The REPEATER

The OFFICIAL newsletter of the Rogue Valley Amateur Radio Club

W7DTA

Volume 2012, Issue 1 **January 2012**

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Club Web Page:		http://www.qsl.net/w7dta		

Next Club Meeting

Thursday, January 5, 2012, 7:00 PM
Red Cross Building, 60 Hawthorne St., Medford, OR
Across from Hawthorne Park
Program: Swap Meet

President's Letter

It is an honor to suddenly find myself serving as president of the Rogue Valley Amateur Radio Club. I've been a club member less than a year and I am still getting to know many of you. My name is Jeff Statchwick, W7KNX and I thought I would share a little about my background with you and why I joined the club to begin with.

I have had a life-long passion for radio and electronics, and received my novice license at age 13. I currently hold an Extra class amateur license and the GROL FCC commercial license (formerly known as first class radiotelephone). I worked for many years as a systems field technician for Clackamas Communications where I worked primarily on Motorola VHF land mobile radio systems and 911 communication centers. I now work for the Medford Water Commission, main-

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Secretary's Report

RVARC 1 DEC 11 MINUTES

1. Allan Taylor, K7GT officiated at our annual Christmas dinner which was held at the New Far East restaurant in Medford starting at 1800L.
2. The first order of business was socialize and eat.
3. After everyone finished eating Allan had everyone introduce themselves and their spouses.
4. Next Allan had each of us come forward, pick a gift from the one stacked on the table, and unwrap it. We were allowed to challenge some one else's gift if they had one you liked better.
5. Then Allan handed the gavel over to our new president Jeff Statchwick, W7KNX.

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President's Letter, Continued

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taining the radio telemetry (SCADA) system as well a multitude of instrumentation and control devices used in the automated water distribution system. I'm also a single dad with two wonderful (really!) teenage daughters.

My primary areas of interest in the hobby are vintage HF gear, antennas and antenna design, RTTY, and recently thanks to Allan, K7GT and Tom, N5EG have become smitten with the contesting bug.

The primary reason I joined the club last year after being inactive in the hobby for many years was to find opportunities to help others. I know we are all very busy with our responsibilities and our discretionary time is limited. But if you need help with an antenna project or any other project that is ham radio related or not, please let me know. I would be glad to help if I can. I have extensive experience with tower and antenna construction and repair.

On January 5th we will be having our annual swap meet. I love swap meets. So dig out those hidden treasures you no longer need and bring them to the club meeting. If any one needs any help with heavy or bulky items please contact me and we'll make sure you have a way to get your junk treasures there and if need be home again.

I have found that everyone I meet has something to teach me if I will just take the time to listen. I'm looking forward to getting to know all of you better in the coming year and helping make 2012 a memorable year for the Rogue Valley Amateur Radio Club. Merry Christmas and Happy New Year to you all.

Jeff

Secretary's Report, Continued

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6. Jeff announced that the January 2012 meeting would be a swap meet at the Red Cross building.
7. He adjourned the gathering at 2000L.
8. Thirteen people were present and enjoyed the festivities.

Submitted by Jacob O. (Jack) Schock, WA7IHU

Skin Depth & Related Topics

One of the more interesting electrical phenomenon is the strange behavior of RF current in conductors. At low frequencies (such as 60 hertz) we have a good grasp of how to treat electrical conductors. We know the wire gauge required for certain amounts of current flow in order to minimize losses.

For 60 Hertz power we simply need to know the cross-sectional area of the conductor. Since we know the resistance per unit length of material, we can compute the voltage drop along the conductor, and can estimate the power loss per unit length.

As the frequency of the applied AC is increased, first to LF, then to MF, and on to HF—an interesting effect starts to occur. The current in the center of the conductor induces eddy currents in the conductor. These eddy currents in turn generate alternating electrical fields that oppose the flow of current inside that that conductor. The eddy currents tend to push the current further out away from the center of the conductor. The higher the frequency, the greater the effect. This leads to what is called the 'skin effect' - that is—the current tends to flow mostly on the outermost portion of the conductor and not in the center of the conductor. The current is greatest at the outside surface of the conductor, and decreases exponentially inwards.

The 'skin depth' is the depth at which the current has decreased to 37% of the total. That is, 63% of the current is contained from the surface down to the skin depth, while 37% is deeper than one skin depth. Table 1 shows the skin depth versus frequency for copper conductors. For comparison, 12 AWG copper wire is 81 mils in diameter, which means at 60 Hertz that it is smaller than the skin depth, and thus skin depth can be ignored. However at 10 MHz, the skin depth in copper is only 0.82 mils, so most of the RF current is in fact just in the thin outer layer of the 12 AWG wire.

Frequency	Skin depth (mils) for copper
60 Hz	333
10 kHz	26
100 kHz	8.2
1 MHz	2.6
10 MHz	0.82
100 MHz	0.26
1 GHz	0.082

Table 1—Skin depth in mils for copper conductors.

One consequence of this is that at RF it is possible to reduce the resistance of the wire by composing the conductor of multiple parallel small individually insulated strands rather than one large conductor. Since the current divides across the multiple strands, each strand carries less of the total current. Each strand is small compared to an equivalent single conductor; as long as each small strand is as large as the skin depth, the net parallel connected resistance of all the small strands will have less resistance than the equivalent amount of copper that's composed as one solid conductor. This type of wire is called *Litz* wire, and is commonly used for winding inductors up to perhaps one megahertz. Litz comes from the German word litzendraht meaning braided, stranded, or woven wire. The wires have to be braided in a certain manner—the same wires can't always be at the outside of the bundle, or skin effect would push all the current just to those few wires. Instead, the individual wires have to weave in and out of the bundle of wires making up the Litz wire.

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Unfortunately as the frequency is increased beyond a few hundred kilohertz, or one megahertz, the capacitance of the wires to one another cause the current to couple between the individual wires and the net result is that the loss increases. Thus Litz wire is only useful over a limited range of frequencies.

The National Institute of Standards and Technology (NIST) station WWVB on 60 KHz which provides standard frequency and time, utilizes Litz wire for the inductors that tune the antenna.

At RF frequencies, hollow conductors provide essentially the same resistance loss as solid wire, so tubing is commonly used as a center conductor for very high power coaxial cables.

At very high frequencies, such as UHF and higher, and where very low losses are important (such as resonators, filters, etc.) it is common to silver-plate the conductors. This is because the resistance of silver is even lower than that of copper (but not in fact, by very much). The skin depth beyond UHF is so small, that virtually all the current flow can be confined to the extremely thin silver plated outer section of the conductor(s). Typical silver plating is on the order of 50 microns, or 0.002 mils., so the plating has to be very thick in order for the performance of the conductor to be improved even microwave.

At HF, where the skin depth is in the range of 1 mil, silver plating is nowhere near thick enough to have any appreciable impact on the performance of the conductors. <u>Thus for HF use, silver plating is merely cosmetic—it has no effect on the performance.</u> That beautiful silver-plated HF amplifier tank coil is all for show—it has the same loss as an unplated copper coil.

One of the common statements that you we see repeated is that silver plating of conductors is useful because when the surface of the conductor oxidizes (as copper and silver do) that silver oxide [or silver sulfide] remains a good conductor—and thus the silver plating preserves the performance of the conductor after oxidation. It has been repeated so many times in so many places even in some reputable places that almost everyone takes it for granted. <u>But it is absolutely and completely wrong.</u>

Material	Resistivity
Silver	0.000000016 ohm-meter
Silver Sulfide	0.0015 ohm-meter
Silver Oxide	1000000000 ohm-meter
Copper	0.000000017 ohm-meter
Copper Oxide	range 1-10 ohm-meter

Table 2—Resistivity of some silver and copper compounds.

We can see that both silver and copper are excellent conductors. Silver Sulfide and Copper Oxide are in the middle—they are semiconductors (basically a really terrible conductor) while Silver Oxide is an insulator.

If we surround a conductor with an insulator it does not impact the skin depth or the current flow underneath. For example we can surround a conductor with air (an excellent insulator) or plastic (another excellent insulator) and it has virtually no effect on RF resistance of the conductor underneath. Similarly, we can surround a silver conductor with highly-insulating silver oxide and it has absolutely no effect on the RF resistance of the silver underneath. The oxide layers tend to be rather thin and thus do not deplete the dimension of most underlying conductors significantly enough to change their resistance.

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Interestingly, there is one application of where the resistance of the underlying conductor can be changed—and that is where the conductor itself is very thin to begin with. In that case the oxide can consume enough of the underlying material that the total resistance increases. This is because the oxide is essentially an insulator while the underlying conductor is eaten away by the oxidation process.

One such device is an oxygen sensor that was constructed by NASA. It is composed of a thin film of silver on a glass substrate with electrical connections and an exposed surface. As sensor is exposed to oxygen, the thin silver conductor becomes thinner and it's resistance increases in direct proportion to the amount of silver consumed and turned into silver oxide. Thus its electrical resistance doubles when half of the thickness of silver is consumed by being turned into silver oxide. It provides a simple way to measure long term oxygen exposure.

Resistivity, Resistance, and Ohms-per-Square

At this point we will digress to explain resistivity. In many years of reading the literature, nor in college materials textbooks have I seen any clear coherent explanation of resistivity. The unit of *resistivity* is the 'ohm-meter' (the product of ohms and meters, NOT ohms-per-meter). This means that if the dimension is doubled that the resistance is one-half (i.e. the ohm * meter product is constant for a particular material). This certainly seems confusing.

The definition of resistivity is as follows: a cube of the material is prepared and two opposing sides of the cube are plated with a perfectly conducting material. The resistance is measured between those two opposing plated surfaces. We can visualize a one-meter cube as containing many small resistors in parallel between those two plated sides. If we double the size of the cube (to two meters on each side) the resistance of each of the small parallel elements doubles due to the doubling of the length of each one. But there are now 4 times as many of those elements in parallel, since we also doubled the width and height of the cube. Then the total resistance is cut in half (2/4 = 0.5). Thus the unit of measurement of *volume resistivity* is the product of resistance and dimension (ohm-meter).

If we look at a long thin wire, then the resistance (not resistivity) is basically controlled by the diameter and the length. If we double the length of the wire without changing the thickness of the wire, it's resistance doubles. Thus the unit of measurement of *resistance per unit length* of a wire material is ohms-per-meter.

An interesting case occurs when the conductor is a very thin film. If we plate the two opposing ends of a square of thin film with a perfect conductor, then we can view the film portion as a number of smaller resistors in parallel. If we double the length and width of the thin film, then the resistance of each small parallel element doubles due to the doubling of the length, but we have twice as many elements in parallel—the net result is that the resistance does not change! Thus for thin film resistors the unit of measurement is ohms-per-square. Note that it isn't per square inch or square cm, but just per-square. Regardless of the dimension of the square the resistance is exactly the same. In the days of thin-film hybrid circuits, the desired value of resistance was achieved by stacking the required number of squares of material end to end, using any square size needed for power or performance reasons.

2012 Dues are Due

RVARC membership dues for 2012 are now due. Please bring cash or a check payable to RVARC to a club meeting, or mail (checks only) to:

RVARC Membership
c/o 3950 Southview Ter.
Medford, OR 97504

Regular Member:	$20.00
Senior Member (62 and over):	$15.00
Family Member:	$20.00
Student Member:	$10.00

Amateur Radio Examinations

In the Rogue Valley, amateur radio exams are provided by the RVARC and the SOARC. The 2012 exam schedules have been announced. New exam participants need to provide identification, while upgrading amateurs need to **provide a copy of their current license** as well as show identification. Exam fee for 2012 is $15.00. To search for other exam locations, go to:
http://www.arrl.org/arrlvec/examsearch.phtml

Medford (White City)

Time: 8:30 AM. Walk-ins welcome.
Location: White City VA Facility (Room 223), Crater Lake Highway, Rt. 62, White City OR 97503-9999
Dates: Feb 25th
Contact: Don Bennett, Email: kg7bp@rfwarrior.com Phone: (541) 973-3625

Grants Pass

Time: Arrive 6:00 PM. Exam session starts at 6:30 PM. Walk-ins welcome.
Location: Fruitdale Grange. 1440 Parkdale Dr., Grants Pass OR 97527-5288
Dates: Feb 24th May 18th Aug 24th Nov 16th
Contact: John Stubbe, K7VSU, email: K7VSU@arrl.net, Phone: (541) 218-2244

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Across from Hawthorne Park
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