

Anatek Comparison of ESR Meters

To assist in your decision on which ESR meter to purchase, AnaTek evaluated and tested the six most popular meters on the market. We offer the three highest-rated meters, the Atlas ESR70 the Blue ESR/Low Ohms Meter and the Capacitor Wizard in our stores. These results come from tests performed on each of the units by AnaTek Instruments. The opinions given are those of the authors.

We also attempted to evaluate the low cost meter supplied by MAT Electronics. Unfortunately that meter failed (broken battery contact) during our tests. The overall quality of this, and many, made-in-China meters are very poor and so we stopped the evaluation. The MAT meter is NOT RECOMMENDED.

	<u>Atlas ESR70</u>	<u>EVB (SXX series)</u>	<u>Blue ESR</u>	<u>Capacitor Wizard</u>	<u>Cap Analyzer 88A</u>	<u>Tenma</u>
Useful Capacitance Range	1 ufd to 22,000ufd	Reads electrolytics accurately for >1ufd.	Reads electrolytics accurately for >1ufd.	Reads electrolytics accurately for >1ufd.	Very accurate for electrolytics >10 ufd. Measurement accuracy is still good below 10 ufd but the scale on the front can be misleading.	> 10 ufd. Handles lower values but gives misleading readings.
ESR range ohms	0.01Ω to 40Ω	0.01 - 99 Ω	0.01 - 99 Ω	0.1 - 30 Ω	0.1 - 20 Ω	0.1 - 50 Ω
DCR range ohms	0.01Ω to 40Ω	0.01 - 99 Ω	0.01 - 99 Ω	0.1 - 30 Ω	0.1 - 500 Ω	0.1 - 50 Ω
Method	Microcontroller analyzes capacitor using a combination of AC (100kHz) and DC signals to determine both ESR and capacitance. Initial capacitor voltage is detected to enable controlled discharge function.	Microcontroller with pulse - effective frequency ~ 100 KHz	Microcontroller with pulse - effective frequency ~ 100Khz	Analog circuitry, 100 KHz sinusoid	100 KHz sinusoid. Manufacturer states up to 150 KHz, but we could not reproduce that	50 KHz sinusoid
Suitable for in-circuit use	Yes	Yes	Yes	Yes	Yes	Yes
Readout	Alphanumeric LCD shows ESR and capacitance value (out of circuit for capacitance value)	2-digit LED	2-digit LED	Custom analog meter	LED bar scale	Analog meter
Audible	Yes, a series of sounds indicates the range of value	No	No	Yes, a beep for values less than 1Ω	Yes	No
Batteries	1 x 12 volt MN12	1 x 9 volt , Blue version is powered by 6 x AA cells or 3x18650 Li-Ion, batteries not supplied.	1 X 9 volt not supplied with kit, but is in fully assembled units. Circuits function down to 5.5 volts.	4AA (not supplied)	4 AA	2 AA
Battery usage	Excellent	Very good, automatic shutoff	The best of the kits, automatic shutoff	Good but no automatic shutoff	OK. No automaticshutoff . Power on is indicated by beep and flashing light.	Poor, no automatic shutoff
Strong points	Very rugged, very small, slowly discharges capacitor charges of up to 400 volts for C < 10 ufd (40 volts for C > 10 ufd). This feature avoids both meter damage and damage to the capacitor due to excessive dv/dt.	Small, can tolerate up to 400V of charge without damage. Digital readout permits use in tracking down low grade shorts.	Very rugged design both electronically and mechanically. The case is solid with rubberized sides.	Very accurate ESR measurement, easy to read meter.	Can tolerate some charged capacitors, limits are noted by the manufacturer but not specified.	Can be safely used on charged capacitors and live circuits up to 500V, rugged construction
	Can be used to track down low grade shorts.	Later version is housed in a stronger ABS case	Can tolerate moderate charges without damage.	<u>The CapWizSavris available to protect against damage by charged capacitors.</u>	Tweezer probes allow one hand operation.	
	Measures capacitance value out of circuit but most electrolytic capacitor failures are due to ESR, not value change.	Digital readout permits use in tracking down low grade shorts.	Integral high quality 20" leads accommodate a variety of clips and probes.	An audible beep for values <1.0 ohms but many capacitors have higher values than that and are still good.	This is the only unit that also measures DC resistance to detect shorted capacitors.	
	The ESR70 has an automatic start feature which eliminates the need to press the "start" button for testing as was required in its predecessor, the ESR60.	Has a version to measure batteries with relevant amount of capacity	Digital readout permits use in tracking down low grade shorts.			
Weakness	Excellent battery lifetime.	Earlier Bob Parker design.	The latest Bob Parker design.	Does not turn off automatically, is susceptible to charged capacitors but see AnaTek's CapWizSavr.	Slow operation due to mandatory discharge, DCR cycle before reading ESR. An ESR only mode is available to speed operation. Scale is misleading for some values - may indicate that good capacitors are either marginal or bad. This is a common issue for all ESR meters - you have to know what is good/bad for the type of capacitor you are measuring. See discussion below. Tweezer probes not suitable for some lead spacings and can be easily broken.	The low frequency used for measurement causes inaccuracy at low capacitor values. No automatic shutoff to save batteries. Scale on meter is inaccurate in some cases. Meter is the smallest of all.
Overall rating	Excellent	Good. Quality components and fairly easy to build but the poor quality case is a liability. Does not pass the drop test.	Excellent, top quality components, solder masked board for easiest assembly.	Excellent if you prefer an analog meter and want ESR accuracy, this is the one.	Good if the DC Resistance measuring capability is important to you.	Does the job but barely.
Where manufactured	England	Portugal	USA	USA	USA	Taiwan
Price	\$125	Kit \$76 Assembled \$87	Kit \$80 Assembled \$99	\$195 (no SVR) \$217 (with SVR)	\$179	\$125

ESR Meter Recommendations

If cost is paramount and you want a quality instrument then the Blue ESR kit is for you. If you want an assembled unit with a digital readout for tracking down low grade shorts then the assembled Blue ESR or the Atlas ESR70 are excellent choices. If you are partial to analog meters or want the most accurate ESR meter available (see accuracy comment above) then the Capacitor Wizard should be your choice. If you do chose the Capacitor Wizard then be sure to add the CapWizSavr to protect against charged capacitors.

The top rated ESR meters measure ESR better than the much more expensive multi-purpose impedance meters available. You can get a "Z-meter" for \$900 to \$4000. These meters measure L, C, leakage, ESR and do ring testing. But the methods used by them for ESR measurement are inferior to the Atlas ESR, EVB kit, Blue ESR kit and the Capacitor Wizard. They are also much less convenient to use. You should have one of these dedicated ESR meters on your bench at all times. Most repair techs use their ESR meter even more than their multi-meter.

Atlas ESR70

Unlike other meters it measures both the ESR and the capacitor value which can be very handy, but some inexpensive capacitors show good ESR but the value can changes 50% or more. The enhanced version (released in the summer of 2008) can also be used to measure low ohms - a good tool for troubleshooting troublesome pc run defects. ESR70 is very accurate, small and easy on battery life but the ESR range is limited to 20 ohms maximum.

Assembled Blue ESR & Kit

These units using the latest design by ESR guru Bob Parker, with many of the documented improvements, perform ESR measurements by sending 8 us current pulses into the test capacitor (0.5, 5 or 50 mA.) and monitoring the response. The output voltage is limited to 500 millivolts maximum so that the unit can be used in-circuit. A microcontroller controls the pulses and makes the measurement. A two-digit LED readout gives the ESR from 0.01 to 99 ohms. The pulse technique becomes inaccurate with capacitors of less than 10 uf. The unit monitors the readout and automatically shuts off power if the indication does not change in three minutes. This feature is a real battery saver.

The digital readout makes the tester useful for tracking down low grade shorts as you can distinguish between 0.10 ohms and 0.08 ohms, for instance. This meter was designed specifically for electrolytic capacitors and measures their ESR accurately down to 1 uf. Other low ESR capacitors (such as polypropylene) give erroneous readings at less than 10 uf. The Blue ESR/low ohms meter is the better of the two designs as it has integral test leads, a much better enclosure, accessible battery compartment and much longer battery lifetime.

Assembled EVB ESR & Kit

These units based on an earlier design by ESR guru Bob Parker perform ESR measurements by sending 8 us current pulses into the test capacitor (0.5, 5 or 50 mA.) and monitoring the response. The output voltage is limited to 500 millivolts maximum so that the unit can be used in-circuit. A microcontroller controls the pulses and makes the measurement. A two digit LED readout gives the ESR from 0.01 to 99 ohms. The pulse technique becomes inaccurate with capacitors of less than 10 uf. The unit monitors the readout and automatically shuts off power if the indication does not change in three minutes. EVB has several models capable of measuring ESR on capacitors and batteries; the latest model has a stronger enclosure.

CapAnalyzer 88A

The CapAnalyzer 88A uses a low-level 100 Khz sine wave for performing in-circuit ESR measurements (the manufacturer states that the frequency goes as high as 150 Khz, but we have not been able to reproduce this condition). A higher operating frequency will result in improved accuracy for lower capacitance values. See the discussion below. The CapAnalyzer 88A steps through a set cycle of tests each time it is connected to a capacitor. First it discharges the capacitor with a relay, then it checks the DC resistance and compares that to the user setting, then it measures ESR and indicates the range of the value with a 20 LED bar. A meter that measures only ESR will indicate that a shorted capacitor is good. The CapAnalyzer 88A detects shorted capacitors in it's DCR cycle and will stop when it detects a DCR lower than the limit set by the user. The DCR limit is set via a slide control. However, the DCR feature can get in the way of measuring resistances of less than 1 ohm. Regardless of the setting, the meter will stop on the DCR cycle when connected to anything with a DC resistance of 4.5 ohms or less. To avoid this problem and permit the user to speed up ESR measurements, the latest version of the CapAnalyzer 88A provides an ESR measurement only feature. When in this mode, the meter does not enter the DCR mode - it goes through the discharge function and then measures ESR.

CapAnalyzer 88A has an audible indicator and a scale next to the LED bar indicating what readings are good. The scale can be misleading in some cases so the user still needs to understand what is a good/bad reading for capacitance/rated voltage combinations.

CapAnalyzer 88A does not have an automatic shutoff but it does beep and an LED flashes when left unattended. That works when you are nearby but if you leave it on and go home the battery will be dead in the morning. High battery usage was a common complaint on earlier versions of CapAnalyzer 88A. This problem has been addressed in the latest version but there is still no automatic shutoff when unattended.

The leads used in the CapAnalyzer 88A are Pomona tweezer leads. These are very good quality and permit one hand operation. Having a free hand can be helpful in some situations such as when a unit has to be balanced on a side while probing. Tweezer leads also have a couple of negatives. They can be easily broken when trying to stretch them to accommodate a wider than usual contact situation. The ends have less mass than other test leads so that arcs drawn from charged caps will chew up the contacts quicker.

The discharge cycle of the CapAnalyzer 88A protects it from charged capacitors up to a point. However, discharging a capacitor through relay contacts can damage both the capacitor under test and the relay contact. CapAnalyzer's manufacturer acknowledges that there are limits to the capacity of the discharge circuit but has not specified those limits. The manufacturer has stated that CapAnalyzer 88A will survive large amounts of capacitor discharge current, however, the capacitor you are testing may not. A discharge system that can damage the capacitor being tested seems like a weakness to us. So, the CapAnalyzer 88a has some strong pluses and some minuses. You decide whether the DC resistance measurement feature outweighs the weaknesses listed above.

Tenma

The main features of this unit is that it is low cost and rugged. It can be used to measure capacitors in live circuits but that is a poor and hazardous practice. However, if you forget to turn off power to the unit you are checking, the meter will not be damaged up to 500 VDC. The small meter and low operating frequency (50 Khz) results in inaccurate readings. No automatic shutoff results in rapid depletion of the two AA batteries.

Discussion of ESR Measurement and Accuracy

Technicians new to ESR measurement frequently get confused about what is a good reading and what is bad. There is no dividing line. The ESR of a good capacitor depends upon it's construction, value and voltage rating. All of the ESR meters compared here have some kind of indication of what is good, fair and bad. But those are only guidelines, not hard and fast rules. Common electrolytic capacitors in the mid-range of capacitance and voltage will have low ESRs. Bad ones are easy to detect and all of the meters evaluated here will do the job. The differences are in ruggedness, battery life and accessibility. The Blue wins hands down on all of these characteristics. But a good 1 ufd, 200 volt aluminum electrolytic can have an ESR of 100 ohms or more. That is beyond the measurement range of all of the meters listed above! The ESR70 is limited to a maximum ESR of 20 ohms.

Film capacitors make matters worse. A good 1 uf, 200 volt metallized polypropylene capacitor can have an ESR of less than 50 milliohms. Yet it's capacitive reactance at 100 Khz is approximately 1.6 ohms, at 50 Khz it is 3.2 ohms. The result is that all of the meters evaluated here except the Atlas ESR60 will indicate 1 ohm or more for such a capacitor even though there is nothing wrong with it. The ESR60 analyzes the capacitors real and imaginary impedances eliminating the reactive component so it can measure the ESR of any capacitor but is still limited to the same ESR range as the others.

A tech can do two things:

1. Limit ESR measurements to mid-range electrolytics only, most capacitors fall into this category and you have not given up much.
2. Learn the characteristics of the different types of capacitors. The capacitor manufacturers make all this information available. Once you to learn it you can get the most out of your equipment.