Measuring L and C.

Measuring small values of Inductance and Capacitance has always been difficult without expensive test equipment. Even with such equipment, the measurement of the inductance of iron and ferrite cored inductors is often unreliable since the inductance will often vary with frequency.

The following describes a method of overcoming some of these difficulties and requires only a digital frequency meter and a capacitor of around 100pF with a tolerance of 1% or better.

When a parallel tuned circuit is resonant, its frequency is given approximately by

$$f = \frac{1}{2\pi\sqrt{LC}} \qquad (1)$$

If an additional value capacitor (C_1) is now connected in parallel with the tuned circuit, then the resonant frequency will be lowered to f_1, where f_1 is given by

$$f_1 = \frac{1}{2\pi\sqrt{L(C + C_1)}}$$

Dividing the first expression into the second gives

$$\frac{f_1}{f} = \frac{\sqrt{C}}{\sqrt{C + C_1}} = \sqrt{\frac{C}{C + C_1}}$$

Note that L has cancelled. Rearranging

$$\Rightarrow C = \frac{C_1}{\left(\frac{f^2}{f_1^2} - 1\right)}$$

Therefore by measuring the resonant frequency with and without the capacitor C_1, the main value of the capacitor, C, of the tuned circuit can be determined.

http://www.ikes.16mb.com/AR/L&C_calc.htm

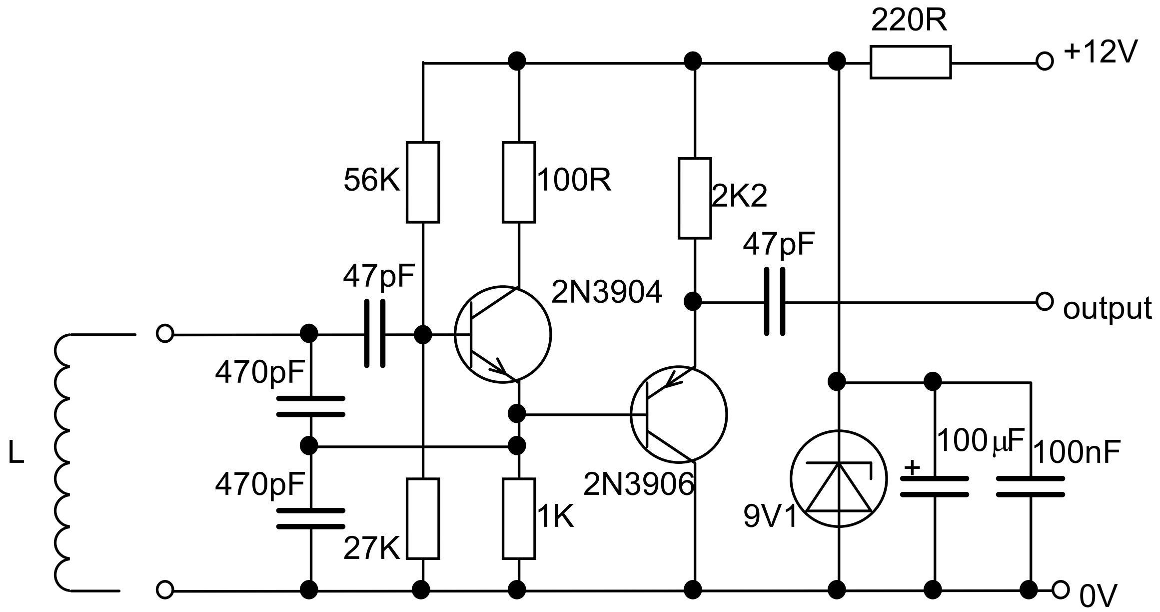
If C_1 has a tolerance of 1% and the frequencies are measured with an accurate frequency meter, then C should be accurate to 1-2%.
L can now be determined using formula 1 above, or by using the calculator at

http://www.ikes.16mb.com/AR/tuned_circuit.htm

Method 1

The easiest way to determine the resonant frequency of a tuned circuit is to make it oscillate.
The circuit diagram given is one that has been found to reliably oscillate and be stable with inductor values from around 0.2µH to around 50µH. It is based on the standard Colpitts type design and was constructed on strip board.
The oscillator circuit operates from a 12V supply and gives an output of ≈ 6V p-p, which is more than adequate to operate most frequency meters.

Circuit diagram.



All pico value capacitors are NPO ceramic

Calibration

Calibration is needed to find the effective capacitance, C, of the circuit in parallel with any inductor L.
To calibrate the circuit an air wound inductor is connected as shown in the circuit diagram. Its value is not critical. (34t of 0.31mm wire on a BIC biro tube was originally used).

The circuit is powered and connected to the frequency meter and left until the frequency is relatively stable. The frequency is measured and this is frequency f.
An accurate capacitor (C_1) is then connected across the inductor (100pF, 1% was originally used) and the circuit is again left until the frequency is stable. The frequency is again measured and this is frequency f_1.
(It is worth remembering that the frequencies only have to be measured to 4 significant figures to achieve an accuracy of ≈<0.5% !)

C is then calculated using $$C = \frac{C_1}{\left(\frac{f^2}{f_1^2} - 1\right)}$$

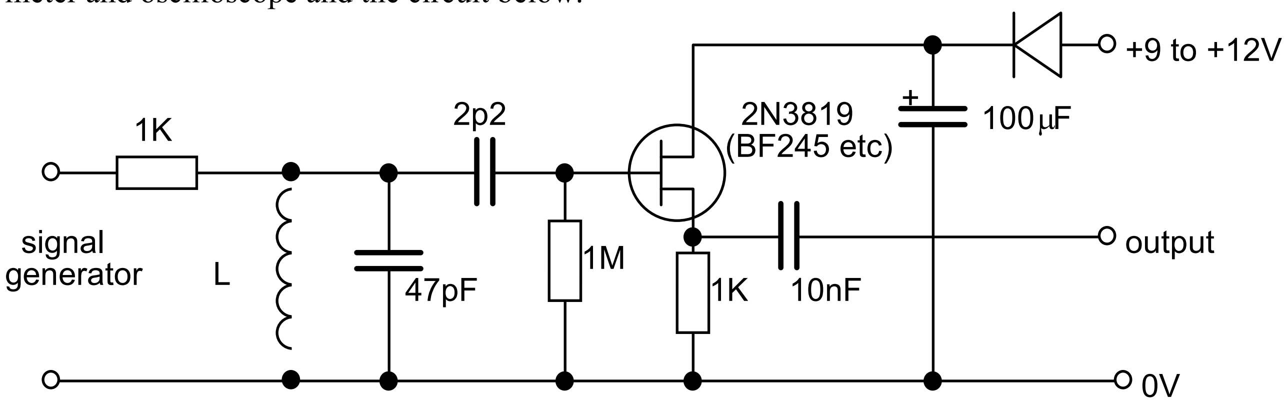
(The two prototype versions of the circuit gave values of C of 250.5pF and 245.6pF)

Once the value of C is known then an unknown inductor value can be found by:-
connected it to the circuit in place of the original coil,
measuring the frequency,
calculate L or use the calculator
http://www.ikes.16mb.com/AR/tuned_circuit.htm

To measure the value of a small capacitor:-
connect an inductor to the circuit and measure the frequency (f),
connect the unknown capacitor (C_1) in parallel with the inductor, and measure the frequency (f_1),
calculate C_1 using $C_1 = C\left(\frac{f^2}{f_1^2} - 1\right)$.

Method 2

Inductance and capacitance measurement can also be made using an rf signal generator, frequency meter and oscilloscope and the circuit below.



A tuned circuit is formed by L and the 47pF capacitor (plus any stray capacitance). The J-FET acts as a source follower to isolate the output from the tuned circuit. The J-FET used is not critical.

The rf signal generator used was based on the circuit given in
http://www.ikes.16mb.com/AR/Colpitts_Oscillator.pdf
and gave a square wave output.

In use, the signal generator is connected to the input and the frequency meter. The output is connected to an oscilloscope, and the frequency of the signal generator is adjusted until the maximum output of a sine wave is seen on the oscilloscope.
(It is worth checking that this is the first sine wave that occurs - resonance can also occur at harmonics of the signal generator frequency.)
The frequency at which this maximum occurs is the resonant frequency of the inductor and the circuit.

The circuit is calibrated using the same method as for the oscillator circuit -
the resonant frequency (f) is found with the inductor and the circuit
an accurate capacitor (C_1) is then connected across the inductor (100pF, 1% was originally used) and the resonant frequency is again measured (f_1).

C is then calculated using $$C = \frac{C_1}{\left(\frac{f^2}{f_1^2} - 1\right)}$$

(The prototype version of the circuit gave a value of C of 57.5pF)

When measuring small values of inductance with this method, it may be necessary to connect a capacitor of known value in parallel with the inductor in order to lower the resonant frequency.