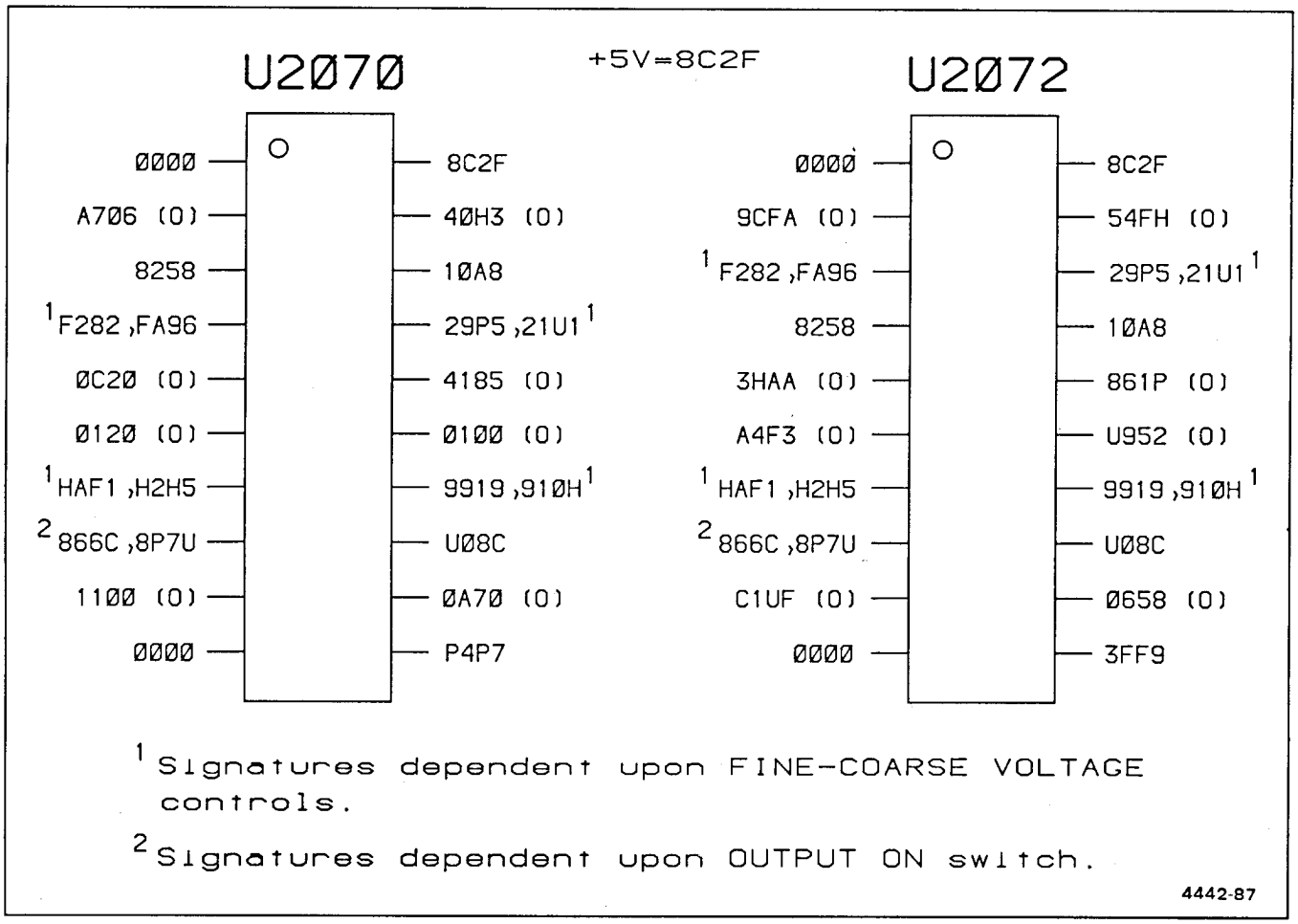


Fig. 9-14. Signatures.

REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```
1 2 3 4 5                    Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
                - - - * - - -
   Detail Part of Assembly and/or Component
   Attaching parts for Detail Part
                - - - * - - -
      Parts of Detail Part
      Attaching parts for Parts of Detail Part
                - - - * - - -
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ABBREVIATIONS

"	INCH
#	NUMBER SIZE
ACTR	ACTUATOR
ADPTR	ADAPTER
ALIGN	ALIGNMENT
AL	ALUMINUM
ASSEM	ASSEMBLED
ASSY	ASSEMBLY
ATTEN	ATTENUATOR
AWG	AMERICAN WIRE GAGE
BD	BOARD
BRKT	BRACKET
BRS	BRASS
BRZ	BRONZE
BSHG	BUSHING
CAB	CABINET
CAP	CAPACITOR
CER	CERAMIC
CHAS	CHASSIS
CKT	CIRCUIT
COMP	COMPOSITION
CONN	CONNECTOR
COV	COVER
CPLG	COUPLING
CRT	CATHODE RAY TUBE
DEG	DEGREE
DWR	DRAWER
ELCTRN	ELECTRON
ELEC	ELECTRICAL
ELCTLT	ELECTROLYTIC
ELEM	ELEMENT
EPL	ELECTRICAL PARTS LIST
EQPT	EQUIPMENT
EXT	EXTERNAL
FIL	FILLISTER HEAD
FLEX	FLEXIBLE
FLH	FLAT HEAD
FLTR	FILTER
FR	FRAME or FRONT
FSTNR	FASTENER
FT	FOOT
FXD	FIXED
GSKT	GASKET
HDL	HANDLE
HEX	HEXAGON
HEX HD	HEXAGONAL HEAD
HEX SOC	HEXAGONAL SOCKET
HLCPS	HELICAL COMPRESSION
HLEXT	HELICAL EXTENSION
HV	HIGH VOLTAGE
IC	INTEGRATED CIRCUIT
ID	INSIDE DIAMETER
IDENT	IDENTIFICATION
IMPLR	IMPELLER
IN	INCH
INCAND	INCANDESCENT
INSUL	INSULATOR
INTL	INTERNAL
LPHLDR	LAMPHOLDER
MACH	MACHINE
MECH	MECHANICAL
MTG	MOUNTING
NIP	NIPPLE
NON WIRE	NOT WIRE WOUND
OBD	ORDER BY DESCRIPTION
OD	OUTSIDE DIAMETER
OVH	OVAL HEAD
PH BRZ	PHOSPHOR BRONZE
PL	PLAIN or PLATE
PLSTC	PLASTIC
PN	PART NUMBER
PNH	PAN HEAD
PWR	POWER
RCPT	RECEPTACLE
RES	RESISTOR
RGD	RIGID
RLF	RELIEF
RTNR	RETAINER
SCH	SOCKET HEAD
SCOPE	OSCILLOSCOPE
SCR	SCREW
SE	SINGLE END
SECT	SECTION
SEMICOND	SEMICONDUCTOR
SHLD	SHIELD
SHLDR	SHOULDERED
SKT	SOCKET
SL	SLIDE
SLFLKG	SELF-LOCKING
SLVG	SLEEVING
SPR	SPRING
SQ	SQUARE
SST	STAINLESS STEEL
STL	STEEL
SW	SWITCH
T	TUBE
TERM	TERMINAL
THD	THREAD
THK	THICK
TNSN	TENSION
TPG	TAPPING
TRH	TRUSS HEAD
V	VOLTAGE
VAR	VARIABLE
W/	WITH
WSHR	WASHER
XFMR	TRANSFORMER
XSTR	TRANSISTOR

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
09922	BURNDY CORP	RICHARDS AVE	NORWALK CT 06852
12327	FREEWAY CORP	9301 ALLEN DR	CLEVELAND OH 44125-4632
13103	THERMALLOY CO INC	2021 W VALLEY VIEW LN PO BOX 810839	DALLAS TX 75381
55285	BERGQUIST CO INC THE	5300 EDINA INDUSTRIAL BLVD	MINNEAPOLIS MN 55435-3707
71159	BRISTOL SOCKET SCREW CO		WATERBURY CT
73743	FISCHER SPECIAL MFG CO	111 INDUSTRIAL RD	COLD SPRING KY 41076-9749
75915	LITTELFUSE TRACTOR INC SUB TRACTOR INC	800 E NORTHWEST HWY	DES PLAINES IL 60016-3049
80009	TEKTRONIX INC	14150 SW KARL BRAUM DR PO BOX 500 MS 53-111	BEAVERTON OR 97077
93907	TEXTRON INC CAMCAR DIV	600 18TH AVE	ROCKFORD IL 61101
TK0392	NORTHWEST FASTENER SALES INC	7923 SW CIRRUS DRIVE	BEAVERTON OR 97005-6448
TK0435	LEWIS SCREW CO	4300 S RACINE AVE	CHICAGO IL 60609-3320
TK0858	STAUFFER SUPPLY CO	105 SE TAYLOR	PORTLAND OR 97214
TK1326	NORTHWEST FOURSLIDE INC	18224 SW 100TH CT	TUALATIN OR 97062

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-1	105-0932-00			2	LATCH,PANEL:SIDE	80009	105-0932-00
-2	214-3364-00			2	FASTENER,LATCH:ACETAL,SIL GRAY	80009	214-3364-00
-3	337-3039-00			2	SHIELD,ELEC:SIDE	80009	337-3039-00
-4	334-5070-00			1	MARKER,IDENT:MKD PS5004	80009	334-5070-00
-5	378-2030-09			1	LENS,LED DSPL:PRINTED	80009	378-2030-09
-6	366-2074-00			1	KNOB:DOVE GRAY,0.284 ID X 0.392 OD X 0.466 H	80009	366-2074-00
	213-0246-00			1	.SETSCREW:5-40 X 0.094,STL	71159	ORDER BY DESCR
-7	366-2072-00			1	KNOB:DOVE GRAY,,0.421 ID X 0.706OD X 0.6 H	80009	366-2072-00
	213-0153-00			2	.SETSCREW:5-40 X 0.125,STL	TK0392	ORDER BY DESCR
-8	136-0731-00			2	JACK,TIP:BLACK	80009	136-0731-00
					(ATTACHING PARTS)		
-9	210-0465-00			1	NUT,PLAIN,HEX:0.25-32 X 0.375,BRS CD PL	73743	3095-402
-10	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-11	136-0732-00			2	JACK,TIP:RED	80009	136-0732-00
					(ATTACHING PARTS)		
-12	210-0465-00			1	NUT,PLAIN,HEX:0.25-32 X 0.375,BRS CD PL	73743	3095-402
-13	210-0940-00			1	WASHER,FLAT:0.25 ID X 0.375 OD X 0.02,STL	12327	ORDER BY DESCR
					(END ATTACHING PARTS)		
-14	366-1851-01			1	KNOB,LATCH:IVORY GY,0.625 X 0.25 X 1.09	80009	366-1851-01
-15	105-0865-00			1	BAR,LATCH RLSE:	80009	105-0865-00
-16	105-0866-00			1	LATCH,RETAINING:SAFETY	80009	105-0866-00
-17	214-3143-00			1	SPRING,HLEXT:0.125 OD X 0.545 L,XLOOP	80009	214-3143-00
-18	220-0633-00			1	NUT,PLAIN,KNURL:0.25-28 X 0.375 OD,BRS NP	80009	220-0633-00
-19	355-0239-00			1	STUD,SHOULDERED:BINDING POST,BRASS	80009	355-0239-00
-20	333-3042-00			1	FRONT PNL ASSY:	80009	333-3042-00
-21	337-3076-00			1	SHIELD,ELEC:FRONT SUBPANEL PS5004	80009	337-3076-00
					(ATTACHING PARTS)		
-22	220-0624-00			2	PUSH ON NUT:0.108 ID X 0.312 OD,CU BE	80009	220-0624-00
					(END ATTACHING PARTS)		
-23	214-3089-00			2	LOCKOUT,PLUG-IN:PLASTIC	80009	214-3089-00
-24	214-3406-00			1	SPRING,FLAT:1.48 L X 0.125 W,CU BE	TK1326	ORDER BY DESCR
-25	426-0725-24			1	FR SECT,PLUG-IN:TOP	80009	426-0725-24
					(ATTACHING PARTS)		
-26	211-0101-00			2	SCREW,MACHINE:4-40 X 0.25,FLH,100 DEG,STL	TK0435	ORDER BY DESCR
					(END ATTACHING PARTS)		
-27	----- -----			1	CA ASSY,SP,ELEC:(SEE W500 REPL)		
-28	----- -----			1	CKT BOARD ASSY:PROGRAMMER(SEE A11 REPL)		
					(ATTACHING PARTS)		
-29	211-0244-00			1	SCR,ASSEM WSHR:4-40 X 0.312,PNH STL	TK0858	211-0244-00
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-30	----- -----			1	.CONN,RCPT,ELEC:(SEE A11J1070 REPL)		
-31	253-0135-01			1	.PLASTIC STRIP:VINYL FOAM,0.062 X 0.5	80009	253-0135-01
-32	136-0729-00			1	.SKT,PL-IN ELEK:MICROCKT,16 CONTACT	09922	DILB16P-108T
-33	136-0755-00			1	.SKT,PL-IN ELEK:MICROCIRCUIT,28 DIP	09922	DILB28P-108
-34	----- -----			14	.TERM,PIN:(SEE A11J4020,J4022&J4024 REPL)		
-35	----- -----			2	.BUS,COND:(SEE A11P4020&P4024 REPL)		
-36	136-0757-00			2	.SKT,PL-IN ELEK:MICROCIRCUIT,40 DIP	09922	DILB40P-108
-37	----- -----			2	.TERM,TEST POINT:(SEE A11TP3020, .TP3021 REPL)		
-38	129-0502-00			4	SPACER,POST:0.9 L,4-40,DELRIN,0.25 OD	80009	129-0502-00
					(ATTACHING PARTS)		
-39	211-0244-00			4	SCR,ASSEM WSHR:4-40 X 0.312,PNH STL	TK0858	211-0244-00
-40	211-0097-00			1	SCREW,MACHINE:4-40 X 0.312,PNH,STL	TK0435	ORDER BY DESCR
					(END ATTACHING PARTS)		
-41	----- -----			1	CKT BOARD ASSY:FRONT PANEL(SEE A10 REPL)		
					(ATTACHING PARTS)		
-42	211-0244-00			3	SCR,ASSEM WSHR:4-40 X 0.312,PNH STL	TK0858	211-0244-00
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-43	----- -----			1	.ENCODER,DI:(SEE A10S3020 REPL)		
-44	----- -----			1	.CONN,RCPT,ELEC:(SEE A10J1030 & J5021 REPL)		
-45	----- -----			1	CKT BOARD ASSY:MAIN(SEE A12 REPL)		
					(ATTACHING PARTS)		
-46	211-0097-00			2	SCREW,MACHINE:4-40 X 0.312,PNH,STL	TK0435	ORDER BY DESCR
-47	211-0101-00			2	SCREW,MACHINE:4-40 X 0.25,FLH,100 DEG,STL	TK0435	ORDER BY DESCR

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-48	210-0406-00			2	NUT,PLAIN,HEX:4-40 X 0.188,BRS CD PL	73743	12161-50
-49	210-1178-00			2	WASHER,SHLDR: (END ATTACHING PARTS) CKT BOARD ASSY INCLUDES:	13103	7721-7PPS
-50	----- -----			1	.CONN,RCPT,ELEC:(SEE A12P1030 REPL)		
-51	----- -----			1	.CONN,RCPT,ELEC:(SEE A12J4101 REPL)		
-52	----- -----			1	.TERM SET, PIN:(SEE A12J4041 REPL)		
-53	253-0135-01			1	.PLASTIC STRIP:VINYL FOAM,0.062 X 0.5	80009	253-0135-01
-53.1	136-0756-00	B010651		1	.SKT,PL-IN ELEK:MICROCIRCUIT,18 DIP	09922	DILB18P-108
-53.2	136-0729-00	B010651		1	.SKT,PL-IN ELEK:MICROCKT,16 CONTACT	09922	DILB16P-108T
-54	----- -----			5	.TERM,TEST POINT:(SEE A12TP1021,TP1051, .TP1052,TP2041&TP5051 REPL)		
-55	344-0326-00			10	.CLIP,ELECTRICAL:FUSE,BRASS	75915	102071
-56	----- -----			1	.CONN,RCPT,ELEC:(SEE A12J1071 REPL)		
-57	----- -----			4	.BUS,COND:(SEE A12P4041 REPL)		
-58	----- -----			1	.TRANSISTOR:(SEE A12U1030 REPL)		
-59	----- -----			1	.TRANSISTOR:(SEE A12U1051 REPL)		
-60	342-0355-00			2	INSULATOR,PLATE:TRANSISTOR,SILICONE RUBBER	55285	7403-09FR-51
-61	426-0724-25			1	FR SECT,PLUG-IN:BOTTOM (ATTACHING PARTS)	80009	426-0724-25
-62	211-0101-00			1	SCREW,MACHINE:4-40 X 0.25,FLH,100 DEG,STL	TK0435	ORDER BY DESCR
	211-0025-00			1	SCREW,MACHINE:4-40 X 0.375,FLH,100 DEG,STL (END ATTACHING PARTS)	TK0435	ORDER BY DESCR
-63	220-0729-00			1	NUT BLOCK:4-40 X 0.188,BRS NP (ATTACHING PARTS)	80009	220-0729-00
-64	211-0008-00			1	SCREW,MACHINE:4-40 X 0.25,PNH,STL (END ATTACHING PARTS)	93907	ORDER BY DESCR
-65	255-0581-00			AR	PLASTIC CHANNEL:0.156 X 0.156,POLYETHYLENE	80009	255-0581-00
-66	386-4910-01			1	SUPPORT,FRAME:REAR (ATTACHING PARTS)	80009	386-4910-01
-67	213-0868-00			2	SCREW,TPG,TF:6-32 X 0.375 L,FILH,STL	93907	ORDER BY DESCR
-68	386-3657-01			2	SUPPORT,PLUG-IN: (END ATTACHING PARTS)	93907	ORDER BY DESCR
					STANDARD ACCESSORIES		
	070-4442-00			1	MANUAL,TECH:INSTR,PS5004	80009	070-4442-00
	070-4596-00			1	MANUAL,TECH:GUIDE,PS5004	80009	070-4596-00
	070-4789-00			1	MANUAL,TECH:INSTR,PS5004	80009	070-4789-00

6.

PLEASE INSERT(1) Z-FOLD

FIG. 1

~~THRU~~

HERE

SEE SEQ. LIST.

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REVISION INFORMATION

Manual Part No. 070-4442-00 **First Printing** January 1984

Product: PS 5004 Precision Power Supply **Revised** August 1988

Manual Insert Status

DATE	CHANGE REFERENCE	STATUS
AUG 87	M63831	Effective
SEP 87	M64265	Effective
JUL 88	M67435	Effective
AUG 88	C2/0888	Effective
JUN 89	M69881	Effective
JUN 89	M70167	Effective

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MANUAL CHANGE INFORMATION

Date: 8-24-87 Change Reference: M63831

Product: PS5004 Manual Part No.: 070-4442-00

DESCRIPTION

These changes are effective at serial number B011152 of the PS5004 (kit # 670-0017-00):

	Circuit #	Part Number	Description
Remove:	A10S3031	263-0019-36	Switch, pushbutton assy
Add:	A10S3031	263-0114-00	Switch, pushbutton assy

000-2775-00D

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MANUAL CHANGE INFORMATION

Date: 9-25-87 Change Reference: M64265

Product: PS5004 Manual Part No.: 070-4442-00

DESCRIPTION Product Group 76

These changes are effective at serial number B011209:

Replaceable Electrical Parts List.

	Circuit #	Part Number	Description
	(Kit # 673-0024-01)		
Remove:	A11U3061	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4060	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4062	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4081	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4082	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	(Kit # 673-0025-02)		
	A12U4062	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
	A12U4063	156-0885-00	OPTOELECTRONIC ISOLATOR, 5KV
Add:	(Kit # 673-0024-01)		
	A11U3061	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4060	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4062	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4081	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	A11U4082	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	(Kit # 673-0025-02)		
	A12U4062	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV
	A12U4063	156-0885-05	OPTOELECTRONIC ISOLATOR, 5KV

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MANUAL CHANGE INFORMATION

Date: July 19, 1988 Change Reference: M67435

Product: PS 5004 Precision Power Supply Manual Part No: 070-4442-00

DESCRIPTION

For Serial Numbers B011547 and above, please make the following changes:

Replaceable Electrical Parts

Change:

Page 8-5

A11C3092	281-0788-00	Cap,Fxd,Cer Dl:470 pF,10%,100V
A11C3093	281-0788-00	Cap,Fxd,Cer Dl:470 pF,10%,100V
A11R3092	315-0331-00	Res,Fxd,Film:330 ohm,5%,0.25W
A11R3093	315-0331-00	Res,Fxd,Film:330 ohm,5%,0.25W

MANUAL CHANGE INFORMATION

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Date: Aug 10, 1988 Change Reference: C2/0888

Product: PS 5004 Precision Power Supply Manual Part No: 070-4442-00

DESCRIPTION

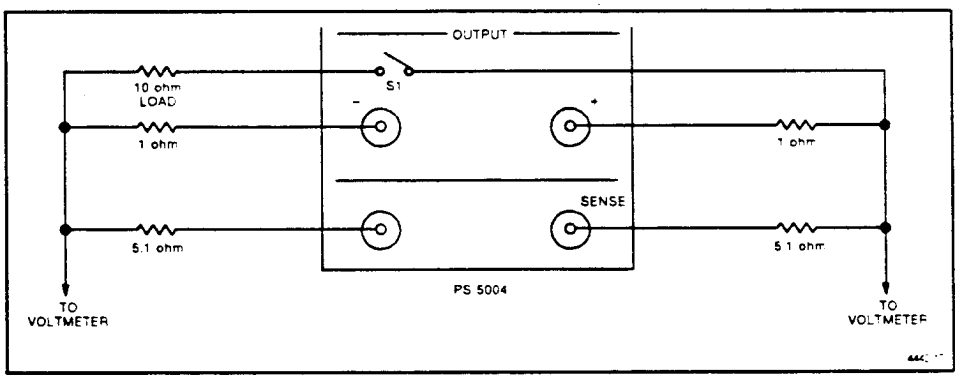
For all Serial Numbers, please make the following changes:

Calibration Performance Check

Correct as follows:

Page 5-4

Replace Fig. 5-1 with the following illustration.



Page 5-6

Change part c of step 6, 7A13 Comparison Voltage setting to read:

Comparison Voltage 0.224V +

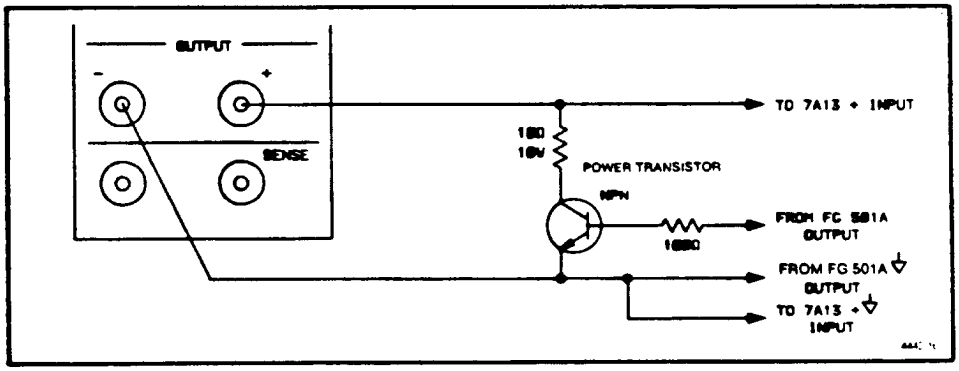
Delete all the control settings following part c of step 6 for the 7A22 and 7603 instruments

Change part d of step 6, FG 501A Amplitude to read:

Amplitude Fully CW.

Delete parts g and h of step 6 and re-letter all remaining parts of step 6, i.e., last part of step 6 is now part m.

Replace Fig. 5-2 with the following illustration.



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MANUAL CHANGE INFORMATION

Date: Jun 12, 1989 Change Reference: M69881

Product: PS 5004 Precision Power Supply Manual Part No: 070-4442-00

DESCRIPTION

For Serial Numbers B011780 and above, please make the following changes:

Section 8

REPLACEABLE ELECTRICAL PARTS

Change:

Pages 8-4, 8-7 & 8-12

A11	670-0024-03	CIRCUIT BD ASSY:PROGRAMMER
A12	670-0025-03	CIRCUIT BD ASSY:MAIN
A11U3061	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION
A11U4060	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION
A11U4062	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION
A11U4081	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION
A11U4082	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION
A12U4062	156-0885-00	CPLR,OPTOELECTR:LED,5KV ISOLATION

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MANUAL CHANGE INFORMATION

Date: Jun 19, 1989 Change Reference: M70167

Product: PS 5004 Precision Power Supply Manual Part No: 070-4442-00

DESCRIPTION

For Serial Numbers B011791 and above, please make the following changes:

Section 8

REPLACEABLE ELECTRICAL PARTS

Change:

Page 8-4

A12	670-0025-04	CIRCUIT BD ASSY:MAIN

Change:

Page 8-11

A12R4031	308-0231-00	RES,FXD,WW:220 OHM,5%,3W