

Important update to the Elektor 500 ppm LCR Meter

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Since this project was published in three installments [1], several hundred of the instrument have been built, to the great satisfaction of their users, the author, and Elektor editors alike. The author has now corrected two shortcomings liable to interfere with proper operation under certain conditions.

The two points worthy of attention are the fact that the instrument seems to 'hang up' when measuring low resistances ($<1\ \Omega$); and the apparent impossibility to perform Trim actions. The author has already commented and acted on these problems in the Elektor forums [2], [3], but it's useful to revert to them here.

When measuring resistances with a value lower than $1\ \Omega$, in order to obtain an adequate measuring voltage, the firmware sets the "**voltage measurement gain**" to maximum:

- range 1 ($R_{\text{sense}} = 100\ \Omega$ and PGA103 gain at 100);
- final amplification gain close to maximum (step E or F).

Unfortunately, the input offset voltage is strongly amplified as well, and using the circuit published in the March 2013 edition, this is no longer compensated. This can lead to the maximum voltage at the input to the analog/digital converter being exceeded all the time. This erratic phenomenon is not systematic and depends to a great extent on the cumulative offset voltage of U6 and U4, and on the (low) resistance (or inductance) being measured. So that's the first one!

As for the second, when there is no component connected during the 'TRIM - OPEN-CIRCUIT' operation, here too the '**current measurement gain**' is maximum at the frequency of 100 Hz (or 120Hz):

- range 8 ($R_{\text{sense}} = 100\ \text{k}\Omega$ and PGA103 gain at 100);
- final amplification gain close to maximum (step E or F).

At this point, the 'current' measuring circuit is very sensitive to interference picked up by the measuring leads, particularly from the power line (50 Hz or 60 Hz). The result of the measurement is so erratic that the firmware refuses to display it, and does not validate the "TRIM". So much for the second one!

Two problems—two solutions

Depending on whether you are handy with a soldering iron or not, there are two solutions:

- Modify the hardware—the best solution—to enable the input **offset voltage** compensation circuit to be adapted, and at the same time update the firmware (v. 3.0.0) along with the AU2011 program (v. 3.0.0). The software will automatically detect the hardware modification at runtime, due to the presence of a resistor on the P2.2 port line (LCD_SI) (**Figure 1**).
- Update with the same versions of the firmware (v. 3.0.0) and AU2011 program (v. 3.0.0), without modifying the hardware.

Important: Updating the software to version 3.0.0 must be done in either case. The new version is equally compatible with the original hardware and with the modified version described below.

Modifying the hardware

As originally designed, input offset voltage compensation is achieved by injecting a current into U6's input. Unfortunately, the result is too dependent on the (DC) resistance of the DUT.

The new circuit (**Figure 1**) applies the correction voltage at the output of U5 (INA128), and hence

the DUT impedance no longer has any effect; this also makes it possible to separate the compensation for the 'current' and 'voltage' measurements. To achieve this, U5's pin 5 is no longer connected to analog ground, but to a software-adjustable voltage via a low-value resistor.

There are four steps to the modification:

- remove R34 to disable the original compensation. R42 and C35 are no longer used and can also be removed;
- replace R46 by a 10 Ω resistor (prefera-

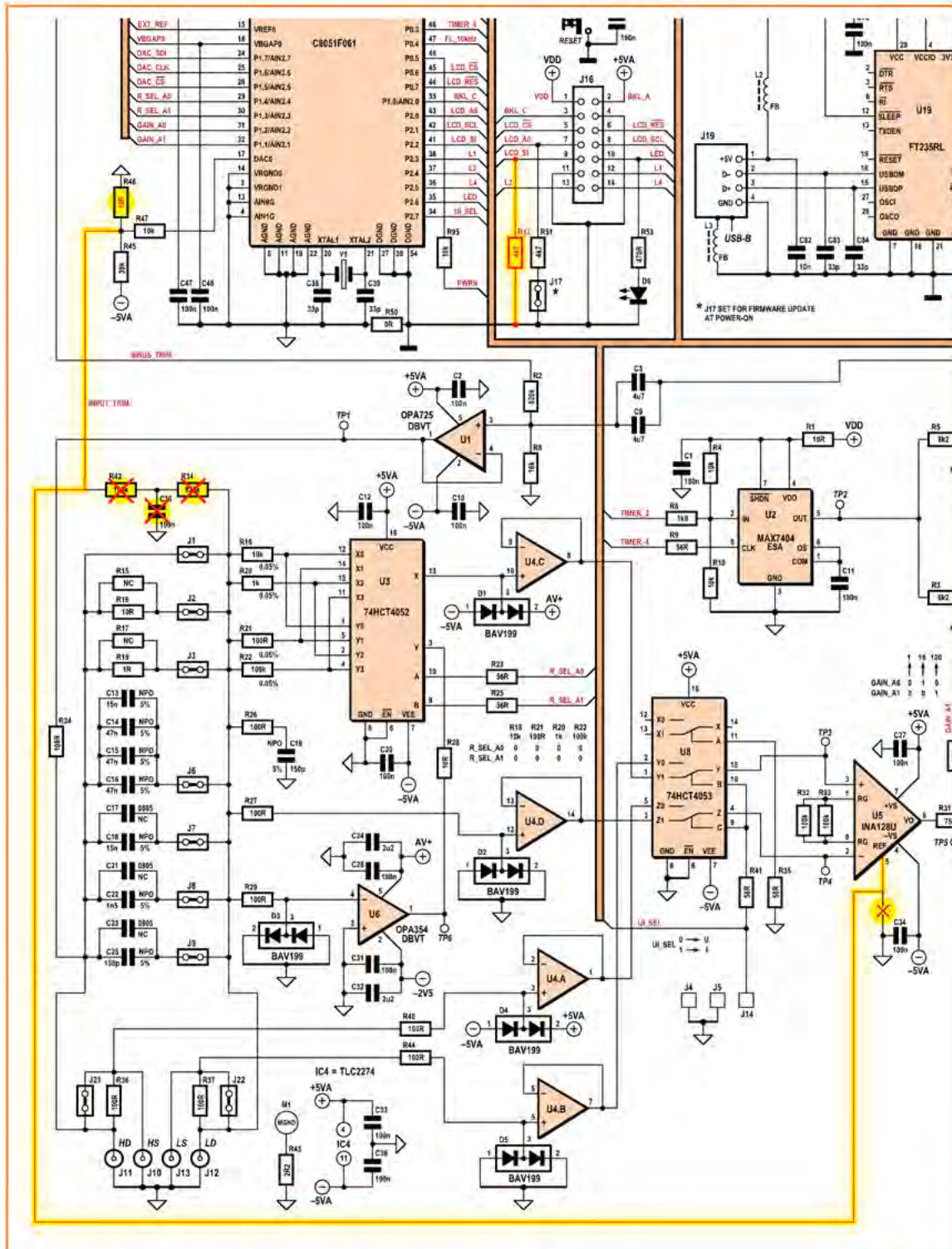
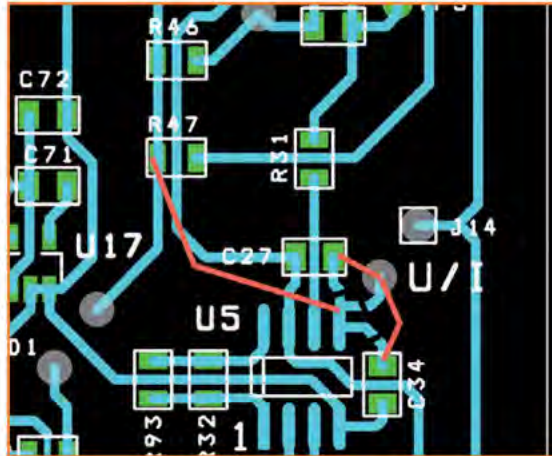


Figure 1.
Partial schematic with
corrections to be made to
improve the 500 ppm LCR
Meter.

Figure 2.
Modifications to the offset
voltage compensation circuit
around U5.



bly 0805). The 10- Ω resistor can also be soldered directly across the 680- Ω resistor that's already there;

- the third step is more tricky: U5's pin 5 must be isolated from its present connections and connected to the junction of R45,

Figure 3.
Don't try to unsolder pin 5
on U5—you risk disaster!
Use a scalpel to isolate
it, then re-make the
connections using wire.

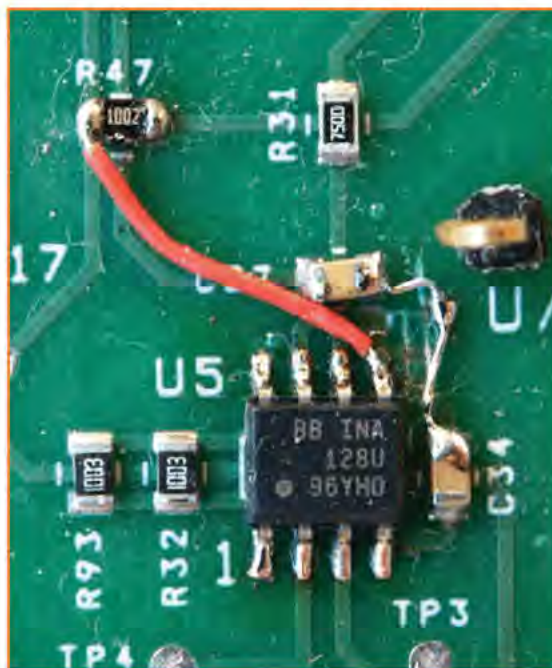


Figure 4.
This resistor tells the
firmware that the circuit has
been modified as shown in
Figures 1, 2 and 3.



R46, and R47. It's possible to do this by lifting pin 5, but **we advise against this, as you should not take the risk of damaging U5**. So we suggest instead making a clean cut in the (visible) tracks between U5.5 and C27, U5.5 and C34, and U5.5 and the through-hole adjacent to J14 (**Figure 2**). You'll then need to reconnect C27 and C34 to the through-hole (analog ground) via small wires (**Figure 3**); and use a short wire to create the new link between U5 pin 5 and the junction of R45, R46, and R47;

- solder a 4.7 k Ω to 10 k Ω resistor between pins 9 and 11 of J17, on the opposite side of the PCB (**Figure 4**). The presence of this resistor will allow the firmware to detect the modified circuit.

New programs [4]

The version 3.0.0 firmware (*LCR3A_firmware_V300.hex*) supports the new input offset voltage compensation circuit if, and only if, a resistance to ground is detected on pin 9 of J17

This results in a re-arrangement in the menus in the *AU2011* program, which also updates to version 3.0.0:

the original *Input_offset adjustment...* menu is replaced by two menus *Input_offset_U adjustment...* and *Input_offset_I adjustment...*, the first with the input shorted, the second with it open circuit.

For users who do not wish (or are unable) to modify the hardware, the solution consists in limiting the overall gain in range 1. Hand-in-hand with this, similar limiting can be performed in range 8, if there is too much interference in the surroundings, preventing the *TRIM – OPEN-CIRCUIT* compensation being performed correctly.

The gain limiting solution is valid whether or not the device has been modified.

The *initial* maximum value will be 5 for an unmodified device and 15 (step F) for a modified device. Naturally, the value modifications are stored in the device's memory, just like the other settings/options in the Preferences window.

It follows that we also have to add two menus in standalone mode, and modify the Preferences window in PC mode when the *access to adjust. menus* option is checked (**Figures 5 & 6**).

Other modifications have been made to improve

convenience in use, like the appearance of a "Port / Close the Port" menu, handy if you originally chose the wrong port; all you then have to do is select the right port and click the 'Open COM' button in the main window.

Measuring high impedances

The 'voltage' and 'current' signals are amplified with no low-frequency filtering prior to sampling. It is only after digitizing, by performing the measurement over a whole number of AC power-line cycles and taking the average of several measurements, that it is possible to reduce the influence of the stray signals picked up by the measuring device.

This means it is possible for the signal applied to the analog/digital converter (ADC) to briefly exceed this ADC's input range and invalidate the measurement.

Consequently, particular care must be taken when measuring high impedances, when the LCR meter is set to range 7 and above all 8; this is the case during *TRIM – OPEN-CIRCUIT*.

- Put the electronics in an earthed metal case (iron is preferable to aluminum at low frequencies). Take care if you are using the LCR Meter in standalone mode with a USB supply, or in PC mode with a laptop: in these cases, there is no earth connection and you'll need to make one. The power plug on a USB PSU doesn't have a pin to connect the LCR Meter case to the AC powerline protective earth; and a laptop running on its battery isn't earthed either.
- Minimize the length of the measuring cables, and keep away from power cords. To protect the device and the measuring leads from radiated fields, place a grounded metal plate (preferably iron) of adequate size between them and any powerline wiring.
- If there is still interference, reduce the gain of the measuring chain to range 8 (*Max DACIndex I* in standalone mode).

To conclude, let's just note that experience has shown that in practice, the 4-BNC measuring unit solution (TONGHUI TH26001A or HAMEG HZ181) is very much preferable to the Kelvin clip.

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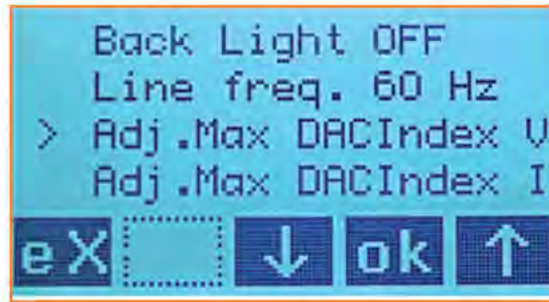


Figure 5.
Two new menus in
standalone mode.

Internet Links

- [1] 500 ppm LCR Meter
Part 1, Elektor no. 417, March 2013
www.elektor.com/110758
Part 2, Elektor no. 418, April 2013
www.elektor.com/130022
Part 3, Elektor no. 419, May 2013
www.elektor.com/130093
- [2] www.elektor.fr/forumLCR (in French)
- [3] www.elektor.com/forum/elektor-forums/fields-of-interest/test-measurement.1543743.lynkx
- [4] www.elektor.com/130093

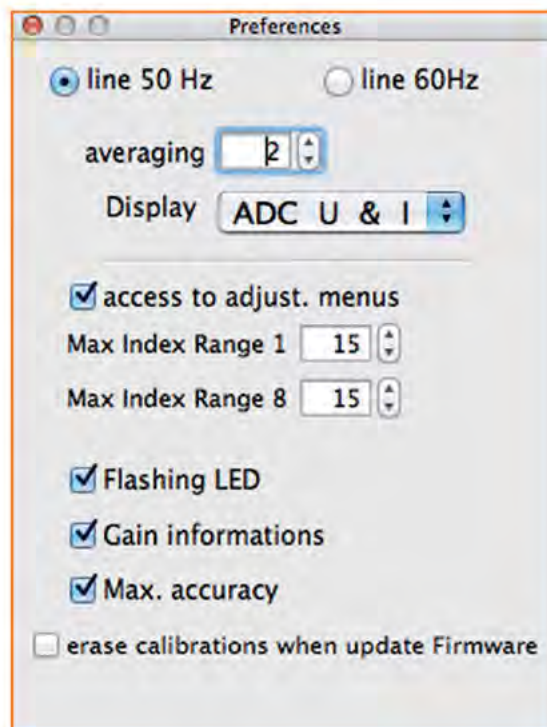


Figure 6.
The 'access to adjust.
menus' option under the
Preferences in PC mode.