Quality is the indispensable component of every Simpson instrument . . . . . .

OBSOLETE

Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

WARNING

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

MODEL 460 SERIES 3
DIGITAL MULTIMETER

SIMPSON ELECTRIC COMPANY

853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

DIGITAL INSTRUMENT
Warranty

SIMPSON ELECTRIC COMPANY warrants each digital instrument manufactured by it to be free from defects in material and workmanship under normal use and service, its obligation under this warranty being limited to making good at its factory any digital instrument which shall within one (1) year after delivery of such instrument or other article of equipment to the original purchaser be returned intact to it, or to one of its authorized service stations, with transportation charges prepaid, and which its examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on its part, and SIMPSON ELECTRIC COMPANY neither assumes nor authorizes any other persons to assume for it any other liability in connection with the sale of its products.

This warranty shall not apply to any digital instrument which shall have been repaired or altered outside the SIMPSON ELECTRIC COMPANY factory or authorized service stations, nor which has been subject to misuse, negligence or accident, incorrect wiring by others, or installation or use not in accord with instructions furnished by the manufacturer.

Simpson
INSTRUMENTS THAT STAY ACCURATE

ELECTRIC COMPANY
853 Dundee Ave., Elgin, Illinois 60120 Phone: (312) 697-2260
IN CANADA: Bach-Simpson, Ltd., London, Ontario
IN ENGLAND: Bach-Simpson (U.K.) Limited, Wadebridge, Cornwall
IN INDIA: Rutonsha-Simpson Private, Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

OBSOLETE

OPERATOR'S MANUAL

SIMPSON 460 SERIES 3 DIGITAL MULTIMETER

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853 Dundee Ave., Elgin, Illinois 60120
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Printed in U.S.A.
6251277 (123.03)

Part No. 5-118911

Figure 1-1. Digital Multimeter, 460-3

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WARNING

This instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

SECTION I
INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson 460 Series 3 Digital Multimeter is a versatile 3½ digit instrument, suitable for use in general electronic maintenance, production, and laboratory. It features 0.1% DCV accuracy, integrated circuit electronics, solid-state LED display, and pushbutton switch selection for ranges and functions. Additional features are automatic polarity, analog indication, separate "low" and "high" power resistance ranges, and excellent temperature and over-ranging characteristics.

1.1.2 The 460-3 is available in two versions: the 460A is a standard instrument designed to operate from a 120 or 240 volts AC (50-400 Hz) power source (check rear panel designation). The 460D is an optional version designed for either AC line operation or battery operation using rechargeable nickel-cadmium cells. The battery can operate the Instrument for eight hours continuously. **Recharging is automatic when the Instrument is in the OFF position and with the line cord connected to an AC power source.** Hereafter, all information and data applies to both instruments (referred to as the 460, or the Instrument).

1.1.3 The 460 (Figure 1-1) measures DC and AC voltage, DC and AC current and resistance as specified in Table 1-1. The up-down integration technique is used for the analog-to-digital (A/D) conversion because of its inherently excellent stability, accuracy, and noise immunity. The use of a Simpson custom MOS-LSI integrated circuit achieves high reliability, low power dissipation, and a compact design.

1.1.4 The numerical display is a 7-segment light-emitting-diode (LED) display for easy viewing and solid-state reliability. The numerals are .043 inch high and in a single plane for distant and wide-angle viewing. Ambient lighting effects are

minimized by a filter which reduces reflections and background illumination.

1.1.5 The analog meter provides quick and convenient indications for nulling, peaking, scanning and varying signal applications. Both linear and decibel (dB) are shown on the analog display.

1.2 ACCESSORIES AND SUPPLIES

1.2.1 All supplies and accessories required for the operation of the 460 (using powerline) are furnished with the Instrument and listed in Table 2-1. Batteries for the 460D are not supplied. Available replacement parts are listed in Table 7-1.

1.3 TECHNICAL DATA

1.3.1 Table 1-1 lists the technical data for the 460.

Table 1-1. Technical Data

1. DC VOLTAGE:

Range	Maximum Indication	Input Resistance	Overload Protected To
200 mV	±199.9 mV	10 MΩ	±1100 V
2V	±1.999 V	10 MΩ	±1100 V
20 V	±19.99 V	10 MΩ	±1100 V
200 V	±199.9 V	10 MΩ	±1100 V
1000 V	±1000 V (Max. Input)	10 MΩ	±1100 V

Accuracy (from +15°C to +35°C):	±(0.1% of reading + 1 digit)
Input Bias Current:	50pA at reference conditions
Sensitivity:	100μV on 200 mV range
Full Range Step Response (to rated accuracy):	1 second

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Normal Mode Rejection:	55 dB minimum at 60 Hz
Common Mode Rejection:	90 dB minimum at 60 Hz with 1,000 Ω unbalance
Overrange Capability:	Linear to 1000 counts beyond maximum indication (except on 1000 V range, where any indication greater than 1000 is an overload).
Temperature Coefficient (from 0°C to +55°C):	±(0.01% of reading + 0.1 digit)/°C

2. AC VOLTAGE:

(Average-Sensing, RMS Calibrated Sine Wave; 40 Hz to 20 kHz)

Range	Maximum Indication	Input Impedance	Overload Protected To
200 mV	199.9 mV	10 MΩ and 75 pF	350 V RMS
2 V	1.999 V	10 MΩ and 75 pF	350 V RMS
20 V	19.99 V	10 MΩ and 75 pF	650 V RMS
200 V	199.9 V	10 MΩ and 75 pF	650 V RMS
600 V	600 V (Max. Input)	10 MΩ and 75 pF	650 V RMS

Accuracy (from +15°C to +35°C):	±(0.5% of reading + 2 digits), 40 Hz to 10 kHz, except 600 V range, which is 40 Hz to 400 Hz ±(1.0% of reading + 2 digits), 10 kHz to 20 kHz, except 600 V range, which is 400 Hz to 20 kHz
Sensitivity:	100μV on 200 mV range
Full Range Step Response (to rated accuracy):	5 seconds

Introduction

Overrange Capability:	Linear to 500 counts beyond maximum indication (except on 600 V range, where any indication greater than 600 is an overload).
Temperature Coefficient (from 0°C to +55°C):	±(0.05% of reading + 0.1 digit)/°C

3. RESISTANCE:

A. LO OHMS (Maximum Open-Circuit Voltage = 1V)

Range	Maximum Indication	Full Scale Voltage	Test Current	Overload Protected To
200 Ω	199.9 Ω	200 mV	1 mA	135 V RMS
2 kΩ	1.999 kΩ	200 mV	100 μA	135 V RMS
20 kΩ	19.99 kΩ	200 mV	10 μA	250 V RMS
200 kΩ	199.9 kΩ	200 mV	1 μA	250 V RMS
2000 kΩ	1999 kΩ	200 mV	100 nA	250 V RMS

B. HI OHMS

Range	Maximum Indication	Full Scale Voltage	Test Current	Overload Protected To
2 kΩ	1.999 kΩ	2 V	1 mA	135 V RMS
20 kΩ	19.99 kΩ	2 V	100 μA	250 V RMS
200 kΩ	199.9 kΩ	2 V	10 μA	250 V RMS
2000 kΩ	1999 kΩ	2 V	1 μA	250 V RMS
20 MΩ	19.99 MΩ	2 V	100 nA	250 V RMS

Accuracy (from +15°C to +35°C):	±(0.25% of reading + 1 digit) except on the 2000 kΩ and 20 MΩ ranges, which are ± (0.5% of reading +2 digits)
Sensitivity:	0.1Ω on 200Ω range
Full Range Step Response (to rated accuracy):	1 second, except on 20 MΩ range, which is 10 seconds

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Full Range Step Response (to rated accuracy): 1 second

Temperature Coefficient (from 0°C to +55°C): ±(0.02% of reading + 0.1 digit)/°C

Overrange Capability: Linear to 500 counts beyond maximum indication (except on 10A range, where any indication greater than 1000 is an overload).

4. DC CURRENT:

Range	Maximum Indication	Full Range Voltage Drop	Overload Protected To
200 μA	±199.9 μA	200 mV	±2.5 A†
2 mA	±1.999 mA	200 mV	±2.5 A†
20 mA	±19.99 mA	200 mV	±2.5 A†
200 mA	±199.9 mA	200 mV	±2.5 A†
2000 mA	±1999 mA	200 mV	±2.5 A†
10 A	±10.00 A	100 mV	±10 A (50 V Max.)

†Fuse Protected

Accuracy (from +15°C to +35°C): ±(0.25% of reading + 1 digit), except on 2000mA and 10A ranges, which are ±(1.0% of reading + 1 digit)

Sensitivity: 100 nA on 200 μA range

Full Range Step Response (to rated accuracy): 1 second

Temperature Coefficient (from 0°C to +55°C): ±(0.02% of reading + 0.1 digit)/°C

Overrange Capability: Linear to 500 counts beyond maximum indication (except on 10 A range, where any indication greater than 1000 is an overload).

Introduction

5. AC CURRENT (40 Hz to 10 kHz):

Range	Maximum Indication	Full Range Voltage Drop	Overload Protected To
200 μA	199.9 μA	200 mV	±2.5 A†
2 mA	1.999 mA	200 mV	±2.5 A†
20 mA	19.99 mA	200 mV	±2.5 A†
200 mA	199.9 mA	200 mV	±2.5 A†
2000 mA	1999 mA	200 mV	±2.5 A†
10A	10.00 A	100 mV	10A (50 V Max.)

†Fuse Protected

Accuracy (from +15°C to +35°C): ±(0.7% of reading + 2 digits), except on 2000 mA and 10A ranges, which are ±(1.5% of reading + 2 digits)

Sensitivity: 100nA on 200μA range

Full Range Step Response (to rated accuracy): 5 seconds

Temperature Coefficient (from 0°C to +55°C): ±(0.05% of reading + 0.1 digit)/°C

Overrange Capability: Linear to 500 counts beyond maximum Indication (except on 10A range, where any indication greater than 1000 is an overload)

6. *RATED CIRCUIT-TO-GROUND VOLTAGE: ⚠

(Maximum Common Mode Voltage): 1000 volts (DC plus peak AC) maximum from any measuring terminal to power line (earth) ground terminal, except on 10A ranges, which is 50 volts maximum.

*Per ANSI C-39.5-1974: The specified voltage with respect to ground which may be safely and continuously applied to the circuits of an Instrument.

7. RESOLUTION: 1 part in 2000

8. DISPLAY:

Numerical Display:	3-1/2 digit, 7-segment light-emitting-diode (LED) type, with 0.43 inch high numerals.
Conversion Rate:	4 readings per second, nominal.
DC Polarity Selection:	Automatic with "+" or "−" indication.
Overrange Indication:	Automatic beyond 1999, with the "1" digit blinking.
Analog Display:	1-1/2 inch edgewise meter with both linear and dB scale markings

9. POWER REQUIREMENT:

AC Operating (460A) or Battery Charging (460D):	120 VAC or 240 VAC ±10% (check rear panel designation), 50-400 Hz, 5 VA nominal. (8 VA for Model 460D).
Battery Operation (460D):	Four nickel-cadmium "D" size rechargeable cells, Eveready type CH4 or equivalent (each cell is rated at 1.25V, 4-ampere-hours).
Battery Operation Time (continuous with fully charged battery):	8 hours, nominal
Battery Recharge Time:	16 hours, nominal

10. TEMPERATURE RANGE:

Operating:	0°C to +55°C
Storage:	−40°C to +60°C

11. REFERENCE CONDITIONS:

Temperature:	+23°C ±1°C
Relative Humidity:	30 to 60%
Atmospheric Pressure:	575 to 800 mmHg

12. DIMENSIONS:

Height:	2.70 in. (68.6mm)
Width:	8.40 in. (213.4mm)
Depth:	9.00 in. (228.6mm)

13. WEIGHT: Approximately 3 lbs. (1.36 kg), (without batteries)

Table 1-2. Items Furnished with This Instrument

Quantity	Description	Part No.
1	Test Lead Set: One black and one red insulated lead having probe tips with provisions for screw-on alligator clips (one red and one black supplied).	10-830115
1	Power Cord	5-118916
1	Operator's Manual	5-118911

1.4 SAFETY CONSIDERATIONS

1.4.1 This operator's manual contains cautions and warnings alerting the user to hazardous operating and maintenance conditions. This information is flagged by a CAUTION or WARNING heading and/or the symbol . The symbol appears on the front panel and at certain paragraphs in this manual, and is an international symbol meaning: "refer to the operating or service sections of the Operator's Manual." To ensure the safety of the operating and maintenance personnel and to retain the operating condition of the instrument, these instructions must be adhered to.

SECTION II

INSTALLATION

2.1 GENERAL

2.1.1 This section contains information and instructions for the installation and shipping of the Simpson 460. Included are unpacking and inspection procedures, warranty, shipping, power source requirements, and installation.

2.2 UNPACKING AND INSPECTION

2.2.1 Unpack and inspect the Instrument for possible damage in shipment. Check the electrical performance as soon as possible. If damage is noted, notify the carrier and supplier before using the Instrument. Also check that all items are included (Table 1-2).

2.2.2 Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.3 POWER SOURCE REQUIREMENTS

2.3.1 The 460A is designed to be operated from the AC line only. The 460D is designed to be operated from either the AC line or self-contained nickel-cadmium cells (not furnished with the Instrument but available from any local electronic parts distributor. Refer to Table 1-1, item 9).

2.3.2 AC Line Operation

2.3.3 The 460 is wired at the factory for 120 VAC (50 to 400 Hz) operation. To convert your Instrument for 240 VAC operation, consult your nearest Simpson Authorized Service Center.

CAUTION

For AC line operation, ensure that the grounding pin of the power plug is securely connected to an earth (powerline) ground. Use a 3-wire grounded outlet which conforms to the latest National Electrical Code.

2.3.4 Battery Operation (460D)

2.3.5 Battery operation is automatic whenever cells are installed, the line cord is disconnected, and one of the FUNCTION switches set to a position other than the POWER OFF position.

2.3.6 For battery installation and battery test refer to paragraph 6.5.

2.4 WARRANTY

2.4.1 The Simpson Electric Company warranty policy is printed on the inside front cover of this manual. Read it carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Authorized Service Center for instructions (listed on the last pages of this manual). If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number, serial number (at the back of the Instrument) and date of purchase. Service data or shipping instructions will be sent to you promptly. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without your prior approval.

2.5 SHIPPING

2.5.1 Pack the Instrument carefully and ship it prepaid to the proper destination. Insure the Instrument.

2.6 INSTALLATION

2.6.1 The Instrument may be set horizontally on its four rubber feet or vertically on its back and operated in either position. The Instrument can also be set at an inclined angle by positioning the 8-position carrying handle under the unit. To set the Instrument at a desirable viewing angle, use the following procedure:

a. Pull out both knobs on sides of Instrument.

b. Rotate handle to one of eight positions.

c. Push both knobs into a locking position.

CONTROLS, CONNECTORS AND INDICATORS

3.1 GENERAL

3.1.1 All operating and adjusting controls, connectors and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

3.2 FRONT AND REAR PANEL DESCRIPTION

3.2.1 Table 3-1 lists all front and rear panel controls, connectors and indicators (Figure 3-1 and 3-2).

Table 3-1. Front and Rear Panel Description

1. POWER Switch:	
ON	Applies primary power to the Instrument.
OFF	Disconnects primary power from all circuits except the battery charging circuit.
2. FUNCTION Switches:	
Position	
AC mA	Connects the COMMON and mA jacks to the AC current measuring circuits.
AC V	Connects COMMON and V-Ω jacks to the AC voltage measuring circuits.
DC mA	Connects the COMMON and mA jacks to the DC current measuring circuits. Also used when measuring 10 amps.
DC V	Connects COMMON and V-Ω jacks to the DC voltage measuring circuits.

HI OHMS (kΩ)	Connects the COMMON and V-Ω jacks to the standard power resistance measuring circuits.
LO OHMS (kΩ)	Connects the COMMON and V-Ω jacks to the "low power" resistance measuring circuits.

3. RANGE Switches:

Position	
200 mV, μA Ω	Selects the circuits required for full range measurements of 0 to ±200mV DC, 0 to 200 mV AC, 0 to ±200 μA DC, 0 to 200 μA AC, 0 to 200 ohms, depending on the function switch selected.
2, 20, 10A, 200, 2000 1000 VDC 600 VAC	Selects the circuits required for full range measurements of 0 to the corresponding numerical values of AC mA, ±DC mA, kΩ, ±DC V or AC V depending on the function switch selected.
20 MΩ	Selects the circuits required for the full range measurement of resistance from 0 to 20 MΩ when the function switch HI OHMS (kΩ) is selected.

4. ⚠ Refer to Table 1-1, Item 6.

5. V-Ω Jack: This terminal is used to connect the "high" side of the circuit being measured to all voltage and resistance measuring circuits through the FUNCTION and RANGE switches.

6. COMMON Jack: This jack is used to connect the "low" side of the circuit measured to the internal circuit COMMON and is isolated from the AC power line ground.

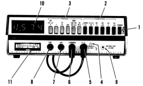

Figure 3-1. Front Panel Description

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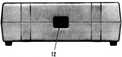

Figure 3-2. Rear Panel Description

7. mA Jack: This terminal is used to connect the "high" side of the currents being measured to the current measuring circuits through the FUNCTION and RANGE switches. The "low" side is connected to the COMMON jack.

8. 10A Jack: This terminal is used to connect the "high" side of the 10 ampere full scale current being measured to the current measuring circuits when RANGE switch 20 (10A) and FUNCTION switch DC mA or AC mA are selected. The "low" side is connected to the COMMON jack.

9. BATTERY TEST 4.7-6V: (Model 460D only) This jack connects to the positive terminal of the battery installed. For battery test, connect a test lead between the V-Ω jack and the BATTERY TEST jack, with the FUNCTION switch DCV and the RANGE switch 20 (10A) selected. The numerical display must indicate a voltage between +4.7 volts and +6.0 volts for proper operation. If the display indicates greater than +6.0 volts, either the battery is not installed or the battery is not installed properly.

10. Numerical Display: The digital display uses LED's and includes a polarity (+, −) sign, a "1" digit, three 7-segment type 0 to 9 digits and a decimal point, to indicate the polarity and the value of the signal being measured. The decimal point is properly positioned by the selection of the range switch. Over-range (or out-of-range) condition is indicated by a flashing "1" display for 2000 counts or greater.

11. Analog Display: The analog meter displays in analog form the relative value of the input signal being measured. The reading is determined in conjunction with the position setting of the range switch. Two scale markings are provided: a linear scale and a decibel scale marked −20 dB to +8 dB. The dB readings are referenced to 0 dB power level of 1 milliwatt into a 600 Ω load (an actual voltage of 0.775V). The actual decibel value is determined by:

(1) Reading the dB scale value, and
(2) adding the appropriate range factor as follows:

Range	Add
200mV	−20 dB
2 V	0 dB
20 V	+20 dB
200 V	+40 dB
600 V	+60 dB

12. AC Power Receptacle: This receptacle accepts the AC line power cord used for AC operation or battery charging.

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SECTION IV

OPERATION

4.1 GENERAL

WARNING

The Simpson 460 is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read completely prior to making any measurements. Failure to do so can result in a serious or fatal accident.

4.1.1 This section of the manual contains information required to use and operate the 460-3 in a safe and proper manner.

4.2 SAFETY PRECAUTIONS

4.2.1 The 460 is designed to be used only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page v.

4.2.2 Do not work alone when making measurements where a shock hazard can exist. Notify another person nearby that you are or intend to make such measurements.

REMEMBER: Voltages might appear unexpectedly in defective equipment. An open bleeder resistor can result in a capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured and remove all power from the 460 before making connections or disconnections.

4.2.3 Locate all voltage sources and accessibility paths prior to making any measurements or connections.

4.2.4 For your own safety, before each use, inspect the test leads, prods, connectors and power cable for cracks, breaks or crazes in the insulation. If any defects exist, destroy and replace the defective item(s) immediately.

4.2.5 Do not make measurements in a circuit where corona is present. Corona can be identified by a pale-blue color emanating from sharp metal points in the circuit or a buzzing sound, or the odor of ozone. In rare instances, such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates the presence of high voltage, and probably a malfunction of some kind.

4.2.6 Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the test leads or the Instrument.

4.2.7 For maximum safety, do not touch test leads, circuit, or Instrument while power is applied to the circuit being measured.

4.2.8 Use extreme caution when making measurements in an r-f circuit where dangerous composite voltages could be present, such as in an r-f amplifier.

4.2.9 Do not use test leads which differ from those originally furnished with the Instrument.

4.2.10 Before the Instrument is used for AC operation, make sure that the "third wire" on the AC power cord is connected to an earth or powerline ground.

4.2.11 Do not float any measuring terminal more than the rated circuit to ground voltage as specified in Table 1-1, item 6.

4.3 PRELIMINARY NOTES AND CHECKS

NOTE: Prior to operation of the Instrument, review and perform (where applicable) the following notes and checks. These steps can be used also as a general functional check.

4.3.1 For AC Line Operation

a. Ensure that the power source used matches the requirements of the Instrument as marked on rear panel.

b. Insert the plug into a 3-wire power outlet which conforms to the latest National Electrical Code. The 460D will operate with or without battery power. When the 460D is operating on the AC line with the internal battery installed, the battery is being "trickle" charged.

4.3.2 For 460D battery operation follow this procedure:

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CAUTION

Do not operate the Instrument with cells in the completely discharged state, which is common for all new cells as acquired from the vendor. See paragraph 6.6.

a. Disconnect the AC line cord and set the POWER switch to the OFF position. Install four "D" size nickel-cadmium cells (not supplied with Instrument). Observe polarity as shown on label inside battery holder. Re-assemble case and turn power ON.

b. Depress the DCV function and 20 (10A) range switches.

c. Connect a test lead between the V-Ω jack and the BATTERY TEST jack. The reading must be between +4.7 volts, or if the display does not emit light, either the battery is improperly installed or recharging is required.

d. If the battery voltage is below +4.7 volts, or if the display does not emit light, either the battery is improperly installed or recharging is required.

4.3.3 To recharge the battery, follow this procedure:

a. Set the POWER switch to the OFF position. Connect the line cord plug into a 3-wire power outlet which conforms to the power requirements of the Instrument as marked on the rear panel, and to the latest National Electrical Code.

b. The battery is being charged at full rate (≈ 400mA).

NOTE: If the battery test indicates a voltage below +4.7 volts, set the POWER switch in the OFF position for at least 15 minutes before operating.

4.4 GENERAL FUNCTIONAL CHECK

a. **Review the safety precautions in paragraph 4.2.**

b. Connect the black test lead to the COMMON jack and the red test lead to the V-Ω jack. Short the test leads together.

c. Depress and set the HI OHMS function and "2" range switches.

d. Open the test leads. The numerical display will be flashing in the out-of-range condition.

e. Short the test leads together. The display reading will return to .000 ±1 digit.

f. If difficulty is encountered in the above steps, see Section VI.

4.5 DC VOLTAGE MEASUREMENTS

a. **Review the safety precautions in paragraph 4.2.**

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Depress DCV function switch.

d. Depress the appropriate voltage range switch as indicated in Table 4-1. If the voltage being measured is unknown, begin with the 1000 range VDC switch.

e. Turn off the power to the device or circuit under test and discharge all capacitors.

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The Instrument will automatically indicate the correct polarity. The value of the voltage being measured will be indicated on the numerical display. The analog display will indicate the relative value and can be used for nulling or peaking applications.

h. **Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.**

f. Open the circuit in which the current is to be measured and securely connect the test leads in series. Ensure that the 460-3 is not connected across a voltage source which can exceed ratings of the Instrument.

Table 4-1. DC Voltage Ranges and Connections

Range	Range Switch	Function Switch	Input Connections	Max. Voltage	Remarks
0 to ±200mV	200 mV	DCV	V-Ω, COMMON	±1100V	Auto-Polarity on all ranges
0 to ±2 V	2	DCV	V-Ω, COMMON	±1100V	
0 to ±20V	20	DCV	V-Ω, COMMON	±1100V	
0 to ±200V	200	DCV	V-Ω, COMMON	±1100V	
o to ±1000V	1000 VDC	DCV	V-Ω, COMMON	±1100V	

Table 4-2. AC Voltage Ranges and Connections

Range	Range Switch	Function Switch	Input Connections	Max. Voltage	Remarks
0 to 200mV	200mV	ACV	V-Ω, COMMON	350V RMS	40 Hz-20 kHz on all ranges
0 to 2V	2	ACV	V-Ω, COMMON	350V RMS	
0 to 20V	20	ACV	V-Ω, COMMON	650V RMS	
0 to 200V	200	ACV	V-Ω, COMMON	650V RMS	
0 to 600V	600 VAC	ACV	V-Ω, COMMON	650V RMS	

4.6 AC VOLTAGE MEASUREMENT

a. **Review safety precautions in paragraph 4.2.**

b. Connect input test leads to the V-Ω and COMMON terminals.

c. Depress the ACV function switch.

d. Depress the appropriate voltage range switch as indicated in Table 4-2. If the voltage being measured is unknown, begin with the 600 range VAC switch.

CAUTION

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Do not attempt to measure voltages on the 600 VAC range which might be greater than 650 volts.

e. Remove all power from the circuit being measured and discharge all capacitors.

f. Connect test leads to the circuit being measured.

g. Apply power to the circuit being measured. The value of the voltage being measured will be indicated on the numerical display. The analog display can be used for nulling or peaking applications.

h. **Remove all power from the circuit being measured and discharge all capacitors prior to disconnecting test leads.**

4.7 RESISTANCE MEASUREMENTS

4.7.1 GENERAL

The 460 measures resistance from 0.1Ω to 20 MΩ in two overlapping modes — LO OHMS and HI OHMS. The LO OHMS mode is useful for measurements which require low power dissipation, low voltage drop (200mV F.S.) across the resistance, and low open-circuit voltage (less than 1 volt). These features are especially desireable for in-circuit resistance measurements which require non-conduction of semiconductor junctions. The low open-circuit voltage in the LO OHMS mode eliminates the possibility of damaging certain semiconductor junctions. The HI OHMS is useful for measurements which require a higher voltage across the resistance, such as testing conduction in transistors and diodes.

4.7.2 MEASUREMENT PROCEDURE

a. **Review the Preliminary Notes and Checks in paragraph 4.3.**
b. Connect input test leads to the V-Ω and COMMON terminals.
c. Depress either the HI OHMS or the LO OHMS function switch.
d. Depress the appropriate resistance range switch as indicated in Table 4-3.
e. If the resistance being measured is connected into a circuit, be certain that all power is removed from the circuit and all capacitors are discharged. Check for current paths other than through the resistance being measured. These paths can result in a measured value which is lower than the actual value of the resistance being measured.

Table 4-3. Resistance Ranges and Connections

A. LO OHMS (Maximum Open-Circuit Voltage = 1V)

Range	Range Switch	Function Switch	Input Connections	Test Current	Full Scale Voltage
0 to 200Ω	200Ω	LO OHMS	V-Ω, COMMON	1mA	200mV
0 to 2kΩ	2	LO OHMS	V-Ω, COMMON	100μA	200mV
0 to 20kΩ	20	LO OHMS	V-Ω, COMMON	10μA	200mV
0 to 200kΩ	200	LO OHMS	V-Ω, COMMON	1μA	200mV
0 to 2000kΩ	2000	LO OHMS	V-Ω, COMMON	100nA	200mV

B. HI OHMS

Range	Range Switch	Function Switch	Input Connections	Test Current	Full Scale Voltage
0 to 2kΩ	2	HI OHMS	V-Ω, COMMON	1mA	2V
0 to 20kΩ	20	HI OHMS	V-Ω-COMMON	100μA	2V
0 to 200kΩ	200	HI OHMS	V-Ω, COMMON	10μA	2V
0 to 2000kΩ	2000	HI OHMS	V-Ω, COMMON	1μA	2V
0 to 20MΩ	20MΩ	HI OHMS	V-Ω, COMMON	100nA	2V

f. Connect the test leads to the resistance being measured. Be careful not to contact adjacent points, even if insulated, particularly when making high resistance measurements. Some insulators can have relatively low insulation resistance, which can sufficiently shunt the resistance being measured to result in a measured value lower than the presumed value.

NOTE: If the resistance being measured is polarity or voltage sensitive (for example, semiconductors), careful considerations must be given when making connections and selecting the resistance range (refer to Table 4-3).

g. Allow time for the display to stabilize. This procedure is especially important when measuring a high value resistance shunted by a large value of capacitance.
h. Disconnect test leads.

4.8 DC CURRENT MEASUREMENTS

a. **Review Safety Precautions in paragraph 4.2.**
b. Depress the DC mA function switch.

c. Depress the appropriate current range switch as indicated in Table 4-4. If the current being measured is unknown (but less than 10A), begin with the 20 (10A) switch. Connect the red test lead to the 10A jack and the black test lead to the COMMON jack.

d. **Remove all power to the circuit being measured and discharge all capacitors.**

e. Connect the test leads according to Table 4-4.

Table 4-4. DC Current Ranges and Connections

Range	Range Switch	Function Switch	Input Connections	Max. Current Amperes	Remarks
0 to ±200μA	200μA	DCmA	mA, COMMON	±2.5	
0 to ±2mA	2	DCmA	mA, COMMON	±2.5	
0 to ±20mA	20mA	DCmA	mA, COMMON	±2.5	Auto-Polarity on all ranges
0 to ±200mA	200	DCmA	mA, COMMON	±2.5	
0 to ±2000mA	2000	DCmA	mA, COMMON	±2.5	
0 to ±10A	20 10A	DCmA	10A, COMMON	±10.	

f. Open the circuit in which the current is to be measured and securely connect the test leads in series. Ensure that the Model 460-3 is not connected across a voltage source which can exceed ratings of the Instrument.

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g. Apply power to the circuit being measured.

h. The value of the current being measured is indicated on the

numerical display. The analog display can be used for nulling or peaking applications.

i. **Remove all power from the circuit being measured and discharge all capacitors.**

j. Disconnect the test leads and reconnect the circuit which was originally opened.

4.9 AC CURRENT MEASUREMENTS

a. **Review Safety Precautions in Paragraph 4.2.**

b. Depress ACmA function switch.

c. Depress the appropriate current range switch as indicated in Table 4-5. If the current being measured is unknown (but less than 10A), begin with the 20 (10A) switch. Connect the red test lead to the 10A jack and the black test lead to the COMMON jack.

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Table 4-5. AC Current Ranges and Connections

Range	Range Switch	Function Switch	Input Connections	Max. Current Amperes	Range
0 to 200μA	200μA	ACmA	mA, COMMON	2.5	
0 to 2mA	2	ACmA	mA, COMMON	2.5	
0 to 20mA	20 10 A	ACmA	mA, COMMON	2.5	40 Hz to 10 kHz on all ranges
0 to 200mA	200	ACmA	mA, COMMON	2.5	
0 to 2000mA	2000	ACmA	mA, COMMON	2.5	
0 to 10A	20 10A	ACmA	10A,COMMON	10	

d. **Remove all power to the circuit being measured and discharge all capacitors.**
e. Connect the test leads according to Table 4-4.
f. Open the circuit in which the current is to be measured and securely connect the test leads in series. Insure that the 460-3 is not connected across a voltage source which can exceed ratings of the Instrument.
g. Apply power to the circuit being measured.
h. The value of the current being measured is indicated on the numerical display. The analog display can be used for nulling or peaking applications.
i. **Remove all power from the circuit being measured and discharge all capacitors.**
j. Disconnect the test leads and reconnect the circuit which was originally opened.

SECTION V
THEORY OF OPERATION

5.1 GENERAL

5.1.1 This section describes the theory of operation of the Simpson 460. All modes of operation are described first; then, description of the circuits follows.

5.2 OVERALL SYSTEM

5.2.1 The basic system block diagram for the 460 is shown in Figure 5-1.

5.2.3 Signal Conditioning Section

5.2.4 The parameter being measured is connected to the appropriate input terminals. The corresponding Signal Conditioning circuits convert this parameter into a proportional DC voltage. The conversion is accomplished by the Attenuator, Current Shunts, Resistance Converter, AC-to-DC Converter, and associated switching.

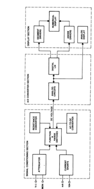

Figure 5-1. Basic System Block Diagram, 460-3

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5.2.5 Analog-To-Digital Converter Section

5.2.6 The Analog-To-Digital (A/D) Converter section changes the DC output voltage from the Signal Conditioning section to digital information. The A/D Converter also provides a proportional analog signal for the Analog Display.

5.2.7 Display Section

5.2.8 Through the Segment and Anode Drivers, the digital information from the A/D Converter is indicated on the 7-segment Numerical Display. The proportional analog signal is indicated by the Analog Display.

5.3 INPUT CIRCUITS

5.3.1 DC Voltage Measurements

a. The basic DC voltage measurement circuit is shown in Figure 5-2, (a). The DC voltage being measured is connected to the V-Ω and COMMON jacks, attenuated according to the range selected and converted into digital information by the A/D Converter.

b. The A/D Converter circuit provides two basic full range sensitivities: 200mV and 2V. This feature simplifies the attenuator design. No attenuation is required on the 200mV and 2V ranges. The same attenuator ratio is used on the 20V and 200V ranges. A separate attenuator tap is provided for the 1000 volt range.

5.3.2 AC Voltage Measurements

a. The basic AC voltage measurement circuit is shown in Figure 5-2, (b).

b. The AC voltage being measured is connected to the V-Ω and COMMON jacks, attenuated according to the range selected, and applied to an Input Amplifier. The output of the amplifier is converted into DC by an AC to DC Converter, and the resulting DC voltage is measured by the A/D Converter.

c. The attenuator is not used on the 200mV and 2V ranges. On the higher ranges, the attenuator is frequency-compensated to provide accurate readings over a wide frequency range.

d. The Input Amplifier achieves a high input impedance and presents a low output impedance to the converter.

e. The AC to DC Converter uses a half-wave operational amplifier/rectifier circuit which provides two basic full range sensitivities: 200mV and 2V. It is average-responding, but its calibration (gain) is based on the rms value of a sine wave.

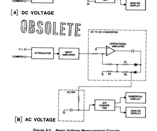

Figure 5-2. Basic Voltage Measurement Circuits

f. The output of the Operational Amplifier has two rectifying diodes and two feedback resistors, R1 and R2. These components drive a summing resistor R3. The junction of the summing resistor and feedback resistors is connected to the amplifier input to provide negative feedback. With a sine-wave input signal, the positive half cycles of the output waveform go through one diode, and the negative half cycles through the other diode. The positive half cycle is filtered and the resulting DC voltage is measured by the A/D Converter.

g. The indications of the numerical display are calibrated to the rms sine wave value being measured.

5.3.3 AC Current Measurements

5.3.4 The basic AC current measurement circuit is essentially the same as the DC current measurement circuit (refer to 5.3.5), except that the voltage developed across the internal shunt resistance is measured by the AC voltage measurement circuit.

5.3.5 DC Current Measurements

a. The basic DC current measurement circuit is shown in Figure 5-3, (a).

b. The current being measured is connected in series with the COMMON and the mA (or 10A) jacks and an internal precision shunt resistance. The value of the shunt resistance depends on the current range used and is selected so that the voltage developed across it is proportional and numerically equal to the current being measured. The A/D Converter measures this voltage, and the value indicated on the numerical display is equal to the current being measured.

c. The full range sensitivity of the digital voltmeter circuit measurement is 200mV. Therefore, the internal resistance for each current range equals 200mV divided by the full range current. For example, if the full range current is 200μA, then the internal resistance would be 1000 ohms.

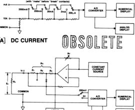

Figure 5-3. Basic DC Current and Resistance Measurement Circuits

5.3.6 Resistance Measurements

a. The basic resistance circuit is shown in Figure 5-3, (b).

b. The resistance being measured, Rx, is connected to the V-Ω and COMMON jacks and a constant current is applied through it by the Instrument. The resulting voltage is proportional to the value of Rx. The value of the current is determined by the resistance of the range selected.

c. The current through Rx is controlled by an Operational Amplifier whose inputs "follow" Ex and the output is always Ex + Er (where Er is a reference voltage). This reference voltage is developed by the current from a constant current source through a feedback resistor.

d. The Ex + Er output of the amplifier maintains a constant current through Rx, regardless of the value of Rx. The magnitude of the current is determined by the resistance (precision resistors selected by the ohms range switch) in series with Rx.

e. The A/D Converter measures the voltage developed across Rx, and the value indicated on the numerical display is equal to the resistance of Rx.

f. When the Instrument is set for LO OHMS measurements, the full scale voltage across Rx is set to 200 mV. The maximum open circuit voltage for this function is 1 volt. This condition is accomplished by the "ON" state of the Active Voltage Clamp.

g. When the Instrument is set for HI OHMS measurements, the full scale voltage across Rx is set to 2 volts. The maximum open circuit voltage for this function is 7 volts.

5.4 A/D CONVERTER

5.4.1 The basic block diagram of the A/D Converter is shown in Figure 5-4. The circuit utilizes the "Up-Down" integration technique for the analog-to-digital conversion. This technique is based on the conversion of a DC voltage into a proportional time period. The converter initially accumulates a charge proportional to the input signal on an integrating capacitor for a fixed period of time. In the second integration period, the capacitor discharges back to the "zero" voltage starting point, when the input signal is removed and a reference voltage opposite in polarity is placed at the input of the converter. The ratio of the time required to remove the integrator charge to the initial fixed time period is proportional to the amplitude of the input DC voltage.

5.4.2 The "Up-Down" A/D Converter requires two periods of integration for each measurement. The input signal (E_{in}) is integrated on the "up" slope during the first period; the reference voltage is integrated on the "down" slope of the second period. The

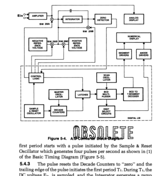

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Figure 5-4. A/D Converter Block Diagram

first period starts with a pulse initiated by the Sample & Reset Oscillator which generates four pulses per second as shown in (1) of the Basic Timing Diagram (Figure 5-5).

5.4.3 The pulse resets the Decade Counters to "zero" and the trailing edge of the pulse initiates the first period T_1. During T_1, the DC voltage E_{in} is sampled, and the Integrator generates a ramp whose slope is proportional to the value of the input signal. Also during T_1, the Master Oscillator (2) produces pulses which are counted by the Decade Counters until a total of 1,000 counts is accumulated. At this moment, period T_1 ends and T_2 begins.

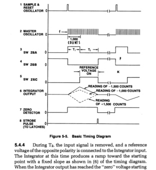

Figure 5-5. Basic Timing Diagram

5.4.4 During T_2, the input signal is removed, and a reference voltage of the opposite polarity is connected to the Integrator input. The Integrator at this time produces a ramp toward the starting point with a fixed slope as shown in (6) of the timing diagram. When the Integrator output has reached the "zero" voltage starting point, the Zero Detector changes state. At this point the reference voltage is removed and the Control Logic inhibits the Master Oscillator.

5.4.5 The count stored in the Decade Counters is in turn transferred to the Latches via a strobe pulse (8) generated by the Control Logic. The BCD information is then multiplexed, decoded into

7-Segment information, and numerically displayed through the Segment and Anode Drivers.

5.4.6 The other requirements of the A/D Converter such as overrange and polarity indications are accomplished by the Control Logic and Counter Circuits.

5.5 POWER SUPPLY CIRCUITS

5.5.1 AC Line Power

a. The AC line power supply is shown in Figure 7-1, Schematic Diagram. The incoming AC power is applied to the primary power transformer T_1. The primary winding is tapped for 240 VAC, 220 VAC and 120 VAC operation. The secondary windings generate step-down voltages to provide 3 regulated DC voltages.

b. Regulated DC voltages of +12V and −12V are produced by two full-wave rectifiers, followed by two series-type voltage regulators. These regulated voltages are used to supply power to the analog circuits.

c. A full-wave rectifier, followed by IC12, provides a regulated +5V supply to all digital integrated circuits and the LED display. An unregulated +15V supply is generated for operating the Resistance Converter.

5.5.2 Battery Power (460D only)

a. The battery-operated power supply of the 460D is shown on Figure 7-1, Schematic Diagram. With the POWER switch ON, the battery is connected to the input of the DC-To-DC converter consisting essentially of T201 and transistors Q201 and Q202 in a multivibrator configuration. The multivibrator signal is coupled by T201 to the bridge rectifier and regulators to generate DC voltages of +12V, −12V, and +15V. The required +5 volt supply is provided by the battery.

b. The battery is charging whenever the 460D is connected to the AC line. A secondary winding from Transformer T_1 and the associated rectifier provides power to operate a constant current source for charging the battery. The constant current source, consisting essentially of Z201 and Q28, provides a charging current of approximately 400 milliamperes when the Instrument is OFF. Approximately 50 milliamperes is supplied to charge the battery when the Instrument's POWER switch is set to ON.

c. When the 460D is operated with AC line power (no battery power) the battery-charging constant current source provides the +5V supply required for operation.

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WARNING

These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

SECTION VI

SERVICING INSTRUCTIONS

6.1 GENERAL

6.1.1 The Simpson 460 is carefully designed and constructed with high quality components. By providing reasonable care and following the instructions in this manual, the user can expect a long, useful service life from his Instrument.

6.2 COVER REMOVAL

The bottom cover can be removed for maintenance purposes by the following procedures:

WARNING

Remove all power and connections to the Instrument before removing the case cover. Do not operate the Instrument with the bottom cover removed.

a. Depress the POWER switch to the OFF position.
b. Disconnect the line cord from the power source and all connections from the Instrument.
c. Pull out the knobs on sides of Instrument and raise the handle towards the rear of Instrument.
d. Turn the Instrument over and remove the four screws in the rubber feet.
e. Lift bottom cover and remove handle.
f. Reverse this procedure when replacing the cover.

6.3 BATTERY INSTALLATION (460D only)

NOTE: Refer to Table 7-1 for recommended batteries.

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To avoid dangers associated with recharging batteries, use only the type specified in Table 7-1. Do not attempt to use cadmium zinc, alkaline or the like that is not designed to be recharged.

a. Remove bottom cover (refer to paragraph 6.2). Remove the retainer tubings from the battery holder. Insert two cells into each retainer. Then install the combination into the holder. Insure that the cells are installed according to the polarity orientation designated on the battery holder label. **Failure to do so can damage the 460D.**
b. Check that the battery contacts are clean and making good connection.
c. Replace the bottom cover.
d. For battery recharging, refer to paragraph 6.4, below.
e. Test the battery according to paragraph 4.3.2.

6.4 BATTERY CHARGING (Model 460D only)

a. The battery is being charged at full rate when the POWER switch is set to the OFF position and AC power is applied to the Instrument. Approximately 16 hours are required to fully charge the battery in this mode of operation.

NOTE: If the battery voltage checks below +4.7 volts, charge the battery with the POWER switch set to OFF for at least 15 minutes before operating the Instrument.

b. The battery is being "trickle" charged whenever the Instrument is operated by the AC power line.

6.5 BATTERY CARE

a. Avoid discharging the cells completely. Check the battery voltage periodically using the BATTERY TEST jack (refer to paragraph 4.3.2). Charge the battery whenever the voltage is close to or below +4.7 Volts.

b. Do not operate the Instrument with discharged cells. Make sure to recharge all newly purchased batteries (refer to 6.6, step a) for at least 15 minutes before operating the Instrument.

c. Whenever the line cord is not connected and the Instrument is not in use, remember to set the POWER switch to the OFF position.

d. With nickel-cadmium cells installed in the 460D, avoid storing in an area where the temperature exceeds +60°C.

6.6 FUSE REPLACEMENT

6.6.1 The line and current fuses are mounted inside fuse holders on the main P.C. Board as shown in Figure 6-1. Use the following procedure to replace a fuse.

WARNING

Remove all power and input connections to the Instrument before removing bottom cover. Do NOT replace a blown fuse with a fuse which has a larger rating or slower time lag characteristic than those specified.

a. Remove bottom cover as described in paragraph 6.2.

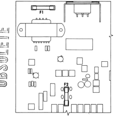

Figure 6-1. Fuse Location, 460-3

b. Carefully lift the defective fuse from the holder and replace with appropriate fuse (refer to Table 7-2).

c. Replace the bottom cover.

6.7 PREVENTIVE MAINTENANCE

6.7.1 Daily Care

WARNING

Do not attempt to clean this Instrument with the test leads connected to a power source or when it is connected to the AC power line.

a. Immediately clean all spilled materials from the Instrument and wipe dry. If necessary, moisten a cloth with soap and water to clean plastic surfaces.

b. Do not allow the battery to fully discharge. A completely discharged battery generally becomes inoperative and a replacement will be necessary. Check the battery voltage according to paragraph 4.3.2.

c. Whenever possible, avoid exposure or usage in areas which are subject to temperature and humidity exposures, vibration or mechanical shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

6.7.2 Monthly Care

Verify Instrument calibration by performing operational checks using known value sources. If the need for calibration is indicated, contact your nearest Authorized Simpson Service Center.

6.7.3 Annual Care

It is recommended that the Instrument be returned annually to a Simpson Authorized Service Center or the factory for a complete overall check and calibration.

6.7.4 Storage

When the Instrument is not in use, store it in a location free from temperature extremes, dust and corrosive fumes, and mechanical vibration or shock.

6.8 TROUBLESHOOTING

6.8.1 If the Instrument does not yield satisfactory results, follow this procedure, before attempting maintenance on the Instrument.

a. Review and comply with the Preliminary Notes and Checks, listed in paragraph 4.3.

b. Check that all switches are positioned correctly for the parameter and range of value being measured and that the measurement situation is within the ratings of the Instrument.

c. If the 460D has been operated with battery power, be sure that the cells are charged and properly installed (refer to paragraph 6.3).

d. If the 460A has been operated with AC power insure that power source is within the Instrument specifications, and free from excessive fluctuations and transients.

e. Insure that the environment in which the Instrument is being used is within the Instrument specifications.

f. Inspect the device being measured and the measurement test set-up to insure that proper shielding and grounding techniques have been used. Also consider whether the Instrument is significantly affecting the circuit being measured.

6.8.2 If the steps taken in paragraph 6.8.1 do not yield satisfaction refer to the troubleshooting chart (Table 6-1). Direct all other repair and adjustment needs to a Simpson Authorized Service Center.

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Table 6-1. Troubleshooting Chart

Symptom	Probable Causes	Cure
1. No indication on numerical display when 460D is battery operated. AC operation is OK.	Cells — Discharged, defective, not installed properly, making poor contact, or missing.	Check battery voltage. Refer to para. 4.3.2. If OK contact nearest Simpson Authorized Service Center.
2. LOW intensity on numerical display in battery operation, (464D).	Cells not fully charged.	Check battery voltage Refer to para. 4.3.2. If battery checks low, remove cover and check that the cells are installed correctly and making good contact. Refer to 6.5. If they are,

Symptom	Probable Causes	Cure
		replace cover and charge battery overnight. Refer to para. 6.4.
3. No indication on the numerical display when Instrument is AC line operated (no cells installed).	a. Low or no voltage at power source receptacle. b. Line cord disconnected. c. Defective line cord. d. Line fuse open.	a. Restore correct voltage at power receptacle. b. Connect line cord. c. Repair or replace cord. d. Replace line fuse. Refer to 6.6.
4. Batteries do not respond to charge. 460D operation OK when connected to AC power.	Cells defective, not installed properly, making poor contact, or missing.	Remove cover and check that cells are installed correctly and making good contact. Refer to 6.3. If they are, check the voltages of the individual cells. Replace those which check significantly lower than normal (1.25 volts).
5. Operation normal on all functions and ranges except AC and DC Current.	Current fuse F2 open.	Replace fuse to 6.6.
6. Indications fluctuate and/or drift, even though indication is OK at 000 with the input terminals shorted, and at 1000 counts when using a stable and low impedance input.	Fluctuations and/or drift are being generated by the device being measured or the measurement test set up.	Use proper shielding, grounding techniques and connections to minimize "pick-up" of unwanted signals due to ground loops, poor connections, and capacitive and/or inductive coupling. Op-

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Symptom	Probable Causes	Cure
		erate Instrument (460D only) on battery for complete isolation from the power line. NOTE: If the drift and/or fluctuation is coming from the device being measured, no cure is required, the measurement is valid, and the device must be corrected.
7. Indication is OK on battery. However, on AC operation, the reading fluctuates and/or drifts at 0, with the input shorted, and/or at 1000 counts using a stable and low impedance input. (460D)	AC power source is low or fluctuating (including transients).	Correct the power source or use Instrument on battery.
8. Same as 7 above, except indication OK on AC but not battery operation.	a. Battery voltage low. b. One or more cells defective, not installed correctly.	a. Check battery condition. Refer to para. 4.3.2. If not OK charge battery, refer to para. 6.6. b. Remove cover and check that cells are installed correctly and making good contact. If OK, replace all cells temporarily with conventional carbon

Symptom	Probable Causes	Cure
		zinc "D" size cells for checking purposes only. If problem still exists, contact nearest Simpson Authorized Service Center.
9. Slow response. Operation OK when using a low impedance input.	Parameter being measured has a high source impedance.	None required.
10. Accuracy not within specifications when checked with a stable, higher accuracy (at least 5 times better) low impedance (voltage measurements) source.	a. Instrument is out of calibration. b. Instrument not zeroed properly.	Contact nearest Simpson Authorized Service Center.
11. Accuracy of Instrument is within specifications but measurements appears in error.	a. Instrument affects circuit being measured. b. Common and/or normal mode specifications is being exceeded.	a. Study circuit being measured vs. Instrument specifications. Correct indications accordingly. b. Refer to cure in item 6 above.

SECTION VII

Replacement Parts, Schematic Diagram, and Authorized Service Centers

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Table 7-1. Replacement Parts List

Reference Symbol	Description	Part No.
	( ) = Parts used on 460A only	
	[ ] = Parts used on 460D only	
	All other parts are common to both Instruments	
	*Battery, "D" size, 1.25V, 4-Ampere-Hrs., Nickel-Cadmium, Eveready Type CH4 Rechargeable, or Equal	
	Bracket, Assembly, Power, Connector	10-863216
	Board, PC Assembly, DC Converter	10-863336
	Board, PC Assembly, Readout	10-863331
	Board, Printed Circuit, Main	10-863334
	Bracket, Readout	5-168403

*Available at local electronic parts distributors

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	Button, Black	5-118378
	Button, Grey	5-118086
	Button, Red	5-118379
	Cable, Ribbon, 18 Conductor	5-118428
	Case Assembly, Top	10-863217
	Case Assembly, Bottom	5-118373
	Clip, Fuse, PC Mounting	5-117739
	Handle, Molded	5-118375
	Handle, Insert	5-118398
[ ]	Holder, Battery	5-118399
	Panel, Assembly	10-863337
	Rubber Foot	1-117829
	Shield, Amplifier, AC	5-168903
	Spacer, Hex	5-328427
	Screw, Rubber Foot	5-144572
	Switch, Pushbutton, 13 Station	5-118909
C-1	Capacitor, 3.3 pF, ±5%, 1 kV C.D.	5-117138
C2	Capacitor, 390 pF, ±5%, 250V, Poly.	5-118405
C3	Capacitor, 270 pF, ±5%, 500V, Poly.	5-118896
C4, C5	Capacitor, Variable, 5.5 −60 pF, 100V	5-116235
C6	Capacitor, .033 μF, ±20%, 100V	5-117732
C7, C19	Capacitor, .022 μF, ±20%, 100V	5-116188
C8, C15	Capacitor, 100 pF, ±10%, 500V	5-113021
C9	Capacitor, .1 μF, ±20%, 100V	5-113612
C10, 11, 12, 14, 24, 26, 32, 34	Capacitor, .01 μF, ±20%, 50V	5-113215
C13, 20, 23, 27, 29, 31, 33, 35	Capacitor, 15 μF, 16V, Tantalum	5-115534
C16	Capacitor, .001 μF, 1 kV	5-111119
C17	Capacitor, .1 μF, −20 +80%, 30V	5-113883
C18	Capacitor, .1 μF, ±10%, 630V	5-116189
C21	Capacitor, 100 μF, 10V, Tantalum	5-117306
C22	Capacitor, 62 pF, ±5%, 300V, Mica.	5-116187
C25	Capacitor, 6 pF, ±.5 pF, 300V, Mica.	5-115539
C28	Capacitor, 330 pF, ±20%, 500V, C.D.	5-112690
C30	Capacitor, .47 μF, 16V, Tantalum	5-115530

OBSOLETE

(C36, 37)	Capacitor, 470 μF, 25V, Elctlt.	5-118408
C38	Capacitor, 2200 μF, 16V, Elctlt.	5-118084
D1-D8, D13-D17	Diode, Silicon, 75 PIV, 75 MA, 1N914	5-112004
D9, D10	Diode, Silicon, Low Leakage, DE113	5-118868
D11, D12	Diode, Silicon, 75 PIV, 75 MA, Sel. 1N914	5-117379
D18-D21	Diode, Silicon, 200 PIV, 2.5A, 1N5059	5-113826
[D22, 26, 27]	Diode, Silicon, .100 PIV, 1A, 10D1	5-114005
(D23, 24 25)	Diode, Silicon, 100 PIV, 1A, 10D1	5-114005
F1	Fuse, 120 VAC Operation, Slow Blow	1-113835
	Fuse, 240 VAC Operation, Slow Blow	1-116104
F2	Fuse, 2.5A, 125V, Normal Blow	5-118087
Q1, 2, 4, 6, 16, 21, 23	Transistor, Silicon, NPN GET2222	5-115934
Q3, 5, Q7-Q15, Q19, 20, 22, 24, 26, 27	Transistor, Silicon, PNP MPS3702	5-113864
Q17	Transistor, FET, N-Channel, 2N5458	5-112747
Q18	Transistor, Silicon, PNP, 2N4248	5-115484
Q25	Transistor, Silicon, NPN, GET5306	5-115938
[Q28]	Transistor, Silicon, NPN D40C1	5-118404
R1, R2, R3	Resistor Set, Matched, ±0.05%, 10.0kΩ, ±.25%, 1W; 90.9 kΩ, ±.25%, 1W; 9.90 MegΩ, ±.25%, 2W	5-118897
R4	Resistor, 470kΩ, ±10%, 2W	5-118421
R5, 6, 8, 13	Resistor, 100 kΩ, ±1%, ¼W	5-115506
R7	Pot, 100kΩ, ±20%, ½W, Cermet	5-118899
R9, R15	Resistor, 200kΩ, ±1%, 1/8W	5-117685
R10	Pot, 50Ω, ±20%, ½W, Cermet	5-118898
R11	Resistor, 980Ω, ±20%, ¼W	5-114792
R12	Pot, 50kΩ, ±20%. ½W, Cermet	5-118764
R14	Resistor, 100Ω, ±1%, ¼W	5-116164

Replacement Parts

R16, 17, 19, 20, 50, 52, 57, 80, 81, 85, 99	Resistor, 10kΩ, ±10%, 1/4W	5-113624
R18, R76	Resistor, 27Ω, ±5%, 1/4W	5-116089
R21	Resistor, 9.0k, ±1%, 1/4W	5-116162
R22, 71, 74, 87	Resistor, 10.0k, ±1%, 1/4W	5-114962
R23	Resistor, 33kΩ, ±10%, 1/4W	5-113875
R24	Resistor, 47.5k, ±1%, 1/4W	5-118761
R25	Resistor, 28.7k, ±1%, 1/4W	5-115443
R26, R30	Pot, 1kΩ, ±10%, 1/2W, Cermet 25 Turn	5-118923
R27	Resistor, 4.99k, ±1%, 1/4W	5-115502
R28, R65	Resistor, 6.8kΩ, ±10%, 1/4W	5-114976
R29, R86	Resistor, 6.98k, ±1%, 1/4W	5-117485
R31, 32, 67	Pot, 1kΩ, ±20%, 1/2W, Cermet	5-118079
R33	Resistor, 4.7kΩ, ±10%, 1/4W	5-113873
R34	Resistor, 4.0k, ±1%, 1/4W	5-117695
R35	Resistor, 24kΩ, ±5%, 1/4W	5-118752
R36	Resistor, 270k, ±5%, 1/4W	5-118755
R37	Resistor, 15MΩ, ±10%, 1/4W	5-118423
R40	Resistor, .885Ω, ±.1%, 1.5W	5-119088
R41	Resistor, 9.0Ω, ±.1%, .75W	5-115576
R42	Resistor, 90.0Ω, ±.1%, .75W	5-115577
R43	Resistor, 900Ω, ±.1%, .75W	5-115578
R44	Resistor, 51kΩ, ±5%5%, 1W	1-114626
R45, R91	Resistor, 22kΩ, ±10%, 1/4W	5-117196
R46, 62, 66, 94, 95, 96	Resistor, 1kΩ, ±10%, 4/4W	5-113871
R47, 48, 100, R5	Resistor, 100kΩ, ±10%, 1/4W	5-115514
R49	Resistor, 1.5kΩ, ±10%, 1/4W	5-113872
R51, 75, 81, 82	Resistor, 470k, ±10%, 1/4W	5-114983
R53	Pot, 5kΩ, ±20%, 1/2W, Cermet	5-118080
R54	Resistor, 37.5k, ±1/2%, 1/4W	5-118416
R55, R78	Resistor, 25.5k, ±.25%, 1/8W	5-119043

OBSOLETE

R56, R79	Resistor, 10kΩ, ±.25%, 1/4W	5-118413
R58, 59, 61, 93, 97, 98	Resistor, 68Ω, ±5%, 1/4W	5-118419
R60	Resistor, 47Ω, ±10%, 1/4W, C.C.	5-114967
R63, R64	Resistor, 10MΩ, ±5%, 1/4W	5-116632
R68	Resistor, 17.6kΩ, ±1%, 1/4W	5-115496
R69, R70	Resistor, 2.0kΩ, ±1%, 1/4W	5-115491
R71, 74	Resistor, 10kΩ, ¼W	5-114962
R72	Pot 100Ω, ±20%, ½W, Cermet	5-119044
R73	Resistor, 536Ω, ±1%, ¼W	5-118924
R77	Resistor, 100kΩ, ±10%, ½W	1-113949
R84, R92	Resistor, 8.2kΩ, ±10%, ¼W	5-114977
R88	Resistor, 1.62kΩ, ±1%, ¼W	5-118942
R89	Resistor, 19.3kΩ, ±1%, ¼W	5-117683
R90	Resistor, 34kΩ, ±1%, ¼W	5-117501
RN1	Resistor, Network, 10kΩ	5-116582
RN2	Resistor, Network, 68Ω	5-118425
T1	Transformer, Power	5-119145
Z1	I.C., Op. Amp., LF355A	5-118894
Z2, Z10	I.C., Op. Amp., LM308A	5-116598
Z3	I.C., Op. Amp., LM301AN	5-118745
Z4	I.C., Op. Amp., 741	5-115928
Z5, 9, 11	I.C., Dual Op. Amp., LM1458	5-117432
Z6	I.C., Quad Bilateral Switch	5-118895
Z7	I.C., A/D Digital LSI	5-118744
Z8	I.C., Op. Amp., 709	5-113642
(Z12)	I.C., +5V, Voltage Regulator	5-117149
ZD1, ZD2	Diode, Zener, 5.1V, ±5%, 400 MW, 1N751A	5-113197
ZD3	Diode, Zener, 6.4V, ±5%, 400 MW, 1N4576	5-119555

OBSOLETE

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- **BCD output is standard**
- **Input/output edge connector included**
- **Highly reliable LSI circuitry**
- **Choice of 120/240 VAC, 50-400 Hz or 5 VDC operation**

Model 2850 120/240 VAC input; 0.55" planar gas discharge display complete with panel mounting clips, edge connector and manual.

Model 2851 5 VDC input, 0.55" planar gas discharge display complete with panel mounting clips, edge connector and manual.

Model 2852 120/240 VAC input, 0.43" LED display complete with panel mounting clips, edge connector and manual.

Model 2853 5 VDC input, 0.43" LED display complete with panel mounting clips, edge connector and manual.

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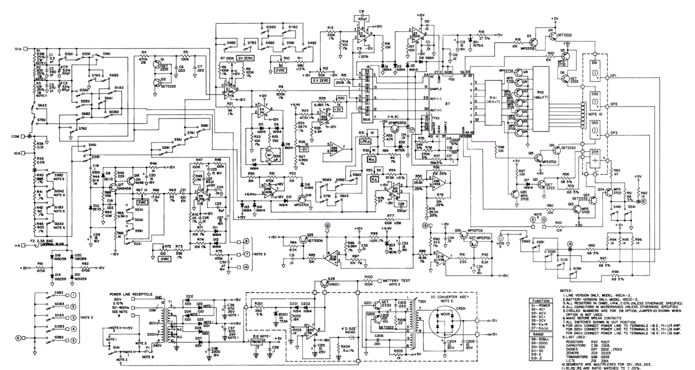

FUNCTION
S1 – POWER
S2 – ACI
S3 – ACV
S4 – DCI
S5 – DCV
S6 – KΩ HI
S7 – KΩ Lo

RANGE
S8 – 20MΩ
S9 – 2000
S10 – 200
S11 – 20
S12 – 2
S13 – .2

NOTES:

1. LINE VERSION ONLY, MODEL 460A-3.
2. BATTERY VERSION ONLY, MODEL 460D-3.
3. ALL RESISTORS IN OHMS, 1/4W, ± 10% UNLESS OTHERWISE SPECIFIED.
4. ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
5. CIRCLED NUMBERS ARE FOR DB OPTION, JUMPER AS SHOWN WHEN OPTION IS NOT USED.
6. MAKE BEFORE BREAK CONTACTS.
7. ALL SWITCHES SHOWN IN OUT POSITION.
8. FOR 120V CONNECT POWER LINE TO TERMINALS 1 & 2, F1 = 1/4 AMP.
   FOR 220V CONNECT POWER LINE TO TERMINALS 1 & 3, F1 = 1/8 AMP.
   FOR 240V CONNECT POWER LINE TO TERMINALS 1 & 4, F1 = 1/8 AMP.
9. LAST USED:

RESISTORS	R101	R207
CAPACITORS	C39	C205
DIODES	D27	D202, CR201
ZENERS	ZD3	ZD201
TRANSISTORS	Q28	Q202
I.C.'S	Z12	Z201

10. SEGMENTS ARE MULTIPLEXED FOR DS1, DS2, DS3.
11. R1, R2, R3 ARE RATIO MATCHED TO ± .05%.

Figure 7-1. Schematic Diagram, 460-3