Fixture for Measuring Inductor Q with your Antenna Analyzer
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Introduction
Over the past several years I've been experimenting with a variety of portable antennas.
These antennas usually use one or more loading coils in order to keep the antennas
relatively compact. Since my loading coils also tend to by physically small, I have found
it valuable to measure the Q of the antenna loading coils in order to determine the
antenna efficiency.

Determining Inductor Q
At resonance, a tuned circuit has a Q factor equal to the ratio of the inductive or
capacitive reactance to the total series loss resistance in the tuned circuit. If one of the
elements has a significantly higher Q than the other element, then a majority of the loss
resistance can be associated with the lower-Q element. Capacitors generally have a much
higher Q than inductors. And air-variable and mica capacitors typically have a Q well in
excess of 1000. Therefore the loss resistance of a tuned circuit using these types of
capacitors is essentially that of the inductor

Measuring inductor Q is not difficult with an antenna analyzer. First, measure the
resistance of a fixed resistor with the antenna analyzer. Then place the fixed resistor in
series with the inductor to be measured and a high-Q variable capacitor. Tune the
variable capacitor for series resonance at your operating frequency giving the circuit's
series-resonant resistance which consists primarily of the fixed resistor and the inductor
loss resistance. Subtracting the measured fixed resistor value from the series-resonant
resistance value gives the loss resistance associated with the inductor. Once you know
the inductor loss resistance at resonance, you can determine the coil Q ($Q = 2\pi fL/R$). Or
you can use the loss resistance directly to determine antenna efficiency. So, this is easy
to describe. But how do you implement the test set-up? This article describes the
compact and easy to use Q-meter adapter that I came up with.

The Q-Meter Adapter
My Q-meter adapter is shown in Figure 1. I used a 51 ohm metal film reference resistor
since antenna analyzers tend to be pretty accurate as you get closer to 50 ohms. Metal
film resistors are surprisingly non-inductive into the VHF range. I used a MFJ
Enterprises 6-180pf air variable capacitor with a built-in 8:1 vernier drive. Obviously
you can use whatever air-variable capacitor you have on hand, however the vernier drive
in the MFJ capacitor makes tuning very non-critical. I included the capability to switch
in a 180pf fixed capacitor in parallel with the variable should you need additional
capacitance for lower value inductors.

Wiring is not critical over the 1.8-30 MHz frequency range. Everything mounts
comfortably in the small aluminum box called out in the parts list. The MFJ variable
capacitor has front mounting holes that can easily be tapped for #6 screws. Or you can
use #4 screws/nuts and lockwashers, but mounting these may be a bit tricky. The #4
solder lug mounts under one of the SO-239 screws and is used to ground the 51 ohm

resistor through one switch. The #6 solder lug mounts on the back of the variable capacitor (tapped #6 hole is already available there) and grounds the mica capacitor through the second switch. I used slide switches since I prefe r the way they look compared to toggle switches, but there is much more work involved in cutting out the mounting holes (I use a small metal file to cut out the rectangular holes). Incidentally, only SPST switches are necessary, but I liked the size and price of the DPDT switches called out. The shaft of the variable capacitor is centered on the front of the aluminum box, and the SO-239 is centered on one side of the box. Both require a 5/8" diameter hole cut-out. Photo A shows an internal view of the unit. Photo B shows the front panel, and Photo C shows the Q-meter adapter mounted to a MFJ-259B antenna analyzer with a double-male UHF connector. All labeling was done using Casio "Black on Clear" labeling tape.

Using the Q-Meter Adapter
Set the "Additional Capacitance" switch to 0 pf, and the input switch to "50 Ohm Reference". Set your antenna analyzer to the desired frequency and record the measured resistor value. This should be close to 50 ohms with little or no reactance. Next, install the inductor to be measured across the 5-way binding posts. Flip the input switch to "Measure Rs" and tune the variable capacitor for resonance as indicated by zero reactance and a resistance value relatively close to , but higher than, 50 ohms. Add in the additional 180pf capacitor if necessary for achieving resonance. Record the resonated series resistance. Now subtract the 50 ohm reference value from the resonated resistance. The answer is the loss resistance of the coil.

As an example, my favorite portable antenna is a 20-meter dipole with switches in the antenna wires that disconnect sections of the antenna to make it resonant from 20-10 meters. For 40- and 30-meters the antenna becomes a center-loaded resonant antenna using inductors clipped across the 10 meter open switches. Using the Q-meter adapter, I measured the reference resistor as 51 ohms and the resonant Rs of my 18.5uhy torroid-wound 40 meter loading coil as 60 ohms. This leaves an inductor loss resistance of 9 ohms, so the coil $Q = 2p(7.2)(18.5)/9 = 93$. Since the 20-meter antenna is now a 1/4 wavelength center-loaded antenna on 40 meters, some rough calculations indicate that the antenna radiation resistance should be about 25 ohms. With 9 ohms of loss resistance in each arm of the dipole, the total loss resistance is 18 ohms for the dipole. Therefore the efficiency of this antenna on 40 me ters is: $Eff(\%) = 100 \times 25/(25+18) = 58\%$. Not too bad, especially for compact loading coils.

My torroid-wound 6.5uhy 30 meter coils only have 3 -ohms of loss resistance , so $Q = 2p(10.1)(6.5)/3 = 137$. On 30 meters the antenna now becomes a center-loaded 0.36 wavelength dipole w ith an approximate radiation resistance of about 35 ohms. Therefore this antenna has an efficiency of around 85% ($Eff = 100 \times 35/(35+6) = 85\%$). Even better! You can use equations in the ARRL Antenna Book or antenna modeling software to determine more accurate values of radiation resistance, but these numbers are probably pretty close. Of course, this same technique works for determining the efficien cy of vertical antennas with traps or loading coils as well.

Conclusion

I've described a simple , convenient and relatively inexpensive antenna analyzer adapter that permits you to measure the Q of most inductors used on HF frequencies. Build this adapter to give you more insight into the efficiency of your inductor designs.

Parts List

| Description	QTY	Source	Price ea.
6-180pf Var. Capacitor	1	MFJ 282-5160	$17.97
5-Way Binding Post (Red)	1	MFJ 606-0003	$0.85
5-Way Binding Post (Blk)	1	MFJ 606-0004	$0.85
1-1/2"D Knob	1	MFJ 760-0125	$2.80
DPDT Slide Switch	2	MFJ 501-1003	$0.20
PL-259 Double Male	1	MFJ-7702	$3.95
SO-239	1	MFJ-7721	$1.49
180pf Mica Capacitor	1	Mouser 5982-15-500V180	$0.74
51 ohm ½-watt film resistor	1	Mouser 660-CF1/2C-510J	$0.05
AL Box (3.25x2.13x1.63")	1	Mouser 563-CU-3001A	$4.75
#4x3/8" binding head screws	6	Mouser 534-9401	$0.14
#4 nuts	6	Mouser 534-9600	$0.03
#4 solder lug	1	Mouser 534-916	$0.15
#6x1/4" binding head screws	3	Mouser 534-9407	$0.06
#6 solder lug	1	Mouser 534-917	$0.15
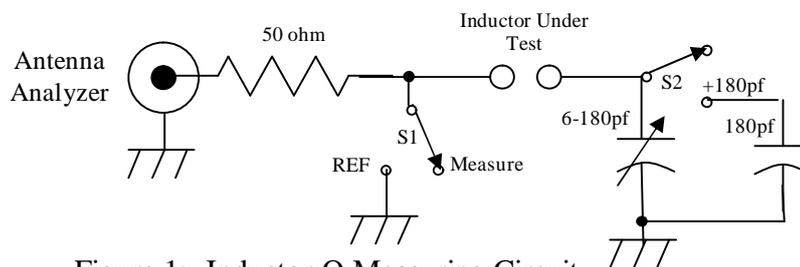
Figure 1: Inductor O Measuring Circuit
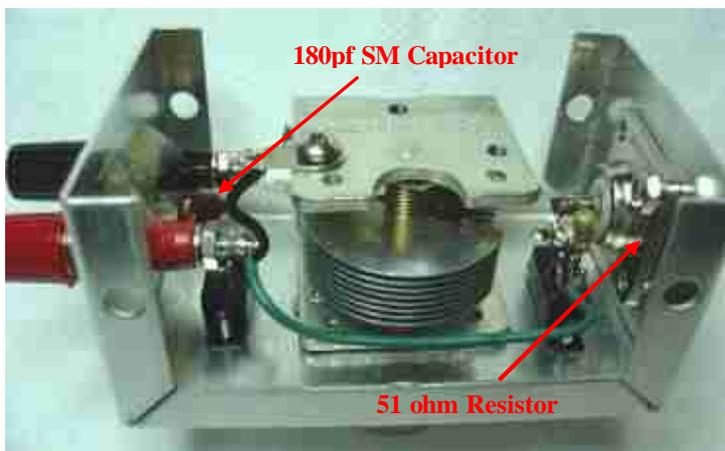
Photo A: Internal wiring of the Q-meter Adapter

Photo B: Q-Adapter front panel

Photo C: Measuring inductor Rs