The TE1000, TE3000 and TE3001 analysers are excellent tools for the electrical measurement and characterisation of components. Results are able to be viewed in a variety of formats to ensure the particular parameters you want to measure are easily obtained. This article is a practical guide to the effective measurement of inductors and capacitors using the TE3000 series analysers.

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**Equipment Used:**
- TM5200 Tweezer attachment
- TE3001 Network Analyser
1. Holding the device
The first task is to decide how to hold the device. Many devices are best held in the Tweezer attachment shown below, directly connected to the TE3001 via an N type Male to Male adaptor.

This type of setup is the most accurate because the measurement fixture is very close to the analyser which minimises errors due to transmission line effects.

Axial components can be mounted on either the passive or the active probe by winding one lead around the probe pin and holding the other against the probe body with the thumb.

This is a rough and ready approach, but is sufficient for many purposes. Take care not to let your thumb or fingers get close to the live end of the component or the measurement will be inaccurate!
2. Calibration
Before accurate results can be obtained the measurement fixture used must be calibrated to. This is easily achieved by following the three step custom calibration procedure outlined in the Calibration Guide available from our website.

For the Tweezer attachment, select SMD on the analyser and use the TM5174 cal kit. For bare probe measurements, select PROBE on the analyser and use the TM5175 cal kit.

3. General principle
In order to obtain reliable measurements, the magnitude of the impedance presented to the analyser must be in a reasonable detection range, say 1-1000 Ohms.

The formula for impedance of a capacitor and inductor is:
\[ X_C = \frac{1}{2\pi f C} \quad X_L = 2\pi f L \]

Using the analyser frequency range of 30kHz to 300MHz and the detectable impedance limits we can calculate the theoretical measurement range for each.

\[ C_{\text{max}} = \frac{1}{2\pi f_{\text{min}} X_{C_{\text{min}}}} \quad C_{\text{min}} = \frac{1}{2\pi f_{\text{max}} X_{C_{\text{max}}}} \quad L_{\text{max}} = \frac{X_{L_{\text{max}}}}{2\pi f_{\text{min}}} \quad L_{\text{min}} = \frac{X_{L_{\text{min}}}}{2\pi f_{\text{max}}} \]

For capacitors: \( C_{\text{min}}=0.5\text{pF}, \quad C_{\text{max}}=5\text{uF} \)

For inductors: \( L_{\text{min}}=0.5\text{nH}, \quad L_{\text{max}}=5.3\text{mH} \)

In practice, the effective range is about 1pf-10uF and 1nH-50mH

I usually start measurements at 1MHz. This is below the self resonant point most HF caps and inductors. Once you’ve established what ball park you’re in, you can increase or decrease the frequency to improve the accuracy of the results.

Measurements are best displayed using a parallel equivalent circuit for caps and series equivalent circuit for inductors. This way the parasitic resistances don’t mask the results.
4. Measuring Capacitors

1. Place the capacitor in the measurement fixture.
2. Press the R-L-C key and select ‘parallel’ with the Format key.
3. Set the analyser frequency to 1MHz.
4. Read the value off the LCD screen.

Below is the result measuring a 0805 AVX ceramic chip 15pF +/- 5% capacitor.

16.7pF is not far off the true measurement, but now that we know it’s a fairly small capacitor, we can safely increase the frequency to improve the result.

15pF has an impedance of 10k at 1MHz so there’s not much current signal for the analyser measure. Press the Z key and select polar format to view the actual impedance presented by the cap.

I use scan mode (press and hold the Enter key) to increase the frequency until the impedance drops to something sensible like 1k Ohm.

This will increase the current signal and improve the accuracy of the measurement.

15.4pF is now within the stated tolerance for the device.

Below is the result measuring a 1uF 1206 KEMET +80%-20% ceramic chip capacitor.
Now we know it’s a big capacitor, it’s a good idea to decrease the frequency. (1uF at 1MHz presents an impedance of just 0.16 Ohms to the analyser so there’s not much voltage signal to measure) Decreasing the frequency to 30kHz gives a more stable result and closer to the stated value.

Using this technique, the effective measurement range is about 1pF – 10uF.

If you want to view the actual impedance presented to the analyser, just press the Z key and choose the polar format. Reliable results can be obtained when the magnitude of the impedance is between about 1 and 1000 ohms.

5. Measuring Inductance
   1. Place the inductor in the measurement fixture.
   2. Press the R-L-C key and select ‘series’ with the Format key.
   3. Set the analyser frequency to 1MHz.
   4. Read the value off the LCD screen:

   Below is the result measuring a 0805 EPCOS ceramic chip 22nH +/- 5% inductor.

   25.7nH is not far off the true measurement, but now that we know it’s a fairly small inductor, we can safely increase the frequency to improve the result.

   22nH has an impedance of 0.138 Ohms at 1MHz so there’s not much voltage signal for the analyser measure. Press the Z key and select polar format to view the actual impedance presented to the analyser.

   Only 0.2 Ohms!

   Increase the frequency until the impedance rises to something sensible.
29 Ohms is much better. This will increase the voltage signal and improve the accuracy of the measurement.

23.1nH is now within the stated tolerance for the device.

The effective measurement range at 1MHz is 1nH – 50mH.

6. Higher Frequencies
Using higher frequencies than 1MHz can sometimes give surprising results due to component self resonance. Self resonance is the point where parasitic reactances begin to dominate the components electrical behaviour. Above this frequency, inductors become capacitors and vice versa! This leads to the realm of component characterisation, not covered here, but hopefully in an article soon.