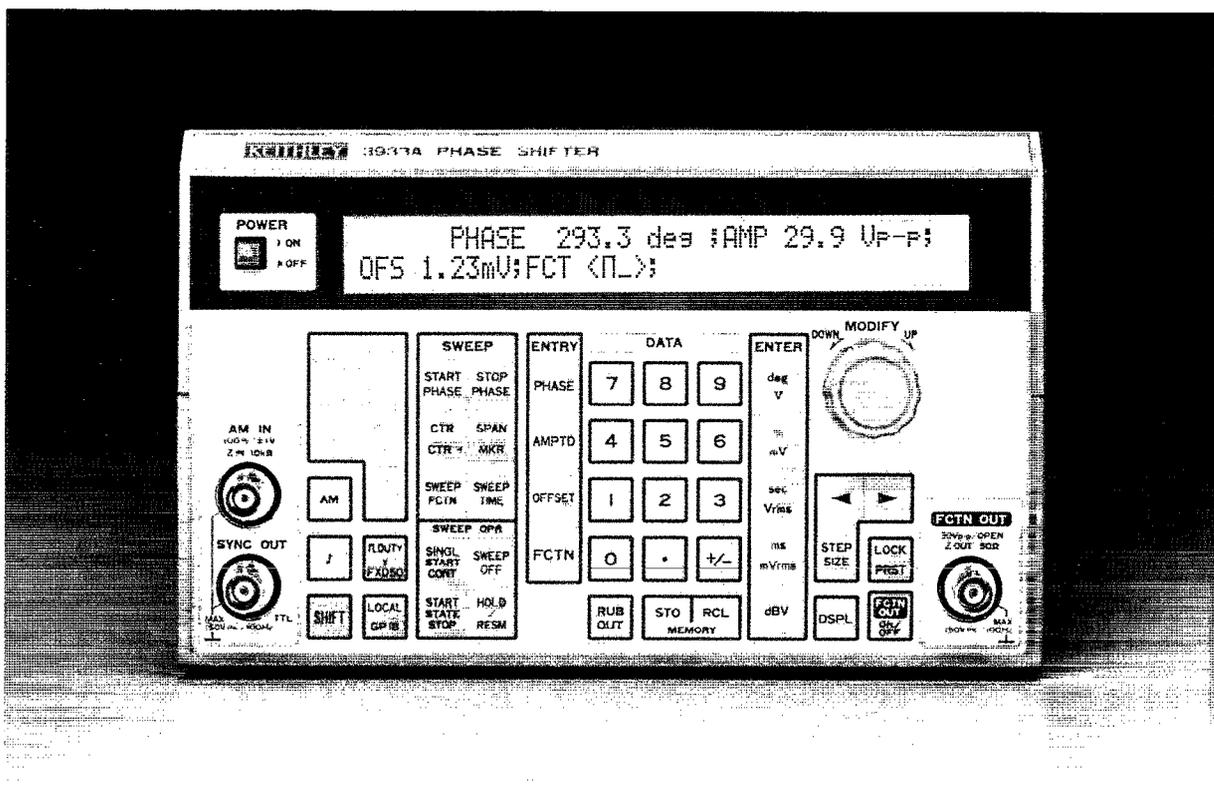


KEITHLEY INSTRUMENTS

Model 3933A Phase Shifter Service Manual



Contains Servicing Information

Publication Date: August 1991

Document Number: 3933A-902-01 Rev. A

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the product, transportation prepaid, to the indicated service facility. Repairs will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from product modification without Keithley's express written consent, or misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, damage from battery leakage, or problems arising from normal wear or failure to follow instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE. THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES.

NEITHER KEITHLEY INSTRUMENTS, INC. NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OF ITS INSTRUMENTS AND SOFTWARE EVEN IF KEITHLEY INSTRUMENTS, INC., HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES. SUCH EXCLUDED DAMAGES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

KEITHLEY INSTRUMENTS

Instruments Division, Keithley Instruments, Inc. • 28775 Aurora Road • Cleveland, Ohio 44139 • (216) 248-0400 • Fax: 248-6168

WEST GERMANY: Keithley Instruments GmbH • Heighhofstr. 5 • Munchen 70 • 089-71002-0 • Telex: 52-12160 • Fax: 089-7100259
GREAT BRITAIN: Keithley Instruments, Ltd. • The Minster • 58, Portman Road • Reading, Berkshire RG 3 1EA • 011 44 734 575 666 • Fax: 011 44 734 596 469
FRANCE: Keithley Instruments SARL • 3 Allee des Garays • B.P. 60 • 91124 Palaiseau/Z.I. • 1-6-0115 155 • Telex: 600 933 • Fax: 1-6-0117726
NETHERLANDS: Keithley Instruments BV • Avelingen West 49 • 4202 MS Gorinchem • P.O. Box 559 • 4200 AN Gorinchem • 01830-35333 • Telex: 24 684 • Fax: 01830-30821
SWITZERLAND: Keithley Instruments SA • Kriesbachstr. 4 • 8600 Dubendorf • 01-821-9444 • Telex: 828 472 • Fax: 0222-315366
AUSTRIA: Keithley Instruments GesmbH • Rosenhugelstrasse 12 • A-1120 Vienna • (0222) 84 65 48 • Telex: 131677 • Fax: (0222) 8403597
ITALY: Keithley Instruments SRL • Viale S. Gimignano 4/A • 20146 Milano • 02-4120360 or 02-4156540 • Fax: 02-4121249

**Service Manual
Model 3933A
Phase Shifter**

**©1991, Keithley Instruments, Inc.
All Rights Reserved
Instruments Division
Cleveland, Ohio, U. S. A.
Document Number: 3933A-902-01**

All Keithley product names are trademarks or registered trademarks of Keithley Instruments, Inc.

Other brand and product names are trademarks or registered trademarks of their respective holders.

Safety Precautions

The following safety precautions should be observed before using the Model 3933A Phase Shifter and any associated instruments.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over this manual carefully before using the instrument.

Exercise extreme caution when a shock hazard is present at the test circuit. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V rms or 42.4V peak are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the test cables or any instruments while power is applied to the circuit under test. Turn off the power and discharge any capacitors before connecting or disconnecting cables from the instrument.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

Instrumentation and accessories should not be connected to humans.

HOW TO USE THIS MANUAL

Details procedures to verify that the instrument meets stated specifications.

SECTION 1 **Performance Verification**

Describes basic operating principles for the various circuits in the Model 3933A.

SECTION 2 **Principles of Operation**

Covers fuse replacement, calibration and repair of the instrument, and lists replacement parts.

SECTION 3 **Service Information**

WARNING

The information in this manual is intended for qualified service personnel who can recognize possible shock hazards. Do not attempt these procedures unless you are qualified to do so.

Table of Contents

SECTION 1 — Performance Verification

| | | |
|--------|---|------|
| 1.1 | INTRODUCTION | 1-1 |
| 1.2 | ENVIRONMENTAL CONDITIONS | 1-1 |
| 1.3 | INITIAL CONDITIONS | 1-1 |
| 1.4 | LINE POWER | 1-1 |
| 1.5 | RECOMMENDED TEST EQUIPMENT | 1-1 |
| 1.6 | VERIFICATION PROCEDURES | 1-2 |
| 1.6.1 | Synthesizer Connections | 1-2 |
| 1.6.2 | Frequency and Duty Cycle Accuracy | 1-3 |
| 1.6.3 | Amplitude Accuracy | 1-4 |
| 1.6.4 | Frequency Response (Sine) | 1-6 |
| 1.6.5 | Frequency Response (Triangle, Sawtooth, Square) | 1-8 |
| 1.6.6 | Total Harmonic Distortion | 1-9 |
| 1.6.7. | DC Voltage Accuracy | 1-10 |
| 1.6.8 | DC Level (Square) and DC Offset Error (Sine) | 1-10 |
| 1.6.9 | Rise and Fall Times | 1-10 |

SECTION 2 — Principles of Operation

| | | |
|-------|---------------------------------------|-----|
| 2.1 | INTRODUCTION | 2-1 |
| 2.2 | BLOCK DIAGRAM | 2-1 |
| 2.2.1 | Control Section | 2-1 |
| 2.2.2 | Display and Keyboard Section | 2-1 |
| 2.2.3 | Phase Shift Section | 2-1 |
| 2.2.4 | Analog Section | 2-1 |
| 2.2.5 | Power Supply Section | 2-3 |
| 2.3 | ANALOG CIRCUIT DESCRIPTION | 2-3 |
| 2.3.1 | Analog Section Block Diagram | 2-3 |
| 2.3.2 | D/A Converter | 2-3 |
| 2.3.3 | Square Wave Generator | 2-3 |
| 2.3.4 | Amplitude Modulation | 2-3 |
| 2.3.5 | Amplitude and DC Offset Control | 2-3 |
| 2.4 | MULTIPHASE OSCILLATOR OPERATION | 2-3 |

SECTION 3 — Service Information

| | | |
|-------|--------------------------------|-----|
| 3.1 | INTRODUCTION | 3-1 |
| 3.2 | LINE FUSE REPLACEMENT | 3-1 |
| 3.3 | CALIBRATION | 3-1 |
| 3.3.1 | Environmental Conditions | 3-2 |
| 3.3.2 | Initial Conditions | 3-2 |
| 3.3.3 | Line Power | 3-2 |

| | | |
|-------|---|------|
| 3.3.4 | Recommended Calibration Equipment | 3-2 |
| 3.3.5 | Cover Removal | 3-3 |
| 3.3.6 | Calibration Adjustments | 3-3 |
| 3.3.7 | Function Synthesizer Connections | 3-5 |
| 3.3.8 | Calibration Procedures | 3-5 |
| 3.3.9 | Cover Replacement | 3-8 |
| 3.4 | FAN FILTER CLEANING | 3-9 |
| 3.5 | FCTN OUT JUMPER | 3-9 |
| 3.6 | RECHARGEABLE BATTERY REPLACEMENT | 3-9 |
| 3.7 | REPAIR | 3-9 |
| 3.7.1 | Factory Service | 3-9 |
| 3.7.2 | Power Supply Test Points | 3-10 |
| 3.7.3 | Board-level Repair | 3-10 |
| 3.8 | REPLACEABLE PARTS | 3-10 |
| 3.8.1 | Parts List | 3-10 |
| 3.8.2 | Ordering Parts | 3-10 |

APPENDICES

- A Typical Data
- B Model 3933A Specifications

List of Illustrations

SECTION 1 — Performance Verification

| | | |
|------------|---|-----|
| Figure 1-1 | Connections Between Model 3933A and Model 3930A Multifunction Synthesizer | 1-2 |
| Figure 1-2 | Connections to Timer/Counter | 1-3 |
| Figure 1-3 | Connections to Model 197A DMM | 1-4 |
| Figure 1-4 | Connections to Wideband AC DVM | 1-6 |
| Figure 1-5 | Connections to Audio Analyzer | 1-9 |

SECTION 2 — Principles of Operation

| | | |
|------------|---|-----|
| Figure 2-1 | Overall Block Diagram | 2-2 |
| Figure 2-2 | Analog Section Block Diagram | 2-4 |
| Figure 2-3 | Multiphase Oscillator Block Diagram | 2-5 |

SECTION 3 — Service Information

| | | |
|------------|---|------|
| Figure 3-1 | Cover Removal | 3-3 |
| Figure 3-2 | Analog Board (NP-21022) Calibration Adjustments | 3-4 |
| Figure 3-3 | Function Synthesizer Connections | 3-5 |
| Figure 3-4 | Connections to Model 197A DMM | 3-5 |
| Figure 3-5 | Second Model 3930A Connections | 3-6 |
| Figure 3-6 | Connections to PM6654C Counter | 3-7 |
| Figure 3-7 | Connections to Wideband AC DVM | 3-8 |
| Figure 3-8 | Power Supply Test Point Locations | 3-11 |
| Figure 3-9 | Model 3933A Exploded View | 3-12 |

List of Tables

SECTION 1 — Performance Verification

| | | |
|-----------|--|------|
| Table 1-1 | Verification Equipment | 1-2 |
| Table 1-2 | Limits for Frequency and Duty Cycle Accuracy | 1-3 |
| Table 1-3 | Limits for Amplitude Accuracy | 1-5 |
| Table 1-4 | Limits for Frequency Response (Sine) | 1-7 |
| Table 1-5 | Limits for Frequency Response (Triangle, Sawtooth, Square) | 1-8 |
| Table 1-6 | Limits for Total Harmonic Distortion | 1-9 |
| Table 1-7 | Limits for DC Voltage Accuracy | 1-10 |
| Table 1-8 | Limits for DC Level (Square) and DC Offset Error (Sine) | 1-10 |
| Table 1-9 | Limits for Rise/Fall Times | 1-11 |

SECTION 3 — Service Information

| | | |
|-----------|--|------|
| Table 3-1 | Recommended Line Fuses | 3-1 |
| Table 3-2 | Recommended Test Equipment for Calibration | 3-2 |
| Table 3-3 | Power Supply Test Point Summary | 3-10 |
| Table 3-4 | Board Level Repair Summary | 3-10 |
| Table 3-5 | Replaceable Parts | 3-13 |

SECTION 1

Performance Verification

1.1 INTRODUCTION

The procedures outlined in this section may be used to verify that the Model 3933A is operating within the limits stated in the specifications. Performance verification may be done when the instrument is first received to ensure that no damage or misadjustment has occurred during shipment. Verification may also be performed whenever there is a question of instrument accuracy, or following calibration, if desired.

NOTE

If the instrument is still under warranty (less than one year from the date of shipment), and its performance falls outside the specified range, contact your Keithley representative or the factory to determine the correct course of action.

1.2 ENVIRONMENTAL CONDITIONS

All measurements should be made at 18-28°C (65-82°F) and at less than 70% relative humidity.

1.3 INITIAL CONDITIONS

The Model 3933A must be turned on and allowed to warm up for at least one hour before beginning the verifi-

cation procedures. If the instrument has been subjected to extremes of temperature (outside the range specified in the previous paragraph), additional time should be allowed for internal temperatures to reach normal operating temperature. Typically, it takes one additional hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

1.4 LINE POWER

Be sure to set the line voltage switch for the correct voltage. The instrument should be operated at a voltage within $\pm 10\%$ of the line voltage setting and at a frequency from 48 to 62Hz.

1.5 RECOMMENDED TEST EQUIPMENT

Table 1-1 lists all the test equipment needed for verification. The procedure for performance verification is based on using this exact equipment.

NOTE

The verification limits reflect only the accuracy specifications of the Model 3933A. They do not include test equipment tolerance.

Alternate equipment may be used as long as the substitute equipment has specifications at least as good as

Table 1-1. Verification Equipment

| Manufacturer | Model | Description | Specifications |
|--------------|----------|--|--|
| Keithley | 3930A | Multifunction Synthesizer | 0.1mHz to 1.2MHz; ± 5 ppm |
| Keithley | 197A | DMM (DC volts, AC volts) (5-1/2 digits) | 20V range; $\pm(0.015\%$ of rdg + 3 counts) |
| Fluke | 8920A | DVM (AC volts) (3-1/2 digits) | ACV; $\pm(0.35\%$ of rdg + 100 counts) |
| Philips | PM 6654C | Timer/Counter | 20V range; 1kHz-200kHz (0.5% of rdg), 200kHz-1MHz (0.7%), 1-10MHz (3%), 10-20MHz (5%) |
| Panasonic | PM 9678 | TCXO option | 0.01Hz-120MHz; time base aging |
| | VP-7722A | Audio Analyzer | $<1 \times 10^{-7}$ /month; Vp-p measurements |
| Keithley | 7051-2 | BNC Interconnect Cable | 10Hz-110kHz; 0.001% at full scale; ± 1 dB harmonic distortion accuracy from 10Hz to 15.99kHz |
| Keithley | 7755 | 50 Ω Feed-through Terminator | 50 Ω coaxial cable (RG-58C), male BNC connectors, 2ft (0.6m) |
| Pomona | 1468 | BNC-banana Adapter | BNC to BNC adapter, 50 Ω termination, DC to 250MHz, VSWR of <1.1 |
| | | | Female BNC connector to double banana plug |

those listed in Table 1-1 (except for the Model 3930A Multifunction Synthesizer, which is required in all cases).

1.6 VERIFICATION PROCEDURES

The following paragraphs contain the detailed procedures for verifying the accuracy specifications of the Model 3933A using the equipment listed in Table 1-1. The allowable reading limits in these procedures do not include error that could be contributed by this equipment.

These procedures are intended for use only by qualified personnel using accurate and reliable test equipment. If the instrument is out of specifications and not under warranty, refer to the calibration information in Section 3.

1.6.1 Synthesizer Connections

The Model 3933A must be tested in conjunction with a Model 3930A Multifunction Synthesizer. Figure 1-1 shows DIGITAL OUT/DIGITAL IN in connections using the CA-94 cable supplied with the Model 3933A. Note that frequency is set on the Model 3930A Synthesizer.

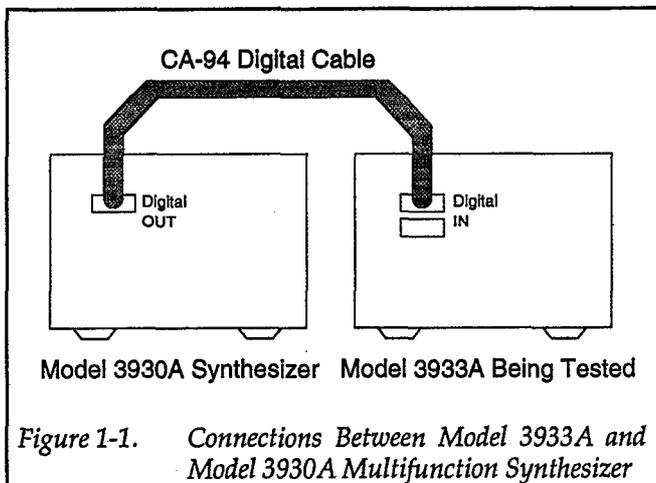


Figure 1-1. Connections Between Model 3933A and Model 3930A Multifunction Synthesizer

1.6.2 Frequency and Duty Cycle Accuracy

1. Connect the phase shifter to the Model 3930A and a timer/counter as shown in Figure 1-2. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a frequency on the Model 3930A. Set the Model 3933A for the sine function with an amplitude of 20Vp-p.
4. Set the timer/counter to display the frequency at Channel A, and verify that the frequency reading is within the limits specified in Table 1-2.
5. Program a Model 3930A frequency of 100Hz. Set the Model 3933A for a square wave with 50% fixed duty cycle.
6. Set the timer/counter to display the pulse width of Channel A, and verify that the reading is within specifications shown in Table 1-2.
7. Modify the frequency and duty cycle settings of the phase shifter and synthesizer according to Table 1-2, and verify the pulse width readings.

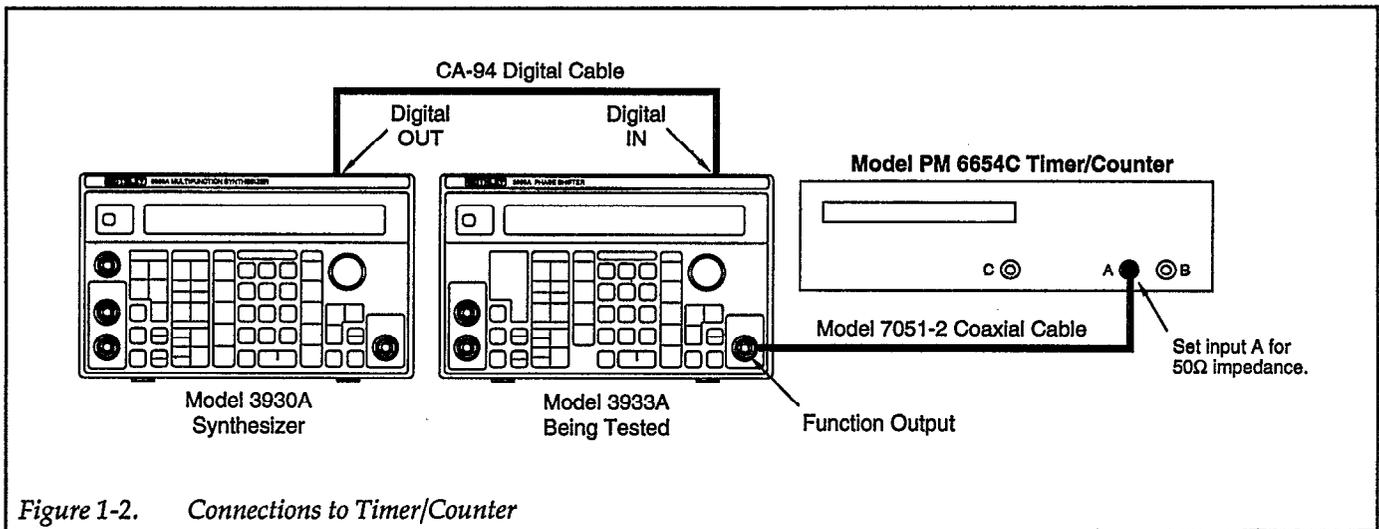


Figure 1-2. Connections to Timer/Counter

Table 1-2. Limits for Frequency and Duty Cycle Accuracy

| 3933A Function | 3933A Amplitude | 3930A Frequency | Allowable Timer/Counter Reading (18°C to 28°C) | |
|----------------|-----------------|-----------------|--|----------------|
| Sine | 20Vp-p | 1MHz | 999.995kHz | to 1.000005MHz |
| Square (FXD50) | 20Vp-p | 100Hz | 4.97msec | to 5.03msec |
| | | 1kHz | 497μsec | to 503μsec |
| | | 5kHz | 99.4μsec | to 100.6μsec |
| | | 10kHz | 49.7μsec | to 50.3μsec |
| Square (VAR50) | 20Vp-p | 100Hz | 4.98msec | to 5.02msec |
| | | 1kHz | 498μsec | to 502μsec |
| | | 5kHz | 99.6μsec | to 100.4μsec |
| | | 10kHz | 49.8μsec | to 50.2μsec |

NOTE: Frequency accuracy is determined by the Model 3930A Multifunction Synthesizer.

1.6.3 Amplitude Accuracy

1. Connect the phase shifter to a DMM as shown in Figure 1-3. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a 1kHz frequency on the Model 3930A. Set the Model 3933A for the sine function with an amplitude of 7.49Vp-p.
4. Set the DMM to measure AC volts with autoranging, and verify that the voltage reading is within the limits specified in Table 1-3.
5. Change the function, frequency, and amplitude settings of the phase shifter and synthesizer according to Table 1-3 and verify the voltage readings.

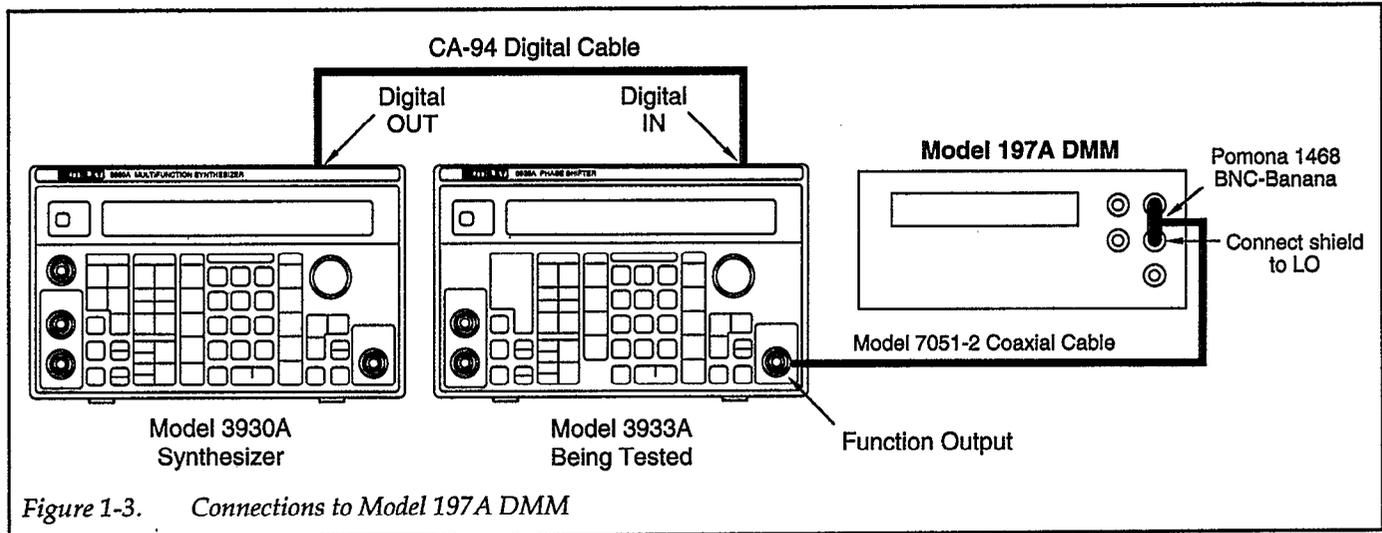


Figure 1-3. Connections to Model 197A DMM

Table 1-3. Limits for Amplitude Accuracy

| 3933A Function | 3933A Amplitude | 3930A Frequency | Allowable DMM Reading (18°C to 28°C) |
|----------------|-----------------|-----------------|--------------------------------------|
| Sine | 7.49Vp-p | 1kHz | 2.6349Vrms to 2.6613Vrms |
| Square (FXD50) | | | 3.558Vrms to 3.782Vrms |
| Triangle | | | 2.0541Vrms to 2.1837Vrms |
| Sawtooth Up | | | 2.0541Vrms to 2.1837Vrms |
| Sawtooth Down | | | 2.0541Vrms to 2.1837Vrms |
| Sine | 30Vp-p | 1kHz | 10.5536Vrms to 10.6596Vrms |
| | | 10kHz | 10.5536Vrms to 10.6596Vrms |
| | | 20kHz | 10.5536Vrms to 10.6596Vrms |
| | | 50kHz | 10.5536Vrms to 10.6596Vrms |
| Sine | 10Vp-p | 1kHz | 3.5179Vrms to 3.5532Vrms |
| | | 10kHz | 3.5179Vrms to 3.5532Vrms |
| | | 20kHz | 3.5179Vrms to 3.5532Vrms |
| | | 50kHz | 3.5179Vrms to 3.5532Vrms |
| Sine | 3Vp-p | 1kHz | 1.05536Vrms to 1.06596Vrms |
| | | 10kHz | 1.05536Vrms to 1.06596Vrms |
| | | 20kHz | 1.05536Vrms to 1.06596Vrms |
| | | 50kHz | 1.05536Vrms to 1.06596Vrms |
| Triangle | 30Vp-p | 1kHz | 8.6170Vrms to 8.7468Vrms |
| Square | | | 14.25Vrms to 15.15Vrms |
| Sawtooth Up | | | 8.6170Vrms to 8.7468Vrms |
| Sawtooth Down | | | 8.6170Vrms to 8.7468Vrms |

1.6.4 Frequency Response (Sine)

1. Connect the phase shifter to the Model 3930A and a wideband AC DVM as shown in Figure 1-4. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a 1kHz Model 3930A frequency and a Model 3933A sine function of 30Vp-p.
4. Set the DVM to measure AC volts with autoranging, and verify that the voltage reading is within the limits specified in Table 1-4.
5. Set the DVM to measure dB, and select a 50Ω reference impedance. Press REL to establish the present voltage reading as the relative dB reference.
6. Change the frequency setting of the synthesizer according to Table 1-4, and verify the subsequent \pm dB readings.
7. Program a 1kHz sine function of 3.75Vp-p, and verify that the voltage reading is within limits. Press REL to establish the reading as the relative dB reference. Verify the \pm dB readings for the remaining frequencies.
8. Program a 1kHz sine function of 3.74Vp-p, and verify the reading. Establish the present reading as the relative dB reference. Verify the \pm dB readings for the remaining frequencies.

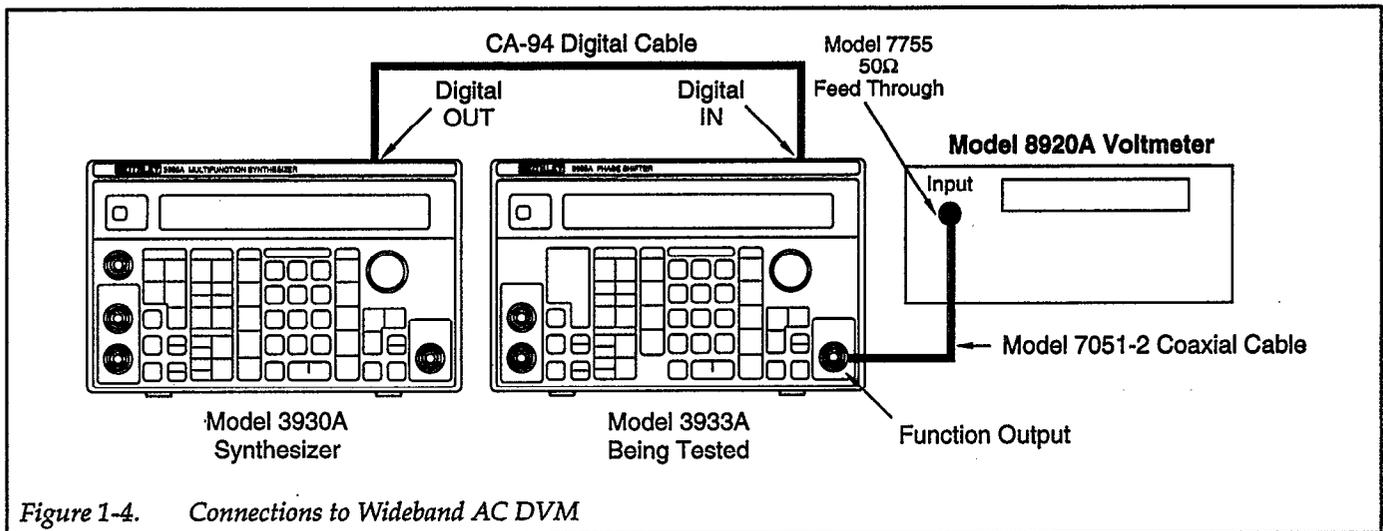


Figure 1-4. Connections to Wideband AC DVM

Table 1-4. Limits for Frequency Response (Sine)

| 3933A Function | 3933A Amplitude | 3930A Frequency | Allowable Voltmeter Reading (18°C to 28°C) | |
|-------------------|--------------------|--------------------|---|---------------------|
| Sine | 30Vp-p | 1kHz | 5.2Vrms | to 5.4Vrms (=REF) |
| | | 10kHz | -0.1dB | to +0.1dB |
| | | 100kHz | -0.1dB | to +0.1dB |
| | | 200kHz | -0.3dB | to +0.3dB |
| | | 350kHz | -0.3dB | to +0.3dB |
| | | 500kHz | -0.3dB | to +0.3dB |
| | | 700kHz | -0.3dB | to +0.3dB |
| | | 800kHz | -0.5dB | to +0.3dB |
| | | 900kHz | -0.5dB | to +0.3dB |
| | | 1MHz | -0.5dB | to +0.3dB |
| | | 1.2MHz | -1.0dB | to +0.3dB |
| Sine | 3.75Vp-p | 1kHz | 0.65Vrms | to 0.676Vrms (=REF) |
| | | 10kHz | -0.1dB | to +0.1dB |
| | | 100kHz | -0.1dB | to +0.1dB |
| | | 200kHz | -0.3dB | to +0.3dB |
| | | 350kHz | -0.3dB | to +0.3dB |
| | | 500kHz | -0.3dB | to +0.3dB |
| | | 700kHz | -0.3dB | to +0.3dB |
| | | 800kHz | -0.5dB | to +0.3dB |
| | | 900kHz | -0.5dB | to +0.3dB |
| | | | | 1.2MHz |
| Sine | 3.74Vp-p | 1kHz | 0.648Vrms | to 0.674Vrms (=REF) |
| | | 10kHz | -0.1dB | to +0.1dB |
| | | 100kHz | -0.1dB | to +0.1dB |
| | | 200kHz | -0.3dB | to +0.3dB |
| | | 350kHz | -0.3dB | to +0.3dB |
| | | 500kHz | -0.3dB | to +0.3dB |
| | | 700kHz | -0.3dB | to +0.3dB |
| | | 800kHz | -0.5dB | to +0.3dB |
| | | 900kHz | -0.5dB | to +0.3dB |
| | | | | 1.2MHz |

1.6.5 Frequency Response (Triangle, Sawtooth, Square)

1. Connect the phase shifter to the synthesizer and a timer/counter as shown in Figure 1-2. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a 1kHz Model 3930A frequency and a Model 3933A triangle wave of 30Vp-p.
4. Set the timer/counter to display the peak-to-peak voltage at Channel A, and verify that the voltage reading is within the limits specified in Table 1-5. Call this reading REF.
5. Change the synthesizer frequency to 5kHz. The new reading should be between 0.97 times the REF reading and 1.03 times the REF reading.
6. Modify the frequency and function settings of the synthesizer and phase shifter according to Table 1-5, and verify that the corresponding readings are within the specified limits.

Table 1-5. Limits for Frequency Response (Triangle, Sawtooth, Square)

| 3933A Function | 3933A Amplitude | 3930A Frequency | Allowable Timer/Counter Reading (18°C to 28°C) | | |
|----------------|-----------------|-----------------|--|----|------------------|
| Triangle | 30Vp-p | 1kHz | 14.25Vp-p | to | 15.75Vp-p (=REF) |
| | | 5kHz | 0.97 × REF | to | 1.03 × REF |
| | | 10kHz | 0.97 × REF | to | 1.03 × REF |
| Sawtooth Up | 30Vp-p | 1kHz | 14.25Vp-p | to | 15.75Vp-p (=REF) |
| | | 5kHz | 0.95 × REF | to | 1.05 × REF |
| | | 10kHz | 0.95 × REF | to | 1.05 × REF |
| Sawtooth Down | 30Vp-p | 1kHz | 14.25Vp-p | to | 15.75Vp-p (=REF) |
| | | 5kHz | 0.95 × REF | to | 1.05 × REF |
| | | 10kHz | 0.95 × REF | to | 1.05 × REF |
| Square | 30Vp-p | 1kHz | 14.25Vp-p | to | 15.75Vp-p (=REF) |
| | | 5kHz | 0.98 × REF | to | 1.02 × REF |
| | | 10kHz | 0.98 × REF | to | 1.02 × REF |
| | | 100kHz | 0.98 × REF | to | 1.02 × REF |

1.6.6 Total Harmonic Distortion

1. Connect the phase shifter to the synthesizer and an audio analyzer as shown in Figure 1-5. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a 1kHz Model 3930A frequency and a Model 3933A sine function of 30Vp-p.
4. Set the audio analyzer to measure distortion, and verify that the reading is within the limits specified in Table 1-6.
5. Change the frequency setting of the synthesizer according to Table 1-6, and verify the distortion readings.

Table 1-6. Limits for Total Harmonic Distortion

| 3933A Function | 3933A Amplitude | 3930A Frequency | Allowable Analyzer Reading (18°C to 28°C) |
|----------------|-----------------|-----------------|---|
| Sine | 30Vp-p | 1kHz | < 0.1% |
| | | 10kHz | < 0.1% |
| | | 20kHz | < 0.1% |
| | | 35kHz | < 0.1% |
| | | 50kHz | < 0.1% |
| | | 70kHz | < 0.1% |
| | | 100kHz | < 0.1% |

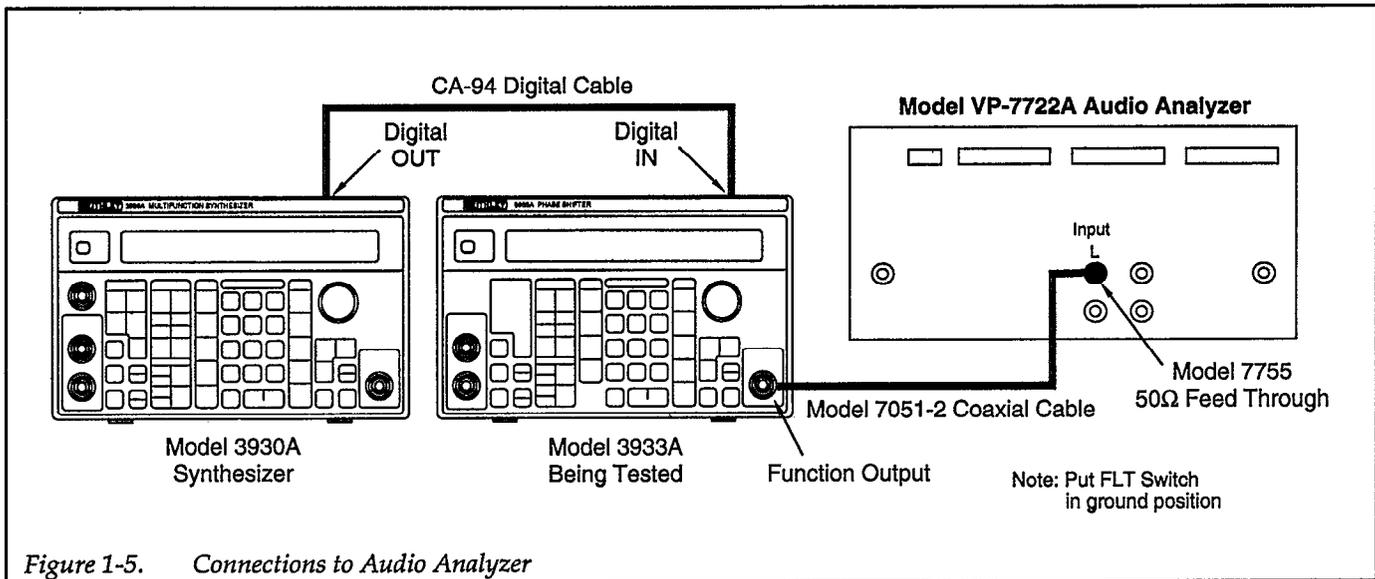


Figure 1-5. Connections to Audio Analyzer

1.6.7. DC Voltage Accuracy

1. Connect the phase shifter to the synthesizer and a DMM as shown in Figure 1-3. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program the Model 3933A for the DC function, 2.00mV amplitude, with +15V offset.
4. Set the DMM to measure DC volts with autoranging, and verify that the voltage reading is within the limits specified in Table 1-7.
5. Change the offset setting of the phase shifter according to Table 1-7, and verify the subsequent voltage readings.

1.6.8 DC Level (Square) and DC Offset Error (Sine)

1. Connect the phase shifter to the synthesizer and a DMM as shown in Figure 1-3. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Set the Model 3933A for a 7.49Vp-p square wave with a phase setting of +90°. Set the Model 3930A for gated mode and the EXT ∇ trigger source.
4. Set the DMM to measure DC volts with autoranging, and verify that the voltage reading is within the limits specified in Table 1-8.
5. Change the function, amplitude, mode, trigger source, and phase settings of the phase shifter and synthesizer according to Table 1-8 and verify the voltage readings.

Table 1-7. Limits for DC Voltage Accuracy

| 3933A Function | 3933A Offset | Allowable DMM Reading (18°C to 28°C) |
|----------------|--------------|--------------------------------------|
| DC | +15V | +14.842V to +15.158V |
| | -15V | -14.842V to -15.158V |
| | +5V | +4.942V to +5.058V |
| | -5V | -4.942V to -5.058V |
| | +1.5V | +1.477V to +1.523V |
| | -1.5V | -1.477V to -1.523V |

1.6.9 Rise and Fall Times

1. Connect the phase shifter to the synthesizer and a timer/counter as shown in Figure 1-1. Turn on all instruments.
2. Restore factory defaults on the Model 3933A by pressing SHIFT PRST.
3. Program a 100kHz square wave (FXD50) of 30Vp-p.
4. Set the timer/counter to measure rise/fall times of Channel A and verify that the rise time is within the limit specified in Table 1-9. Then change the slope to measure the fall time and verify the reading.
5. Change the amplitude setting of the phase shifter according to Table 1-9, and verify the remaining rise/fall times.

Table 1-8. Limits for DC Level (Square) and DC Offset Error (Sine)

| 3933A Function | 3933A Amplitude | 3930A Mode | 3930A Trigger Source | 3933A Phase | Allowable DMM Reading (18°C to 28°C) |
|----------------|-----------------|------------|----------------------|--------------|--|
| Square | 7.49Vp-p | Gate | Ext ∇ | +90° -90° | 3.715V to 3.774V -3.715V to -3.774V |
| Sine | 30Vp-p 3Vp-p | Gate | Ext ∇ | 0° | ±68mV ±14mV |

Table 1-9. Limits for Rise/Fall Times

| 3933A Function | 3930A Frequency | 3933A Amplitude | Time | Allowable Timer/Counter Reading (18°C to 28°C) |
|---------------------------|----------------------------|----------------------------|-------------|---|
| Square (FXD50) | 100kHz | 30Vp-p | Rise | < 150nsec |
| | | | Fall | < 150nsec |
| | | 3.75Vp-p | Rise | < 150nsec |
| | | | Fall | < 150nsec |
| | | 3.74Vp-p | Rise | < 150nsec |
| | | | Fall | < 150nsec |

SECTION 2

Principles of Operation

2.1 INTRODUCTION

This section covers basic operating principles of the Model 3933A.

2.2 BLOCK DIAGRAM

Figure 2-1 shows an overall block diagram of the Model 3933A. The various sections include the control section, display and keyboard section, phase shift section, digital I/O section, analog section, and the power supply and GPIB interface sections.

2.2.1 Control Section

The control section supervises all instrument operations. The control section includes the 68008 microprocessor, EPROM for program storage, and battery backed-up RAM for working storage and memory to store operating parameters.

2.2.2 Display and Keyboard Section

This section includes a 40-character X 2-line LCD (liquid crystal display) and a membrane keyboard. The LCD is backlit for better visibility.

2.2.3 Phase Shift Section

This section produces digital waveform data by phase shifting the signal from the Model 3930A Synthesizer or another Model 3933A Phase Shifter. Key parts of the phase shift section include the phase shift addition circuit, sine wave conversion ROM, sweep I/O circuits, and the digital output circuits to provide the necessary signals for any additional Model 3933A Phase Shifters.

2.2.4 Analog Section

The analog section includes a D/A converter to convert digital waveform data produced by the phase shift section into the analog output signal. The analog section also controls the amplitude of the output waveform and adds the DC offset to the output signal.

The analog section is isolated from other parts of the digital system by a pulse transformer and photo coupler.

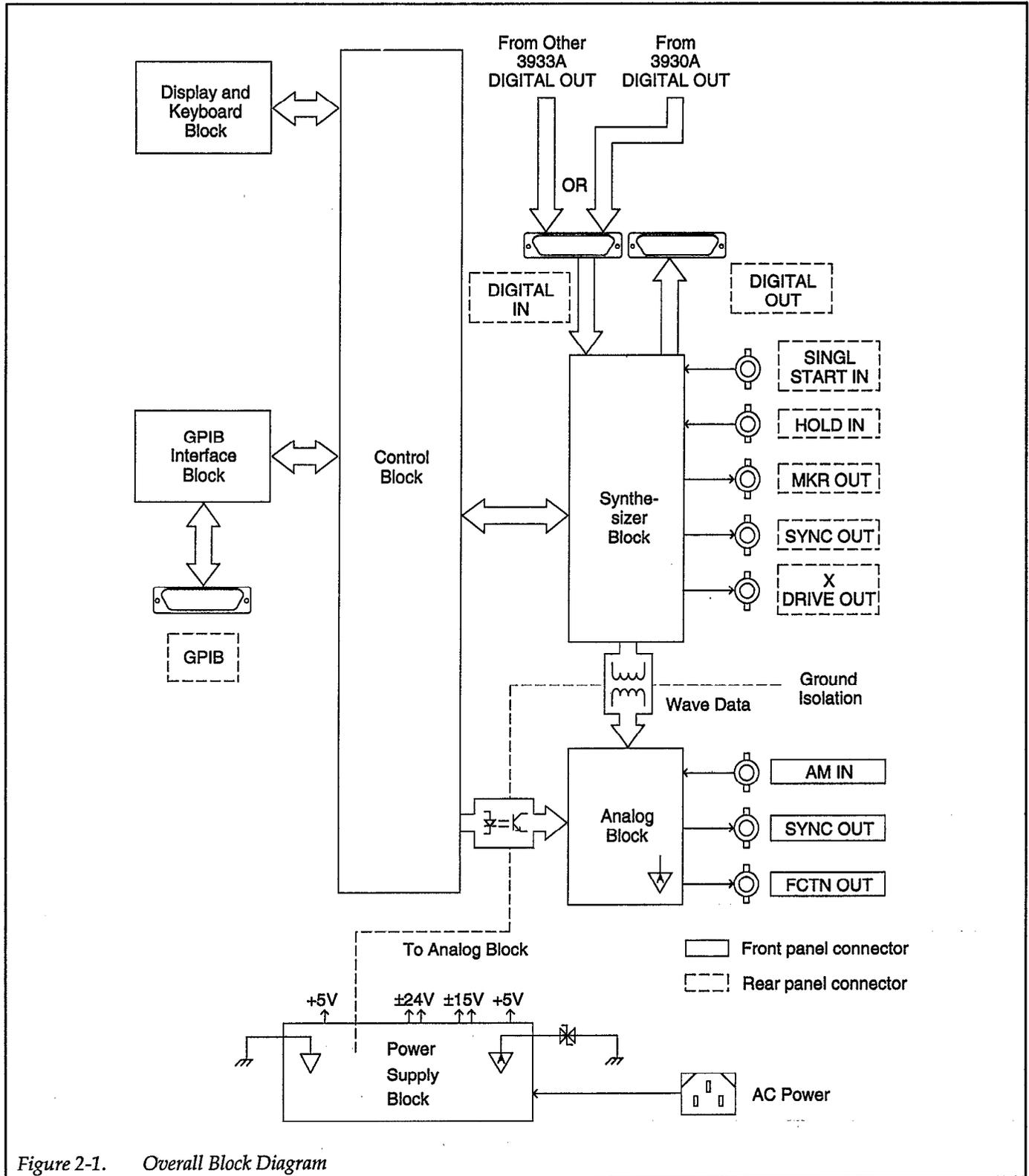


Figure 2-1. Overall Block Diagram

2.2.5 Power Supply Section

The power supply provides several DC operating voltages to various other sections in the instrument and is made up of a transformer and series regulators. Supply voltages include $\pm 24V$, $\pm 15V$, and two $+5V$ DC supplies.

Note that power supply common for all circuits except the analog section is connected to chassis ground. Analog common is connected to chassis ground through a varistor.

2.3 ANALOG CIRCUIT DESCRIPTION

2.3.1 Analog Section Block Diagram

Figure 2-2 shows a block diagram of the analog section of the instrument. Key sections include the D/A converter, square wave generator, amplitude modulation circuits, and multiplying D/A and attenuator for amplitude and DC offset control.

2.3.2 D/A Converter

Digital waveform data is converted into an analog signal by the D/A converter. The converted signal is then passed through a low-pass filter to remove any spurious components. This conversion process is used to generate sine, triangular, and sawtooth waves.

2.3.3 Square Wave Generator

Square waves with fixed 50% duty cycle are generated by applying sine waves to an analog comparator. The analog comparator has a certain amount of hysteresis, which results in good-quality square waves at the output.

Variable duty cycle square waves are generated by a digital comparator. Digital sawtooth waveform information is used as the input signal to the digital comparator.

2.3.4 Amplitude Modulation

A signal applied to the AM IN jack can be used to amplitude modulate the output signal. This modulating signal

is applied to the AM multiplier, which performs the modulating function.

2.3.5 Amplitude and DC Offset Control

Control of the AC amplitude and DC offset amplitude is performed the multiplying D/A section in conjunction with the output amplifier. Further amplitude control is provided by the output attenuator, which includes 1:10 and 1:100 attenuation ratios. Combining these two ratios yields overall attenuation ratios of 1:1, 1:10, 1:100, and 1:1000.

2.4 MULTIPHASE OSCILLATOR OPERATION

Figure 2-3 shows a block diagram of a multiphase oscillator made up of a Model 3930A Multifunction Synthesizer and two Model 3933A Phase Shifters. In this multiphase oscillator, the output of the Model 3930A is assigned as the first phase, while the second and third phase outputs are outputs from the two phase shifters as shown. In this manner, a multiphase oscillator up to a maximum of six phases can be configured. The oscillating frequency and oscillation mode for all units are determined by the main synthesizer signal, but the phase, amplitude, DC offset, and waveform type can be independently programmed for each unit.

Note that the main synthesizer signal, which provides a reference phase for each unit, is not directly output, and that the phase of each unit can be set independently of the others. Also note that the first phase signal (Model 3930 FCTN OUT) is determined by the programmed start/stop phase of the Model 3930A, while the second and third phase signals are determined by the phase settings of those units.

The phases of the various units can be determined from the programmed phase values (start/stop phase for the Model 3930A, phase setting for the Model 3933A). For example, if the Model 3930A start/stop phase is set to 0° , the Model 3933A phases are simply the programmed values. When the Model 3930A is set to the burst or gate oscillation modes, the start/stop phase of the synthesizer is 0° . Therefore, the Model 3933A signal phases will always be the same as the programmed phase values when the burst or gate oscillation mode is used.

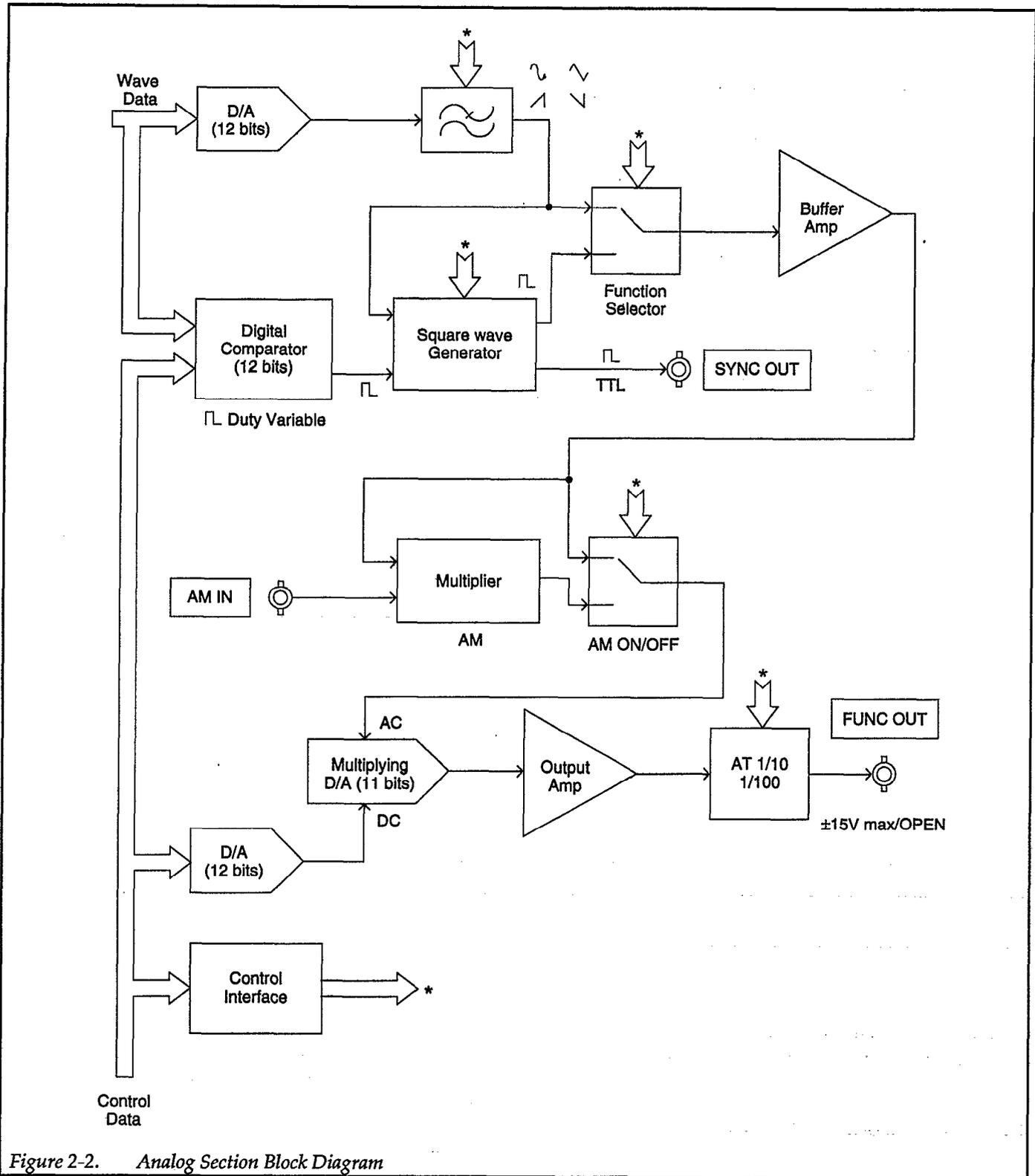


Figure 2-2. Analog Section Block Diagram

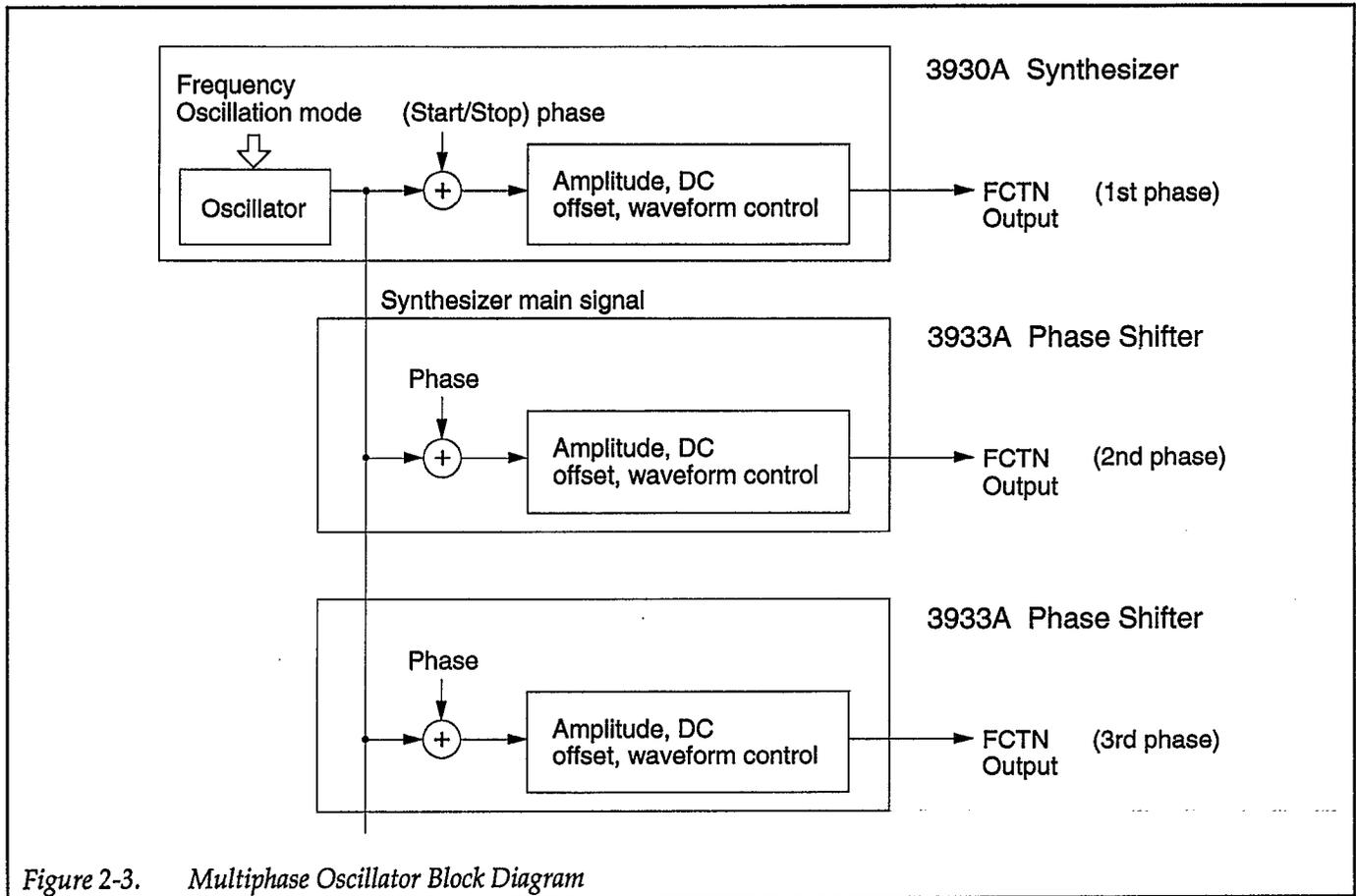


Figure 2-3. Multiphase Oscillator Block Diagram

SECTION 3

Service Information

3.1 INTRODUCTION

This section contains information on fuse replacement, instrument calibration and repair, and replacement parts for the Model 3933A.

3.2 LINE FUSE REPLACEMENT

WARNING

Disconnect the line cord and all other equipment from the instrument before replacing the line fuse.

The line fuse, which is located on the rear panel, protects the power line input from excessive current. To replace the fuse, first unplug the line cord, then unscrew the fuse from its fuse holder. Replace the fuse only with the type recommended in Table 3-1.

CAUTION

Using the wrong fuse type may result in instrument damage.

3.3 CALIBRATION

The following paragraphs give step-by-step procedures for calibrating the Model 3933A. This calibration procedure

Table 3-1. Recommended Line Fuses

| Line Voltage | Description | Keithley Part No. |
|--------------|-------------------------------------|-------------------|
| 100V/120V | 1A, 250V, normal blow, 5mm × 20mm | FU-96-2 |
| 220V/240V | 1/2A, 250V, normal blow, 5mm × 20mm | FU-96-1 |

can be performed at specified intervals, or if the performance verification procedures covered in Section 1 show that instrument performance is not within specifications.

NOTE

Calibration must be performed in the sequence covered below. If any of the calibration procedures cannot be performed successfully, refer to the repair information in paragraph 3.7 unless the unit is still under warranty. (Units still under warranty should be returned to the factory or authorized repair facility for repair.)

3.3.1 Environmental Conditions

Calibration should be performed at 18-28°C (65-82°F) and at less than 70% relative humidity.

3.3.2 Initial Conditions

The Model 3933A and the test equipment should be turned on and allowed to warm up for one hour before calibration. If the instrument has been subjected to extreme temperature or humidity, allow additional time for stabilization.

3.3.3 Line Power

Before calibrating the instrument, be sure the rear panel line voltage is set to the correct operating voltage. The Model 3933A should be calibrated while operating at a line voltage within $\pm 10\%$ of the line voltage switch setting and at a line frequency from 48Hz to 62Hz.

3.3.4 Recommended Calibration Equipment

Table 3-2 summarizes recommended equipment for calibrating the Model 3933A. Similar equipment may be used as long as corresponding specifications are comparable.

Table 3-2. Recommended Test Equipment for Calibration

| Manufacturer | Model | Description | Specifications |
|--------------|-------------------|--|---|
| Keithley | 3930A | Multifunction Synthesizer (2 required) | 0.1mHz to 1.2MHz; ± 5 ppm |
| Keithley | 197A | DMM (DC volts, AC volts) (5-1/2 digits) | 20V range; $\pm(0.015\%$ of rdg + 3 counts) ACV; $\pm(0.35\%$ of rdg + 100 counts) |
| Fluke | 8920A | DVM (AC volts) (3-1/2 digits) | 20V range; 1kHz-200kHz (0.5% of rdg), 200kHz-1MHz (0.7%), 1-10MHz (3%), 10-20MHz (5%) |
| Philips | PM6654C PM9678 | Timer/Counter TCXO option | 0.01Hz-120MHz; time base aging $<1 \times 10^{-7}$ /month; Vp-p measurements |
| Keithley | 7051-2 | BNC Interconnect Cable (2 required) | 50 Ω coaxial cable (RG-58C), male BNC connectors, 2ft (0.6m) |
| Keithley | 7755 | 50 Ω Feed-through Terminator | BNC to BNC adapter, 50 Ω termination, DC to 250MHz, VSWR of <1.1 |
| Pomona | 1468 | BNC-banana Adapter | Female BNC connector to double banana plug |

3.3.5 Cover Removal

Before calibration, the top and bottom covers must be removed as covered below (see Figure 3-1).

WARNING

Potentially hazardous voltages may be present inside the instrument. Use caution when performing calibration.

CAUTION

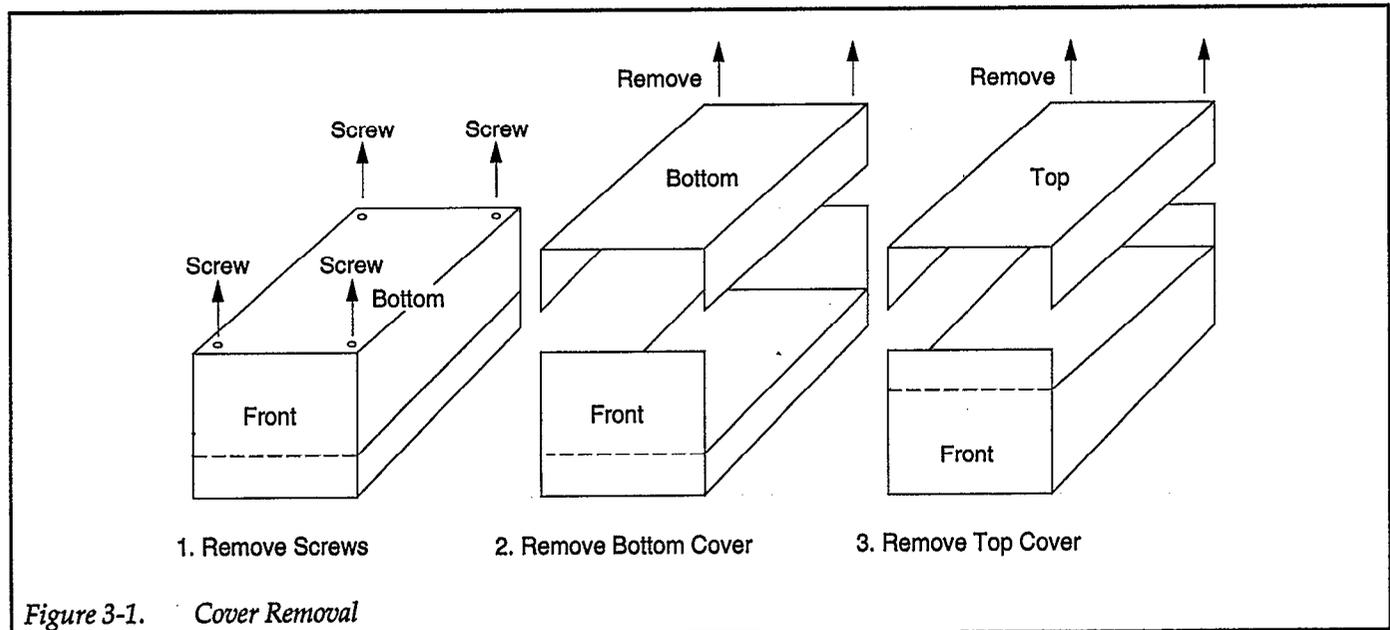
A conductive coating is applied to the inner surface of the covers. Be careful not to scratch the coating when removing the covers. Also be careful not the peel off the corners of the

polyester film covering the front panel; the film can be peeled off relatively easily.

1. Place the instrument upside down on a soft cloth or rubber mat to avoid scratching the top cover.
2. Remove the four corner screws that secure the bottom cover, then remove the cover.
3. Place the instrument right side up.
4. Remove the top cover by separating it from the chassis.

3.3.6 Calibration Adjustments

Calibration adjustments are shown in Figure 3-2.



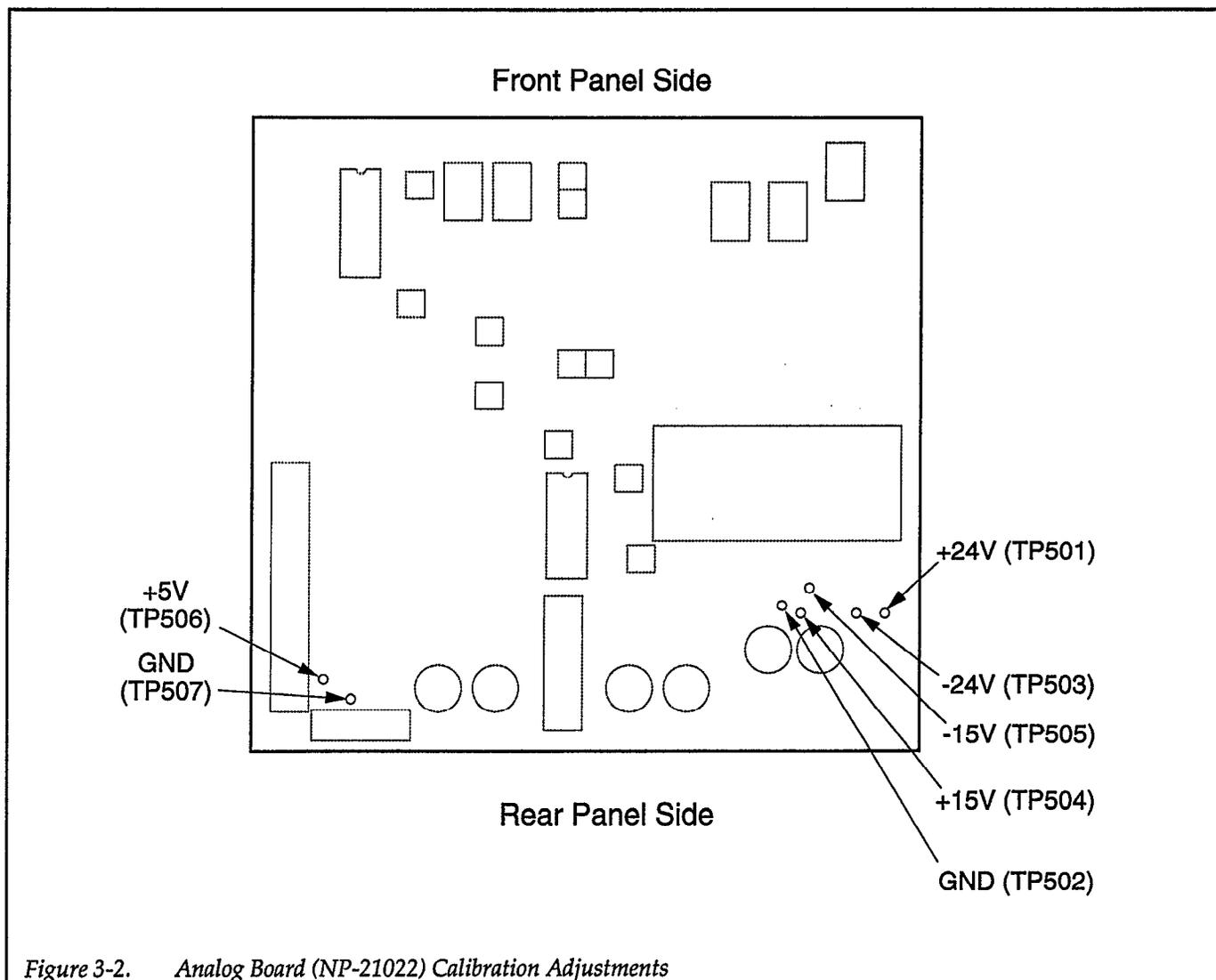


Figure 3-2. Analog Board (NP-21022) Calibration Adjustments

3.3.7 Function Synthesizer Connections

For all adjustment procedures, a Model 3930A Multifunction Synthesizer must be connected to the DIGITAL IN connector of the Model 3933A, as shown in Figure 3-3. Use the CA-94 digital cable supplied with the Model 3933A to make the connections.

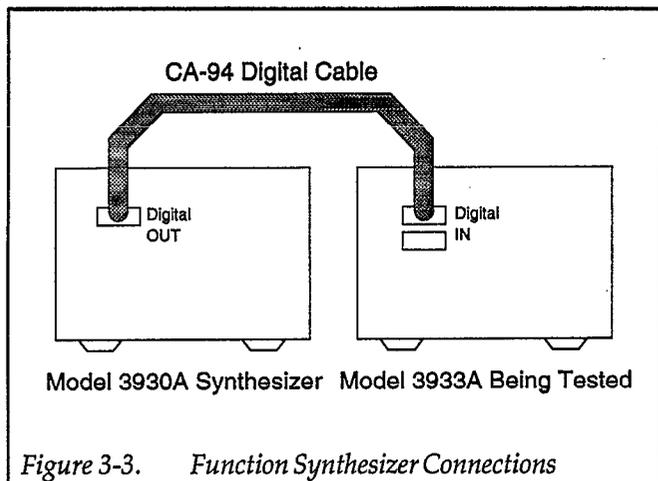


Figure 3-3. Function Synthesizer Connections

3.3.8 Calibration Procedures

NOTE

Calibration should be performed in the sequence presented.

DC Offset

1. Connect the Model 197A DMM to the Model 3933A FCTN OUT jack, as shown in Figure 3-4. Also make sure the Model 3930A is connected properly as indicated.
2. Set the Model 197A to the DCV function, and enable auto-ranging.
3. Setup the Models 3930A and 3933A as follows:

Model 3933A: Factory Default (press SHIFT PRST)
RANGE: FXD (press SHIFT 0)
FCTN: DC

Model 3930A: Factory Default (press SHIFT PRST)
SOURCE: EXT ∇
MODE: GATE

4. Adjust R213 (DC OFS) so that the DMM reads $0V \pm 1mV$.
5. Program a Model 3933A DC offset value of $-15V$ (use OFFSET).
6. Adjust R211 (DC SPAN) for a DMM reading of $-15V \pm 0.002V$.
7. Program a Model 3933A DC offset voltage of $+15V$.
8. Verify that the DMM reading is between $14.996V$ and $15.002V$. If not, repeat the DC span adjustment (step 6) to minimize the errors in the $-15V$ and $+15V$ readings.
9. Program a DC offset voltage of $0V$, and verify that the DMM reading is still $0V \pm 1mV$. If not, re-adjust R213 (DC OFS) for a reading within these limits.
10. Setup the Model 3933A as follows:
FCTN: SIN
OFFSET: $0V$
AMPTD: $30Vp-p$
11. Adjust R101 (OFS) for a DMM reading of $0V \pm 1mV$.

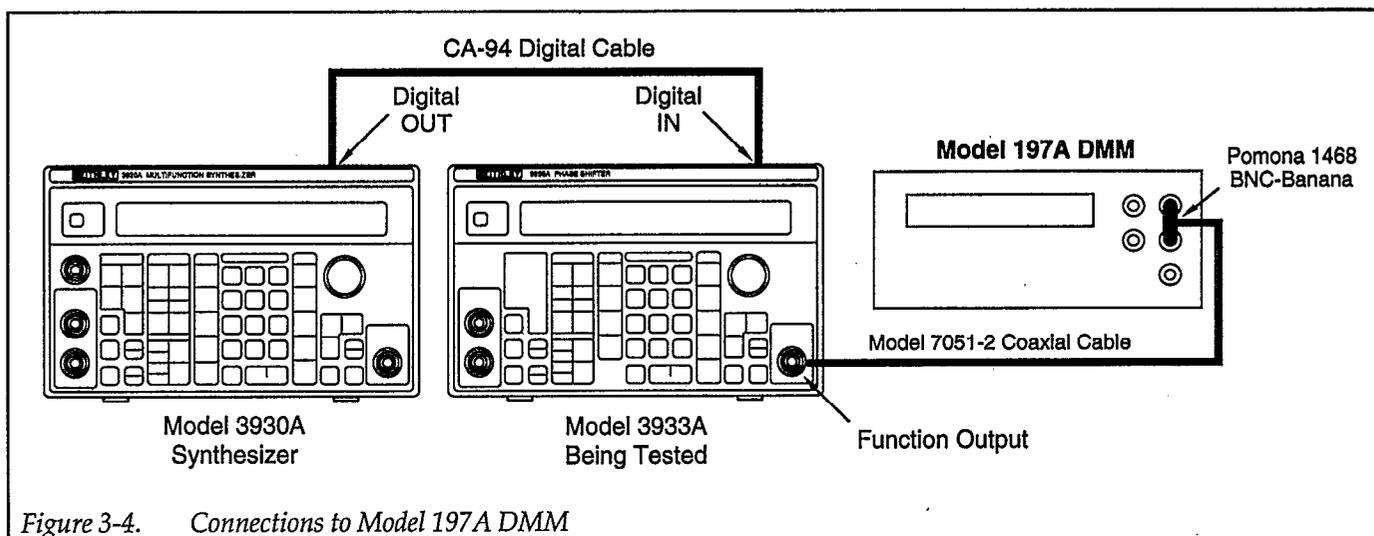


Figure 3-4. Connections to Model 197A DMM

SIN Level

1. Connect the Model 197A DMM to the FCTN OUT jack of the Model 3933A (Figure 3-4). Also make sure the Model 3930A is connected properly as indicated.
2. Set the Model 197A to the DCV function, and select auto-range.
3. Setup the Models 3930A and 3933A as follows:
 Model 3933A: Factory Default (press SHIFT PRST)
 PHASE: -90°
 AMPTD: 7.49Vp-p
 Model 3930A: Factory Default (press SHIFT PRST)
 SOURCE: EXT ∇
 MODE: GATE
4. Adjust R109 (AMP) for a DMM reading of $-3.745V \pm 0.004V$.

AM Balance

1. Connect a Model 197A DMM to FCTN OUT, and

connect a second Model 3930A to the AM IN jack of the Model 3933A being calibrated (see Figure 3-5). The second Model 3930A will be used to provide an amplitude modulation signal.

NOTE

Connect an oscilloscope, if one is available, in parallel with the Model 197A input terminals in order to make adjustments easier.

2. Set the DMM to the ACV function, and select auto-ranging.
3. Setup the Model 3930A used for the AM signal as follows:

Factory Default (press SHIFT PRST)
 AMPTD: 2Vp-p

4. Setup the first Model 3930A and the Model 3933A being calibrated as follows:

Model 3933A: Factory Default (press SHIFT PRST)
 AMPTD: 7.49Vp-p
 AM: ON

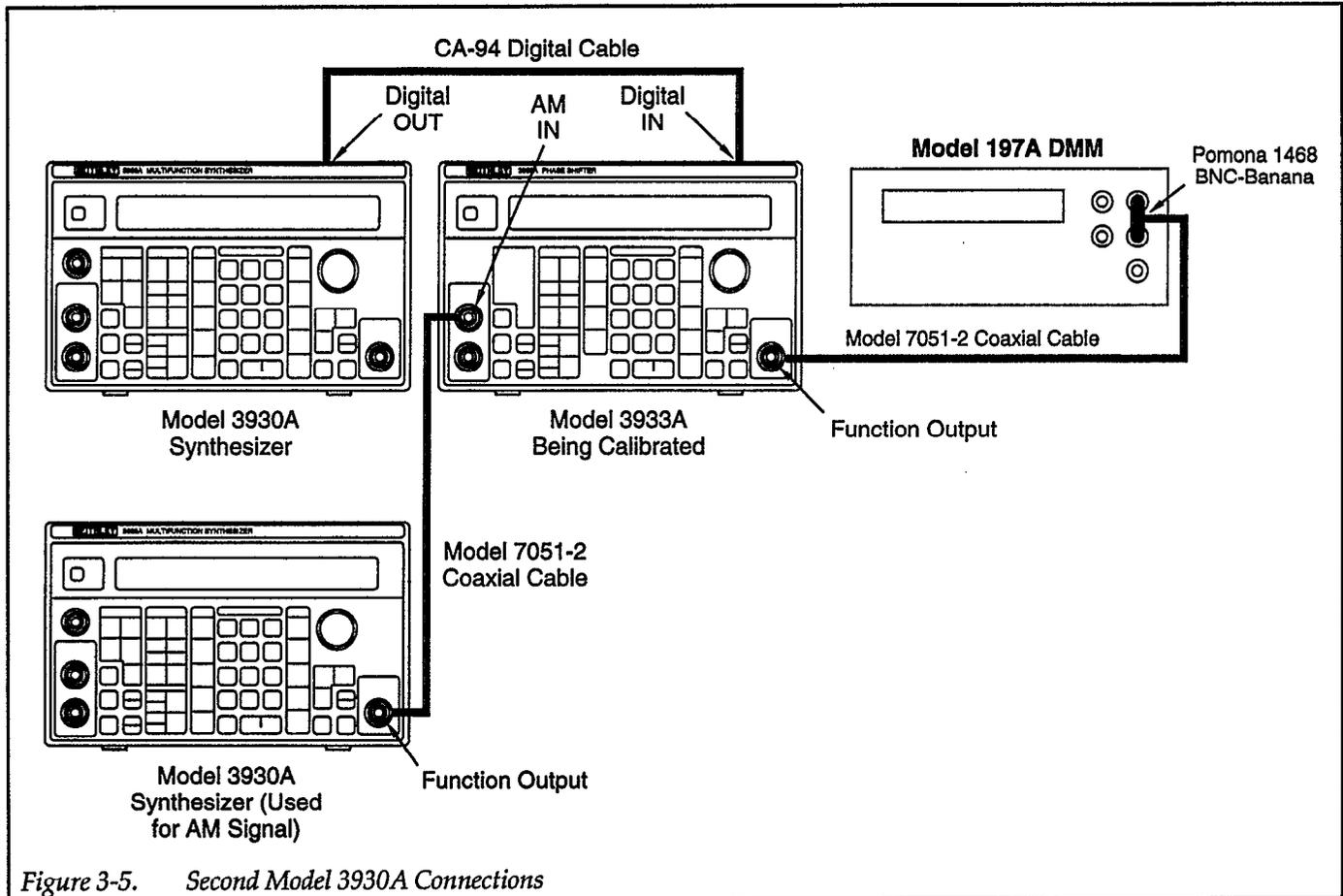


Figure 3-5. Second Model 3930A Connections

Model 3930A: Factory Default (press SHIFT PRST)
SOURCE: EXT ∇
MODE: GATE

5. Adjust R207 (AM BAL) so that the multimeter indicates 10mV or less. (If an oscilloscope is being used, adjust for minimum signal amplitude.)
6. Select the DCV function on the DMM.
7. Adjust R208 (AM OFS) for a DMM reading of $0V \pm 20mV$.
8. Repeat steps 2 through 7 three or four times until both the AM balance and AM offset reading limits stated in steps 5 and 7 are satisfied.

AM Gain

1. Disconnect the second Model 3930A from the AMIN connector, and make sure the DMM is still connected to the FCTN OUT jack of the Model 3933A being calibrated (Figure 3-4).
2. Select the DCV function and auto-ranging on the DMM.
3. Setup the Model 3933A as follows:
PHASE: -90°
4. Adjust R203 (AM GAIN) for a DMM reading of $-1.872V \pm 0.009V$.

AM Offset

1. Connect the Model 197A DMM to FCTN OUT (Figure 3-4).
2. Select the DCV function and auto-ranging on the DMM.
3. Setup the Model 3933A as follows:
PHASE: 0°

4. Adjust R208 (AM OFS) for a DMM reading of $0V \pm 10mV$.

Square Wave DC Level

1. Connect the Model 197A DMM to FCTN OUT (Figure 3-4).
2. Select the DCV function and auto-ranging on the DMM.
3. Setup the Model 3933A as follows:
Factory Default (press SHIFT PRST)
FCTN: \square
AMPTD: 7.49Vp-p
PHASE: $+90^\circ$
4. Setup the Model 3933A as follows:
PHASE: -90°
5. Adjust R316 (SQ-) for a DMM reading of $-3.7445V \pm 0.0055V$.

Square Wave Duty Cycle

1. Connect the PM 6645C counter A input to the FCTN OUT jack, as shown in Figure 3-6.
2. Set the PM 6654C counter to the pulse width measurement mode.
3. Setup the Model 3933A as follows:
Factory Default (press SHIFT PRST)
FREQ: 100Hz
AMPTD: 20Vp-p
FCTN: \square
4. Adjust R308 (DUTY) for a counter reading of 5msec \pm 0.005msec.

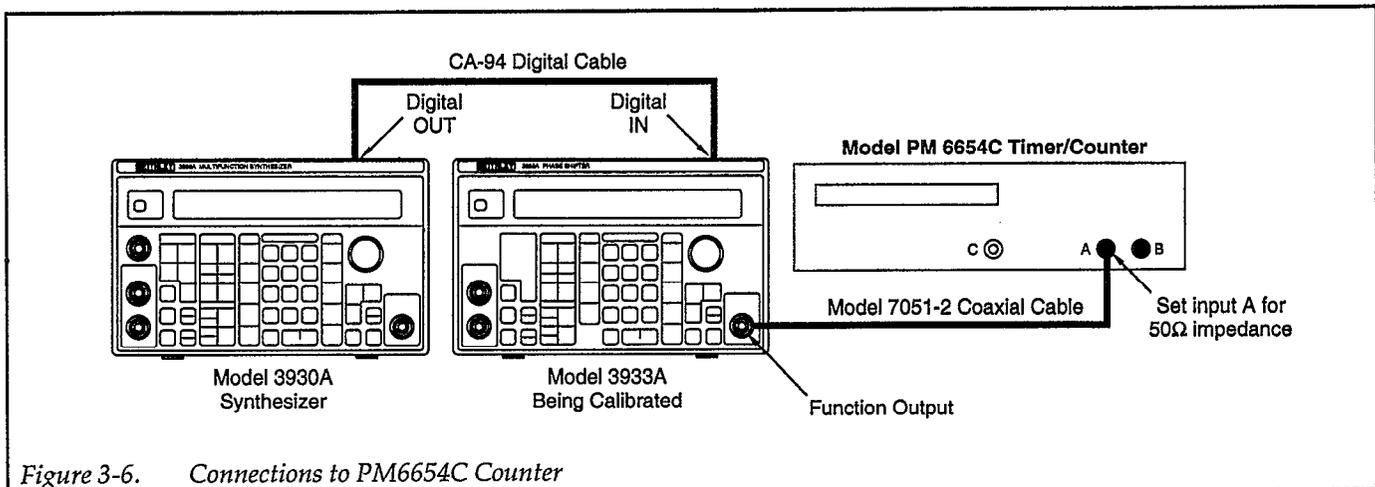


Figure 3-6. Connections to PM6654C Counter

Frequency Response

1. Connect the Model 8920A RMS Voltmeter to the FCTN OUT jack, as shown in Figure 3-7. Be sure to use the 50Ω feed-through terminator as indicated.
2. Make sure the voltmeter dB and REL modes are disabled.
3. Setup the Models 3930A and 3933A as follows:
 Model 3933A: Factory Default (press SHIFT PRST)
 AMPTD: 3.74Vp-p
 Model 3930A: FREQ: 1kHz
4. Allow the voltmeter reading to settle, then enable dB and REL in that order.
5. Setup the Model 3930A as follows:
 FREQ: 800kHz
6. Adjust C108' for an RMS voltmeter reading of $+0.04\text{dB} \pm 0.03\text{dB}$.

Display Contrast

7. Press the front panel DSPL key to return the display to normal.
8. Adjust R752 (CONTRAST) for the desired display contrast. (R752 is located on the control board (NP-10409) near the front panel.)

3.3.9 Cover Replacement

After calibration, replace the top and bottom covers, and secure them with the four screws removed earlier. Be careful not to scratch the conductive coating applied to the inside of the covers, and be sure not to peel off the front panel polyester film.

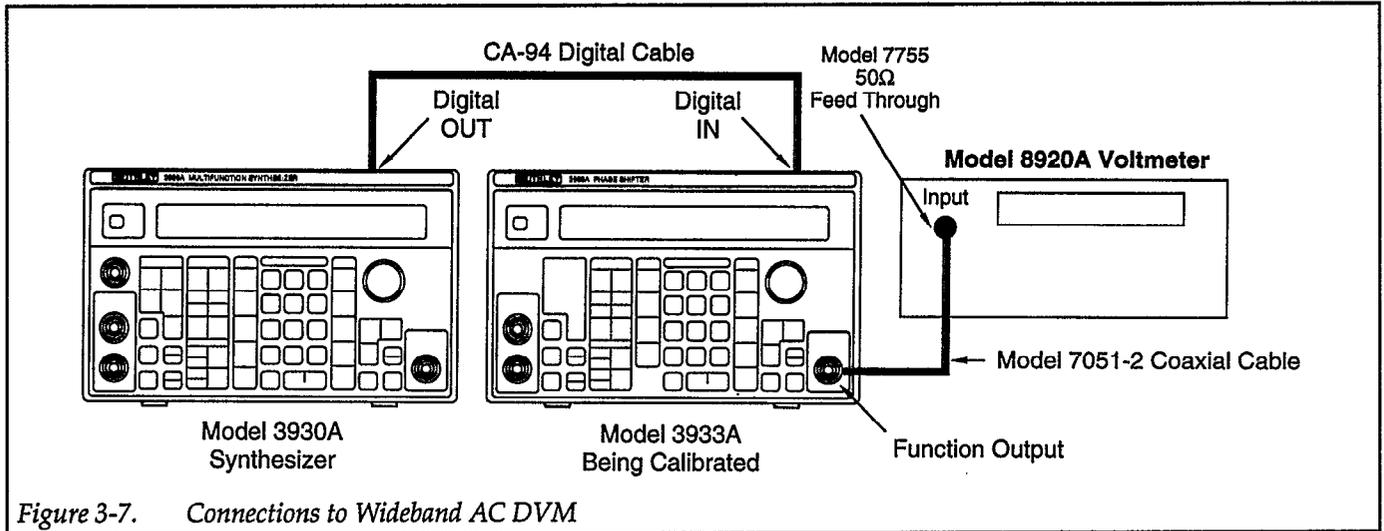


Figure 3-7. Connections to Wideband AC DVM

3.4 FAN FILTER CLEANING

The fan filter should be cleaned at least once every three months when the unit is operated in a clean environment or at least once a month when the unit is operated in a dirty environment. The fan filter element should be cleaned as follows:

1. Turn off the instrument power and disconnect the line cord.
2. Remove the filter cover on the rear panel.
3. Remove the filter element.
4. Soak the filter element in a solution of mild detergent and water until clean.
5. Rinse the filter element thoroughly in clean water, then allow the filter to dry thoroughly before replacement.
6. When the filter has dried completely, install the filter and cover.

CAUTION

The instrument should not be operated without the filter in place.

3.5 FCTN OUT JUMPER

The FCTN OUT jumper, which is located on the control board, allows you to select whether or not the output signal is turned on when power is first applied to the instrument. (As shipped, FCTN OUT is enabled when power is turned on). Use the procedure below to set the jumper position.

1. Disconnect the line cord and all other instruments from the Model 3933A.
2. Remove the top and bottom covers (see paragraph 3.3.5 for details).
3. Set J401 (FCTN OUT) to the desired position. (J401 is located on the control board, NP10409, near the rear panel.) Set the jumper to FCTN OUT ON to enable FCTN OUT at power on, or set it to FCTN OUT OFF to leave FCTN OUT disabled at power on.
4. Replace the top and bottom covers.

3.6 RECHARGEABLE BATTERY REPLACEMENT

The rechargeable battery (BT151), which backs up setup RAM, does not normally require field replacement.

However, if you notice the instrument no longer stores setups even after charging the battery, the battery is probably defective and should be replaced. Follow the steps below to replace the battery.

CAUTION

Many parts on the internal circuit boards are static sensitive. To avoid possible damage, perform any repair operations only at a properly grounded workstation, and use only grounded-tip soldering irons and anti-static de-soldering tools.

1. Disconnect the line cord and all other instruments from the Model 3933A.
2. Remove the top and bottom covers (refer to paragraph 3.3.5 for procedure).
3. Note the positions of the various cables connected to the control board, then disconnect all cables from the board.
4. Remove the screws, and release the fasteners that secure the control board to the chassis.
5. Slide the control board towards the front panel until the jacks clear the rear panel.
6. Remove the control board.
7. Unsolder the battery leads, and cut the sealant that secures the battery. Remove the battery.
8. Install a new battery, taking care to observe polarity.
9. After soldering, secure the battery to the board using an electronics-approved silicone or RTV sealer.
10. Install the control board, and connect all cables to the board.
11. Replace the covers.
12. Turn on the power for 50 hours to fully charge the new battery.

3.7 REPAIR

Instrument repair may be necessary in cases where the unit cannot be properly calibrated.

3.7.1 Factory Service

If the Model 3933A is still under warranty, it is recommended that the unit be returned to the factory or Keithley authorized repair facility for repair or calibration. When returning the unit for service, include the following:

- Complete the service form at the back of this manual.
- Advise as to the warranty status of the instrument.

- Write the following on the shipping label: ATTENTION REPAIR DEPARTMENT.

3.7.2 Power Supply Test Points

Table 3-3 summarizes power supply test points, and Figure 3-8 shows the test point locations. Note that $\pm 15V$ and $\pm 24V$ supply voltages are reference to TP502, and the +5V supply is referenced to TP507.

Table 3-3. Power Supply Test Point Summary

| Test Point | Description |
|------------|---------------------------------------|
| TP501 | +24V supply |
| TP502 | GND ($\pm 15V$, $\pm 24V$ supplies) |
| TP503 | -24V supply |
| TP504 | +15V supply |
| TP505 | -15V supply |
| TP506 | +5V supply |
| TP507 | GND (+5V supply) |

3.7.3 Board-level Repair

Table 3-4 summarizes which circuit board is most likely at fault for various problems. Paragraph 3.8 below lists replacement boards and certain other parts. If board replacement fails to fix the problem, the most likely cause of the fault is the wiring between the boards.

Table 3-4. Board Level Repair Summary

| Problem | Probable Cause |
|-------------------------|----------------|
| 1. DC OFFSET VAR | B |
| 2. OUTPUT ATT | B |
| 3. FCTN OUT ON/OFF | B |
| 4. PHASE VAR | A |
| 5. WAVE FORM | A or B |
| 6. AMPLITUDE VAR | B |
| 7. AM | B |
| 8. DUTY CYCLE VAR | A or B |
| 9. DUTY CYCLE STABILITY | B |
| 10. PHASE SWEEP | A |
| 11. SYNC OUT | B |
| 12. SWEEP MKR OUT | A |
| 13. SWEEP SYNC OUT | A |
| 14. X DRIVE OUT | A |

A: Control circuit board (NP-10409)
B: Analog circuit board (NP-21022)

3.8 REPLACEABLE PARTS

3.8.1 Parts List

Table 3-5 summarizes available Model 3933A replacement parts. Figure 3-9 shows the location of mechanical parts.

3.8.2 Ordering Parts

To order a part, or to obtain information on replacement parts, contact your Keithley representative or the factory. When ordering parts, include the following information:

- Instrument model number
- Instrument serial number
- Keithley part number
- Part description

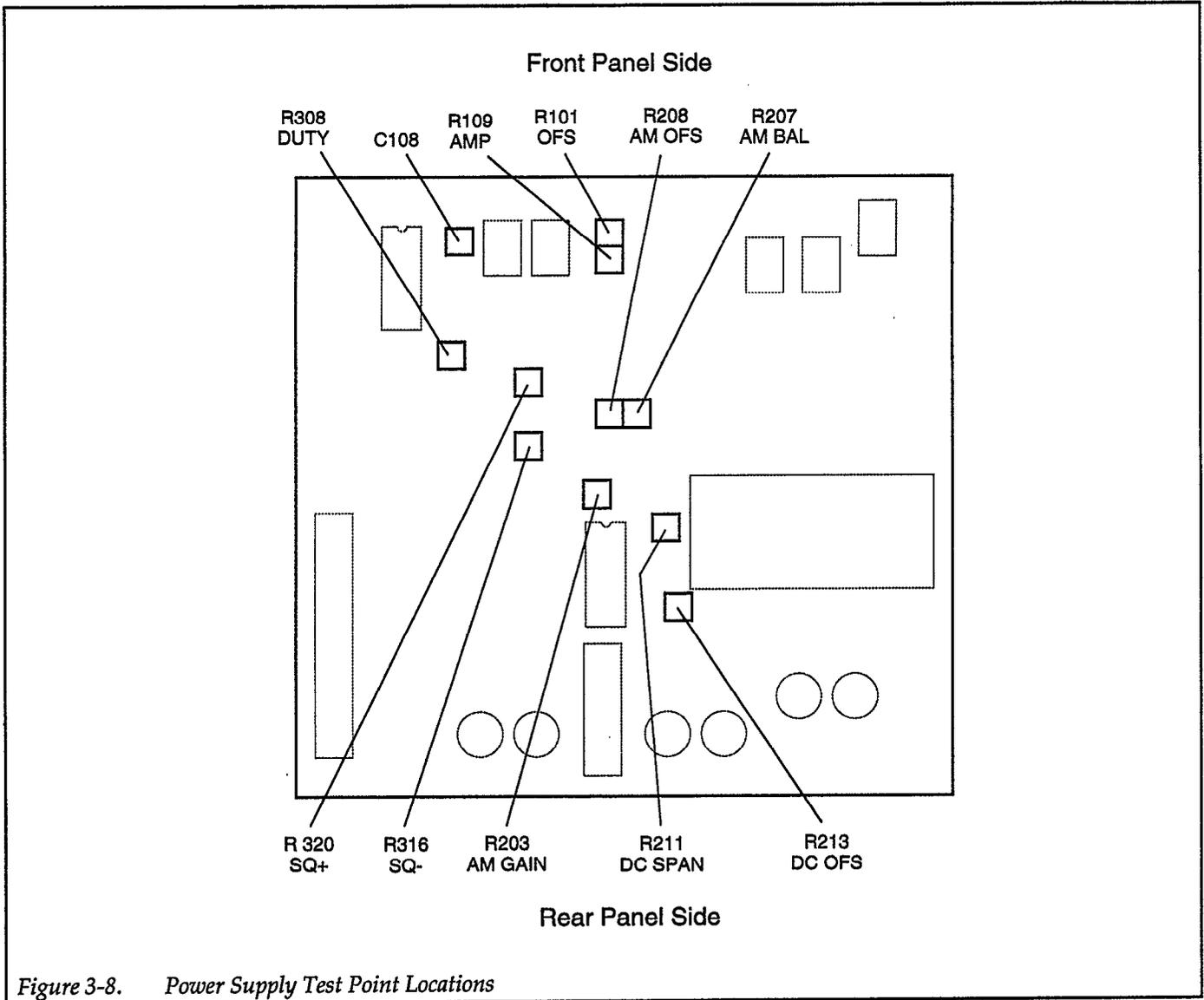


Figure 3-8. Power Supply Test Point Locations

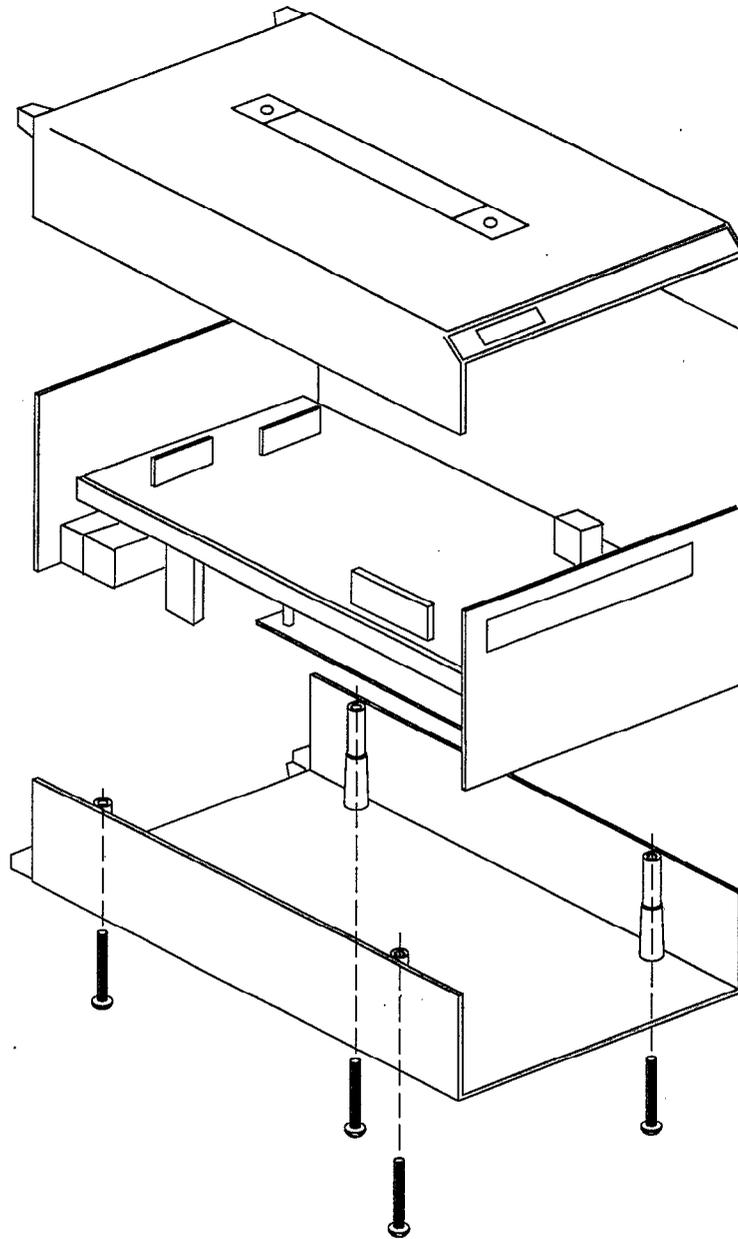


Figure 3-9. Model 3933A Exploded View

Table 3-5. Replaceable Parts

| Description | Part Number | Qty. |
|-------------------------------------|--------------|------|
| Control board (NP-10409) | 080-33641-00 | 1 |
| Analog board (NP-21022) | 080-33650-00 | 1 |
| Fan | 300-00718-00 | 1 |
| Air filter | 459-00205-00 | 1 |
| Flat head screw (for air filter) | 600-01241-00 | 4 |
| Fuse holder | 302-04054-00 | 1 |
| Noise filter (AC receptacle) | 240-03328-00 | 1 |
| BNC connector | 310-00347-00 | 3 |
| Power switch (internal) | 332-19141-00 | 1 |
| Power switch (on front panel) | 332-19133-00 | 1 |
| Flexible wire (for power switch) | 332-19150-00 | 1 |
| Voltage selecting switch | 332-50057-00 | 1 |
| Rotary encoder | 332-90041-00 | 1 |
| Ground terminal | 330-05389-00 | 1 |
| LCD | 304-10118-00 | 1 |
| EL back light (for LCD) | 100-70028-00 | 1 |
| Power transformer | 244-10890-00 | 1 |
| Rear panel | 400-11704-00 | 1 |
| Hex. stud | 606-00187-00 | 4 |
| Grommet | 546-00146-00 | 3 |
| SW spacer (for power switch) | 520-05356-00 | 1 |
| Collar (for LCD) | 606-02236-00 | 4 |
| BNC bush | 446-00046-00 | 4 |
| BNC spacer | 540-00157-00 | 4 |
| Spacer (for rotary encoder) | 520-05976-00 | 1 |
| Hex. spacer (for power switch) | 606-01892-00 | 2 |
| Knob (for rotary encoder) | 486-24060-00 | 1 |
| Button (for power switch) | 359-03554-00 | 1 |
| Hex. stud (for NP-10409) | 606-00101-00 | 2 |
| Standoff (for NP-10409) | 529-00185-00 | 4 |
| Battery | * | 1 |
| Fuse (100V/120V) | FU-96-2 | 1 |
| Fuse (220V/240V) | FU-96-1 | 1 |

*Part number not available at time of printing; contact repair department.

APPENDIX A

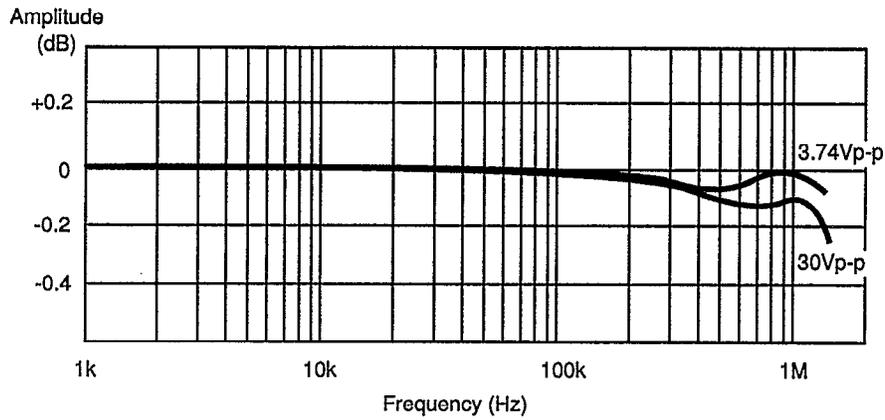
Typical Data

INTRODUCTION

Appendix A provides the typical performance data for the Model 3933A.

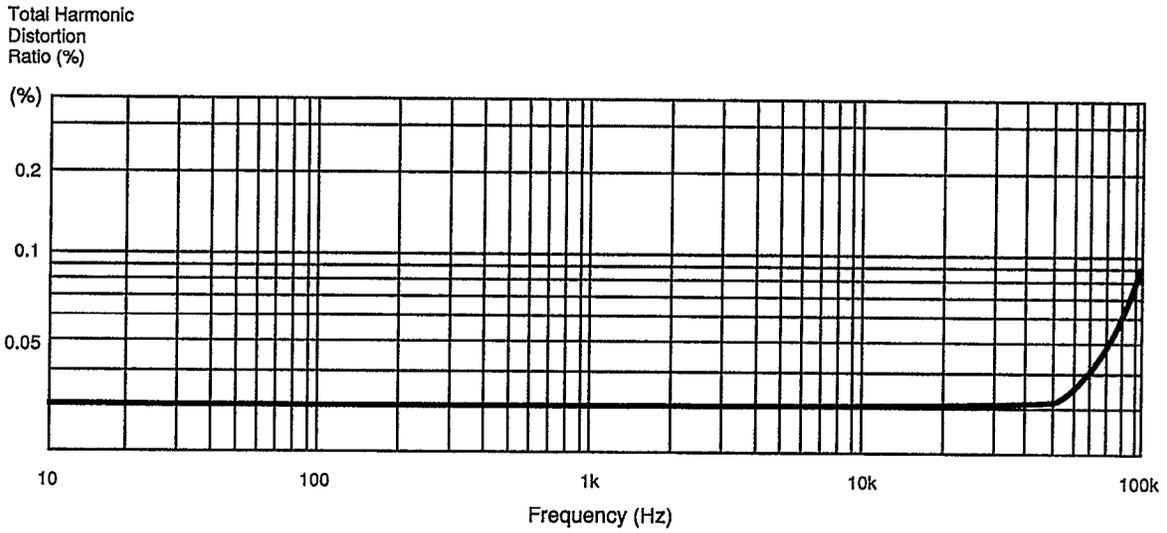
This instrument was thoroughly tested and inspected

and certified as meeting its published specifications when it was shipped from the factory. However, the typical data represents mean values of measurements for each Model 3933A. Thus, measured performance of your Model 3933A may be different than that indicated by the typical data curves shown here.



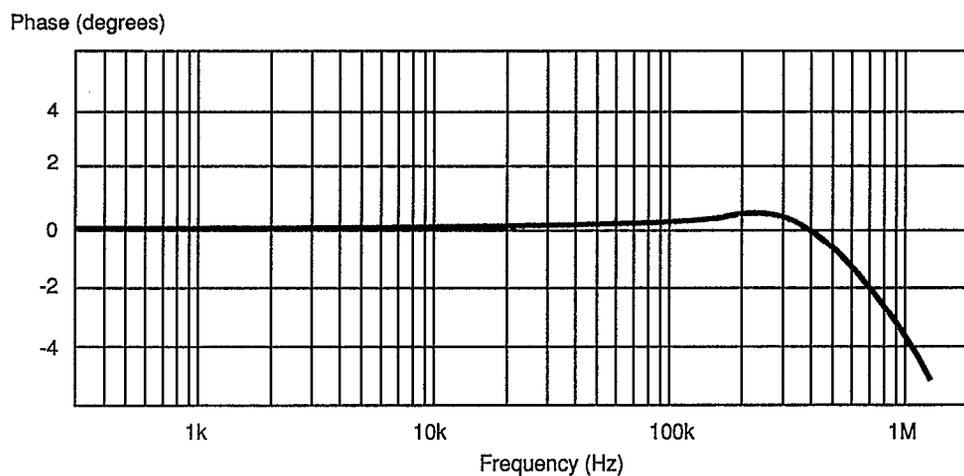
Note: Voltage is set voltage, load 50 ohms,
1 kHz base

Figure A-1. Sine Wave Amplitude - Frequency Characteristics



Note: Amplitude setting 30Vp-p, load 50 ohms

Figure A-2. Total Harmonic Distortion - Frequency Characteristics



Note: Phase re 1930A when it's two-phase

1930A's start/stop phase: 0 degrees

1933A's phase: 0 degrees

Both 1930A and 1933A have amplitude 30 Vp-p, waveform sine, load 50 ohms.

Figure A-3. Phase - Frequency Characteristics

APPENDIX B

Model 3933A Specifications

B.1 ELECTRICAL SPECIFICATIONS

| Waveforms | |
|-----------|---|
| Types | DC only, \sim , \square , \sphericalangle , \sphericalangle , \sphericalangle |

| Oscillation Modes |
|--------------------|
| Set by 3930A mode. |

| Frequency | | |
|------------------------------|--|------------------|
| Set by 3930A frequency. | | |
| Waveform and Frequency Range | \sim , \square (Duty cycle fixed at 50%) | 0.1mHz to 1.2MHz |
| | \sphericalangle , \sphericalangle , \sphericalangle , \square (Duty cycle varies from 5% to 95%) | 0.1mHz to 100kHz |

| Phase | | | | | | | | | | | | | | | | | | |
|---------------------------------------|---|------------------------------|--|------------------------------|-----------------------------|------------------------------|------------------------------|-----------------------------|------------------------------|-------------------|--|-----------------------------|-----------------------------------|--|------------------------------|----------------------------------|--|------------------------------|
| Setting Range | -360° to 360° (Value corresponding to 0° at 3930A's start/stop phase) | | | | | | | | | | | | | | | | | |
| Display | Maximum 4 digits \pm resolution 0.1° (fixed) | | | | | | | | | | | | | | | | | |
| Accuracy (when 3930A is in CONT mode) | <ul style="list-style-type: none"> ◦ Set both 3930A and 3933A to these settings: DC offset 0V, AM off, 50Ω load, same waveform, 18°-28°C. ◦ Waveform duty cycle is fixed or variable on both devices. (cycle is optional) ◦ Amplitude setting is from 30.0mVp-p to 30.0Vp-p (when output range is FXD, above 300Vp-p), and can be set independently. ◦ When connecting in sequence, phase number n is per this diagram: <div style="text-align: center; margin: 10px 0;"> </div> <p>However, $n \leq 6$ (to max of 6 phases)</p> <ul style="list-style-type: none"> ◦ Accuracy corresponds to: (3933A phase setting) - (3930A's start/stop phase setting) $D = + 0, -(n-2) \times 40ns$ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">\sim</td> <td></td> <td>$\pm(0.1^\circ + 120ns) + D$</td> </tr> <tr> <td rowspan="2">\square (while rising)</td> <td>When duty cycle is 50% (FXD)</td> <td>$\pm(0.5^\circ + 120ns) + D$</td> </tr> <tr> <td>When duty cycle is variable</td> <td>$\pm(0.1^\circ + 220ns) + D$</td> </tr> <tr> <td>$\sphericalangle$</td> <td></td> <td>$\pm(0.1^\circ + 90ns) + D$</td> </tr> <tr> <td>$\sphericalangle$ (while falling)</td> <td></td> <td>$\pm(0.1^\circ + 240ns) + D$</td> </tr> <tr> <td>$\sphericalangle$ (while rising)</td> <td></td> <td>$\pm(0.1^\circ + 240ns) + D$</td> </tr> </table> | \sim | | $\pm(0.1^\circ + 120ns) + D$ | \square (while rising) | When duty cycle is 50% (FXD) | $\pm(0.5^\circ + 120ns) + D$ | When duty cycle is variable | $\pm(0.1^\circ + 220ns) + D$ | \sphericalangle | | $\pm(0.1^\circ + 90ns) + D$ | \sphericalangle (while falling) | | $\pm(0.1^\circ + 240ns) + D$ | \sphericalangle (while rising) | | $\pm(0.1^\circ + 240ns) + D$ |
| \sim | | $\pm(0.1^\circ + 120ns) + D$ | | | | | | | | | | | | | | | | |
| \square (while rising) | When duty cycle is 50% (FXD) | $\pm(0.5^\circ + 120ns) + D$ | | | | | | | | | | | | | | | | |
| | When duty cycle is variable | $\pm(0.1^\circ + 220ns) + D$ | | | | | | | | | | | | | | | | |
| \sphericalangle | | $\pm(0.1^\circ + 90ns) + D$ | | | | | | | | | | | | | | | | |
| \sphericalangle (while falling) | | $\pm(0.1^\circ + 240ns) + D$ | | | | | | | | | | | | | | | | |
| \sphericalangle (while rising) | | $\pm(0.1^\circ + 240ns) + D$ | | | | | | | | | | | | | | | | |

Specifications subject to change without notice.

ELECTRICAL SPECIFICATIONS (CONT.)

| Output Characteristics (Waveform Output) | | | | | |
|--|--|---|-----------------------|--------------------|----------------|
| Maximum Output | AC only | 30Vp-p/open, 15Vp-p/50Ω | | | |
| | DC only | ±15V/open, ±7.5V/50Ω | | | |
| Display (Open Circuit Value) | When output range mode is automatic (AUTO) | | | | |
| | AC | Vp-p | Max. 3 digits | Minimum Resolution | 0.01mVp-p |
| | | Vrms | | | 0.01mVrms |
| | | dBV | | | 0.1dBV (fixed) |
| | DC | Max. 3 digits, min. resolution 0.01mV when output range mode is fixed (FXD) | | | |
| AC (Vp-p only) | Maximum 4 digits, minimum resolution 10mVp-p (fixed) | | | | |
| DC | Maximum 4 digits, minimum resolution 10mV (fixed) | | | | |
| AC Oscillation Setting Range (at DC offset 0V) | Per Table B-1: AC Amplitude Setting Range for 0V DC Offset | | | | |
| AC Amplitude Accuracy (when 3930A is in CONT mode) | Frequency up to 50kHz, DC offset 0V, AM off, open load, effective value measurement, 18°-28°C | | | | |
| | ~ | When output range is AUTO | 3.00Vp-p to 30.0Vp-p | ±0.5% | |
| | | | 300mVp-p to 2.99Vp-p | ±1.0% | |
| | | | 30.0mVp-p to 299mVp-p | ±1.5% | |
| | ~ | When output range is FXD | 3.00Vp-p to 30.00Vp-p | ±0.5% | |
| | | | 0.30Vp-p to 2.99Vp-p | ±1.0% | |
| | | | 3.00Vp-p to 30.0Vp-p | ±1.0% | |
| □ (duty ratio fixed/variable 50%) | When output range is AUTO | 300mVp-p to 2.99Vp-p | ±1.5% | | |
| | | 30.0mVp-p to 299mVp-p | ±2.0% | | |
| | | 3.00Vp-p to 30.00Vp-p | ±1.0% | | |
| ~ , / , \ (When frequency is 1kHz) | When output range is FXD | 3.00Vp-p to 30.00Vp-p | ±1.0% | | |
| | | 0.30Vp-p to 2.99Vp-p | ±1.5% | | |
| DC Voltage Setting Range and Accuracy (when DC only) | Per Table B-2: DC-only Voltage Setting Range, Resolution, and Accuracy | | | | |
| AC and DC Setting Range and DC Voltage Accuracy when AC + DC | Per Table B-3: AC + DC Minimum AC Amplitude, Resolution and Accuracy. The sum of AC amplitude's absolute peak and DC voltage's absolute value is less than 15V. | | | | |
| Amplitude and Frequency Characteristics (when 3930A is in CONT mode) | 1kHz reference frequency, DC offset 0V, AM off, 50Ω load, amplitude setting 30.0mVp-p to 30.0Vp-p (when output range is FXD, more than 3.00Vp-p), ~ is effective value measurement; otherwise measure p-p value. | | | | |
| | ~ | Up to 100kHz | ±0.1dB | | |
| | | 100kHz to 700kHz | ±0.3dB | | |
| | | 700kHz to 1MHz | +0.3dB, -0.5dB | | |
| | | 1MHz to 1.2MHz | +0.3dB, -1.0dB | | |
| | ~ | Up to 10kHz | ±3% | | |
| | □ (duty cycle fixed/50% variable) | Up to 100kHz | ±2% | | |
| △ , \ | Up to 10kHz | ±5% | | | |
| ~ Spectrum Purity (when 3930A is in CONT mode) | DC offset 0V, AM off, 50Ω load, amplitude setting from 30.0mVp-p to 30.0Vp-p (when output range is FXD, more than 3.00Vp-p) | | | | |
| | Total harmonic distortion | 10Hz to 100kHz | 0.1% max | | |
| | Harmonic (when amplitude setting is 30.0Vp-p) | 100kHz to 500kHz | -40dBc max | | |
| | | 500kHz to 1.2MHz | -30dBc max | | |
| | Spurious (when amplitude setting is 30.0Vp-p) | Up to 500kHz | -55dBc max | | |
| 500kHz to 1.2MHz | | -40dBc max | | | |

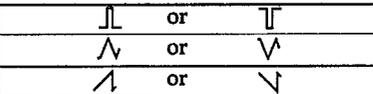
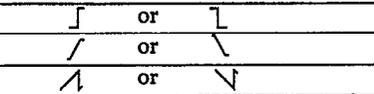
ELECTRICAL SPECIFICATIONS (CONT.)

| Output Characteristics (Waveform Output) (Cont.) | | | | |
|--|---|--------------------|--|---------------------------------|
| □ Waveform Characteristics | DC offset 0V, AM off, 50Ω load, amplitude setting from 30.0mVp-p to 30.0Vp-p (when output range is FXD, more than 3.00Vp-p) | | | |
| | Rise, fall time | | 150ns max | |
| | Over and undershoot | | <5% of output p-p amplitude | |
| | Duty cycle (when 3930A is in CONT mode) | 50% fixed accuracy | | Period ±0.3% (Up to 10kHz) |
| | | When varied | Setting range | 5.0% to 95.0% (resolution 0.1%) |
| | | Accuracy | Period ±0.2% (Up to 10kHz) Jitter below 150ns | |
| Status at Power On | Output is on. | | | |
| Output Impedance | 50Ω ±1%, unbalanced (open when output is off) | | | |
| Signal Ground | Insulated from chassis (insulation breakdown voltage: below 150Vpeak/100Hz) | | | |
| Connector | BNC, front panel | | | |

| Sync Output | |
|----------------|--|
| Output Voltage | TTL Level (51Ω in series with 74AC00 output) |
| Signal Ground | Common with waveform output |
| Connector | BNC, front panel |

| AM Input | |
|------------------------|---|
| Gain | At ±1V, 100% modulation. At 0V, output is half of displayed value. At -1V DC, carrier is suppressed. |
| Input Voltage Range | -3V to +1V |
| Modulation Range | ≥100% |
| Modulation Signal Band | DC to 100kHz |
| Carrier Signal | Up to 100kHz (√) |
| Input Impedance | 10kΩ |
| Signal Ground | Common with waveform output |
| Connector | BNC, front panel |

ELECTRICAL SPECIFICATIONS (CONT.)

| Phase Sweep | | | | |
|---------------------|-------------------|--|---|--|
| Types | | Sweep functions | CONT | |
| | | |  | |
| | | | SINGL | |
| | | |  | |
| Sweep Range | | -360° to 360° | | |
| Minimum Sweep Width | | 0.1° | | |
| Sweep Time | | Setting range | 5ms to 9999s | |
| | | Display | Maximum 4 digits, minimum resolution 1ms | |
| Range of Settings | | According to start and stop, or center and span, phase setting | | |
| Operation | | CONT START | Starts continuous sweep | |
| | | SINGL START | Starts single sweep | |
| | | START STATE | Sets output to the start frequency output state | |
| | | STOP STATE | Sets output to the stop frequency output state | |
| | | HOLD/RESM | Holds and resumes sweep | |
| Input | Singl Start Input | Input voltage | TTL Level (input to 74HC14 is pulled up by 4.7kΩ.) | |
| | | Signal characteristics | Single sweep starts at falling edge | |
| | | Minimum pulse width | 50ns | |
| | | Connector | BNC, rear panel | |
| | Hold Input | Input voltage | TTL Level | |
| | | Signal characteristics | Low Holds sweep High Resumes sweep | |
| | | Connector | BNC, rear panel | |
| Output | Sweep Sync Output | Output voltage | TTL Level (output to 74F404 is pulled up by 56Ω) | |
| | | Signal characteristics | Low While sweeping from start frequency toward stop phase High Other cases | |
| | | Connector | BNC, rear panel | |
| | | Marker Output | Output voltage | TTL Level (56Ω in series with 74HC14 output) |
| | X Drive Output | Signal characteristics | Low While output signal is above marker frequency during sweep High Other cases | |
| | | Connector | BNC, rear panel | |
| | | Output voltage | 0V to +10V (±5%)/open | |
| | | Signal characteristics | 0V to +10V (phase increasing) +10V to 0V (phase decreasing) | |
| | | Output Impedance | 600Ω, unbalanced | |
| | Load impedance | 10kΩ minimum | | |
| | Connector | BNC, rear panel | | |
| | Other Functions | Replace marker phase with center phase | | |

| Digital I/O for Multi-Phasing | | |
|-------------------------------|----------------|---|
| Digital In | Input Voltage | TTL level |
| | Connector | 36-pin, rear panel |
| | Connection | Connect 3930A's or 3933A's digital out with this device's DIGITAL IN via a special cable. |
| Digital Out | Output Voltage | TTL level |
| | Connector | 36-pin, rear panel |

ELECTRICAL SPECIFICATIONS (CONT.)

| Memory | |
|------------------------|--|
| Memory Contents | Main Phase*, amplitude*, DC offset*, waveform Sweep-Related Start*, stop*, center*, span*, marker*, sweep time*, sweep function Other Square wave duty cycle*, AN on/off, beep sound (on/off), output range mode AUTO/FXD Modify Note: Parameters listed with * show cursor position and step size. |
| Number of Memory Units | 10 units |
| Battery Backup | 30 days or more after full charge (stored at room temperature) |

| Setting Protection When Power is Off | |
|---|---|
| Function | Parameters in effect prior to power-off are stored and become effective at next power-on (except for waveform output on/off). |
| Contents Protected | Same items as in Memory Contents, plus lock (on/off), GPIB address, delimiter. |
| Battery Backup | Identical to Memory |

| Modify | | |
|---|--|--|
| Format | Per cursor movement and MODIFY knob. | |
| Up/Down Step Size | ±1 | Increases or decreases cursor position value by 1. |
| | ±5 | Increases or decreases cursor position value by 5. |
| | x+2 | Multiplies or divides entire value by 2. |
| | x+10 | Multiplies or divides entire value by 10. |
| Note: The above step sizes apply only to the parameters listed with * in Memory Contents. Others change step size by ±1 only, and cursor position is fixed. | | |
| Parameters that can't be modified | Memory number, GPIB address, and delimiter | |

| Display Function |
|---|
| Synchronously displays waveform output on/off, frequency, amplitude, DC offset, waveform, oscillation mode, AM on/off, and sweep state. |

| Lock |
|--|
| Disables most front panel key entries and operating condition changes. Current parameter values can be displayed. GPIB input and certain BNC inputs are enabled. |

ELECTRICAL SPECIFICATIONS (CONT.)

| Preset | |
|---|----------------------|
| Sets the parameters listed below. The modification step size is ± 1 . The underline indicates the cursor position. | |
| Main | |
| Phase | 0.0 deg |
| Amplitude | 3.00mVp-p (0.00Vp-p) |
| DC offset | 0.00mV (0.00V) |
| Waveform | \sim |
| Sweep-Related | |
| Start phase | -180.0 deg |
| Stop phase | 180.0 deg |
| Center phase | 0.0 deg |
| Span phase | 360.0 deg |
| Marker phase | 0.0 deg |
| Sweep time | 1.000s |
| Sweep function | \wedge |
| Others | |
| AM | off |
| \square Duty cycle | fixed 50.0% |
| Beep sound | on |
| Output range mode | AUTO |
| Display | |
| Main parameter display status | |

B.2 GPIB INTERFACE

| GPIB Interface | | |
|----------------|--|--|
| Functions | SH1 | Full source handshake capability |
| | AH1 | Full acceptor handshake capability |
| | T6 | Basic talker, serial poll, talker unaddressed if MLA |
| | L4 | Basic listener, unaddressed if MTA |
| | SR1 | Full service request capability |
| | RL1 | Full remote local operation capability |
| | PP0 | No parallel-polling function capability |
| | DC1 | Full device clear capability |
| | DT0 | No controller function capability |
| | C0 | No controller function capability |
| Data | ISO 7-bit code (ASCII code) | |
| Delimiter | Transmission | CR or CR/LF, EOI also sent simultaneously |
| | Reception | CR, CR/LF, CR + EOI, CR/LF + EOI or EOI |
| Address | 0 - 30 (selected by numeric keys on the panel) | |
| Output Driver | DIO1 - DIO8, NDAC, NRFD, SRQ | Open collector |
| | DAV, EOI | Tri-state |
| Local Key | Switch for return-to-local function | |
| Connector | IEEE-488 24-pin GPIB connector, rear panel | |

B.3 GENERAL

| | | |
|---|--|--|
| Signal Ground | The grounding pins of all input/output connectors are connected to chassis except for waveform output, synchronous output, and AM input. | |
| Power Source | Voltage | 100, 120, 220 or 240V AC $\pm 10\%$ (250V max.) |
| | Frequency | 48 to 62Hz |
| | Power Consumption | Approx. 38VA |
| Range of Ambient Temperature and Humidity | Operating | 0°-40°C, 10-90% RH (without condensation) |
| | Storage | -10°-50°C, 10-80% RH (without condensation) |
| External Size | Excluding Projections | 216 (W) \times 132.5 (H) \times 350 (D) mm, 8.5 (W) \times 5-1/4 (H) \times 13-3/4 (D) in. |
| Weight | Approx. 4.6kg (10 lbs.) | |

Table B-1. AC Amplitude Setting Range for 0V DC Offset

| Output Range Mode | AC (p-p) | \sim | | Hardware Resolution (p-p) | Output Attenuator (See note) |
|-------------------|------------------|------------------|----------------|---------------------------|------------------------------|
| | | rms | dBV | | |
| AUTO | 30.0V to 3.00V | 10.6V to 1.06V | 20.5 to 0.5 | 15mV | 1/1 |
| | 2.99V to 300mV | 1.05V to 106mV | 0.4 to 19.5 | 1.5mV | 1/10 |
| | 299mV to 30.0mV | 105mV to 10.6mV | -19.6 to -39.5 | 150 μ V | 1/100 |
| | 29.9mV to 0.30mV | 10.5mV to 0.11mV | -39.6 to -79.2 | 15 μ V | 1/1000 |
| FXD | 30.00V to 0.00V | (Vp-p only) | (Vp-p only) | 15mV | 1/1 |

| Output Range Mode | AC (p-p) | $\sim \nearrow \searrow$ | | Hardware Resolution (p-p) | Output Attenuator (See note) |
|-------------------|------------------|--------------------------|----------------|---------------------------|------------------------------|
| | | rms | dBV | | |
| AUTO | 30.0V to 3.00V | 8.66V to 866V | 18.8 to 1.2 | 15mV | 1/1 |
| | 2.99V to 300mV | 865V to 86.6mV | -1.3 to -21.2 | 1.5mV | 1/10 |
| | 299mV to 30.0mV | 86.5mV to 8.66mV | -21.3 to -41.2 | 150 μ V | 1/100 |
| | 29.9mV to 0.30mV | 8.65mV to 0.09mV | -41.3 to -80.9 | 15 μ V | 1/1000 |
| FXD | 30.00V to 0.00V | (Vp-p only) | (Vp-p only) | 15mV | 1/1 |

| Output Range Mode | AC (p-p) | \square | | Hardware Resolution (p-p) | Output Attenuator (See note) |
|-------------------|------------------|------------------|----------------|---------------------------|------------------------------|
| | | rms | dBV | | |
| AUTO | 30.0V to 3.00V | 15.0V to 1.50V | 23.5 to 3.5 | 15mV | 1/1 |
| | 2.99V to 300mV | 1.49V to 150mV | 3.4 to -16.5 | 1.5mV | 1/10 |
| | 299mV to 30.0mV | 149mV to 15.0mV | -16.6 to -36.5 | 150 μ V | 1/100 |
| | 29.9mV to 0.30mV | 14.9mV to 0.15mV | -36.6 to -76.5 | 15 μ V | 1/1000 |
| FXD | 30.00V to 0.00V | (Vp-p only) | (Vp-p only) | 15mV | 1/1 |

Note: When switching the output attenuator, the instantaneous waveform goes off.

**Table B-2. DC Only Voltage Setting Range, Resolution, and Accuracy
(open load, 18°-28°C)**

| Output Range Mode | DC (+ or -) | Hardware Resolution | Accuracy | Output Attenuator (See note) |
|-------------------|------------------|---------------------|-----------------|------------------------------|
| AUTO | 15.0V to 1.50V | 7.3mV | ±(0.1% + 8mV) | 1/1 |
| | 1.49 to 150mV | 730µV | ±(0.6% + 0.8mV) | 1/10 |
| | 149mV to 15.0mV | 73µV | ±(1% + 80µV) | 1/100 |
| | 14.9mV to 0.00mV | 7.3µV | (Not specified) | 1/1000 |
| FXD | 15.00V to 0.00V | 7.3mV | ±(0.1% + 8mV) | 1/1 |

Note: When switching the output attenuator, the instantaneous waveform output goes off.

Table B-3. AC + DC Minimum AC Amplitude, Resolution, and Accuracy (open load)

| Output Range Mode | Cumulative Voltage (See Note 2) | Minimum AC Amplitude | | | | | | | Hard. ACA Resl. | Hard. DCV Resl. | DC Voltage Accuracy | Output Atten. (See Note 1) |
|-------------------|-----------------------------------|----------------------|-------------|-------|--------|-------|--------|-------|-----------------|-----------------|--|----------------------------|
| | | p-p | ~ | | ∩ / ∪ | | ⊓ | | | | | |
| | | | rms | dBV | rms | dBV | rms | dBV | | | | |
| AUTO | More than 1.5V | 286mV | 101mV | -19.9 | 82.5mV | -21.6 | 143mV | -16.9 | 15mVp-p | 7.3mV | ±(0.2% of AC amplitude setting (p-p) +0.1% of DC voltage setting +8mV) | 1/1 |
| | More than 150mV | 28.6mV | 10.1mV | -39.9 | 8.25mV | -41.6 | 14.3mV | -36.9 | 1.5mVp-p | 730µV | ±(0.2% of AC amplitude setting (p-p) +0.6% of DC voltage setting +0.8mV) | 1/10 |
| | More than 15mV | 2.86mV | 1.01mV | -59.9 | 0.83mV | -61.6 | 1.43mV | -56.9 | 150µVp-p | 73µV | ±(0.2% of AC amplitude setting (p-p) +1% of DC voltage setting +80µV) | 1/100 |
| | Less than 15mV | 0.30mV | 0.11mV | -79.2 | 0.09mV | -80.9 | 0.15mV | -76.5 | 15µVp-p | 7.3µV | (Not specified) | 1/1000 |
| FXD | Not related to cumulative voltage | 0.00V | (Vp-p only) | | | | | | 15mVp-p | 7.3mV | ±(0.2% of AC amplitude setting (p-p) +0.1% of DC voltage setting +8mV) | 1/1 |

Notes:

1. When switching the output attenuator, the waveform output goes off for a moment.
2. Cumulative voltage = AC amplitude setting (p-p) divided by 2 plus DC voltage setting (V).
3. DC voltage accuracy is when frequency is about 1kHz, ~, AM off, open load, 18°-28°C.

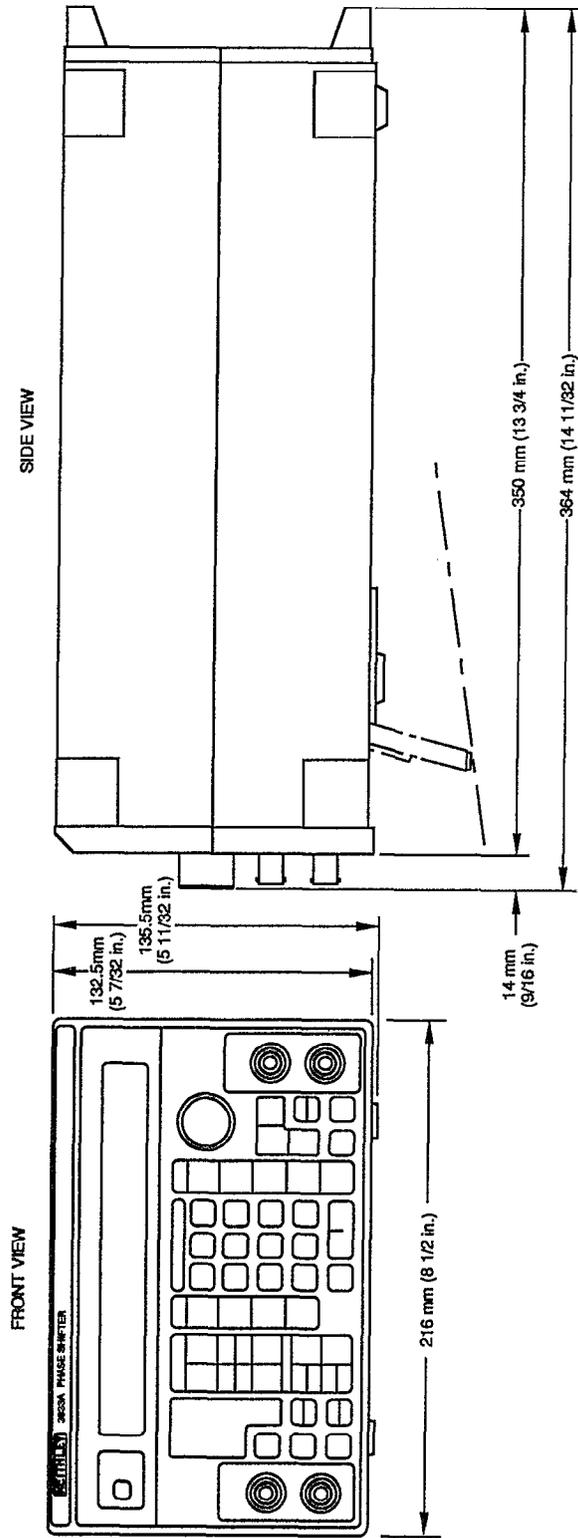


Figure B-1. Outer Dimensions of the Model 3933A

Index

A

AM Balance, 3-6
AM Gain, 3-7
AM Offset, 3-7
Amplitude Accuracy, 1-4
Amplitude Modulation, 2-3
Amplitude Oscillator Operation, 2-3
Analog Circuit Description, 2-3
Analog Section, 2-1
Analog Section Block Diagram, 2-3

B

Block Diagram, 2-1
Board-level Repair, 3-10

C

Calibration, 3-1
Calibration Adjustments, 3-3
Calibration Procedures, 3-5
Control Section, 2-1
Cover Removal, 3-3
Cover Replacement, 3-8

D

D/A Converter, 2-3

DC Level (Square) and DC (Offset) Error
(Sine), 1-10

DC Voltage Accuracy, 1-10
Display and Keyboard Section, 2-1
Display Contrast, 3-8

E

Environmental Conditions, 1-1, 3-2

F

Factory Service, 3-9
Fan Filter Cleaning, 3-9
FCTN Out Jumper, 3-9
Frequency and Duty Cycle Accuracy, 1-3
Frequency Response, 3-8
Frequency Response (Sine), 1-6
Frequency Response (Triangle, Sawtooth,
Square), 1-8
Function Synthesizer Connections, 3-5

I

Initial Conditions, 1-1, 3-2

L

Line Fuse Replacement, 3-1

Line Power, 1-1, 3-2

M

Multiphase Oscillator Operation, 2-3

O

Ordering Parts, 3-10

P

Parts List, 3-10
Performance Verification, 1-1
Phase Shift Section, 2-1
Power Supply Section, 2-3
Power Supply Test Points, 3-10
Principles of Operation, 2-1

R

Rechargeable Battery Replacement, 3-9
Recommended Calibration Equipment, 3-2
Recommended Test Equipment, 1-1
Repair, 3-9
Replaceable Parts, 3-10
Rise and Fall Times, 1-10

S

Service Information, 3-1
SIN Level, 3-6
Square Wave DC Level, 3-7
Square Wave Duty Cycle, 3-7

Square Wave Generator, 2-3
Synthesizer Connections, 1-2

T

Total Harmonic Distortion, 1-9

V

Verification Procedures, 1-2

KEITHLEY INSTRUMENTS

SERVICE FORM

Model No. _____ Serial No. _____ Date _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

- | | | |
|--|--|--|
| <input type="checkbox"/> Intermittent | <input type="checkbox"/> Analog output follows display | <input type="checkbox"/> Particular range or function bad; specify _____ |
| <input type="checkbox"/> IEEE failure | <input type="checkbox"/> Obvious problem on power-up | <input type="checkbox"/> Batteries and fuses are OK |
| <input type="checkbox"/> Front panel operational | <input type="checkbox"/> All ranges or functions are bad | <input type="checkbox"/> Checked all cables |

Display or output (circle one)

- | | |
|-----------------------------------|--|
| <input type="checkbox"/> Drifts | <input type="checkbox"/> Unable to zero |
| <input type="checkbox"/> Unstable | <input type="checkbox"/> Will not read applied input |
| <input type="checkbox"/> Overload | |

- | | |
|---|--|
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of Calibration required |
| <input type="checkbox"/> Data required | |

(attach any additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

What power line voltage is used? _____ Ambient Temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.) _____

Be sure to include your name and phone number on this service form.

KEITHLEY INSTRUMENTS

Instruments Division, Keithley Instruments, Inc. • 28775 Aurora Road • Cleveland, Ohio 44139 • (216) 248-0400 • Fax: 248-6168

WEST GERMANY: Keithley Instruments GmbH • Heighhofstr. 5 • Munchen 70 • 089-71002-0 • Telex: 52-12160 • Fax: 089-7100259
GREAT BRITAIN: Keithley Instruments, Ltd. • The Minster • 58, Portman Road • Reading, Berkshire RG 3 1EA • 011 44 734 575 666 • Fax: 011 44 734 596 469
FRANCE: Keithley Instruments SARL • 3 Allee des Garays • B.P. 60 • 91124 Palaiseau/Z.I. • 1-6-0115 155 • Telex: 600 933 • Fax: 1-6-0117726
NETHERLANDS: Keithley Instruments BV • Avelingen West 49 • 4202 MS Gorinchem • P.O. Box 559 • 4200 AN Gorinchem • 01830-35333 • Telex: 24 684 • Fax: 01830-30821
SWITZERLAND: Keithley Instruments SA • Kriesbachstr. 4 • 8600 Dubendorf • 01-821-9444 • Telex: 828 472 • Fax: 0222-315366
AUSTRIA: Keithley Instruments GesmbH • Rosenhugelstrasse 12 • A-1120 Vienna • (0222) 84 65 48 • Telex: 131677 • Fax: (0222) 8403597
ITALY: Keithley Instruments SRL • Viale S. Gimignano 4/A • 20146 Milano • 02-4120360 or 02-4156540 • Fax: 02-4121249