Almost All Digital Electronics

L/C Meter IIB
Neil Heckt

• Specifications

Range

- **.001 µHy (1 nHy) to 100 mHy (most units measure to 150 mHy)**
- **.010 pF to 1 µFd (most units measure to 1.5 uFd)**
- **(Capacitors must be non-polarized)**
- **AUTOMATIC RANGING**

The unit is intended to measure components designed to be inductors or capacitors, not items which may happen to have inductance or capacitance such as motors, power transformers, solenoids, relays, metal detector coils etc. or any 60Hz component such as oil filled capacitors. Results may vary when measuring such items.

Accuracy 1% of reading Typical

- **Typical means the average error for 60 inductance calibration standards:**
  - **20 HP 16470A standard calibration inductors**
  - **16 Booton type 103A standard calibration inductors**
  - **6 Booton type 62-2A standard calibration inductors**
  - **18 Marconi type TM 4520 standard calibration inductors**
- **and 83 capacitance calibration standard**
  - **7 Heathkit 0.25% capacitance calibration standards**
  - **37 Vero 0.1% capacitance calibration standards**
  - **39 0.5% decade capacitance calibration standard**
  - **10 2% high value capacitance calibration standards**
- **See http://www.aade.com/lcm2binst/HP.html for detailed results.**
- **SELF-CALIBRATING**

Display

16 Char intelligent LCD
Four Digit Resolution
Direct display in engineering units, ie: Lx= 1.234 µHy / Cx= 123.4 pF

Sampling Rate:

Approximately 5 samples / second. (will track while adjusting adjustable components)

The unit displays values in one of two modes which can be changed during operation. The "micro mode" displays values in uHy, mHy, pF, and uF when applicable. In this mode, for example, 10.00 nano-Farads displays as .01000 micro-Farads and 1 nano-Henry displays as .001 micro-Hy. It is for old timers like me and is the way many parts are marked. The "nano mode" is for those more metrically inclined. Table 1 shows how each range is displayed in each mode.

INDUCTANCE nano mode	INDUCTANCE micro mode	CAPACITANCE nano mode	CAPACITANCE micro mode
000-999 nHy	0.000 - 0.999 µHy	0.00 - 0.99 pF	0.00 - 0.99 pF
1.000 - 9.999 µHy	1.000 - 9.999 µHy	1.00 - 9.99 pF	1.00 - 9.99 pF
10.00 - 99.99 µHy	10.00 - 99.99 µHy	10.00 - 99.99 pF	10.00 - 99.99 pF
100.0 - 999.9 µHy	100.0 - 999.9 µHy	100.0 - 999.9 pF	100.0 - 999.9 pF
1.000 - 1.999 mHy	1.000 - 1.999 mHy	1.000 - 9.999 nF	1000 - 9999 pF
10.00 - 99.99 mHy	10.00 - 99.99 mHy	10.00 - 99.99 nF	.01000 - .09999 µF
100.0 - 150.0 mHy *	100.0 - 150.0 mHy *	100.0 - 999.9 nF	.1000 - .9999 µFd
		1.000 - 1.500 µFd *	1.000 - 1.500 µFd *

TABLE 1. Display Options (* Some values may be out of range).

Operating Modes

When the **Lx** and **Cx** switches are off pressing the **ZERO** button sequences L/C Meter IIB through five different operating modes.

READY MEASURE n measures Lx or Cx and displays the result in "nano mode"
ie: Lx = 99 nHy, Cx = 12.34 nF

READY MEASURE u measures Lx or Cx and displays the result in "micro mode"
id: Lx = .099 uHy, Cx = .01234 uF

READY MATCHnMODE first measures a reference component Lz or Cz and displays the value in "nano mode". When the **ZERO** button is pressed this value is stored in RAM and the difference between it and subsequent components is displayed in "nano mode"
ie: Lx - Lz = 99 nHy, Cx - Cz = 12.34 nF

READY MATCHuMODE first measures a reference component Lz or Cz and displays the value in "micro mode". When the **ZERO** button is pressed this value is stored in RAM and the difference between it and subsequent components is displayed in "micro mode"
ie: Lx - Lz = .099 uHy, Cx - Cz = .01234 uF

READY MATCH%MODE first measures a reference component Lz or Cz and displays the value in "nano mode". When the **ZERO** button is pressed this value is stored in RAM and the ratio of the difference between it and subsequent components is displayed in percent.
ie: (Lx - Lz)/Lz*100 =12.34%, (Cx - Cz)/Cz*100 = 12.34%

Note that a positive reading in the matching modes means Lx is greater than Lz or Cx is greater than Cz and visa versa.

L/C Meter II is intended to measure inductors and capacitors "out of the circuit". Inductors must have a reasonable Q for their value and negligible distributed capacitance for their value. I have tested it using commercially available RF chokes ranging from 0.1 micro-Henry to 1000 mico-Henry , Hash chokes up to 100 mico-Henry wound on ferrite rods, on Pi-wound RF chokes up to 7.5 milli-Henry, on toroid wound inductors up to 150 milli-Henry (such as the HI-Q series obtainable from Mouser Electronics), and on several slug tuned inductors from a Coilcraft Slot-10 designers kit (similar to the TOKO line of tunable inductors).

Stray Inductance and Capacitance

The circuit traces on the PCB, the switches , and the test leads all contribute a small amount of "Stray" inductance (Ls) and capacitance (Cs). These stray values add to the values of Lx or Cx. The unit is zeroed by pressing the ZERO switch which causes the unit to store the values of stray inductance or capacitance and subtracts them from the measured values.

To zero Ls the operator must short circuit the test leads, press Lx and then press the ZERO button. Similarly, for capacitors, the operator open circuits the test leads, presses Cx and then presses ZERO.

The stored values of Ls and Cs are saved until the operating mode is changed. When measuring components, it is not necessary to re-ZERO between components. When the operating mode is changed from MEASURE to MATCH these values are reset to zero.

If an inductor is inserted when the Cx switch is depressed it will display "NOT A CAPACITOR". This does not work for very large values of Lx and the unit may display an erroneous reading.

Putting a capacitor in when the Lx switch is pressed displays "NOT AN INDUCTOR". This is not true for very large values of Cx in which case the unit may display an erroneous reading.

L/C Meter IIB can zero out ANY value in it's range. If a value is inserted and ZERO'd the unit will display the difference between it and subsequent components similar to the MATCHnMODE and MATCHuMODEs. The difference in the MATCHxMODEs is that the range is frozen to the resolution of the initial component. This limits the minimum difference in values to be 1 part in 10,000 or .01%. The reason for this may not be obvious. The maximum resolution of the unit is four digits **at the value of the components being measured**. Consider two components, one with an exact value of 5000 pF and the other with an exact value of 5010.25 pF. The difference would be 10.25 pF, however the unit cannot resolve less than 1 pF at this range and it would be misleading to display the fractional portion of the difference.

Operation

The typical stray inductance is .04 to .06 µHy's and the typical stray capacitance is 5 to 7 pF's. When measuring inductors less than 5 µHy's or capacitance's less than 50 pF's it is advisable to ZERO the unit first. For small values of inductance maximum accuracy is obtained if you short the test leads before you turn the unit on.

For larger values the strays are insignificant to the result. It is difficult to retain a reading of 0.000 pF's because of the extreme sensitivity of the unit. Your body capacitance influences the reading. Try ZEROing the capacitance and then move your hands around the test leads without touching them. You will find your can adjust the reading a few hundredths of a pF.

To measure inductance place the unknown across the test leads and depress Lx. To measure capacitance place the unknown across the test leads and press Cx.

The oscillator tends to drift a few Hertz during the first few minutes of operation. When measuring very small values the unit should be allowed to warm up for about five minutes. With a resolution of 5 Hz, thermal drift will always occur as evidenced by a slowly drifting reading. The first readings after pressing Lx or Cx are the most accurate.

Accuracy and Resolution

L/C Meter IIB has four digit resolution which for small values of L and C are 1 nHy and .01 pF. You cannot accurately measure values this small. The resolution greatly exceeds the accuracy. You can measure values as small as .01µHy and .1 pF with about 15% accuracy. You generally won't find components this small. For example a piece of wire less than one inch long is .01 µHy. The resolution is, however, relative and can be used for sorting a batch of similar components as it truly does indicate which are slightly larger of smaller than others. Also, for small values of inductance, the leads will contribute quite a bit to the value. Measuring from the ends of the leads instead of next to the body of the component can add up to .025µHy.

For small values the frequency of operation (test frequency) is about 750 KHz decreasing to about 60 KHz at .1 µFd's or 10 mHy's and about 20 KHz at 1 µFd or 100 mHy's.

About winding toroid inductors

The inductance obtained winding toroid inductors depends on several things. Winding diameter, length, number of turns etc. (similar to air wound but on a higher permeability core). Just as in airwound, inductance can be varied by varying the length of the winding. **AL values are normally specified for windings spaced over at least 80% of the core circumference and wound tightly to maximize magnetic coupling**.

As a test I *close wound* 10 turns #20 wire on a T-50-6, AL = 40 uHy/100 turns
The calculated L was 0.4uHy
Measured value was 0.7uHy
I then spread the turns evenly over at least 80% of the core.
Measured value was 0.45uHy.
Clearly winding method has large influence on inductance.
A wealth of information can be found at http://www.micrometals.com/ and http://www.bytemark.com/

When measuring capacitors the value may change rapidly at first finally settling to a stable value.

Some capacitors make excellent temperature sensors. The meter puts a small amount of current thru the cap being measured and changes its temperature. The temperature must stabilize before the capacitance will. This is particularly true of ceramics with a Z5U temperature coefficient, meant for use as bypass caps, and less true for ceramics with NPO or C0G temperature coefficients.

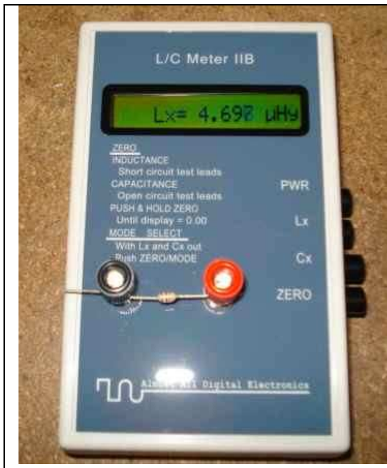
You can determine if temperature is the cause by squeezing the cap between your fingers to heat it up and watch the meter. The cap may change value rapidly and when you let go will slowly go back to a stable reading.

See: http://www.uoguelph.ca/~antoon/gadgets/caps/caps.html for tons of information on capacitors.

Measuring small values of iductance

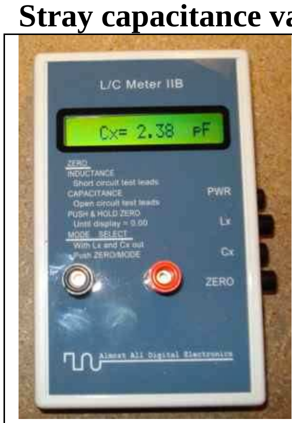
Think of stray capacitance as subtracting from the inductance. The stray capacitance of the test leads reduces the inductance reading and steps should be take to minimize it.

For small values of inductance maximum accuracy is obtained if you short the test leads before you turn the unit on. This includes some of the stray inductance in the self-calibration cycle.

		
4.7uHy choke directly across test jacks which is minimum stray capacitance. 4.697uHy after zeroing stray inductance	Same choke with test leads closely spaced which is high stray capacitance. 4.637uHy after zeroing stray inductance.	Same choke with test leads spread for minimum stray capacitance. 4.709uHy after zeroing.

Values below 1uHy should be measured without test leads if possible.
Obviously the effect is greater for even smaller inductors where the stray capacitance is more significant.

Stray capacitance varies with test lead spacing and hand capacitance

			
No test leads 2.38pF	**Close spacing 5.00 pF**	**Wide spacing 4.54 pF**	**Hand capacitance 5.08pF**

If the test jack have not been installed (so I could use a smaller box to ship the unit in) then disassemble the included jacks and discard the portions circled, Screw the posts into the unit and then add the knurled caps.

Opening the unit

If for some reason you need to open the unit, first remove the knurled parts of the test jacks then remove the test jacks by un-screwing them. Finally remove the four screws from the rear of the unit. Lift the front off to expose the PCB. It is held with three #4 sheet metal screws.

Assembling the optional SMD probe is a bit of a no-brainer. Just remember to clip the plastic part at the tips even with the metal part using a finger nail clipper as shown in upper right.

The kit of parts is shown on the top and the finished product and how to use it on the bottom.

Pick up the part with the spring loaded tweezer and then let go to keep your body capacitance from upsetting the reading.

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