



Measuring ESR

This second, concluding instalment completes the description of Alan Willcox's latest ESR meter, with a suggested stripboard layout and component specifications

In Part 1 last month I dealt with ESR and its measurement, and described the significant features of my latest ESR meter design. I'll start this month with a description of the basic circuitry used.

Circuit description

Fig. 4 (see page 78 last month) shows the basic ESR meter circuit. The important features of the oscillator and test interface sections were covered last month. There is no need for a regulated power supply. Just to remind you, the amplitude of the HF output waveform obtained from the oscillator (IC1a) is set by the characteristics, which are virtually temperature-stable, of the two diodes D1 and D2 in the negative-feedback path between pins 1 and 2. The amplification and detection levels provided by the other stages are set by the ratio of the source and feedback resistor values used. This is standard operational-amplifier practice. The way in which operational amplifiers work was covered in some detail in my articles in the March/April

1999 issues, so only a brief description is given here.

The frequency of the Wien-bridge oscillator is approximately equal to $1/(2\pi RC)$ when resistors R1 and R2 and capacitors C1 and C2 have equal values. At this frequency there is no phase shift across the bridge and thus maximum positive feedback. At resonance, the upper section of the network (R1, C1) has twice the impedance of the lower section (R2, C2), so there's a transmission loss of 1/3. To sustain oscillation, the overall gain (ALC) must be greater than unity. The transmission loss through the network is offset by the gain determined by the ratio $1 + (R3/R4)$. In this circuit the ALC would be more than the three times required were it not for diodes D1 and D2, which override the effect of R3 as mentioned above.

The following two stages of amplification (IC2a and IC1b) are straightforward, with no need for correction circuitry. Capacitor C3 in the feed to the detector stage (IC2b) is included to remove any DC component and also to reduce sensitivity

to low frequencies (mains hum or whatever). R12 sets the gain in the detector stage. Because of the high intrinsic gain of an operational amplifier, the forward voltage drop across detector diodes D3 and D4 is overcome and detection at even mV level is not a problem.

Split-rail generator and buzzer

That is all there is to the basic circuit. But the operational amplifiers require positive and negative supplies. This requirement is provided by IC3b, see Fig. 6, which is configured as a voltage-follower. There is 100 per cent negative feedback (pins 7-6), so the output voltage must settle at half the supply voltage, set by the equal ratio of R14 and R15. I was pleased to find that the circuit remains stable with outputs as low as $\pm 3.1V$. This lower supply voltage range is quite consistent.

IC3a is configured as a voltage comparator. When the ESR reading is less than 0.5Ω , the output from the detector goes higher than the forward voltage drop across D8. The output at pin 1 of IC3 therefore

Parts list

Item	Value/type	CPC order code
R1, 2	3k Ω	REMFR4 followed by the value
R3	220 Ω	
R4	100 Ω	
R5	1 Ω	
R6	2.7 Ω	
R7, 9, 11, 16, 17	10k Ω	
R8, 10	100k Ω	
R12	*68k Ω	
R13	3.9k Ω	
R14, 15	56k Ω	
R18	*100 Ω	
R19	*2.7k Ω	
All 0.5W, 1% metal film		
VR1	10k Ω cermet preset	RE01881
C1, 2	470pF low-loss high-stability**	CA02068
C3, 4	0.1 μ F ceramic multilayer	CA02098
C5, 6, 7	22 μ F, 16V	CA01613
D1, 2, 3, 4, 8, 9	1N4148	SC1N4148
D5, 6	1N4004	SC1N4004
D7	1N4002	SC1N4002
IC1, 2, 3	TL082CN	SCTL802
LED	3mm Superbright	SC00023
M1	100 μ A moving-coil	PM11119
S1	Miniature toggle switch	SW-Z201/Z
Buzzer	5V DC	LS00654
Case	ABS box	EN55030. See text
Test leads	2mm plug to probes	IN00772. See text
Veroboard		PC00046
Spot face cutter for Veroboard		PC00066
PP3 battery clip lead		BT02187
High-current protection choke		PW00037. See text

*The value of R12 sets the turn-on point for the buzzer, see text. R18 sets the charge current, see text. R19 is chosen for good brightness with the LED specified.

**For correct oscillator operation C1 and C2 must be of the type specified.

quick in-circuit location of faulty electrolytic capacitors. If anyone contemplates the design of a PCB for the project, it is important that separate operational-amplifier chips are used for the oscillator and the first amplifier stage – to avoid interference between the oscillator and the sensitive first amplifier stage. Fig. 7 shows a stripboard layout for the meter's circuitry. Fig. 8 shows the meter scale.

Don't be tempted to use plugs and sockets for the test leads – you would in time get problems in the low-ohms range. Soldered connections should be used throughout. I use 2mm test leads with the plugs cut off. Make sure that you file the probes to give sharp points. The coating that's on them has a significant resistance.

The case specified in the parts list is a bit on the deep side. To

achieve a slimmer appearance, I bought another case, type EN55029 (too slim), and combined the halves. This might sound extravagant, but you still end up with two cases and they cost only about £2.

Protection methods

In a letter in the August issue this year Jim Littler suggested wiring an inductor across the test lead terminals to protect the meter should it be connected to a charged capacitor. I can see no problem with this, and followed up with a letter in the September issue. If a value somewhat lower than the 150 μ H recommended there is used, producing a reading of say 30 Ω , this reading will be present each time the meter is switched on and you will know that it is working correctly. It will not affect the use of the meter. We are only interested in values that

are much lower.

If this method of protection is used with a digital meter, the display will settle at a fixed reading. This will show that all is well with the meter and will also eliminate superfluous readings. In the case of a moving-coil display, it will double-up as a power-on indicator.

The use of a circuit protector in series with the test leads has been suggested. The problem is that it would tend to blow too easily and require frequent replacement.

To reiterate, diode protection (D5, D6) should always be included.

Any comments about high-current choke protection, which seems to be a unique idea, and on ESR measurement in general would be welcome.

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I think that covers everything. ■