Equivalent Series Resistance and Electrolytic Capacitance Meter «ESR-micro v4.0»

(Brief description and operation manual)

The device is designed to measure the equivalent serial resistance (ESR) and the capacitance of electrolytic capacitors within the circuit board, making it an irreplaceable instrument for every self-respecting electronic technician. As you know, most problems in electronic equipment stem from defective electrolytic capacitors. They cause such things as transistor failure, output over-voltage of a pulsed power supply and its related failures, etc. Capacitors can quickly fail in the high heat of a switching power supply. Testing with a capacitance meter can be misleading, for example, although the capacitance value may be within tolerance, the ESR can be high. ESR is a very important parameter to measure when testing a capacitor. Short circuited capacitors or those with low DCR (Direct Current Resistance - DC resistance), are extremely rare.

ESR can be explained as follows. A capacitor consists of metal plates, which are filled with a dielectric that separates the plates consisting of an oxide layer on the lining, and the electrolyte. All this is placed in an aluminum casing. There are many electrochemical processes taking place while there is voltage to a capacitor, including corrosion at the connection plates. This, in turn, causes resistance from pathway deterioration for the alternating current witthin the capacitor, causing heat, and consequently, accelerates the processes described above. All losses may be summarized in the so-called equivalent series resistance (ESR) - an imaginary resistor in series with the capacitor itself.

The measuring principle is similar to ESR used in a well-known meter, developed by Bob Parker (ESR meter K7214). Testing on capacitors was with voltage of short pulses of constant current. For the “ideal” capacitor with zero ESR, the charge will begin at a level of zero voltage. The higher the ESR, the greater the initial “voltage step” at the time current is applied. The microcontroller analyzes this “voltage step” and converts it into the ESR. In this method, measured ESR for capacitors with low capacitance (1 ... 10 uF) will be slightly higher than actual ESR due to the fact that for a test pulse time, the capacitor has time to charge up to a certain voltage level, which gives increased ESR readings.

For example, the 1 uF capacitor charged with 30mA for 2 microseconds has time to recharge voltage U = t * I / C = 60mV. That would be consistent with the measured ESR = U / I = 60/30 = 2 ohms. At the same current a 100 uF capacitor for 2 microseconds charges up to 0.6mV. In this case, an error in the ESR measurement will be equal 0.02 ohms.

Measuring capacitance uses the standard method - measuring the time to charge a capacitor with constant current up to a certain voltage level (in this case up to 0.2 V) and using the formula C = t * I/U. ***Note*** the measurement of capacitors with high ESR *this way gives you an underestimated value (due to the above-mentioned initial voltage step).*

Technical characteristics:

Measuring range:	Capacity	0.02 ... 65535 uF
	ESR	0 ... 100 Ohm
Current consumption:	Operating mode	1 mA
	“Sleep” mode	almost 0
Indication:		LCD TIC283 or TIC55 (Ampire)
Power supply:		6 volts (2 batteries CR2032)
Dimensions (mm):		120x70x20

Operations

«ESR-micro v4.0» (Fig. 1) one button control - «On / off».

Turn the device ON by pushing the On/Off button. The LCD will display battery voltage. When the device switches to the operating mode it will display 2 values on the LCD. The left one is either the ESR when checking a capacitor or the resistance when checking a resistor, both shown in Ohms. The value at right hand side is the capacitance in uF. Use the probes to measure a capacitor without removing it from the printed circuit board.

Check new or removed capacitors using the DIL-socket on the right hand side. One lead of the capacitor connects to one of the four lower panel contacts, the second - one of the four top contacts (lead length permitting). The readings will be displayed so a determination can be made about the status of the capacitor (see table in section "Notes").

It should be noted that a measurement, while in circuit, of several capacitors connected in parallel (usually a filter on power) will show their total capacity. In this instance, the capacitance and ESR value of an individual capacitor can NOT be measured. These capacitors should only be checked after they have been de-soldered.

If the capacitor is shorted (DC resistance is equal to 0), then «-----» - will be displayed on the right part of LCD. The majority of ESR meters detecting this failure will indicate a capacitor with an ESR = 0. The same symbols are displayed while checking low-ohms resistors.

Note: when testing capacitance that exceeds the device limit, «-----» will be displayed. This is due to the capacitor's charging time being longer than the time the device will charge, so the device thinks "the component is not charging, it must be a resistor".

Device Battery Voltage

The rated power supply voltage is 6V, but the device will continue to work down to 4.5V. The voltage is displayed immediately upon turning ON the device. For example, U - 5.6, means the supply voltage of the device is 5.6 volts. When voltage is below 4.5 volts, it is recommended to replace the batteries.

Auto Power Off

In order to prolong the life of the batteries, the device automatically turns off after 40 seconds of inactivity. While switched OFF, the current used is almost equal to zero (the proportion of microamperes). The device can also be switched OFF by holding the button down for more than two seconds.

Compensation for the probes resistance

There is a calibration function to account for probe resistance when measuring the ESR,. To calibrate, in the socket on the left hand side, connect one probe to the 4th bottom contact and the second to the 5th contact BEFORE turning the device on. Turn the device ON by pressing the button. The display shows «CALIBR WAIT» ("Calibration! Wait! ") then «CALIBR DONE» ("The calibration done!"). Make sure the probes have good contact during calibration (don't move probes during calibration). Once calibration has been completed, ESR readings should be no more than 0.01 ohm.

If you are using the socket to test new or removed capacitors, calibration should be done directly on the socket! To do this, connect any jumper (it can be the cut lead of some resistor) to the right side of socket instead of the capacitor. This jumper inserts into the 2 holes on the right side of socket (e.g. 4 - 5 or 3 - 6 ...) and device calibrates as described above. Then remove the jumper and you can start measurements.

Function test device

To simply test device performance there are three test resistors (1, 10 and 100 ohms) connected internally to the left side socket. When the probes are connected to the appropriate socket holes (connection resistors shown on the case) it is easy to verify the resistance accuracy. Particular attention should be given when measuring the 1 Ohm test resistor. If the measured value differs by more than 2-3%, you must re-calibrate the instrument. The 10 and 100 ohms test resistors can be off about 5-7%, because this device is not a precision ohm-meter.

Notes

Warning: To reduce the risk of damage to the device, capacitors to be tested **MUST BE DISCHARGED** first! The device has just simple protection - 2 opposed-parallel diodes in parallel with the probes. With a large charge on the capacitor, it may be ineffective.

The device is powered by two lithium cells CR2032. They sit positive (marked "+") side up.
Approximate allowable ESR values for various capacitors can be taken from the table below.

	10V	**16V**	**25V**	**35V**	**63V**	**160V**	**250V**
1				14	16	18	20
2.2			6	8	10	10	10
4.7			15	7.5	4.2	2.3	5
10		6	4	3.5	2.4	3	5
22	5.4	3.6	2.1	1.5	1.5	1.5	3
47	2.2	1.6	1.2	0.5	0.5	0.7	0.8
100	1.2	0.7	0.32	0.32	0.3	0.15	0.8
220	0.6	0.33	0.23	0.17	0.16	0.09	0.5
470	0.24	0.2	0.15	0.1	0.1	0.1	0.3
1000	0.12	0.1	0.08	0.07	0.05	0.06	
4700	0.23	0.2	0.12	0.06	0.06		

These values are just "tentative". The table was used by Bob Parker in his K7214. The principle of measurement is similar, but in «ESR-micro 4.0» the duration of the test pulse is reduced, so the ESR measurement error of capacitors with low-capacity is reduced compared to the K7214. ESR capacitors with a capacity of up to 10 uF can have a maximum of about 4-5 ohms.

When measuring the capacitance of those close to the minimum limit, accuracy is + / - 0.1uF. Thus, if the display shows C = 2.3, then the capacitance may be in the range from 2.2 to 2.4 microfarads.

The site **http://my.execpc.com/endlr/esr.html** gives the following values as valid for ESR capacitors of different types:

Capacitor Type:	22 uF part	100 uF part	Freq. measured: Hz	Comments
Std. aluminum	7-30	2.7	120	
Low-ESR aluminum	1.5	0.3-1.6	100k	
Solid aluminum	0.2-0.3		500	MnO_2 electrolyte
Sanyo OS-CON	0.04-0.07	0.03-0.06	100k	TCNQ electrolyte
Std. solid tantalum	1.1-2.5	0.9-1.5	100k	SMD
Low-ESR tantalum	0.2-1	0.08-0.4	100k	SMD, for PS filtering
Wet-foil tantalum	2.5-3.5	1.8-3.9	not stated	H_2SO_4 electrolyte
Stacked-foil film	<.015		100k	
Ceramic	<.015		100k	X5R, Y5V

In addition to measuring the ESR, the device is useful for measuring resistance of low-ohms resistors.

In the range of up to 1 ohm, the tolerance should not exceed 0.02 Ohm. In other ranges (especially the 20-100 ohms), the tolerance may be higher. However, this is not essential since the ESR of ANY usable capacitor is less than 20 ohms.

Warranty: 1 year from the date of purchase.

Order devices: http://www.radiodevices.info/

All comments and suggestions - to E-mail www@radiodevices.info