G4HUP

Inductance and Capacitance Meter

Technical Manual

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Contents

Unit Specifications

Model Ref Inductance and Capacitance Meter

Performance

Measurement Range	Min	Max
Capacitance	0	>0.1µF
Inductance	0	>10mH

Accuracy	±1%	C and L
Resolution	±0.1pF	
	±10nH	

Performance data is taken from http://sites.google.com/site/vk3bhr/home/index2-html

Supply Requirements

Internal Battery – PP3, 9v; current typically <10mA at switch on, then decreasing

External DC supply – 9v to 15v max 9v recommended
White stripe conductor is positive in DC power cord!

Scope of Document

This document is intended to provide all necessary information to guide users in the construction and installation of the G4HUP Inductance and Capacitance Meter Model LC V3 in normal operation.

This document is relevant for units constructed on Issue V3_0 PCB's.

Reference data can be found on the LC Meter pages of the DFS web-site, including any identified issues or problems – http://g4hup.com/LCM/LCMeter.htm.

LC Meter Description – V3_0 updates

The LC Meter is a combination of VK3BHR's excellent PIC software and its associated hardware, engineered into a simple to construct mechanical design. The completed unit forms a piece of test equipment useful in any electronics workshop. In addition to the basic hardware design, some extra features have been included :

- The revised V3_0 PCB includes the battery on the PCB, and also has a DC power connector for external power connection.
- Although the new PCB layout is still designed to fit the Hammond 1455 series extruded aluminium enclosure, it is easier to incorporate into other enclosures than the previous version – there is adequate space to drill mounting holes for the PCB
- The PCB can be constructed as a stand alone item, and used without any enclosure if you wish – it is recommended that you add some plastic feet or standoffs to raise the back of the PCB above the bench when in use – this will avoid any inadvertent short circuits!

A full description of how the software works can be found on VK3BHR's website, http://sites.google.com/site/vk3bhr/home/index2-html

Physical Description

The LC Meter is constructed on a PCB measuring 115m x 100mm; the section of the PCB above the display houses the battery and the power connectors and switching, whilst all of the operational circuitry is either underneath the display, or at the lower section of the PCB. All of the switches and terminals may be mounted directly to the PCB (for stand-alone use), or connected via short wires when installed in either the recommended Hammond enclosure, or your own choice of housing.

In the Hammond enclosure, the PCB is supported in internal slots in the case walls – no fixing is required. The Cal switch button locates the PCB and holds it in place relative to the front panel. Both external DC input and on/off switching are at the upper edge of the PCB, and are accessible via holes in the end panel when in the Hammond case.

The internal battery is disconnected automatically when external DC power is connected.

A single row, 1 x 16 character, LCD is used for the display – it is mounted on 12 mm stand-off insulators to allow component placement beneath the LCD itself, and to bring the display up against the back surface of the instrument panel.

LC Meter Construction

Construction is straightforward, although some comments on the sequence and methods are appropriate.

PCB Preparation

Apart from any items listed in the Errata section there is no other preparation required for assembling a unit that is to be housed in the recommended Hammond Case.

If you wish to mount the PCB in a different case, then you may need to prepare mounting holes, and you may also need to enlarge the holes of S1 and the two terminals if they are to fix directly to the PCB.

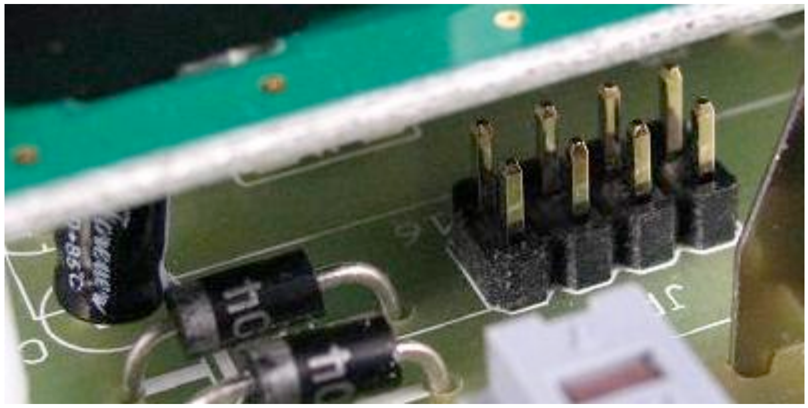
Component Assembly

Install the low-profile passive components and the diodes first, including the relay and the crystal. Save the wire spills that you cut from the resistors and capacitors, as these can be used for the connections from the PCB to the LCD. Note that the 100uH inductor, L1, looks very much like a resistor! Also if you are not familiar with tantalum bead capacitors, note that the polarity is marked differently to electrolytics – it is the +ve side that is marked as shown in Fig 1a.

Fig 1a – View of one of the tantalum bead capacitors on a partly completed board.

Once all the passive components are in, mount the regulator (IC2) and the PIC directly to the PCB (you may use a low-profile socket if you prefer), but do not add the switches yet. Also mount the header for JP1 – this mounts from the top side of the PCB, so that the long side of the pins are accessible from the underside of the PCB once the LCD is in place and the PCB is assembled into the case – see Fig 1b.

Fig 1 – View of partially constructed LC Meter, showing how JP1 is installed, and mounting of LCD above PCB



Mount the LCD on its spacers and bolts. The head of the bolt should be on the LCD PCB, a spacer is between the LCD and the PCB, and a washer and nut are used on the underside of the PCB. For the supplied case, the spacer needs to be 12mm in total. If you are using a different case you may decide to mount the LCD directly to the case.

To mount and connect the LCD, pass wires (end clippings from the resistors are ideal) through the PCB and the LCD and solder each in place. Not all the connections are required – make sure that you have wires in pins 1 - 6, and 11 – 14. No other pins are used in this design.

The two battery connectors should be pushed right down to the PCB surface – the positive battery terminal is the female press stud connector, whilst the negative is the male one.

Finally install the switches, but do not attach the two terminal posts yet. Make sure that you solder the switch pins very well – a lot of solder is needed to ensure a reliable connection. At this stage, you can test to confirm that the circuit is operating correctly, before installing it in the case. Attach a 9v PP3 battery, with polarity as marked on the PCB. Adjust the trimpot, R1, to set the display contrast. If your module does not show any signs of life, see the Troubleshooting section, below.

Case Preparation

– applies to Hammond 1455 series enclosure only

Use the downloaded paper template for drilling the case panel. Remove the sliding panel from the box and using a glue stick, attach the template accurately in place. You can centre punch the circular holes and also use the template as a guide to cutting the aperture for the LCD. The paper will come away from the panel easily once the cutting work is completed.

Repeat this process for the end cover panel, to locate the holes for the DC connector and power switch

A second inclusion with the kit is a prepared front panel, already laminated and cut to size. You will need to use a scalpel or similar to cut out the holes for the switches and terminals.

Final Assembly

– applies to Hammond 1455 series enclosure only

Remove the protective plastic cover from the LCD face.

Mount the two terminals through the front panel overlay and the metal panel and do the nuts up tight. Solder a short length of wire to each terminal pin. Mount S2 to the panel, tighten up the nut and also solder a short length of flexible wire to each pin.

Push the cap for the Cal switch firmly into place, and offer the PCB up from the back of the panel so that the PCD aligns with the window, and the Cal button protrudes through the panel. Make sure that the wires from the terminals and S2 all through the correct holes in the PCB.

Partially slide the panel and PCB into the Hammond case, with the PCB on the bottom slot. It is a good idea to have a 9v PP3 battery clipped in place to ensure that there is adequate space between the PCB and the panel. With the panel and PCB located, the switch and terminal wires can now be soldered to the PCB.

The edges of the laminated panel can be held down onto the aluminium panel by a bead of cyano-acrylate (Superglue) carefully run round just inside the edge of the panel.

Assemble the LC meter by sliding the front panel and PCB into the case. Take care when adding the end panels, as they should cover the ends of the panel overlay, and hold it firmly in place. The danger here is that the lamination of the panel may be damaged. When completed, the Power switch, S1, should protrude through the end panel, adjacent to the external DC connector. The adhesive feet can also be attached to the rear of the case.

Finally, the DC power cord can be attached – ensure that the side with the white stripe is connected to the positive of your supply!

Operation

The LC meter is easy to use. At switch on, S2 should be set in the 'C' position, and after a few seconds the display will rest at a small positive capacitance – typically around 1 to 3pF. Pressing the Cal switch should zero this reading. Before trying to measure any components accurately, the Meter needs to be calibrated.

Troubleshooting

If your LC Meter does not show any signs of operating at switch on, then try the following:

1. Make sure you have carried out the DC power connector track modifications as per Errata item 1 (for V3.00 PCB's)
2. make sure that you have tried the full range of adjustment on the LCD contrast pot, R1. The correct contrast setting is very near to one end of the rotation, but the trimmer pots as supplied are in the centre of their travel.
3. make sure that there are no solder bridges on the PCB, and that you have soldered all connections.
4. carefully check the placement (and in some cases the orientation) of components

If your meter continually displays 'Over Range' at switch on, regardless of the position of the C/L switch, this is due to either:

- incomplete soldering of the connections of the C/L switch to the PCB. Use plenty of solder and fill up the available space.

If your meter displays the leftmost 8 characters with all pixels black, then:

- The Cal switch is short circuit at switch on

If your meter does have a display, but is unstable in operation, then referring to Fig 2 (below) check the oscillator operation.

Bridge the pins of JP1/2 and check that the display shows 00050000 (within ±10%) – this is the free running frequency. Now move the link to JP1/1 and check the calibration frequency – this should show approx 71% (±5%) of the value you read previously.
If the meter displays 00000000 on the two checks above, then this indicates that the oscillator is not running, and the fault is likely to be around the connection of S2 and its associated components.
If both of these checks are successful, then it is likely that either:

a. you have a construction error or bad joint
b. you have a faulty component in the circuit.

It has been pointed out that when the meter is in the C measurement position, then input RB6 (pin 12) of the PIC is left floating. No problems have been identified for which this has been the cure, however, if you are concerned that it may contribute to a problem you are seeing, this can be eliminated by placing a 100k resistor between the junction of R13 and pin 12 and the +5v supply.

Further information regarding troubleshooting (and modifications) and an FAQ file can be found on Phil's site: http://sites.google.com/site/vk3bhr/home/index2-html

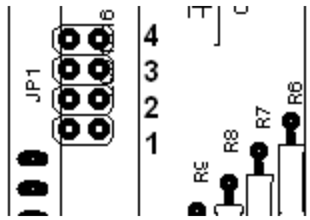


Fig 2 – JP1 connections (viewed from topside of PCB)
JP1 – Oscillator check and Calibration test points

Calibration

The calibration of the meter is good enough for most purposes without any further adjustment, thanks to the excellent software. However, if you have a close tolerance capacitor (1% or better) available, then you can trim the display using the following steps:

- Once the display is stable after the initialization sequence, then press Cal to force a re-calibration – the display should then rest at 0.0pF.
- Connect your 'reference' capacitor to the terminals and note the display.
- If you need to increase the displayed frequency, then bridge JP1/4 until the display is correct – remove the bridge at this point.
- Similarly, to lower the displayed value, bridge JP1/3, and remove it when the display is correct.
- In each of the above steps, the new calibration is automatically stored to the EEPROM memory of the PIC
- No separate calibration is required for inductance measurement – it is implicit with the capacitance calibration. Just short the terminals, make sure the C/L switch is in the L position and press Cal.

For further comment and guidance on the use of the links for troubleshooting and calibration see VK3BHR's site: http://sites.google.com/site/vk3bhr/home/index2-html

Measurement

You can now attach your unknown C to the terminals, and immediately the display will show you the value.

To measure inductors, allow the unit to stabilize as above, move the C/L switch to the L position then short circuit the terminals and press Cal. Now attach your unknown L and measure.

You can also calibrate out the effects of any test connection you need to make. For example, if you need to use some wires to attach the unknown component (C or L) the effect of these can be removed from your measurement, so the reading you see on the display is the true value of the unknown component. Simply attach your test wires, in as close as possible to the position they will be in during the measurement, and press Cal – the display will zero, and once you attach your component, you will see its value. This technique can also be used to take differential readings – for example to confirm the range of a variable capacitor. Attach the capacitor, and set it to one end of its travel. Now press Cal, then move the capacitor to the other end of its range – the display will directly show you the range difference from one end to the other of its travel.

For measuring SMD components a test jig or cable is required, and the above comments apply to this as well – perform a Cal with the test jig/cable connected, but without the component in place. See http://g4hup.com/LCM/LCMeter.htm for details of a suitable set of test tweezers for SMD components.

Errata and Addenda

This section contains information about components that have been changed or added compared with the original PCB design.

1 There is a track fault on the initial batch of V3.00 PCB's. The 0v connections on the external DC power connector are reversed, and the automatic switching does not operate correctly. Each track must be cut and strapped across to the other connection, as shown in the Fig 3.

Fig 3 – Correction to power switching/connector circuit

2 For stand-alone use, the terminals and S2 may be mounted directly to the PCB. The pads for S2 are a bit small so it may be necessary to scrape some resist of the end of the connecting tracks to get a good joint

See http://g4hup.com/LCM/LCMerrata.html for full details, versions impacted and resolution guidance, including pictorial support.

Component Locations

Figs 4 and 5 respectively show the circuit schematic and the locations of components on the top side of the PCB. Following these is a list of the components that should be provided in your kit - if any items are not present, please contact me! Note that the 100uH inductor supplied looks very similar to a resistor!

Maintenance

Construction Practices

Kits are not supplied with any solder, but it is recommended that a small diameter, good quality flux cored solder is used, to ensure minimum flux residues on the PCB after assembly. The PCB will accept lead-free solder, and components used are generally ROHS compliant, and should therefore also accept lead-free solder if you prefer.

It is recommended that lead based solder is used for maximum reliability of hand soldered joints.

Copyright

Acknowledgements

Phil Rice VK3BHR, for an excellent design, that is well supported via the website – thanks!
Paul Galpin, ZS2PG, for expanded troubleshooting comments.
Giles Read, G1MFG, of the RSGB, for useful comments following kit review (published in July 2009 Radcom)

Change History

Date	Iss No	Comment	Author
24 Sep 2008	0.A	First Draft version	G4HUP
4 Oct 2008	0.B	Minor corrections, R12 warning added	G4HUP
17 Nov 2008	1.0	Minor corrections, extended Troubleshooting section	G4HUP
26 Nov 2008	1.01	Comment re C/L switch soldering added to Troubleshooting	G4HUP
21 Jan 2009	1.02	Expanded troubleshooting, Front Panel LED option	G4HUP
25 Apr 2009	1.03	Updated troubleshooting information	G4HUP
15 May 2009	1.04	Updated troubleshooting section, PCB overlay diagram	G4HUP

21 Jun 09	1.05	Minor typographical correction, ICSP and Backlight updates	G4HUP
13 Jul 09	2.0	Backlight version construction details added	G4HUP
14 Jan 2010	2.01	Table reference corrected	G4HUP
21 May 2012	2.02	External references updated, layout improvements	G4HUP
14 Oct 2012	3.0	V3.00 First Draft	G4HUP
23 May 2013	3.01	Comments incorporated, Options removed	G4HUP
4 Jan 2016	3.11	Minor construction updates	G4HUP

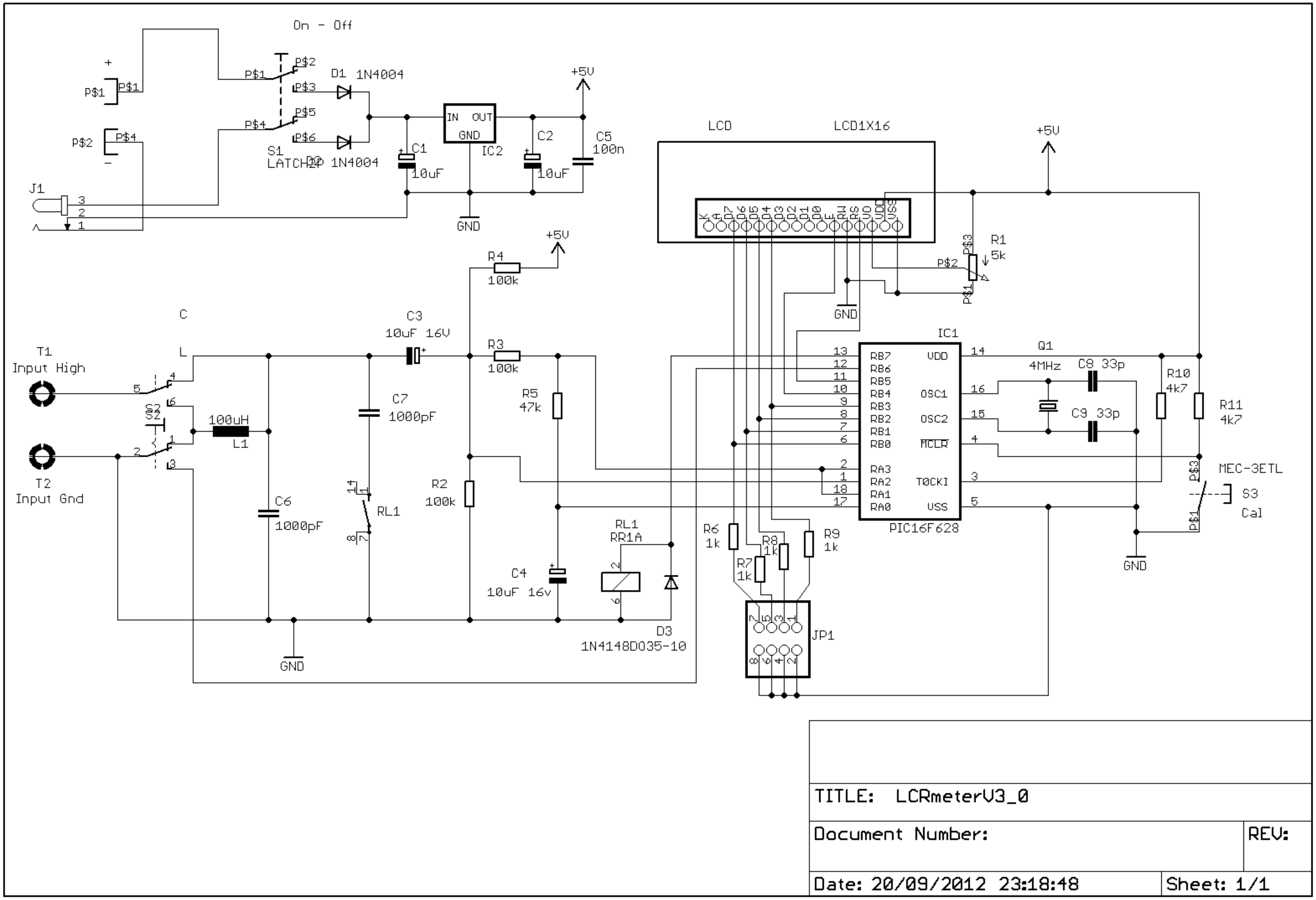


Fig 4 – LC Meter V3_0 circuit schematic diagram

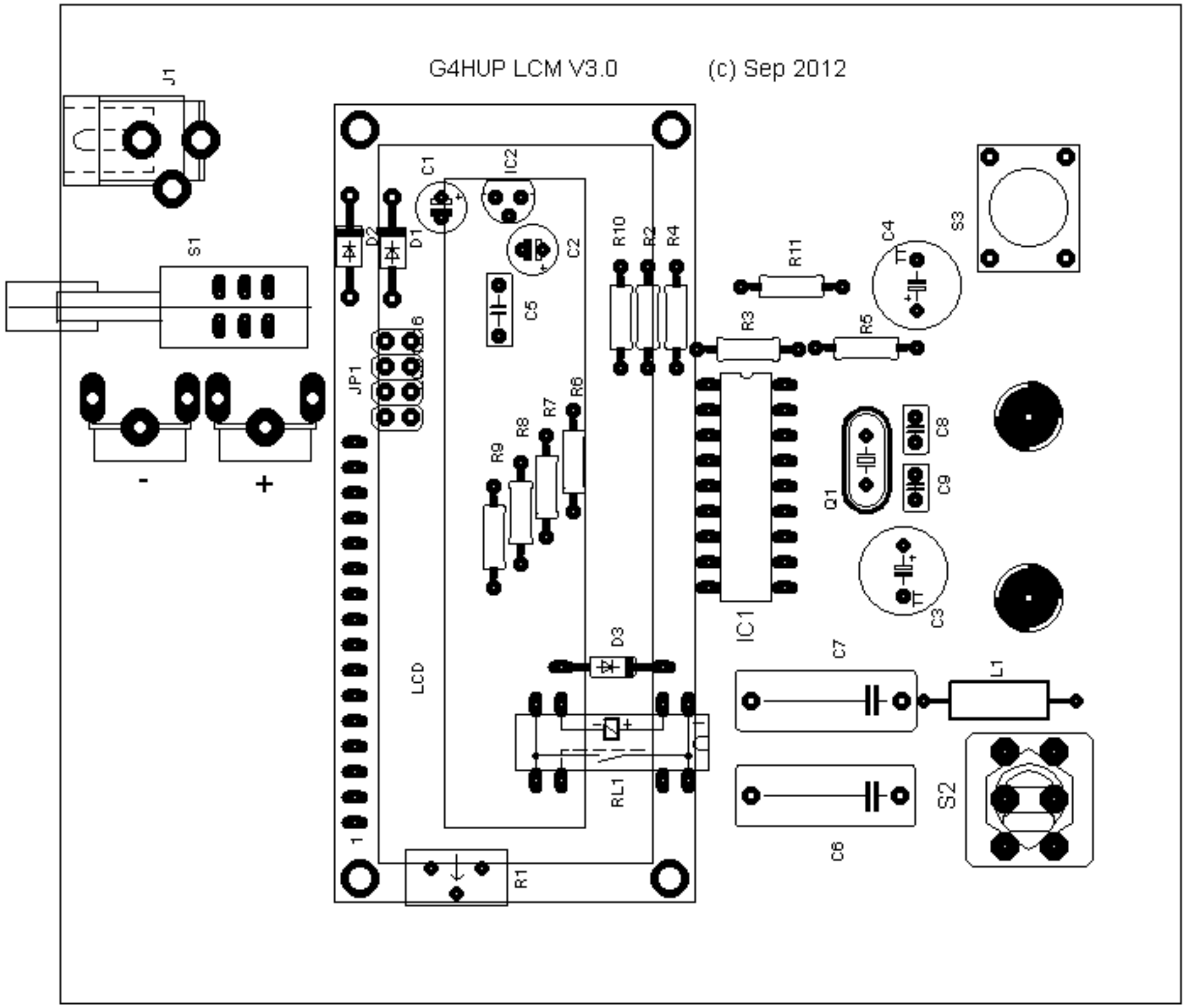


Fig 5 – PCB Component side Locations

Component List

Ref ID	Value	Tolerance	Comment
C1, 2	10uF 25v		Radial 7mm high
C3, 4	10uF 16v		tantalum bead
C5	100n		5mm box poly
C6, 7	1000pF	±2.5%	polystyrene
C8, 9	33pf		ceramic plate
L1	100uH		moulded choke
R1	5k		3/8” trim pot
R2, 3, 4	100k	5%	0.25W MF
R5	47k	5%	0.25W MF
R6, 7, 8, 9	1k	5%	0.25W MF
R10, 11	4k7	5%	0.25W MF
D1, 2	1N4001		
D3	1N4148		
IC1	16F628A		Pre-programmed
IC2	78L05		TO92
Q1	4.00 MHz	±20ppm	HC49/S low profile
RL1	DIL Relay		5V SPNO
S1 power	DPDT		Sub-min latching push switch
S2 C/L	DPDT		ON-ON min toggle
S3 Cal	Press switch		22mm high
Cap	Black, 5mm		Cap for S1
Cap	Black, 22mm		Cap for S3
LCD	1601ARS		1x16 character
JP1	4 x 2 Header		
PCB	VK3BHR V3.0		©G4HUP 2012
Case	1455 Hammond		Full kit only
Panel Overlay			Full kit only
Terminals	4mm binding post		1 red, 1 black
PP3 Battery clips			1 positive(female) 1 negative (male)
DC power socket	2.1mm PCB mounting		
Power cord	2.1mm, 1.8m long		White stripe is positive!
Mounting screws	Set of 2		Screws, nuts washers and spacers
Drilling template			©G4HUP 2012
Panel overlay			©G4HUP 2012