



User and  
Service Guide

HP 3400B  
RMS Voltmeter



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The HP 3400B is a true root-means-square (RMS) analog voltmeter capable of measuring ac voltages from 100 microvolts to 300 volts. It is extremely flexible for audio and RF measurements from 10 Hz to 20 MHz and allows you to measure broadband noise and fast rise-time pulses.

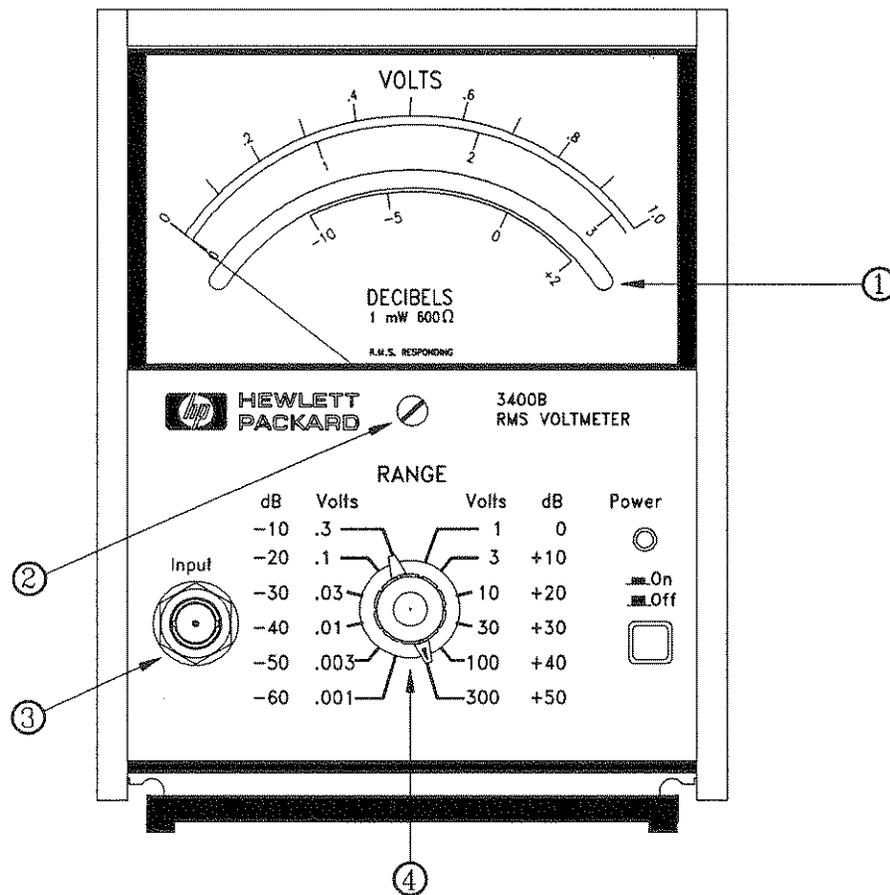
- Full-scale measurements of non-sinusoidal waveforms with crest factors (the ratio of peak voltage to RMS voltage) up to 10:1 can be made. At 1/10th of full scale, pulse trains with 0.01% duty cycle (100:1 crest factor) can be measured accurately.
- A single front-panel control selects one of 12 voltage ranges (1 mV to 300 V) or decibel ranges (-72 dBm to +52 dBm).
- A dc output is provided on the rear panel which is proportional to the front-panel meter reading. By using this voltage to drive auxiliary equipment, you can use the voltmeter as an RMS ac-to-dc converter.
- Suitable for bench use or can be rack-mounted using the available combining case or adapter frame accessories.

The HP 3400B is a form, fit, and function replacement for the original *HP 3400A*. Completely redesigned, the "B" version extends the bandwidth from 10 MHz, available with the "A" version, to 20 MHz. The *HP 3400B User and Service Guide* contains new specifications and calibration procedures for the improved performance of the HP 3400B. Updated schematics and replaceable parts lists are also included.

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## HP 3400B RMS Voltmeter

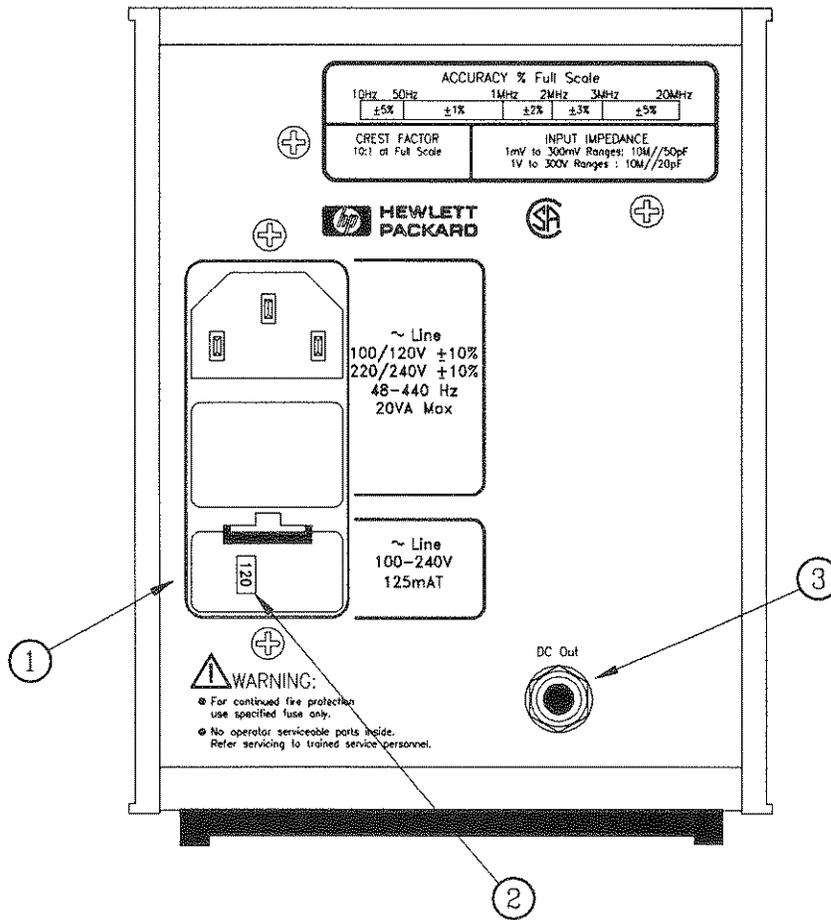
## The Front Panel at a Glance



1 Direct reading meter (RMS volts and dB)  
2 Zero adjustment screw

3 Input BNC connector  
4 Range selector switch (volts and dB)

## The Rear Panel at a Glance



1 Power-line fuse-holder assembly  
2 Power-line voltage setting

3 DC output jack. Provides -1 Vdc output at full-scale deflection; output is proportional to deflection; source impedance is 1 kΩ.

## Specifications

**Voltage Ranges:** 1 mV, 3 mV, 10 mV, 30 mV, 100 mV, 300 mV, 1 V, 3 V, 10 V, 30 V, 100 V, 300 V full scale.

**dB Range:** -72 dBm to +52 dBm  
(0 dBm = 1 mW into 600Ω).

**Frequency Range:** 10 Hz to 20 MHz

**Response:** Responds to RMS value (heating value) of input.

**Measurement Accuracy:** From 1/10th scale to full scale is % of full scale.  
Temperature coefficient:  $\pm 0.10\%$  per °C from 0°C to 20°C and 30°C to 55°C.  
20°C to 30°C  
(1 Year)

Frequency	$\pm$ % of Full Scale
10 Hz to 50 Hz	$\pm 5\%$
50 Hz to 1 MHz	$\pm 1\%$
1 MHz to 2 MHz	$\pm 2\%$
2 MHz to 3 MHz	$\pm 3\%$
3 MHz to 20 MHz	$\pm 5\%$

Note: The voltmeter may show a zero offset with no voltage applied to the input terminal.

**AC-to-DC Converter Accuracy:** 20°C to 30°C

Temperature coefficient:  $\pm 0.10\%$  per °C from 0°C to 20°C and 30°C to 55°C.

Frequency	$\pm$ % of Full Scale
10 Hz to 50 Hz	$\pm 5\%$
50 Hz to 1 MHz	$\pm 0.75\%$
1 MHz to 2 MHz	$\pm 2\%$
2 MHz to 3 MHz	$\pm 3\%$
3 MHz to 20 MHz	$\pm 5\%$

Note: The voltmeter may show a zero offset with no voltage applied to the input terminal.

**Input Impedance:** 1 mV to 300 mV ranges: 10 MΩ shunted by < 50 pF. AC-coupled input.  
1 V to 300 V ranges: 10 MΩ shunted by < 20 pF. AC-coupled input.

**Crest Factor:** (Ratio of peak-to-RMS amplitude of input.)  
10:1 at full scale except where limited by maximum input, and inversely proportional to meter deflection (e.g. 20:1 at half-scale, 100:1 at tenth-scale).

**AC Overload:** 30 dB above full scale or 800 V<sub>peak</sub>, whichever is less, on each range.

**Max. Continuous Input Voltage:** 500 Vac peak at 1 kHz or 600 Vdc on all ranges.

**Max. DC Input:** 600 V on any range.

**Response Time:** For a step function, < 5 seconds to respond to final value.

**DC Output:** Negative 1 Vdc into open circuit for full scale deflection, proportional to meter deflection.  
1 mA max; nominal source impedance 1 kΩ.

**Output Noise:** < 1 mV RMS

**Power:** 100 V / 120 V / 220 V / 240 V  $\pm 10\%$ .  
48 Hz to 440 Hz, 10 Watts.

**Weight:** 2.2 kg (4.9 lbs); shipping: 4.0 kg (8.7 lbs).

**Size:** 16.5 cm (H) x 13.0 cm (W) x 29.7 cm (D)

**Storage Temperature:** -10°C to +60°C

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## Quick Start

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## Quick Start

One of the first things you will want to do with your voltmeter is to become acquainted with its front panel. We have written the exercises in this chapter to prepare the voltmeter for use and help you get familiar with some of its front-panel operations.

Chapter 1 Quick Start  
To prepare the voltmeter for use

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## To prepare the voltmeter for use

The following steps help you verify that the voltmeter is ready for use.

### 1 Check the list of supplied items.

Verify that you have received the following items with your voltmeter. If anything is missing, contact your nearest Hewlett-Packard Sales Office.

- One double binding post to BNC adapter.
- One power cord.
- One 125 mA power-line fuse is installed.
- This *User and Service Guide*.

### 2 Verify the power-line voltage setting.

Four line voltage settings are available: *100, 120, 220, or 240 Vac*. The line voltage was preset at the factory to the proper value for your location. Change the voltage setting if it is not correct (see page 12).

A 125 mA fuse is installed when the voltmeter is shipped from the factory. This is the correct power-line fuse for 100, 120, 220, or 240 Vac operation.

### 3 Connect the power cord and turn on the voltmeter.

The front-panel **Power** indicator will light up when you turn on the voltmeter. Allow *five minutes* for the voltmeter to warm up and stabilize before making measurements.

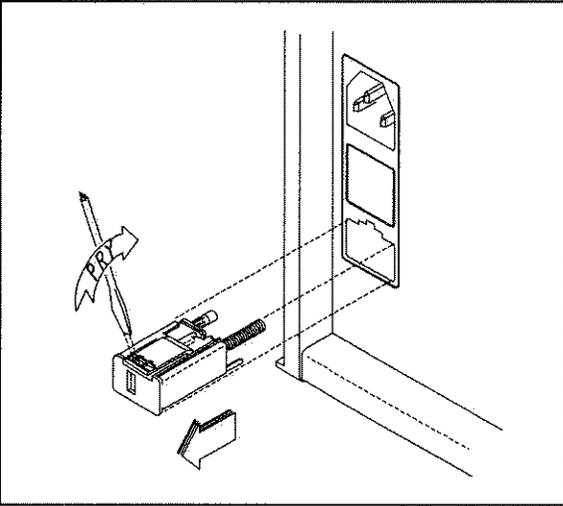
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**Caution**

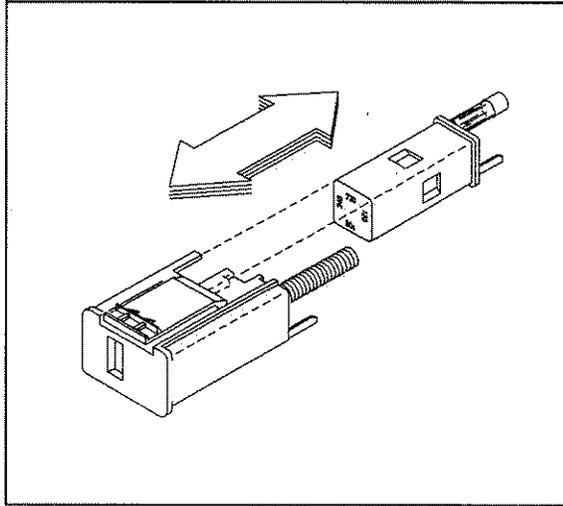
*Do not measure signals greater than 80 volts with 10 to 1 crest factor, otherwise, the maximum input rating of 800 volts peak will be exceeded. When measuring signals up to 80 volts with a 10 to 1 crest factor, use the double binding post to BNC adapter (or equivalent) supplied with the voltmeter.*

**Chapter 1 Quick Start**  
**To prepare the voltmeter for use**

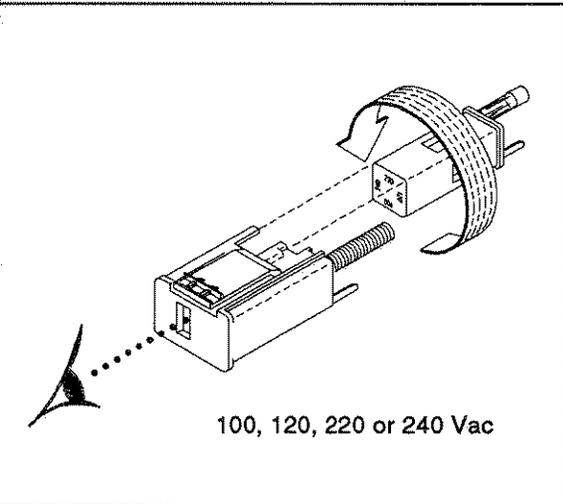
**1 Remove the fuse-holder assembly from the rear panel.**



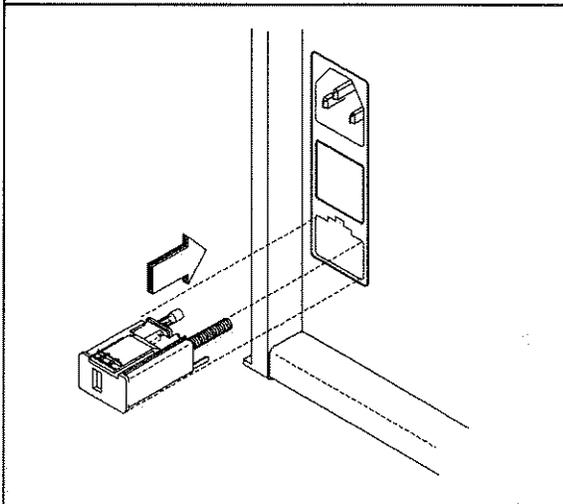
**2 Remove the line-voltage selector from the assembly.**



**3 Rotate the line-voltage selector until the correct voltage appears in the window.**



**4 Replace the fuse-holder assembly in the rear panel.**



**Verify that the correct line voltage appears in the window.**

Chapter 1 Quick Start  
To select the range

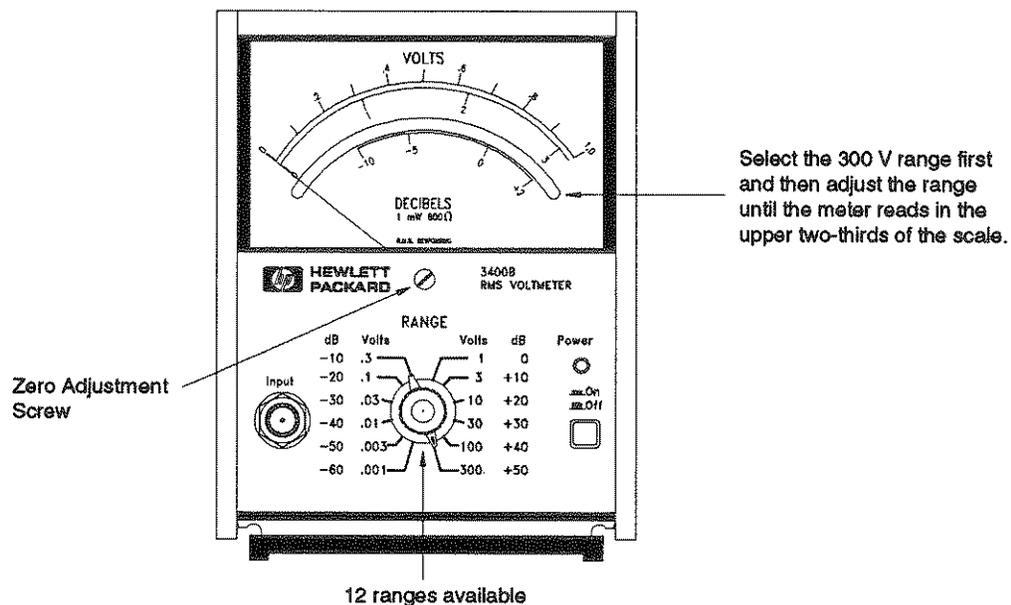
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## To select the range

You can make measurements using one of 12 voltage ranges available. The voltmeter is capable of measuring true-RMS ac voltages from 100  $\mu$ V to 300 V.

### Caution

*When measuring an ac signal superimposed on a dc level, you should always set the range selector switch to the 300 volt position. A high-voltage transient caused by the application of a dc voltage will damage the voltmeter's input circuitry.*



**Note** The voltmeter may show a zero offset with no voltage applied to the input terminal.

**Note** If the meter pointer does not indicate "0" when the voltmeter has been turned off for at least one minute, you should adjust the zero screw setting. See chapter 2, "Calibration Procedures," for more information.

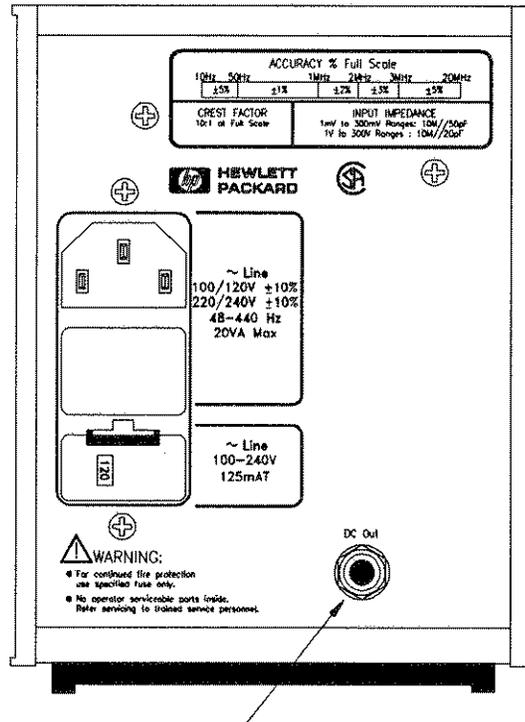
## Chapter 1 Quick Start

### To use the DC output signal

## To use the DC output signal

You can create plots of measured data and make higher resolution measurements by connecting an X-Y plotter or digital multimeter to the rear-panel DC output jack. On the 1's ranges (0.001, 0.01, 0.1, 1, etc.), the voltage measured at the jack is normalized to  $-1$  Vdc and is proportional to the RMS input voltage ( $-1$  Vdc corresponds to a full-scale meter deflection). On the 3's ranges (0.003, 0.03, 0.3, 3, etc.), the full-scale output is  $-0.9487$  Vdc.

*A phone plug for the DC output jack is available by ordering HP part number 1251-0067.*



Negative 1 Vdc into open circuit for full scale deflection; proportional to meter deflection.

1 mA max; nominal source impedance 1 kΩ.

Chapter 1 Quick Start  
To rack mount the voltmeter

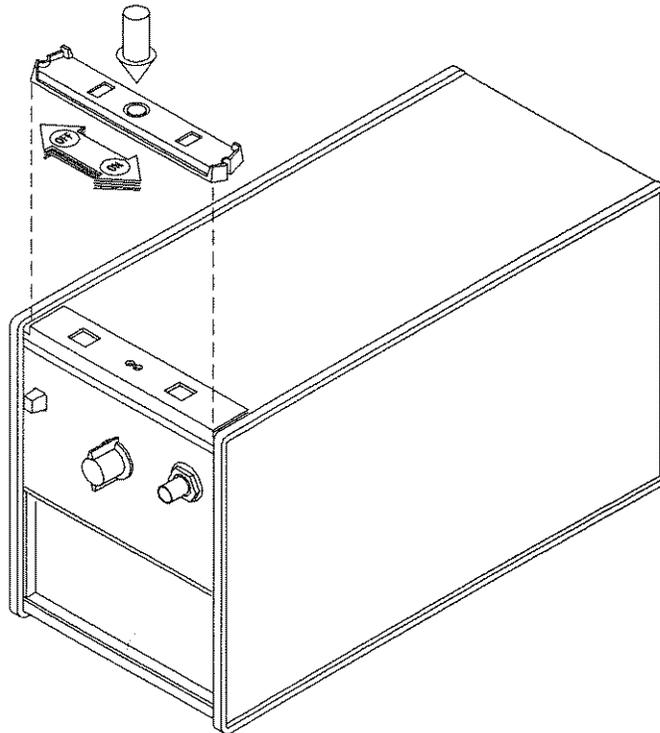
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## To rack mount the voltmeter

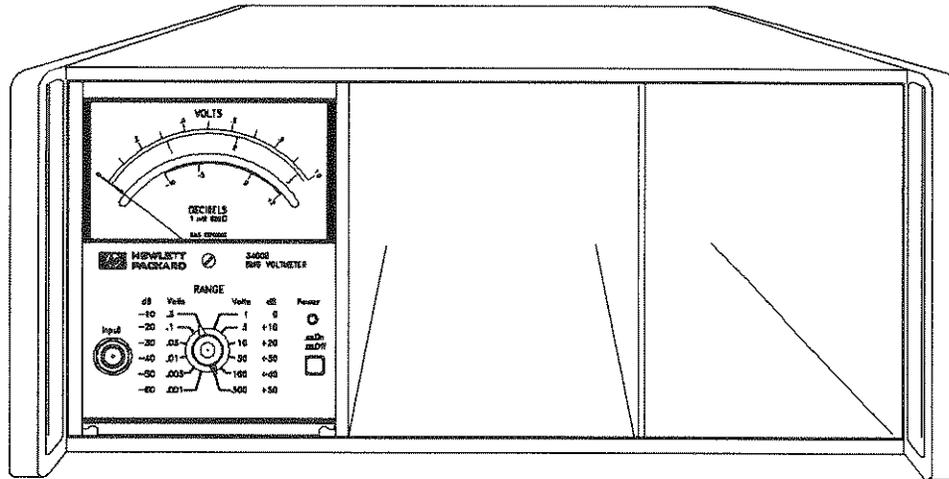
You can mount the voltmeter in a standard 19-inch rack cabinet using one of two optional kits available. If your application requires that you frequently remove the voltmeter from the cabinet, the *combining case* is recommended. You can also use the combining case on the bench to mount the voltmeter with other HP System I instruments. The *rack adapter frame* is recommended for permanent or semi-permanent rack mounting applications.

*Remove the front and rear feet before mounting the voltmeter in the combining case or rack adapter frame.*

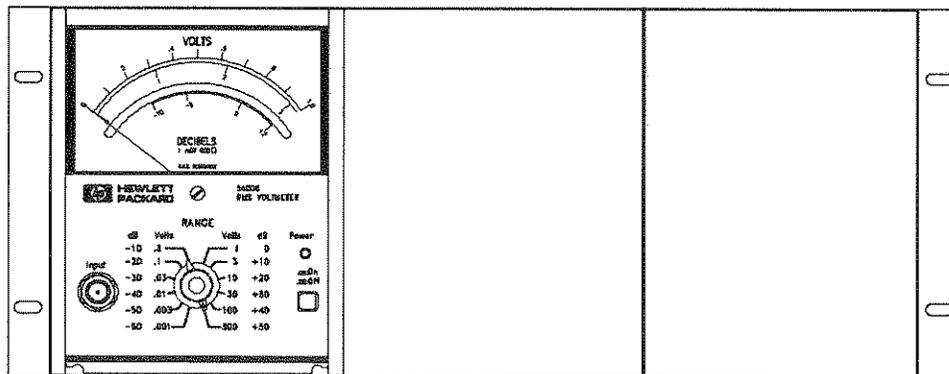


**To remove the feet, press down on the release tab and slide to side.**

Chapter 1 Quick Start  
 To rack mount the voltmeter



To use the combining case, order part number HP 1052A and rack mount kit 5060-8741.



To use the rack adapter frame, order part number HP 5060-8762.



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Calibration  
Procedures

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## Calibration Procedures

This chapter contains procedures for performing the voltmeter's verification and adjustment procedures. Notice that the verification procedures are divided into two levels: *Operation Verification* (verifies that the voltmeter meets selected testable specifications) and *Performance Verification* (verifies that the voltmeter meet all testable specifications). The chapter is divided into the following sections:

- Calibration Interval 19
- Time Required for Calibration 19
- Recommended Test Equipment 20
- Test Considerations 20
- Operation Verification Procedures 21
- Performance Verification Procedures 22
- Adjustment Procedures 28
- Test Connector Pinout 36

The verification tests use the voltmeter's specifications listed in "Specifications" on page 4.

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### Warning

*The information in this chapter is for service-trained personnel who are familiar with electronic circuitry and are aware of the hazards involved. To avoid personal injury or damage to the instrument, do not perform procedures in this chapter or do any servicing unless you are qualified to do so.*

*Some procedures in this chapter must be performed with power applied to the voltmeter while the protective covers are removed. Energy available at many points may, if contacted, result in personal injury.*

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### Caution

*Static electricity is a major cause of component failure. To prevent damage to the electrical components in the voltmeter, observe anti-static techniques whenever working on the voltmeter.*

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## Chapter 2 Calibration Procedures

### Calibration Interval

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#### Calibration Interval

The voltmeter should be calibrated on a regular interval determined by the measurement accuracy requirements of your application. A 90-day interval is recommended for the most demanding applications, while a 1-year or 2-year interval may be adequate for less demanding applications. Hewlett-Packard does not recommend extending calibration intervals beyond 2 years for any application.

Whatever calibration interval you select, Hewlett-Packard recommends that complete re-adjustment should always be performed at the calibration interval. This will increase your confidence that the HP 3400B will remain within specification for the next calibration interval. This criteria for re-adjustment provides the best measure of the voltmeter's long-term stability. Performance data measured using this method can easily be used to extend future calibration intervals.

When your voltmeter is due for calibration, contact your local Hewlett-Packard Service Center for a low-cost recalibration. Calibrations to MIL-STD-45662 are also available at competitive prices.

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#### Time Required for Calibration

The Operation Verification, Performance Verification, and Adjustment procedures in this chapter show you how to manually calibrate the voltmeter. A complete verification and adjustment using these procedures will take approximately one hour.

## Chapter 2 Calibration Procedures Recommended Test Equipment

### Recommended Test Equipment

The test equipment recommended for the verification and adjustment procedures is listed below. If the exact instrument is not available, select an equivalent substitute.

Application	Recommended Equipment
Range/Frequency Response Check (page 23, 24)	Fluke 5700A Calibrator, HP 3458A Multimeter
Amplifier Stability Check (page 25)	HP 8161A Pulse Generator, HP 3458A Multimeter
Overload Protection Circuitry Check (page 26)	Fluke 5700A Calibrator, HP 3458A Multimeter
Crest Factor Check (page 27)	HP 8161A Pulse Generator, HP 3458A Multimeter
Front-Panel Meter Zero Adjustment (page 28)	None
Full Scale Gain Adjustment (page 29)	Fluke 5700A Calibrator, HP 3458A Multimeter
Tenth Scale Gain Adjustment (page 30)	Fluke 5700A Calibrator, HP 3458A Multimeter
Full Scale Pointer Adjustment (page 32)	None
20 MHz Flatness Adjustment (page 33)	Fluke 5700A Calibrator, HP 3458A Multimeter
Input Attenuator Adjustment (page 34)	Fluke 5700A Calibrator, HP 3458A Multimeter

### Test Considerations

To ensure proper instrument operation, verify that you have selected the correct power line voltage prior to attempting any test procedure in this chapter. See chapter 1, "Quick Start," for more information.

- Assure that the calibration ambient temperature is stable and between 18°C and 28°C.
- Assure that the ambient relative humidity is less than 80%.
- Allow the voltmeter to warm up for 30 minutes, with the covers in place, before attempting any performance checks.

Chapter 2 Calibration Procedures  
 Operation Verification Procedures

## Operation Verification Procedures

The procedures in this section are used to provide a high level of confidence that the voltmeter is meeting published specifications. The Operation Verification test is a subset of the Performance Verification tests and is suitable for checkout after performing repair.

The Operation Verification test is performed by completing a partial range/frequency response test as described later in the Performance Verification test procedures. This test verifies the voltmeter's frequency response on the 1 volt range at full scale input levels. The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to -1 Vdc and is proportional to the RMS input voltage (-1 Vdc corresponds to a full-scale meter deflection).

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
1 V	1 V	10 Hz	-1.05 V to -0.95 V
1 V	1 V	50 Hz	-1.0075 V to -0.9925 V
1 V	1 V	1 MHz	-1.0075 V to -0.9925 V
1 V	1 V	2 MHz	-1.02 V to -0.98 V
1 V	1 V	3 MHz	-1.03 V to -0.97 V
1 V	1 V	20 MHz	-1.05 V to -0.95 V

- 1 HP 3400B: Select the 1 volt range.
- 2 Calibrator: Select a 1 volt ac signal at 10 Hz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Verify that the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table above.
- 5 Continue checking the dc output as you adjust the calibrator's output voltage and frequency to each of the remaining values shown in the table above.

Chapter 2 Calibration Procedures  
Performance Verification Procedures

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## Performance Verification Procedures

The procedures in this section are used to test the voltmeter's electrical performance using the specifications given on page 4 as the performance standard. You can use these tests for incoming inspection, periodic maintenance, and specification checks after a repair.

*Note Allow the voltmeter to warm up for 30 minutes, with the covers in place, before attempting any performance checks.*

### Range/Frequency Response Check

This test verifies the voltmeter's frequency response on all 12 input voltage ranges. The test is performed both at full scale and tenth scale input levels. The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. On the 1's ranges (0.001, 0.01, 0.1, 1, etc.), this voltage is normalized to  $-1$  Vdc and is proportional to the RMS input voltage ( $-1$  Vdc corresponds to a full-scale meter deflection). On the 3's ranges (0.003, 0.03, 0.3, 3, etc.), the full scale output is  $-0.9487$  Vdc.

## Chapter 2 Calibration Procedures

### Performance Verification Procedures

#### Full Scale Test

- 1 HP 3400B: Select the 0.001 volt range.
- 2 Calibrator: Select a 0.001 volt ac signal at 10 Hz.
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Verify that the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table below.
- 5 Continue checking the dc output as you adjust the calibrator's output voltage and frequency to each of the remaining values shown in the table below.

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HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
0.001 V	0.001 V	10 Hz	-1.05 V to -0.95 V
0.003 V	0.003 V	1 kHz	-0.9558 V to -0.9416 V
0.01 V	0.01 V	1 kHz	-1.0075 V to -0.9925V
0.03 V	0.03 V	1 kHz	-0.9558 V to -0.9416 V
0.1 V	0.1 V	1 kHz	-1.0075 V to -0.9925V
0.3 V	0.3 V	1 kHz	-0.9558 V to -0.9416 V
1 V	1 V	10 Hz	-1.05 V to -0.95 V
1 V	1 V	50 Hz	-1.0075 V to -0.9925 V
1 V	1 V	1 kHz	-1.0075 V to -0.9925 V
1 V	1 V	10 kHz	-1.0075 V to -0.9925 V
1 V	1 V	100 kHz	-1.0075 V to -0.9925 V
1 V	1 V	1 MHz	-1.0075 V to -0.9925 V
1 V	1 V	2 MHz	-1.02 V to -0.98 V
1 V	1 V	3 MHz	-1.03 V to -0.97 V
1 V	1 V	10 MHz	-1.05 V to -0.95 V
1 V	1 V	20 MHz	-1.05 V to -0.95 V
3 V	*3 V	1 kHz	-0.9558 V to -0.9416 V
10 V	*10 V	1 kHz	-1.0075 V to -0.9925V
30 V	*30 V	1 kHz	-0.9558 V to -0.9416 V
100 V	*100 V	1 kHz	-1.0075 V to -0.9925V
300 V	*300 V	1 kHz	-0.9558 V to -0.9416 V

\* For all outputs less than 3 volts, use the "Wideband" output on the Fluke 5700A. For outputs greater than 3 volts, use the low frequency output.

Chapter 2 Calibration Procedures  
Performance Verification Procedures

- Tenth Scale Test**
- 1 HP 3400B: Select the 1 volt range.
  - 2 Calibrator: Select a 0.1 volt ac signal at 10 Hz.
  - 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
  - 4 Verify that the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table below.
  - 5 Continue checking the dc output as you adjust the calibrator's output voltage and frequency to each of the remaining values shown in the table below.

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
1 V	0.1 V	10 Hz	-0.15 V to -0.05 V
1 V	0.1 V	50 Hz	-1.075 V to -0.0925 V
1 V	0.1 V	1 MHz	-1.075 V to -0.0925 V
1 V	0.1 V	2 MHz	-0.12 V to -0.08 V
1 V	0.1 V	3 MHz	-0.13 V to -0.07 V
1 V	0.1 V	10 MHz	-0.15 V to -0.05 V
1 V	0.1 V	20 MHz	-0.15 V to -0.05 V

## Chapter 2 Calibration Procedures

### Performance Verification Procedures

#### Amplifier Stability Check

This test verifies the stability of the voltmeter's input amplifier by measuring the rolloff of the frequency response at 40 MHz. The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to  $-1$  Vdc and is proportional to the RMS input voltage ( $-1$  Vdc corresponds to a full-scale meter deflection).

  
2

HP 3400B Range	Source Output Voltage	Source Output Frequency	DC Output (DMM Reading)
0.1 V	0.1 V	40 MHz	$-0.65$ V to $-0.45$ V

- 1 HP 3400B: Select the 0.1 volt range.
- 2 Source: Select a 0.1 volt ac signal at 40 MHz.
- 3 External Multimeter: Select the 10 Vdc range with  $5\frac{1}{2}$  digits of resolution.
- 4 Verify that the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table above.

Chapter 2 Calibration Procedures  
Performance Verification Procedures

### Overload Protection Circuitry Check

This test verifies the voltmeter's overload protection circuitry by applying a voltage slightly greater than the range limit. The signals measured for this test are dc voltages measured on test connector pin 8 (+VBB) and pin 9 (-VBB). At the end of the overvoltage sequence, the input voltage is returned to 0.1 volts to ensure that the voltmeter will recover to normal operation.

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	+VBB Reading	-VBB Reading
0.1 V	0.1 V	1 kHz	+11.5 V to +15.5 V	-15.5 V to -11.5 V
0.1 V	0.4 V	1 kHz	+1.0 V to +5.0 V	-5.0 V to -1.0 V

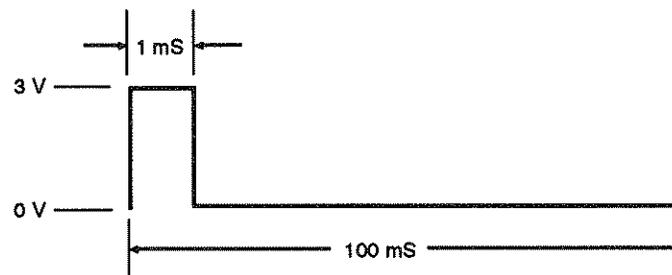
- 1 HP 3400B: Select the 0.1 volt range.
- 2 Calibrator: Select a 0.1 volt ac signal at 1 kHz (use the low frequency output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Measure +VBB (pin 8 on the test connector) and -VBB (pin 9 on the test connector). Verify that the measured voltages are within the limits shown in the table above for a 0.1 volt output from the calibrator.
- 5 Increase the calibrator's output voltage from 0.1 volts to 0.4 volts at 1 kHz.
- 6 Measure +VBB and -VBB. Verify that the measured voltages are within the limits shown in the table above for a 0.4 volt output from the calibrator.
- 7 To ensure that the voltmeter will still operate properly, decrease the calibrator's output voltage from 0.4 volts to 0.1 volts.
- 8 Measure +VBB and -VBB. Verify that the measured voltages are within the limits shown in the table above for a 0.1 volt output from the calibrator.

## Chapter 2 Calibration Procedures

### Performance Verification Procedures

#### Crest Factor Check

This test verifies the voltmeter's crest factor performance. The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to  $-0.9487$  Vdc and is proportional to the RMS input voltage ( $-0.9487$  Vdc corresponds to a full-scale meter deflection).



HP 3400B Range	Source Configuration	DC Output (DMM Reading)
0.3 V	Vout=1.5 V, Offset=750 mV, Pulse Output Width=1 mSec, Frequency=10 Hz, Mode=Pulse	-1.05 V to -0.95 V

- 1 HP 3400B: Select the 0.3 volt range.
- 2 Source: Program the source to output a pulse train with the following characteristics: Vout=1.5 volts, offset=750 mV, pulse output width=1 mSec, frequency=10 Hz, mode=pulse.
- 3 External Multimeter: Select the 10 Vdc range with  $5\frac{1}{2}$  digits of resolution.
- 4 Verify that the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table above.

## Chapter 2 Calibration Procedures Adjustment Procedures

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### Adjustment Procedures

The procedures in this section are used to adjust the voltmeter for peak performance. For best performance, the voltmeter should always be adjusted after repair. Do not perform the adjustment procedures unless they are required. If you make unnecessary adjustments of the internal controls, you may actually cause more difficulty.

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**Warning**

*Some procedures in this section must be performed with power applied to the voltmeter while the protective covers are removed. To avoid personal injury or damage to the instrument, do not perform procedures in this section unless you are qualified to do so.*

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*Note Allow the voltmeter to warm up for 30 minutes, with the covers in place, before attempting any adjustments.*

### Front-Panel Meter Zero Adjustment

The zero adjustment screw is located on the voltmeter's front panel. If the meter pointer does not indicate zero when power has been turned off for at least one minute, adjust the screw setting as described below.

- 1 Turn off the voltmeter and remove any input signals from the front panel and any connections to the rear panel.
- 2 Allow one minute for the meter pointer to stabilize.
- 3 Rotate the zero adjustment screw clockwise until the pointer is to the left of zero on the meter scale. Continue adjusting until the pointer is at zero. *If the pointer overshoots zero, repeat this step.*
- 4 When the pointer is exactly at zero, rotate the adjustment screw slightly counterclockwise to remove tension on the pointer's internal mechanism. *If the pointer moves to the left during this adjustment repeat steps 3 and 4.*

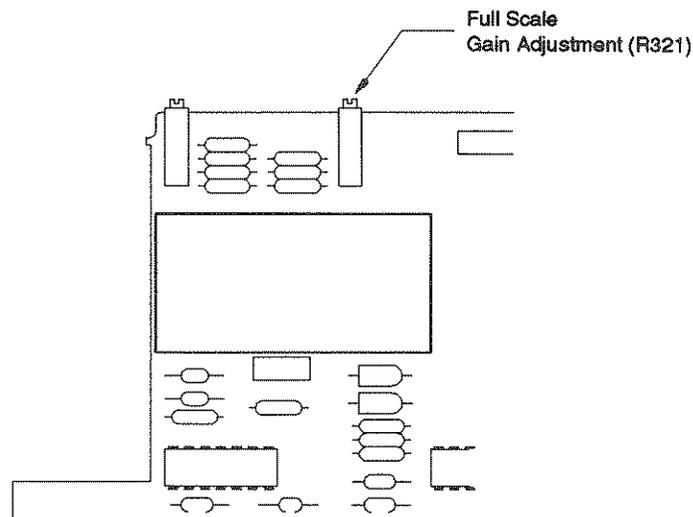
## Chapter 2 Calibration Procedures Adjustment Procedures

### Full Scale Gain Adjustment

This procedure manually adjusts the voltmeter for full scale readings. The full scale adjustment and the tenth scale adjustment (described in the next section) are interdependent and you should repeat the adjustments until both measurements are within the recommended limits.

The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to  $-1$  Vdc and is proportional to the RMS input voltage ( $-1$  Vdc corresponds to a full-scale meter deflection).

For this adjustment, all measurements are made on the 0.01 volt range at 1 kHz. You will make the full scale adjustments using R321 which is located on the main circuit board (see below).



## Chapter 2 Calibration Procedures

### Adjustment Procedures

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
0.01 V	0.01 V	1 kHz	-1.0019 V to -0.9981 V

- 1 HP 3400B: Select the 0.01 volt range.
- 2 Calibrator: Select a 0.01 volt ac signal at 1 kHz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Remove *only* the top cover from the HP 3400B (it is important that you *do not* remove the side or bottom covers). Adjust R321 until the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table above.

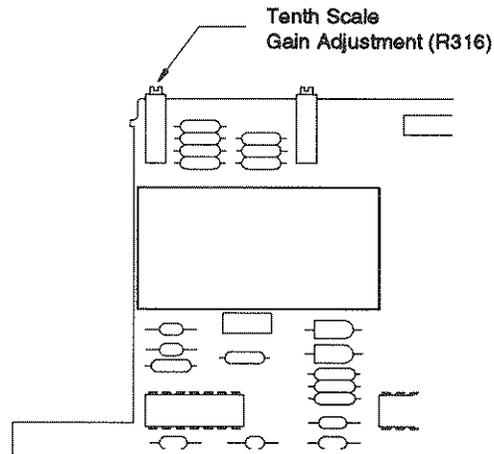
### Tenth Scale Gain Adjustment

This procedure manually adjusts the voltmeter for tenth scale readings. The tenth scale adjustment and the full scale adjustment (described in the previous section) are interdependent and you should repeat the adjustments until both measurements are within the recommended limits.

The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to -1 Vdc and is proportional to the RMS input voltage (-1 Vdc corresponds to a full-scale meter deflection).

For this adjustment, all measurements are made on the 0.01 volt range at 1 kHz. You will make the tenth scale adjustments using R316 which is located on the main circuit board (see next page).

## Chapter 2 Calibration Procedures Adjustment Procedures



2

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
0.01 V	0.001 V	1 kHz	-0.1019 V to -0.0981 V

- 1 HP 3400B: Select the 0.01 volt range.
- 2 Calibrator: Select a 0.001 volt ac signal at 1 kHz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Remove *only* the top cover from the HP 3400B (it is important that you *do not* remove the side or bottom covers). Adjust R316 until the dc voltage measured at the rear-panel dc output jack is within the limits shown in the table above.

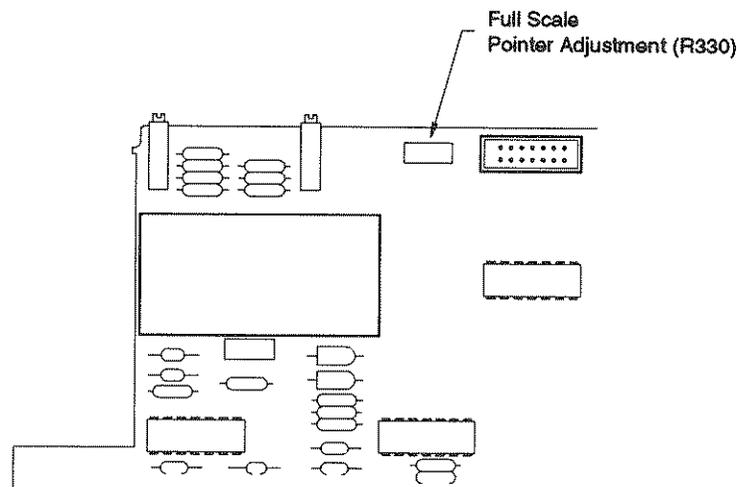
*Note* Since the full scale and tenth scale adjustments are interdependent, you should repeat both adjustments again. Repeat the procedures again, starting with step 1 for the full scale adjustment, on page 30.

## Chapter 2 Calibration Procedures Adjustment Procedures

### Full Scale Pointer Adjustment

This procedure shows you how to manually adjust the position of the meter pointer for full scale readings. When properly adjusted, the meter pointer should be aligned with the full scale marking on the right side of the meter scale.

This adjustment is made on the 0.1 volt range at 1 kHz. You will use R330 which is located on the main circuit board to make the adjustment (see below).



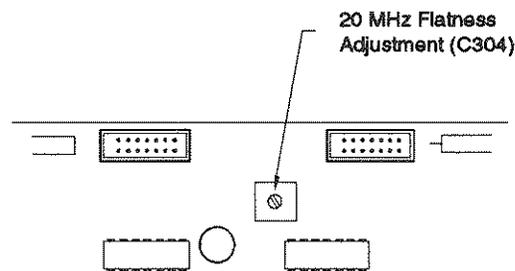
- 1 HP 3400B: Select the 0.1 volt range.
- 2 Calibrator: Select a 0.1 volt ac signal at 1 kHz (use the "Wideband" output on the Fluke 5700A).
- 3 Allow one minute for the meter pointer to stabilize.
- 4 Remove *only* the top cover from the HP 3400B (it is important that you *do not* remove the side or bottom covers). Adjust R330 until the meter pointer is aligned with the full scale marking on the right side of the meter scale.

## Chapter 2 Calibration Procedures Adjustment Procedures

### 20 MHz Flatness Adjustment

This procedure manually adjusts the 20 MHz flatness. The adjustment is made with a 100 mV signal applied at 20 MHz. You will make the flatness adjustment using C304 which is located on the main circuit board (see below).

The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to  $-1$  Vdc and is proportional to the RMS input voltage ( $-1$  Vdc corresponds to a full-scale meter deflection).



HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
0.1 V	0.1 V	20 MHz	$-1.0125$ V to $-0.9875$ V

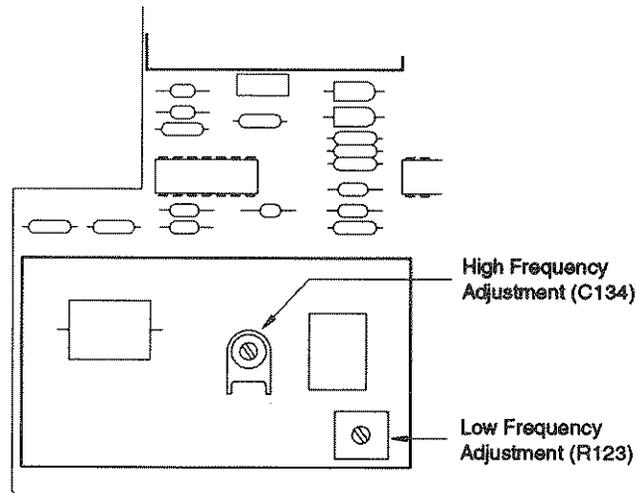
- 1 HP 3400B: Select the 0.1 volt range.
- 2 Calibrator: Select a 0.1 volt ac signal at 20 MHz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with  $5\frac{1}{2}$  digits of resolution.
- 4 Remove *only* the right-side cover from the HP 3400B (as viewed from the front panel). It is important that you *do not* remove the left-side, top, or bottom covers. Adjust C304 until the voltage measured at the rear-panel dc output jack is within the limits shown in the table above.

## Chapter 2 Calibration Procedures Adjustment Procedures

### Input Attenuator Adjustment

This procedure performs a manual adjustment of the input attenuator at 50 Hz and 100 kHz. First, you will make the low frequency adjustment at 3V/50 Hz using R123 on the main circuit board (see below). You will make the high frequency adjustment at 3V/100 kHz using C134 on the main circuit board (see below).

The signal measured for this test is a dc voltage taken at the rear-panel dc output jack. This voltage is normalized to  $-0.9487$  Vdc and is proportional to the RMS input voltage ( $-0.9487$  Vdc corresponds to a full-scale meter deflection).



## Chapter 2 Calibration Procedures Adjustment Procedures

HP 3400B Range	Calibrator Output Voltage	Calibrator Output Frequency	DC Output (DMM Reading)
3 V	3 V	50 Hz	-0.950 V to -0.947 V
3 V	3 V	100 kHz	-0.950 V to -0.947 V

2

### Low Frequency

- 1 HP 3400B: Select the 3 volt range.
- 2 Calibrator: Select a 3 volt ac signal at 50 Hz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Remove *only* the right-side cover from the HP 3400B (as viewed from the front panel). It is important that you *do not* remove the left-side, top, or bottom covers. Adjust R123 until the voltage measured at the rear-panel dc output jack is within the limits shown in the table above for 50 Hz.

### High Frequency

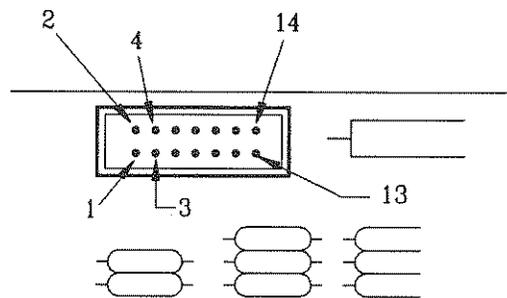
- 1 HP 3400B: Select the 3 volt range.
- 2 Calibrator: Select a 3 volt ac signal at 100 kHz (use the "Wideband" output on the Fluke 5700A).
- 3 External Multimeter: Select the 10 Vdc range with 5½ digits of resolution.
- 4 Remove *only* the right-side cover from the HP 3400B (as viewed from the front panel). It is important that you *do not* remove the left-side, top, or bottom covers. Adjust C134 until the voltage measured at the rear-panel dc output jack is within the limits shown in the table above for 100 kHz.

## Chapter 2 Calibration Procedures

### Test Connector Pinout

### Test Connector Pinout

Test connector J3 gives you access to several test points on the main circuit board. You can build your own custom ribbon cable interface if is convenient for your application. The table below shows the pinout for the test connector. *Refer to the schematics in chapter 7 for more detailed information on the circuitry that interfaces with the test connector.*



**Test Connector J3**

Pin Number	Description
1	K101B, Relay Drive Logic for Relay K101 (low true, see the table on page 45).
2	K201B, Relay Drive Logic for Relay K201 (low true, see the table on page 45).
3	K202B, Relay Drive Logic for Relay K202 (low true, see the table on page 45).
4	K203B, Relay Drive Logic for Relay K203 (low true, see the table on page 45).
5	Remote/Local Control, Ground or Hold Low to Disable Range Selector Switch.
6	+VCC (4.7 k $\Omega$ Series Resistor).
7	CGND, Common Ground
8	+VBB
9	-VBB
10	-VRAW (10 k $\Omega$ Series Resistor), Output from Power Transformer (T1).
11	Not Used
12	OPAMP_DC, Output from Wideband Amplifier (U301).
13	DC_OUT, Same as Rear Panel Output (loading on this line will affect signal on rear-panel output; loading on rear-panel output will affect signal on this line).
14	CGND, Common Ground



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Theory of  
Operation

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## Theory of Operation

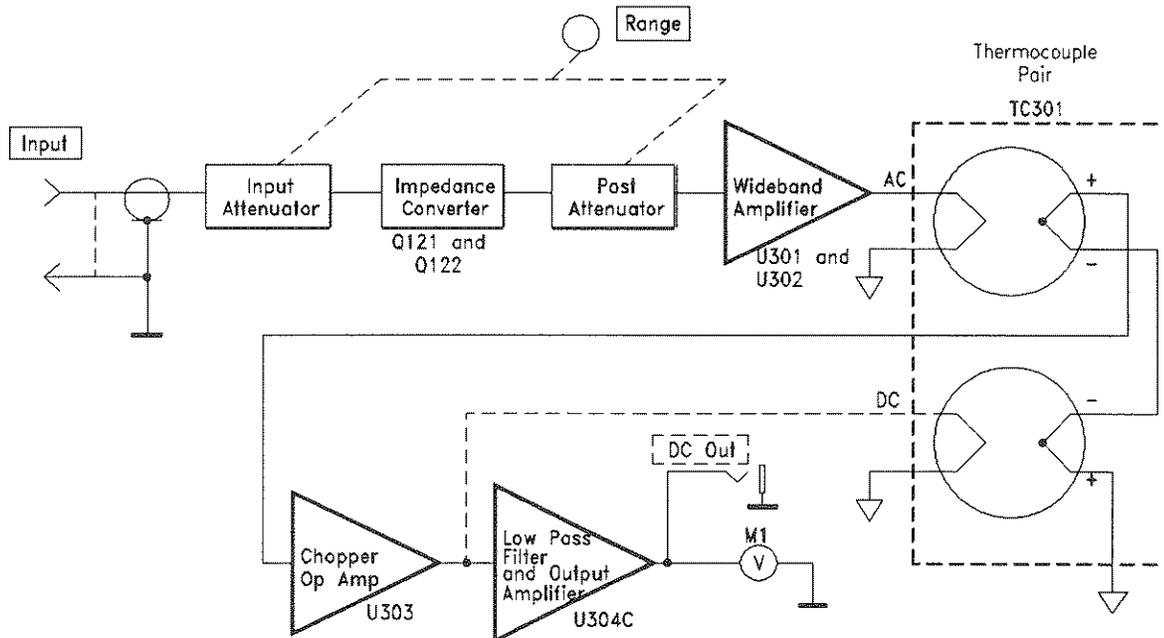
This chapter is organized to provide descriptions of the circuitry contained on each schematic shown in chapter 7. A block diagram overview is provided followed by more detailed descriptions of the circuitry contained in the schematics chapter.

- Block Diagram 39
- Input Attenuator 41
- Impedance Converter 41
- Post Attenuator 42
- Wideband Amplifier 42
- Chopper Op Amp / Thermocouple Pair 43
- Power Supplies 44
- Switch Board 45

Chapter 3 Theory of Operation  
Block Diagram

## Block Diagram

Referring to the instrument block diagram shown below, you can see that the voltmeter's operational circuitry consists of two attenuators, an impedance converter, a wideband amplifier, a chopper op amp, a thermocouple pair, and a direct reading meter.



HP 3400B Block Diagram

### Chapter 3 Theory of Operation

#### Block Diagram

A signal being measured is applied to the input attenuator through the input connector, located on the voltmeter's front panel. The input attenuator has an input impedance of  $10\text{ M}\Omega$  and provides two ranges of attenuation. The output of the input attenuator is applied to the impedance converter. The impedance converter is a non-inverting unity voltage gain amplifier. It presents a high impedance to the input signal and provides a low impedance output to drive the post attenuator. The post attenuator provides six ranges in a 1, 3, 10 sequence. The two attenuators are switched to provide 12 ranges of attenuation.

The output of the post attenuator is amplified by the wideband amplifier. The wideband amplifier is a two-stage amplifier (U301 and U302). The ac output of the wideband amplifier is amplified to drive one of the thermocouples in the thermocouple pair (TC301).

The dc output of TC301 is applied to the chopper op amp (U303) which modulates the voltage. The resultant modulated signal is then amplified and, after the amplification, the signal is demodulated back to a dc voltage. This voltage is the output of the chopper op amp. The value of the voltage is proportional to the dc input voltage.

The output of the chopper op amp is applied to a filter and also to the second thermocouple of the thermocouple pair (TC301). The output of the filter is applied to a dc output amplifier (U304C) which is used to drive the meter (M1).

The thermocouple pair (TC301) acts as a summing point for the ac output of the wideband amplifier and the dc output of the chopper op amp. The difference in the heating effect of these voltages is the dc input to the chopper op amp. This difference input is amplified and is fed to TC301 and also, after going through the output amplifier (U304C), to the meter (M1). This voltage represents the RMS value of the ac signal applied to the input connector. By using a "matched" thermocouple pair and measuring the difference, the output of the chopper op amp will be linear. Using a matched thermocouple pair also provides temperature stability.

## Chapter 3 Theory of Operation

### Input Attenuator

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### Input Attenuator

The input attenuator is a capacitive-compensated attenuator which provides two ranges of attenuation for the 12 positions of the Range selector switch. When the selector switch is positioned to one of the six most sensitive ranges (1 mV to 300 mV), the attenuator output voltage is equal to the input voltage. When the selector switch is positioned to one of the six higher ranges (1 V to 300 V), the input signal is attenuated 60 dB (1000:1 voltage division) by the resistive voltage divider consisting of R121, R122, and R123. Trimmer C134 is adjusted at 100 kHz, and R123 is adjusted at 50 Hz to provide constant attenuation over the input frequency range.

  
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### Impedance Converter

The impedance converter uses a FET-follower circuit to match the high output impedance of the input attenuator to the low input impedance of the post attenuator. The FET-follower circuitry has unity gain with no phase inversion between the input and output signals.

The ac input signal to the impedance converter is resistor/capacitor coupled via R127 and C149 to the gate of FET Q121. The output of the converter is developed across Q122 which acts like a variable load resistor for the FET.

The bootstrap circuitry, consisting of C152 and R130, increases the input impedance of the converter circuitry and the compensating feedback circuitry, consisting of C151, decreases the output impedance of the converter. The bias voltage for Q122 is developed by resistors R133, CR125, R134, and R140.

## Chapter 3 Theory of Operation

### Post Attenuator

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#### Post Attenuator

The post attenuator is a resistive divider which attenuates the ac input signal while maintaining a low impedance output for the following amplification stages. The ac input signal is applied to a precision resistive voltage divider. These resistors are arranged to give six ranges of attenuation at 10 dB per range. The six ranges of the post attenuator combined with the two ranges of the input attenuator make up the 12 ranges of attenuation (1 mV to 300 V).

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#### Wideband Amplifier

The wideband amplifier provides constant gain to the ac signal being measured over the entire frequency range of the HP 3400B. The wideband amplification required to drive the thermocouple heater is provided in two gain stages. The first stage has a gain of 36 dB and consists of a differential transistor pair Q301 and Q302 driving U301. This gain stage also includes the capacitor feedback adjustment (C304) to adjust the voltmeter's frequency response at 20 MHz. The second stage has a gain of 14 dB to the thermocouple heater and consists of U302.

The combined gain of 50 dB amplifies the 1 mV RMS full-scale input signal to 316 mV RMS applied to the thermocouple heater. The nominal resistance of the heater is 90 $\Omega$  and there is 3.5 mA RMS of current flowing at full-scale input signal.

Protection against excess current to the thermocouple heater is provided by controlling the power supply voltages to the heater drive op amp (U302). The output from U302 is peak-detected by CR306 and CR307 and is then averaged with an RC network. The average dc level is compared with a reference by comparators U304A and U304B. The comparator output lowers the supply voltage via Q303 and Q304 when the average dc level exceeds the reference level. The average dc level of the input signal allows for 10-to-1 crest factor signals to be applied to the heater at proper levels without being attenuated.

Chapter 3 Theory of Operation  
Chopper Op Amp / Thermocouple Pair

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## Chopper Op Amp / Thermocouple Pair

The chopper op amp and the thermocouple pair form a servo loop which functions to position the direct reading meter (M1) to the RMS value of the ac input signal. The wideband amplifier output is applied to the heater of thermocouple pair (TC301). The ac voltage causes a dc voltage to be generated in the resistive portion of TC301 which is proportional to the heating effect (RMS value) of the ac input. The dc voltage is applied to the chopper op amp.

The chopper op amp circuitry consists of a chopper op amp (U303), filter, and output amplifier (U304C). The chopper op amp is a high-gain, low-drift op amp and is used to modulate the applied dc voltage, amplify the voltage, and then demodulate the voltage back to a dc voltage (the output voltage of the amplifier). The output of the amplifier is the ac stabilizing and summing feedback for the thermocouple pair (TC301), and is also applied to the filter. The ac stabilizing feedback (using R323, R320, and C309) is used to prevent the circuitry from oscillating.

The output from the chopper op amp (summing feedback) is applied to the heating element of thermocouple pair (TC301). The dc voltage developed in the resistive portion of TC301 is effectively subtracted from the voltage developed by TC301. The input signal to the chopper op amp then becomes the difference in the dc outputs of the two thermocouples. When the difference between the two thermocouples becomes zero, the dc output from the chopper op amp will be equal to the ac output from the wideband amplifier.

The low pass filter, consisting of R325, R326, C312, C313, and U304C, is used to further reduce the noise on the output of the chopper op amp. This is to make the meter reading quiet.

The output of the low pass filter and output amplifier (U304C) drives the meter (M1) and the DC Out connector on the rear panel. The rear terminal's output impedance is approximately 1000Ω.

## Chapter 3 Theory of Operation

### Power Supplies

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## Power Supplies

The power supplies provide dc operating voltages for the circuitry used in the HP 3400B. The input line power is applied to an input line module. The module contains a line filter, a fuse, the line switch, and voltage tap selection for the power transformer. Four line voltage selections are available: 100, 120, 220, 240 Vac.

The outputs from the power transformer drive three voltage regulators. The voltages produced by the three voltage regulators are: +27 Vdc, -15 Vdc, and +5 Vdc. The +27 Vdc supply is used to power the impedance converter Q121 and Q122. The +27 Vdc supply is also dropped by a 12 volt zener diode (CR112) to develop +15 Vdc for U302 through overload regulator Q303. In addition, the +27 Vdc supply is regulated by a 15 volt zener diode (CR111) for U301 and U304. The dc chopper amplifier is powered by temperature-compensated 6.2 volt zener diodes (CR113 and CR114) to provide a stable dc source to U303 and its associated circuits. The +5 Vdc supply is used to power the logic circuitry and attenuator relays.

## Chapter 3 Theory of Operation

### Switch Board

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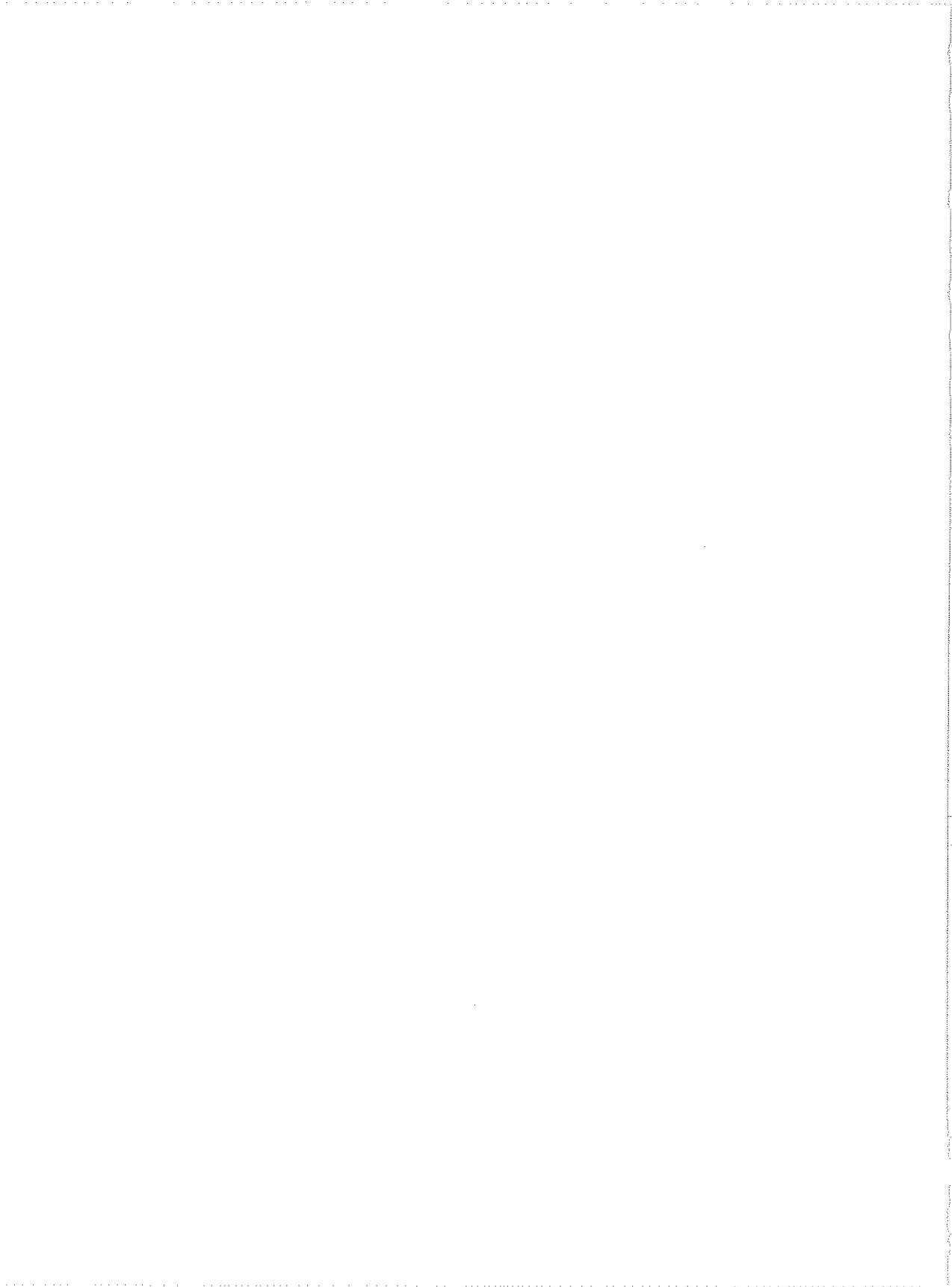
## Switch Board

The switch control circuitry is located on the small circuit board which is connected to the front-panel Range selector switch. The Schottky diodes (CR41 through CR60) on the switch board provide the appropriate relay logic for the relay drivers on the main circuit board (see table below). The switch board connects to the main circuit board using a ribbon cable (P1). The switch board also provides the interface for wiring to the meter mechanism, the front-panel power LED, and the rear-panel DC Out connector.

  
3

Voltage Range	K101	K201	K202 and K204	K203
0.001	0	0	0	1
0.003	0	1	0	1
0.01	0	0	0	0
0.03	0	1	0	0
0.1	0	0	1	1
0.3	0	0	1	0
1.0	1	0	0	1
3.0	1	1	0	1
10.0	1	0	0	0
30.0	1	1	0	0
100.0	1	0	1	1
300.0	1	0	1	0

0 = Relay De-Energized; 1 = Relay Energized.



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