Homebrew and Experimenters Group

HF Inductance Bridge (Compiled by VK2TOX)

There are a number of ways to measure inductances used in construction of RF equipment. One of the most versatile ways is with a variation of the Wheatstone Bridge. In commercial test equipment this bridge is often excited by an audio frequency source which does not always respond correctly to various RF parameters such a interwinding capacitance, core material (be it ferrite or air) and "Q" of the coil under test.

To overcome this limitation the bridge can be excited with an RF frequency close to that which the coil is actually going to be used. This can be a bit complicated for the general experimenter as depending on the construction of the bridge components a separate calibrated scale would be required for each band of interest.

For coils to be used at HF a frequency in the 80m band usually provides reasonably accurate results.

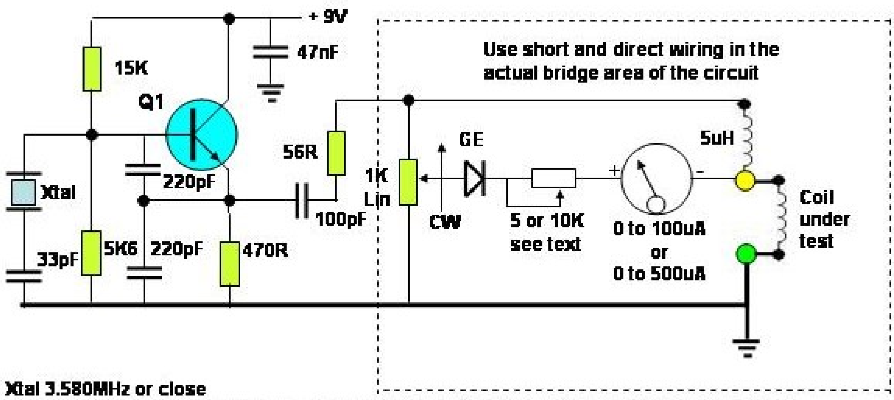
This exciting signal does not need to be very accurate so long as the output amplitude is reasonably stable, if not it just makes finding the "dip" more difficult. A free running oscillator or xtal oscillator running around 3 or 4 MHz is just fine. If you have a RF Signal Generator with a reasonable output it could be used as the source, but remember that calibration of the bridge would only be accurate over a small range of frequencies (depending on the construction of the bridge).

A Wheatstone Bridge excited by an AC signal needs a sensitive indicating circuit to detect the "dip" in the measurement. This can take the form of a sensitive panel meter or a transistor amplifier and a LED indicator.

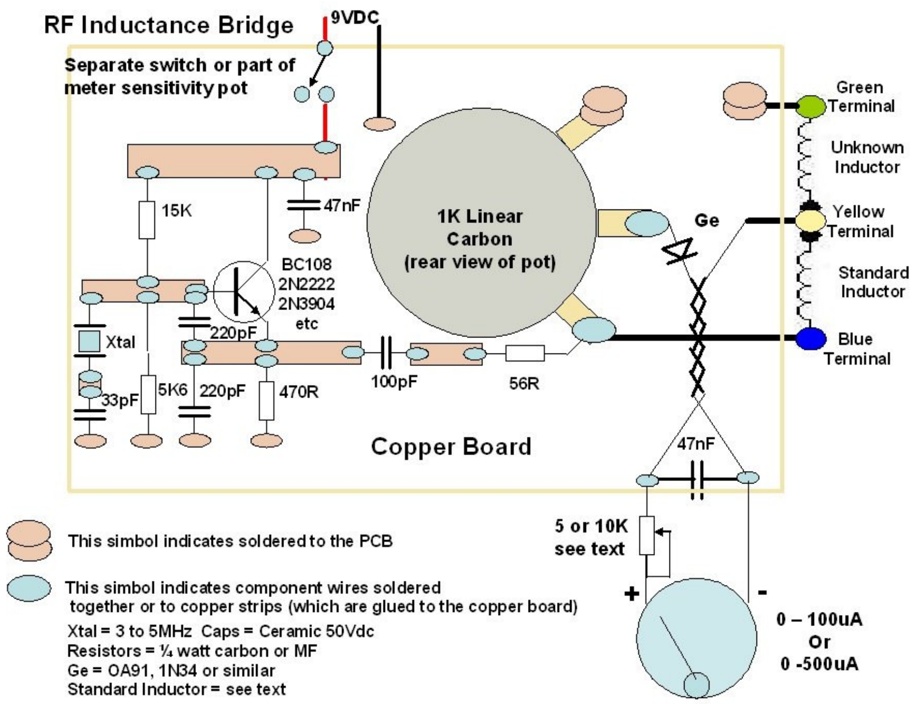
The actual bridge circuit can be set up in a number of different ways. For a simple instrument we will stick with a resistive rather than a capacitive bridge. This can also be done in a couple of different ways. The first with the variable element as one arm of the bridge with a switched set of standard resistances as the measurement element of the bridge. This allows quite good accuracy but needs a number of standard resistances to get a reasonable measurement range. For a simpler and more versatile piece of equipment the variable resistance is set up as a "ratio" component as shown, the wiper of the potentiometer determines the balance point of the bridge. In this configuration the mid point of the pot indicates a 1:1 ratio i.e. the "unknown" coil is the same value as the "standard" coil. In theory at the extreme clockwise end of the pot a 10:1 ratio is detected i.e. the "unknown: coil is 10 times the value of the "standard" coil and at the extreme anticlockwise end of the pot a 1:10 ratio is detected i.e. the "unknown: coil is 1/10 the value of the "standard" coil. Note the "in theory" part of this explanation, in practice the distributed inductance and capacitance of the components and construction of the bridge upset this idea because of the RF signal exciting the bridge.

A practical RF excited Bridge Circuit.

Basic two terminal RF Inductance Meter (based on Drew VK3XU project)

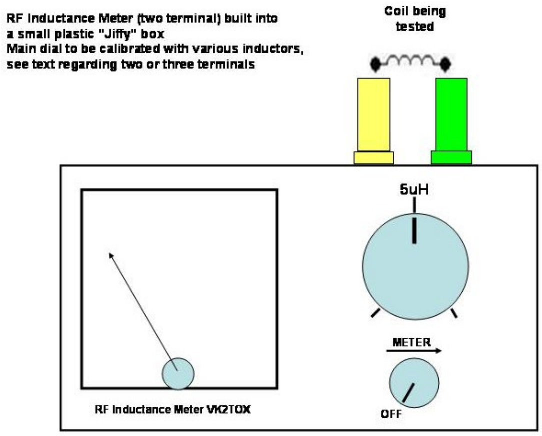


Xtal 3.580MHz or close
Use separate switch for battery supply or a switched pot for meter sensitivity adjustment
Q1 is a BC108, 2N2222, 2N3904 etc
Various standard values of Inductance used to calibrate the 1K pot.
Caps are disc ceramic and R's are 1/4W 5%
5uH is 28T #22 B&S 90.63mm) wire on an Amidon T68-2 Core



Commments

Construction.. Whatever box you are going to put the instrument in depends mostly on the size of the meter you are planning to use.
Suggest you breadboard the copper board first by building up the oscillator circuit, which can be tested by putting it near a HF receiver tuned to the oscillator frequency, if you can't hear the oscillator, find out why, as not much point in carrying on if you have no "excitement" of your bridge.
Basically keep all leads short and direct to minimize stray capacitance and inductance which make it difficult to find a good "dip" and effect the accuracy of measurements. The lead from the Blue Terminal to the top of the pot should be a heavy wire or a thin strip of PCB kept away from the copper board. The diode leads from the center of the pot and the wire from the Yellow Terminal should be as short as possible with the twisted pair connected to these components a short as possible too. The twisted pair runs away to the meter circuit which ideally should be shielded from the RF parts of the circuit, a bit of PCB soldered to the copper board will do this nicely.



Oscillator .. This can be the Xtal oscillator shown, a free running LC oscillator or a TTL/CMOS Oscillator block, these last two are illustrated later in this article.

Meter.. As mentioned this item is used to determine the "dip" in the bridge balance pot, it can be anything from a standard 50uA, 100uA or 500uA movement. No form of scale is really needed as you are just looking for a dip. The little rectangular signal strength or VU meters from old radios or tape recorders are usually quite OK for this function. The value of the "sensitivity" pot in series with the meter quite obviously depends on the output level from the oscillator and the sensitivity of the meter movement. To find out the value for this pot, first temporarily connect say a 10K pot in series with the meter, with no coil connected to the "Unknown" terminals (reference coil is connected), turn the bridge on, the meter should move towards the upper end of the scale (if it goes backwards, you have most likely connected the diode or the meter in reverse, fix one of them so that meter reads in the correct direction). If the meter goes past full scale then switch off and replace the pot with a higher value and start again.

If there is no deflection then slowly turn the pot backwards till the meter starts to go up scale. The ideal position is about 90% of full scale. Run the front panel measuring pot fully anti-clockwise and fully clock-wise to make sure the meter does not go off scale adjust a little if necessary to keep the meter around the 90% mark. Connect a short to the test terminals and make sure the meter behaves. If all this works then switch off, remove the sensitivity pot and measure the value of resistance required to set the meter, now locate a pot with a similar value and preferably with an inbuilt switch and fit it to the case. If you can't locate a pot with an inbuilt switch just fit a separate switch to the front panel or simply disconnect the battery when not in use. Trick is to wire the new sensitivity pot such that in the off position it is maximum resistance. That way as you turn the pot clockwise the meter will become more sensitive.
If you can't get a decent reading on your meter (and it actually works) then either you have a low output from your oscillator or more likely the meter is not sensitive enough, perhaps even both !!.
Now connect a coil the same value as the reference coil, to the test terminals and adjusting the measuring pot to somewhere near mid scale to find a "dip" in the bridge. As you approach the dip, adjust the meter sensitivity pot to make the meter more sensitive, keep adjusting the main pot and the sensitivity pot until you find the deepest "dip" or "null" you can find, really deep "nulls" indicate a coil with a high "Q". Careful !!, don't thrash around with the measurement pot or you will bash the meter up scale, if you loose the "dip", set the sensitivity pot to maximum and start again.
If you have troubles with a residual reading on the meter you may be picking up RF. A small capacitor of 200 or 300pF directly across the meter terminals should fix this. Also perhaps a bit of shielding too.

Once you are happy with the meter and its components, complete the assembly of your instrument, only when the instrument is complete can you calibrate the main measurement pot scale.

Variations (Three Terminal)
In the couple of these instruments that I have built, the reference inductor has been mounted external to the case. In this way if I have to wind up a few coils of the same value (say for a band pass filter), I just wind the first, use the bridge to check its value, then replace the reference inductor with the coil I have just wound, using it as the reference for the remainder of the coils, that way they will all be the same value. This obviously involves having three terminals, if you don't need this facility then mount the reference inductor inside the case and just have a set of terminals for the unknown coil you are measuring.

Parts.
1K Linear Carbon Pot (not a real small one or you will have difficulty adjusting it)
Terminals as required.
Case .. if you are fussy then mount in a metal box else a plastic jiffy box is OK.
Meter.. see the text.

Oscilator components.. depends on which oscillator circuit you are going to use.

Extras which will be needed

A set of calibration inductors will be needed to calibrate the instrument. For three or four bucks you can pick up a set of low value chokes from Altronics (other places could be a little more expensive) or do what Drew VK2XU did in his No.01 Book and wind up a set of inductors (always handy to have around, the book and the inductors).

Following are the set he wound for his “Little L” Inductance Bridge.

Note: All wound on Amidon T68-2 (RED) Cores

0.5uH	8 turns of 0.8mm
1uH	11 turns of 0.63mm
2uH	16 turns of 0.63mm
4uH	24 turns of 0.63mm
8uH	35 turns of 0.51mm
16uH	50 turns of 0.40mm

Parallel or series up a couple of the above to produce intermediate values. If you have built a three terminal box it may be worthwhile marking up the ratios on the dial as well, that way you can use almost any known inductor as a standard to measure others, within the capabilities of the instrument.

Conclusion.

If you need a quick and simple instrument to measure small RF inductors used in HF Ham Radio equipment then this instrument is perfect. If you need to measure and test a wider range of inductors or test them at higher frequencies then a more complex, though not necessarily more difficult instrument will be required. Our members are building multiple frequency units so that inductors can actually be tested at their operating frequencies. Although having a narrower range of measurement the type which detects resonance of the inductor with an internal adjustable capacitor only require a peak detector, therefore the detection of the value is easier and cheaper. For audio and power supply components the type using a 555 timer and a meter are very handy, recent copies of the ARRL, although careful as components for switchmode power supplies really should be tested at or near their normal operating frequency. ARRL Handbook usually have both capacitance and inductance measuring instruments in them.

We will have a look at some of these in future articles.

Happy Homebrewing, please contact us if you have any problems.