July 2012
Volume 13, Issue 1

ANODE

Inside this issue:

Special points of interest:

- **Contact details on back page UPDATED 2012-07-14**
- **Next Ham-Comp Meeting is on the 28th of July.**

Anode Editor's Comments

Volume 13, Issue 1
July 2012

So we are into our 13th year!. Let us hope it is not unlucky! We also have a Friday the 13th this month as well...

L = (d^2 n^2) / (1 + 0.45d)
[what a strange heading...]
I wanted to make an input filter for the 40 metre band for my new direct conversion receiver. I wanted to listen to the bulletin re-broadcast on 7140 kHz. This led me into the murky world of filter design and high quality (Q factor) coil fabrication.

It also made me construct and test the LC meter kit I had bought from OM Bob some months ago. See Below.

What's New?

Well we have a new committee at the club. All these were voted in at the AGM. Also at the AGM, the club supporters were honoured with presentations. For the pictures see the next pages.

Lifelong passion for ham radio still burns at 92
http://www.dispatch.com/content/stories/local/2012/07/13/man-of-the-air.html

Inductor Q Tests
http://www.bnk.com/w0qe/Technical_Topics/inductor_Q_tests.html

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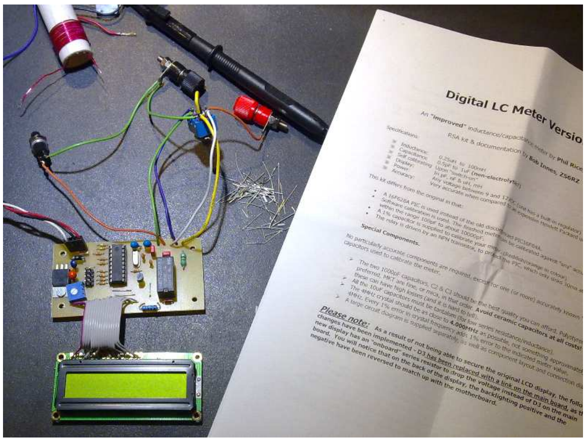
LC Meter from ZS6RZ - A local kit

I used to have a Marconi Q meter to measure the coils I needed for my designs. Recently I was given a bridge by OM Ron Eva. But this is 'finicky' to operate to say the least.

When I started with a Direct Conversion receiver some time ago, the main problem with it was H.F. 'breakthrough' from the BBC. This transmission is on 6190 kHz and at a very high power level. So some input filtering was going to be vital if this was to be eliminated.

This led me into the murky world of filter design. I took a good long look



at my notes and then read an interesting web site explanation for filter design. This page has some good expla-

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Editor's comments - Club News

(continued from page 1)

Move over Raspberry Pi, give kids a Radio Ham Pi - minister
http://www.theregister.co.uk/2012/07/12/national_radio_centre_cheap_radio_kit/

"Schoolchildren should be given simple radio kits to build so they can learn basic electronics, (U.K.) communications minister Ed Vaizey said yesterday."

Optical Morse code in space

The amateur radio **CubeSat** FITSAT-1 will carry an optical communications experiment that aims to write Morse Code across the night sky using high intensity LEDs. It launches to the ISS on 21 July, from where it will be deployed in September. For more information see www.uk.amsat.org/2037.

World Amateur Radio Day
On 18 April 2012, radio amateurs will be celebrating World Amateur Radio Day, on the 87th anniversary of the founding of the International Amateur Radio Union or IARU.

This year's theme is "Amateur Radio Satellites: Celebrating 50 Years in Space" in remembrance of the launching of OSCAR 1 on 12 December 1961 and the launch of OSCAR 2 on 2 June 1962.

In 1924, ARRL President Hiram Percy Maxim, W1AW, had scheduled a business trip to Europe. While in Europe, Maxim was asked by the ARRL Board of Directors to represent the ARRL in fostering international relations between amateurs.

Following an informal meeting in 1924, representatives from France, Great Britain, Bel-

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Editor's comments - Club News

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gium, Switzerland, Italy, Spain, Luxembourg, Canada and the United States formulated a plan to hold an International Amateur Congress in Paris, France, in April 1925, for the purpose of founding the IARU. Representatives from Europe, North America, South America and Asia attended the congress, adopting a constitution for the IARU on April 17. At a closing assembly on the following day, officers were elected and the actions of the congress ratified by representatives from 25 countries. Thus, April 18 became the official "birthday" of the IARU and is now designated World Amateur Radio Day.

There will be several special event stations from I.A.R.U's Member Societies active on different dates during April:

South Africa - ZS6IARU, will be active on 18 April. QSL via ZS4BS.

LC Meter from ZS6RZ

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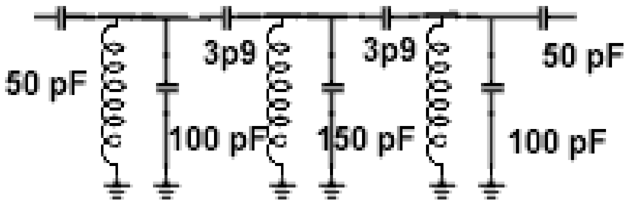
nations and worked examples:-

Ian Purdie's Amateur Radio Tutorial Pages

http://my.integritynet.com.au/purdic/index.html



Example filter

["*A competent qualified design engineer, with a wealth of experience may design, construct and align an LC filter of about 1% bandwidth".*
This would mean at 10 MHz an excellent filter would have a bandwidth of 100 kHz.]

Having worked out that I needed a 2.5 uH coil of quite high Q factor, I looked at my table of coils that I had documented many years ago. None of them came near to the Q factor or 2.5 uH. So I went looking for the wire gauge and diameter information to get the required Q and inductance. This search led me here:-

Single-layer Coil Inductance and Q
http://www.qsl.net/in3otd/indcalc.html

This page has a 'calculator' for both the inductance and the Q factor. That is when it hit me that I needed to construct some fairly large coils. Both the diameter needs to be about 20 mm and the wire gauge needs to be quite thick. About 1 mm. Now what can I use for the former that is not expensive?

1 White (not black*) 20 mm conduit tubing.
2 Cardboard toilet roll (used or finished - that is without paper.)
[* Black conduit may have carbon black in it. So a shorted turn or very lossy coil can result if wound on it.]

So I used a piece of white conduit and wound a 15 turn coil on it. I used 0.7 mm wire that I had here. Then came the 'problem'. How do I measure it?

The Wayne Kerr LCR bridge will measure micro Henries but to do so requires more patience than most people have these days. I tried measuring the coil on it but gave up after 15 minutes. So what can I use that is quick and reasonably accurate? I spotted the LC kit that Bob had sold me some months ago. It was still lying there waiting for me to have some 'spare time'…

Due to television programs coming to an end of series and others not needing recording for lack of interest, I had an hour on two consecutive nights. So I set to work.

Bob's printed notes are good and to the point. I checked the three component plastic packs. Found the PCB inside the display's box marked "PCB inside". Laid it on the anti-static worktop and switched on the soldering iron.

The PCB's component placement picture shows where all the components should be inserted. This usually is the silk screen that is printed on the top side of the PCB. Unfortunately it only shows the component identification. E.g. L1, R2 or C3. So I had to write out the parts list with the description of each component. Fortunately this is not a complicated circuit with lots of components. A few minutes later I had identified the components and was ready to 'populate' the PCB.

At the end of my first hour, I had the PCB pretty well filled. I put down the bits and switched off the iron. The next evening saw me switch on the iron and finish according to Bob's instructions without connecting the display.

Time to check the PCB and components without plugging in the PIC chip. This is where I found that I had missed soldering pin 1 of the PIC. As I had applied about 8 Volts to the PCB and tested with a multimeter. The voltage on pin 1 of the

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LC Meter from ZS6RZ

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socket had some random voltage there. On checking the solder side, I had not even soldered the socket pin to the PCB track!

Once I had soldered the connections I had missed, the voltages checked out against the ones that Bob had put in his notes.

I followed all his instructions and finally wired up the switches and sockets. Applied power and connected the 'standard' capacitor supplied. I adjusted the calibration jumper to get the correct reading. All fine and good.

I switched over to inductance (L meter) and connected my coil. It read 3.86 uH. Too many turns but easily remedied.

It is a well known phrase; "When all you have is a hammer, everything looks like a nail." Now I went looking for all my coils to check…

This has been a very worthwhile project for me. I now have a quick capacitance checker that is more accurate than the one on my DVM. (Digital Volt Meter)

I also have a quick and fairly accurate means of measuring coils' inductance. To assess more accurately I shall use the bridge. Maybe I shall build that Q meter I have wanted for some years now.

[JB 2012-07-17]

Inductor Q Tests

I recently needed some inductors in the 0.2 to 3.0 uH range to use for impedance matching in the HF frequency range. I thought about winding them with bare copper wire, enamel covered copper wire, or even having them silver plated but decided to do an experiment to try to understand some of the issues. High quality air core inductors are often silver plated. Higher Q is always a goal for inductors as it represents less dissipative loss (heat) and for a given form factor winding the inductor out of a better conductor (including the effects of permeability) results in higher Q.

A quick search on the Internet finds numerous references about the ability of silver plated inductors to have a higher Q over life (compared to copper) due to the oxides that form on silver being conductive. However you can also find numerous references to the effect that the above hypothesis is not true. So I decided to run some experiments to see how inductor Q changed relative to shiny copper.

FACTS

The resistance of silver is about 7% less than copper at DC but at RF frequencies there is no longer a 7% difference. Skin depth is proportional to the square root of resistivity meaning that since silver has 7% less resistance than copper the skin depth is about 3.5% less than for copper which causes slightly more current at RF to flow nearer the surface for silver than for copper.

Calculating the differences in RF resistance between silver and copper for a given wire size is mathematically quite complicated but published tables show the difference at 28 MHz to be about 4%. The skin depth at 28 MHz is 0.000484" for copper and is .000465" for silver. Also skin depth is inversely proportional to the square root of the RF frequency (skin depth at 0.28 MHz is 10 times greater than at 28 MHz). Therefore if I use a silver plated inductor, with silver plating at least 4 skin depths thick the best Q will be about 4% higher than the same shape inductor made with bare shiny copper wire of the same size. Carefully scraping the silver plating off some old coils showed silver plating that seemed to be a little thinner than expected which would reduce the Q slightly.

Comments about degradation in Q centre on the conductivity of the oxides, sulphides, and other compounds that form on the outside surface of the copper of silver. If these materials have extremely high resistivity, such as air or enamel coating, the Q is unaffected since no current flows in these compounds. Likewise if these compounds have nearly the same resistivity of the underlying conductor there is no problem but if they have some finite resistivity higher than the copper or silver then there will be a reduction in Q as some current will flow in this region. The 2006 ARRL Handbook states, "Also, a thin highly conductive layer, such as silver plating, can lower resistance for UHF or microwaves, but does little to improve HF conductivity." Unfortunately the ARRL Handbook says nothing about changes to the resistance that may occur over time. G3YNH has an excellent unbiased web site dealing with many topics such as materials, skin depth, compounds formed on copper and silver at

http://www.g3ynh.info/zdocs/comps/part_1.html.

PROBLEM

If I assume that the shiny copper inductor has acceptable Q then the problem becomes understanding how badly the Q deteriorates with time as the copper wire reacts with the environment. Also I decided to include a few other tests since not all inductors will be self supporting air core types. This experiment is not a detailed study of inductor Q but merely some observations and measurements with some interesting conclusions. For this experiment I decided to test inductors having a value of 1.00 uH.

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Inductor Q Tests

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The measurements were made on an HP4342A Q meter that measures Q up to 70 MHz. Attempts were made to have all the inductors be 1.00 uH but it was difficult to get them much closer than a couple percent. Fortunately slight variations in inductance cause predictable changes in Q since the coil format changed very minimally and the amount of wire in the coil did not change at all.

Therefore all the measured Q's were normalized for 1.00 uH. Also the 2 inductors on the powdered iron coils were scaled to 1.00 uH since they were much harder to adjust. The Q's were measured at 3.5 MHz for some of the coils and at 28.0 MHz for all of the coils where 1.00 uH represents 176 ohms of inductive reactance.

The "cast" of inductors

All the air core inductors are 8 turns wound on a 0.95" diameter form on a lathe resulting in a 1.00" inside diameter when removed from the form and are about 1.5" long. The length was adjusted slightly to produce an inductance of 1.00 uH +/- 3%.

#1) #10 (0.100" diameter) bare shiny copper wire
#2) #10 bare copper wire that has been outside for 3 years in Colorado
#3) #10 bare copper wire heavily treated with Selenium dioxide resulting in a black Copper (II) Oxide (CuO) finish
#4) 0.093" copper tubing from an old mini-refrigerator that was a deep reddish brown Copper (I) Oxide (Cu2O) - Diameter about the same as #10.5 wire
#5) #10 bare copper wire heavily subjected to acetic acid fumes resulting in a heavy blue green Copper Carbonate (Cu(CO)3) patina
#6) #10 bare copper wire painted with gloss black high temperature Rustoleum barbeque grill paint
#7) #10 Black insulation covered THWN copper wire (sold in 500' rolls at Lowes or Home Depot) with a clear overcoat for pulling in conduits
#8) #12 Black insulation covered THWN copper wire same as #7 except for size of copper wire
#9A) Not shown: #10 bare copper wire covered with 1 layer of clear 3M polyolefin shrink tubing
#9) Starting with #9A and adding a second layer of black Raychem heavy black polyolefin shrink tubing
#10) #10 bare copper wire covered with about a 0.3" thick covering of GE Silicone II clear sealant
#11) 9 turns of #14 enamelled copper wire on a FT-200-6 (u=8) powdered iron toroid (1.105 uH)

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Inductor Q Tests

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#12) 8 turns of #14 enamelled copper wire on a FT-200-2 (u=10) powdered iron toroid (1.027 uH)
#13) 1" O.D. solid G-10 to use as inductor core
#14) 0.96" O.D./ 0.75" I.D. G-10 tube to use as inductor core
#15) 3/4" schedule 40 PVC tubing turned down .05" to 1.00" O.D./ 0.82" I.D. to use as inductor core
#16) 1" O.D./ 0.75" I.D. fibreglass tubing to use as inductor core

RESULTS

Description	Q measured @ 3.5MHz & scaled to 1.00uH	Q measured @ 28MHz & scaled to 1.00uH	R(loss) ohms @ 3.5MHz	R(loss) ohms @ 28MHz	Power loss @ 28MHz with 5A of RF current (W)
#1	181	570	0.121	0.309	7.7
#1 with #13 core		520		0.338	8.5
#1 with #14 core		550		0.320	8.0
#1 with #15 core		550		0.320	8.0
#1 with #16 core		540		0.326	8.1
#2		540		0.326	8.1
#3		550		0.320	8.0
#4		510		0.345	8.6
#5		530		0.332	8.3
#6		570		0.309	7.7
#7	173	545	0.127	0.323	8.1
#8		530		0.332	8.3
#9A		530		0.332	8.3
#9	165	515	0.133	0.342	8.5
#10		565		0.311	7.8
#11	200	195	0.110	0.902	22.6
#12	195	180	0.113	0.977	24.4

CONCLUSIONS

The air core inductors were measured well below their self resonant frequency which was about 140-150 MHz. The expected increase in Q from 3.5 MHz to 28 MHz matched the measurements well and is due to the inductive reactance increasing linearly with frequency and the skin depth decreasing inversely to the square root of frequency resulting in an increase in Q of approximately the square root of 8 when the frequency was increased 8 times. The 2 inductors wound on the powdered iron toroids had slightly higher Q's at 3.5 MHz than the air core inductors due to the shorter lengths of wire needed to achieve 1.0 uH but the losses in these cores

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Inductor Q Tests

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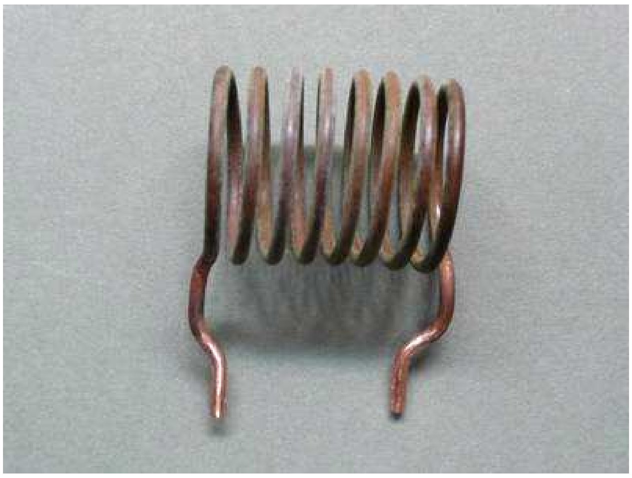
showed up at 28 MHz.

However the expected reductions in Q for inductors #2 thru #5 which used weathered wire did not happen. Additionally wire insulation, shrink tubing, paint, and inside support cores (#13 thru #16) all had amazingly little effect on the Q. The column on the right in the above table shows less than a 1 watt difference in the expected power dissipation in the air core inductors with 5A of RF current flowing at 28 MHz. These results are quite different from what I would have expected based on material I have read over the years. I tried to include all the usual types of corrosion that happens to copper over time. Inductors #3 and #5 were artificially corroded but the corrosion was heavy and severe. If anyone sees any flaws in these tests I would very much appreciate hearing about them. I did not include any data but large reductions in Q were noticed when metal was brought into proximity of the inductor stressing the importance of giving the inductor space to "breathe" if maximum Q is important. However the covering and/or corrosion on the wire itself had amazingly little effect on the inductor Q. From this data it would appear to be more beneficial to increase the wire size by one wire gauge rather than silver plating. I ended up using bare copper wire for my project.

Update Sep. 7, 2011

I did one final test with a piece of bare #10 copper wire that had been buried in a flower bed for about 5 years and had laid on the ground for another 5 years in Colorado. During this time the wire was watered from the lawn sprinkler system, subjected to fertilizer periodically, and to the environment. The surface of the wire, as seen in the picture to the right, had a brownish-green hue and was no longer smooth. The wire was wound into the same size coil as was done for the original experiment and measured on the same HP4342A Q meter at 28 MHz. The Q was 550 which was virtually the same as the original coil with shiny new copper wire.



http://www.bnk.com/w0qe/Technical_Topics/inductor_Q_tests.html

The West Rand Amateur Radio Club
Established in 1938
KG33XU 26.14122 South - 27.91870 East

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1715

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Email: zs6wr.club@gmail.com
Web page: www.zs6wr.co.za

Bulletins (Sundays at …)
11h15 Start of call in of stations
11h30 Main bulletin start

Frequencies
Output: 439.000 MHz 7.6 MHz split
Input: 431.4 MHz (West Rand Repeater)
145,625 MHz (West Rand Repeater)
(HF Relay when possible on 7140kHz)

Radio Amateurs do it with more frequency!

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