

ESR METER

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You will be constructing a versatile piece of test equipment used to measure the ESR (Equivalent Series Resistance) of electrolytic capacitors. When these capacitors age over time, the series resistance can increase significantly causing them to have a larger AC voltage drop and attenuate the very signal they were meant to couple on to a following stage or filter out ripple voltages.

In either case, while they may measure the correct capacitance, the series resistance or leakage to ground causes them to create different voltage and bias conditions in the circuit potentially rendering it inoperable. Trying to measure this resistance with conventional Volt Ohm Meters is ineffective and causes solid state junctions to bias on giving false indications. This ESR meter uses a low 200 millivolt peak to peak AC signal to couple through the capacitor being tested and does not bias on surrounding diodes or transistors. Therefore it can isolate faulty capacitors in circuit. This saves valuable time by not requiring the removal of capacitors until they are deemed suspect. Once removed, they can be rechecked for ESR and measured with a capacitance meter capable of measuring higher value electrolytic capacitors.

Capacitor values lower than 10 uF tend to have a higher ESR than 1 ohm and thus may not be bad even though they read a lower bar (higher ESR) on the ESR meter. Regardless, they should not read more than a few ohms, not 5 to 20 ohms.

The overall construction is fairly straight forward and the detailed step by step instructions should make assembly relatively easy. Still, there are over 28 steps and careful soldering is required due to some fairly small components.

No calibration is required apart from shorting the leads together and adjusting the CAL pot until the last LED to the right on the bar-graph meter just lights. The CAL pot is a 30 turn trimmer, so it is easy to make this slight adjustment.

The ESR meter design is partially based on a circuit that can be found at this WEB site:

<http://www.ludens.cl/Electron/esr/esr.html> More detailed information about ESR measurements and electrolytic capacitors can also be found at this site.

Since 50 and 100 u-amp meter movements are relatively expensive and getting harder to find surplus, I chose to use a LM3914 ten LED driver IC and a 10 count LED bar graph to replace the meter movement. The 10 LED bar graph reads from 30 ohms of ESR when the first LED is lit to .22 ohms when the last LED is lit. The fixed resistor that calibrates the full scale meter range allows the CAL trimmer POT to set the full scale reading so it can measure effectively over this range, which is typical of ESR meters.

ESR METER BAR GRAPH DISPLAY

24	18	15	11	8.2	6.8	5.1	2.7	.39	
R	R	R	R	R	R	R	Y	G	G
30	20	16	12	10	7.5	6.2	3.9	1	.1
Ω									

ESR METER ASSEMBLY INSTRUCTIONS

If you are a skilled DIY assembler, you may choose to install the parts in an order you prefer. For those of you that like a more structured approach and a check list to go by, you may want to follow the step by step process. In either case, the picture of the PCB parts layout has the location of components and values identified.

- [] 1. Install the 1 each 680 ohm $\frac{1}{4}$ watt resistors. (blue, grey, brown)
- [] 2. Install the 1 each 100 ohm $\frac{1}{4}$ watt resistor. (brown, black, brown)
- [] 3. Install the 1 each 1.2 K $\frac{1}{4}$ watt resistor. (brown, red, red)
- [] 4. Install the 1 each 270 ohm $\frac{1}{4}$ watt resistors. (red, violet, brown)
- [] 5. Install the 1 each 1 K $\frac{1}{4}$ watt resistor. (brown, black, red)
- [] 6. Install the 1 each 8.2 K $\frac{1}{4}$ watt resistor. (grey, red, red)
- [] 7. Install the 1 each 39 K $\frac{1}{4}$ watt resistor. (orange, white, orange)
- [] 8. Install the 5 each 100 K $\frac{1}{4}$ watt resistor. (brown, black, yellow)
- [] 9. Install the 2 each 10 ohm $\frac{1}{4}$ watt resistor. (brown, black, black)
- [] 10. Install the 2 each jumper wires marked on the PCB Parts Layout.
- [] 11. Install the 3 each 10 uF electrolytic caps. (Observe the band on the negative lead)
- [] 12. Install the 2 each .1 uF monolithic caps.
- [] 13. Install the 2 each 1 uF monolithic caps.
- [] 14. Install the 1 each .001 monolithic cap.
- [] 15. Install the 2 each small blue 1N4148 diodes. Observe the band on the cathode end.
- [] 16. Install the LED power on indicator. Flat side is the cathode (black lead) and faces toward the ON / OFF switch. It has Teflon sleeves to space it the correct distance from the PCB so it protrudes through the front cover. Mount so sleeves are flush with the PCB.
- [] 17. Install the 5 volt regulator. Observe the orientation from the PCB Parts Layout drawing.
- [] 18. Install the 8 pin DIP socket. Orient the pin 1 end toward the dot on the PCB.
- [] 19. Install the 18 pin DIP socket. Orient the pin 1 end toward the dot on the PCB.
- [] 20. Install the 20 pin wire wrap DIP socket. Orient the pin 1 end toward the dot on the PCB. Note the Teflon sleeves on the 4 corner pins. Make sure the socket is seated firmly on the PCB. This spacing is important so the LED bar graph is flush with the front of the instrument panel.
- [] 21. Install the tiny transformer. The **red mark** goes toward the end where the 2 test jacks are located.

- [] 22. Install the 30 turn trimmer POT. Orient it so the knob is centered on the PCB to align with the hole in the instrument cover. See the POT orientation on the PCB Parts Layout page.
- [] 23. **Install the ON / OFF switch on the back side of the PCB.** Press firmly down so it is seated squarely on the PCB, then solder.
- [] 24. Install the 2 pin header on the pads that connect to the LM3914, pin 9.
- [] 25. Install the 2 mini banana jacks. Press them down firmly and make sure they are straight up and down so they will align with the holes in the instrument case.
- [] 26. Install the battery connector.
- [] 27. You are now ready to connect a 9 volt battery and check the 5 volt DC regulator. Measure it at the output side of the regulator. Pin 1 as marked on the back side of the PCB. See the Parts Layout drawing for reference.
- [] 28. Once you verify the 5 VDC, remove the battery and install the 2 ICs into the 8 pin and the 18 pin DIP sockets. Note the pin 1 orientation by referring to the Parts Layout drawing.
- [] 29. Now install the LED bar graph into the 20 pin socket. Make sure its pin 1 is located as shown on the Parts Layout drawing. It faces the opposite direction of the 2 ICs.
- [] 30. You are now ready to connect the 9 volt battery again and test the operation of the ESR meter.
- [] 31. Begin by shorting the 2 mini banana jacks together and adjusting the CAL POT until the last LED on the right side of the meter just lights. This right most LED represents no series resistance. Now you can connect various values of resistance from a few tenths of an ohm up to about 30 ohms. At around 30 ohms, the 1st LED to the extreme left of the bar-graph should light. Past 30 ohms, the display should not have any LEDs lit.
- [] 32. Once you are satisfied with the operation, install it in the instrument case and secure with the 2 small 2-56 nuts.
- [] 33. You are now ready to test some electrolytic capacitors. Choose a few values below 10 uF so you can see that values below 10 do have some ESR. Typically it will be a few ohms to around 10 ohms for values like .001 uF. For smaller capacitance values, the bar graph will read on the lower bars, indicating a greater ESR. Values of 10 uF and above should only show an ohm or less if they are OK. High readings of ESR indicate internal resistance to the 50 KHz signal that is being passed through them to the OP amp and detector circuit and then measured by the LED bar graph meter.

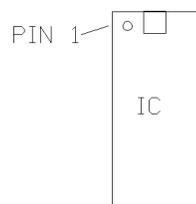
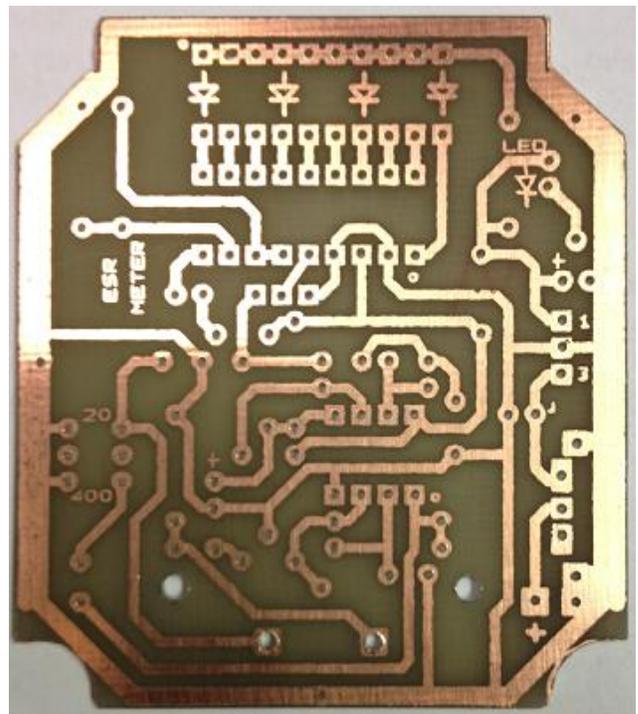
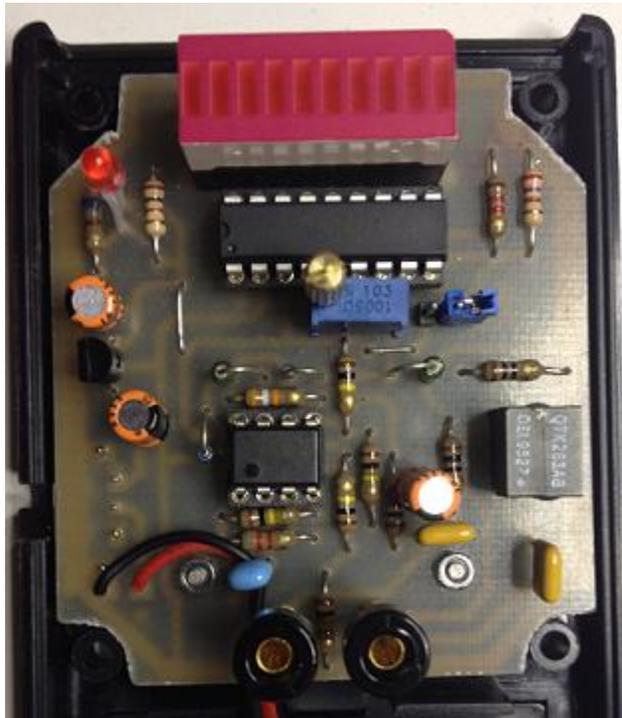
To have a better feel for the actual resistance that is associated with each LED on the bar-meter, you can connect the test leads to a low ohm POT (50 to 100 ohm) and adjust it until the first LED lights, then measure the resistance and log it. Proceed to decrease the resistance of the POT logging the resistance for each LED until you have a chart with ten values. As the meter nears the next LED to light, the current one will slowly dim and the next one will begin to turn on brighter. Over adjusting the full scale calibration POT will affect these calibrated values you charted. Always adjust the CAL POT with the leads shorted until the right hand LED just lights.

The 2 pin header on the PCB allows pin 9 of the LM3914 to be connected to +5 volts. This causes the meter to light all left hand LEDs up to the one indicating the actual value of the ESR measurement. Using this option

draws about 48 ma instead of 29 ma. Also all the LEDs will be slightly dimmer, and of course battery life will be less.

Remember that this ESR meter design is partially based on a circuit that can be found at this WEB site: <http://www.ludens.cl/Electron/esr/esr.html> More detailed information about ESR measurements and electrolytic capacitors can also be found at this site.

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ESR METER BAR GRAPH DISPLAY

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PARTS LIST

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Part	Schm Ref	Qty	Notes
Instrument Case		1	Prefabed for controls, screws
10 K trimmer POT	R11	1	30 turn CAL POT
PWR Switch SPDT	SW1	1	PWR switch
LED PWR light	LED	1	PWR light, neg lead black
Mini banana jack	Test Jacks	2	filled for holes
.001 uF monolithic cap	C1	1	marked 102
.1 uF Monolithic cap	C4, 5	2	marked 104
1 uF Monolithic cap	C2, 3	2	marked 105
10 uf 16 V electrolytic	C7, 8	3	
10 ohm ¼ watt	R5, 6	2	brown, black, black
100 ohm ¼ watt	R15	1	brown, black, brown
270 ohm ¼ watt	R14	1	red, violet, brown
680 ohm ¼ watt	R12	1	blue, grey, brown
1 K ¼ watt	R7	1	brown, black, red
1K2 ¼ watt	R13	1	brown, red, red
8K2 ¼ watt	R4	1	grey, red, red
39 K ¼ watt	R8	1	orange, white, orange
100 K ¼ watt	R1 ,2 ,3, 9, 10	5	brown, black, yellow
1N4148 diodes	D1, 2	2	tiny blue diodes, black band is Cathode.
10 LED DIP Array	DIP Array	1	bar graph display
78L05 5 VDC Reg	VR2	1	120 ma
TL028 IC	IC1	1	dual OP Amp J-FET input
LM3914 LED driver	IC2	1	
Mach. IC socket 8 pin		1	
Mach. IC socket 18 pin		1	
Mach. IC socket 20 pin		1	
2 pin header		1	
header jumper		1	
9 VDC Battery Clip		1	
ferrite transformer	T1	1	
Miscellaneous		2	small 2-56 nuts
PCB		1	

