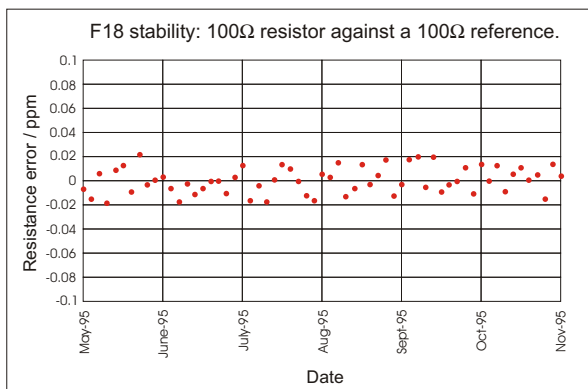


## Why is AC better than DC?

The ability to measure resistance accurately is key to precision thermometry, where the practical temperature scale is implemented using the resistance of a PRT (platinum resistance thermometer). Resistance is measured using a bridge circuit in which the unknown resistance is compared with a known reference resistor. The bridge can be excited using AC (sine-wave excitation) or DC and both have their advantages and disadvantages. The advantages of DC technology are simplicity and therefore cost. In terms of performance, AC technology is always better and it is therefore the technique of choice for all those involved with the most accurate measurements. The reasons why AC bridges offer better performance arise from fundamentals in the physics associated with measurement and the devices used in the implementation of a measurement bridge. These are as follows:

### ● The ratio transformer

At the heart of an AC bridge is a ratio transformer. This is used to scale the voltage developed across the reference resistor in order to balance the bridge. Since the voltage ratio in a transformer depends only on the turns ratio and this is an integer and fixed ratio (turns cannot be lost or gained) this represents a fundamental measurement standard. This basic stability, which is inherent in the AC measurement technique, is unsurpassed. The stability of an ASL F18 bridge was monitored by a National Standards Laboratory over a 6 months period and shows no measurable trend. The spread of results was found to fall well within the quoted specification:



By comparison, DC bridges depend on a larger number of components to achieve their performance, none of which offer equivalent inherent stability. Although modern analogue techniques and self-calibrating strategies using microprocessors improve the performance of the more recent DC bridges, these still cannot match the stability of an AC bridge.

### ● Elimination of thermal & electrochemical EMFs

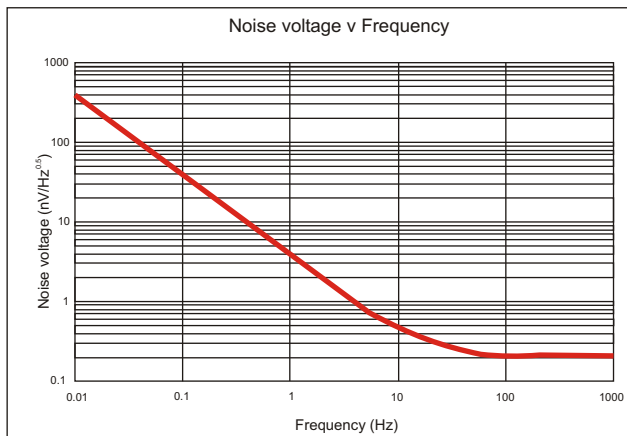
Any practical measurement system is subject to thermally generated EMFs which arise when the dissimilar metals in the PRT, reference resistor or measurement circuit are exposed to temperature gradients. A straight DC measurement of the voltage across the PRT would therefore lead to an incorrect value of resistance being determined. DC bridges periodically reverse the measurement current (actually using a low frequency AC excitation!) and average the voltages measured in an attempt to eliminate these effects. Whilst this eliminates truly static thermal and electrochemical EMFs, any changes that occur during the measurement time (which may be several minutes) lead to errors. Also, this current reversal strategy does not eliminate the effect of Peltier heating which leads to unavoidable errors in switched DC systems. The measurement current flowing in a circuit leads to the expected resistive heating effects in the PRT and conductors. However, it also leads to Peltier heating at any inter-metallic junctions. These junctions will either absorb or liberate heat, depending on the direction of the current flow. When a DC bridge reverses the measurement current, this also reverses the direction of the Peltier heating in the system (junctions which gave out heat and got hotter now absorb heat and are cooled) which changes junction temperatures and the corresponding thermal EMFs. This always leads to a positive error in indicated resistance. By contrast, AC bridges measure only the AC component of any voltage and do not allow time for significant heating or cooling to take place during the measurement cycle (typically 7ms). They are therefore completely immune to thermal and electrochemical EMFs.

### ● Line frequency rejection

The measurement frequencies chosen for an AC bridge are harmonically linked to the local mains power frequency and allow for complete rejection of line/mains frequency interference and all its harmonics. An AC bridge is able to achieve this rejection on a cycle to cycle basis, whereas a DC bridge achieves similar rejection only by averaging over a long measurement period. The frequency used in ASL's high performance bridges is locked to the local mains supply to provide the very best immunity.

### ● Better noise performance

All electronic systems are subject to internally generated noise that ultimately limits their measurement uncertainty. The inherent spectrum of noise in electronic systems shows a characteristic 1/f form in which the noise power increases in proportion to the reciprocal of frequency below a given 'corner' frequency (this is basically the tendency of systems to move around the longer you leave them).



AC bridges operate above the 1/f corner frequency and are therefore subject to a much lower “noise floor “ than DC bridges which by definition operate at a near zero frequency. The lower noise level of an AC bridge offers lower uncertainty in the readings for measurements taken over the same time as an equivalent DC bridge.

### ● Speed of response

This is a corollary of the above noise feature. Basically, noise and speed of response are performance parameters than can be ‘traded’. Given that AC offers a lower “noise floor” this means that an AC bridge can balance to the same precision much faster than its DC counterpart. Also, the elaborate and time wasting “auto-zero” and “self calibrate” cycles used in DC bridges are of course not required by an AC bridge which provides continuous temperature measurement. This means that the measurement time and consequently the throughput of any calibration system are much better with an AC bridge system. This is particularly important when a bridge is used with a scanner to multiplex around a number of probes.

### ● Ideal for temperature measurement

DC bridges were primarily developed for the measurement of resistance in electrical metrology rather than temperature metrology applications. They make sequential measurements with forward and reverse current and also incur further delays caused by complex “auto-zero” and “self calibrate” cycles.

All instruments



## AUTOMATIC SYSTEMS LABORATORIES

275 King Henry’s Drive, New Addington,  
Croydon, CR0 0AE, UK.

Tel: +44 (0)1689 800799

Fax: +44(0)1689 800405

email: [sales@aslltd.co.uk](mailto:sales@aslltd.co.uk)

web: [www.aslltd.co.uk](http://www.aslltd.co.uk)

This means that the measurement results are updated only every few seconds or even minutes (for more accurate measurements). When measuring the value of a fixed resistor where the resistance is relatively stable with temperature, a DC bridge is quite adequate for the task. On the other hand, the temperature and hence the resistance of a PRT are dynamic properties, subject to significant change over a relatively short time period. The fast and continuous measurement technique embodied in an AC bridge is therefore more appropriate than the slowly sampled output provided by DC bridge technology. AC bridges can in fact be used to provide measurement of dynamic effects which would completely defeat DC based systems.

### ● Noise matching of probe

Noise matching transformers can be supplied with an AC bridge to match the noise of the probe to the bridge circuit, thereby reducing overall measurement noise. This is not possible with DC measurement techniques.

### ● No warm up time

Because the heart of an AC bridge is the ratio transformer which provides inherent stability, it requires no warm-up time and can be used immediately after being switched on. By comparison, DC bridges usually require extended warm-up times for their internal circuits to stabilise.

### ● Are there any disadvantages of AC bridges?

There is only one.... the cost. AC bridge technology is by nature more complicated than its DC counterpart which makes it a more expensive solution. As with all things in life, you get what you pay for and AC bridges are simply the best devices for temperature measurement applications. Certainly, in primary standards laboratories, there is no question that the AC bridge has been and remains the device of choice for the temperature metrologist. Even, at the secondary calibration laboratory and at the industrial level, the inherent stability of AC with the corresponding measurement confidence and the high speed/throughput of the AC bridge offers the customer significant benefits.

### application support

If you have a temperature, or temperature related measurement or calibration problem, or are not sure what level of performance you need, our application engineers will be pleased to advise you.