LC-100A Inductance/Capacitance Meter Calibration

MOST IMPORTANT: None of the published "self-calibration" instructions are complete. They all omit a critical step. The highlighted calibration step with probes shorted together is the key to getting accurate readings. If this calibration step is omitted the accuracy will be absolutely awful when measuring capacitors >.047uF

Quick sanity check for "small C" mode: With probes open the readout should be <5pF. With probes shorted together the readout should be "over range".

The self-calibration process works best when performed in the following specific order:

1] Power-up LC100-A and permit to operate for 10 minutes. This allows it to thermally stabilize. The LC100-A has sensitivity to room temperature

Capacitance calibration:

2] Probes must be connected to LC100-A, but the clips at the end of the probes must not touch each other (open circuit)

3] Configure buttons to measure small C (L/C, Hi-C, Hi-L buttons are all released)

4] Press and hold down ZERO button for as long as it takes for the LC100-A to display <DATA SAVED> This requires several seconds.
Calibration is NOT complete until <DATA SAVED> appears on display

5] Click Hi-C button down. This configures LC100-A to measure large capacitance

6] Probe clips must remain in the "not touching each other" condition (open circuit)

7] Press and hold down ZERO button until LC100-A displays <DATA SAVED>. This may require more than one full minute.
It is much slower than the other calibration processes. Calibration data is NOT stored until <DATA SAVED> appears.

Inductance calibration:

8] Short the probe clips to each other

9] Hi-C and Hi-L buttons must be released

10] Click L/C button into inductance measurement mode (L/C button down)

11] Press and hold down "ZERO" button until LC100-A displays <DATA SAVED>. This may require several seconds.
Calibration data is NOT stored until <DATA SAVED> appears.

12] Click "Hi L" button into down position

13] Press and hold down "ZERO" button until LC100-A displays <DATA SAVED>. This may require several seconds.
Calibration data is NOT stored until <DATA SAVED> appears.

There is some interaction between calibrating "small C" and calibrating "small L." When measuring capacitors, I recommend the final step should be repeating the "small C" calibration again, just before measuring the capacitors.

I think it best to avoid using the "Zero" button except when performing the entire self-calibration process as listed above.

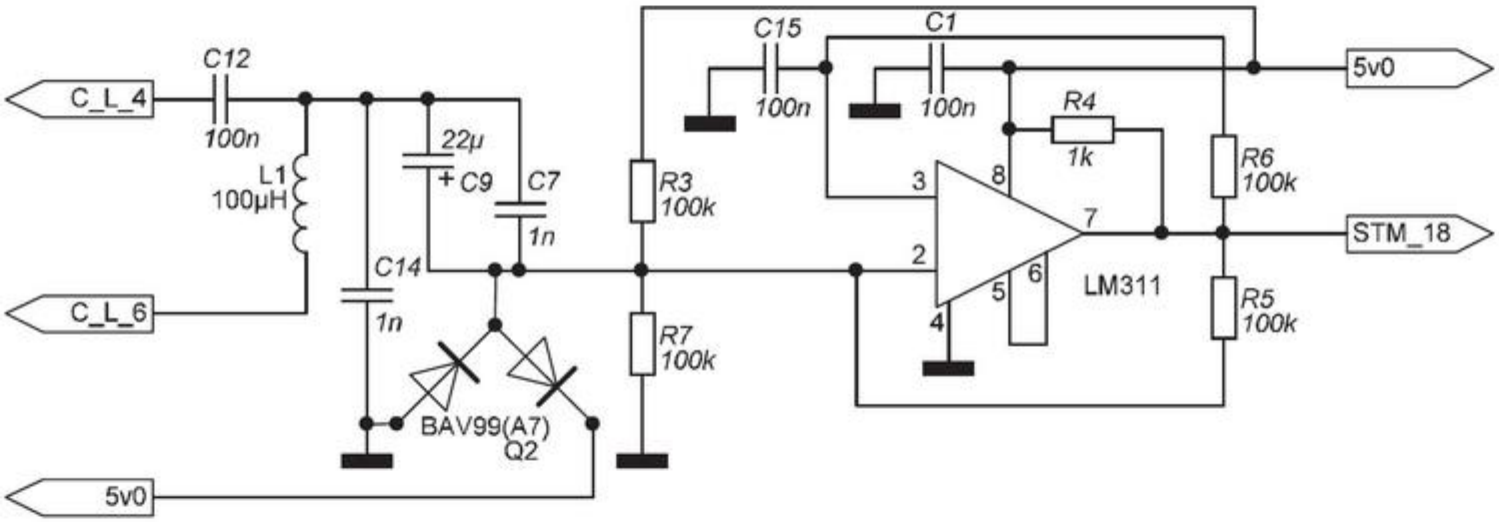
The LC100-A firmware has bugs when changing between C and L measurement. It does not properly re-initialize everything after changing modes between C and L. To avoid this issue, **always power off the LC100-A before changing between C and L mode.**

Power-up the LC100-A after selecting the desired mode (L or C). OK to change between small L and Hi-L, and to change between small C and Hi-C without power cycling. But **always** power cycle when changing between C and L. This issue is because the firmware is somewhat "buggy."

The toroid inductor, L1, which comes with "generic clone unbranded" LC100-A is sub-standard in performance. Checking the faulty L1 removed from a generic unit shows that it oscillates at much lower *amplitude* than every other inductor tested. There is evidently something wrong with its ferrite core material----some sort of hysteresis or "loss" that other inductors don't have. Therefore, for those LC100-A units that still aren't accurate after performing the self-calibration several times, **REPLACE L1**. **This single alteration improved the accuracy of the LC100-A to better than +/-2% measuring a large number of capacitors from 10pF up to 100nF.** The published schematics for the LC100-A suggest that the inductor should be 100uH; But many units came with inductors that measure from 47 to 56uH. The LC100-A requires a reference inductor with its highest Q between 70-700kHz. After performing the on-board "zero" adjustment, all 3 values (47uH, 100uH, and 220uH) of substitute reference inductor provided similar results.

Unresolved is why the published schematics call for 100uH. It turns out the uH value of this inductor isn't nearly as important as its "Q." The inductor has been replaced in several "generic" LC100-As which originally came with low-Q inductors. After installing a decent quality inductor, they became as accurate as genuine MingHe units. Note: The uH value can be anything from 47uH to 100uH. **The Q of the inductor** is what's important.

This is the "front end" for measuring small capacitors, and for measuring both small and large inductors.



Note that the only output from this circuit is a single line (STM_18) which goes to the MCU. The signal on this pin is a square wave. The MCU measures the frequency on this pin and then calculates the pF or uH. Note that there are only two "source" connections for connecting the unknown C or L. The LM311 is the "active" portion of the L-C oscillator for measuring "small C," "small L," and "large L." When measuring a capacitor, pin C_L_6 and the negative test probe are grounded. Pin C_L_4 is connected to the positive test probe. The unknown capacitor to be tested is connected between ground and C_L_4, and is in series with C12 (100nF). When measuring larger values (e.g., 1uF), the internal 100nF "reference" capacitor is in series with the 1uF capacitor under test, and thus has a huge influence on the displayed measurement. When testing small values of capacitance, however, the value of C12 (100nF) won't matter very much.

Pressing the LC-100A “big C” button switches to a totally different measurement technique that relies on yet another internal reference capacitor. But this so-called “reference” capacitor is a 100uF electrolytic. In this case a timed charge-discharge is used to determine the uF. There is no L-C tank circuit for this mode. The LM393 forms a different type of oscillator (triangle wave R-C oscillator) for measuring "large C" (Hi-C button down). "Large C" is the only operational mode which uses the LM393. When measuring a small inductance (“small L” mode---Hi-L button released), the unknown inductance resonates with C14 (1 nF) only. Pin C_L_6 is connected to the positive test probe; the negative test probe is grounded. and pin C_L_4 is open circuit. The LM311 oscillation frequency ranges from 5kHz to 700kHz. This is appropriate for measuring inductors in the uH range, up to perhaps 10mH. Most RF coils and inductors are within this range of uH/mH.

When measuring large inductance (Hi L---“large L” mode---Hi-L button down), pin C_L_4 is grounded, and C12 (100nF) connects in parallel with C14 (1nF). This provides 101nF to resonate with the unknown inductance, reducing the frequency of oscillation by a factor of 10, to a maximum frequency of about 50kHz. Inductances of several H will cause oscillation at much lower frequencies, perhaps as low as 100Hz to 1kHz. This is actually appropriate for measuring inductances in the 100mH to 10H range. These will typically be inductors which operate in the audio frequency range. It is desirable to test these large inductances with audio frequencies rather than RF frequencies.

Examples: If the unknown capacitor is 100nF, then the total "C" that resonates with L1 is 51nF. If the unknown capacitor is 1nF, then the total "C" that resonates with L1 becomes 1990pF. If the unknown capacitor is 1uF, then the total "C" that resonates with L1 becomes 91.91nF. It can be seen that the "C" portion of the LC tank circuit will never be <1nF or >101nF regardless of the actual value of the unknown capacitor. This limits the resolution for measuring very small or very large capacitors. In fact, although the LC-100A is specified to measure up to 10uF in the "small C" mode, the largest capacitor that can be measured with decent accuracy is probably about 2uF. The LC-100A internal calibration process automatically compensates for slight variations in the value of L1 and C14. I'm not sure how well it compensates for variations in the value of C12. In order to fully calibrate itself, the "Zero" button operation must be performed for the following three configurations:

Mode: C, Hi-C and Hi-L buttons released. This calibrates the LC-100A for the condition of LC tank circuit = L1 and C14

Mode: L, Hi-L and Hi-C buttons released. This calibrates for LC tank circuit = L1 and (C12 + C14).

Mode: L, Hi-L button depressed, Hi-C button released. This calibrates for LC tank circuit = L1 and C14.

The “driving signal” for the LC tank circuit is a 5V peak-to-peak square wave from the LM311 is fed back into the LC tank circuit through a 100k ohm resistor (R5 on schematic)---a VERY small signal (50uA). The frequency of oscillation in the LC100-A is about 500kHz when measuring a 1nF capacitor or a 100uH inductor. To get that tiny bit of driving power to resonate into a sinusoidal signal with 1V peak-to-peak amplitude requires a “high Q” LC circuit - both the inductor and the capacitor. The Q of the inductor strongly depends on the type of ferrite core it has. "Ferrite" cores have lower losses than "powdered iron" cores, and are usually a uniform gray color. A "high Q" inductor will generally perform better than an inductor with lower Q. With a good quality inductor for L1, the oscillation amplitude can reach nearly 2V peak-to-peak.

Some LC100-A boards have slightly different micro controller part numbers. The older and more buggy version is the STM8S103 chip. The later units have the STM8S003 micro controller chip and Rev 4.8 of the LC100-A firmware.

A very simple way to observe the performance of L1: LC100-A in "small C" mode; LC100-A probes open, except oscilloscope is connected to LC100-A probes using x10 oscilloscope probe; the LC100-A will display the capacitance of the x10 oscilloscope probe (usually 12-15pF), and the oscilloscope displays the waveform, amplitude, and frequency of the LC100-A LM311 oscillator section. Larger is better. Ideally it should be 300-500mV RMS, 1V peak-peak. On a "genuine MingHe" LC100-A, amplitude is 430mV RMS, 1.25V peak-peak, but with the the yellow inductor from the "unbranded generic" LC100-A, the oscillation is only 40mV RMS, 128mV peak-peak. **This is a difference of nearly 10x in oscillation amplitude!!**

LC-100A(LCM 4.7)