Building and Operating

The LC Meter
from Jackson Harbor Press
A Morse code Inductance / Capacitance Meter

The LC METER kit is an inductance / capacitance meter with Morse code output.

General notes on building the LC Meter kit

U1 is a MOSFET device. This means that it should be handled as little as possible to prevent static damage. The builder should use a grounding strap and anti-static mat if available or at the very least, work on a grounded metal surface and be sure to touch ground prior to touching this part.

The pads and traces are small and delicate - a small tipped, low power (25 watts or less) soldering iron should be used.

Building the LC Meter

Step 1) Get the parts together: All of the board mounted components have been supplied but you will still have to provide off-board items to fully implement the kit. These items are mentioned at the end of the kit parts list and include a power connector and a method of connecting to the unknown capacitor and inductor.

Step 2) Identify and orient the components: Most of the components should be fairly easy to identify and place - see the parts list and the parts placement diagram for descriptions. The orientation of the capacitors: C3 & C8 are especially important since they are polarized (electrolytic) capacitors. C8 is a small cylindrical cap, the negative (-) side is indicated with a white stripe on one side of the cap. Be sure to match these polarity marks with the ones on the parts placement diagram and in the building procedure to follow.

Step 3) Form the leads, place and solder the components on the main circuit board: Use the parts placement diagram for information on the placement and orientation of the parts. Clip the leads of the parts after soldering.

a) 8 pin DIP sockets - place them as shown on the parts placement diagram for U1 and U2 with the notch to the left side of the board.

b) C1, .1 uF capacitor (marked 104, small yellow, .1” lead space). Place C1 as shown on the parts placement diagram, at the left center part of the board and solder in place.

c) C2, .1 uF capacitor (marked 104, small yellow, .1” lead space). Place C2 as shown on the parts placement diagram, above and to the left of C1 at the left top of the circuit board and solder in place.

d) C6, .1 uF capacitor (marked 104, small yellow, .1” lead space). Place C6 as shown on the parts placement diagram, above and to the left of U2 at the top right of the circuit board and solder in place.

e) C7, .1 uF capacitor (marked 104, small yellow, .1” lead space). Place C7 as shown on the parts placement diagram, below the U2 dip socket at the right center of the circuit board and solder in place.

f) R2, 4.7 k ohm resistor (yellow, violet, red, gold). Form the leads of R2 by bending them both at a 90 degree angle for horizontal mounting and place R2 as shown on the parts placement diagram, at the top center of the circuit board and solder in place.

g) R1, 10 k ohm resistor (brown, black, orange, gold). Form the leads of R1 by bending them both at a 90 degree angle for horizontal mounting and place R1 as shown on the parts placement diagram, to the right of the U1 DIP socket and solder in place.

h) R4, 100 k ohm resistor (brown, black, yellow, gold). Form the leads of R4 by bending them both at a 90 degree angle for horizontal mounting and place R4 as shown on the parts placement diagram, to the right of R1 and solder in place.

i) R5, 100 k ohm resistor (brown, black, yellow, gold). Form the leads of R5 by bending them both at a 90 degree angle for horizontal mounting and place R5 as shown on the parts placement diagram, below R6 and solder in place.

j) R7, 51 k ohm resistor (green, brown, orange, gold). Form the leads of R7 by bending them both at a 90 degree angle for horizontal mounting and place R7 as shown on the parts placement diagram, to the left of the U2 DIP socket and solder in place (it is crowded near the top lead of R7, don't short R7 to the large ground trace).

l) L1, 100 uH green body choke (brown, black, brown, gold). Form the leads of L1 by bending them both at a 90 degree angle for horizontal mounting and place L1 as shown on the parts placement diagram, below C7 (from step e above(below the U2 DIP socket)) and solder in place.

m) C4, 27 pF capacitor (marked 27, small orange disc, .1" lead space). Place C4 as shown on the parts placement diagram, above the LC Meter and WB9KZY legend and solder in place.

n) C5, 27 pF capacitor (marked 27, small orange disc, .1" lead space). Place C5 as shown on the parts placement diagram, to the right of C4 and solder in place.

o) U3, 5V regulator (marked 78L05). Place U3 as shown on the parts placement diagram, at the leftmost center part of the board with the flat face oriented left and solder in place.

p) D1, 1n5818/19 diode (marked 1n5818 or 1n5819) First, form the leads of D1 by bending over the lead on the banded end 180 degrees until both leads of D1 are parallel. Then place D1 as shown on the parts placement diagram, just below U3, put the banded end towards U3 and solder in place.

q) C10, 1000 pF calibration capacitor (marked 102F on one side and with a number from 1 to 10 in magic marker on the other side, brownish red, short pre-formed leads, .2" lead space). Straighten the leads using a small pliers. Place C10 as shown on the parts placement diagram, at the bottom right portion of the board and solder in place. Note that there should be a slip of paper with the estimated value of this capacitor in the parts bag.

r) C9, 1000 pF capacitor (marked 102G, brownish red, .2" lead space). Place C9 as shown on the parts placement diagram, just to the right of C10 (installed in the previous step) and solder in place.

s) 2 pin calibration header - Place the header as shown on the parts placement diagram just to the left and above C10 (installed two steps ago) and solder in place. This jumper is a tight fit and C10 may need to be tilted away from the jumper and/or the jumper plastic may need to be trimmed slightly with a diagonal cutter to get a good fit.

t) 2 pin inductance header - Place the header as shown on the parts placement diagram just to the right of the U2 socket on the right edge of the board and solder in place. Installing this jumper is optional since the function can be replaced by connecting the inductance clip to ground.

u) C3, 10 uF capacitor (marked 10 uF 25V, larger blue cap of the two 10 uF cylindrical caps). Place C3 as shown on the parts placement diagram, at the top right corner of the U1 socket, orient the negative stripe to the top edge of the board and solder in place.

v) C8, 10 uF capacitor (marked 10 uF 16V, smaller black cap of the two 10 uF cylindrical caps). Place C8 as shown on the parts placement diagram, at the left of the 2 pin calibration header, orient the negative stripe to the bottom edge of the board, leave the leads a little long to allow the cap to be tilted slightly away from the header (don't push the cap fully down flush with the board) and solder in place.

w) R6, 51 k ohm resistor (green, brown, orange, gold). First, form the leads of R6 by bending over one lead 180 degrees until both leads of R6 are parallel. Then place R6 as shown on the parts placement diagram, between R4 and R7 (and just above C8), and solder in place.

x) R3, 1 k ohm resistor (brown, black, red, gold). First, form the leads of R3 by bending over one lead 180 degrees until both leads of R3 are parallel. Then place R3 as shown on the parts placement diagram, just above U2, and solder in place.

y) X1, 4 MHz crystal (marked 4.00 - 20). Place X1 as shown on the parts placement diagram, between the U1 socket and the C4 and C5 capacitors soldered in steps m and n above and solder in place.

z) SW1 and SW2, momentary switches (red and black). Place SW1 and SW2 as shown on the parts placement diagram, at the center bottom edge with the flat side of each switch towards the right and solder in place. Note that C10 may have to be tilted against the calibration header to allow SW2 to fit.

aa) Piezo speaker, Solder the red wire to the piezo speaker hole on the top edge of the circuit board as shown on the parts placement diagram. Solder the black wire to the ground hole just to the left of the red wire.

ab) power connector, Solder the power connector to the +Vin and ground holes on the left bottom edge of the circuit board.

ac) component clips, Solder either alligator clips or some other means of connecting to the inductor/capacitor the builder's choice, to the Lx, Cx and Ground holes on the right side of the board.

Step 4) Check the board: Before proceeding, take the time to check the top (mostly) and the bottom of the board for solder bridges. Use the parts placement and bottom view diagrams as a guide to visually check for these shorts. It may help to clean the flux from the board and then use a strong light in conjunction with a magnifying glass to see these problems. Also, double check the orientation of the critical components such as the 5V regulator U3 and the electrolytic caps C3 and C8. Here are some quick measurements that can be made to confirm that the board is working correctly:

Attach the negative lead of a DVM to ground, then use the positive lead to measure the resistance at the 8 pins of the open U1 IC socket.:

pin	resistance measurement
1	3.35 k ohms after charging up
2	infinity
3	infinity
4	13.2 k ohms
5	9 k ohms
6	infinity
7	infinity
8	0

open U2 IC socket.:

pin	resistance measurement
1	0
2	28.7 k ohms
3	63.8 k ohms
4	0
5	infinity
6	infinity
7	4.3 k ohms
8	3.35 k ohms after charging up

Next, try applying power (9 volts were applied for this test)
open U1 IC socket

pin	voltage measurement

1	5.0 volts
2	0
3	0
4	5.0
5	5.0
6	0
7	0
8	0

open U2 IC socket

pin	voltage measurement
1	0 volts
2	3.7
3	5.0
4	0
5	0
6	0
7	5.0
8	5.0

After you are convinced that the board is OK, form the leads of U1 (the 8 pin DIP PIC IC) and insert it into the 8 pin socket with pin 1 oriented towards the left edge of the board as shown on the parts placement diagram. Form the leads of U2 (the 8 pin DIP LM311 IC) and insert it into the 8 pin socket with pin 1 oriented towards the left edge of the board as shown on the parts placement diagram. Connect the board to a 9V battery using a VOM to measure the current used, current should be about 8.5 mA or less. If it's much larger OR too small (zero mA), power down and re-check the board for opens, shorts and polarity problems. The LC Meter should send an: FB O via the piezo speaker.

Voltage measurements with the PIC inserted into the U1 socket and power at 9 volts

pin	voltage measurement
1	5.0 volts
2	2.0
3	2.4
4	5.0
5	2.6
6	5.0
7	0
8	0

Voltage measurements with the LM311 inserted into the U2 socket and power at 9 volts

pin	voltage measurement
1	0 volts
2	2.5
3	2.5
4	0
5	5.0
6	5.0
7	2.5
8	5

Powerup: Immediately after powerup the LC Meter will send an FB through the sidetone to signal correct operation, then an O (for Open calibration header) will be sent. Make sure that the calibration jumper has been removed (also, be sure that the inductance jumper is in place OR that the inductance clip is grounded), then PAR the capacitance (left) button, after a second the LC Meter will send SH (for SHort the calibration header), install the calibration jumper. Then PAR the capacitance button again, after a second, the LC Meter will send an R. Remove the calibration jumper and then LC Meter is ready to measure !

Operation: General notes on using the switches to control the kit: The switches can be pressed and released (PAR) OR pressed and held for two seconds (PAH). This doubles the number of combinations of the two control switches.

Generally, PAR is used for actions: send the cap value. PAH is used for settings: change the speed.

A PAR of SW1, the capacitance (left) button, will result in the LC Meter sending:

C <then a 1 second delay> 1T000 PF (for a 1000 pF cap such as the calibration cap)

The T (or dah) is a shortened version of a comma (dah dah di-di dah dah).
Be sure to remove the calibration jumper when measuring a capacitor and be sure to have the inductance jumper in place OR remove the inductance jumper and connect the Lx alligator clip to ground. Connect the capacitor to be tested between the Cx clip (shown in the hookup diagram) and the ground clip. Then PAR SW1 to measure the cap value.

A PAR of SW2, the inductance (right) button, will result in the LC Meter sending:

L <then a 1 second delay> 100E00 UH (for a 100 uH inductor)

The E (or dit) is a shortened version of a period (di-di dah dah di-dit).
Be sure to remove the calibration jumper when measuring an inductor and be sure to remove the inductance jumper. Connect the inductor to be tested between the Lx clip (shown in the hookup diagram) and the ground clip. Then PAR SW2 to measure the inductor value.

A PAR of both SW1 and SW2, will result in the LC Meter sending the oscillator frequency:

F <then a 1 second delay> 367T783 HZ

Again, the T (or dah) is a shortened version of a comma (dah dah di-dit dah dah).

Note that if both SW1 and SW2 are PAH, after 2 seconds the LC Meter will re-enter the calibration routine entered after the FB at powerup. An O (for calibration jumper Open) will be sent and the calibration will proceed as mentioned above. This allows the user to re-calibrate the unit at any time, handy because the oscillator used to do the capacitance and inductance measurements will drift with time and temperature which could make the measurements less accurate. If the user hears any "nonsense" results such as 16T777T216 for an open socket, it may be time to re-calibrate using the double switch PAH.

If SW1 alone is PAH, after 2 seconds the LC Meter will enter the main menu for setting the various parameters of the LC Meter. Note that if the user leaves the switches untouched for roughly 13 seconds after hearing any menu item, the LC Meter will automatically exit the menu and return to the normal mode of waiting for a button press.

SW1 (left - capacitance switch) menu (PAR SW1 to advance to the next menu item)

	Menu item	PAR:	PAH:
Sxx	code speed, default is 15 WPM	advance to next menu item	Increase the code speed by 1 step
SS	Sidetone Set	advance to next menu	Increase sidetone frequency 1

		item	step
CCxxxx	Calibration Capacitor value	advance to next menu item	increase the delay multiple by 1
CA	CAlibrate 4 MHz oscillator	exits menu	starts calibration signal output

Speed set - Sxx: After the initial 2 seconds SW1 switch press, the LC Meter will enter the Speed set menu item S. The default speed is 15 WPM. The user can select any speed from 5 to 35 WPM in the 10 step (ARRL) sequence (5, 7.5, 10, 13, 15, 18, 20, 25, 30 and 35 WPM). To increase the speed to the next speed in the sequence, PAH SW1 (left capacitance switch) for two seconds until the LC Meter responds with S 18 (or whatever the next speed value is). After 35 WPM, the LC Meter will "wraparound" to 5 WPM. To decrease the speed to the previous speed in the sequence, PAH SW2 (right inductance switch) for two seconds until the LC Meter responds with S 13 (or whatever the previous speed value is). After 5 WPM, the LC Meter will "wraparound" to 35 WPM. PAR SW1 to proceed to the next menu item.

SS - Sidetone Set: After the Speed set menu item, the LC Meter will enter the Sidetone Set menu item SS. The currently programmed sidetone frequency will then be sent (keydown). The user can select any of the 16 sidetone frequencies: 494, 523, 587, 659, 698, 784, 880, 988, 1046, 247, 262, 294, 330, 349, 392 and the default 440 Hz. PAH SW1 to increase the sidetone frequency to the next tone in the sequence. Note that the LC Meter will turn off the sidetone and wait for the user to release the switch. After 1046, the LC Meter will "wraparound" to 247 Hz. The tone frequencies are approximate and are roughly equal to the notes of the musical scale from B3 to C6. PAH SW2 to decrease the sidetone frequency to the previous tone in the sequence. After 247, the LC Meter will "wraparound" to 1046 Hz. PAR SW1 to proceed to the next menu item.

CC - Calibration Capacitor value set: After the Sidetone Set menu item, the LC Meter will enter the Calibration Capacitor value set menu item. The pre-programmed calibration capacitor value can be changed by the user if the calibration capacitor is changed or just if the user wants to experiment with a different value. PAH SW1 to increase the current value by 1 pF. PAH SW2 to decrease the current value by 1 pF. PAR SW1 to proceed to the next menu item.

CA - 4 MHz clock Calibration signal output: After the CC menu item, the LC Meter will enter the 4 MHz clock CAlibration signal output routine by playing CA. If SW1 is PAH, the LC Meter will send an L (for infinite Loop) and then enter the infinite loop, the only way to exit this is to turn off the power to the LC Meter. While in the infinite loop the LC Meter will output a 250 kHz signal on the piezo output pin. The user will probably want to disconnect the piezo during the calibrate since the capacitance of the piezo will distort the output waveform so that it is unusable. The user can then either measure the 250 kHz signal with a calibrated frequency counter or use it as a crystal calibrator against a signal source such as WWV. With the two capacitors C4 and C5 at 27 pF each, the output frequency is probably going to be slightly high. This can either just be noted, or if desired, additional capacitance can be added in parallel to either or both C4 and C5 to decrease the frequency. A variable (trimmer) capacitor will make this easy. Be sure to allow the unit to fully cool down after any soldering for best results. PAR SW1 to return to the normal measurement mode.

Notes:

The LC Meter uses the well known technique of a shifted oscillator to measure inductance and capacitance. Additional capacitance (Cx) OR additional inductance (Lx) will shift the oscillator frequency down. This shifted frequency is used in a computation along with the open and short frequencies measured at powerup or re-calibration to determine the value of the inductor or capacitor.

Modification ideas:

1) an ON/OFF switch: especially if you are using a 9V battery as a power source, it won't last long connected between the 9V snap and the +Vin hole on the LC Meter circuit board.

2) add length to the calibration shorting jumper by gluing on a short piece of plastic or wood to make it easier to do the calibration. Another idea from Dick, K9LW, is to use some large wire insulation (or maybe shrink tubing) over the end of the shorting jumper as a handle.

3) use a different inductor in place of L1, this may reduce the oscillator drift which can cause strange outputs. Unfortunately, 100 uH is a fairly large inductance requiring a lot of turns on the substitute coil.

4) Another idea from Dick, K9LW, is to use color co-ordinated (red or black) alligator clips (the color of the plastic handle or boot) with the color (red or black) of the corresponding switch, use a plain or yellow or some other color for the ground connection/s.

Please feel free to email with any questions, comments, suggestions or problems with the LC METER. Email to: `jacksonharbor@att.net`

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LC METER parts list

Qty.	Ref.	Part Name	Description
1	U1	12F683	LC METER 8 pin PIC DIP chip
1	U2	LM311	8 pin DIP comparator IC
1	U3	78L05	TO-92 5 volt regulator IC
4	C1,2,6,7	.1 uf	.1" lead space, radial multi-layer ceramic capacitor
1	C3	10 uf	radial electrolytic capacitor
2	C4,5	27 pf	.1" lead space ceramic NPO disc capacitor
1	C8	10 uf	small radial electrolytic capacitor
1	C9	1000 pf	.2" lead space, radial 2% polypropylene capacitor
1	C10	1000 pf	.2" lead space, radial 1% polypropylene capacitor
1	D1	1n5818 or 1n5819	Schottky power diode
1	L1	100 uH	axial conformal coated choke
1	R1,	10 K ohm	Brown black orange gold - 1/4 watt carbon film resistor
1	R2	4.7 K ohm	yellow violet red gold - 1/4 watt carbon film resistor
1	R3	1 K ohm	brown black red gold - 1/4 watt carbon film resistor
2	R4,5	100 k ohm t	brown black yellow gold - 1/4 watt carbon film resistor
1	R6,7	51 k ohm	green brown orange gold - 1/4 watt carbon film resistor
2	SW1,2	switch	normally open momentary switch
1	X1	4 MHz crystal	HC49 crystal
2		2 pin header	.1" spaced square header
2		2 pin jumper	.1" spaced jumpers for above headers
2	-	socket	8 pin DIP socket
1	-	PCB	LC METER circuit board

The following items are ***NOT*** included with the kit:

1	9V snap or other power connector
1	Piezo transducer (high impedance speaker)
	alligator clips or other fixturing for inductors / capacitors

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