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NUCLEAR INSTRUMENT MODULE MAINTENANCE MANUAL

PART 20

-15 VOLT AND -25 VOLT VOLTAGE REGULATORS, ORNL MODEL Q-2620

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ABSTRACT

The -15 Volt and -25 Volt Voltage Regulator module is for use in providing regulated voltages for nuclear reactor instrumentation. The input is a dc voltage in the range of -28 to -36 v.

The regulators are packaged in a standard plug-in module of the ORNL Modular Reactor Instrumentation Series.

This report describes the circuits, applications, maintenance procedures, and acceptance test for the regulators.

CONTENTS

1. DESCRIPTION

1.1 General

The -15 Volt and -25 Volt Voltage Regulator module is intended for use in providing regulated voltages for nuclear reactor instrumentation. The input to the regulator circuits is a dc voltage in the range of -28 to -36 v. The regulator outputs have a common electrical ground.

1.2 Construction

The -15 Volt and -25 Volt Voltage Regulators are constructed in a single module 5.63 in. wide, 4.72 in. high, and 11.90 in. deep. It is a standard "4-unit" plug-in module of the ORNL Modular Reactor Instrumentation series depicted on ORNL drawings Q-2600-1 through Q-2600-5.

Each regulator circuit is constructed on a printed circuit board mounted within the module and is unshielded.

1.3 Application

The -15 Volt and -25 Volt Voltage Regulators are used to provide sources of well-regulated voltage to any instrument requiring either -15 v dc or -25 v dc within the current rating of the regulators. The input to the regulators is normally a bank of 32-v batteries. The battery-bank terminal voltage can vary from 28 to 36 v, however, depending upon the charge condition of the battery bank.

1.4 Specifications

1.4.1 -15 Volt Regulator

1.	Input voltage:	-28 to -36 v dc.
2.	Output voltage:	-15 v dc.
3.	Maximum output current:	1.5 amp.
4.	Ambient temperature range:	10 to 55°C.
5.	Load regulation:	0.01%.
6.	Line regulation:	0.01%.
7.	Maximum temperature coefficient:	0.005%/°C.
8.	Long-term stability:	0.01%/24 hours.

1.4.2 -25 Volt Regulator

1.	Input voltage:	-28 to -36 v dc.
2.	Output voltage:	-25 v dc.
3.	Maximum output current:	750 ma.
4.	Ambient temperature range:	10 to 55°C.
5.	Line regulation:	0.01%.
6.	Load regulation:	0.01%.
7.	Maximum temperature coefficient:	0.002%/°C.
8.	Long-term stability:	0.01%/24 hours.

1.5 Applicable Drawings

The following list gives the drawing numbers (ORNL Instrumentation and Controls Division drawing numbers) and subtitles and the fabrication specification number for the -15 Volt and the -25 Volt Voltage Regulators:

1.	Q-2620-1	Circuit.
2.	Q-2620-2	Details.
3.	Q-2620-3	Metalphoto Panel.
4.	Q-2620-4	Printed Circuit Board.
5.	Q-2620-5	Assembly.
6.	Q-2620-6	Parts List.
7.	SF-250	Fabrication Specification.

The following list gives the drawing numbers (ORNL Instrumentation and Controls Division drawing numbers) and subtitles for the Plug-In Chassis System:

1.	Q-2600-1	Assembly.
2.	Q-2600-2	Details.
3.	Q-2600-3	Details.
4.	Q-2600-4	Details.
5.	Q-2600-5	Details.

2. THEORY OF OPERATION

2.1 General

The -25 Volt and the -15 Volt Voltage Regulators are transistorized series-voltage regulators. These regulators are essentially high-gain feedback amplifiers. Each regulator provides a stable output voltage when either the input voltage or the output current is varied over the range for which each was designed.

2.2 Circuit Description

This circuit description applies to the -25 Volt Voltage Regulator and the -15 Volt Voltage Regulator.

Figure 1, a block diagram of the regulator circuits, is included as an illustration to supplement this circuit description. The complete circuit diagram is shown in Fig. 2.

Each regulator has a single-ended differential amplifier which samples the output voltage and compares it with the voltage drop across a temperature-compensated reference diode. This amplifier produces an output voltage proportional to the difference between the change in the reference voltage and the change in the sampled output voltage when a change occurs in the output voltage. The two differential-amplifier transistors in each regulator are packaged in a single TO-5 case. These transistors are Q12A and Q12B in the -25 v regulator, and Q6A and Q6B in the -15 regulator. The two transistors in each package are closely matched in their V_{BE} and h_{FE} characteristics.

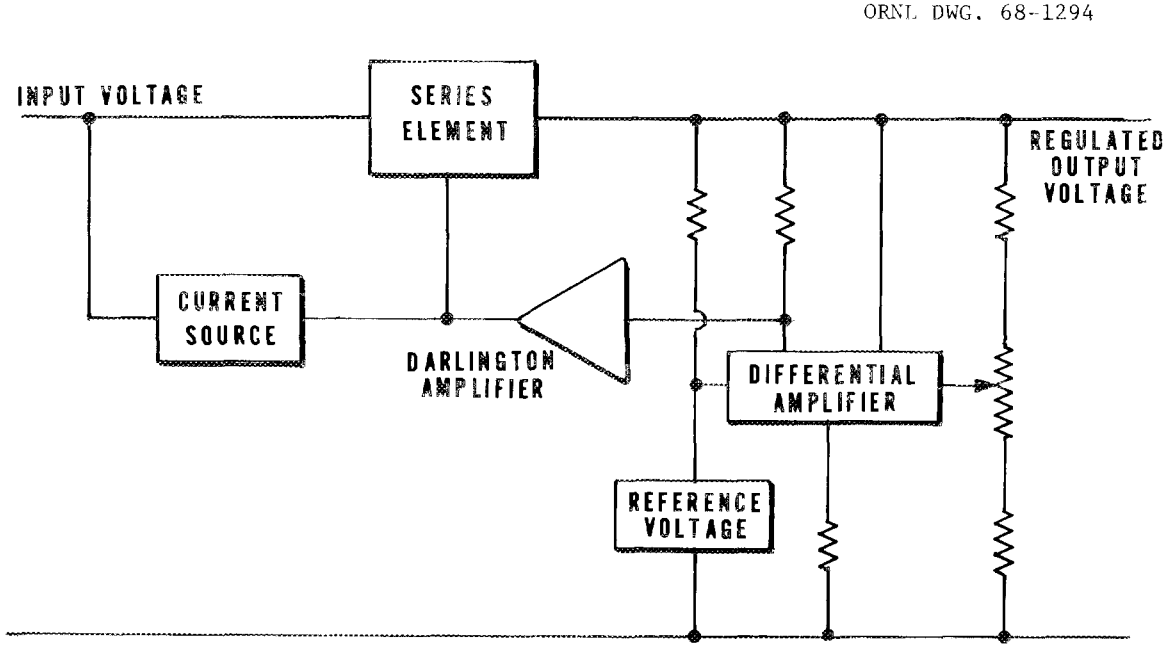

Fig. 1. Diagram of -15 Volt and -25 Volt Regulator Circuits.

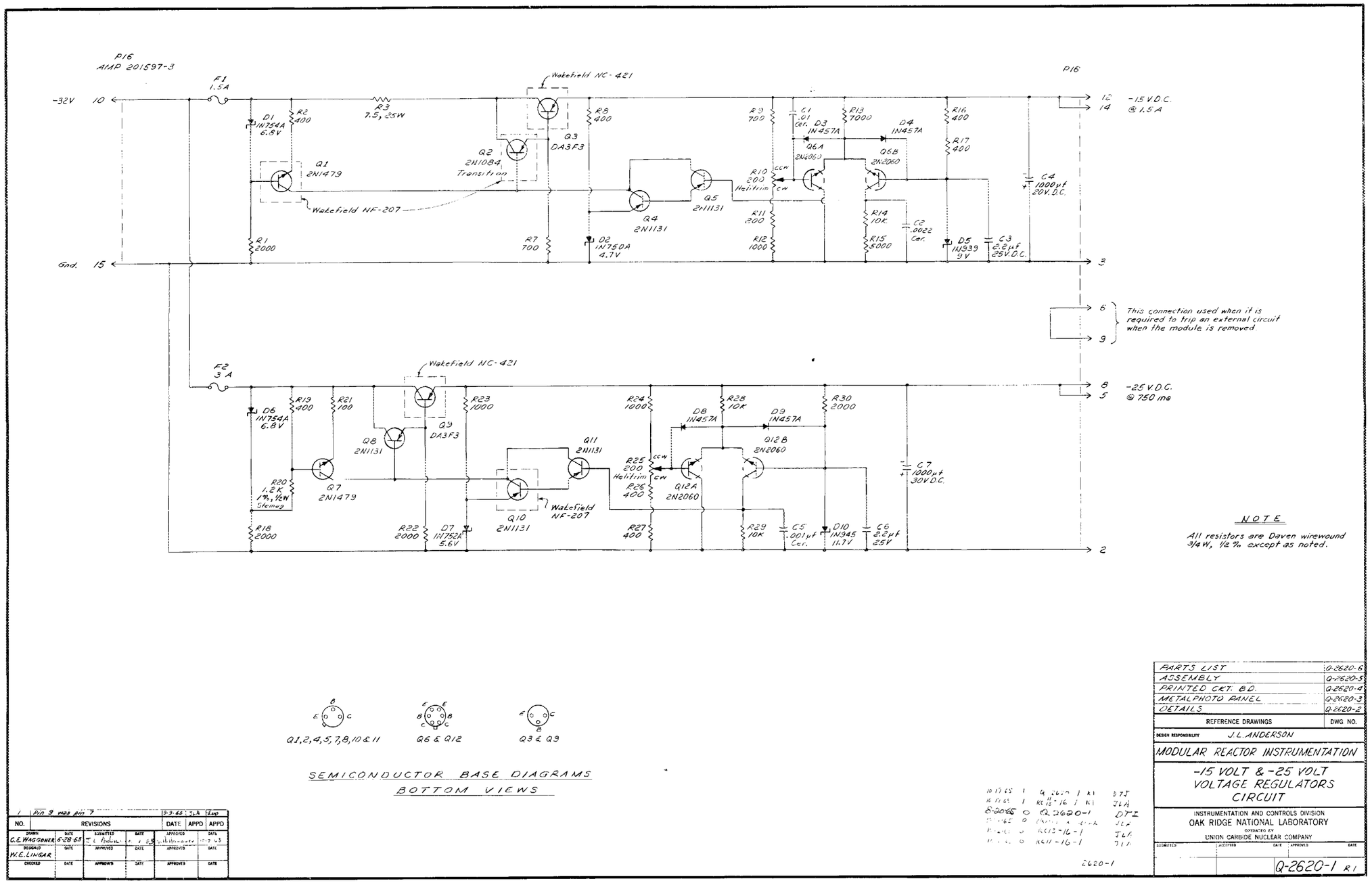

Fig. 2. Circuit of -15 Volt and -25 Volt Voltage Regulators.

The output voltage of the differential amplifier is fed into a Darlington pair amplifier which produces a large voltage gain from the differential amplifier to the series regulating element. The collectors of the Darlington pair are connected to a node that joins a current source and the series regulating element.

The series regulating element in each regulator is a Darlington pair amplifier which provides a large current gain from the node to the regulator output. The series regulating element is connected in series with the regulator input and the regulator output. The output of the series element is varied when either the input voltage or the output current is changed so that constant output voltage is maintained.

3. OPERATING INSTRUCTIONS

3.1 Installation

The -25 v and -15 v Voltage Regulator is a module of the ORNL Modular Reactor Instrumentation series. Like the other modules in this series, it has standard connectors and dimensions and has a pin- and hole-code on the rear plate so that the module will not be inserted in a wrong location in a drawer. The module is installed by placing it in its proper location, inserting the module firmly, and tightening the thumb screw. The module may be plugged in with power on without damage.

3.2 Operating Controls

There are no operating controls on the module.

3.3 Connections

All connections are made through the rear connector P16 when the module is inserted.

4. MAINTENANCE INSTRUCTIONS

4.1 General

This module is designed to operate continuously with a minimum of maintenance and no adjustments. Should a failure occur, any part listed in the Replaceable Parts List, Sect. 5, may be replaced.

4.2 Periodic Maintenance

There is no specific periodic maintenance procedure.

4.3 Calibration

Potentiometer R25 on the -25 v voltage regulator card can be adjusted to bring the output voltage to -25 v, and potentiometer R10 on the -15 v voltage regulator card can be adjusted to bring the output voltage to -15 v. For both potentiometers, clockwise rotation of the adjustment screw increases the output voltage, and counterclockwise rotation decreases the output voltage.

4.4 Trouble Shooting

The most likely source of trouble is an open fuse in the input circuit. The input fuse in the -15 v regulator is F1, and the input fuse in the -25 v regulator is F2. In addition, any of the transistor or diode junctions could become faulty under certain load conditions.

4.5 Transistor Voltage Chart

The voltage of all transistors are listed in Table 1.

Table 1. Transistor Voltage Chart[1]

Transistor	Emitter	Base	Collector
Q1	-25.82	-25.24	-15.7
Q2	-15.08	-15.7	-31.54
Q3	-15.00	-15.08	-31.54
Q4	- 4.79	- 5.42	-15.7
Q5	- 5.42	- 5.99	-15.7
Q6A	- 9.81	- 9.20	0.00
Q6B	- 9.81	- 9.19	- 5.99
Q7	-31.04	-30.45	-25.75
Q8	-25.08	-25.75	-32.01
Q9	-25.00	-25.08	-32.01
Q10	- 5.64	- 6.28	-25.75
Q11	- 6.28	- 6.88	-25.75
Q12A	-12.04	-11.43	0.00
Q12B	-12.04	-11.43	- 6.88

[1] All voltages were measured with respect to ground with a Cubic V-85 digital voltmeter. The input voltage to the regulators was -32 v dc, and the output of each regulator was unloaded.

5. REPLACEABLE PARTS LIST

A description and an ORNL stores number for all replaceable parts are given in Table 2.

Table 2. Replaceable Parts List

Part No.	ORNL Stores No.	Description
C4		Capacitor, 1000 mf, -10 +100%, 20 v dc w, -10 to +85°C operating temperature, 0.750 in. diameter by 2.0 in. long, type PSD, Callins Industries, Inc.
C7		Capacitor, 1000 mf, -10 +100%, 30 v dc w, -10 to +85°C operating temperature, 0.875 in. diameter by 2.50 in. long, type PSD, Callins Industries, Inc.
C3, C6	06-802-0091	Capacitor, 2.2 mf, ±20%, 25 v dc w, ceramic monolithic, Sprague No. 5C15.
C1	06-802-0084	Capacitor, 0.01 mf, ±20%, 25 v dc w, ceramic, monolithic, Sprague No. 3C3.
C5	06-802-0390	Capacitor, 0.001 mf, ±10%, 1000 v dc w, ceramic, disc, formulation C28, Sprague No. 29C151A1.
C2	06-802-0395	Capacitor, 0.0022 mf, ±20%, 1000 v dc w, ceramic, disc, formulation C40, Sprague No. 20C162.
R20	06-932-0099	Resistor, 1200 ohms, ±1%, 1/2 w, deposited carbon, Stemag type SLAK, double high-temperature varnish impregnated, H.E. Priester Corp., Scarsdale, N.Y. (ORNL supplied).
R10, R25	06-930-8204	Potentiometer, trimmer, 200 ohms, ±10%, 1-1/2 w, conductive glass resistance element, "Helitrim" series 53 with printed circuit pins, Helipot Div.
R3		Resistor, 7.5 ohms, ±5%, 25 w, ww, vitreous enamel coating, Dividohm, Ohmite No. 0362B.
R21	06-936-0660	Resistor, 1000 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
R11	06-936-0665	Resistor, 200 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R2, R8, R16, R17, R19, R26, R27	06-936-0670	Resistor, 400 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R7, R9	06-936-0675	Resistor, 700 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R12, R23 R24	06-936-0680	Resistor, 1000 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R1, R18, R22, R30	06-936-0685	Resistor, 2000 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R15	06-936-0692	Resistor, 5000 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R13	06-936-0695	Resistor, 7000 ohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
R14, R28, R29	06-936-0700	Resistor, 10 kilohms, ±1/2%, 3/4 w at 125°C, ww, noninductive, temp coeff not to exceed 20 ppm/°C, Daven type 1252.
Q4, Q5, Q8, Q10, Q11	06-996-1710	Transistor, PNP, silicon, type 2N1131, Texas Instr.
Q1, Q7	06-996-1985	Transistor, NPN, silicon, type 2N1479, RCA.
Q2		Transistor, PNP, type 2N1084, Transitron Electronic Corp.
Q3, Q9	06-996-2050	Transistor, PNP, type DA3F3, Honeywell.
Q6, Q12	06-996-1994	Transistor, dual NPN, type 2N2060, Fairchild.
D1, D6	06-995-6244	Diode, zener, 6.8 v, ±5%, 400 mw, type 1N754A, Motorola.
D3, D4, D8, D9	06-995-5820	Diode, silicon, type 1N457A, Electrical Ind. Assoc.

Table 2 (continued)

Part No.	ORNL Stores No.	Description
D2	06-995-6216	Diode, zener, 4.7 v, ±5%, 400 mw, type 1N750A, Motorola.
D5		Diode, zener, 9.0 v, temperature compensated, type 1N939, Motorola.
D7	06-995-6230	Diode, zener, 5.6 v, ±5%, 400 mw, type 1N752A, Motorola.
D10		Diode, zener, 11.7 v, temperature compensated, type 1N945, Motorola.
F1	06-874-3076	Fuse, micro, 1.5 amp, Littlefuse No. 27301.5.
F2	06-874-3080	Fuse, micro, 3 amp, Littlefuse No. 273003.

6. ACCEPTANCE TEST PROCEDURE

6.1 Test Equipment

The following test equipment is required:

1. A dc regulated power supply, adjustable from 28 to 36 v dc and capable of supplying 2.5 amp.
2. An oscilloscope, dc to 10 Mc, 1 mv/cm sensitivity.
3. A differential voltmeter capable of resolving 10^{-4} v with inputs from 10 to 25 v dc.
4. A temperature test chamber.
5. A 33-ohm, 25-w and a 10-ohm, 25-w resistor for dummy loads.

6.2 Acceptance Test

1. Adjust the power supply for 32 v dc output. Connect the positive terminal of the power supply to pin 15 of the regulator connectors, and the negative terminal to pin 10 of the regulator connector (P16).
2. Connect pin 2 of the regulator to the positive input terminal of the differential voltmeter, and pin 8 of the regulator to the negative input terminal of the voltmeter.
3. Adjust potentiometer R25 until the voltmeter reads 25.000 v.
4. Connect the oscilloscope probe to pin 8 of the regulator, and connect the probe ground lead to pin 2 of the regulator connector. Observe the oscilloscope trace for any evidence of oscillations with the oscilloscope sensitivity at 1 mv/cm.

5. Change the power supply output voltage from its 32-v setting to 28 v dc and observe the oscilloscope trace for evidence of oscillations. Next, while observing both the differential voltmeter for changes in regulator output voltage and the oscilloscope trace for oscillations, adjust the power supply voltage slowly until 36 v dc output is reached. The change in regulator output voltage should not be greater than 2.5 mv from its value of 25.000 v. A typical change is less than 0.25 mv. Reset the power supply output voltage to 32 v dc.

6. Connect a 33-ohm, 25-w resistor across pin 8 and pin 2 of the regulator connector and observe the voltage change on the differential voltmeter. The voltage change should not be greater than 2.5 mv. The typical change is 0.25 mv. Also, observe the oscilloscope trace for evidence of oscillations while the regulator is loaded.

7. Connect pin 3 of connector P16 to the positive input terminal of the differential voltmeter, and pin 12 of connector P16 to the negative input terminal of the voltmeter.

8. Adjust potentiometer R10 until the voltmeter reads 15.000 v.

9. Connect the oscilloscope probe to pin 12 of connector P16, and connect the probe ground lead to pin 3 of connector P16. Observe the scope trace for any evidence of oscillations on 1 mv/cm sensitivity.

10. Repeat step 5 of the acceptance test. The change in the regulator output voltage should not be greater than 1.5 mv from its value of 15.000 v. The typical change is less than 0.5 mv. Reset the power supply voltage to 32 v dc.

11. Connect a 10-ohm, 25-w resistor across pin 12 and pin 3 of connector P16, and observe the voltage change on the differential voltmeter. The voltage change should not exceed 1.5 mv. The typical change is 0.5 mv. Observe the oscilloscope trace for evidence of oscillations while the regulator is loaded.

12. A temperature stability test can be made by placing the module in a temperature controlled oven. Approximately 15 minutes should be allowed for the module to reach equilibrium after the oven temperature is changed.

The -25 v voltage regulator can be tested by making the connections indicated in steps 1, 2, and 4 of the acceptance test. The oscilloscope trace should be observed for evidence of oscillations during the test. The output voltage of the -25 v dc voltage regulator should not change more than 22.5 mv from its -25.00 v dc value over the temperature range 10 to 55°C. The typical change is 7 mv.

The -25 v dc voltage regulator can be tested by making the connections indicated in steps 1, 7, and 9 of the acceptance test. Observe the oscilloscope trace for evidence of oscillations during the test. The output voltage of the -15 v dc voltage regulator should not change more than 33.75 mv from its -15.000 v dc value over the temperature range of 10 to 55°C. The typical change is 12 mv.

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Part 20

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