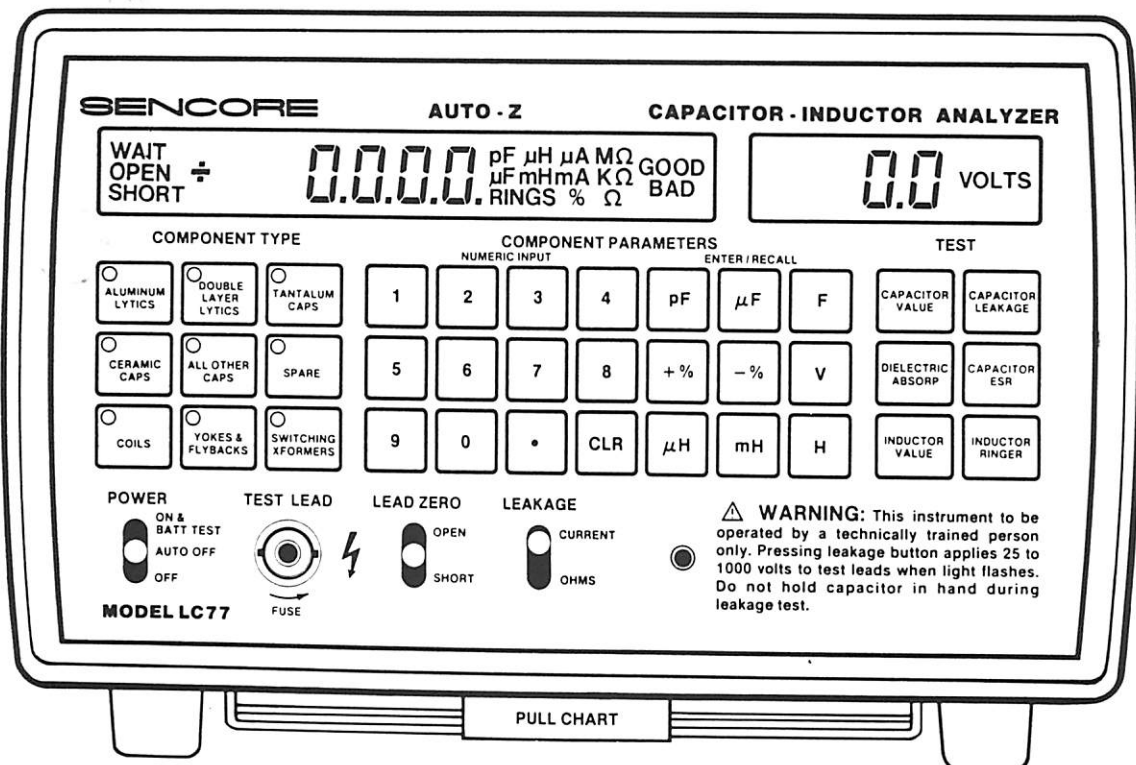


LC77

"AUTO-Z"

CAPACITOR — INDUCTOR ANALYZER

Operation, Application, and Maintenance Manual



SENCORE
 3200 Sencore Drive, Sioux Falls, SD 57107

WARNING

PLEASE OBSERVE THESE SAFETY PRECAUTIONS

Do not attempt to check capacitors in-circuit. This unit is to be operated only by technically trained people who understand the shock hazard and dangers of applying up to 1000 volts during the leakage test.

Every precaution has been taken in the design of your "Auto-Z" to insure that it is as safe as possible. However, safe operation depends on you, the operator.

- 1. Do not use the "Auto-Z" in circuits where power is still applied.** Disconnect the AC line cord from AC power and discharge filter capacitors before making any test lead connections.
- 2. Never exceed the limits of the "Auto-Z"** as printed in the specification section, and additional warnings throughout this manual.
- 3. Be sure your test equipment is in good working order.** Broken or frayed test leads can cause improper test results and expose you to dangerous test voltages. A burned out warning LED will fail to tell you that dangerous, high leakage voltage is present at the test leads.
- 4. Observe the voltage rating and polarity of the component under test.** Exceeding the voltage rating of a capacitor or applying the wrong voltage polarity during the leakage test, may damage the capacitor or cause it to explode.
- 5. Improper fuse voids warranty.** Fuses are for your protection, so always replace any fuse with the proper type and rating. Avoid situations that blow the fuse. When a protection fuse blows, note what caused the failure. Then prevent future fuse failure by following proper procedures.

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SENCORE

3200 Sencore Drive, Sioux Falls, South Dakota 57107

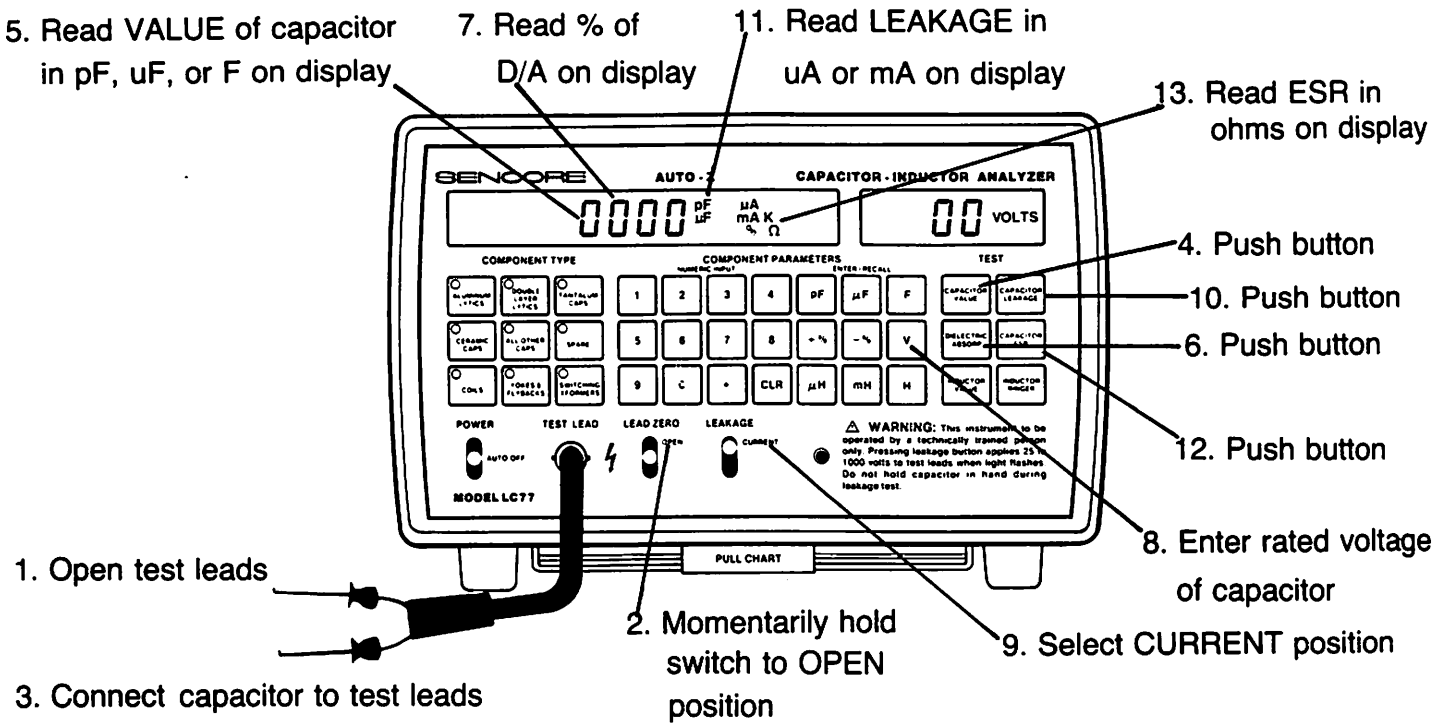
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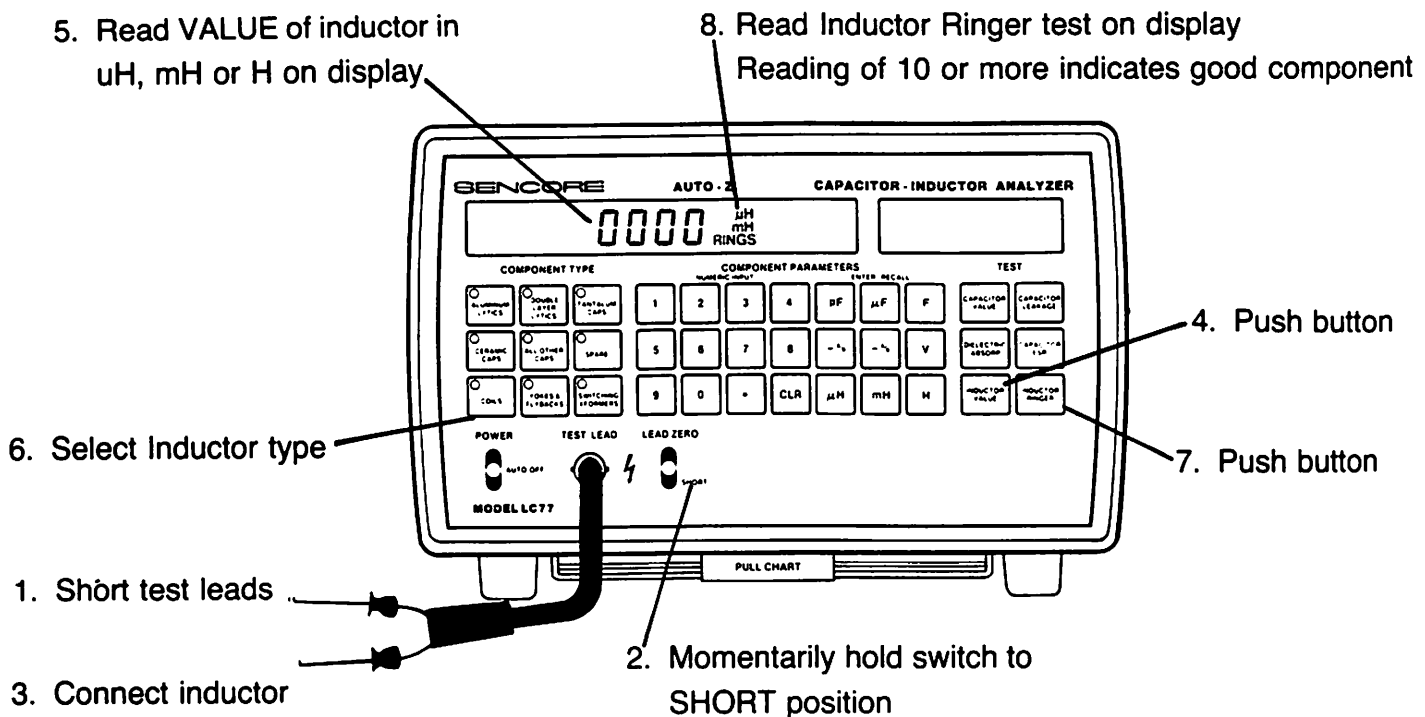
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SIMPLIFIED OPERATIONS

Capacitor Parameter Tests



Inductor Parameter Tests



DESCRIPTION

Introduction

Capacitor and inductor usage is extensive, encompassing all facets of industrial and consumer electronics. Very few circuits lack either of these components. Because the transistor gave way to the IC, and the IC gave way to the LSIC, capacitor and inductor usage continues to increase rapidly since neither of these components can be physically incorporated into ICs on a broad basis. Though they have changed some in physical size, capacitors still perform the same basic functions. But in today's circuits, more than ever before, the tolerances and parameters of capacitors and inductors are critical to proper circuit operation.

Capacitor value and tight tolerance is just one important parameter. In today's high performance circuits, leakage, dielectric absorption, and ESR are necessary indicators of a capacitor's ability to perform properly in circuit. Inductors too, require tight tolerances and quality checks. Unless all of these parameters can be thoroughly analyzed, troubleshooting becomes a guessing game.

The Sencore LC77 "AUTO-Z" takes the guess work out of capacitor and inductor testing. It provides automatic tests of capacitor value, leakage, ESR, and a patented dielectric absorption test. Inductors are automatically analyzed for value and quality with patented tests. The LC77 is a complete, automatic, microprocessor-controlled capacitor and inductor analyzer. Its features make it ideally suited for both single component analyzing in service or maintenance work, or for large volume batch testing in a lab or incoming inspection.

Features

The Sencore LC77 "AUTO-Z" is a dynamic, portable, automatic capacitor and inductor tester. It is designed to quickly identify defective components by simply connecting the capacitor or inductor to the test leads and pushing a test button. The test result is readily displayed on an LCD readout in common terms. All capacitor and inductor test results may also be displayed as good/bad compared to standards adopted by the Electronic Industries Association (EIA). User defined limits may also be programmed into the LC77 for the good/bad comparison.

In addition to testing capacitors for value up to 20 Farads, the LC77 checks capacitors for leakage at their rated working voltage, up to 1000 volts. ESR is checked with a patent-pending test, and an automatic, patented test checks capacitor dielectric absorption. A patented inductance value test provides a fast, accurate test of true inductance. A patented ringing test checks coils, deflection yoke, switching power supply transformers, and other non-iron core inductors with a fast, reliable good/bad quality test.

Automatic lead zeroing balances out test lead capacitance, resistance, and inductance for accurate readings on small capacitors and inductors. The LC77 is protected from external voltages applied to the test leads by a fuse in the TEST LEAD JACK and special circuitry which locks out all test buttons when voltage is sensed on the test leads.

Battery operation makes the LC77 completely portable for on-location troubleshooting in all types of servicing from industrial equipment to avionics to cable fault locating. An optional SCR & Triac tester extends the LC77 test capabilities to provide a fast, accurate test of these components. The LC77 may be interfaced into any IEEE 488 Bus system for fully automatic, computer controlled testing in a laboratory or incoming inspection area.

Specifications

DIGITAL READOUT

TYPE: .45", 6 digit, 7 segment LCD

READINGS: Fully autoranged with auto decimal placement. One or two place holding zeros added as needed to provide standard value readouts of pF, uF, F, uH or mH.

ANNUNCIATORS: pF, uF, F, uH, mH, H, uA, mA, %, V, kΩ, MΩ, OHMS, RINGS, SHORT, OPEN, WAIT, GOOD, BAD.

CAPACITORS (Out of circuit)

Dynamic test of capacity value is determined by measuring one RC time constant as capacitor is charged to +5 V through:

1.5 Megohms for 0 - .002 uF

15 Kilohms for .002 uF - 2 uF

Values above 2 uF are charged with a constant current of:

60 mA for 2uF - 2000uF

416 mA for 2000 uF - 19.99 F

Maximum voltage across capacitors larger than 2000 uF limited to 1.75 V.

ACCURACY: +/- 1% +/- 1pF +/- 1 digit for values to 1990 uF. +/- 5% +/- .1% of range full scale for values 2000 uF to 19.99 F.

RESOLUTION AND RANGES: 1.0 pF to 19.99 F, fully autoranged:

.1 pF —	1.0 pF	to	199.9 pF
1 pF —	200 pF	to	1999 pF
.00001 uF —	0.00200 uF	to	0.01999 uF
.0001 uF —	0.0200 uF	to	0.1999 uF
.001 uF —	0.200 uF	to	1.999 uF
.01 uF —	2.00 uF	to	19.99 uF

.1 uF —	20.0 uF	to	199.9 uF
1 uF —	200 uF	to	1,999 uF
10 uF —	2,000 uF	to	19,990 uF
100 uF —	20,000 uF	to	199,900 uF
.001 F —	0.200 F	to	1.999 F
.01 F —	2.00 F	to	19.99 F

CAPACITOR LEAKAGE

READOUT: User selectable between leakage current and resistance.

ACCURACY: +/- 5% +/- 1 digit.

APPLIED VOLTAGE: Keyboard entry; 1.0 to 999.9 volts in .1 volt steps; accuracy +0 -5%. Short circuit current limited to 900mA, power limited to 6 watts.

RESOLUTION AND RANGES: .01uA to 20 mA, fully autoranged:

.01 uA —	0.01 uA	to	19.99 uA
.1 uA —	20.0 uA	to	199.9 uA
1 uA —	200 uA	to	1999 uA
.01 mA —	2.00 mA	to	19.99 mA

CAPACITOR ESR (Test patent pending)

ACCURACY: +/- 5% +/- 1 digit.

CAPACITOR RANGE: 1 uF to 19.99 F.

RESOLUTION AND RANGES: .10 ohm to 2000 ohms, fully autoranged:

.01 ohm —	0.10 ohms	to	1.99 ohms
.1 ohm —	2.0 ohms	to	19.9 ohms
1 ohm —	20 ohms	to	199 ohms
10 ohm —	200 ohms	to	1990 ohms

CAPACITOR D/A (U.S. Patent # 4,267,503)

ACCURACY: +/- 5 counts.

RANGE: 1 to 100%.

CAPACITOR RANGE: .01 uF to 19.99 F.

INDUCTORS (In or out of circuit)

A dynamic test of value determined by measuring the EMF produced when a changing current is applied to the coil under test. (U.S. Patent # 4,258,315)

CURRENT RATES: automatically selected

50 mA/uSec —	0 uH	to	18 uH
5 mA/uSec —	18 uH	to	180 uH
.5 mA/uSec —	180 uH	to	1.8 mH
50 mA/mSec —	1.8 mH	to	18 mH
5 mA/mSec —	18 mH	to	180 mH
.5 mA/mSec —	180 mH	to	1.8 H
.05 mA/mSec —	1.8 H	to	19.99 H

ACCURACY: +/- 2% +/- 1 digit

RESOLUTION AND RANGES: .10 uH to 20 H, fully autoranged

.01 uH —	0.10 uH	to	19.99 uH
.1 uH —	20.0 uH	to	199.9 uH
1 uH —	200 uH	to	999 uH
.001 mH —	1.000 mH	to	1.999 mH
.01 mH —	2.00 mH	to	19.99 mH
.1 mH —	20.0 mH	to	199.9 mH
1 mH —	200 mH	to	999 mH
.001 H —	1.000 H	to	1.999 H
.01 H —	2.00 H	to	19.99 H

RINGING TEST

A dynamic test of inductor quality determined by applying an exciting pulse to the inductor and counting the number of cycles the inductor rings before reaching a preset damping point. (U.S. Patent # 3,990,002)

INDUCTOR RANGE: 10 uH and larger, non-iron core

ACCURACY: +/- 1 count on readings between 8 and 13.

RESOLUTION: +/- 1 count.

EXCITING PULSE: 5 volts peak; 60 Hz rate.

GENERAL

TEMPERATURE: **Operating range:** 32° to 104°F (0° to 40°C) **Range for specified accuracy** (after 10 minute warmup): 50° to 86°F (10° to 30°C)

POWER: 105-130V AC, 60Hz, 24 watts max. with supplied PA251 power adapter. Battery operation with optional BY234 rechargeable battery. 210-230V AC operation with optional PA252 Power Adapter.

AUTO OFF: Removes power during battery operation if unit sits idle longer than 15-20 minutes.

BATTERY LIFE: 8 hours typical inductor testing; 7 hours typical capacitor testing.

SIZE: 6" x 9" x 11.5" (15.2cm x 22.9cm x 29.1cm) HWD

WEIGHT: 6 lbs. (2.7kg) without battery, 7.6 lbs (3.4kg) with battery.

GOOD/BAD INDICATION: Functions on all tests. Requires user input of component type and value, or input of desired limits.

IEEE: Requires the use of Sencore IB72 Bus Interface Accessory.

The following interface codes apply: SH1, AH1, T8, L4, SRO, RLO, PPO, DCO, DTC, CO. All readings are test accuracy +/- 1 count.

Specifications subject to change without notice

ACCESSORIES

SUPPLIED:

- 39G143 Test Leads
- 39G144 Test Lead Adapter
- 39G201 Test Button Hold Down Rod
- 64G37 Test Lead Mounting Clip
- PA251 AC Power Adapter/Recharger

OPTIONAL:

- 39G85 Touch Test Probe
- FC221 Field Calibrator
- BY234 Rechargeable Lead Acid Battery
- SCR250 SCR/Triac Tester
- CC254 Carrying Case
- CH255 Component Holder
- CH256 Chip Component Test Lead
- IB72 Bus Interface Accessory
- PA252 220V AC Power Adapter/Recharger

Controls

1. COMPONENT TYPE select buttons. Use with **TEST** buttons (4), and **COMPONENT PARAMETERS** buttons (6) for component limit testing.

- a. - e. capacitor type buttons - Use with other beige color coded capacitor buttons (4a - d) and (6m - o).
- f. **SPARE** - Provides a spare button to allow for future component types and internal memory updates.
- g. - i. Inductor type buttons - Use with other blue color coded inductor buttons (4e - f) and (6s - u).

2. LCD DISPLAY

- 2a. **SHORT** - Indicates that test leads, or component connected to test leads, are shorted when **LEAD ZERO OPEN** button (9a) or **CAPACITOR VALUE TEST** button (4a) is pushed.
- 2b. **OPEN** - Indicates that test leads, or component connected to test leads, are open when **LEAD ZERO SHORT** button (9b) or **INDUCTOR VALUE TEST** button (4e) is pushed.
- 2c. **WAIT** - Indicates internal circuits are discharging after **CAPACITOR LEAKAGE TEST** button (4c) is released. Also indicates external voltage on test leads. All tests are locked out while **WAIT** indicator is on.
- 2d. **DIGITAL READOUT** - Indicates value of test result. Last two digits are place holders and indicate 0 on large readings. Displays error message if error condition exists.
- 2e. **READING ANNUNCIATORS** - Automatically light to qualify the reading displayed in the **DIGITAL READOUT** (2d).
- 2f. **GOOD** - Indicates that component meets pre-defined tolerances for the test selected by **TEST** button (4).
- 2g. **BAD** - Indicates that the component does not meet the pre-defined tolerances for the test selected by **TEST** button (4).

3. APPLIED VOLTAGE LCD DISPLAY - Displays the amount of leakage voltage to be applied to the **TEST LEAD** (10) when the **CAPACITOR LEAKAGE** button (4b) is pressed. Voltage is selected using **COMPONENT PARAMETERS** keypad (6a-l & 6r).

4. TEST buttons

- a. **CAPACITOR VALUE** - Depress to test capacitor value.
- b. **DIELECTRIC ABSORP** - Depress to read percentage of dielectric absorption.
- c. **CAPACITOR LEAKAGE** - Depress to test capacitor leakage after the capacitor working voltage is entered with the **COMPONENT PARAMETERS** keypad (6).
- d. **CAPACITOR ESR** - Depress to test capacitor ESR.
- e. **INDUCTOR VALUE** - Depress to test inductor value.
- f. **INDUCTOR RINGER** - Depress for ringing (quality) test on coils, yokes/flybacks and switching transformers after selecting inductor type with **COMPONENT TYPE** switches (1g-i).

5. CAUTION INDICATOR LED - Blinks as a warning when leakage voltage is set to 25 volts or higher, as indicated on **APPLIED VOLTAGE LCD DISPLAY** (3). Voltage is only present at test leads when **CAPACITOR LEAKAGE** test button (4c) is depressed.

6. COMPONENT PARAMETERS keypad - Use to enter parameters for limit testing.

- a-k. **NUMERIC INPUT** - Use to enter numerical value portion of parameters. Use with **COMPONENT PARAMETERS** buttons (m-u).
- l. **CLR** - Push once to clear **NUMERIC INPUT** entry. Push twice to clear all parameters and **COMPONENT TYPE** switches (1).
- m-o. **CAPACITOR VALUE MULTIPLIER** - Use after **NUMERIC INPUT** entry (6a-k) to enter capacitor value. Push to recall entered value.
- p-q. **PERCENTAGE** buttons - Use after **NUMERIC INPUT** entry (6a-k) to enter component tolerance. Push to recall entered value.
- r. **VOLTS** - Use with **NUMERIC INPUT** (6a-k) to select desired test voltage for capacitor leakage tests.
- s-u. **INDUCTOR VALUE MULTIPLIER** - Use after **NUMERIC INPUT** entry (6a-k) to enter inductor value. Push to recall entered value.

7. PULL CHART - Provides simplified operating instructions and quick reference tables.

8. LEAKAGE Switch

- a. **CURRENT** - Selects readout of leakage current in uA or mA when **CAPACITOR LEAKAGE** button (4c) is depressed.
- b. **OHMS** - Selects readout of leakage in ohms when **CAPACITOR LEAKAGE** button (4c) is depressed.

9. LEAD ZERO Switch

- a. **OPEN** - Use with **CAPACITOR VALUE** button (4a) and open test leads to balance out test lead capacitance.
- b. **SHORT** - Use with **INDUCTOR VALUE** button (4e) and shorted test leads to balance out test lead inductance.

10. TEST LEAD INPUT JACK - Provides a connection for attaching supplied test leads (17) or optional **CHIP COMPONENT TEST LEADS** (30). Unscrew jack for access to protection fuse.

11. POWER Switch

- a. **OFF** - Removes power from all circuits.
- b. **AUTO OFF** - Provides power for approximately 15 minutes after auto off circuitry is reset. Auto off is bypassed when LC77 is powered from the AC Power Adapter.
- c. **ON & BATT TEST** - Turn unit on and reset auto off circuitry. Remaining battery life is displayed in **LCD DISPLAY** (2d).

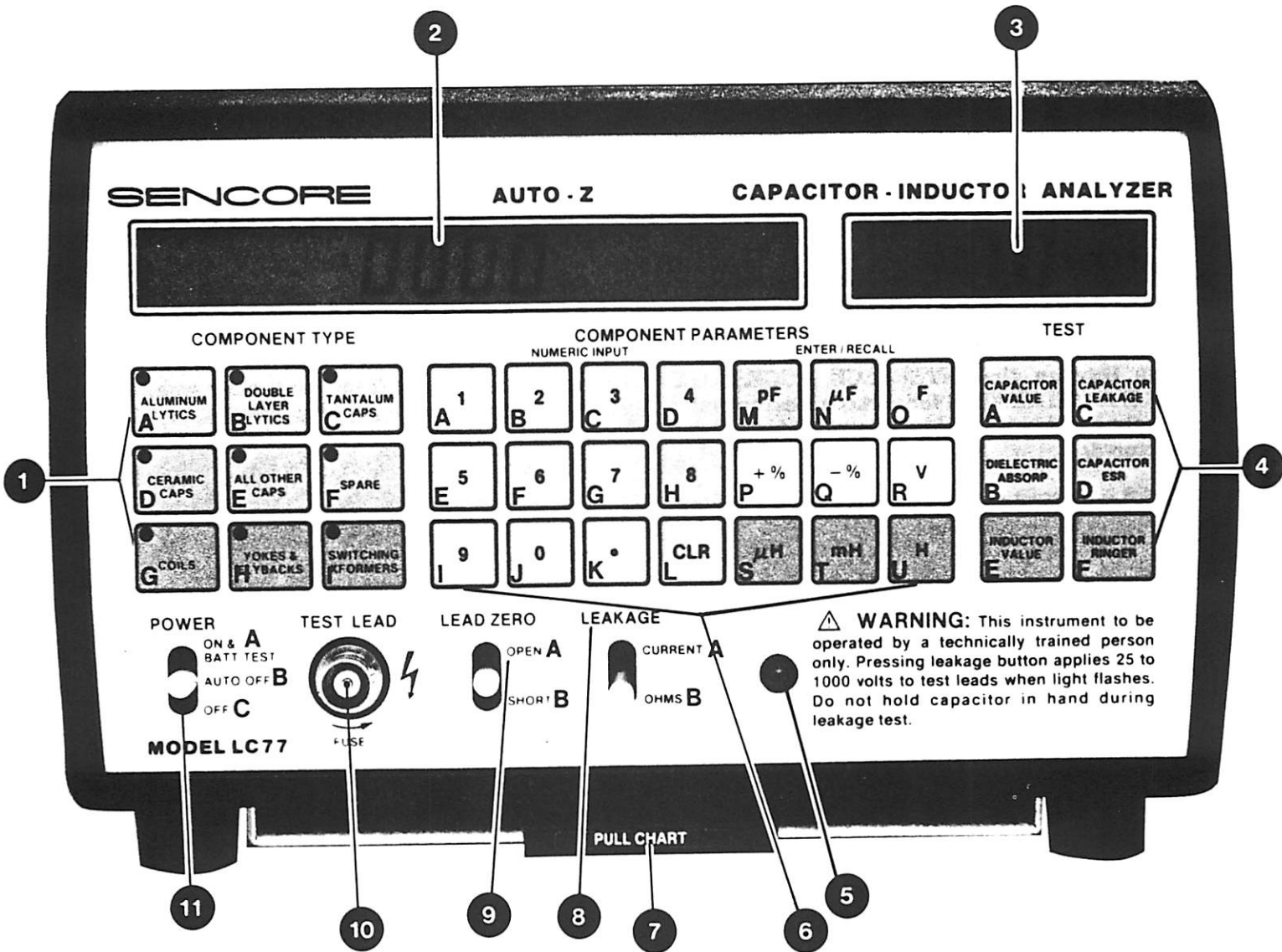


Fig. 1 — Location of front panel controls and features.



Fig. 2 — LCD annunciators.

Optional Accessories

22. 39G85 TOUCH TEST PROBE - Use for in-circuit testing of coils and inductors from foil side of P.C. board.

23. FIELD CALIBRATOR (FC221) - Use to periodically check calibration of LC77.

24. RECHARGEABLE BATTERY (BY234) - Provides portable operation for the LC77. One battery required.

25. SCR/TRIAC TEST ACCESSORY (SCR250) - Use for testing SCRs and Triacs.

26. IEEE 488 BUS INTERFACE ACCESSORY - Connects between the INTERFACE ACCESSORY JACK (13) AND THE IEEE 488 port of a Bus controller to allow the LC77 to be used in automated test setups. (Not Pictured)

E-Z Hook® is a registered trademark of Tele Tek Inc.

27. 220 VOLT POWER ADAPTER (PA252) - Plugs into POWER INPUT (15) to power unit from 210-230 VAC line. Also recharges the (optional) BY234 Battery when installed inside the LC77.

28. CARRYING CASE (CC254) - Provides protection and easy carrying for the LC77 and its accessories.

29. COMPONENT HOLDER (CH255) - Use to hold components for fast tests when doing volume testing. (Not Pictured)

30. CHIP COMPONENT TEST LEAD (CC256) - Special shielded test leads for testing small surface mount (Chip) components. (Not Pictured)

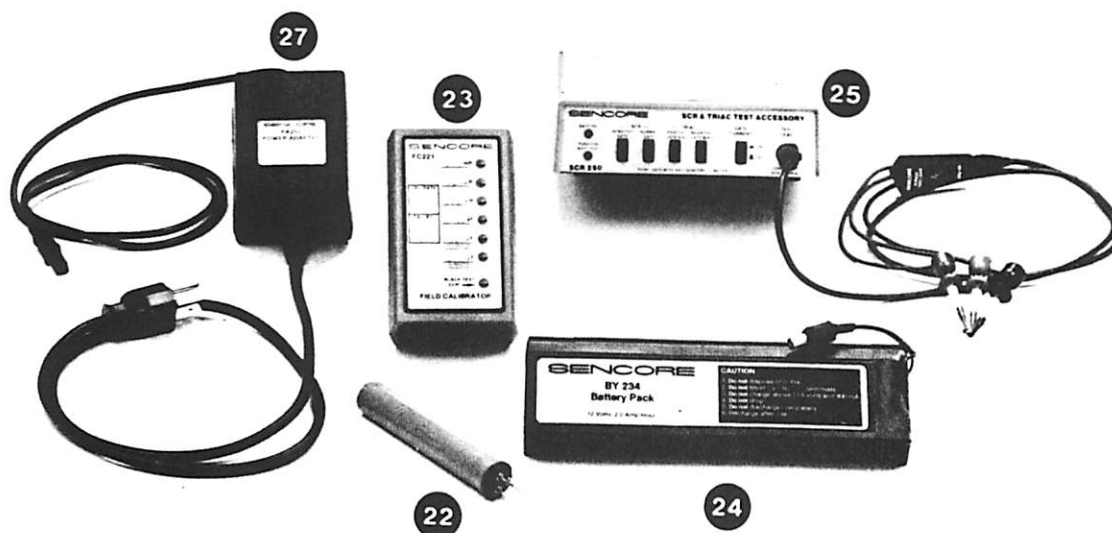


Fig. 5 — Optional Accessories.

Supplied Accessories

17. **TEST LEADS (39G145)** - Special low capacity cable with E-Z Hook® clips. Connect to TEST LEAD INPUT (10).

18. **39G144 TEST LEAD ADAPTER (39G144)** - Use to adapt TEST LEADS (17) to large, screw terminal capacitors.

19. **TEST BUTTON HOLD DOWN ROD (39G201)** - Use to hold CAPACITOR LEAKAGE button (4c) depressed when reforming capacitors.

20. **TEST LEAD MOUNTING CLIP (64G37)** - Use to hold Test Lead when not in use.

21. **POWER ADAPTER (PA251)** - Plugs into POWER INPUT (16) to power unit from 105-130 VAC line. Also recharges the (optional) BY234 Battery when installed inside the LC77.



Fig. 4 — Supplied Accessories.

Rear Panel Features

12. BATTERY COMPARTMENT COVER - Provides access to the (optional) BY242 rechargeable battery.

13. INTERFACE ACCESSORY JACK - Allows the (optional) IB72 IEEE 488 Bus Interface Accessory (26) to be connected to feed LC77 readings to an automated measuring system.

14. TEST BUTTON HOLD DOWN ROD HOLDER - Holds TEST BUTTON HOLD DOWN ROD (19) when not in use.

15. 39G144 TEST LEAD ADAPTER MOUNTING CLIP.

16. POWER INPUT - Connects to supplied PA251 POWER ADAPTER (21) for 110V AC operation, or to PA252 (27) for 220V AC operation.

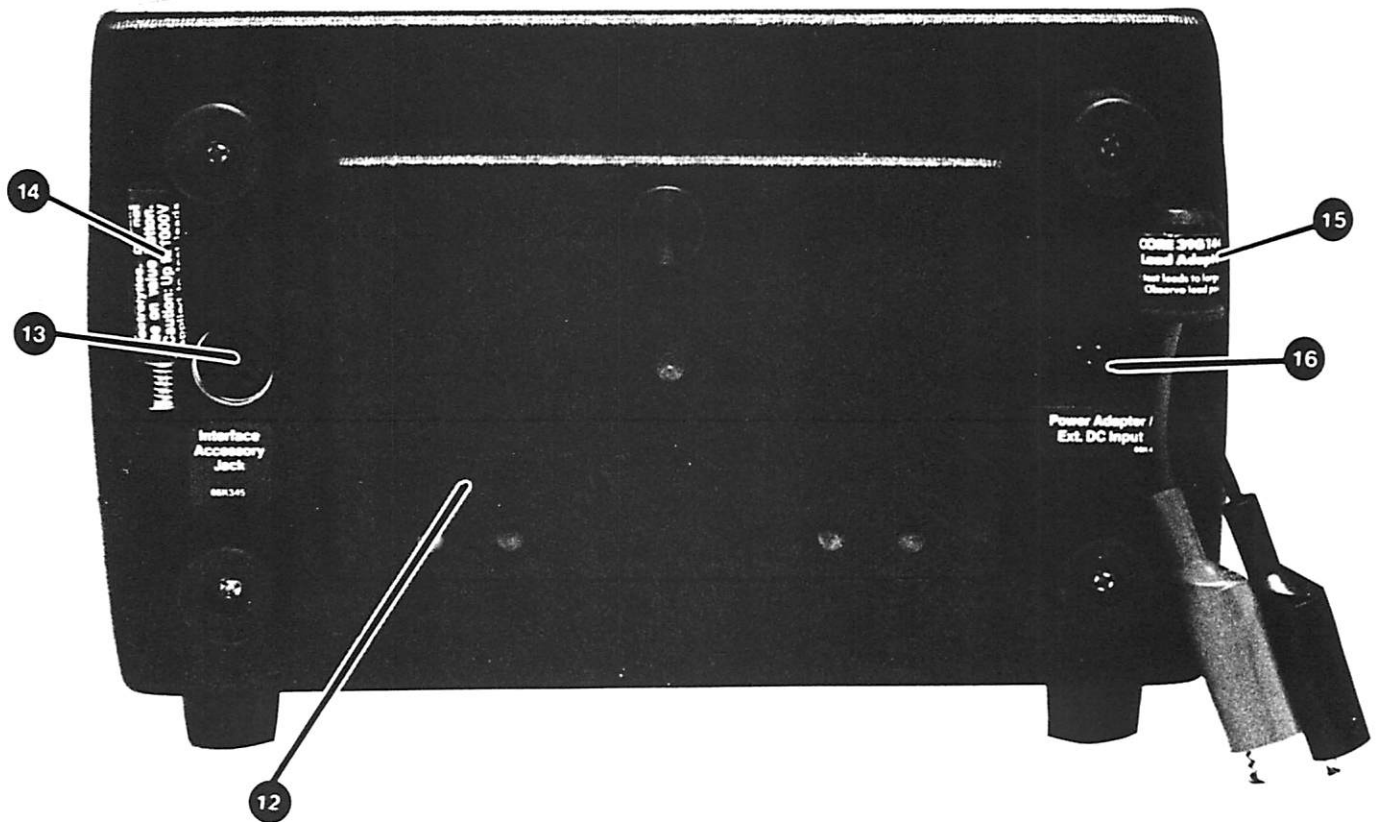


Fig. 3 — Location of rear panel features.

OPERATION

Introduction

Before you begin to use your LC77 "Auto-Z", take a few minutes to read through the Operations and Applications sections of this manual and acquaint yourself with the features and capabilities of your instrument. After you have familiarized yourself with the general operation of the LC77, most tests can be performed with the information on the front panel.

AC Power Operation

For continuous bench operation the LC77 is powered from any standard 105-130V (50-60 Hz) AC line using the PA251 Power Adapter. When 220V AC operation is required, power the LC77 with the optional PA252 220 VAC Power Adapter. Connect the Power Adapter to the POWER IN JACK located on the rear of the LC77, as shown in Figure 6.

The power adapter serves as a battery charger to recharge the (optional) BY234 battery when it is installed in the unit. The BY234 may be left installed in the LC77 at all times without danger of over charging. Connecting the Power Adapter bypasses the auto-off circuitry in the LC77 and allow continuous, uninterrupted operation.

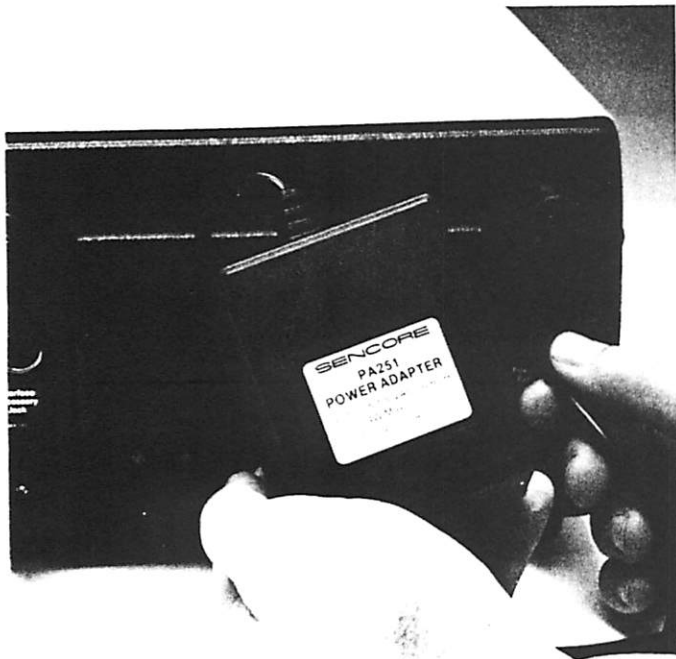


Fig. 6 — Connect the PA251 to the 12 V DC input for AC bench operation and to recharge the optional battery.

WARNING

Using an AC adapter other than the PA251 or PA252 may cause damage to the LC77, may cause the optional battery (if installed) to improperly charge, or may cause measurement errors on low values of components. Only use a Sencore PA251 or PA252 Power Adapter for AC operation.

To operate the LC77 from an AC line:

1. Connect the AC line cord of the power adapter to an adequate source of AC power.
2. Connect the power adapter lead to the POWER INPUT JACK on the back of the LC77, as shown in figure 6.
3. Push the POWER switch on the LC77 up to the ON & BATT TEST position and release. The WARNING LED will momentarily blink to indicate it is operational and the displays will reset and read zeros.
4. The LC77 is immediately ready for use. If precise measurements are required, allow the unit to operate for 10 minutes to reach specified accuracy.

WARNING

The CAUTION INDICATOR LED must momentarily flash when the POWER switch is first turned on and moved from the OFF to the ON & BATT TEST position. Failure of the light to flash indicates a problem with the LED or safety circuits. DO NOT operate the LC77 in this condition, since it exposes the operator to dangerous voltages without adequate warning.

Battery Operation

The LC77 is designed to operate as a completely portable unit with the optional BY234 rechargeable battery installed. The operation of the LC77 when it is battery powered is the same as when it is AC powered. The length of time the "Auto-Z" will operate before the battery needs recharging depends on several factors: 1. the test functions used; 2. temperature; 3. battery age.

Leakage tests place the heaviest current drain on the battery - greater currents result in shorter battery life between recharging. Value tests place the least drain on the battery. For typical operation, the LC77 provides approximately 7 hours of complete capacitor testing (value, ESR, D/A and leakage), and 8 hours of complete

inductor testing (value and ringing). These times, of course, will vary with temperature and battery age.

As the temperature of the battery decreases, its capacity also decreases. The operating time between rechargings decreases at the rate of approximately 1 hour for every 20 degrees F drop in temperature below 70°F. The BY234 battery is a sealed, lead-acid type which requires no maintenance other than recharging. As a battery ages, it will require more frequent rechargings. If used properly, the BY234 will provide several years of service before needing replacement.

You can maximize the lifetime of the BY234 several ways: 1. Never allow the battery to deeply discharge. The LC77 has a built-in battery test and low battery shut off circuitry. Check the remaining charge periodically and recharge the battery before the low battery circuit shuts the unit off. 2. Keep the battery fully charged. The BY234 will not be harmed if it is left installed in the LC77 during AC operation. Instead, this will keep the battery fresh and ready for use and will actually lengthen its useful lifetime. 3. Recharge the battery before using it if it has sat idle for more than a couple of weeks. Lead-acid batteries normally lose some of their charge if they sit idle for a period of time.

WARNING

Observe these precautions when using lead-acid batteries:

1. Do not dispose of old lead-acid batteries in fire. This may cause them to burst, spraying acid through the air.
2. Do not short the "+" and "-" terminals together. This will burn open internal connections, making the battery useless.
3. Do not charge 12 volt lead-acid batteries with a voltage greater than 13.8 VDC. High charging voltage may damage the battery or cause it to explode.
4. Do not drop the battery. While lead-acid batteries are well sealed, they may break if dropped or subjected to a strong mechanical shock. If the battery does break and the jelled electrolyte leaks out, neutralize the acid with baking soda and water.
5. Do not charge the battery below 0° C or above +40° C.

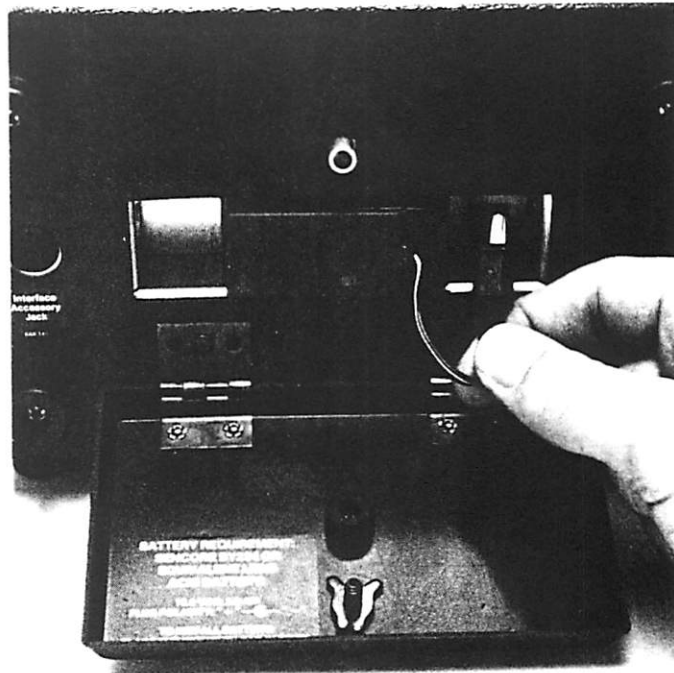


Fig. 7 — The optional BY234 is installed in the LC77 for portable operation.

To install the optional BY234 Battery:

1. Open the BATTERY COMPARTMENT COVER located on the rear of the unit by unscrewing the thumbscrew. Fold the cover down on its hinge.
2. Slide the battery end that does not have the connector attached into the battery compartment. (The wire should be facing out after the battery is in place.)
3. Connect the plug from the battery to the jack inside the battery compartment.
4. Close the battery compartment cover and tighten the thumbscrew to hold the door and batteries in place.

Note: Recharge the BY234 overnight before using it for the first time.

Battery Test

The LC77 has a built-in battery test feature which shows the remaining battery recharge. A reading of 100% indicates that the battery is fully charged. As the battery charge is used up, the reading will drop in 10% intervals. The low battery circuits will turn the unit off shortly after the battery test reading drops to 0%, and before the battery level drops too low for reliable operation. The LC77 never fully discharges the battery which helps extend the life of the BY234.

To perform the battery test:

1. With a BY234 installed, move the POWER switch to the ON & BATT TEST position.
2. Read the percentage of remaining battery charge in the LCD DISPLAY, as shown in figure 8.
3. If the reading shows 0%, the unit may not operate, or operate for just a short time since the low battery circuit turns the LC77 off at this battery level.

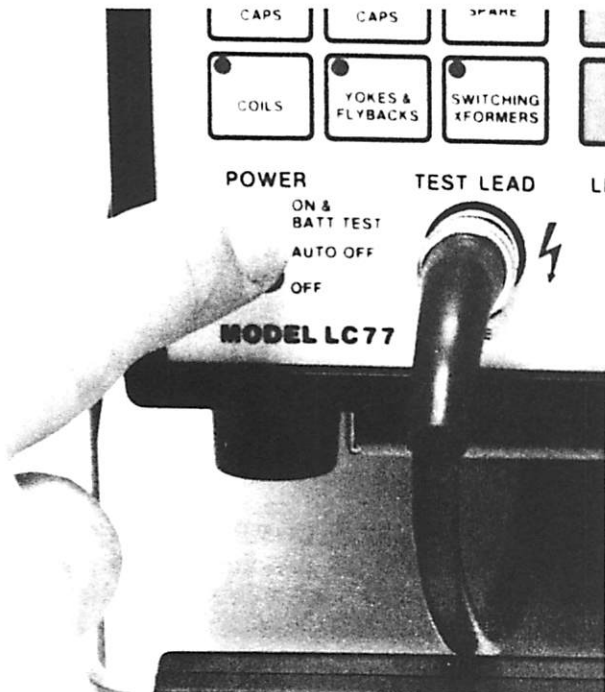


Fig. 8 — Push the Power switch to “On & Batt Test” to read the remaining battery charge.

Recharging the Battery

The BY234 battery should never be allowed to remain discharged for more than a few hours, since this will shorten its lifetime. The battery must be recharged whenever the battery test reads 0%. However, you should recharge the battery more often than this to lengthen the battery's lifetime and keep the LC77 ready for portable use at all times.

To recharge the battery, simply leave it installed inside the LC77 while the unit is connected to the PA251 AC Adapter/Charger and the Power Adapter is connected to a source of AC power. The charging time required to return the battery to 100% depends on how far it is discharged. The battery will trickle charge while the LC77 is in use and powered from the AC adapter, but it will recharge the quickest if the POWER switch is in the “OFF” position. Normally, a battery will completely recharge in about 8 hours with the POWER switch “OFF”.

Auto Off

To conserve battery charge, the LC77 contains an auto off circuit. This circuit keeps the batteries from running down if you should forget to turn the unit off, but keeps the “Auto-Z” powered up during use. The auto off circuit will shut the LC77 off after approximately 15 minutes if none of the front panel buttons have been pushed. Pushing any COMPONENT TYPE button, COMPONENT PARAMETERS button, TEST button, or momentarily moving the POWER button to the ON & BATT TEST position will reset the auto off circuits. The auto off circuits are bypassed when the LC77 is operated from the PA251 AC Adapter/Charger.

To operate the LC77 using the optional BY234 battery:

1. Install the BY234 battery into the LC77 battery compartment.

NOTE: If you are using the BY234 for the first time, be sure to charge the battery before using the LC77. Though factory tested, the BY234 may not be charged when you receive it.

2. Push the POWER switch to the ON & BATT TEST position and release. The WARNING LED will momentarily blink to indicate it is operational and the displays will reset and read zeros.

3. The LC77 is immediately ready for use. If precise measurements are required, allow the unit to operate for 10 minutes to reach specified accuracy.

—WARNING—

The CAUTION INDICATOR LED must momentarily flash when the POWER switch is moved from the OFF to the ON & BATT TEST position. Failure of the light to flash indicates a problem with the LED or safety circuits. DO NOT operate the LC77 in this condition, since it exposes the operator to dangerous voltages without adequate warning.

Test Leads

The test leads supplied with the LC77 (39G143) are made of special, low capacity coaxial cable. Using any other cable will add extra capacity to the meter circuits, which may not be within the range of the lead zeroing circuits. Attempting to zero the leads with another, higher capacitance cable connected will cause the LCD DISPLAY to show the message error. This indicates that the value is beyond the zeroing limits of the LC77.

If the test leads ever require replacement, new leads (part # 39G143) may be ordered directly from the: SENCORE SERVICE DEPARTMENT at 3200 Sencore Drive, Sioux Falls, SD 57107.

Test Lead Mounting Clip

A TEST LEAD MOUNTING CLIP (64G37) is supplied with the LC77. This clip is useful to hold the test leads out of the way when not in use, but keeps them ready and within reach at any time. The mounting clip may be attached on the top of the LC77, on the side of the handle, or wherever it is most convenient. To mount the clip, peel off the backing, place the clip in the desired location and press it firmly in place.

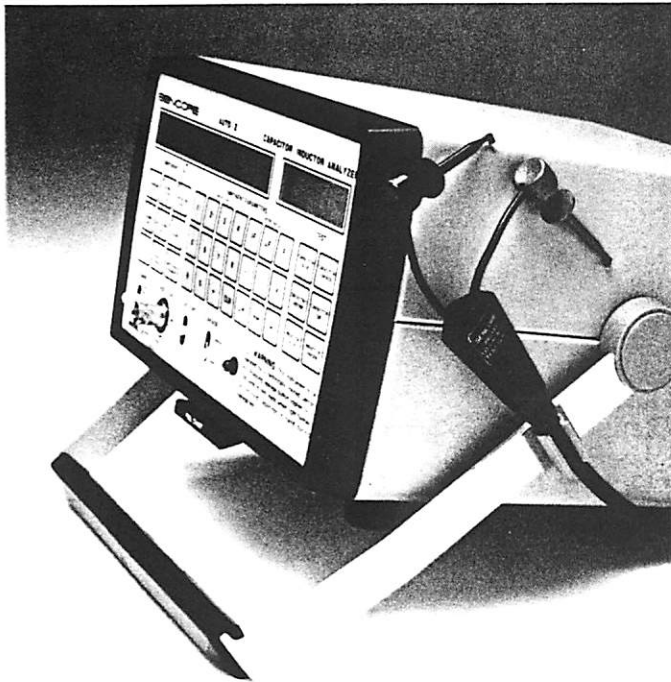


Fig. 9 — The test lead mounting clip holds the test leads out of the way, yet ready for use at anytime.

NOTE: Do not mount the TEST LEAD MOUNTING CLIP to the sides of the "Auto-Z" as this will interfere with the handle movement.

Test Lead Adapter

Some larger value electrolytic capacitors have screw terminals rather than the conventional wire leads or solder terminals. To connect the LC77 to these capacitors you will need to use the supplied 39G144 TEST LEAD ADAPTER. The TEST LEAD ADAPTER converts the E-Z Hook® clips of the test leads to alligator clips which will clamp onto the large screw terminals. A mounting clip on the back of the LC77 stores the TEST LEAD ADAPTER when it is not in use.

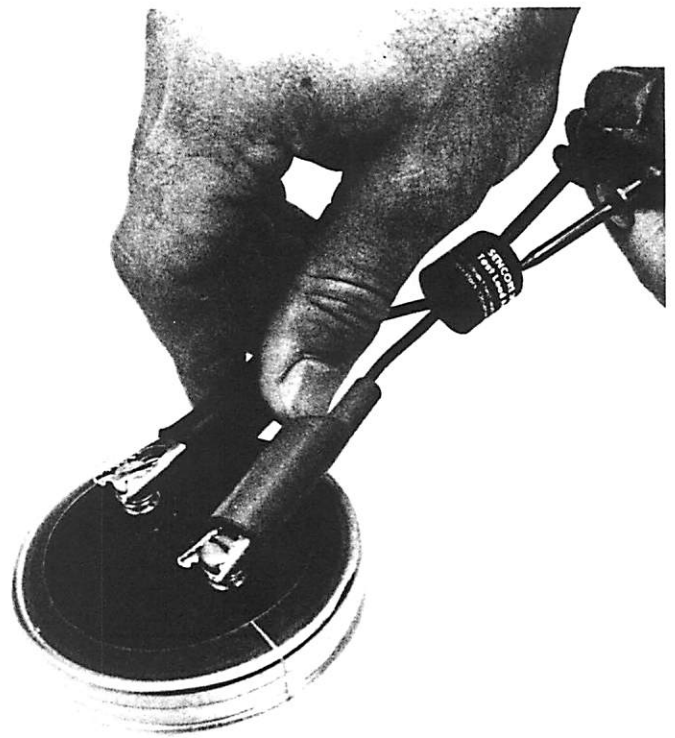


Fig. 10 — The 39G144 Test Lead Adapter allows large, screw-terminal capacitors to be connected to the LC77.

To use the TEST LEAD ADAPTER:

1. Connect the red E-Z Hook® of the LC77 test lead to the red TEST LEAD ADAPTER terminal.
2. Connect the black E-Z Hook® to the black adapter terminal.
3. Connect the red TEST LEAD ADAPTER lead to the "+" capacitor terminal, and the black lead to the "-" terminal.
4. Test the capacitor in the usual manner.

Test Lead Fuse

A 1 amp, Slo-Blo (3AG) fuse is located in the TEST LEAD input jack on the front of the "Auto-Z". This fuse protects the unit from accidental external voltage or current overloads. The fuse may need replacement if the following conditions exist:

BLOWN FUSE CONDITIONS:

- Display reads "OPEN" during inductor lead zeroing
- Display reads "OPEN" during inductance test
- Ringing test reads "0"
- ESR test reads "Error 7"
- No Leakage readings
- Readings do not change with test leads open or shorted

Refer to the maintenance section, located at the back of this manual for information on replacing the test lead fuse.

Leading Zeroing

The test leads connected to the LC77 have a certain amount of capacitance, resistance, and inductance which must be balanced out before measuring small value capacitors and inductors or before measuring capacitor ESR. The test lead impedance should be zeroed when the LC77 is first turned on. It will remain zeroed as long as the unit is powered on. If the LC77 is battery operated and is turned off by the Auto Off circuits, however, the leads must be rezeroed.

To zero the test leads:

1. Turn the LC77 on by momentarily pushing the POWER switch to the ON & BATT TEST position.
2. Connect the test leads to the TEST LEAD INPUT jack on the front of the "Auto-Z".
3. Place the open test leads (with nothing connected) on the work area with the red and black test clips next to each other, but not touching.
4. Move the LEAD ZERO switch to the "Open" position. Release when a "-" begins to move through the display.
5. Connect the red and black test clips together.

6. Move the LEAD ZERO switch to the "Short" position, and release when a "-" begins to move through the display.



Fig. 11 — The impedance of the test leads is balanced out with the LEAD ZERO button.

Entering Component Data

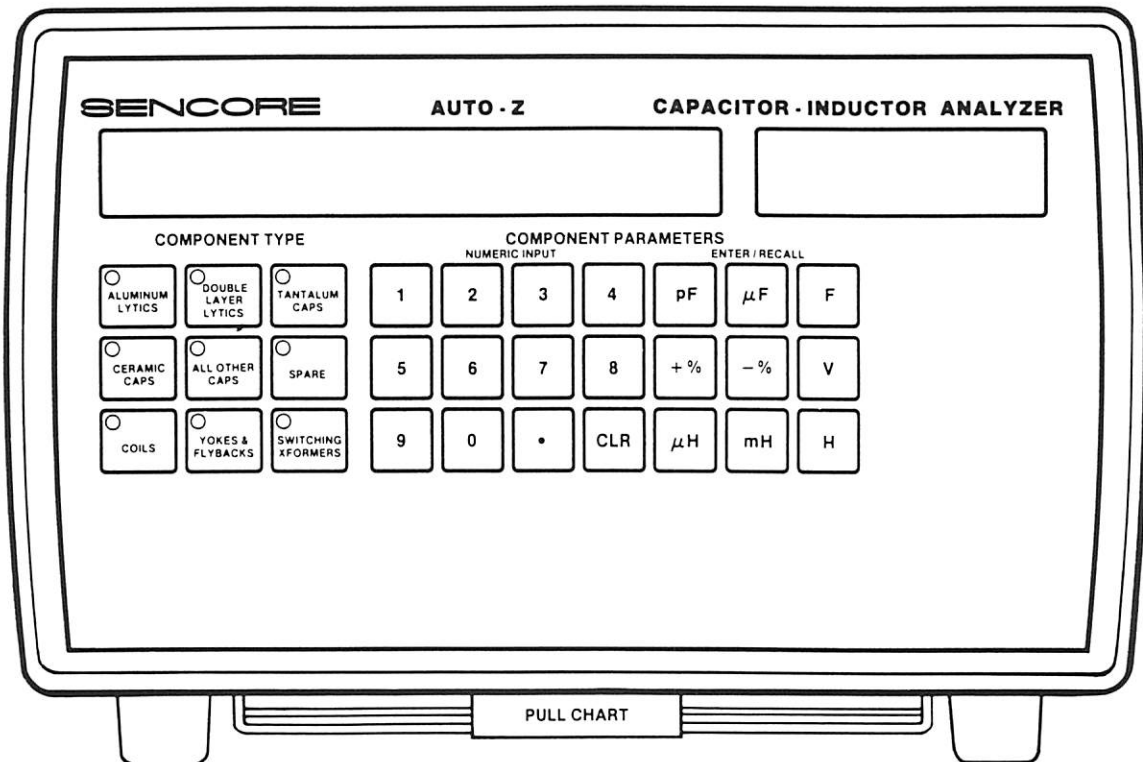


Fig. 12 — Controls used for entering component data.

To use the LC77 to perform the automatic Good/Bad tests explained later in this manual, you must enter data about the component under test into the LC77 "Auto-Z" (All component tests can be performed with-

out entering component data if automatic Good/Bad test indications are not desired). The component data tells the LC77 the "ideal" parameters necessary to make the Good/Bad determination.

The component data which can be entered into the LC77 includes: component type, value, tolerance and rated working voltage for capacitors, and component type, value, and tolerance for inductors and coils. These parameters are usually marked on the component, or can be determined by looking the component up in a parts list or replacement guide. The Applications section of this manual contains information on how to identify capacitor and inductor types.

NOTE: All component data can be cleared by pushing the "CLR" button on the gray COMPONENT KEYPAD twice.

To Enter Component Type:

NOTE: The component type switches tell the LC77 what kind of component is being tested.

1. Press the desired COMPONENT TYPE button. Use the beige color coded buttons when checking capacitors and the blue buttons when checking inductors.
2. A red LED indicator in the corner of the COMPONENT TYPE button lights when that button is selected.

To Enter Component Value:

1. Enter a number, up to 3 significant digits, equal to the value of the capacitor or inductor. (Example: "123" or "123000"). Each digit will appear in the display as a key is pushed.

a. The LC77 rounds the entry down if you enter a number having more than 3 significant digits (Example: "1239" becomes "1230").

b. The LC77 accepts numbers up to 6 places before the decimal. (Example: "100000"). Entries larger than this reset to 0.

c. The LC77 accepts numbers up to 5 places after the decimal for numbers less than 1. (Example: "0.00001"). Entries smaller than this result in "Error 2".

d. All unnecessary place holder digits are dropped. (Example: ".06700" becomes ".067").

e. Push the "CLR" button once to clear the value entry and start over.

2. Enter the desired CAPACITOR VALUE MULTIPLIER or INDUCTOR VALUE MULTIPLIER.

a. The capacitor value range is 1 pF to 19.9 F. The inductor value range is .1 uH to 19.9 H. Entering values beyond this range causes an "Error 2".

b. The LC77 accepts non-conventional value notations, such as ".00001 F", ".00002 uF" or "100000 pF"

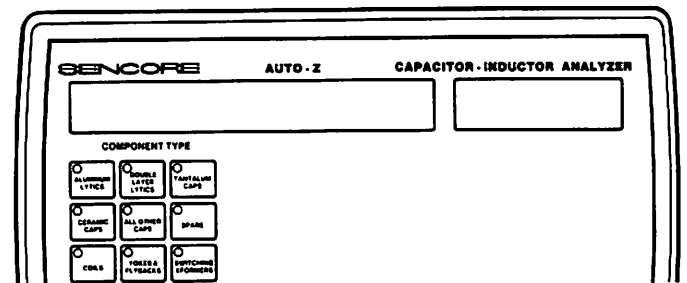
3. After entering the multiplier, the display momentarily shows the entered value and multiplier before returning to a "0000" reading. The LC77 is now ready for the next parameter entry.

4. To check the entered capacitor value at any time, push any beige colored CAPACITOR VALUE MULTIPLIER button. To check the entered inductor value push any blue colored INDUCTOR VALUE MULTIPLIER button.

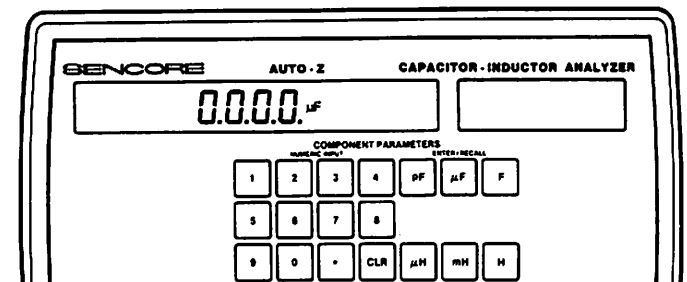
5. To change an entered value parameter, repeat steps 1 & 2.

To Enter Component Tolerance:

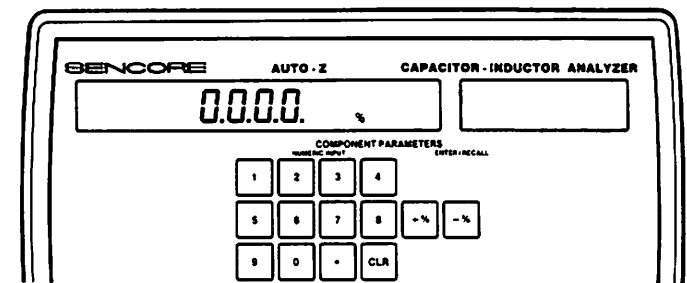
1. Enter a 1, or 2 or 3 digit number up to 100 which equals to the "+" value tolerance of the capacitor or inductor. Do not use a decimal.
2. Press the white "+" PERCENTAGE button.
3. Enter a 1 or 2 digit number up to 99 which equals to the "-" value tolerance of the capacitor or inductor. Do not use a decimal.
4. Press the white "-%" PERCENTAGE button.
5. To check the entered percentage, press the white "+%" or "-%" button at any time.



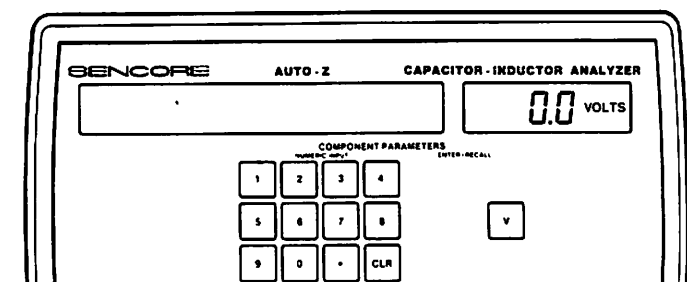
a



b



c



d

Fig. 13 — To enter component data select the COMPONENT TYPE switch which corresponds to the component being tested (a). Next, enter the component value (b) and value tolerance (c). Finally, if testing a capacitor, enter the rated working voltage (d).

To Enter Leakage Voltage:

1. Enter the desired voltage from 1 to 999.9 using the gray keys on the NUMERIC INPUT keypad. A decimal, followed by one digit may be entered, but is not necessary.

2. Push the white "V" key to enter the voltage. The voltage will appear in the APPLIED VOLTAGE LCD DISPLAY. For values greater than 25 volts the red CAUTION INDICATOR LED will blink.

NOTE: The voltage is applied to the component Test Leads when the CAPACITOR LEAKAGE test button is pushed.

3. To enter a different voltage, repeat steps 1 & 2.

Error Codes

Several error conditions may occur while using the LC77 which cause an error message to appear in the LCD display. These are usually caused by small errors in the operation of the LC77, although severely defective components may also cause certain error conditions. The error conditions are explained below.

Error 1 - Component Type Selection Error - This error occurs when a component test is attempted, and either an incorrect COMPONENT TYPE switch is selected for the test, or no COMPONENT TYPE switch is selected when required.

Possible causes:

1. Performing a capacitor test with an inductor COMPONENT TYPE switch selected.
2. Performing an inductor test with a capacitor COMPONENT TYPE switch selected.
3. Performing the INDUCTOR RINGER test without an inductor COMPONENT TYPE switch selected.
4. Performing any component test with the "Spare" capacitor COMPONENT TYPE button selected.

Error 2 - Entered Value Beyond Range of Unit - The component parameter entered via the keypad or IEEE is beyond the measuring range of the LC77.

Possible causes:

1. Entering a capacitance value greater than 19.9 Farads, or less than 1 picofarad.
2. Entering an inductance value greater than 19.9 Henrys, or less than .1 microhenrys.
3. Entering a leakage voltage greater than 999.9 volts.
4. Entering a tolerance percentage greater than +100%, or less than -99%.
5. Entering a tolerance percentage that includes a decimal.

NOTE: Entering a leakage voltage less than 1 volt will set the leakage supply to 0 volts.

Error 3 - Entered Value Beyond Range Of Test - The component parameter entered via the keypad or IEEE is beyond the limits of the automatic good/bad test. The component may still be able to be tested, but not for a good/bad indication.

Possible causes:

1. Performing an ESR test with a capacitor value of less than 1 uF entered.
2. Performing a D/A test with a capacitor value of less than .01 uF entered.
3. Performing an INDUCTOR RINGER test with an inductor value of less than 10 uH entered.

Error 4 - Value Beyond Zeroing Limit - The amount of inductance or capacitance at the TEST LEAD INPUT is beyond the range of the zeroing circuits. An open (greater than 20 Kilohms) or shorted (less than 1 ohm) test lead will cause the "OPEN" or "SHORT" annunciator to come on, rather than produce an "Error 4".

Possible causes:

1. The capacitance at the TEST LEAD INPUT is greater than 1800 pF.
2. The inductance at the TEST LEAD INPUT is greater than 18 uH.
3. The resistance at the TEST LEAD INPUT is greater than 1 ohm.

Error 5 - No Voltage Entered - This error occurs when the CAPACITOR LEAKAGE button is pushed and no test voltage has been entered.

Error 6 - Invalid IEEE Command - An improper command was sent to the LC77 via the IEEE bus.

Possible causes:

1. Sending a command that is not recognized by the LC77.
2. Wrong command syntax.

NOTE: Refer to the IEEE 488 Bus Operation section of this manual for information on using the "Auto-Z" with IEEE control.

Error 7 - Component Out Of Test Range - The component under test exceeds the limits of the test which was attempted.

Possible causes:

1. Measuring ESR of a capacitor having a value less than 1 uF.
2. Measuring capacitance value on an extremely leaky capacitor.
3. Attempting a capacitor value test with 1 ohm to 2 Megohms of resistance connected across test leads.

Capacitor Testing

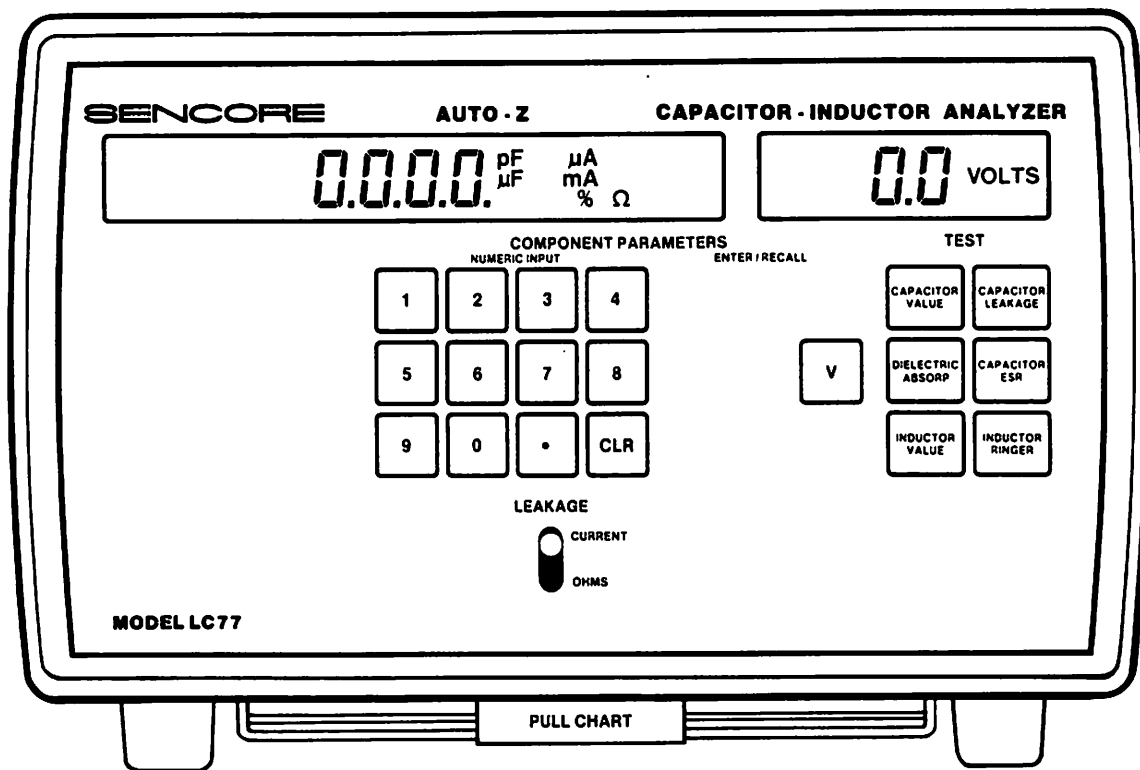


Fig. 14— Controls used for capacitor parameter tests.

The LC77 "Auto-Z" checks capacitors for value from 1.0 pF to 20 Farads in 12 automatically selected ranges. The automatic features of the LC77 "Auto-Z" allow you to perform two levels of automated capacitor testing: basic parameter testing, and automatic good/bad testing. For basic parameter testing, you simply connect the component to the test leads and push the test button. The LC77 measures the capacitor and displays the test result. You must look up the values of leakage, ESR and dielectric absorption in a table to determine if the capacitor is good or bad.

For automatic good/bad testing, you first enter the parameters of the capacitor before performing the test. Then the LC77 will display the test results along with a good/bad indication of the capacitor. Only selected parameters need to be entered into the LC77, depending upon which tests you desire a good/bad readout for.

Capacitance Measurement Accuracy

The LC77 measures the RC charge time as the capacitor is charged through a precision resistor. This gives the most accurate measurement of true capacity available. Capacity values measured with the "Auto-Z" may or may not exactly match readings on other instruments which use a different measuring technique. Bridges, for example, measure capacitive reactance using an AC

signal. Capacitive reactance changes with frequency. Therefore, two bridges operating at different frequencies will give different capacity readings.

Electrolytic capacitors may normally read up to 50% higher than their marked value when measured with the LC77. This is because electrolytics are marked according to their value as measured on an AC-type impedance bridge. The value of an electrolytic changes greatly with the measurement frequency. This should cause no problem in determining if an electrolytic capacitor is good or bad, since most electrolytic capacitors have up to 80% value. The capacitor should read close to its marked value, or within tolerance when checked with the LC77. In addition, electrolytics most commonly fail due to leakage, dielectric absorption, or ESR. When an electrolytic does change value, the value drops far below the marked value.

The LC77 "Auto-Z" is designed to measure capacitors out of circuit. Impedances found in the circuit will upset the "Auto-Z" readings. Capacitors can not be checked in circuit accurately or reliably with any test method. Capacitors in circuit however, may be tested by unsoldering one lead from the circuit. When doing this, be sure to remove power from the circuit. If the unit is AC powered, unplug the AC line cord. Whenever possible, remove the capacitor completely from the circuit to test it.

WARNING

When checking capacitors, remove the capacitor from circuit if possible. Otherwise, make sure the power is removed from the circuit and the AC line cord to the unit containing the capacitor is unplugged. Always connect the capacitor to the LC77 test leads before depressing the CAPACITANCE VALUE test button.

Measuring Small Capacitance Values In Noisy Environments

The sensitive "Auto-Z" measuring circuits may be affected by large, outside signals (such as the AC fields radiated by some lights and power transformers) when small capacitance values are being measured. Special circuits in the LC77 help minimize noise pickup and stabilize the readings.

Measurements of small value capacitors in noisy environments may be further improved by grounding the LC77 case to earth ground. When possible, power the LC77 with the PA251 AC Adapter/Charger connected to a properly grounded AC outlet. The PA251 Adapter/Charger maintains the third wire ground shield and keeps the noise away from the measuring circuits inside the "Auto-Z".

Capacitor Parameter Testing

The LC77 checks capacitors for capacitance value, leakage, dielectric absorption and Equivalent Series Resistance (ESR). These tests are made directly using the beige colored TEST buttons. Simply connect the component to the test leads, push the desired TEST button, and read the test result in the LCD display. You can determine if the component is good or bad by comparing the measured ESR and leakage values to the standard values listed in the tables in this manual and on the Pull Chart underneath the LC77.

NOTE: Except for the capacitor leakage test, no component parameters need to be entered to perform any capacitor parameter test. If any blue Inductor COMPONENT TYPE button is selected, error code "Error 1" will appear in the LCD readout when you attempt to make a capacitor test. Push the "CLR" key on the gray NUMERIC KEYPAD twice to clear any parameters.

The following procedures provide all the necessary information required to perform the capacitor parameter tests. A more detailed description of each of the capacitor tests and failure modes can be found in the Applications section of this manual.

Measuring Capacitor Value

To Measure Capacitor Value:

1. Zero the test leads, as explained on page 16.
2. Connect the capacitor to the test leads. If the capacitor is polarized, be sure to connect the black test clip to the "-" terminal of the capacitor and the red test clip to the "+" capacitor terminal.
3. Depress the CAPACITOR VALUE button.
4. Read the value of the capacitor in the LCD DISPLAY.

NOTE: The "SHORT" annunciator appearing in the LCD display when the CAPACITOR VALUE button is depressed indicates a resistance of 1 ohm or less at the test leads. Check the test leads. If they are not shorted, the capacitor is bad.

Some capacitors will cause the display to read "Error 7". These capacitors have too much leakage current to allow the LC77 to make a value check and should be considered bad.



Fig. 15 — To measure capacitance, connect the capacitor to the test leads and push the CAPACITOR VALUE button. The amount of capacity appears in the LCD display.

Measuring Capacitor Dielectric Absorption

Dielectric Absorption is often called "battery action" or "capacitor memory" and is the inability of the capacitor to completely discharge. While all capacitors have some minute amounts of dielectric absorption, electrolytics may often develop excessive amounts which affect the operation of the circuit they are used in.

To check a capacitor for dielectric absorption, press the DIELECTRIC ABSORPTION button and compare the value to the chart. A fully automatic good/bad test may also be used to test for dielectric absorption. This test is explained in a later section.

To measure capacitor dielectric absorption:

1. Connect the capacitor to the test leads. If the capacitor is polarized, connect the red test clip to the “+” capacitor terminal and the black test clip to the “-” terminal.
2. Depress the DIELECTRIC ABSORPTION button. A “-” will appear and slowly move through the display indicating that the test is in progress.
3. Read the percentage of dielectric absorption on the display.
4. Compare the measured D/A to the amount listed in Table 1 for the capacitor type you are testing to determine if the capacitor is good or bad.

NOTE: Depending on the capacitor’s value, type and actual D/A, the LC77 may, in a few cases, take up to 10 seconds to display a reading.

Maximum Allowable Percent Of D/A

Capacitor type	Maximum % of D/A
Double Layer Lytic	Meaningless. D/A may normally be very high.
Aluminum Lytic	15%
Tantalum Lytic	15%
Ceramic	10%
All others	0%

Refer to the Applications section of this manual for capacitor type identification.

Table 1 — Maximum amounts of Dielectric Absorption.

Measuring Capacitor Leakage (In microamps)

Capacitor leakage occurs when some of the voltage from one plate flows (leaks) through the dielectric to the other plate. The amount of leakage current through the dielectric depends on the voltage applied across the plates. For this reason, always check a capacitor for leakage at (or as close as possible to) its rated voltage. Voltages up to 999.9 volts may be applied with the LC77.

To check capacitors for leakage, enter the working voltage of the capacitor and press the CAPACITOR LEAKAGE button. Compare the measured leakage current to the maximum allowable amounts in the leakage

charts. The capacitor is good if the measured leakage is below the amount shown in the chart. A fully automatic good/bad test may also be used to check capacitors for leakage. This test is explained in a later section.

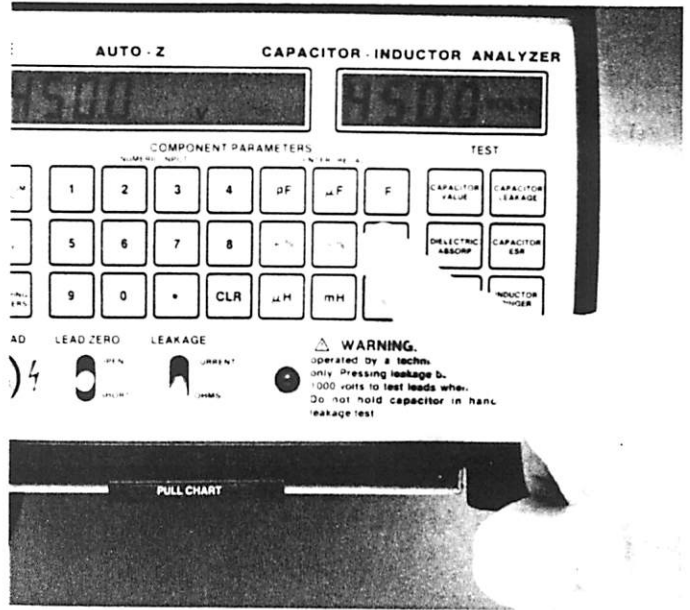


Fig. 16 — To test capacitor leakage, enter the working voltage of the capacitor.

To measure capacitor leakage:

1. Connect the capacitor to the test leads. If the capacitor is polarized, connect the red test clip to the “+” capacitor terminal and the black test clip to the “-” terminal.
2. Set the LEAKAGE switch to the “Current” position to read the leakage of the capacitor in uA or mA.
3. Enter the normal working voltage of the capacitor as explained earlier in the section “Entering Component Parameters” on page 16.

WARNING

The LC77 is designed to be operated by a technically trained person who understands the shock hazard of up to 1000 volts applied to the test leads during the capacitor leakage test. **DO NOT** hold the capacitor in your hand, or touch the test leads or capacitor leads when making the leakage test.

4. Depress the CAPACITOR LEAKAGE button and read the amount of leakage in the LCD display.
5. Compare the measured leakage to the maximum allowable amount listed in the Leakage Charts on pages 23 and 24 for the type, value, and voltage rating of the capacitor you are testing.

NOTE: By entering the Component Type and Value parameters for the capacitor, the LC77 will automatically display the measured leakage along with the same good/bad indication as the Leakage Charts.