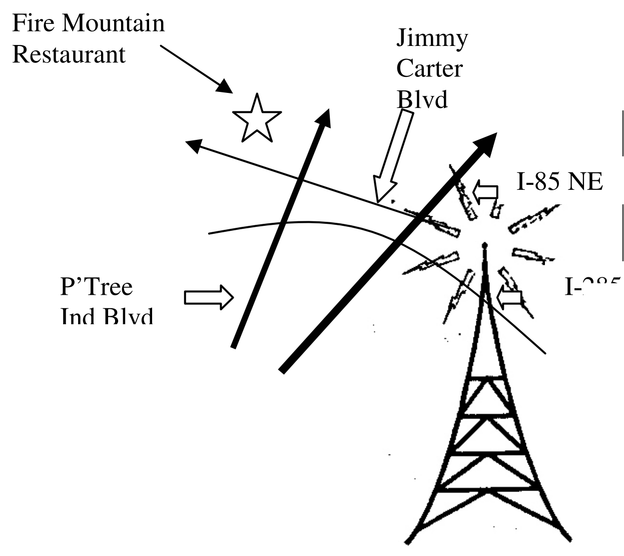
Fall 2006 Newsletter

Caution: Performing repairs on radios could be dangerous. SARS assumes no responsibility for accidents resulting from any information contained in this web site or newsletters.

JOIN SARS! Dues are $12 per calendar year. Join after June 30 and dues are pro-rated to $6.00 for the remainder of the year. Send payment to the SARS address above.

SUPPORT YOUR CLUB!
The Southeastern Antique Radio Society meets on the second Monday of each month at Fire Mountain Restaurant, 7045 Jimmy Carter Blvd. Norcross, GA 30093. Meetings start at approximately 6:30 PM. Most attendees arrive early and eat before the meeting. In addition to club business, meetings have a "Show and Tell" session where members bring in items to display and discuss. All are encouraged to participate in this activity. See the monthly schedule elsewhere in the newsletter and the map below.

ANNUAL DUES ARE NOW PAYABLE! ONLY $12! JOIN OR RENEW TODAY!



SARS RADIO CLUB

Fall BULLETIN
<u>September, 2006</u>

Check out our website! http://www.sarsradio.com

GENERAL INFO

Southeast Antique Radio Society
113 Laurel Ridge Drive
Alpharetta, GA 30004

Club Officers:
President: Jim DelPrincipe

Vice President: Les Cane

Publicity & Membership: Bob Niven

Secretary: Gary Beale

Treasurer: Tom Knutson

Newsletter Editor: Mark Palmquist

Webmaster: Rich Rodgers

Next Swap Meet: October 7, 2006 at 8:00 AM at the Winder Picnic Pavilion, 113 E. Athens Street, Winder, GA 30680. Telephone (770) 867-9011

Check http://www.sarsradio.com for details. **See Map on Page 8**

Next Meeting: Monday, October 9, 2006
Fire Mountain Restaurant Norcross 6:30 pm
Discussion Topic: Nominations of Officers for 2007
Show & Tell: Radios with Chrome Grills

IMPEDANCE: The total passive opposition offered to the flow of electric current. *Note 1:* Impedance is determined by the particular combination of resistance, inductive reactance, and capacitive reactance in a given circuit *Note 2:* Impedance is a function of FREQUENCY except in the case of purely resistive networks. Note 3: The impedance at 0 Hz is the DC impedance, or resistance (someone asked me about DC impedance once and that's the best answer I could come up with).

As defined in the reference http://www.schoenbaumlab.org/nicoweb/defs.html

> "**Capacitive Reactance:** The component of impedance that is associated with capacitance. Capacitive reactance (X_C) is inversely proportional to frequency and capacitance. When driven by a sinusoidal source, capacitive reactance is given by:
>
> $$X_C = 1 / (2 \pi f C)$$
>
> where f is the frequency of the sinusoid in Hertz (Hz), C is the capacitance in Farads (F) and X_C is the capacitive reactance in Ohms (Ω)."

Inductive reactance has the formula (L is expressed in Farads) :

$$X_L = 2 \pi f L$$

The reactance of an arbitrary network with resistance, inductance and capacitance is a complex quantity and is given by

$$Z = R + jX$$

where

> *Z* is impedance in ohms
> *R* is resistance in ohms,
> *X* is reactance in ohms,
> and j is the imaginary unit $\sqrt{-1}$

reference: see http://en.wikipedia.org/wiki/Inductive_reactance

Where the composite reactance X is given by:

$$X = X_L - X_C$$

where X_L and X_C are the inductive and capacitive reactances, respectively. For a capacitor, the impedance decreases with increasing frequency. For an inductor, the impedance increases with frequency.

In the definitions above we made reference to a complex number $\mathbf{R} + j\mathbf{X}$. A purely capacitive circuit will have a phase angle of –90 degrees. A purely inductive circuit will have a phase angle of +90 degrees. A nonzero phase angle means that changes in the current occur at a different time than changes in the voltage. I you connect a battery to a capacitor, the current begins to flow immediately, but the voltage across the capacitor lags behind the current. If you connect a battery to an inductor, the voltage appears immediately across the inductor but the current lags behind. If you connect a sine wave source to a capacitor, the voltage will lag the current by 90 degrees. If you connect a sine wave source to an inductor, the current will lag the voltage by 90 degrees.

WHAT DOES IMPEDANCE HAVE TO DO WITH ANTIQUE RADIOS?

There are at least four areas where impedance matching is important in making your radio perform at its best:

1. Output Transformer Matching

The output tube of your radios is a high impedance source, typically 2000 to 10000 ohms. The voice coil of your speaker is a low impedance load, typically 1 to 16 ohms. Simply connecting a speaker between B+ and the plate of your output tube would essentially short out the power supply and could smoke the speaker voice coil. The OUTPUT TRANSFORMER matches the high-voltage low-current source (your output tube) to the low voltage, high current load (your speaker).

I often find radios with output transformers that have failed because of overloading caused by too much DC current. The cause of the overload is often a bad coupling capacitor to the grid of the output tube, which increases the grid bias voltage and makes the tube run hot. To find the correct output transformer you need to look up the load resistance of the tube in a tube manual. Load resistance varies with the plate voltage but typical values for popular tubes are as follows:

- 6V6 5000 Ohms
- 50C5 2500 Ohms
- 50L6 4000 Ohms
- 45 3900 Ohms
- 6K6 7600 Ohms

When you look for a replacement output transformer try to get as close as possible to the correct impedance. Here is a typical listing from Antique Electronics for a replacement transformer:

TRANSFORMER, OUTPUT, HAMMOND, 8 WATT P-T125C

Specifications
Audio Watts: 8
Max DC Bias: 60 mA
Primary Impedance (Ohms): 1200 ohms to 25000 ohms center-tapped
Secondary Impedance (Ohms): 1.5 to 15 ohms

This transformer has 5 taps on the secondary and comes with a table that shows the nominal impedance for several different connection possibilities for speakers from 1.5 to 15 ohm impedance.

The DC resistance of a speaker voice coil is a fair estimate of the impedance. A 4-ohm speaker usually measures about 3 ohms and an 8-ohm speaker measures 5-6 ohms on your DC multimeter. Replacement transformers have secondaries that are tapped to match different speakers. The transformer above has taps for 1.5-ohm to 15-ohm speakers.

Measuring DC resistance does NOT give a good estimate of output transformer impedance. To do this you will need an impedance meter or you can estimate the impedance of an unknown transformer by calculating the turns radio. If you put 1 volt AC into the 4 ohm secondary of your output transformer and measure the voltage at the primary, you might get 25 volts AC. This means the turns ratio is about 25:1. Since impedance is a function of the square of the turns ratio, the primary impedance is about 4*25*25 or 2500 ohms. This will be a function of frequency, so you will get a different answer at 60 Hz than at 1000 Hz. It is my understanding that manufacturers spec transformers at 400 Hz.

Awhile back a customer asked me to hook up his horn speaker to his computer. Computers have output TRANSISTORS, which are typically low impedance devices. The horn speaker is a high impedance device with many turns of wire around a moving iron core that vibrates when the coil is excited and causes a wire or diaphragm to couple sound waves to the horn or to a cone. We connected the 8-ohm side of the transformer to the computer and the 2500-ohm side to the coil of the speaker and it worked reasonably well.

Matching the source to the load is an example of the MAXIMUM POWER THEOREM, a principle taught to electrical engineering students. See notes at the end of this article for more details.

2. Antenna Matching

Sometimes you get a radio with a missing loop antenna on the back. In many radios this “loop” is the antenna coil that resonates with the antenna section of the radio to make the reception optimum at the listening frequency. The loop needs to have the correct inductance to cause the antenna to “resonate” and track with the tuning capacitor across the dial as you tune from 550 KHz to 1550 KHz. If your radio has and external antenna connected to an internal antenna coil this is not so much an issue. There will still be a step in the alignment instructions to optimize the antenna at different frequencies or bands.

3. IF Alignment

Superheterodyne radios have a mixer stage that mixes the radio station frequency with an variable oscillator that causes the radio signal to be converted to a single **Intermediate Frequency** or **IF** that is amplified. It is much simpler to design an amplifier that works at a single frequency than one that works over all frequencies (such as found in a Tuned Radio Frequency or TRF radio). Tweaking the IF coils optimizes the impedance and transfers the most power at the IF frequency, typically 455 KHz. Other frequencies from the mixer tube are rejected because the IF transformer is not tuned to that frequency. A tank circuit will have a phase angle of 0 degrees at its resonant frequency.

4. Bypass and Coupling

Capacitors are used to couple audio frequencies to the volume control and to the control grid of the output tube in a radio and to bypass RF frequencies to ground so they don't get into the audio section.

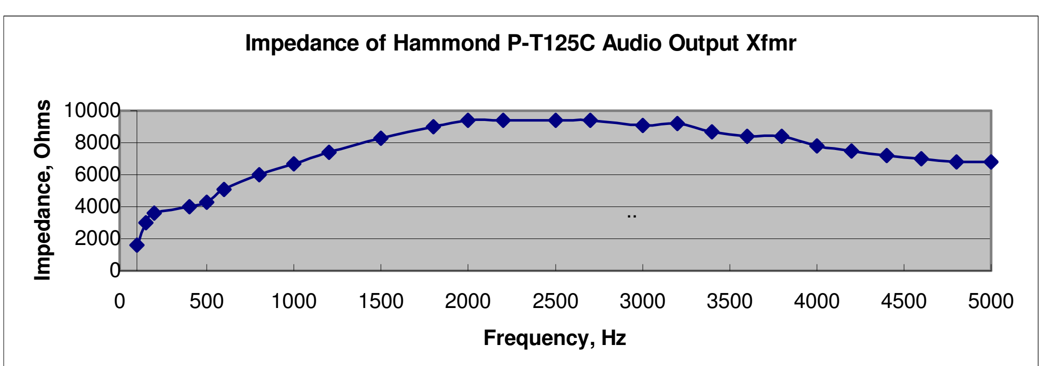
MEASURING IMPEDANCE DIRECTLY

Test instruments are available that will tell you both the magnitude and phase of the impedance of a device or network as a function of frequency. My favorite is the Hewlett-Packard 4800A Vector impedance meter. This 1970's vintage instrument has two large meters on the front, one that reads impedance and one that reads phase angle. There is a dial that can be used to set the frequency anywhere between 5 Hz and 500 KHz. The device under test connects to the red terminals.

Figure 1 HP 4800A Vector Impedance Meter

Other impedance meters, such as the ESI Model 253 and the General Radio 1650A measure at one frequency, typically 1000 Hz.

I purchased the output transformer referenced earlier (Hammond model P-T125C) and connected the speaker taps 2-5 to an 8 ohm Optimus speaker. The nominal impedance from the table for this combination is **8200 ohms.** Here is a plot showing the primary impedance for frequencies from 100 to 5000 Hz. Remember that the speaker impedance also is a function of frequency.



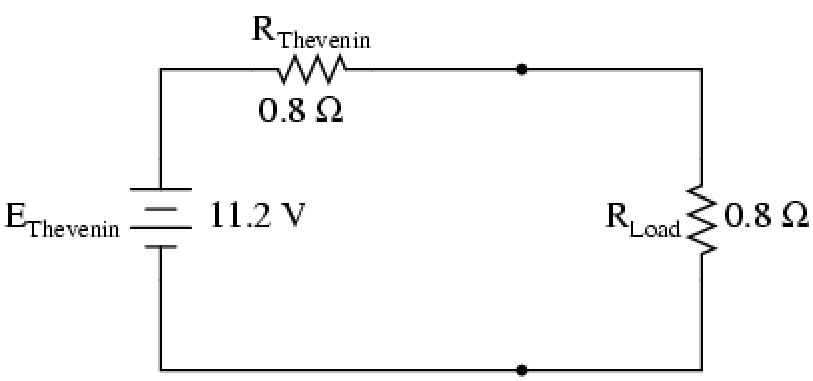
MAXIMUM POWER THEOREM

http://www.allaboutcircuits.com/vol_1/chpt_10/11.html

The Maximum Power Transfer Theorem is not so much a means of analysis as it is an aid to system design. Simply stated, the maximum amount of power will be dissipated by a load resistance when that load resistance is equal to the Thevenin/Norton resistance of the network supplying the power. If the load resistance is lower or higher than the Thevenin/Norton resistance of the source network, its dissipated power will be less than maximum.

This is essentially what is aimed for in stereo system design, where speaker "impedance" is matched to amplifier "impedance" for maximum sound power output. Impedance, the overall opposition to AC and DC current, is very similar to resistance, and must be equal between source and load for the greatest amount of power to be transferred to the load. A load impedance that is too high will result in low power output. A load impedance that is too low will not only result in low power output, but possibly overheating of the amplifier due to the power dissipated in its internal (Thevenin or Norton) impedance.

Taking our Thevenin equivalent example circuit, the Maximum Power Transfer Theorem tells us that the load resistance resulting in greatest power dissipation is equal in value to the Thevenin resistance (in this case, 0.8 Ω):



With this value of load resistance, the dissipated power will be 39.2 watts:

	$R_{Thevenin}$	R_{Load}	Total	
E	5.6	5.6	11.2	Volts
I	7	7	7	Amps
R	0.8	0.8	1.6	Ohms
P	39.2	**39.2**	78.4	Watts

If we were to try a lower value for the load resistance (0.5 Ω instead of 0.8 Ω, for example), our power dissipated by the load resistance would decrease:

SARS Meeting Dates for 2006 - Mark Your Calendars!

Date	Show & Tell Topic	Meeting Topic	Speaker
Oct 9, 2006	**Radios with chrome grills**	**TBA**	**TBA**
Nov 13, 2006	**Radios with colorful dials**	**TBA**	**TBA**
Dec 11, 2006	**Anything Goes**	**TBA**	**TBA**

Upcoming Radio Events

Date	Event	Location	Contact
October 7, 2006 8:00 am	SARS FALL SWAP MEET	Winder GA	http://www.sarsradio.com
Oct 9, 2006 6:30 pm	SARS Monthly Meeting 6:30	Norcross Fire Mountain Café	http://www.sarsradio.com
October 14, 2006 7:00 am	Nashville Swap Meet	**Nashville, TN 1604 Elm Hill Pike**	
November 4-5, 2006	Lawrenceville GA Hamfest	Gwinnett Fairgrounds	http://www.totr-radio.org

Map to Winder Swap Meet Oct 7 8:00 AM