FLUKE ®

57LFC/AN

System Calibrator

Operators Manual

March 2004

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P.O. Box 9090
Everett, WA 98206-9090
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5602 BD Eindhoven
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11/99

To register your product online, visit register.fluke.com

Claims

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty (30) days of arrival, give Fluke notice of shortages or any nonconformity with the terms of the order. If purchaser fails to five notice, the delivery shall be deemed to conform with the terms of the order.

The purchaser assumes all risk of loss or damage to instruments upon delivery by Fluke to the carrier. If an instrument is damaged in transit, PURCHASER MUST FILE ALL CLAIMS FOR DAMAGE WITH THE CARRIER to obtain compensation. Upon request by purchaser, Fluke will submit an estimate of the cost to repair shipment damage.

Fluke will be happy to answer all questions to enhance the use of this instrument. Please address your requests or correspondence to: Fluke Corporation, P.O. Box 9090, Everett, WA 98206-9090.

Interference Information

This equipment generates and uses radio frequency energy and if not installed and used in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of more of the following measures:

- Reorient the receiving antenna
- Relocate the equipment with respect to the receiver
- Move the equipment away from the receiver
- Plug the equipment into a different outlet so that the computer and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: How to Identify and Resolve Radio-TV Interference Problems. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 004-000-00345-4.

OPERATOR SAFETY SUMMARY

⚠⚠WARNING

HIGH VOLTAGE

is used in the operation of this equipment

LETHAL VOLTAGE

may be present on the terminals, observe all safety precautions!

To avoid electrical shock hazard, the operator should not electrically contact the output hi or sense hi binding posts. During operation, lethal voltages of up to 2200 V ac or dc may be present on these terminals.

Whenever the nature of the operation permits, keep one hand away from equipment to reduce the hazard of current flowing thought vital organs of the body.

Terms in this Manual

This instrument has been designed and tested in accordance with the safety standards listed in the General Specifications, which are located in Chapter 1 of this manual. This manual contains information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in safe condition.

⚠⚠WARNING statements identify conditions or practices that could result in personal injury or loss of life.

⚠⚠CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

Symbols Marked on Equipment

⚠	Caution, risk of electric shock.
⏚	Protective ground (earth) terminal.
⏚	Functional earth terminal.
⚠	Caution, risk of danger. Refer to the manual to maintain the safety provided by the equipment.

⚠⚠Warning

- **Do not operate this calibrator in a position where it is difficult to operate the power switch.**
- **Do not operate this calibrator in a manner not specified in the manual or the protection provided by the equipment may be impaired.**
- **Do not operate the calibrator if it shows signs of damage or malfunction, the protection provided by the equipment may be impaired.**
- **Do not use hook-up wire on the calibrator with an insulation or current rating of less than the calibrator output.**

Power Source

The 57LFC is intended to operate from a power source that will not apply more than 246 V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified on the line voltage selection switch label, and which is identical in type voltage rating, and current rating.

Grounding the 57LFC

The 57LFC is Safety Class I (grounded enclosure) instruments as defined in IEC 61010 2nd Edition. The enclosure is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired earth grounded receptacle before connecting anything to any of the 57LFC terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Use the Proper Power Cord

- Use only the power cord and connector appropriate for proper operation of a 57LFC.
- Use only a power cord that is in good condition.
- Refer cord and connector changes to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate the 57LFC in an atmosphere of explosive gas.

Do Not Remove Cover

To avoid personal injury, do not remove the cover from the 57LFC. Do not operate the 57LFC without the cover properly installed. There are no user-serviceable parts inside the 57LFC, so there is no need for the operator to ever remove the cover.

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Chapter 1
Introduction and Specifications

Introduction

The Fluke Model 57LFC System Calibrator (hereafter called the Calibrator) is a precise instrument that calibrates a wide variety of electrical measuring instruments. This calibrator maintains a high accuracy over a wide ambient temperature range, and is able to test instruments in harsh environments, eliminating the restriction of calibrating only in a temperature-controlled standards laboratory. With a 57LFC, you can calibrate precision multimeters that measure ac or dc voltage, ac or dc current, and resistance. The Calibrator operates in a similar manner to the 57XXA series calibrators.

Specifications are provided at the end of this chapter. The Calibrator is a fully-programmable precision source of the following:

- DC voltage to 220 V.
- AC voltage to 220 V rms, with output available from 10 Hz to 100 kHz.
- AC and DC current to 2.2 A, with AC output available from 10 Hz to 20 kHz.
- Resistance in values from 0 Ω to 19 MΩ in 1 and 1.9x.

Features of the calibrator include the following:

- Automatic meter error calculation obtained through using a simple remote adjust.
- Programmable entry limits used for restricting the levels that can be remotely keyed into the calibrator, preventing access to levels that may be harmful to equipment or personnel.
- Real-time clock and calendar.
- Offset and scaling modes that simplify linearity testing of multimeters.
- Standard IEEE-488 (GPIB) interface, complying with ANSI/IEEE Standards 488.1-1987 and 488.2-1987.
- Internal self-testing and diagnostics of analog and digital functions.
- Status LEDs on front panel to indicate standby (yellow), operate (green), high voltage (red), and fault (red and yellow).

About this Manual

This manual provides complete information for installing the calibrator and operating it in remote. It also provides a glossary of calibration-related terms as well as general items such as specifications and error code information. The following topics are covered in this manual:

- Instrument specifications: Chapter 1
- Unpacking and setup: Chapter 2
- Installation and rack mounting: Chapter 2; also the rack mount kit instruction sheet
- AC line power and interface cabling: Chapter 2
- Remote operation (IEEE-488): Chapter 3
- Maintenance: Chapter 4

Service Information

Each calibrator is warranted to the original purchaser for a period of one year beginning on the date received. The warranty is located at the front of this manual.

Service and technical advice for the calibrator is available at Fluke Service Centers. For a complete list of Fluke Service Centers, visit **www.fluke.com.**

A worldwide network of Fluke service centers supports Fluke instruments and assists customers in many ways. Most service centers have standards and calibration laboratories certified by local national standards organizations. The following is a partial list of the services provided by most service centers:

- Repair and certified traceable calibration of all Fluke products.
- Certified traceable calibration of many non-Fluke standards and calibrators.
- Worldwide exchange of calibrator internal modules. Delivery inside the U.S.A. is typically within 48 hours.
- Service agreements with the flexibility to suit your needs. These can be a simple warranty extension or an agreement that includes on-site support. Calibration service agreements are also available in many areas.
- Training programs and seminars, including laboratory metrology, system applications, and product maintenance.
- Application help and consulting, including system design, hardware selection, custom software, site evaluation and installation.
- Replacement parts inventory, including recommended spare parts and module kits.

Visit **www.fluke.com** for locations and phone numbers of authorized Fluke service centers.

Accessories

Table 1-1 summarizes the accessories available for the Calibrator. Following the table is a brief description of each accessory.

Table 1-1. 57LFC Accessories

Model	Description
5440A-7002 5440A-7003	Low Thermal EMF Test Lead Set with Banana Plugs: One 4 ft. cable (122 cm) and two 2 ft. (61 cm) cables. Low Thermal EMF Test Lead Set with Spade Lugs. Two 4 ft. (122 cm) cables and One 2 ft. (61 cm) cable.
Y8021	IEEE-488 Shielded Interface Cable, 1 Meter
Y8022	IEEE-488 Shielded Interface Cable, 2 Meters
Y5537	Rack Mount Kit for 57LFC and 5500A

Low Thermal EMF Test Leads

Two types of low thermal test leads are available. These cables are designed to exhibit low thermal emfs. The types available are:

- Model 5440A-7002. Low Thermal Test Lead cables with banana plugs.

  Set includes one 4 ft. (122 cm) cable and two 2 ft. (61 cm) cables. Each cable includes two conductors and a shield lead.

- Model 5440A-7003. Low Thermal Test Lead cables with spade lugs.

  Set includes two 4 ft. (122 cm) cables and one 2 ft. (61 cm) cable. Each cable includes two conductors and a shield lead. Shield lead has a banana plug connector.

Rack Mount Kit

The rack mount kit provides all the hardware necessary to mount the 57LFC. Rack mount instructions are included with each kit.

Shielded IEEE-488 Cables (Y8021, Y8022, and Y8023)

Shielded IEEE-488 cables are available in two lengths (See Table 1-1). The cables attach the calibrator to any other IEEE-488 device. Each cable has double 24-pin connectors at both ends to allow stacking. Metric threaded mounting screws are provided with each connector. Figure 4-2 in Chapter 4 shows the pinout for the IEEE-488 connector.

Contacting Fluke

All Calibrators delivered to the Navy, contractors and subcontractors for the RTCASS program will be repaired and calibrated at the Fluke Technical Support Center in Everett, Washington. Contact Fluke Technical Support at 1-888-993-5853 or by sending a fax to 1-425-446-6390. The address for the Fluke Technical Support Center address is:

Fluke Technical Support Center
1420 75th ST SW
Everett, WA 98203-6256
U. S. A.

Once full production is started the following service centers will also maintain and calibrate the Calibrator in Europe.

FLUKE NEDERLAND B.V.
Customer Support Services
Science Park Eindhoven 5108
5692 EC Son
Netherlands

FLUKE DEUTSCHLAND GMBH
Customer Support Services
Heinrich Hertz Straße 11
D-34123 Kassel
Germany

and in Asia,

FLUKE SOUTH EAST ASIA PTE LTD.
Service Center
83 Clemenceau Avenue
#15-15/06 Ue Square
239920
Singapore

Specifications

The 57LFC System Calibrators are verified and calibrated at the factory prior to shipment to ensure they meet the accuracy standards required for all certified calibration laboratories. By calibrating to the specifications in this chapter, you can maintain the high performance level throughout the life of your calibrator.

Specifications are valid after a warm-up period of twice the time the calibrator has been turned off, up to a maximum of 30 minutes. For example, if the calibrator has been turned off for five minutes, the warm-up period is ten minutes.

To ensure the validity of the specifications, a dc zeros calibration must be performed at least every 15 days. If more than 15 days elapse without a dc zeros calibration a warning message appears. This procedure does not require any external equipment or connections and takes approximately 5 minutes to complete.

General Specifications

Factory set IEEE488 address 4
Warm-up Time .... Twice the time since last warmed up, to a maximum of 30 minutes
Temperature Performance .... Operating: 0 to 50 °C
Calibration: 15 to 37.7 °C
Storage: -40 to 75 °C
Temperature Coefficient............... Temperature Coefficient for temperatures outside tcal ±5 °C is 10% of the 1-year spec per °C.
Relative Humidity
Operating: .... <95% to 43 °C (non-condensing), <40% to 50 °C.
Storage:...................................... <95%, non-condensing
Altitude
Operating: .... 3,050 m (10,000 ft) maximum
Non-operating: .... 12,200 m (40,000 ft) maximum
Safety .... Designed to comply with IEC 61010-1 2000-1; ANSI/ISA-S82.01-1994; CAN/CSA-C22.2 No. 1010.1-92
Analog Low Isolation.................... 20 V
EMC .... Designed to comply with IEC 61326-1 2000-11 (EMC) Class A Criteria C
Line Power
Line Voltage (selectable): .... 100 V, 120 V, 208 V, and 230 V
Line Frequency: .... 47 to 63 Hz
Line Voltage Variation: .... ±7% about line voltage setting
Maximum VA: 200
Settling Time .... ≤ 3 to 10 seconds, similar to 5700A.
Chassis Dimensions, H x W x D... 178 mm x 432 mm x 457 mm (7 in x 17 in x 18 in) maximum
Weight... Less than 18.15 kg (40 pounds)
Electrical/Signal Interface .... Fluke 5700A/LP equivalent signal interface, AC Mains, IEEE-488, and RS-232 connectors, AC power switch, and Line Voltage selection all on front panel
Cooling... 1.42 cubic meters (50 cubic feet) per minute

⚠⚠Caution

Internal damage may occur if excessive external power is applied to the binding posts while the instrument is operating in current, voltage, or ohms. In voltage and current, exceeding 30 V may cause damage. In ohms, do not exceed the maximum specified current.

Accuracy Specifications

DC Voltage Accuracy

Ranges	Absolute Uncertainty, tcal ±5 °C ±(% output + V) 1 Year		Resolution	Maximum Burden [1]
0 mV to 220 mV	0.004%	3 µV	0.1 µV	50 Ω output impedance
0 V to 2.2 V	0.0025%	3 µV	1 µV	50 mA
0 V to 11 V	0.0025%	30 µV	10 µV	50 mA
0 V to 22 V	0.0025%	30 µV	10 µV	50 mA
0 V to 220 V	0.004%	300 µV	100 µV	20 mA

[1] Remote sensing provided on all but 220 mV range.

Note: minimum output 0 V for all ranges.

DC Current Accuracy

Ranges	Absolute Uncertainty, tcal ±5°C± (% of output + A) 1 year		Resolution	Maximum Compliance Voltage	Maximum Inductive Load
0 µA to 220 µA	0.05%	0.02 µA	1 ηA	10 V	400 µH
0 mA to 2.2 mA	0.05%	0.05 µA	0.01 µA	10 V	400 µH
0 mA to 22 mA	0.05%	0.25 µA	0.1 µA	10 V	400 µH
0 mA to 220 mA	0.05%	2.5 µA	1 µA	10 V	400 µH
0 A to 2.2 A	0.07%	40 µA	10 µA	4 V	400 µH

Resistance Accuracy

Nominal Resistance Value [1]	Absolute Uncertainty of Characterized Value, tcal ± 5 °C ± (Ω) 1 Year	Full Specification Current	Maximum Peak Current	Two-Wire Active Compensation Adder (ohms) [2]
0 Ω	0.001 Ω	8 mA to 200 mA	220 mA	0.001
1 Ω	0.001 Ω	8 mA to 100 mA	220 mA	0.001
1.9 Ω	0.002 Ω	8 mA to 100 mA	220 mA	0.001
10 Ω	0.004 Ω	8 mA to 11 mA	220 mA	0.001
19 Ω	0.008 Ω	8 mA to 11 mA	160 mA	0.001
100 Ω	0.01 Ω	8 mA to 11 mA	70 mA	0.001
190 Ω	0.02 Ω	8 mA to 11 mA	50 mA	0.001
1 kΩ	0.1 Ω	1 mA to 2 mA	22 mA	0.010
1.9 kΩ	0.2 Ω	1 mA to 1.5 mA	16 mA	0.010
10 kΩ	1 Ω	0.1 mA to 0.5 mA	3 mA	0.100
19 kΩ	2 Ω	0.05 mA to 0.25 mA	1.6 mA	0.200
100 kΩ	10 Ω	0.01 mA to 0.1 mA	0.3 mA	1.000
190 kΩ	20 Ω	5 µA to 50 µA	0.16 mA	2.000
1 MΩ	100 Ω	5 µA to 20 µA	30 µA	NA
1.9 MΩ	200 Ω	2.5 µA to 10 µA	16 µA	NA
10 MΩ	4 kΩ	0.5 µA to 2 µA	3 µA	NA
19 MΩ	10 kΩ	0.25 µA to 1 µA	1.6 µA	NA

[1] Discrete resistors with characterized values stored in non-volatile memory. Specifications apply to the characterized value using 4-wire connections.

[2] Active two-wire compensation may be selected for values up to 190 kΩ. Active compensation is 11 mA load and 2 V burden minimum.

AC Voltage Accuracy

Ranges	Frequency	Absolute Uncertainty, tcal ±5 °C ± (% output + V) 1 year		Resolution	Maximum Burden [1] [2]
10 mV to 22 mV	10 Hz to 45 Hz	0.15%	20 μV	1 μV	50 Ω output impedance
	45 Hz to 20 kHz	0.08%	20 μV		
	20 kHz to 50 kHz	0.25%	20 μV		
	50 kHz to 100 kHz	0.5%	50 μV		
22 mV to 220 mV	10 Hz to 45 Hz	0.15%	50 μV	1 μV	50 Ω output impedance
	45 Hz to 20 kHz	0.05%	50 μV		
	20 kHz to 50 kHz	0.25%	50 μV		
	50 kHz to 100 kHz	0.4%	200 μV		
0.22 V to 2.2 V	10 Hz to 45 Hz	0.1%	250 μV	10 μV	50 mA
	45 Hz to 20 kHz	0.05%	100 μV		
	20 kHz to 50 kHz	0.1%	320 μV		
	50 to 100 kHz	0.25%	2000 μV		
2.2 V to 22 V	10 Hz to 45 Hz	0.1%	1 mV	100 μV	50 mA
	45 Hz to 20 kHz	0.05%	1 mV		
	20 kHz to 50 kHz	0.1%	1 mV		
	50 kHz to 100 kHz	0.25%	2 mV		
22 V to 220 V [2]	10 Hz to 45 Hz	0.1%	10 mV	1 mV	20 mA
	45 Hz to 20 kHz	0.05%	10 mV		
	20 kHz to 50 kHz	0.25%	20 mV		
	50 kHz to 100 kHz	0.5%	50 mV		

[1] Remote sensing provided on all but 22 mV and 220 mV ranges. Maximum output current is reduced by 50% above 40 °C. Maximum load capacitance is 500 pF.

[2] V x Hz limited to 11.8e6.

Note: Frequency uncertainty is specified to be 0.01% of frequency setting.

AC Voltage Distortion

Ranges	Frequency	Max Distortion and noise 10 Hz to 10 MHz Bandwidth ±(% output + V) [1]	
10 mV to 22 mV	10 Hz to 45 Hz	0.15%	90 μV
	45 Hz to 20 kHz	0.035%	90 μV
	20 kHz to 50 kHz	0.15%	90 μV
	50 kHz to 100 kHz	0.25%	90 μV
22 mV to 220 mV	10 Hz to 45 Hz	0.15%	90 μV
	45 Hz to 20 kHz	0.035%	90 μV
	20 kHz to 50 kHz	0.15%	90 μV
	50 kHz to 100 kHz	0.20%	90 μV
0.22 V to 2.2 V	10 Hz to 45 Hz	0.15%	200 μV
	45 Hz to 20 kHz	0.035%	200 μV
	20 kHz to 50 kHz	0.15%	200 μV
	50 kHz to 100 kHz	0.20%	200 μV
2.2 V to 22 V	10 Hz to 45 Hz	0.15%	2 mV
	45 Hz to 20 kHz	0.035%	2 mV
	20 kHz to 50 kHz	0.2%	2 mV
	50 kHz to 100 kHz	0.5%	2 mV
22 V to 220 V	10 Hz to 45 Hz	0.15%	10 mV
	45 Hz to 20 kHz	0.05%	10 mV
	20 kHz to 50 kHz	0.8%	10 mV
	50 kHz to 100 kHz	1.0%	10 mV

[1] For larger resistive loads, multiply uncertainty specifications by (actual load/maximum full load for accuracy)^{2}.

AC Current Accuracy

Ranges [3]	Frequency	Absolute Uncertainty, tcal ±5 °C ±(% of output + A) 1 year		Resolution	Maximum Compliance Voltage (rms) [2]	Maximum Inductive Load [1]
30 µA to 220 µA	10 Hz to 20 Hz	0.3%	0.2 µA	0.01 µA	7 V	50 µH
	20 Hz to 45 Hz	0.15%	0.2 µA			
	45 Hz to 1 kHz	0.125%	0.2 µA			
	1 kHz to 5 kHz	0.4%	0.3 µA			
	5 kHz to 10 kHz	1.5%	0.4 µA			
0.22 mA to 2.2 mA	10 Hz to 20 Hz	0.2%	0.3 µA	0.1 µA	7 V	50 µH
	20 Hz to 45 Hz	0.15%	0.3 µA			
	45 Hz to 1 kHz	0.1%	0.3 µA			
	1 kHz to 5 kHz	0.2%	0.3 µA			
	5 kHz to 10 kHz	0.8%	0.5 µA			
2.2 mA to 22 mA	10 Hz to 20 Hz	0.2%	3 µA	1 µA	7 V	50 µH
	20 Hz to 45 Hz	0.1%	3 µA			
	45 Hz to 1 kHz	0.1%	3 µA			
	1 kHz to 5 kHz	0.2%	3 µA			
	5 kHz to 10 kHz	0.4%	5 µA			
	10 kHz to 20 kHz	0.8%	5 µA			
22 mA to 220 mA	10 Hz to 20 Hz	0.18%	30 µA	10 µA	7 V	50 µH
	20 Hz to 45 Hz	0.1%	30 µA			
	45 Hz to 1 kHz	0.1%	30 µA			
	1 kHz to 5 kHz	0.3%	50 µA			
	5 kHz to 10 kHz	0.4%	100 µA			
	10 kHz to 20 kHz	0.8%	200 µA			
0.22 A to 2.2 A	10 Hz to 45 Hz	0.18%	300 µA	100 µA	4 V	2.5 µH
	45 Hz to 1 kHz	0.1%	300 µA			
	1 kHz to 5 kHz	1%	3000 µA			
	5 kHz to 10 kHz	5%	5000 µA			

[1] 400 µH with inductive compensation ON.

[2] See AC Current Compliance Adder and Distortion Table for impact of compliance voltage on specification.

[3] I-guard, (as on the 5700A rear panel), required when sourcing low-level currents through a long cable.

Note: Frequency uncertainty is specified to be 0.01% of frequency setting.

AC Current Distortion

Ranges	Frequency	Maximum Resistive Load For Full Accuracy Ω[1]	Max Distortion & Noise 10 Hz to 50 kHz BW <0.5V Burden ±(%output + A)	
30 µA to 220 µA	10 Hz to 20 Hz	20 kΩ	0.15%	0.5 µA
	20 Hz to 45 Hz		0.1%	0.5 µA
	45 Hz to 1 kHz		0.05%	0.5 µA
	1 kHz to 5 kHz		0.5%	0.5 µA
	5 kHz to 10 kHz		1.0%	0.5 µA
0.22 mA to 2.2 mA	10 Hz to 20 Hz	10 kΩ	0.15%	1.5 µA
	20 Hz to 45 Hz		0.06%	1.5 µA
	45 Hz to 1 kHz		0.05%	1.5 µA
	1 kHz to 5 kHz		0.5%	1.5 µA
	5 kHz to 10 kHz		1.0%	1.5 µA
2.2 mA to 22 mA	10 Hz to 20 Hz	3.18 kΩ	0.15%	5 µA
	20 Hz to 45 Hz		0.05%	5 µA
	45 Hz to 1 kHz		0.07%	5 µA
	1 kHz to 5 kHz		0.3%	5 µA
	5 kHz to 10 kHz		0.7%	5 µA
	10 kHz to 20 kHz		1.0%	5 µA
22 mA to 220 mA	10 Hz to 20 Hz	318 Ω	0.15%	50 µA
	20 Hz to 45 Hz		0.05%	50 µA
	45 Hz to 1 kHz		0.07%	50 µA
	1 kHz to 5 kHz		0.30%	50 µA
	5 kHz to 10 kHz		0.70%	50 µA
	10 kHz to 20 kHz		1.0%	50 µA
0.22 A to 2.2 A	10 Hz to 45 Hz	18 Ω	0.2%	500 µA
	45 Hz to 1 kHz		0.07%	500 µA
	1 kHz to 5 kHz		1.0%	500 µA
	5 Hz to 10 kHz		2.0%	500 µA

[1] For larger resistive loads, multiply uncertainty specifications by actual load/maximum full load for accuracy.

Note: Current times Load cannot exceed the maximum compliance voltage.

Chapter 2
Installation

Title	Page

Introduction

This chapter provides instructions for unpacking and installing the calibrator. The procedures for line voltage selection, fuse replacement, and connection to line power are provided here. Read this chapter before operating the calibrator.

Unpacking and Inspection

The calibrator is shipped in a container designed to prevent damage during shipping. Inspect the calibrator carefully for damage, and immediately report any damage to the shipper. Instructions for inspection and claims are included in the shipping container.

When you unpack the calibrator, check for all the standard equipment listed in Table 2-1 and check the shipping order for any additional items ordered. Report any shortage to the place of purchase or to the nearest Fluke Service Center. If performance tests are required for your acceptance procedures, refer to the *57LFC/AN Service Manual* for instructions.

If you need to reship the calibrator, use the original container. If it is not available, you can order a new container from Fluke by indicating the Calibrator model and serial number.

Table 2-1. Standard Equipment

Item	Model or Part Number
Calibrator	57LFC
Line Power Cord	See Table 2-3 and Figure 2-4
CD-ROM containing the *57LFC/AN Operators Manual* and *57LFC/AN Service Manual*	2103419

Placement and Rack Mounting

Place the calibrator on top of a bench or mounted in a standard-width, 18-inch (45.72 cm) deep equipment rack. To mount the calibrator in an equipment rack, use the Rack Mount Kit, Model Y5537; instructions are included with the kit.

Cooling Considerations

A hidden but important feature of the calibrator is its internal cooling system. Baffles direct cooling air from the fans throughout the chassis to internally dissipate heat during operation. The accuracy and dependability of all internal parts of the calibrator are enhanced by maintaining the coolest possible internal temperature. By observing the following rules, you can lengthen the life of the calibrator and enhance its performance:

- The area around the air filter must be at least 3 inches from nearby walls or rack enclosures.
- The exhaust perforations on the sides of the calibrator must be clear of obstructions.
- The air entering the instrument must be room temperature. Make sure that exhaust from another instrument is not directed into the fan inlet.
- Clean the air filter every 30 days or more frequently if the calibrator is operated in a dusty environment.

⚠⚠Caution

Damage caused by overheating may occur if the area around the air intake is restricted, the intake air is too warm, or the air filter becomes clogged.

Output Binding Posts

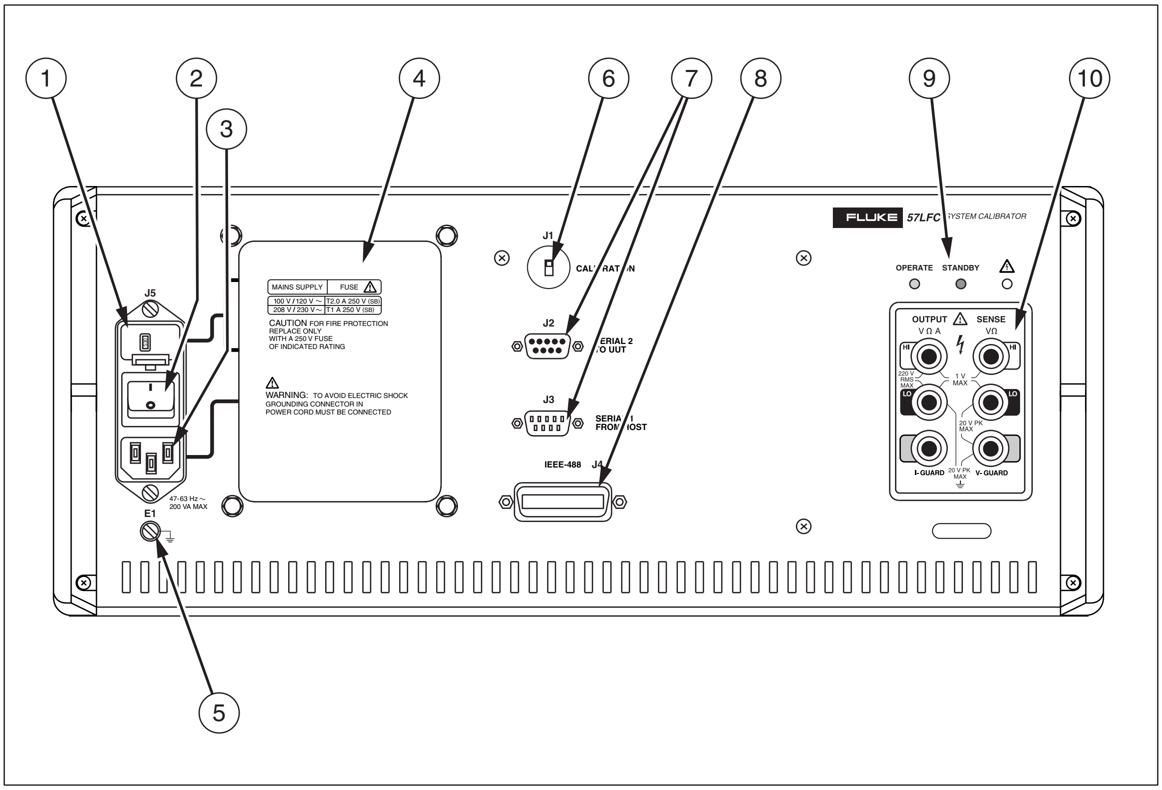
The calibrator is equipped with binding posts for OUTPUT, SENSE, IGUARD (Current Guard) and V GUARD (Voltage Guard) on the front panel.

Front and Rear Panel Features

Front and rear panel features are described in Table 2-2.

Table 2-2. Front and RearPanel Features

①	Fuseholder/Line Voltage Selection Switch	The line power fuse. Refer to "Accessing the Fuse" later in this Chapter for fuse rating information and the fuse replacement procedure. Select the operating line voltage. Refer to "Selecting Line Voltage" in this Chapter for how to select operating line voltage.
②	On/Off Switch	Turns the Calibrator on and off.
③	AC Power Input (J5)	A grounded male three-prong connector that accepts the line power cord.
④	Line Voltage and Fuse Rating Label	Shows the various settings of the line voltage switches, and the correct replacement fuse ratings for operating voltages of 110 (93 - 107), 120 (111 - 128), 208 (193 - 222, and 230 (214 - 246) V ac. Refer to "Accessing the Fuse" later in this Chapter for the fuse replacement procedure.
⑤	CHASSIS GROUND Binding Post	A binding post that is internally grounded to the chassis. If the calibrator is the location of the ground reference point in a system, this binding post can be used for connecting other instruments to earth ground. (The chassis is normally connected to earth ground through the three-conductor line cord instead of through the earth ground binding post).
⑥	CALIBRATION Switch (J1)	A slide switch that write enables and disables the nonvolatile memory that stores calibration constants, dates, and setup parameter settings. Switching to ENABLE write enables the memory, and switching to NORMAL protects data in memory from being overwritten. The switch must be in the ENABLE position to set the clock.
⑦	RS 232C Connectors (J2 and J3)	Used in manufacturing test only.
⑧	IEEE-488 Connector (J4)	A standard interface connector for operating the calibrator in remote control as a Talker or Listener on the IEEE-488 Bus.
⑨	LEDs	Green (Left) Power/Operate Orange (Center) Standby Red (Right) Output Exceeds 30 V
⑩	Binding Posts	VΩA – Red and black Sense VΩ - Red and black I-Guard – Purple V-Guard – Blue
	Fan Filter	Located on the rear panel, the filter covers the air intake to keep dust and debris out of chassis air baffles. Fans inside the calibrator provide a constant cooling air flow throughout the chassis. Circuitry inside the calibrator monitors correct operation of the internal fans.



apw001f.eps

Figure 2-1. Front Panel Features

Accessing the Fuse

⚠⚠Caution

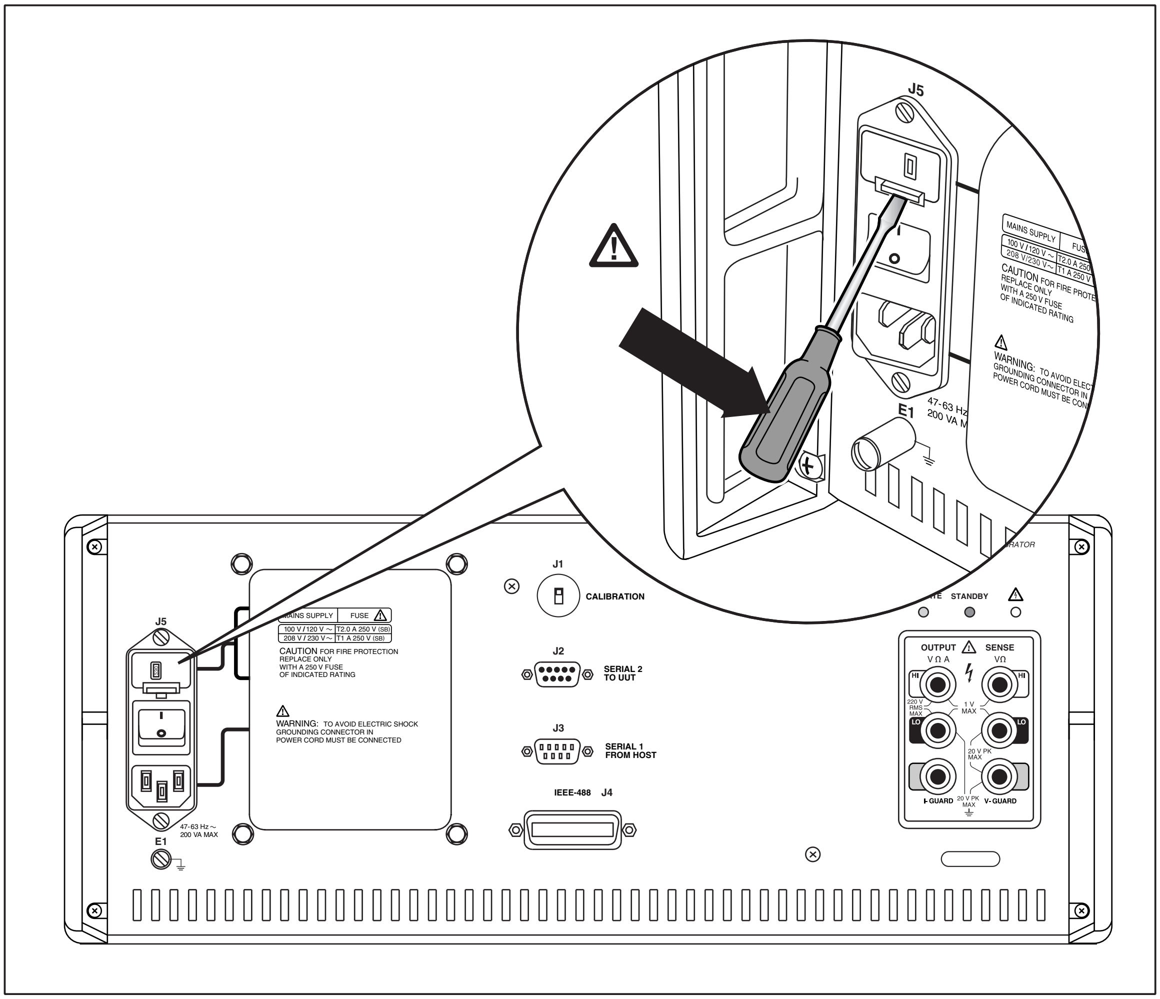
To prevent instrument damage, verify that the correct fuse is installed for the line voltage setting.

The line power fuse is accessible on the front panel. The fuse rating label to the right of the fuse holder shows the correct replacement fuse rating for each operating voltage. To check or replace the fuse:

1. Disconnect line power.
2. Insert a small screwdriver in the fuse holder release slot and push upward until the fuse compartment pops free. See Figure 2-2.
3. Slide the fuse and fuse holder out of the fuse compartment.
4. Inspect or replace the fuse.
5. Install the fuse compartment in the calibrator.

Fuse ratings are 100 V/120 V – T2.0 A 250 V and 208 V/230 V – T1 A 250 V.

- For 100 or 120 V ac operation, use a fuse rated T (time delay) 2 A 250 V.
- For 208 or 230 V ac operation, use a fuse rated T 1 A 250 V.



apw004f.eps

Figure 2-2. Accessing the Fuse

Selecting Line Voltage

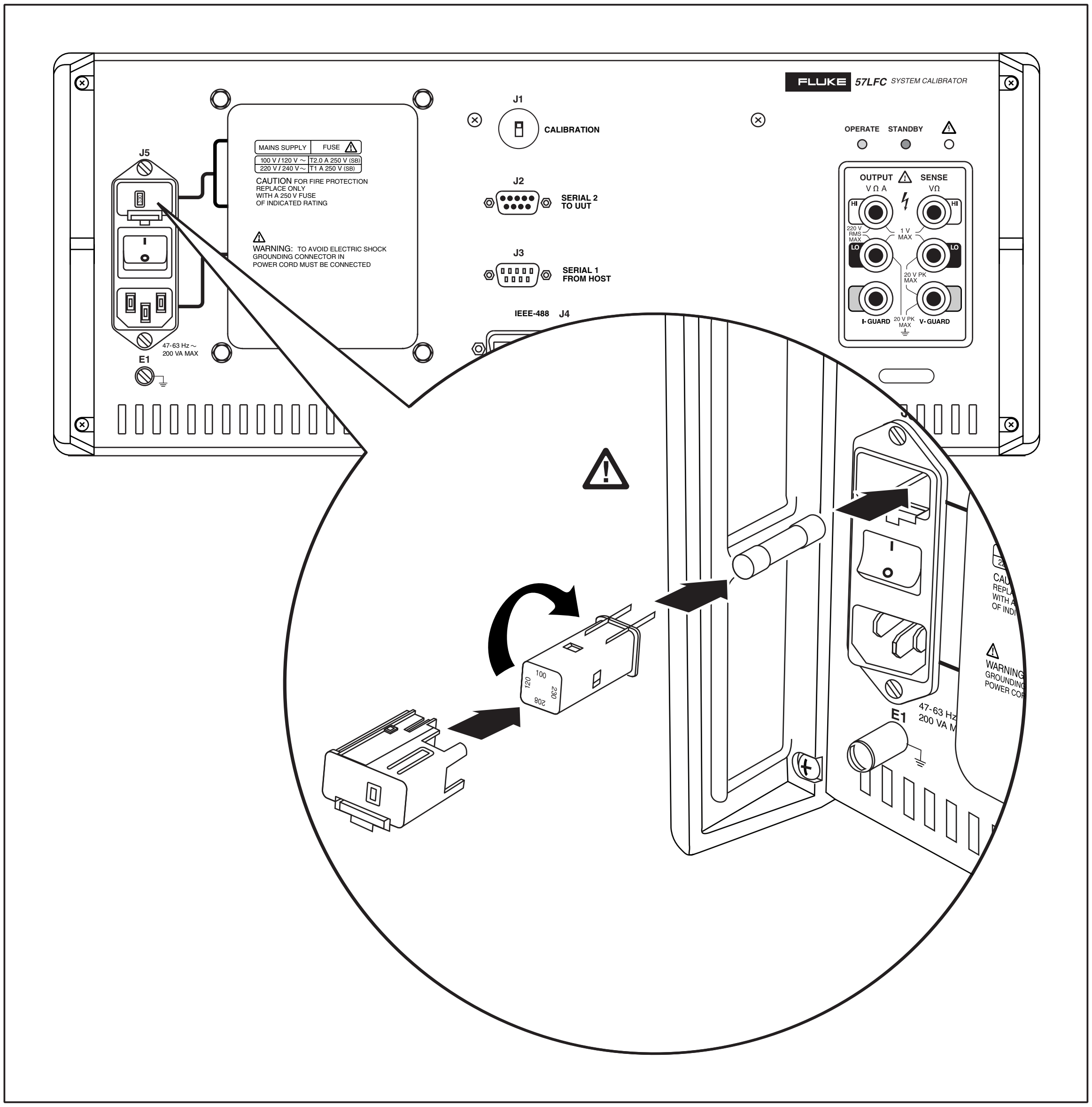
The calibrator arrives from the factory with a 120 V ac mains setting. The calibrator also comes with the appropriate line power plug for the country of purchase. If you need a different type, refer to Table 2-3 and Figure 2-4. They list and illustrate the line power plug types available from Fluke.

Check the line power label on the front panel of the calibrator to verify that the line voltage matches local line power. Figure 2-1 shows the location of the line power label.

You can set the calibrator to operate from four different nominal line voltages; each voltage setting has a voltage tolerance of ± 7%, and frequency range of 47 to 63 Hz. The line voltage selection switch is located in the input power receptacle on the front panel. To change the live voltage:

1. Disconnect line power.
2. Insert a small screwdriver in the fuse holder release slot and push upward until the fuse compartment pops free.
3. Slide the fuse and fuse holder out of the fuse compartment.
4. Remove the fuse from the fuse holder. Line voltages are printed on the end of the fuse holder.

5. Rotate the fuse holder until the correct voltage is displayed and reinsert the fuse.
6. Install the fuse holder in the calibrator.



apw005f.eps

Figure 2-3. Selecting the Line Voltage

Table 2-3. Line Power Cord Types Available from Fluke

Type	Voltage	Fluke Option Number
North America	120 V	LC-1
North America	240 V	LC-2
Universal Euro	220 V	LC-3
United Kingdom	240 V	LC-4
Switzerland	220 V	LC-5
Australia	240 V	LC-6
South Africa	240 V	LC-7

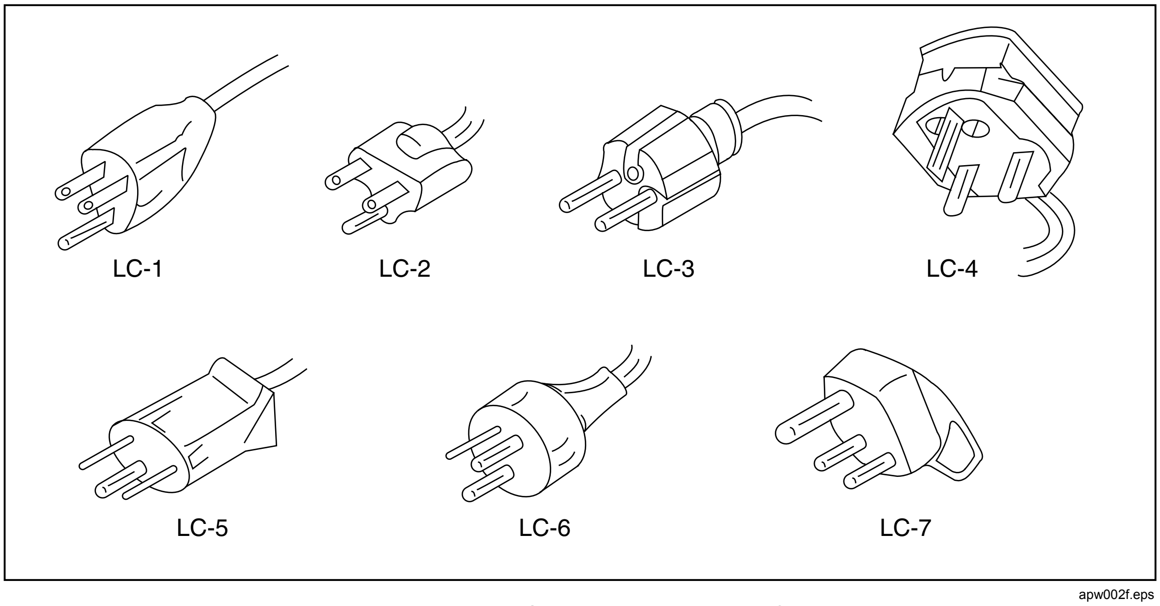


Figure 2-4. Line Power Cord Types Available from Fluke

Connecting to Line Power

After you verify that the line voltage selection switch is set to the correct position, verify that the correct fuse for that line voltage is installed. Connect the calibrator to a properly grounded three-prong outlet.

⚠⚠Warning

To avoid shock hazard, connect the factory supplied three-conductor line power cord to a properly grounded power outlet. Do not use a two-conductor adapter or extension cord; this will break the protective ground connection. If a two-conductor power cord must be used, a protective grounding wire must be connected between the ground terminal and earth ground before connecting the power cord or operating the instrument.

Chapter 3
Remote Operation

Title	Page

Introduction

This chapter describes methods for operating the Calibrator by remote control. Remote control can be interactive, with the user controlling each step from a terminal, or under the control of a computer program running the Calibrator in an automated system. The Calibrator front panel has three ports for remote operations: IEEE-488 parallel port (also known as a General Purpose Interface Bus, or GPIB port), and two RS-232 serial ports, SERIAL 1 FROM HOST and SERIAL 2 TO UUT which are used for manufacturing test purposes only.

The IEEE-488 parallel port is usually used in larger control and calibration systems. An IEEE-488 system is more costly to set up, but has the ability to serve multiple Calibrators and multiple UUTs. Also, parallel system throughput is faster than serial system throughput. The controller in an IEEE-488 system is typically a MS-DOS compatible personal computer (PC) equipped with one or more IEEE-488 ports. You can write your own computer programs for system operation using the command set, or you can purchase optional Fluke calibration software MET/CAL, and property management software MET/TRACK. Typical IEEE-488 connections are shown in Figure 3-1. The configuration showing the PC with two IEEE-488 ports is used with MET/CAL, which prefers UUTs on a separate IEEE-488 port. You can also “piggy-back” the connectors on a single IEEE-488 port.

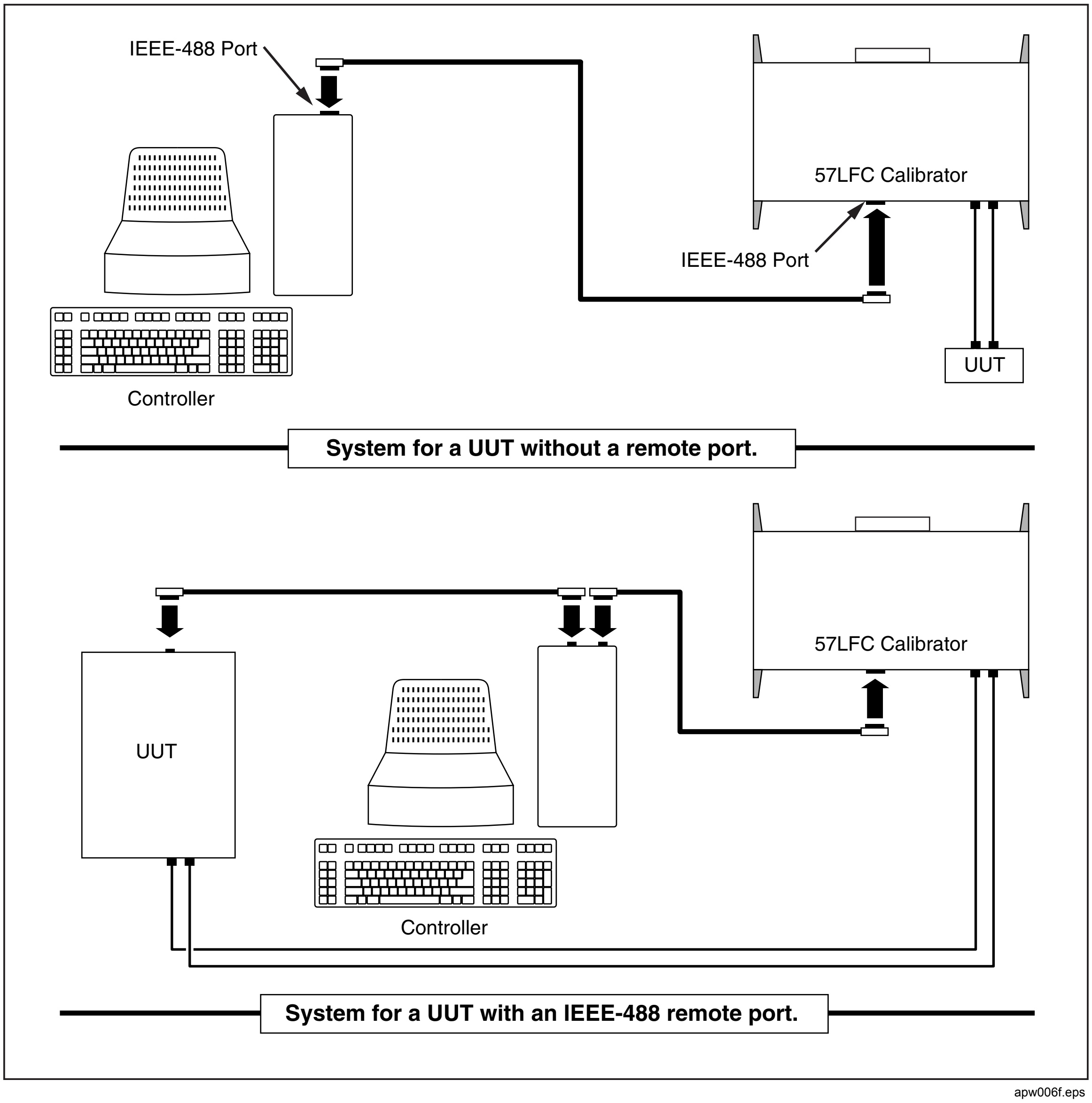


Figure 3-1. Typical IEEE-488 Remote Control Configuration

⚠⚠ Warning

The Calibrator can produce voltages up to 220 V rms and must be programmed with caution to prevent hazardous voltages from being produced without sufficient warning to the operator.

Write programs carefully and test them extensively to ensure safe operation of the Calibrator. Fluke suggests that you include error-catching routines in your programs. These error-catching routines will help you identify programming errors that may cause the Calibrator to behave other than intended. You can program the Calibrator to cause an SRQ when an error is detected by setting the Service Request Enable (SRQ) register.

The following skeleton program includes error-catching code:

```
10    PRINT @4, “*CLS”        ! Clear status
20    PRINT @4, “*SRE 8”      ! Set SRE Error Available
30    ON SRQ GOTO 1000        ! Enable SRQ Function
100                           ! Place body of program here

900   STOP                    ! End of program

1000  REM Start of SRQ Handler      ! Start routine
1010  PRINT @4, “FAULT?”            ! Request fault code
1020  INPUT @4, A%                  ! Input fault code
1030  PRINT @4, “EXPLAIN? “;A%      ! Request fault text
1040  INPUT @4, A$                  ! Input fault text
1050  PRINT “Fault “;A$” detected”  ! Print message
1060  PRINT @4, “STBY”              ! Place 57LFC in standby
1070 STOP
```

IEEE-488 Interface Overview

The IEEE-488 parallel interface sends commands as data and receives measurements and messages as data. The maximum data exchange rate is 1 MB, with a maximum distance of 20 meters for the sum length of the connecting cables. A single cable should not exceed 4 meters in length.

The IEEE-488 interface is based on the IEEE Standards 488.1 and 488.2. For detailed information, refer to the IEEE-488.1 and IEEE-488.2 Standards.

IEEE-488.1 is the hardware portion of the interface. The parallel signal lines are divided into eight lines for the data bus, three lines for the handshake, and five lines for bus management. The handshake lines take care of the timing for data exchange. The bus management lines control the operation of data exchange. The ATN line indicates the use of the DIO lines for addresses or messages (true), or for DIO data (false). The EOI line is used with the data lines to mark the end of a message, and with the ATN line for polling. The SRQ line is used by the devices to indicate to the controller that they require service. The IFC line is used by the controller to quickly get all the devices on the bus to stop talking and start listening. The REN line is used to implement the remote/local states.

IEEE-488.2 is the software portion of the interface, specifying data formats, common commands, message exchange protocol and the status register implementation.

Use the following to decode the columns in Figure 3-4.

Type	M - Multiline U - Uniline	
Class	AC - Addressed Command AD - Address (Talk or listen) UC - Universal Command ST - Status	DD - Device Dependent HS - Handshake SE - Secondary
Other	B1, B2, etc. - Information Bits Blanks - Doesn't Care condition	Logic Zero = 0 = False Logic One = 1 = True

Setting up the IEEE-488 Port for Remote Control

The Calibrator is fully programmable for use on the IEEE Standard 488.1 interface bus. The IEEE-488 interface is also designed in compliance with supplemental standard IEEE-488.2, which describes additional IEEE-488 features. Devices connected to the IEEE-488 bus are designated as talkers, listeners, talker/listeners, or controllers. Under remote control of an instrument, the Calibrator operates as a talker/listener. See Figure 3-2 for typical IEEE-488 remote control connections.

A PC equipped with an IEEE-488 interface, controls the Calibrator. Compatible software for IEEE-488 operation may be purchased from Fluke, including METCAL and METRACK. When using the IEEE-488 remote control interface, there are two restrictions:

1. **Number of Devices** A maximum of 15 devices can be connected in a single IEEE-488 bus system. For example, one instrument controller, one Calibrator, and thirteen units under test (UUTs).
2. **Cable Length** The total length of IEEE-488 cables used in one IEEE-488 system is 2 meters times the number of devices in the system, or 20 meters, whichever is less. For example, if 8 devices are connected, the maximum cable length is 2 x 8 = 16 meters. If 15 devices are connected, the maximum cable length is 20 meters.

Testing the IEEE-488 Port

The procedure below tests IEEE-488 communications between the PC and the Calibrator using the Win32 Interactive Control utility. This utility is supplied with National Instruments interface cards for the PC, which are the recommended interfaces. A typical connection is shown in Figure 3-3.

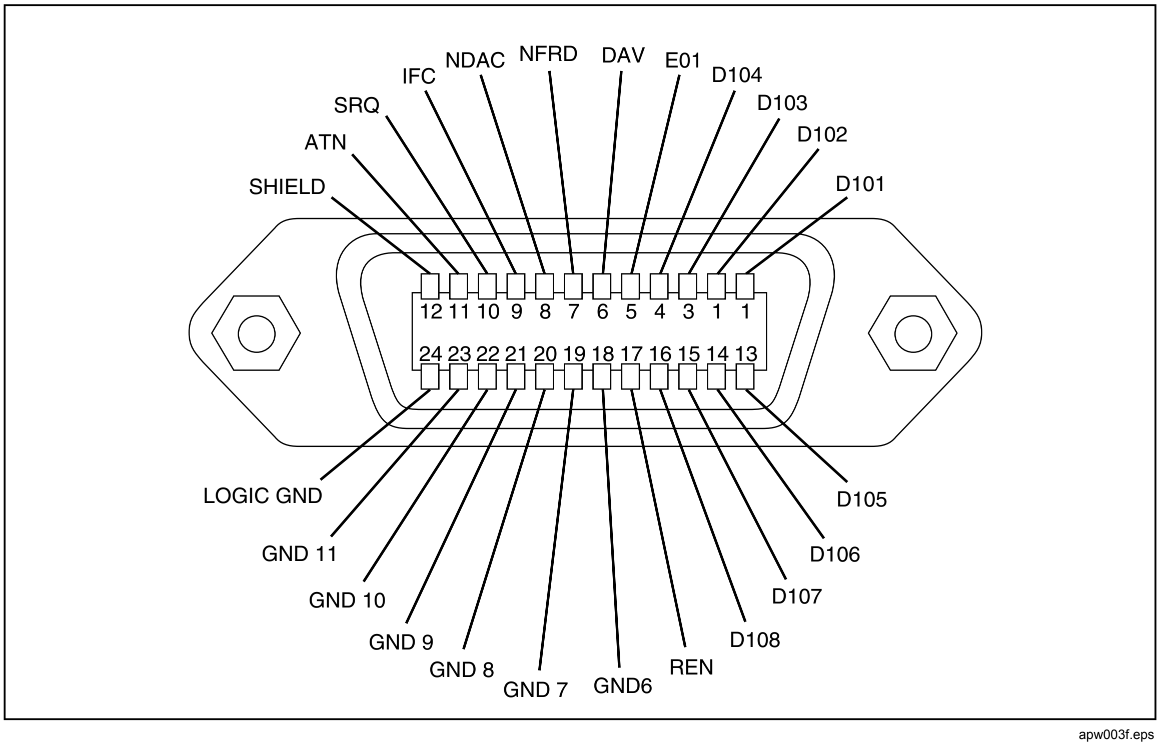


Figure 3-2. Typical IEEE-488 Remote Control Connections

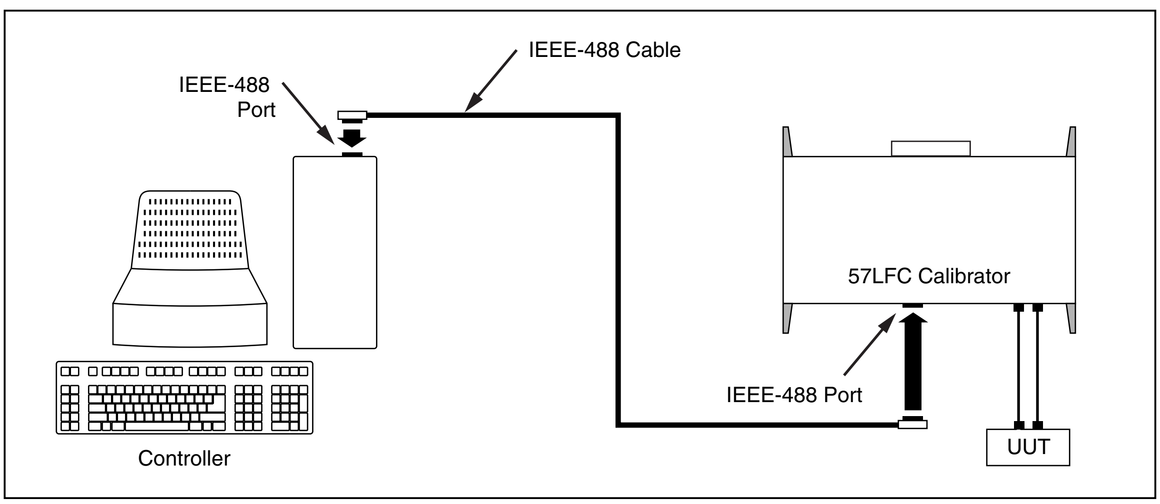


Figure 3-3. Testing the IEEE-488 Port

Complete the following procedure to test IEEE-488 operation using Win32 Interactive Control.

1. Ready the Calibrator for GPIB operation. Note the default GPIB Address Port is 4 and can be changed using the IEEE_ADDR remote command.
2. Connect the PC and the Calibrator IEEE-488 ports using a standard IEEE-488 cable. (See Table 1-1 for IEEE-488 cables available from Fluke.)
3. From the programs menu, select "NI-488.2M software for...(your operating system)".
4. From the NI488.2M software menu, select "Win32 interactive control".
5. A DOS window opens with a prompt as shown below:

apw017s.eps

6. At the prompt, type the following line to activate the IEEE interface card:

   `<ibdev 0 4 0 10 1 0>`
   The second number in this line is the primary address of the calibrator. If the address has been changed from the factory default, change this line accordingly.
7. The prompt reads `<ud0:>`. From this prompt type `<ibwrt "remote">` then press the ENTER (or RETURN) key.
8. Select the Local command from the Control menu, then click OK in the Parameter Input Window. Observe the Calibrator Control Display changes back to the reset condition.
9. From the `<ud0:>` prompt, type `<q>` and then press the ENTER (or RETURN) key.

Table 3-1. IEEE-488 Remote Message Coding

Message Description				Data BUS								Hand-shake			BUS Management				
MNEM	Message Name	Type	Class	DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1	DAV	NRFD	NDAC	ATN	EOI	SRQ	IFC	REN
ACG	Addressed Command Group	M	AC		0	0	0								1				
ATN	Attention	U	UC												1				
DAB	Data Byte	M	DD	B8	B7	B6	B5	B4	B3	B2	B1				0				
DAC	Data Accepted	U	HS											0					
DAV	Data Valid	U	HS									1							
DCL	Device Clear	M	UC		0	0	1	0	1	0	0				1				
END	End	U	ST												0	1			
EOS	End Of String	M	DD	B8	B7	B6	B5	B4	B3	B2	B1				0				
GET	Group Execute Trigger	M	AC		0	0	0	1	0	0	0				1				
GTL	Go To Local	M	AC		0	0	0	0	0	0	1				1				
IDY	Identify	U	UC													1			
IFC	Interface Clear	U	UC															1	
LAG	Listen Address Group	M	AD		0	1									1				
LLO	Local Lock Out	M	UC		0	0	1	0	0	0	1				1				
MLA	My Listen Address	M	AD		0	1	B5	B4	B3	B2	B1				1				
MTA	My Talk Address	M	AD		1	0	B5	B4	B3	B2	B1				1				
MSA	My Secondary Address	M	SE		1	1	B5	B4	B3	B2	B1				1				
NUL	Null Byte	M	DD		0	0	0	0	0	0	0								
OSA	Other Secondary Address	M	SE		(OSA = SCG and MSA-NOT)														
OTA	Other Talk Address	M	AD		(OTA = TAG and MTA-NOT)														
PCG	Primary Command Group	M	----		(PCG = ACG or UCG or LAG or TAG)														
PPC	Parallel Poll Configure	M	AC		0	0	0	0	1	0	1				1				
PPE	Parallel Poll Enable	M	SE		1	1	0	B4	B3	B2	B1				1				
PPD	Parallel Poll Disable	M	SE		1	1	1	B4	B3	B2	B1				1				
PPR1	Parallel Poll Response 1	U	ST								1				1	1			
PPR2	Parallel Poll Response 2	U	ST							1					1	1			
PPR3	Parallel Poll Response 3	U	ST						1						1	1			
PPR4	Parallel Poll Response 4	U	ST					1							1	1			
PPR5	Parallel Poll Response 5	U	ST				1								1	1			
PPR6	Parallel Poll Response 6	U	ST			1									1	1			
PPR7	Parallel Poll Response 7	U	ST		1										1	1			
PPR8	Parallel Poll Response 8	U	ST	1											1	1			
PPU	Parallel Poll Unconfigure	M	UC		0	0	1	0	1	0	1				1				
REN	Remote Enable	U	UC																1
RFD	Ready For Data	U	HS										0						
RQS	Request For Service	U	ST		1										0				
SCG	Secondary Command Group	M	SE		1	1									1				
SDC	Selected Device Clear	M	AC		0	0	0	0	1	0	0				1				
SPD	Serial Poll Disable	M	UC		0	0	1	1	0	0	1				1				

Table 3-1. IEEE-488 Remote Message Coding (cont)

Message Description				Data BUS								Hand-shake			BUS Management				
MNEM	Message Name	Type	Class	DIO8	DIO7	DIO6	DIO5	DIO4	DIO3	DIO2	DIO1	DAV	NRFD	NDAC	ATN	EOI	SRQ	IFC	REN
SPE	Serial Poll Enable	M	UC		0	0	1	1	0	0	0				1				
SRQ	Service Request	U	ST														1		
STB	Status Byte	M	ST	B8		B6	B5	B4	B3	B2	B1				0				
TCT	Take Control	M	AC		0	0	0	1	0	0	1				1				
TAG	Talk Address Group	M	AD		1	0									1				
UCG	Universal Command Group	M	UC		0	0	1								1				
UNL	Unlisten	M	AD		0	1	1	1	1	1	1				1				
UNT	Untalk	M	AD		1	0	1	1	1	1	1				1				

Using Commands

Communications between the controller and the Calibrator consists of commands, queries, and interface messages. (For more information on command structures, see the IEEE 488.2 standard.) Requested information is returned by query, and interface messages are queued and returned by command.

Refer to “Remote Commands” at the end of this Chapter when you require additional information about command references used in this chapter. All commands and units may be entered in UPPER or lower case.

Types of Commands

The commands for the Calibrator can be grouped into one or more categories, depending on how they function. Each category is described below.

Device-Dependent Commands

Device-dependent commands are unique to the Calibrator. An example of a device-dependent command is,

```
OUT 100 V, 60 HZ
```

instructing the Calibrator to source 100 volts of ac voltage.

Common Commands

Common commands are defined by the IEEE 488.2 standard and are common to most bus devices. Common commands always begin with an * character. An example of a common command is,

```
*IDN?
```

instructing the Calibrator to return the instrument identification string.

Query Commands

Query commands request information, which is returned as the command executes, or placed in a buffer until requested. An example of a query, which always ends with a question mark, is,

```
RANGE?
```

returning the Calibrator primary output range.

Interface Messages

Interface messages manage traffic on the IEEE-488 interface BUS. Device addressing and clearing, data handshaking, and commands to place status bytes on the bus are all directed by interface messages. Some of the interface messages occur as state transitions of dedicated control lines. The rest of the interface messages are sent over the data lines with the ATN signal true. (All device-dependent and common commands are sent over the data lines with the ATN signal false.)

An important thing to note about interface messages is that unlike device-dependent and common commands, interface messages are not sent literally (in a direct way). For example, when you send a device-dependent query to the Calibrator, the controller automatically sends the interface message MTA (My Talk Address).

IEEE-488 standards define interface messages. Table 3-2 lists the interface messages that the Calibrator accepts. Table 3-2 also shows the BASIC statement to generate the interface message. Table 3-3 lists the interface messages that the Calibrator sends. The mnemonics listed in the tables are not sent in BASIC PRINT statements as commands are; in this way they are different from device-dependent and common commands.

Interface messages are handled automatically in most cases. For example, handshake messages DAV, DAC, and RFD automatically occur under the direction of an instrument's interface itself as each byte is sent over the bus.

Table 3-2. IEEE-488 Interface Messages (Received)

Mnemonic	Name	Function
ATN	Attention	A control line that, when asserted, notifies all instruments on the bus that the next data bytes are an interface message. When ATN is low, the next data bytes are interpreted as device-dependent or common commands addressed to a specific instrument.
DAC	Data Accepted	Sets the handshake signal line NDAC low.
DAV	Data Valid	Asserts the handshake signal line DAV.
DCL	Device Clear	Clears the input/output buffers
END	End	A message that occurs when the Controller asserts the EOI signal line before sending a byte.
GET	Group Execute Trigger	Trigger a TC measurement and put the reading in the output buffer.
LLO	Local Lockout	Transfers remote/local control of the Calibrator.
IFC	Interface Clear	A control line that sets the interface to a quiescent state.
MLA	My Listen Address	Addresses a specific device on the bus as a listener. The controller sends MLA automatically whenever it directs a device-dependent or common command to a specific instrument.
MTA	My Talk Address	Addresses a specific device on the bus as a talker. The controller sends MTA automatically whenever it directs a device-dependent or common query to a specific instrument.
REN	Remote Enable	Transfer remote/local control of the Calibrator.
RFD	Ready For Data	Sets the handshake signal line NRFD low.
SDC	Selected Device Clear	Does the same thing as DCL, but only if the Calibrator is currently addressed as a listener.
SPD	Serial Poll Disable	Cancels the effect of a Serial Poll Enable.
SPE	Serial Poll Enable	After the Calibrator receives this message, it sends the Status Byte the next it is addressed as a listener, no matter what the command is.
UNL	Unlisten	“Unaddresses” a specific device on the bus as a listener. The controller sends UNL automatically after the device has successfully received a device-dependent or common command.
UNT	Untalk	“Unaddresses” a specific device on the bus as a listener. The controller sends UNL automatically after the device has successfully received a device-dependent or common query.

Table 3-3. IEEE-488 Interface Messages (Sent)

Mnemonic	Name	Function
END	End	A message that occurs when the Calibrator asserts the EOI control line. The 57LFC asserts EOI while it transmits the ASCII character LF for its termination sequence or terminator.
DAC	Data Accepted	Set the handshake signal line NDAC low.
DAV	Data Valid	Asserts the handshake signal line DAV.
RFD	Ready for Data	Sets the handshake line NRFD low.
SRQ	Service Request	A control line that any device on the bus can assert to indicate that it requires attention. Refer to "Checking the Calibrator Status" for details.
STB	Status Byte	The status byte is what the Calibrator sends when it responds to a serial poll (interface message SPE).

Compound Commands.

A compound command is two or more commands in a single command line. For example, the following two commands could be entered individually,

```
OUT 1 V, 60 HZ
OPER
```

where the Calibrator sources 1 V ac at 60 Hz, and then goes into operate, or they could be combined into a compound command,

```
OUT 1 V, 60 HZ ; OPER
```

using a semi-colon as a separator. Care must be taken when a compound command includes any of the coupled commands.

Coupled Commands

A coupled command refers to two or more commands that appear in a compound command (see "Compound Commands") that perform actions that could interfere with each other causing a fault. Commands in a compound command are separated by using the ; character. Compound commands using only coupled commands are not order-dependent.

The coupled commands, are:

```
CUR_POST    OUT
```

Overlapped Commands

Commands that begin execution but require slightly more time to complete are called overlapped commands, because they can be overlapped by the next command before they have completed execution.

The overlapped commands, excluding scope commands, are:

`CUR_POST`		`STBY`
	`OPER`	
	`OUT`	
`EXTGUARD`	`RANGELCK`	
`INCR`		
`LCOMP`	`*RST`	

You can use the command `*WAI` to wait until the overlapped command has completed execution before executing the next command. For example:

```
OUT 1 V, 1 A, 60 HZ ; *WAI
```

You can also use the status commands `*OPC` and `*OPC?` to detect completion of overlapped commands.

Sequential Commands

Commands that execute immediately are called sequential commands.

The majority of the commands are sequential.

Commands that Require the Calibration Switch

The following commands do not work unless the rear panel CALIBRATION switch is in the ENABLE position:

`CAL_STORE`
`CLOCK` (when setting date but not time)
`FORMAT CAL`
`*PUD`

Attempting to use any of these commands with the CALIBRATION switch in the NORMAL position logs an error into the error queue.

Command Syntax

The following syntax rules apply to all the remote commands. Information about syntax of response messages is also given.

Parameter Syntax Rules

Table 3-4 lists the units accepted in command parameters and used in responses. All commands and units may be entered in UPPER or lower case.

Table 3-4. Units Accepted in Parameters and Used in Responses

Units	Meaning
HZ	Frequency in units of hertz
KHZ	Frequency in units of kilohertz
MHZ	Frequency in units of megahertz
UV	Volts in units of microvolts
MV	Volts in units of millivolts
V	Volts in units of volts
KV	Volts in units of kilovolts
UA	Current in units of microamperes
MA	Current in units of milliamps
A	Current in units of amps
OHM	Resistance in units of ohms
KOHM	Resistance in units of kilohms
MOHM	Resistance in units of megohms

The general rules for parameter usage is as follows:

1. When a command has more than one parameter, the parameters must be separated by commas. For example: `OUT 1V, 2A`.
2. Numeric parameters may have up 15 significant digits and their exponents can be in the range +/-1.0E+/-20.
3. Including too many or too few parameters causes a command error.
4. Null parameters cause an error, e.g., the adjacent commas in `OUT 1V, ,2A`.
5. Expressions, for example `4+2*13`, are not allowed as parameters.
6. Binary Block Data can be in one of two forms: Indefinite Length and Definite Length format (both IEEE-488.2 standards).
    - The Indefinite Length format accepts data bytes after the #0 until the ASCII Line Feed character is received with an EOI signal.
    - The Definite Length format specifies the number of data bytes. The data bytes are preceded by #n and an n-digit number. The n-digit number identifies how many data bytes follow. For examples, see the *PUD command descriptions in Remote Commands.

Extra Space or Tab Characters

In the command descriptions in Remote Commands, parameters are shown separated by spaces. One space after a command is required (unless no parameters are required). All other spaces are optional. Spaces are inserted for clarity in the manual and may be left in or omitted as desired. You can insert extra spaces or tabs between parameters as desired. Extra spaces within a parameter are generally not allowed, except for between a number and its associated multiplier or unit. Remote Commands contains examples for commands whose parameters or responses are not self-explanatory.

Terminators

Table 3-5 summarizes the terminator characters for the IEEE-488 remote interface.

Table 3-5. Terminator Characters

Terminator Function	ASCII Character		Control Command Terminator	Language Command Terminator
	Number	Program		
Carriage Return (CR)	13	Chr(13)	<Cntl> M	\n
Line Feed (LF)	10	Chr(10)	<Cntl> J	\r
Backspace (BS)	8	Chr(8)	<Cntl> H	\b
Form Feed (FF)	12	Chr(12)	<Cntl> L	\f

The Calibrator sends the ASCII character Line Feed with the EOI control line held high as the terminator for response messages. The calibrator recognizes the following as terminators when encountered in incoming data:

- ASCII LF character
- Any ASCII character sent with the EOI control line asserts

Incoming Character Processing

The Calibrator processes all incoming data as follows (except Binary Block Data as described under Parameter Syntax Rules):

1. The most significant data bit (DIO8) is ignored.
2. All data is taken as 7-bit ASCII.
3. Lower-case or upper-case characters are accepted.
4. ASCII characters whose decimal equivalent is less than 32 (Space) are discarded, except for characters 10 (LF) and 13 (CR) and in the `*PUD` command argument. Binary Block Data allows all characters in its argument and terminates in a special way.

Response Message Syntax

In the command descriptions in Remote Commands, responses from the Calibrator are described wherever appropriate. In order to know what type of data to read in, refer to the first part of the entry under "Response" in the tables. The response is identified as one of the data types in Table 3-6.

Table 3-6. Response Data Types

Data Type	Description
Integer	Integers for some controllers or computers are decimal numbers in the range -32768 to 32768. Responses in this range are labeled Integer. Example: `*ESE 123; *ESE?` returns: `123`
Floating	Numbers that may have up to 15 significant figures plus an exponent that may range from ±E20. Example: `OUT?` returns: `1.1000000E+02,V,6.0000E+01`
String	Any ASCII characters including quotation mark delimiters. Example: `ECHO? "TextMessage"` returns: `“TextMessage”`
Character Response Data (CRD)	This type of response is always a keyword. Example: `OUT 10V, 100HZ; FUNC?` returns: `ACV`

Table 3-6. Response Data Types (cont)

Data Type	Description
Indefinite ASCII (IAD)	Any ASCII characters followed by EOM. Queries with this type of response MUST be the last Query in a program message. Example: `*OPT?` returns: `"DC Volt Module "` CAL reports and lists which contains Line Feeds are typically of this type.
Binary Block Data	A special data type defined by the IEEE-488.2 standard. This type is used in `*PUD?` query. It is defined as follows: #(non-zero digit) (digits) (user data) The non-zero digit specifies the number of characters that will follow in the <digits> field. Characters allowed in the digits field are 0 through 9 (ASCII 48 through 57 decimal). The value of the number in the <digits> field in decimal defines the number of user data bytes that follow in the <user data> field. The maximum response is 64 characters. Example: `*PUD “test1”; *PUD?` returns: `#205test1`

Checking the Calibrator Status

The programmer has access to status registers, enable registers, and queues in the Calibrator to indicate various conditions in the instrument as shown in Figure 3-4. Some registers and queues are defined by the IEEE-488.2 standard. The rest are specific to the Calibrator. In addition to the status registers, the Service Request (SRQ) control line, and a 16-element buffer called the Error Queue provide status information. Table 3-7 lists the status registers and gives the read/write commands and associated mask registers.

Table 3-7. Status Register Summary

Status Register	Read Command	Write Command
Serial Poll Status Byte (STB)	*STB?	—
Service Request Enable Register (SRE)	*SRE?	*SRE
Event Status Register (ESR)	*ESR?	—
Event Status Enable Register (ESE)	*ESE?	*ESE
Instrument Status Register (ISR)	ISR?	—
Instrument Status Change Register (ISCR)	ISCR?	—
Instrument Status Change Enable Register (ISCE)	ISCE?	ISCE

Each status register and queue has a summary bit in the Serial Poll Status Byte. Enable registers are used to mask various bits in the status registers and generate summary bits in the Serial Poll Status Byte. For IEEE-488 interface operation, the Service Request Enable Register is used to assert the SRQ control line on detection of any status condition or conditions the programmer chooses.

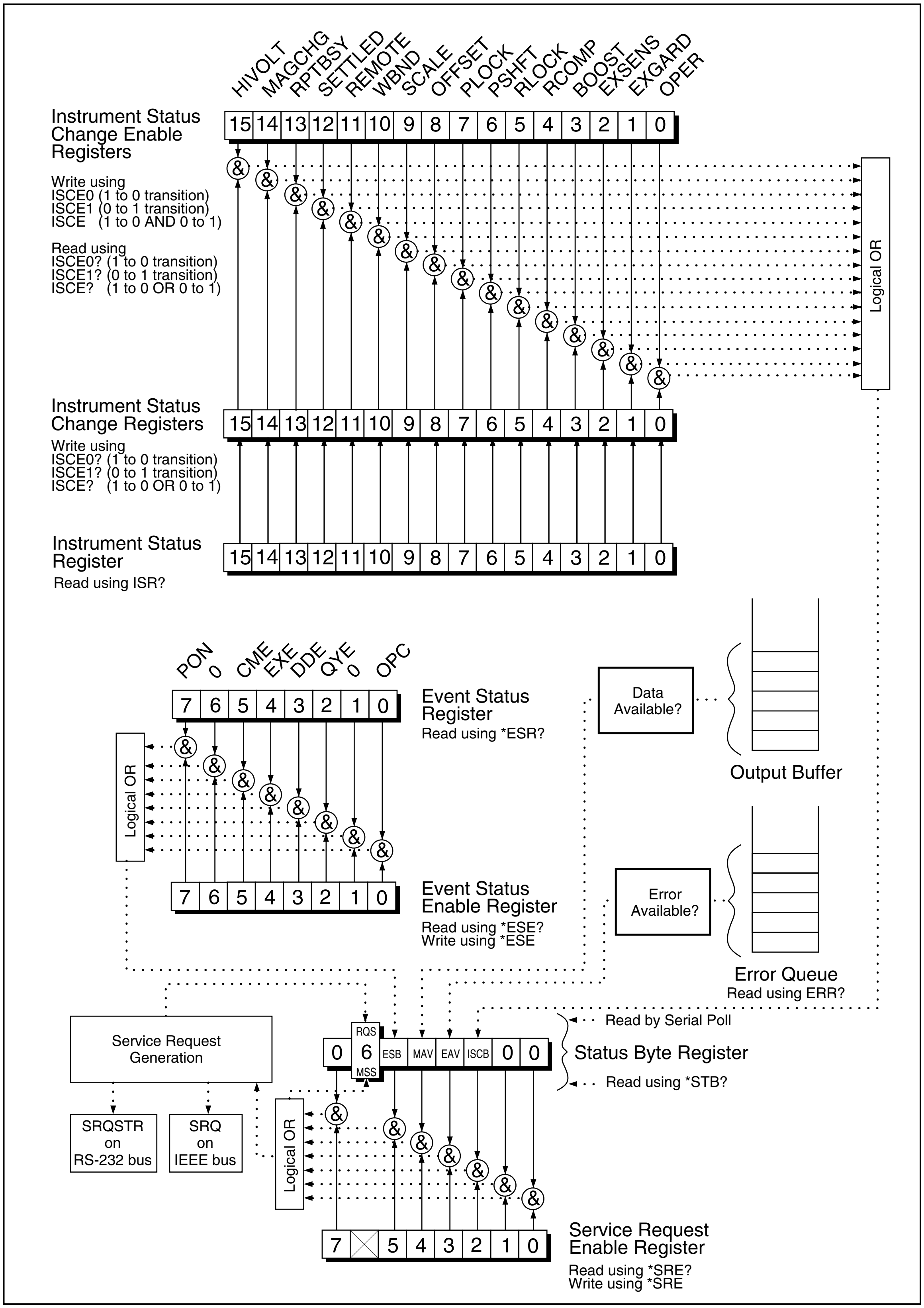


Figure 3-4. Status Register Overview

Service Request (SRQ) Line

Service Request (SRQ) is an IEEE-488.1 bus control line that the Calibrator asserts to notify the controller that it requires some type of service. Many instruments can be on the bus, but they all share a single SRQ line. To determine which instrument set SRQ, the Controller normally does a serial poll of each instrument. The calibrator asserts SRQ whenever the RQS bit in its Serial Poll Status Byte is 1. This bit informs the controller that the Calibrator was the source of the SRQ.

The Calibrator clears SRQ and RQS whenever the controller/host performs a serial poll, sends *CLS, or whenever the MSS bit is cleared. The MSS bit is cleared only when ESB, MAV, EAV, and ISCB are 0, or they are disabled by their associated enable bits in the SRE register being set to 0.

Service Request Enable Register (SRE)

The Service Request Enable Register (SRE) enables or masks the bits of the Serial Poll Status Byte. The SRE is cleared at power up. Refer to Figure 3-5 for the bit functions.

7	6	5	4	3	2	1	0
0	**RQS** **MSS**	**ESB**	**MAV**	**EAV**	**ISCB**	**0**	**0**

RQS	Requesting service. The RQS bit is set to 1 whenever bits ESB, MAV, EAV, or ISCB change from 0 to 1 and are enabled (1) in the SRE. When RQS is 1, the 57LFC asserts the SRQ control line on the IEEE-488 interface. You can do a serial poll to read this bit to see if the 57LFC is the source of an SRQ.
MSS	Master summary status. Set to 1 whenever bits ESB, MAV, EAV, or ISCB are 1 and enabled (1) in the SRE. This bit can be read using the *STB? command in serial remote control in place of doing a serial poll.
ESB	Set to 1 when one or more enabled ESR bits are 1.
MAV	Message available. The MAV bit is set to 1 whenever data is available in the 57LFC IEEE-488 interface output buffer.
EAV	Error available. An error has occurred and an error is available to be read from the error queue by using the ERR? query.
OPER	ISCB One or more enabled ISCR bits are 1.

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Figure 3-5. Serial Poll Status Byte (STB) and Service Request Enable (SRE)

Programming the STB and SRE

By resetting (to 0) the bits in the SRE, you can mask (disable) associated bits in the serial poll status byte. Bits set to 1 enable the associated bit in the serial poll status byte. The following sample BASIC program enables the Error Available (EAV) bit.

```
10  ! THIS PROGRAM SETS EAV IN THE SRE
20  PRINT @6,"*SRE 8"                  ! LOAD THE REGISTER
30  PRINT @6, "*SRE?"                  ! ASK FOR THE SRE CONTENTS
40  INPUT @6, A%                        ! RETRIEVE THE REGISTER CONTENTS
50  PRINT "SRE = ";A%
60  RETURN
```

The following BASIC program generates an error and checks the Serial Poll Status Byte. Enable the EAV bit with the example above.

```
10  ! THIS PROGRAM GENERATES AN ERROR AND CHECKS IT
20  PRINT @6, "OUT 1300V"              ! 1300V IS OUT OF 57LFC RANGE
30  A% = SPL(6)                         ! DO A SERIAL POLL
40  IF ((A% AND 72%)=0%)THEN PRINT "EAV and RQS should have been set"
50  PRINT @6, "*STB?"                  ! RETRIEVE BYTE
60  INPUT @6, A%
70  IF ((A% AND 8%)=0%) THEN PRINT "EAV should have been set"
```

Event Status Register (ESR)

The Event Status Register (ESR) is a two-byte register in which the higher eight bits are always 0, and the lower eight bits represent various conditions of the Calibrator. The ESR is cleared (set to 0) when the power is turned on, and every time it is read.

Many of the remote commands require parameters. Improper use of parameters causes command errors to occur. When a command error occurs, bit CME (5) in the Event Status Register (ESR) goes to 1 (if enabled in ESE register), and the error is logged in the error queue.

Event Status Enable (ESE) Register

A mask register called the Event Status Enable Register (ESE) allows the controller to enable or mask (disable) each bit in the ESR. When a bit in the ESE is 1, the corresponding bit in the ESR is enabled. When any enabled bit in the ESR is 1, the ESB bit in the Serial Poll Status Byte also goes to 1. The ESR bit stays 1 until the controller reads the ESR or does a device clear, a selected device clear, or sends the reset or `*CLS` command to the Calibrator. The ESE is cleared (set to 0) when the power is turned on.

Bit Assignments for the ESR and ESE

The bits in the Event Status Register (ESR) and Event Status Enable Register (ESE) are assigned as shown in Figure 3-7 and 3-8.

15	14	13	12	11	10	9	8
0	0	0	0	0	0	0	0

7	6	5	4	3	2	1	0
PON	**0**	**CME**	**EXE**	**DDE**	**QYE**	**0**	**OPC**

PON	Power on. This bit is set to 1 if line power has been turned off and on since the last time the ESR was read.
CME	Command error. The 57LFC IEEE-488 interface encountered an incorrectly formed command. (The command ERR? fetches the earliest error code in the error queue, which contains error codes for the first 15 errors that have occurred.)
EXE	Execution error. An error occurred while the 57LFC tried to execute the last command. This could be caused, for example, by a parameter being out of range. (The command ERR? fetches the earliest error in the error queue, which contains error codes for the first 15 errors that have occurred.)
DDE	Device-dependent error. An error related to a device-dependent command has occurred.
QYE	Query error. The 57LFC was addressed to talk when no response data was available or appropriate, or when the controller failed to retrieve data on the output queue.
OPC	Operation complete. All commands previous to reception of a *OPC command have been executed, and the interface is ready to accept another message.

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Figure 3-6. Event Status Register (ESR) and Event Status Enable (ESE)

Programming the ESR and ESE

To read the contents of the ESR, send the remote command, `*ESR?`. The ESR is cleared (set to 0) every time it is read. To read the contents of the ESE, send the remote command, `*ESE?`. The ESE is not cleared when it is read. When you read either register, the Calibrator responds by sending a decimal number that when converted to binary represents bits 0 through 15. The following sample BASIC program retrieves the contents of both registers:

```
10  ! THIS PROGRAM READS THE ESR AND THE ESE REGISTERS
20  PRINT @6, "*ESR?"         ! ASK FOR THE ESR CONTENTS
30  INPUT @6, A%               ! RETRIEVE THE REGISTER CONTENTS
40  PRINT @6, "*ESE?"         ! ASK FOR THE ESE CONTENTS
50  INPUT @6, B%               ! RETRIEVE THE REGISTER CONTENTS
60  PRINT "ESR = ";A%         ! DISPLAY THE ESR REGISTER CONTENTS VALUE
70  PRINT "ESE = ";B%         ! DISPLAY THE ESE REGISTER CONTENTS VALUE
80  END
```

Convert the contents of variables A and B into binary, and you can read the status of the registers. For example if A is 32, its binary equivalent is: 00000000 00100000. Therefore, bit 5 (CME) in the ESR is set (1) and the rest of the bits are reset (0). This means that the Calibrator tried to execute an incorrectly formed command.

By setting the bits in the ESE, you can mask (disable) the associated bits in the ESR. For example, to prevent the occurrence of a command error from causing bit 5 (ESB) in the serial poll status byte to go to 1, you can reset (to 0) bit 5 in the ESE register. The following sample program accomplishes this by checking the status of the CME bit, then toggling it if it is 1.

```
10  ! THIS PROGRAM RESETS BIT 5 (CME) IN THE ESE
20  PRINT @6,"*ESE 33"                ! INITIAL ESE IS CME + OPC
30  GOSUB 100                          ! GET AND PRINT INITIAL ESE
40  IF (A% AND 32%) THEN A% = A% - 32% ! CLEAR CME (BIT 5)
50  PRINT @6, "*ESE ";A%              ! LOAD ESE WITH NEW VALUE
60  GOSUB 100                          ! GET AND PRINT NEW ESE
70  END
100 PRINT @6, "*ESE?"                 ! ASK FOR ESE CONTENTS
110 INPUT @6, A%                       ! RETRIEVE REGISTER CONTENTS
120 PRINT "ESE = ";A%
130 RETURN
```

Instrument Status Register (ISR)

The Instrument Status Register (ISR) gives the controller access to the state of the Calibrator, including some of the information presented to the operator on the Control Display and the display annunciators during local operation.

Instrument Status Change Registers

There is one register dedicated to monitoring changes in the ISR. This is the Instrument Status Change Register (ISCR). This status change register has an associated mask register. Each ISCR is cleared (set to 0) when the Calibrator is turned on, every time it is read, and at each `*CLS` (Clear Status) command.

Instrument Status Change Enable Registers

The Instrument Status Change Enable register (ISCE) is instrument status change enable register for ISCR registers. If a bit in the ISCE is enabled (set to 1) and the corresponding bit in the ISCR makes the appropriate transition, the ISCB bit in the Status Byte is set to 1. If all bits in the ISCE are disabled (set to 0), the ISCB bit in the Status Byte never goes to 1. The contents of the ISCE registers are set to 0 at power-up.

Bit Assignments for the ISR, ISCR, and ISCE

The bits in the Instrument Status, Instrument Status Change, and Instrument Status Change Enable registers are assigned as shown in Figure 3-7.

15	14	13	12	11	10	9	8
HIVOLT	**MAGCHG**	**RPTBUSY**	**SETTLED**	**REMOTE**	**WBND**	**SCALE**	**OFFSET**

7	6	5	4	3	2	1	0
PLOCK	**PSHFT**	**RLOCK**	**RCOMP**	**BOOST**	**EXSENS**	**EXGARD**	**OPER**

HIVOLT	High voltage (> 22 V) at output terminals.
MAGCHG	Output value changed after another command.
RPTBUSY	Set to 1 when a calibration report is being printed to the serial port.
SETTLED	Set to 1 when the output has stabilized to within specification or the TC measurement has settled and is available.
REMOTE	Set to 1 when the 57LFC is under remote control.
WBND	Wideband option is active (not used).
SCALE	Scaling is active.
OFFSET	Offset is active.
PLOCK	57LFC output is phase locked to an external source.
PSHFT	Variable phase output active.
RLOCK	Calibrator output range is locked.
RCOMP	Two-wire compensation active when in resistance mode.
BOOST	Boost auxiliary amplifier active (not used).
EXSENS	External sensing active.
EXGARD	External voltage guard selected.
OPER	Set to 1 when the 57LFC is in operate mode, 0 when it is in standby mode.

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Figure 3-7. Bit Assignments for the ISR, ISCEs and ISCRs

Programming the ISR, ISCR, and ISCE

To read the contents of the ISR, send the remote command, ISR?. To read the contents of the ISCR, send the remote command, ISCR?. To read the contents of the ISCE, send the remote command, ISCE?. The Calibrator responds by sending a decimal number that represents bits 0 through 15. Every time you read the ISCR, its contents are zeroed. The following sample program reads all five registers:

```
10  ! THIS PROGRAM READS THE ISR, ISCR, AND ISCE REGISTERS
20  ! NOTE THAT THE ICSR? COMMANDS CLEAR THE ISCR CONTENTS
30  PRINT @6, "ISR?"      ! ASK ISR CONTENTS
40  INPUT @6,A%            ! RETRIEVE REGISTER CONTENTS FROM 57LFC
50  PRINT @6, "ISCR?"    ! ASK FOR AND CLEAR ISCR0 CONTENTS
60  INPUT @6, B%           ! RETRIEVE REGISTER CONTENTS FROM 57LFC
70  PRINT @6, "ISCE?"    ! ASK FOR ISCE0 CONTENTS
80  INPUT @6, C%           ! RETRIEVE REGISTER CONTENTS FROM 57LFC
90  PRINT "ISR =  ";A%    ! DISPLAY ISR
100 PRINT "ISCR0 = ";B%   ! DISPLAY ISCR
110 PRINT "ISCE0 = ";C%   ! DISPLAY ISCE
120 END
```

Convert the returned variables into binary, and you can read the status of the instrument. For example if a register contains 1, its binary equivalent is: 00000000 00000001. Therefore, bit 1 (OPER) is set (1) and the rest of the bits are reset (0).

By setting the bits in an ISCE register, you can mask (disable) the associated bits in the ISCR. For example, to cause an SRQ interrupt when the output has settled, bit 12 (SETTLED) in the ISCE register must be 1. (The ISCB bit must also be enabled in the SRE.) The following sample program loads a decimal 1024 into the ISCE, which sets bit 12 and resets the other bits:

```
10  ! THIS PROGRAM LOADS 00010000 00000000 BINARY INTO THE ISCE
20  PRINT @6, "ISCE 4096" ! LOAD DECIMAL 4096 INTO ISCE
30  PRINT @6, "ISCE?"     ! READ BACK ISCE VALUE
40  INPUT @6, A%            ! "
50  PRINT "ISCE = ";A%     ! PRINT IT, IT SHOULD BE 4096
60  END
```

Output Queue

The output queue is loaded whenever a query is processed, and holds up to 800 characters. The controller reads it with a statement such as a BASIC INPUT statement, removing what it reads form the queue. If the queue is empty, the Calibrator does not respond to the INPUT statement from the controller. The Message Available (MAV) bit in the Serial Poll Status Byte is 1 if there is something in the output queue and 0 if the output queue is empty.

Error Queue

When a command error, execution error, or device-dependent error occurs, its error code is placed in the error queue where it can be read by the ERR? command. (See Appendix A for a list of error messages.) A way to decode an error code is to send the command, EXPLAIN?, which returns a description of a error code. Reading the first error with the ERR? command removes that error from the queue. A response of 0 means the error queue is empty. The Error Available (EAV) bit in the Serial Poll Status Byte indicates whether the queue is empty. The error queue is cleared when you turn off the power, and when you use the *CLS (Clear Status) common command.

FAULT? Displays error number, ERR? also displays error text.

The error queue contains up to 16 entries. If many errors occur, only the first 15 errors are kept in the queue. A 16th entry in the queue is always an "error queue overflow" error, and all later errors are discarded until the queue is at least partially read. The first errors are kept, because if many errors occur before the user can acknowledge and read them, the earliest errors are the most likely to point to the problem. The later errors are usually repetitions or consequences of the original problem.

Remote Program Examples

The following programming examples illustrate ways to handle errors, to take measurements, take a number of successive readings, lock the range, and calibrate the Calibrator. These excerpts from programs are written in DOS BASIC.

Guidelines for Programming the Calibrator

Commands are processed one at a time as they are received. Some commands require a previous condition be set before the command will be accepted by the Calibrator. Using the following programming guidelines will insure that the output is programmed to the desired state.

- All external connections commands should be programmed first. The calibrator will be placed in standby and the output may be changed to accommodate the new external connection. The setting may be set even if the present output does not use the setting (for example, setting the current post while sourcing voltage).
- The output and output mode should be programmed next with the OUT command.
- All other output parameters such as impedance compensation, offset, and waveforms should be programmed next.
- The error status should be checked with the ERR? command. The calibrator will not process the OPER command if an unacknowledged error exists.
- Finally, the Calibrator should be placed in operate with the OPER command.

A controller program first needs to initialize the interface and the Calibrator. Refer to following sample program:

```
10 INIT PORT 0 \ REMOTE @6        ! PUT THE 57LFC INTO THE REMOTE STATE
20 PRINT @6, “*RST;OUT 10V;OPER” ! RESET THE 57LFC, PROGRAM IT TO
                                  ! OUTPUT 10 VOLTS DC
```

If you wish to use SRQs, first use the `*SRE`, `*ESE`, and `ISCE` commands to enable the desired event. Refer to “Checking the Calibrator Status.”

You retrieve instrument parameters with a query (a programming command that ends with a question mark):

```
200 PRINT @6, "FUNC?"              ! RETRIEVE OUTPUT FUNCTION
210 INPUT LINE @6, A$
220 PRINT "Function is: "; A$
230 PRINT @6, "ONTIME?"            ! RETRIEVE ON TIME
240 INPUT LINE @6, A$
250 PRINT "The instrument has been on for "; A$;" minutes"
```

This program generates the following sample output:

```
Function is: DCV
The instrument has been on for 134 minutes
```

Check for programming errors as in the following sample programs. Check the Error Available (EAV) bit in the serial poll register using a serial poll.

```
300 A = SPL(6)                                 ! CHECK FOR ERRORS
310 IF (A AND 8) THEN PRINT "There was an error"
320 PRINT @6, "*CLS"                          ! CLEAR ERRORS
```

Retrieve errors and explanations as follows. Since errors are accumulated in a queue, you must read the entire queue to retrieve and clear all the errors.

```
400 PRINT @6, "ERR?"             ! CHECK FOR ERRORS
410 INPUT @6, A, A$               ! READ IN THE ERROR
420 IF (A = 0) THEN GOTO 500      ! NO MORE ERRORS
430 PRINT "Error# :";A, A$       ! PRINT ERROR# AND EXPLANATION
440 GOTO 400
500 END
```

Writing an SRQ and Error Handler

It is good practice to include fault (error) handling routines in your applications. The following sample program lines show a method for halting program execution on occurrence of an SRQ (Service Request) on the bus, checking to see if the Calibrator is the source of the SRQ, retrieving its fault messages, and acting on the faults. You should modify and extend this code as necessary for your application.

If you want to use SRQs, first use the `*SRE`, `*ESE`, and `ISCE` commands to enable the desired event. Refer to "Checking Calibrator Status" for more information.

```
10   INIT PORT0                  ! IFC the bus
20   CLEAR PORT0                 ! DCL the bus
30   ! INITIALIZE THE 57LFC SRQ HANDLER
40   PRINT @6, "*SRE 8"         ! Enable STB.EAV (error available)
50   ON SRQ GOTO 1100            ! Install SRQ handler
60   ! Body of the application goes here
1100  ! Bus SRQ handler
1110  CLEAR PORT0                ! Make sure devices are not confused
1120  IF (SPL(6) AND 64) THEN GOSUB 1200   ! If (STB.RQS) call SRQ
1130  ! TEST OTHER DEVICES RQS BITS IF DESIRED
1140  RESUME
1200  ! 57LFC SRQ handler
1210  IF (SPL(6) AND 8) THEN GOSUB 1300  ! If (STB.EAV) call handler
1220  ! Test other STB bits if desired here
1299  RETURN
1300  ! 57LFC STB.EAV (error) handler
1320  PRINT @6, "ERR?"          ! Read and clear error
1330  INPUT @6, E%, E$           ! Read in error # and explanation
1340  PRINT "Error# :";E, E$    ! Print error # and explanation
1350  IF (E% <> 0) THEN GOTO 1320 ! Until no more errors
1360  STOP                       ! Other commands for your app
1370  END
```

Verifying a Meter on the IEEE-488 Bus

This program selects 10 V dc output, verifies that the Calibrator is set to 10 V, then triggers a Fluke 45 to take a reading. It displays calibrator output, Fluke 45 reading, and the meter error in ppm. The program assumes that the Calibrator bus address is 4 and the Fluke 45 bus address is 1.

```
10 REM  THIS PROGRAM VERIFIES THE ACCURACY OF A FLUKE 45 AT 10V DC
20 INIT PORT 0                          ! INITIALIZE THE INTERFACE
30 CLEAR PORT 0                         ! “
40 PRINT @1, “VDC;RATE 5;AUTO;TRIGGER 2” ! SETS FLUKE 45 TO 10V DC
50 PRINT @1, “OUT 10 V ; OPER;          ! SET THE 57LFC TO 10V DC
60 PRINT @4, “*WAI; OUT?” ! WAIT FOR SETTLE, REQUEST THE OUTPUT VALUE
70 PRINT @4, V,U$,F,V2,U2$              ! GET THE DATA FROM THE 57LFC
80 PRINT @1, “*TRG;VAL?”               ! TRIGGER 45 TO TAKE READING
90 INPUT @1, VM                         ! GET THE DATA FROM THE 45
100 ER = ABS(V - VM)/V * 1E6            ! COMPUTE ERROR
110 PRINT “57LFC OUTPUT: “;V;U$         ! PRINT THE RESULTS
120 PRINT “45 MEASURED: “;VM;”V”
130 PRINT “ERROR:       “;ER;”PPM”
140 END
```

Verifying a Meter on the RS-232 UUT Serial Port

This program selects 10 V dc output, verifies that the Calibrator is set to 10 V, then triggers a Fluke 45 to take a reading. It displays Calibrator output, the Fluke 45 reading, and the meter error in ppm. The program assumes that the Calibrator uses the IEEE-488 interface with bus address is 4 and the Fluke 45 is on the Calibrator SERIAL 2 TO UUT port.

```
10  REM  THIS PROGRAM VERIFIES THE ACCURACY OF A FLUKE 45 AT 10V DC
20  INIT PORT 0                          ! INITIALIZE THE INTERFACE
30  CLEAR PORT 0                         ! “
40  PRINT @4, “UUT_SEND `VDC;RATE S;AUTO;TRIGGER 2\n’” ! SET FLUKE 45
50  PRINT @4, “UUT_RECV”                ! SEND THE FLUKE 45 PROMPT
60  PRINT @4, P$                         ! GET THE FLUKE 45 PROMPT
70  PRINT @4, “OUT 10 V ; OPER”         ! SET THE 57LFC TO 10 V DC
80  PRINT @4, “*WAI; OUT?”              ! WAIT FOR SETTLE; GET VALUE
90  PRINT @4, “V,U$,F,V2,U2$”           ! GET THE DATA FROM 57LFC
100 PRINT @4, “UUT_SEND `*TRG; VAL?\n’”  ! TRIGGER FLUKE 45 READING
110 PRINT @4, “UUT_RECV?”               ! SEND 45 READING TO 57LFC
120 INPUT @4, VM, P$                     ! GET 45 READING AND PROMPT
130 ER = ABS (V - VM)/V * 1E6            ! COMPUTE ERROR
140 PRINT “57LFC OUTPUT: “;V;U$          ! PRINT THE RESULTS
150 PRINT “FLUKE 45 MEASURED: “;ER;”PPM”  ! PRINT THE RESULTS
160 END
```

Using *OPC?, *OPC, and *WAI

The `*OPC?`, `*OPC`, and `*WAI` commands let you maintain control of the order of execution of commands that could otherwise be passed up by subsequent commands.

If you had sent an `OUT` command, you can check if the output has settled be sending the query `*OPC?`. As soon as the `OUT` command has completed (output settled), a “1” appears in the output buffer. You should always follow an `*OPC?` command with a read command. The read command causes program execution to pause until the addressed instrument responds. The following sample program shows how you can use `*OPC?`.

```
10 PRINT @4, “OUT 100V,1KHZ;OPER; *OPC?” ! 57LFC ADDRESS IS 4
20 INPUT @4, A                          ! READ THE “1” FROM THE 57LFC
30 !PROGRAM HALTS HERE UNTIL A “1” IS PUT INTO THE OUTPUT BUFFER
40 PRINT “OUTPUT SETTLED”
```

The *OPC command is similar in operation to the *OPC? query, except that it sets bit 0 (OPC for "Operation Complete") in the Event Status Register to 1 rather than sending a 1 to the output buffer. One simple use for *OPC is to include it in the program in order for it to generate an SRQ (Service Request). Then an SRQ handler written into the program can detect the operation complete condition and respond appropriately. You can use *OPC similarly to *OPC?, except your program must read the ESR to detect the completion of all operations. The following sample program shows how you can use *OPC.

```
10 REMOTE
20 PRINT @4, "OUT 100V,1KHZ;OPER;*OPC"  ! 57LFC ADDRESS IS 4
30 PRINT @4, "*ESR?"                    ! PUT THE ESR BYTE IN BUFFER
40 INPUT @4, A%                         ! READ THE ESR BYTE
50 IF (A% AND 1%) = 0% GOTO 30          ! TRY AGAIN IF NO OPC
60 PRINT "OUTPUT SETTLED"
70 END
```

The *WAI command causes the Calibrator to wait until any prior commands have been completed before continuing on to the next command, and takes no other action. Using *WAI is a convenient way to halt operation until the command or commands preceding it have completed. The following sample program shows how you can use *WAI.

```
10 REMOTE
20 PRINT @4, "OUT 100V,1KHZ;OPER;*WAI"  ! 57LFC ADDRESS IS 4
30 PRINT @4, "OUT?"                     ! READ THE OUTPUT VALUE
40 PRINT @4, A$,B$,C$                   ! A$ CONTAINS THE OUTPUT VALUE
50 PRINT "OUTPUT SETTLED"
60 PRINT "OUTPUT IS: ";A$;B$;" at ";C$
70 END
```

Input Buffer Operation

As the Calibrator receives each data byte from the controller, it places the bytes in a portion of memory called the input buffer. The input buffer holds up to 350 data bytes and operates in a first in, first out fashion.

The Calibrator treats the EOI IEEE-488 control line as a separate data byte and inserts it into the input buffer if it is encountered as part of a message terminator. Input buffer operation is transparent to the program running on the controller. If the controller sends commands faster than the Calibrator can process them, the input buffer fills to capacity. When the input buffer is full, the Calibrator holds off the IEEE-488 bus with the NRFD (Not Ready For Data) handshake line. When the Calibrator has processed a data byte from the full input buffer, it then completes the handshake, allowing the controller to send another data byte. The calibrator clears the input buffer on power-up and on receiving the DCL (Device Clear) or SDC (Selected Device Clear) messages from the controller.

Remote Commands

CAL_ABORT	
Description	At checkpoints during calibration, causes the cal procedure to abort.
Parameter	NONE
CAL_DATE?	
Description	Sequential command. Returns the date of the most recent calibration of the specified type.
Parameter	CAL (Last calibration of the calibrator) ZERO (Last dc V zero calibration)
Response	(Integer) Date as MMDDYY, DDMMYY, or YYMMDD, or YYYY-MM-DD depending on the setting of DATEFMT.
CAL_DAYS?	
Description	Sequential command. Returns the days since the most recent calibration of the specified type. Changing CLOCK after calibration causes a relative time shift in CAL_DAYS?.
Parameter	CAL (Last calibration of the calibrator) ZERO (Last dc V zero calibration)
Response	(Integer) Days
CAL_FAULT?	
Description	Get information about calibration error (if one occurred).
Parameter	NONE
Response	<error number> <step name>
CAL_INFO?	
Description	Returns message or instructions associated with running a cal step.
Parameter	NONE
Response	Message string
CAL_NEXT	
Description	During calibration, causes the internal procedure to sequence to the next step in the procedure.
Parameter	(optional) reference value in float format
CAL_REF?	
Description	Returns a nominal value expected for reference entry.
Parameter	NONE
Response	<floating point value><Units>

CAL_SKIP	
Description	Skip to the next entry point in the calibration procedure.
Parameter	NONE
Response	NONE

CAL_SECT	
Description	Skip to the next section in the calibration procedure.
Parameter	NONE
Response	NONE

CAL_START	
Description	Start a calibration procedure.
Parameter	MAIN (starts the main calibration procedure) ZERO (see CAL_ZERO for description) FACTORY (starts the procedure run in the factory) DIAG (diagnostic pseudo-cal procedure used for debug) NOT (aborts a procedure after the start)
Response	NONE
Note: This command is an alternate to the CAL_MAIN command used by the 57xxA	

CAL_STATE?	
Description	Return state of current calibration.
Parameter	NONE
Response	RUN - running a calibration step REF - Waiting for a CAL_NEXT with reference value INS - Instruction available, waiting for CAL_NEXT NOT - Not in a calibration procedure (or at the end of one)

CAL_STEP?	
Description	Returns name of step currently running.
Parameter	NONE
Response	Message string

CAL_STORE	
Description	Sequential command. Stores all new calibration constants in nonvolatile memory. Use this command to save the results after you are completely finished with calibration via remote control. The CALIBRATION switch must be in the ENABLE position or an execution fault results.
Parameter	None

CAL_STORE?	
Description	Return whether a Cal Store is needed
Parameter	NONE
Response	1 means yes, 0 means no
CAL_SW?	
Description	Return position of the cal enable switch.
Parameter	NONE
Response	1 is enabled, 0 is disabled
CAL_ZERO	
Description	Overlapped long-term command. Performs internal zeros calibration and does not require setting the CALIBRATION switch.
Parameter	None
Note: The Calibrator will have additional calibration commands to store and retrieve specific calibration constants, and to store calibration date and time.	
CLOCK	
Description	Sequential command. Sets the clock/calendar. The rear panel CALIBRATION switch must be in the ENABLE position or an execution fault results. Changing CLOCK can cause a relative time shift in ONTIME? or CAL_DAYS?.
Parameters:	1. Time in 24-hour format as HHMMSS 2. Date as MMDDYY, DDMMYY, YYMMDD, YYYYMMDD depending on the setting of the DATEFMT.
Examples	CLOCK 133700, 071703 (Sets the clock/calendar to 1:37 p.m., July 17, 2003 if DATEFMT is MDY). CLOCK 20031123, 080000 (Sets the clock/calendar to 8:00 a.m., November 23, 2003 if DATEFMT is ISO8601).
CLOCK?	
Description	Sequential command. Returns the setting of the clock/calendar.
Parameter	None
Response	1. (Integer) Time in 24-hour format as HHMMSS or HH:MM:SS. 2. (Integer) Date as MMDDYY, DDMMYY, YYMMDD, OR YYYY-MM-DD depending on the setting of DATEFMT.
Example:	CLOCK? (Returns 150000,092103 or 2003-09-21 15:00:00 if the clock/calendar is set to 3 p.m., September 21, 2003.

***CLS**	
Description	Sequential command. (Clear status.) Clears the ESR, ISCR, the fault queue, and the RQS bit in the status byte. This command terminates pending operation complete commands (*OPC or *OPC?).
Parameter	None
CUR_POST	
Description	Sequential command. Selects the binding posts for current output. Once set, the calibrator retains the current post setting during power-off periods.
Parameter	NORMAL (Selects the OUTPUT HI binding post).
CUR_POST?	
Description	Sequential command. Returns the binding posts for current output.
Parameter	None
Response	(String) NORMAL (The OUTPUT HI binding post is selected).
DATEFMT	
Description	Determine the format for clock/calendar front panel date display and entry, for entering and reading the date remotely using the CLOCK and CLOCK? commands, and for displaying calibration dates on the front panel and in calibration reports.
Parameter	MDY (Display: MM/DD/YY, remote and front panel entry: MMDDYY) DMY (Display: DD.MM.YY, remote and front panel entry: DDMMYY) YMD (Display: YYMMDD, remote and front panel entry: YYMMDD). `ISO8601` (Display: YYYY-MM-DD HH:MM:SS, date entry: YYYYMMDD, HHMMSS).
DATEFMT?	
Description	Returns the date format setting (see DATEFMT for its applications).
Parameter	None
Response	(String) MDY (Display: MMDDYY, date entry: MMDDYY), DMY (Display: DDMMYY, date entry: DDMMYY), or YMD (Display: YYMMDD, date entry: YYMMDD) `ISO8601` (Display: YYYY-MM-DD HH:MM:SS, date entry:YYYYMMDD, HHMMSS)

DBMOUT?	
Description	Sequential command. Same as OUT? except that if output is ac V, the returned magnitude is converted to dBm for the appropriate load (600 Ω standard ac V).
Parameter	None
Response	(Float) Output value (String) Units (DBM, V, A, or OHM) (Float) Frequency (0 if dc or ohms)
Examples	1.256983E+01,V,0 (12.56983V) 28.345,DBM,442 1.9E+06,OHM,0 (1.9 MΩ)
DIAG	
Description	Overlapped long-term command. Runs a self-diagnostics routine. If any faults are detected, they are logged into the fault queue where they can be read by the FAULT? query. The response to faults that occur during remote-controlled diagnostics depends on the setting of the DIAGFLT command. See Appendix A for diagnostic fault messages.
Parameter	ALL (Runs all diagnostics routines) CONT (Continues execution of diagnostics) ABORT (Terminates execution of diagnostics)
DIAGFLT	
Description	Sequential command. Determines the response to faults that occur during remote-controlled diagnostics. In all cases the fault encountered is logged into the fault queue before the calibrator takes any action as set by this command.
Parameter	ABORT (Terminates diagnostics) CONT (Diagnostics continues to completion, logging any more faults as encountered) SSTEP(single step) BACKUP (default)
DIAGFLT?	
Description	Sequential command. Returns the setting of DIAGFLT.
Parameter	None
Response	(String) ABORT, CONT, SSTEP, or BACKUP

ECHO?	
Description	Sequential command. Echoes a string back to the remote interface port. Upper or lower case remains intact in this command.
Parameter	Any string but backslash is escape character for special character following backslash.
Response	(String including delimiting quotation marks)
Example:	ECHO? "123abc456" Returns: "123abc456"

ERR?	
Description	Returns the first error code with an explanation (and source subsystem in parenthesis) contained in the Calibrator error queue, then removes that error code from the queue .
Parameter	None
Response	
Example:	0,"No Error (REM)"

***ESE**	
Description	Sequential command. Loads a byte into the Event Status Enable Register.
Parameter	The decimal equivalent of the binary number to load into the register (0-255 only).
Example:	*ESE 140 Enables bits 2 (QYE), 3 (DDE), and 7 (PON), and disables all the other bits.

***ESE?**	
Description	Sequential command. Returns the byte from the Event Status Enable register.
Parameter	None
Response	(Integer) Decimal equivalent of the register byte.
Example:	*ESE? Returns: "140" if bits 2 (QYE), 3 (DDE), and 7 (PON) are enabled (1) and the rest of the bits are disabled (0).

***ESR?**	
Description	Sequential command. Returns the byte from the Event Status Register and clears the register.
Parameter	None
Response	(Integer) Decimal equivalent of the register byte.
Example:	*ESR? Returns: "140" if bits 2 (QYE), 3 (DDE), and 7 (PON) are set (1) and the rest of the bits are reset (0)
EXPLAIN?	
Description	Sequential command. Explains a fault code. This command returns a string that explains the fault code furnished as the parameter. The fault code (same as the parameter) is originally obtained by sending the FAULT? query. EXPLAIN? Or FAULT? do not handle any optional error parameters beyond the fault code.
Parameter	The fault code (an integer).
Response	(String) An explanation of the fault code without %value parameter that an actual FAULT? explains.
Example:	EXPLAIN? 1300 Returns: "Bad syntax"
EXTGUARD	
Description	Overlapped command. Sets the calibrator to internal or external guard. (The same as pressing EX GRD in local operation.) The default is internal guard.
Parameter	ON (Sets the calibrator to external guard) OFF (Sets the calibrator to internal guard)
EXTSENSE	
Description	Overlapped command. Selects internal or external sensing. The default is internal sensing.
Parameter	ON (Sets the calibrator to external sensing) OFF (Sets the calibrator to internal sensing)

FAULT?	
Description	Sequential command. Returns the earliest fault code contained in the calibrator's fault queue. After you get the fault code, you can use the EXPLAIN? command to find out the meaning of the fault code. Use the ERR? command instead of FAULT? to obtain the fault code and explanatory text including any optional error parameters. See Appendix A for a listing of fault codes. A zero value is returned if there are no faults, so to read the entire contents of the fault queue, repeat FAULT? until the response is "0."
Parameter	None
Response	(Integer) The fault code

FORMAT	
Description	Sequential command. Use with extreme care. Restores the contents of flash memory to factory defaults. The flash memory holds calibration constants and setup parameters. You lose all calibration data permanently. The CALIBRATION switch must be in the ENABLE position, or an execution fault occurs.
Parameter	CAL (Replaces all cal constants with defaults)

***IDN?**	
Description	Sequential command. Returns instrument model number and firmware version letters for the main, inguard.
Parameter	None
Response	(String, string, 0, string) A message containing four fields separated by commas, as follows: Fluke Model number Serial number Two firmware versions: one each for the Main CPU, the encoder version and the Inguard CPU.
Example:	FLUKE,57LFC,1234567,1.0+1.2+1.8

IEEE_ADDR	
Description	Sequential command. Sets the IEEE address and also stores new IEEE address in non-volatile memory.
Parameters:	IEEE address
Examples	IEEE_ADDR 4

INCR	
Description	Overlapped command. Increments the output amplitude and enters error mode, the same as using the output adjustment knob in local operation.
Parameter	Increment step size; positive for incremental step, negative for decremental step. Units (optional) specify magnitude or frequency.
Examples	INCR -.00001 Enters error mode and decrements the output by .00001. INCR 1 Hz Enters error mode and increments the frequency by 1 Hz.

ISCE	
Description	Sequential command. Loads a byte into the Instrument Status Change Enable register.
Parameter	The decimal equivalent of the binary number to load into the register.
Example:	ISCE 48 Enables bits 4 (RCOMP), and 5 (RLOCK) in the Service Request Enable register.

ISCE?	
Description	Sequential command. Returns the byte from the Instrument Status Change Enable register.
Parameter	None
Response	The decimal equivalent of the register contents byte.
Example:	ISCE? Returns: "32" if bit 5 (RLOCK) is enabled (1) and the rest of the bits are disabled (0).

ISCR?	
Description	Sequential command. Returns and clears the byte from the Instrument Status Change Register. The Calibrator ignores bit assignments that are not applicable (e.g. WBND, SCALE, OFFSET, etc.)
Parameter	None
Response	The decimal equivalent of the register contents byte.
Example:	ISCR? Returns: "4" if bit 2 (EXSENS) is set (1) and the rest of the bits are reset (0). (See "Checking the Calibrator Status" for details.)

ISR?	
Description	Sequential command. Returns and clears the byte from the Instrument Status Register. The Calibrator ignores bit assignments that are not applicable (e.g. WBND, SCALE, OFFSET, etc.)
Parameter	None
Response	The decimal equivalent of the register contents byte.
Example:	ISR? Returns: "16" if bit 4 (RCOMP) is set (1) and the rest of the bits are reset (0). (See "Checking the Calibrator Status" for details.)

LCOMP	
Description	Inductive compensation command. Activates or deactivates inductive load compensation for AC current output. For current output, compensation is allowed when the frequency is less than 440 Hz and the amplitude is less than 0.22 A. Compensation is also allowed when the frequency is less than 1 kHz and the amplitude is greater than or equal 0.22 A .
Parameter	OFF or ON
Example:	LCOMP ON

LCOMP?	
Description	Inductive compensation query. Returns whether inductive load compensation for AC current output is active.
Parameter	OFF (Inductive load compensation circuitry is off) ON (Inductive load compensation circuitry is on)
Example:	LCOMP? Returns: ON

LIMIT	
Description	Sequential command. Sets the maximum permissible output magnitudes, negative and positive. Both parameters must be present, and the units must be none, volts, or amps. The units must not conflict. If no units are specified, V is assumed.
Parameter	Positive limit value with optional multiplier and optional unit. Negative limit value with optional multiplier and optional unit.
Example:	LIMIT 1.8A, -1.2A Sets the limit for ac and positive dc current to 1.8 A, and negative dc current to -1.2 A.

LIMIT?	
Description	Sequential command. Returns the programmed output magnitude limits for voltage and current.
Response	(Float, float, float, float) Positive voltage limit value Negative voltage limit value Positive current limit value Negative current limit value
Example:	LIMIT? Returns: "2.20E-2,-1.0E-2,1.8E0,-1.2E0" if the programmed voltage range is -100 to 220 V, and the programmed current range is -1.2 to 1.8 A.
ONTIME?	
Description	Sequential command. Returns the time in minutes since the calibrator was turned on. Changing CLOCK after power on causes a relative time shift in ONTIME?.
Parameters:	None.
Response	(Integer) Number of minutes since power-up this session.
***OPC**	
Description	Sequential command. Sets bit 0 (OPC for "Operation Complete") in the Event Status Register to 1 when all pending device operations are complete.
Parameter	None
Response	Sets bit 0 (OPC for "Operation Complete") in the Event Status Register to 1 when all pending device operations are complete.
Example:	After sending an OUT command, check if the output has settled by sending *OPC. As soon as the output has settled, a pending *OPC command sets bit 0 (OPC for "Operation Complete") in the Event Status Register to 1. The command to read the ESR is *ESR?.
***OPC?**	
Description	Sequential command. Causes program execution to pause until all operations are complete; returns a 1 upon completion of these operations. (Also see *WAI).
Parameter	None
Response	(Integer) "1" after all operations are complete.
Example:	If you had sent an OUT command, you can check if the output has settled by sending *OPC or *OPC?. As soon as the OUT command has completed (output settled), a pending *OPC command places a "1" in the output buffer to be read by the controller.

OPER	
Description	Overlapped command. Activates the calibrator's output if in standby. OPER is inhibited for outputs 22 V and over, if there are faults in the fault queue (see "Fault Queue").
Parameter	None
OPER?	
Description	Sequential command. Returns the present output operate or standby state.
Parameter	None
Response	1 for Operate or 0 for Standby
***OPT?**	
Description	Sequential command. Returns a list of analog modules installed in the calibrator, including any auxiliary amplifiers that are attached.
Parameter	None
Response	(Series of strings) A list of the modules and auxiliary amplifiers, separated by commas.
Example:	"DC Volt Module ","AC Volt Module ","Current Module ","Ohms Module "
OUT	
Description	Overlapped command. Sets the output of the calibrator and establishes a new reference point for shifting the output to determine UUT error. If only one parameter is supplied, the calibrator makes the minimum change needed to comply with the requested output. For example, if the calibrator setting is 1 V, 100 Hz and you send "OUT 2V", the setting changes to 2 V, 100 Hz.
Parameters:	(Optional) Output amplitude with optional multiplier and unit. (At least one parameter must be sent.) (Optional) Output frequency with optional multiplier and unit. (At least one parameter must be sent.)
Examples	OUT -15.2 V (-15.2 V; frequency unchanged) OUT 188.3 MA, 442 HZ (188.3 mA, 442 Hz) OUT 1.9 MOHM (1.9 MΩ) OUT 100 HZ (Sets the frequency only)

OUT?	
Description	Sequential command Returns the calibrator's output amplitude and frequency (does not include multipliers).
Parameter	None
Response	(Float) Output amplitude (String) Units (V, DBM, A, or OHM) (Float) Frequency (0 if dc or ohms)
Examples	1.256983E+01,V,0 (12.56983V) 1.883E-01,A,4.42E+02 (188.3 mA, 442 Hz) 1.9E+06,OHM,0 (1.9 MΩ)

***PUD**	
Description	Sequential command. (Protected user data command.) Allows a string of bytes to be stored in nonvolatile memory. (The CALIBRATION switch must be enabled.)
Parameter	#0 \<user data\> <ASCII Line Feed with EOI> or #<non-zero digit> \<digits\> \<user data\> For both forms, the bytes received in the \<user data\> field are stored in nonvolatile memory; allowing up to 63 bytes. The first form accepts data bytes after the #0 until the ASCII Line Feed character is received with an EOI signal. In the second form, the non-zero digit specifies the number of characters (0 - 9, or ASCII 48 - 57 decimal), in the \<digits\> field. The value in the \<digits\> field defines the number of user data bytes in the \<user data\> field.
Example:	*PUD #0FLUKE<Line Feed with EOI> or *PUD #15FLUKE Both examples store the word FLUKE in the protected user data area. *Note* *The 1 indicates that one digit must follow (in this case '5'), and the 5 indicates that five characters are in the remainder of the *PUD message (in this case, FLUKE).*

***PUD?**	
Description	Sequential command. Returns the contents of the *PUD (Protected User Data) memory.
Parameter	None
Response	#(non-zero digit) (digits) (user data) The non-zero digit specifies the number of characters that will follow in the \<digits\> field. These characters are 0 through 9 (ASCII 48 through 57 decimal). The value of the number in the \<digits\> field defines the number of user data bytes that follow in the \<user data\> field. The maximum response is 64 characters.
Example	*PUD? Returns: "205FLUKE" assuming that this is stored as in the example for PUD* above.
RANGE?	
Description	Sequential command. Returns the present output range.
Parameter	None
Response	(String) Symbolic name of the range from Table 1-5.
RANGELCK	
Description	Overlapped command. Locks or unlocks the present output range. The range automatically unlocks if the output function changes, for example from dc volts to dc current. Does not apply to alternating ranges.
Parameter	ON (Locks the range) OFF (Unlocks the range)
RCOMP	
Description	Overlapped command. While a resistance output 10 kΩ or lower is selected, RCOMP activates or deactivates two-wire ohms compensation circuitry.
Parameter	ON (Turns on the two-wire compensation circuitry) OFF (Turns off the two-wire compensation circuitry)
***RST**	
Description	Overlapped command. (Reset.) Sets the calibrator to its power-up default state: 0 V, 0 Hz, Standby, [EX SNS] off, range lock off, two-wire compensation off. *RST does not affect any of the following: • Status Register Enable setting • Contents of nonvolatile memory

***SRE**	
Description	Sequential command. Loads a byte into the Service Request Enable register (SRE)
Parameter	The decimal equivalent of the binary number to load into the register.
Example:	*SRE 56 Enables bits 3 (EAV), 4 (MAV), and 5 (ESB) in the Service Request Enable register.
***SRE?**	
Description	Sequential command. Returns the byte from the Service Request Enable register
Parameter	None
Response	(Integer) The decimal equivalent of the register byte.
Example:	*SRE? Returns: "56" if bits 3 (EAV), 4 (MAV), and 5 (ESB) are enabled (1) and the rest of the bits are disabled (0).
***STB?**	
Description	Sequential command. Returns the status byte.
Parameter	None
Response	(Integer) Decimal equivalent of the status byte.
Example:	*STB? Returns: "72" if bits 3 (EAV) and 6 (RQS) are set (1) and the rest of the bits are reset (0).
STBY	
Description	Overlapped command. Puts the calibrator in standby.
Parameter	None
***TST?**	
Description	Sequential command. Initiates a series of self-tests, then returns a "0" for pass or a "1" for fail. If any faults are detected, they are logged into the fault queue where they can be read by the FAULT? query.
Parameter	None
Response	(Integer) 0 (for Pass) or 1 (for Fail)

*WAI	
Description	Sequential command. (Wait-to-Continue.) This command prevents further remote commands from being executed until all previous remote commands have been executed. (See also *OPC.)
Parameter	None
Example:	If you had sent an OUT command, you can cause the calibrator to wait until the output has settled before continuing on to the next command by following OUT with a *WAI command. This is useful because OUT is an overlapped command, which means the calibrator would normally go on to process other commands before completing the OUT command.

Chapter 4
Operator Maintenance

Introduction

This chapter explains how to perform the routine maintenance and calibration tasks required to keep your calibrator in optimal operating condition. The tasks covered in this chapter include the following.

- Replacing the fuse
- Cleaning the air filter and external surfaces
- Calibrating to external standards

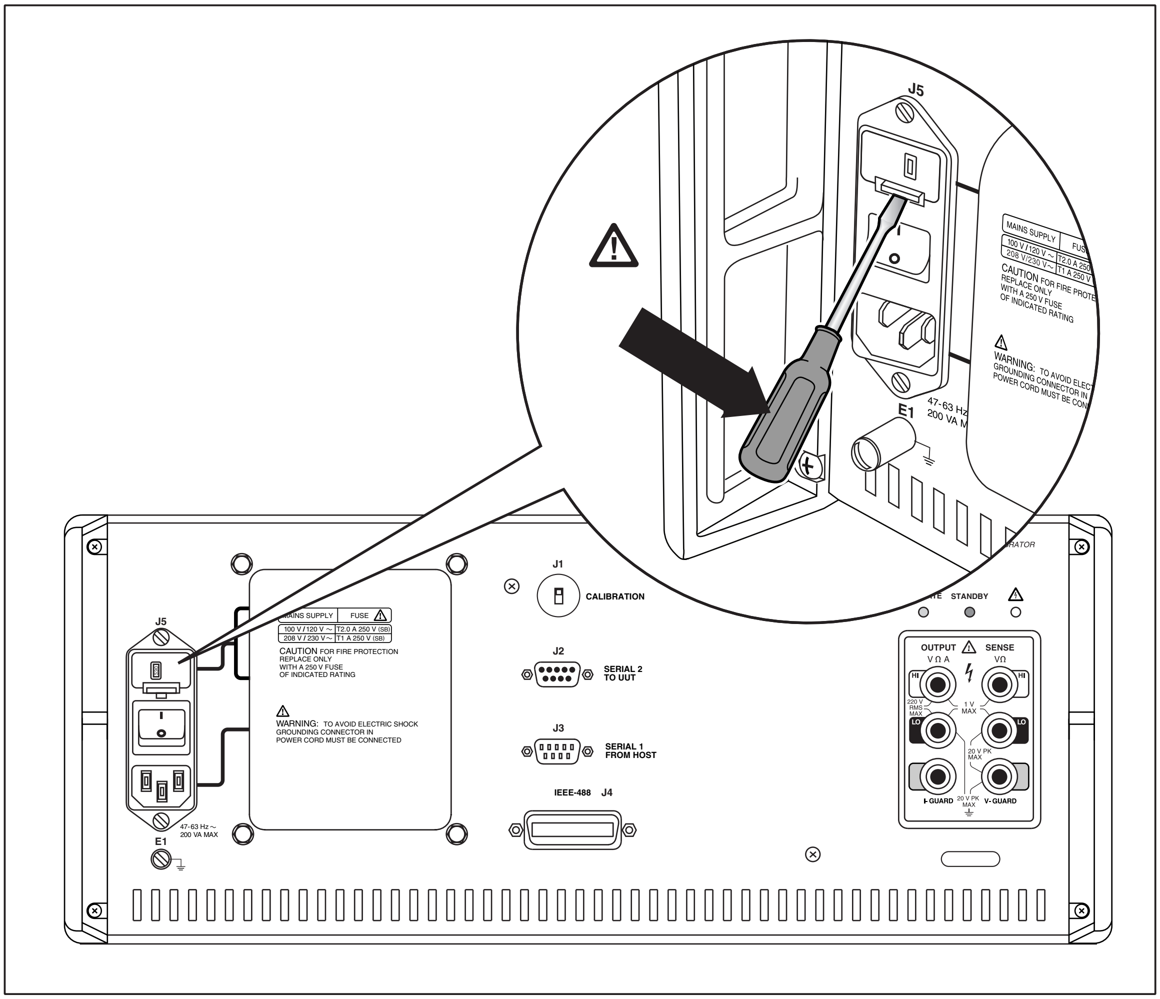
Replacing the Fuse

⚠⚠Caution

To prevent instrument damage, verify that the correct fuse is installed for the line voltage setting.

The line power fuse is accessible on the front panel. The fuse rating label to the right of the fuse holder shows the correct replacement fuse rating for each operating voltage. To check or replace the fuse:

1. Disconnect line power.
2. Insert a small screwdriver in the fuse holder release slot and push upward until the fuse compartment pops free. See Figure 4-1.
3. Slide the fuse and fuse holder out of the fuse compartment.
4. Inspect or replace the fuse.
5. Install the fuse compartment in the calibrator.



apw004f.eps

Figure 4-1. Replacing the Fuse

Cleaning the Air Filter

⚠⚠Caution

Damage caused by overheating may occur if the area around the fan is restricted, the intake air is too warm, or the air filter becomes clogged.

The air filter must be removed and cleaned at least every 30 days, or more frequently if the calibrator is operated in a dusty environment. The air filter is accessible from the rear panel of the calibrator. To clean the air filter:

1. Disconnect line power.
2. Remove the filter by pulling the filter's retainer downwards (it hinges at the bottom) and removing the filter element.
3. Clean the filter by washing it in soapy water. Rinse and dry it thoroughly before reinstalling.
4. Reinstall the filter.

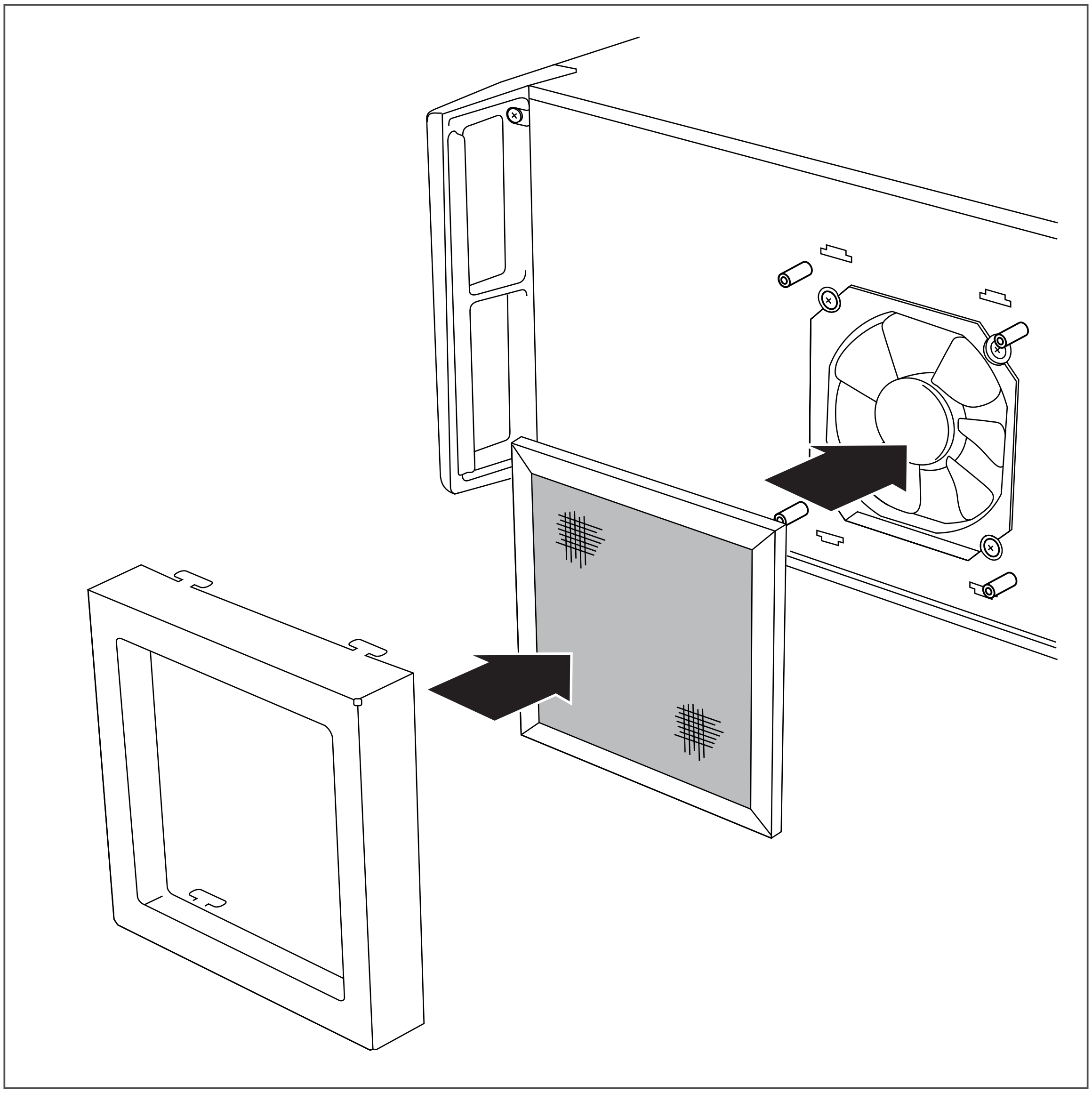


Figure 4-2. Accessing the Air Filter

Cleaning the Exterior

To keep the calibrator looking like new, clean the case using a soft cloth slightly dampened with either water or a non-abrasive mild cleaning solution that is not harmful to plastics.

⚠⚠Caution

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They can damage the plastic materials used in the calibrator.

Calibration

For calibration information, refer to the *57LFC/AN Service Manual*.

Appendices

Appendix A
Fault Codes

Code	Error
0	No Error
1	Error queue overflow
101	Inguard not responding (send)
102	Hardware relay trip occurred
103	Inguard is obsolete
104	Inguard parity error
105	Inguard overrun error
106	Inguard framing error
107	Received unexpected data (IG)
200	Can't download waveform
300	Invalid procedure number
301	No such step in procedure
302	Can't change that while busy
303	Can't begin/resume cal there
304	Wrong unit for reference
305	Entered value out of bounds
306	Not waiting for a reference
307	Continue command ignored
308	Cal constant outside limits
309	Cal try to null failed
310	Sequence failed during cal.
311	A/D measurement failed
312	Invalid cal step parameter
313	Cal switch must be ENABLED

Code	Error
314	Divide by zero encountered
315	Must be in OPER at this step
316	Zero cal needed every 15 days
317	Unusual cal fault %d
318	Fault during %s
400	Encoder not responding VERS
401	Encoder self-test failed
402	Message over display R side
403	Unmappable character #%d
404	Encoder got invalid command
405	Encoder unexpectedly reset
501	Invalid keyword or choice
502	Frequency must be >= 0
503	AC magnitude must be > 0
504	Impedance must be >= 0
505	Function not available
506	Value not available
507	Output exceeds user limits
508	Duty cycle must be 1.0-99.0
509	Can't select that field now
510	Edit digit out of range
511	Not editing output now
512	dBm only for single sine ACV
513	Freq too high for non-sine
514	Value outside locked range
515	Must specify an output unit
516	Can't do two freqs at once
517	Limit too small or large
518	No changes except RESET now
519	Cannot edit to or from 0 Hz
520	Bad state image - not loaded
521	Can't set an offset now
522	Can't lock this range
523	Can't change duty cycle now

Code	Error
524	Can't change compensation now
525	STA couldn’t update OTD
526	Compensation is now OFF
527	Period must be >= 0
528	A report is already printing
529	Time limit must be 1s-60s
530	Can't turn EXGRD on now
531	Slave cannot send SYNCOUT
532	Can't set sensing now
600	Outguard watchdog timeout
601	Power-up RAM test failed
700	Saving to NV memory failed
701	NV memory invalid
702	NV invalid so default loaded
703	NV obsolete so default loaded
800	Serial parity error %s
801	Serial framing error %s
802	Serial overrun error %s
803	Serial characters dropped %s
1000	Sequence failed during diag
1001	Invalid diag step parameter
1002	Setting VDAC
1003	Setting IDAC
1004	Diagnostic circuitry
1005	Relay failure
1006	Test limits exceeded
1007	Temp sensor A7-MP2 faulty
1008	Temp sensor A7-MP3 faulty
1009	Temp sensor A8-MP6 faulty
1010	Temp sensor A8-MP7 faulty
1011	Temp sensor A8-M9 faulty
1012	Temp sensor A8-MP11 faulty
1300	Bad syntax
1301	Unknown command

Code	Error
1302	Bad parameter count
1303	Bad keyword
1304	Bad parameter type
1305	Bad parameter unit
1306	Bad parameter value
1307	488.2 I/O deadlock
1308	488.2 interrupted query
1309	488.2 unterminated command
1310	488.2 query after indefinite response
1311	Invalid from GPIB interface
1312	Invalid from serial interface
1313	Service only
1314	Parameter too long
1315	Invalid device trigger
1316	Serial buffer full
1317	Service command failed
1318	Bad binary number
1319	Bad binary block
1320	Bad character
1321	Bad decimal number
1322	Exponent magnitude too large
1323	Bad hexadecimal block
1324	Bad hexadecimal number
1325	Bad octal number
1326	Too many characters
1327	Bad string
1328	OPER not allowed while error pending
1329	Bad or missing DATEFMT
1330	Invalid time
1331	Invalid date
1501	Compliance voltage exceeded
1502	I Amp thermal limit exceeded
1503	Output current lim exceeded
1504	Input V or A limit exceeded

Code	Error
1505	VDAC counts out of range
1506	IDAC counts out of range
1507	AC scale dac out of range
1508	DC scale dac out of range
1509	IDAC DC OFFSET out of range
1510	Can't read Ext Clk register
1511	External Clock too fast
1512	External Clock too slow
1513	Unknown range
1514	High voltage MP6 temp exceeded
1515	High voltage MP7 temp exceeded
1516	High voltage MP9 temp exceeded
1517	High voltage MP11 temp exceeded
1518	Amps MP2 temp exceeded
1519	Amps MP3 temp exceeded
1520	HV 220V output current exceeded (+)
1521	HV 220V output current exceeded (-)
1522	Sequence failed during NRM
1523	A/D reading failed during NRM
1524	Analog control loop unstable NRM
65535	Unknown error %d

Appendix B
ASCII and IEEE Bus Codes

ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE		ASCII CHAR.	DECIMAL	OCTAL	HEX	BINARY 7654 3210	DEV. NO.	MESSAGE ATN=TRUE	
NUL	0	000	00	0000 0000			ADDRESSED COMMANDS	@	64	100	40	0100 0000	0	MTA	TALK ADDRESSES
SQH	1	001	01	0000 0001		GTL		A	65	101	41	0100 0001	1	MTA	
STX	2	002	02	0000 0010				B	66	102	42	0100 0010	2	MTA	
ETX	3	003	03	0000 0011				C	67	103	43	0100 0011	3	MTA	
EOT	4	004	04	0000 0100		SDC		D	68	104	44	0100 0100	4	MTA	
ENQ	5	005	05	0000 0101		PPC		E	69	105	45	0100 0101	5	MTA	
ACH	6	006	06	0000 0110				F	70	106	46	0100 0110	6	MTA	
BELL	7	007	07	0000 0111				G	71	107	47	0100 0111	7	MTA	
BS	8	010	08	0000 1000		GET		H	72	110	48	0100 1000	8	MTA	
HT	9	011	09	0000 1001		TCT		I	73	111	49	0100 1001	9	MTA	
LF	10	012	0A	0000 1010				J	74	112	4A	0100 1010	10	MTA	
VT	11	013	0B	0000 1011				K	75	113	4B	0100 1011	11	MTA	
FF	12	014	0C	0000 1100				L	76	114	4C	0100 1100	12	MTA	
CR	13	015	0D	0000 1101				M	77	115	4D	0100 1101	13	MTA	
SO	14	016	0E	0000 1110				N	78	116	4E	0100 1110	14	MTA	
SI	15	017	0F	0000 1111				O	79	117	4F	0100 1111	15	MTA	
DLE	16	020	10	0001 0000			UNIVERSAL COMMANDS	P	80	120	50	0101 0000	16	MTA	
DC1	17	021	11	0001 0001		LLO		Q	81	121	51	0101 0001	17	MTA	
DC2	18	022	12	0001 0010				R	82	122	52	0101 0010	18	MTA	
DC3	19	023	13	0001 0011				S	83	123	53	0101 0011	19	MTA	
DC4	20	024	14	0001 0100		DCL		T	84	124	54	0101 0100	20	MTA	
NAK	21	025	15	0001 0101		PPU		U	85	125	55	0101 0101	21	MTA	
SYN	22	026	16	0001 0110				V	86	126	56	0101 0110	22	MTA	
ETB	23	027	17	0001 0111				W	87	127	57	0101 0111	23	MTA	
CAN	24	030	18	0001 1000		SPE		X	88	130	58	0101 1000	24	MTA	
EM	25	031	19	0001 1001		SPD		Y	89	131	59	0101 1001	25	MTA	
SUB	26	032	1A	0001 1010				Z	90	132	5A	0101 1010	26	MTA	
ESC	27	033	1B	0001 1011				[	91	133	5B	0101 1011	27	MTA	
FS	28	034	1C	0001 1100				\	92	134	5C	0101 1100	28	MTA	
GS	29	035	1D	0001 1101				]	93	135	5D	0101 1101	29	MTA	
RS	30	036	1E	0001 1110				^	94	136	5E	0101 1110	30	MTA	
US	31	037	1F	0001 1111				_	95	137	5F	0101 1111		UNT	
SPACE	32	040	20	0010 0000	0	MLA	LISTEN ADDRESSES	‘	96	140	60	0111 0000	0	MSA	SECONDARY ADDRESSES
!	33	041	21	0010 0001	1	MLA		a	97	141	61	0111 0001	1	MSA	
"	34	042	22	0010 0010	2	MLA		b	98	142	62	0111 0010	2	MSA	
#	35	043	23	0010 0011	3	MLA		c	99	143	63	0111 0011	3	MSA	
$	36	044	24	0010 0100	4	MLA		d	100	144	64	0111 0100	4	MSA	
%	37	045	25	0010 0101	5	MLA		e	101	145	65	0111 0101	5	MSA	
&	38	046	26	0010 0110	6	MLA		f	102	146	66	0111 0110	6	MSA	
'	39	047	27	0010 0111	7	MLA		g	103	147	67	0111 0111	7	MSA	
(	40	050	28	0010 1000	8	MLA		h	104	150	68	0111 1000	8	MSA	
)	41	051	29	0010 1001	9	MLA		i	105	151	69	0111 1001	9	MSA	
*	42	052	2A	0010 1010	10	MLA		j	106	152	6A	0111 1010	10	MSA	
+	43	053	2B	0010 1011	11	MLA		k	107	153	6B	0111 1011	11	MSA	
,	44	054	2C	0010 1100	12	MLA		l	108	154	6C	0111 1100	12	MSA	
—	45	055	2D	0010 1101	13	MLA		m	109	155	6D	0111 1101	13	MSA	
.	46	056	2E	0010 1110	14	MLA		n	110	156	6E	0111 1110	14	MSA	
/	47	057	2F	0010 1111	15	MLA		o	111	157	6F	0111 1111	15	MSA	
0	48	060	30	0011 0000	16	MLA		p	112	160	70	0111 0000	16	MSA	
1	49	061	31	0011 0001	17	MLA		q	113	161	71	0111 0001	17	MSA	
2	50	062	32	0011 0010	18	MLA		r	114	162	72	0111 0010	18	MSA	
3	51	063	33	0011 0011	19	MLA		s	115	163	73	0111 0011	19	MSA	
4	52	064	34	0011 0100	20	MLA		t	116	164	74	0111 0100	20	MSA	
5	53	065	35	0011 0101	21	MLA		u	117	165	75	0111 0101	21	MSA	
6	54	066	36	0011 0110	22	MLA		v	118	166	76	0111 0110	22	MSA	
7	55	067	37	0011 0111	23	MLA		w	119	167	77	0111 0111	23	MSA	
8	56	070	38	0011 1000	24	MLA		x	120	170	78	0111 1000	24	MSA	
9	57	071	39	0011 1001	25	MLA		y	121	171	79	0111 1001	25	MSA	
:	58	072	3A	0011 1010	26	MLA		z	122	172	7A	0111 1010	26	MSA	
;	59	073	3B	0011 1011	27	MLA		{	123	173	7B	0111 1011	27	MSA	
<	60	074	3C	0011 1100	28	MLA		|	124	174	7C	0111 1100	28	MSA	
=	61	075	3D	0011 1101	29	MLA		}	125	175	7D	0111 1101	29	MSA	
>	62	076	3E	0011 1110	30	MLA		~	126	176	7E	0111 1110	30	MSA	
?	63	077	3F	0011 1111		UNL		DEL	127	177	7F	0111 1111		UNS	

apw016f.eps

Appendix C
Glossary

adc (analog-to-digital converter)

A device or circuit that converts an analog voltage to digital signals.

absolute uncertainty

Uncertainty specifications that include the error contributions made by all equipment and standards used to calibrate the instrument. Absolute uncertainty is the number to compare with the UUT for determining test uncertainty ratio.

accuracy

The degree to which the measured value of a quantity agrees with the true (correct) value of that quantity. Accuracy is the same as 1 minus the percent uncertainty. (See uncertainty.) For example, an instrument specified to +/-1% uncertainty is 99% accurate.

assert

To cause a digital signal line to go into a logic true state.

af (audio frequency)

The frequency range of human hearing; normally 15 - 20,000 Hz.

artifact standard

An object that produces or embodies a physical quantity to be standardized, for example a Fluke 732B dc Voltage Reference Standard.

base units

Units in the SI system that are dimensionally independent. All other units are derived from base units. The only base unit in electricity is the ampere.

buffer

Refers to either an area of digital memory for temporary storage of data, or an amplifier stage before the final amplifier.

burden voltage

The maximum sustainable voltage across the terminals of a load.

calibration check

A fast, simple, automated procedure to provide ad confidence between calibration recalls, and data that can be used to develop a history of the calibrator's performance between calibrations. No changes are made to stored constants, and the internal check standards are used as the reference points instead of external standards as in the routine calibration procedure.

calibrate

To compare a measurement system or device of unknown accuracy to a measurement system or device of known and greater accuracy to detect or correct any variation from required performance of the unverified measurement system or device.

calibration

The comparison of a measurement system or device of unknown accuracy to a measurement system or device of known and greater accuracy to detect or correct any variation from required performance of the unverified measurement system or device.

calibration constant

A correction factor that is applied manually or automatically to correct the output or reading of an instrument.

calibration curve

A smooth curve drawn through a graph of calibration points.

calibration interval

The interval after which calibration must occur to maintain the performance of an instrument as stated in its specifications.

calibration report

A record of uncertainty and/or correction factors for an instrument as determined during calibration.

calibrator

A device that supplies outputs with a known uncertainty for use in checking the accuracy of measurement devices.

check standard

A device used solely to verify the integrity of another standard. For example in the 57LFC calibrator, one Fluke RMS sensor continuously monitors the output voltage while a second Fluke RMS sensor confirms the integrity of the first.

characterization

The development of a table of calibration constants or correction factors for use in correcting the output or reading of an instrument.

common mode noise

An undesired signal that exists between a device's terminals and ground. Common mode noise is at the same potential on both terminals of a device.

compliance voltage

The maximum voltage a constant-current source can supply.

control chart

A chart devised to monitor one or more processes in order to detect the excessive deviation from a desired value of a component or process.

crest factor

The ratio of the peak voltage to the rms voltage of a waveform (with the dc component removed).

current guard

A generator that drives the inner shield of a triaxial cable with a signal of the same amplitude and phase as a Calibrator's ac current output signal on the center conductor. The current guard shields the Calibrator's output signal from a capacitive leakage path to ground.

dac (digital-to-analog converter)

A device or circuit that converts a digital waveform to an analog voltage.

dBm

Power level expressed as decibels above or below 1 mW.

derived units

Units in the SI system that are derived from base units. Volts, ohms, and watts are derived from amperes and other base and derived units.

distortion

Undesired changes in the waveform of a signal. Harmonic distortion disturbs the original relationship between a frequency and other frequencies naturally related to it. Intermodulation distortion (imd) introduces new frequencies by the mixing of two or more original frequencies. Other forms of distortion are phase distortion and transient distortion.

errors

The different types of errors described in this glossary are: offset error, linearity error, random error, scale error, systematic errors, and transfer error. Each of these are defined in this glossary.

flatness

A measure of the variation of the actual output an ac voltage source at different frequency points when set to the same nominal output level. A flat voltage source exhibits very little error throughout its frequency range.

floor

The part of the uncertainty specification of an instrument that is typically a fixed offset plus noise. Floor can be expressed as units such as microvolts or counts of the least significant digit. For the calibrator, the floor specification is combined with fixed range errors in one term.

full scale

The maximum reading of a range of a meter, analog-to-digital converter, or other measurement device, or the maximum attainable output on a range of a calibrator.

gain error

Same as scale error. Scale or gain error results when the slope of the meter's response curve is not exactly 1. A meter with only gain error (no offset or linearity error), will read 0 V with 0 V applied, but something other than 10 V with 10 V applied.

ground

The voltage reference point in a circuit. Earth ground is a connection through a ground rod or other conductor to the earth, usually accessible through the ground conductor in an ac power receptacle.

ground loops

Undesirable currents induced when there is more than one chassis ground potential in a system of instruments. Ground loops can be minimized by connecting all instruments in a system to ground to one point.

guard

See voltage guard and current guard.

International System of Units

Same as SI System of Units; the accepted system of units. See also units, base units, and derived units.

legal units

The highest echelon in a system of units, for example the U.S. National Bureau of Standards volt.

life-cycle cost

The consideration of all elements contributing to the cost of an instrument throughout its useful life. This includes initial purchase cost, service and maintenance cost, and the cost of support equipment.

linearity

The relationship between two quantities when a change in the first quantity is directly proportional to a change in the second quantity.

linearity error

Linearity error occurs when the response curve of a meter is not exactly a straight line. This type of error is measured by fixing two points on the response curve, drawing a line through the points, then measuring how far the curve deviates from the straight line at various points on the response curve.

MAP (Measurement Assurance Program)

A program for a measurement process. A MAP provides information to demonstrate that the total uncertainty of the measurements (data), including both random error and systematic components of error relative to national or other designated standards is quantified, and sufficiently small to meet requirements.

MTBF (Mean Time Between Failures)

The time interval in operating hours that can be expected between failure of equipment. MTBF can be calculated from direct observation or mathematically derived through extrapolation.

MTTF (Mean Time to Fail)

The time interval in operating hours that can be expected until the first failure of equipment. MTF can be calculated from direct observation or mathematically derived through extrapolation.

MTTR (Mean Time to Repair)

The average time in hours required to repair failed equipment.

metrology

The science of measurement, and its field of knowledge.

minimum use specifications

A compilation of specifications that satisfies the calibration requirements of a measurement system or device. The minimum use specifications are usually determined by maintaining a specified test uncertainty ratio between the calibration equipment and the unit under test. The *57LFC/AN Service Manual* contains a table of minimum use specifications for performing full verification.

noise

A signal containing no useful information that is superimposed on a desired or expected signal.

normal mode noise

An undesired signal that appears between the terminals of a device.

offset error

Same as zero error. The reading shown on a meter when an input value of zero is applied is its offset or zero error.

parameters

Independent variables in a measurement process such as temperature, humidity, test lead resistance, etc.

precision

The degree of agreement among independent measurements of a quantity under the same conditions. (Same as repeatability.)

The precision of a measurement process is the coherence, or the closeness to the one result, of all measurement results. High precision, for example would result in a tight pattern of arrow hits on a target, without respect to where on the target the tight pattern falls.

predictability

A measure of how accurately the output value of a device can be assumed after a known time following calibration. If a device is highly stable, it is also predictable. If a device is not highly stable, but its value changes at the same rate every time after calibration, it's output has a higher degree of predictability than a device that exhibits random change.

primary standard

A standard defined and maintained by some authority and used to calibrate all other secondary standards.

process metrology

Tracking the accuracy drift of calibration and other equipment by applying statistical analysis to correction factors obtained during calibration.

random error

Any error which varies in an unpredictable manner in absolute value and in sign when measurements of the same value of a quantity are made under effectively identical conditions.

range

The stated upper end of a measurement device's span. Usually, however, a measurement device can measure quantities for a specified percentage overrange. (The absolute span including overrange capability is called scale.) In the 57LFC, however, range and scale are identical.

range calibration

An optional calibration procedure available to the enhance the 57LFC specifications by nulling the output to an external standard.

reference amplifier

DC voltage references developed for the 57LFC. These are 6.5 V hybrid devices consisting of a zener diode and a transistor on a heated substrate. These reference amplifiers exhibit extremely low uncertainty and drift, and are superior to zener diode or temperature-compensated zener diode voltage references.

reference standard

The highest-echelon standard in a laboratory; the standard that is used to maintain working standards that are used in routine calibration and comparison procedures.

relative uncertainty

57LFC uncertainty specifications that exclude the effects of external dividers and standards, for use when range constants are adjusted. Relative uncertainty includes only the stability, temperature coefficient, noise, and linearity specifications of the calibrator itself.

reliability

A measure of the uptime of an instrument.

repeatability

The degree of agreement among independent measurements of a quantity under the same conditions. (Same as precision.)

resistance

A property of a conductor that determines the amount of current that will flow when a given amount of voltage exists across the conductor. Resistance is measured in ohms. One ohm is the resistance through which one volt of potential will cause one ampere of current to flow.

resolution

The smallest change in quantity that can be detected by a measurement system or device. For a given parameter, resolution is the smallest increment that can be measured, generated or displayed.

rf (radio frequency)

The frequency range of radio waves; ranging from 150 kHz up to the infrared range.

rms (root-mean-square)

The value assigned to an ac voltage or current that results in the same power dissipation in a resistance as a dc current or voltage of the same value.

rms sensor

A device that converts ac voltage to dc voltage with great accuracy. RMS sensors operate by measuring the heat generated by a voltage through a known resistance (i.e., power); therefore, they sense true rms voltage.

scale

The absolute span of the reading range of a measurement device including overrange capability.

scale error

Same as gain error. Scale or gain error results when the slope of the meter's response curve is not exactly 1. A meter with only scale error (no offset or linearity error), will read 0 V with 0 V applied, but something other than 10 V with 10 V applied.

secondary standard

A standard maintained by comparison against a primary standard.

sensitivity

The degree of response of a measuring device to the change in input quantity, or a figure of merit that expresses the ability of a measurement system or device to respond to an input quantity.

shield

A grounded covering device designed to protect a circuit or cable from electromagnetic interference.

SI System of Units

The accepted International System of Units. See also units, base units, and derived units.

specifications

A precise statement of the set of requirements satisfied by a measurement system or device.

stability

A measure of the freedom from drift in value over time and over changes in other variables such as temperature. Note that stability is not the same as uncertainty.

standard

A device that is used as an exact value for reference and comparison.

standard cell

A primary cell that serves as a standard of voltage. The term standard cell often refers to a Weston normal cell, which is a wet cell with a mercury anode, a cadmium mercury amalgam cathode, and a cadmium sulfate solution as the electrolyte.

systematic errors

Errors in repeated measurement results that remain constant or vary in a predictable way.

temperature coefficient

A factor per °C deviation from a nominal value or range that the uncertainty of an instrument increases. This specification is necessary to account for the thermal coefficients in a calibrator's analog circuitry.

test uncertainty ratio

The numerical ratio of the uncertainty of the measurement system or device being calibrated to the uncertainty of the measurement system or device used as the calibrator. (Also called test accuracy ratio.)

thermal emf

The voltage generated when two dissimilar metals joined together are heated.

traceability

The ability to relate individual measurement results to national standards or nationally accepted measurement systems through an unbroken chain of comparisons, i.e., a calibration audit trail.

Measurements, measurement systems or devices have traceability to the designated standards if and only if scientifically rigorous evidence is produced on a continuing basis to show that the measurement process is producing measurement results for which the total measurement uncertainty relative to national or other designated standards is qualified.

transfer error

The sum of all new errors induced during the process of comparing one quantity against another.

transfer standard

Any working standard used to compare a measurement process, system or device at one location or level with another measurement process, system, or device at another location or level.

transport standard

A transfer standard that is rugged enough to allow shipment by common carrier to another location.

true value

Also called legal value, the accepted, consensus, (i.e., the correct value of the quantity being measured).

uncertainty

The maximum difference between the accepted, consensus, or true value and the measured value of a quantity. Uncertainty is normally expressed in units of ppm (parts per million) or as a percentage. (Accuracy is the same as 1 - % uncertainty.)

units

Symbols or names that define the measured quantities. Examples of units are: V, mV, A, kW, and dBm. See also SI System of Units.

UUT (Unit Under Test)

An abbreviated name for an instrument that is being tested or calibrated.

volt

The unit of emf (electromotive force) or electrical potential in the SI system of units. One volt is the difference of electrical potential between two points on a conductor carrying one ampere of current, when the power being dissipated between these two points is equal to one watt.

watt

The unit of power in the SI system of units. One watt is the power required to do work at the rate of one joule/second. In terms of volts and ohms, one watt is the power dissipated by one ampere flowing through a 1 Ω load.

wideband

AC voltage at frequencies up to and including the radio frequency spectrum.

verification

Checking the functional performance and uncertainty of an instrument or standard without making adjustments to it or changing its calibration constants.

voltage guard

A floating shield around voltage measurement circuitry inside an instrument. The voltage guard provides a low-impedance path to ground for common-mode noise and ground currents, thereby eliminating errors introduced by such interference.

working standard

A standard that is used in routine calibration and comparison procedures in the laboratory, and is maintained by comparison to reference standards.

zero error

Same as offset error. The reading shown on a meter when an input value of zero is applied is its zero or offset error.