

**Northern Colorado Amateur Radio Club**

P.O. Box 272956

Fort Collins, CO 80527-2956

# The Tribander

**The monthly Newsletter of the Northern Colorado Amateur Radio Club**

**Club Meetings are held on the 3<sup>rd</sup> Saturday of each month  
At the Golden Corral, 901 E. Harmony Rd, Fort Collins, CO.**

**All are welcome and encouraged to attend.**

**Bring yourself and your appetite at 8:00 am.  
The Meeting begins at 9:00 am.**

# NCARC Club Information

## Club Officers

President	Steve Henry	N7GN	(970)226-2817	<a href="mailto:n7gn@arri.net">n7gn@arri.net</a>
Vice President	Eric Slutz	N0EAS	(970)282-3752	<a href="mailto:eric@redginger.com">eric@redginger.com</a>
Secretary	Dave Langenberg	KC9FOO		<a href="mailto:dave@thelangenbergs.com">dave@thelangenbergs.com</a>
Treasurer Membership Chair	Willis Whatley	WA5VRL	(970)407-6599	<a href="mailto:whatley@frii.com">whatley@frii.com</a>
Interference Coordinator	Mike Bates	N7DQ	(970)219-3225	<a href="mailto:n7dq@comcast.net">n7dq@comcast.net</a>
Newsletter	Willis Whatley	WA5VRL	(970)407-6599	<a href="mailto:whatley@frii.com">whatley@frii.com</a>
Technical Chair	George Salzmann	AB0SF	(303)961-0841	<a href="mailto:ab0sf@yahoo.com">ab0sf@yahoo.com</a>
Hamfest Chair	Michael Robinson	N7MR	(970)225-7501	<a href="mailto:michael@frii.com">michael@frii.com</a>

## NCARC Repeaters

<b>W0UPS: 145.115 MHz</b> – (144.515 MHz Input) 100 Hz CTCSS Subtone (1* on, 0* off) Autopatch (40-32.926N, 105-11.898W, 7229 ft) Horsetooth Mountain, west of Fort Collins, CO
<b>W0UPS: 447.275 MHz</b> – (442.275 MHz input) 100 Hz CTCSS Subtone Autopatch (40-32.926N, 105-11.898W, 7230 ft) Horsetooth Mountain, west of Fort Collins, CO
<b>W0UPS: 146.625 MHz</b> – (146.025 MHz Input) 100 Hz CTCSS Subtone (40-50.266N, 105-3.017W, 5600 ft) SW of the Rawhide Power Plant, 17.5 miles north of Fort Collins, CO
<b>W0UPS: 146.850 MHz</b> – (146.250 MHz Input) 100 Hz CTCSS Subtone (1* on, 0* off) (Various locations around N. Colorado)
<b>W0UPS-5: 144.390 MHz</b> – APRS Digital Repeater (40-32.926N, 105-11.898W, about 7229 ft) Horsetooth Mountain, west of Fort Collins, CO

## Nets

ARES District 10 Information Net	Wednesday	9:00 pm	145.115 MHz
ARES Statewide Net	Sunday	8:30 pm	145.310 MHz
Central Colorado Traffic Net	Daily	7:30 pm	145.310 MHz
Tech Net	Tuesday	7:00 pm	145.115 MHz

## Web Page

<http://www.ncarc.us>

**TECH NET Announcement!**

This is a reminder that the 145.115 TECH NET is held Tuesday evening 07:00 PM. It is hosted by N0WIQ, Kerry. All amateur radio operators (with 2M privileges) are welcome to check in. It is an open forum net with Questions, Answers and Topics of interest.

If the 145.115 repeater is not available, the net will be held on the 447.275 repeater

**CW Practice Session!**

This is a reminder that the 145.115 CW Practice Session is held Friday evening 06:00 PM. It is hosted by WOEP, Chris. All amateur radio operators (with 2M privileges) are welcome to check in or listen.

**Some Upcoming Swapmeets****Pikes Peak Radio Amateur Association Inc. MEGAFEST****07/08/2006**

Lewis-Palmer High School, 1300 Higby Rd. Monument Doors Open at 8 AM  
Table Cost: \$10.00 Admission: \$5.00

For more info: <http://www.qsl.net/ppraa/>

**Denver Radio Club Hamfest****08/20/2006**

Jefferson County Fairgrounds in Golden 8:30 AM - 2 PM

Table Cost: \$10.00 Admission: \$5.00

Note Table price DOES NOT include admission

For more info: <http://www.qsl.net/w0tx>

**Mountain Amateur Radio Club MARC Campfest****08/25/2006**

8649 Main Street (Not Hwy 24) Lake George, Colorado

For more info: <http://www.qsl.net/nx0g> or contact Paul Moraine at 719-638-0273

**BARC Fest****09/24/2006**

Vendor Setup beginning at 6:00 AM

Doors Open to all at 8:00 AM

Boulder County Fairgrounds

9595 Nelson Road (corner of Nelson and Hover Roads), Longmont

Talk-in on 146.700 (-) Repeater

Admission \$5

Door Prizes Drawn Every Hour!

Breakfast & Lunch by Papa Carr BBQ Catering

Boulder VE Team – License Exam Testing Held at 10AM Sharp!

For More Information Contact: [BARC70@arrl.net](mailto:BARC70@arrl.net)

**New and renewing members for April:**

WA5SWD – Ed KC0WKA – Tracy KC0WKB – Cliff WB9DUN – John K0TAS – Terry N0KNK – Hal K00J – O.J.

N0TQN – Robert K0FCM – Clark K0RAM – Ruth Ann

**The NCARC thanks you for your support.**

**Field Day 2006 is on June 24 and 25**

The **Mountain Moguls** will hold their field day activities on Crowder's Hill west of Loveland Setup will be on Friday afternoon June 23<sup>rd</sup> and operations will be continuous throughout the allowed time on Saturday and Sunday.

They need CW operators to assist with this event.

**NCARC Pizza Party**  
**05 June 06**

The next session of the recurring NCARC Pizza Parties will be held at Woody's Wood Fired Pizza, xxx W. Laurel St. in Fort Collins.  
The indoor meeting room has been reserved from 6 to 8 PM for this significant activity.

**CAST for Kids Event**  
**10 June 06**

**Volunteers are needed for the CAST event from about 6am-noon.**

If you are not familiar with CAST, it is an organization sponsored by the Bureau of Reclamation, which is the federal agency that manages Horsetooth reservoir. The event takes handicapped kids fishing on Horsetooth reservoir, with members of the bass-fishing club. Ask anyone who has done this before... It is a very rewarding experience and our help is greatly appreciated.

They will need about 10-15 people, some will be sea-bound, and some will be landlubbers, but all will have fun. Please contact Rick, W0RCY, soon if you are interested and think you are able to make it at [w0rcy@comcast.net](mailto:w0rcy@comcast.net) or 482-7004.

**The Rat Race**  
**Usually the 2<sup>nd</sup> Saturday in August**  
**Ault, Colorado**

Details to follow in upcoming newsletters.

### **An Important Reminder:**

Well-known DXer Ron J. Spears, W7IX, of Klamath Falls, Oregon, died May 14 when an Amateur Radio tower he was working on in Northern California broke and toppled. He was 44.

News accounts say Spears, an ARRL DXCC Honor Roll member (CW), was attempting to retrieve a 40-meter beam from atop a 170-foot tower near MacDoel, California, when the structure collapsed and fell to the ground with Spears still attached by his safety belt. He was pronounced dead at the scene. His father, Aubrey, was assisting on the ground and witnessed the accident.

Spears had built the tower for its previous owner, Ray Balch, K6VX (SK), and used to do all of Balch's antenna work, so he had prior experience working on the structure. According to his father, Spears had first inspected the tower for safety. Spears earlier had bought the antenna from the current property owner and was attempting to bring it down in pieces. The heavy-duty support structure broke as Spears was about 10 feet from the top.

One unofficial report says that when Spears removed the antenna, it slipped and struck one of the top guy wires, starting the tower swaying until the guy broke. Another account says the beam "got away from" Spears and its huge boom struck and broke the tower guy. All but the lower 40 feet of the structure reportedly fell.

In addition to his father, survivors include his mother, Oletta, N7OHO, and a sister. Spears was a member of the ARRL and of the Southern Oregon Amateur Packet Radio Association --News media reports; The Daily DX; Rod Ingram, WC7N

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**Warning: Technical Content on following pages...**

## Impedance Matching Basics

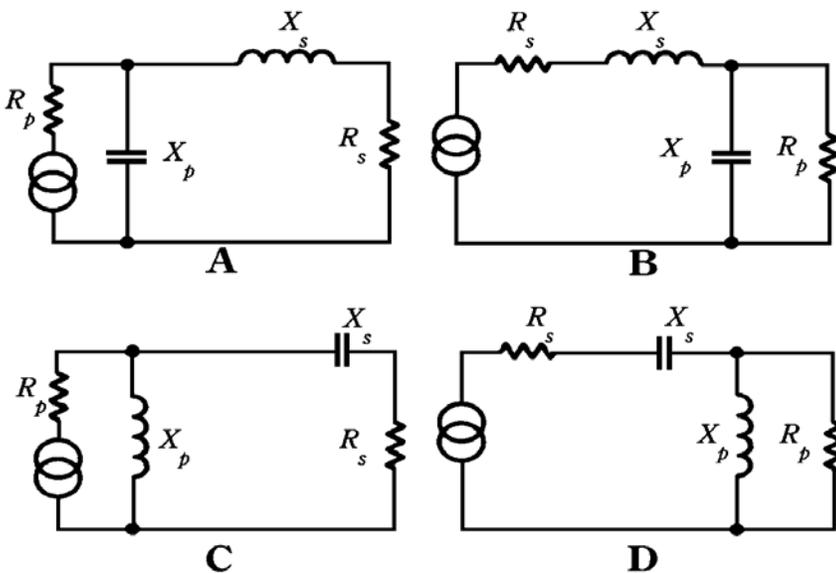
Most amateur radio operators know that combinations of capacitors and inductors are commonly used to “match” different impedances for both receiving and transmitting radio frequency (RF) signals. The most well known applications of this are the “antenna tuner” and the “tank circuit” found in transmitters using vacuum tubes or transistors for the power amplifier stage. Having the impedances matched is desirable because it usually produces the best efficiency and maximum transfer of power between the circuits.

### The “L network”

A basic matching circuit is the “L network”. It is also the building block for the T network, the Pi network, the Pi-L network and other matching configurations. Shown below are four different configurations of the L network. The inductors and capacitors in each circuit form the “L”.

In the drawings below, the resistance connected to the signal source (the interlocking circles) represents the “source impedance”. This can be the output impedance of a vacuum tube or transistor amplifier to be matched to a feedline or to the input of a linear amplifier. It can be an output end of a feedline, such as 50-ohm coax, that needs to be matched to the input feedpoint of an antenna. The other resistance represents the “load impedance”. This can be the input impedance of a feedline, a linear amplifier or an antenna.

For performing calculations on the circuits, the signal source can be ignored. The components with a P subscript form a parallel circuit that has resistance and reactance. The components with the S subscript form a series circuit that has resistance and reactance. As seen from the circuits shown, the reactance in the series or parallel circuits can be from an inductor or a capacitor.



The above configurations perform the following matching functions:

- A: Matches a high resistance source to a lower resistance load.
- B: Matches a low resistance source to a higher resistance load.
- C: Matches a high resistance source to a lower resistance load.
- D: Matches a low resistance source to a higher resistance load.

Note that the higher resistance always has the parallel reactance connected across it. Configurations A and B are more commonly used because they are known as “low pass” networks, which aid in the suppression of undesired harmonics in the RF signal. Configurations C and D are known as “high pass” networks and can result in more reasonably sized reactive components when needed. Each type of network has its own advantages.

## “Equivalency”

The way that the inductor-capacitor (L - C) circuit of a tuner or tank circuit acts as an impedance-transforming device is not obvious. This basic ability comes from a special relationship between series and parallel circuits, each of which have a resistance (R) and a reactance (X). The relationship is known as equivalency.

Every parallel circuit containing a resistance and a reactance (R and X) can be duplicated by an “equivalent” series circuit containing a resistance and a reactance. This equivalent condition exists between the series and parallel circuits when the impedance “seen” across the two terminals of each circuit are the same. Stated another way, if the circuits were placed in a box with just the two terminals of each exposed, the magnitude and phase angle of their impedance measured with test equipment would be the same.

For a specific value of inductance and capacitance, the equivalent condition will occur at a specific frequency. More importantly, for a specific frequency, the inductance and capacitance can be manipulated to produce the equivalency between the series and parallel circuits. A key characteristic of this is that the equivalent condition can occur where the resistance in the series circuit and parallel circuits are different but the reactance in the series and parallel circuits are almost the same.

The formulas for the conversion between equivalent series and parallel circuits are found in many texts in the form shown below. A series circuit can be converted into its parallel equivalent by means of the formulas:

$$X_p = \frac{R_s^2 + X_s^2}{X_s}$$

$$R_p = \frac{R_s^2 + X_s^2}{R_s}$$

(The subscripts P and S represent the parallel and series values, respectively.)

If the parallel values are known, the equivalent series circuit can be found using the formulas:

$$R_s = \frac{R_p X_p^2}{R_p^2 + X_p^2}$$

$$X_s = \frac{R_p^2 X_p}{R_p^2 + X_p^2}$$

While the above text provides a useful description of equivalency, the formulas shown are not necessary to come up with the equivalent circuits when designing LC matching circuits.

## “Q”

Many comparisons in electronics are made using “Q”. It is a figure of merit or quality that has no units of measure. That is because it is used to compare apples to apples or oranges to oranges, but never apples to oranges. It can be a measure of the energy stored to the energy lost in an inductor or a capacitor (joules to joules). It can be the relation of the bandwidth to the center frequency of a tuned circuit (kilohertz to kilohertz) as well as many other comparisons.

For the purpose of designing a matching circuit, it defines numerous relationships. It is the relation between the two impedances to be matched (the network Q). It is the relation of the parallel resistance to the series resistance of the equivalent circuits. It is the relation of the parallel reactance to the series reactance of the equivalent circuits. It is also the ratio of resistance to reactance in the parallel or series circuit.

1. The Q for the impedances that need to be matched:

$$Q_N = \sqrt{\frac{R_p}{R_s} - 1}$$

2. The Q for a series circuit (resistance in series with a reactance):

$$Q_S = \frac{X_S}{R_S} \quad \text{Stated another way: } X_S = Q_S R_S$$

3. The Q for a parallel circuit (resistance in parallel with a reactance):

$$Q_P = \frac{R_P}{X_P} \quad \text{Stated another way: } X_P = \frac{R_P}{Q_P}$$

4. The Q for the relation between the series and parallel resistances:

$$R_p = R_s (Q^2 + 1)$$

5. The Q for the relation between the series and parallel reactances:

$$X_P = X_S \frac{(Q^2 + 1)}{Q^2}$$

There is a significant equality to be remembered in the first three “Q” formulas shown above. The Q of the network, the Q of the series circuit and the Q of the parallel circuits are all equal when the impedances are matched.

$$\text{Stated another way: } Q_N = Q_S = Q_P \text{ and therefore } \sqrt{\frac{R_p}{R_s} - 1} = \frac{X_S}{R_S} = \frac{R_P}{X_P}$$

The reason that this is worth remembering is demonstrated in the example below. The fourth and fifth formulas show why the equivalency will occur when the resistances are different but the reactances are almost the same (when the Q is > 5).

### An Example:

This is an example of matching a 2500-ohm source to a 50-ohm load operating at 4.000 MHz (using configuration “A” of the L network).

First find the required “network Q”:

$$Q_N = \sqrt{\frac{R_P}{R_S} - 1} = \sqrt{\frac{2500}{50} - 1} = 7$$

Next, find “X” of the series and parallel circuits:

$$X_S = Q_S R_S = 7 * 50 = 350 \text{ Ohms}$$

$$X_P = \frac{R_P}{Q_P} = \frac{2500}{7} = 357.143 \text{ Ohms}$$

Now, using the formulas for inductive and capacitive reactance, find the actual value for the series and parallel reactive components at the 4.000 MHz frequency:

$$X_S = X_L = 2\pi FL \therefore L = \frac{X_S}{2\pi F} = \frac{350}{2 * 3.14159 * 4 * 10^6} = 13.926 \text{ uH inductor}$$

$$X_P = X_C = \frac{1}{2\pi FC} \therefore C = \frac{1}{2\pi F X_P} = \frac{1}{2 * 3.14159 * 4 * 10^6 * 357.143} = 111.41 \text{ pF capacitor}$$

Some things to be noted:

The reactance of the inductor and capacitor are not quite the same. This occurs because ohmic resistance has a detuning effect in parallel resonant circuits having a relatively low Q. This effect does not exist in low Q series circuits.

As stated earlier, the equivalency between the parallel and series circuits has occurred where the resistances are different, but the reactances are almost the same.

If the values of inductance and capacitance found in the above example are used in the formula for finding the resonant frequency of an LC circuit,

$$F_R = \frac{1}{2\pi\sqrt{LC}}$$

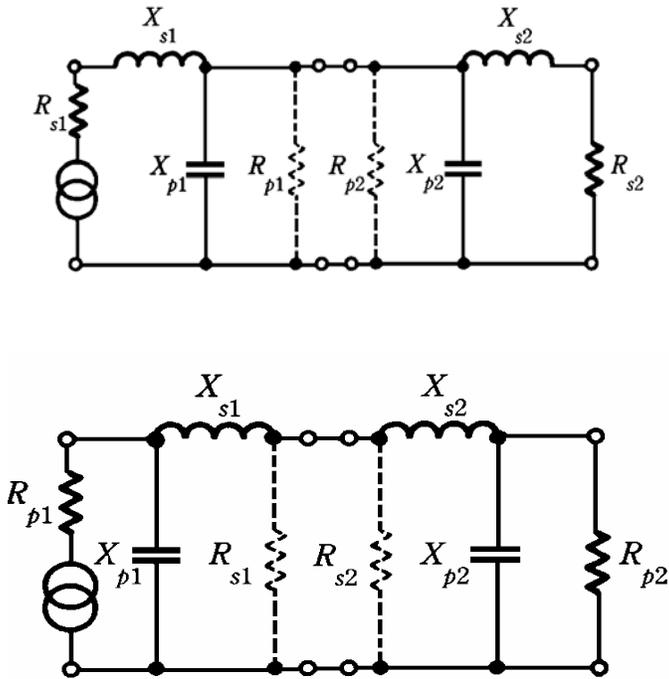
the result will be 4.000 MHz.

The source and load impedances (resistances) selected for the above example are the values needed to match the output of a 4-1000a amplifier tube operating in grounded grid mode to a 50-ohm feedline or load at 4.000 MHz.

By running the calculations again, using 3.500 MHz, the range of inductance and capacitance needed to cover the 75/80-meter band can be found.

## “T and Pi” Networks

Below are T and Pi networks drawn to show that they are made up of two cascaded L networks, the ones depicted in configurations A and B of the L networks. The resistances shown as dashed lines do not actually exist, but they are used during the calculations for the T and Pi networks. This allows each L network to be calculated individually before they are “joined” to complete the “T” or “Pi”. The completed networks operate as if a resistance, equal to the parallel combination of the nonexistent resistors, was connected across their mid-section. When the L networks are “joined”, the capacitors that are in parallel with the imaginary resistors of the “T” will combine to produce a real single capacitor. The inductors that are in series with the imaginary resistors of the “Pi” will combine to produce a real single inductor.



The “imaginary” resistor values should be chosen to provide a reasonable Q for each of the L networks.

The T and Pi configurations shown above are low pass networks. As with the L networks, a high pass T or Pi match can be made by cascading two L networks, the ones depicted in configurations C and D of the L networks.

The information presented in this text is only intended to show how inductors and capacitors are used to match impedances in RF applications. The source and load impedances shown here are represented as pure resistances, which will seldom occur in any real matching applications.

Most source or load impedances have both resistive and reactive elements. The values of the inductors and capacitors that comprise the actual matching network must be “adjusted” to compensate for the reactive portion of the source or load impedance. In addition to the complex impedances of the source or load, there are usually other factors, such as stray capacitance or undesired coupling of inductors, which will impact the design values.

Even the best “design simulation” programs for computers have difficulty in adjusting for “stray” capacitance, undesired coupling between inductors and other factors. It is usually easier to use the arithmetic to get in the ballpark, build the matching network and make any needed adjustments after testing the circuit in its intended application.

