The Signal

OFFICIAL MAGAZINE OF THE
COLLINS COLLECTORS ASSOCIATION

Q4 2019 Issue #96

with the New Collins 20T 1 kw AM transmitter

Let the brilliant overtones of high fidelity flow through circuits engineered *for* high fidelity. The 20T development, a new post-war success, reveals in each detail the quality of its design.

Dual oscillators. Two temperature-controlled oscillators, adjusted to your operating frequency, are self-contained in the 20T. A selector switch enables you to place the spare unit in operation when you remove the other for maintenance.

Two cabinets. Past practice has been to crowd a kilowatt transmitter into a single cabinet. The Collins 20T gives you two cabinets with lots of room, genuine accessibility, ample ventilation, and impressive appearance.

Program protection *and* circuit protection. In addition to magnetic circuit breakers and two-shot d-c overload relays, the 20T has high voltage capacitor fusing. Should a capacitor fail, the fuse opens the circuit and a spring bar shorts the capacitor terminals. The transmitter stays on the air and the faulty capacitor is indicated.

Filament voltage regulator. For longer tube life, and low noise and distortion levels, the 20T tube filaments have a constant voltage supply.

Attractive styling. The cabinets are attractively styled in three-tone gray. Their modern, distinctive appearance, simplicity of design, and pleasing color harmony will give many years of eye appeal and satisfaction.

Eye level metering—centralized controls—motor driven tuning elements—forced air cooling—high safety factors—30-10,000 cps audio response ± 1.0 db—3% audio distortion—minus 65 db noise level.

Only the Collins 20T gives you all these desirable and important features. Deliveries will begin early this year. We suggest you write for detailed specifications, study them, compare them, and then place your order for early delivery. Let us supply your entire equipment needs. You'll have an integrated system that will keep the sparkle in your programs and put a sparkle in your station.

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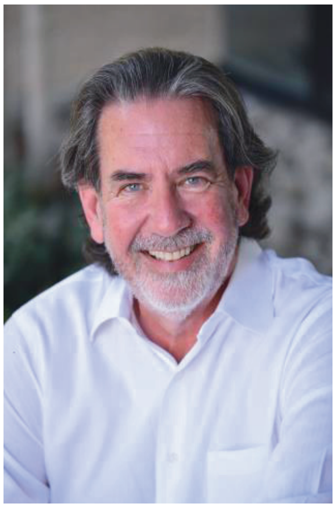
Collins Collectors Association

From the President's Desk...



This is the start of the fun season in the CCA where we begin planning for Dayton. If you have not been to the new Xenia location then you are missing out. The first year or two were rough and the flea market really suffered. But the Dayton club has worked hard to fix the issues and last year the flea market was full of Collins goodies, some at pretty amazing prices. This is a time where we are seeing many of the collectors downsize to new QTH's and it is a great time to add to your collection. Prices for normal A line and S line gear are soft, but prices for rare and unusual pieces seem to be stronger. Anyway, plan on making a trip to Dayton this year!

There is a new board for the CCA. Jim Stizinger, WA3CEX, termed out and is at home recovering slowly from his health issues. I talked with Jim last week and he is making progress and said that he is trying to get to Dayton this year. Would love to see him back!

Bill Carns, K7OTQ, is doing a lot of traveling this year and has dropped off the board but still remains an active advisor. So, Loney Duncan, W0GZV, former Collins and Rockwell Collins engineer and executive, has joined us as a board member for the first time and I am excited about working with him – welcome Loney! Loney will be working with Francesco Ledda on our preservation and museum work and is best known lately for his work with FiFi. Dennis Kidder, W6DQ, has rejoined the board as secretary and also is active in running the CCA Friday night west coast 75 meter net – thanks for coming back Dennis! Ron Mosher, K0PGE, remains as treasurer and Francesco Ledda, K5URG, is our Vice President and Signal Editor. Francesco is learning that Signal Editor remains one of the hardest jobs in the CCA. Wayne Spring, W6IRD, remains a trusted advisor to the board and is on Francesco's museum committee. Wayne is also hard at work documenting some of his vast knowledge of KWM 380's for future Signal Articles. I will remain as President this year and Dayton Chairman.

The entire Board is trying to make plans to gather in California this spring to hammer out an agenda for the next few years of CCA activity. If you have any input for the board please email any one of us and we will take your concerns or ideas to the board. We need new volunteers as net controls and Francesco needs a constant flow of articles for the Signal Magazine. Speaking of nets, there are some sun spots showing up and projections are that we have hit bottom and should start seeing some better propagation in 2020. This is welcome news for our 20 meter net! The first Wednesday 75 meter AM net is a huge hit and we are seeing 20-30 check-ins in each region. AM is having a big resurgence and time to dust off those old AM rigs and get them back on the air!

Looking forward to hearing you on the nets and seeing you in person at Dayton this year!

73, Scott
de Scott – KE1RR
President CCA

The Signal Magazine

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*Tuesday 3805 kHz at 8pm CST
*Thursday 3805 kHz at 8pm CST
*Friday [West Coast] 3895 kHz at 10pm CST
*Sunday 29.050 MHz at 10am CST

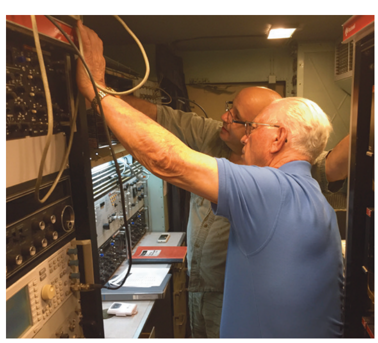
From The Editor...

Well this isn't 'From the Editor' – it is really 'About the Editor'. Since Francesco Ledda, K5URG, Vice President, Signal Editor, and Museum Board Chair of Collins Collectors Association wrote most of this Signal, he thought that someone else should write something for this space.

I first met Francesco at Dayton a few years ago, where he was the speaker at our annual Banquet. I found out then that he was a neighbor of mine – he lived a few miles away from me! With both of our busy careers it was still a few months before we got together for coffee and had a chat. I found out then that he is one of those people who knows WAY more about radios (Collins Commercial and Military in particular) than I will ever know. He spent some time early in life as an officer in the Italian Armed Forces and as a system engineer on missile system for an European defense contractor . After several years he moved to the US and started work at Rockwell Collins. After Collins he moved on to Nortel and then several other telecom companies as an Engineer and Executive and has had a consulting company on the side. He has recently retired and is active restoring radio equipment and helping us our with the CCA when he is not flying his plane and traveling with his lovely wife, Leslie.

Francesco has restored two Collins Shelters full of Collins URG equipment and one only need to look at his well equipped and well used shop full of HP test equipment to realize that he knows what he is doing. The CCA is fortunate to have someone so knowledgeable and passionate helping make the CCA what it is today. I am hoping he will take on the roll of President soon and I can step away for awhile. Although I have moved farther out into the country we still try and have coffee together every few weeks and talk about Collins and compare notes about our latest restoration projects. This is what the CCA is all about – good friends sharing their passion for all things Collins!

de Scott – KE1RR
President CCA

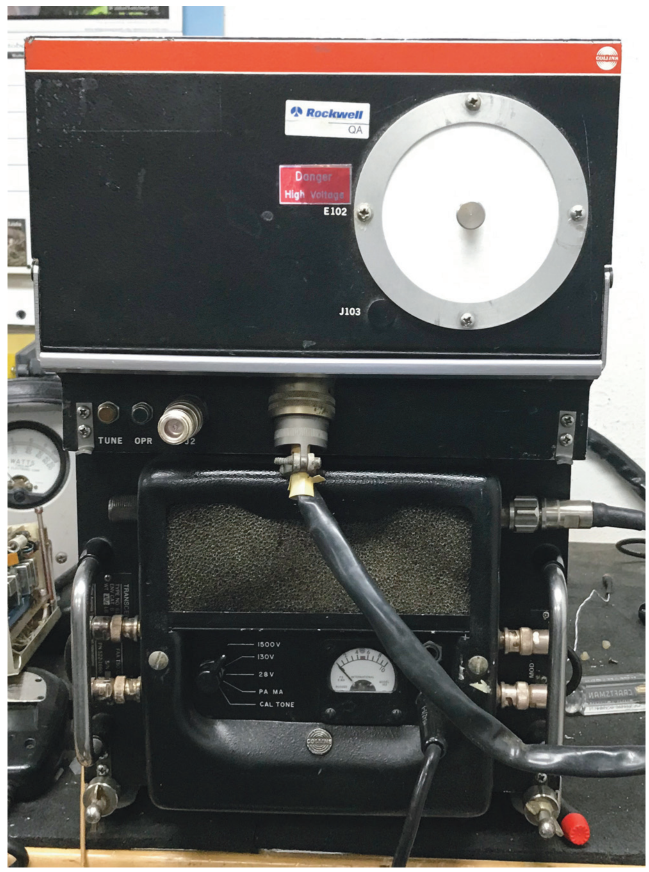


The Collins 490T-x Antenna Couplers Family

Francesco Ledda, K5URG - CCA Vice President

I often felt that an antenna coupler was something magic. A magic machine with almost super-natural powers to beat a high SWR antenna into submission. In the next pages I will share some of the magic inside the box and also provide some insight on the operations of the Collins 490T series couplers.

In the mid-60s, Collins introduced the new 490T series HF antenna coupler. It was light weight, self-contained, fast and with a large tuning range. The 490T series had two very innovative features: low mass variable inductors and the capability of the coupler to identify the incoming frequency of RF signal. These two features allowed for fast tuning speed and simplified wiring to the transceiver. My guess is that that Collins produced in excess of 35,000 units.



Note: The US Army TM 11-5985-326-35 is the source of some of the material covered in this article. This TM can be download-ed from the internet free of charge. The picture on the right side shows a 490T-1 on top of a Collins 618T-3. The picture below shows a 490B-2. The B-2 is a 490T repackaged for use on a vehicle.

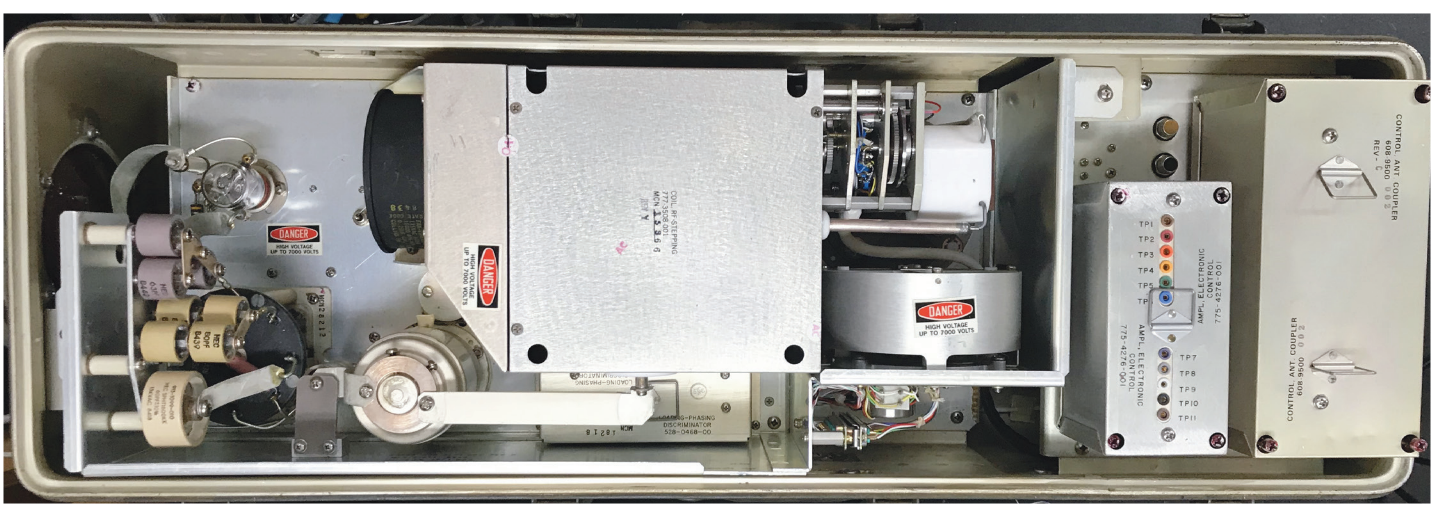
General Tuning Theory

Before we jump in into the Collins coupler discussion, we are go-ing to focus on the different effect that adding a series and parallel reactance have on an impedance.

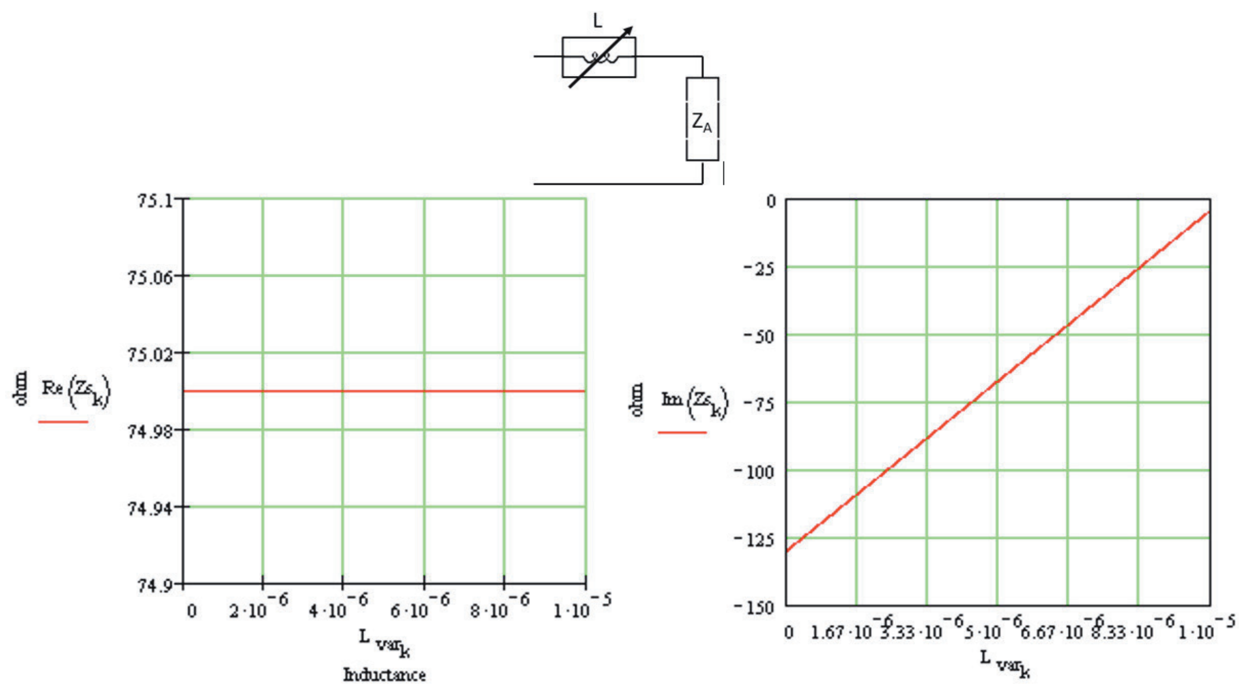
Adding a series variable reactance XL to an impedance Z=75-i130Ω @2MHz

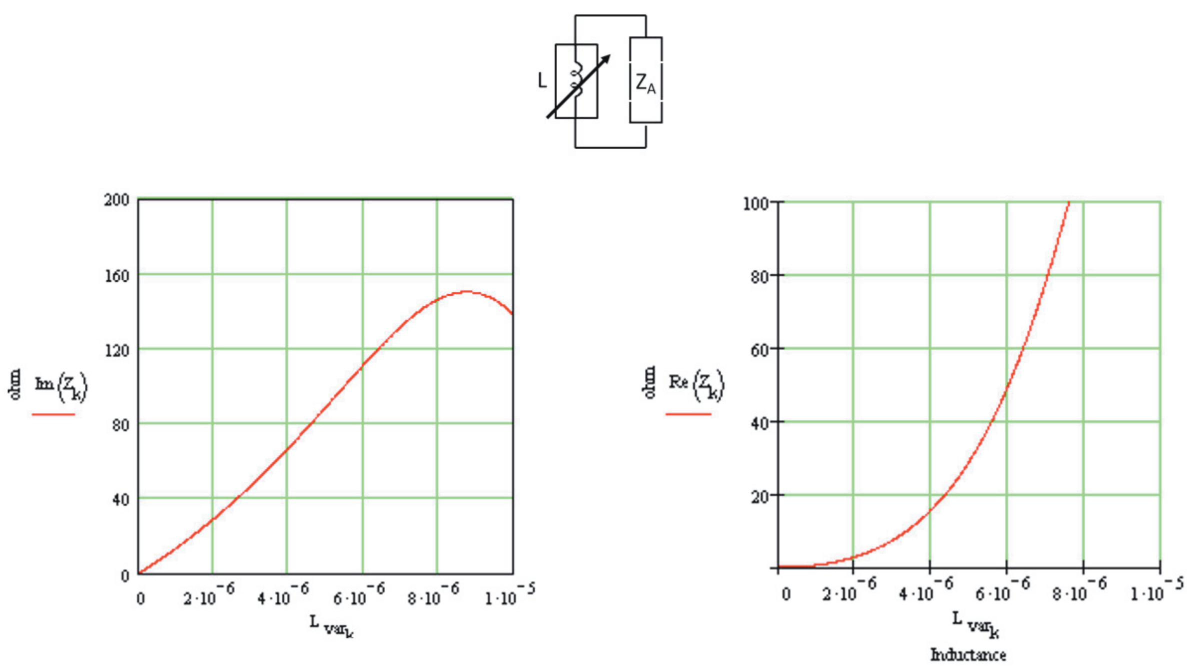
The important thing to notice is that the additional reactance has not affected the resistive component of the impedance.

Adding a parallel variable reactance XL to an impedance Z=75-i130Ω @2MHz



Collins Collectors Association



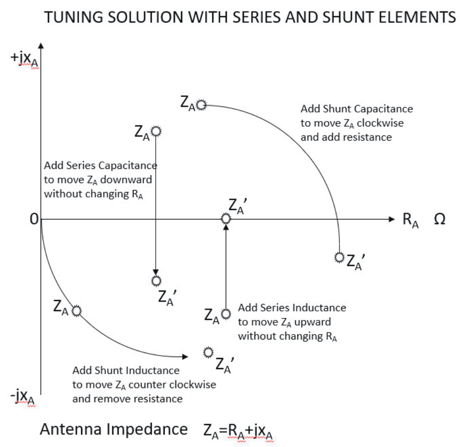


In this case, we can notice that the parallel reactance effects the resistance portion of the total impedance, and that the total reactance doesn't follow a linear law. Couplers take advantage of these behaviors to manipulate and match impedance.

In very general terms, the 490T couplers, first, add a series reactance to almost cancel out the reactive component of the antenna and thend add shunt reactance to bring the antenna resistance to 50Ω (if the antenna real part is less than 50Ω).

Any antenna impedance (Z A = RA ± jXA) can be represented graphically on an R-X impedance plane. Resistive (resonant) impedances (RA + jO) lie on the horizontal RA axis. Inductive impedances (RA + jXA) are above the axis, and capacitive impedances (RA - jXA) are below the axis. Each tuning element produces a predictable translation of antenna impedance ZA as shown. Series tuning elements translate Z A upward for added inductive reactance (+jX) or downward for added capacitive reactance (-jX). Shunt tuning elements translate Z A around on a circle which passes through both the Z A point and the 0+j0 origin point.

Capacitive reactances produce clockwise rotation and inductive reactances produce counterclockwise rotation (From Collins 490T-1 Maintenance Manual 523-0756805-501114).



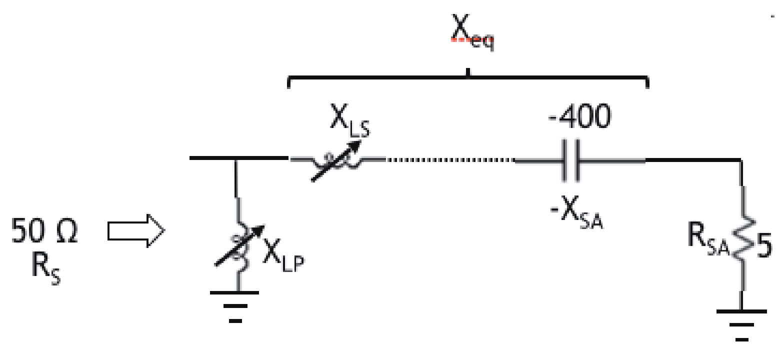
Practical Analytical Examples

These examples are based on the 490T architectural configuration.

Here we have a typical short antenna at 2MHz; Its impedance is Za = 5-j400 Ω. The transmitter impedance Zin is 50 +j0 Ω. XLS and XLP are the variable servo-controlled reactances that the coupler will utilize to match the antenna. They create an equivalent L-Network to match Rsa to Rp to 50Ω. Below, we show three methods to find the solution.

Q Method

This method can generate two acceptable solutions. The 490T architecturally can only implement the solution with a capacitive residual reactance Xeq , since it uses a shunt inductor . Therefore, the pictures on the right show such solution.



Antenna Impedance

$Z_a := (5 - i \cdot 400)\ \Omega$

$R_{sa} := Re(Z_a)$ Real part of Za

$R_{sa} = 5\ \Omega$

$X_{sa} := Im(Z_a)$ Imaginary part of Za

$X_{sa} = -400\ \Omega$

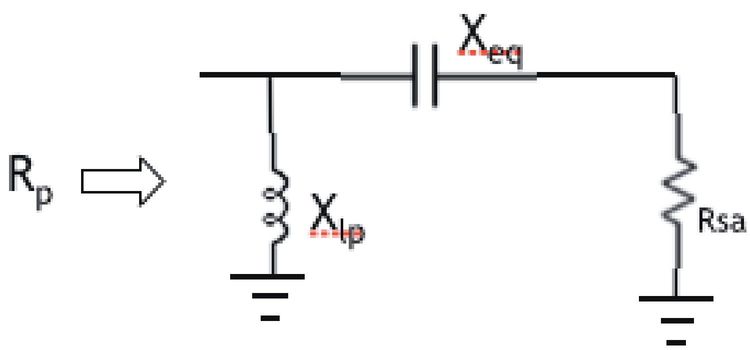
Transmitter Required Load Impedance

$Z_{in} := (50 + (i \cdot 0))\ \Omega$

$R_p := Re(Z_{in})$

$R_p = 50\ \Omega$ Real part of Zin

$Q := \frac{Xeq}{R_{sa}}$ Series Impedance $\qquad Q := \frac{R_p}{X_{lp}}$ Parallel Impedance



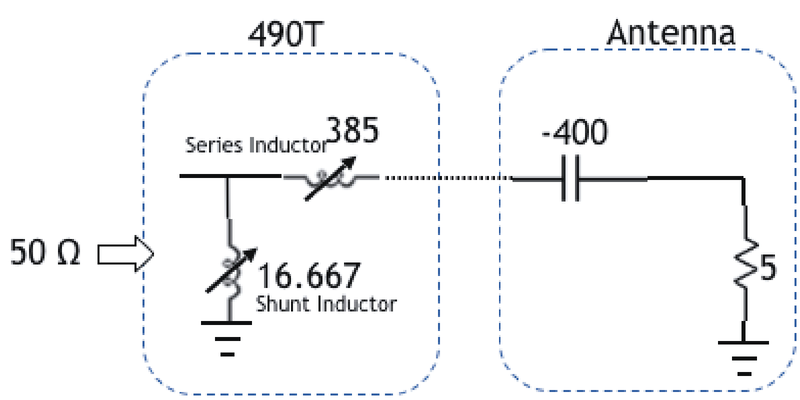
By using the Series to Parallel Impedance Transform (*), solve for Q, Xlp & Xls

$Q^2 := \frac{R_p}{R_{sa}} - 1 \qquad \sqrt{\frac{R_p}{R_{sa}} - 1} = 3 \qquad Q := 3$

$X_{lp} := \frac{R_p}{Q}$ * $\qquad X_{lp} = 16.667\ \Omega$

$X_{eq} := (R_{sa} \cdot Q) \qquad X_{eq} = 15\ \Omega$

$X_{ls} := (-X_{sa} - X_{eq})$ * $X_{ls} = 385\ \Omega$



For more details about Series to Parallel transforms refer to: https://www.eee.hku.hk/~msang/Impedance-TransformSP.pdf

Electric Circuit Analysis Method

This method only uses the formulas for series and parallel impedances. Please, refer to the precious figures.

$$Z_{in} := \left(\frac{1}{i \cdot x_{lp}} + \frac{1}{Z_a + i \cdot x_{ls}} \right)^{-1}$$ Paralleling Xlp with Xls+Za

$Z_{in} := R_p + i \cdot x_t$ $\qquad R_p := 50 \quad \Omega$

For a purely resistive source

$$R_p := \frac{\left(-x_{lp} \cdot x_{ls} - x_{lp} \cdot x_a\right) + i \cdot R_a \cdot x_{lp}}{R_a + i \cdot \left(x_a + x_{ls} + x_{lp}\right)}$$

$$R_p \cdot \left[R_a + i \cdot \left(x_a + x_{ls} + x_{lp}\right)\right] := -x_{lp} \cdot \left(x_{ls} + x_a\right) + i \cdot R_a \cdot x_{lp}$$

At resonance, the imaginary terms (reactances) are zero.

Therefore,

eq.1 $\qquad R_p \cdot R_a := -x_{lp} \left(x_{ls} + x_a\right)$

and

eq.2 $\qquad i \cdot R_p \cdot \left(x_a + x_{ls} + x_{lp}\right) - i \cdot R_a \cdot x_{lp} := 0$

Now, we solve eq.2 for Xp

$$x_{lp} := \frac{R_p \cdot \left(x_a + x_{ls}\right)}{\left(R_a - R_p\right)}$$

Now, we substitute Xp into eq.1

$$x_{ls}^2 + 2 \cdot x_a \cdot x_{ls} + x_a^2 + R_a^2 - R_a \cdot R_p := 0$$

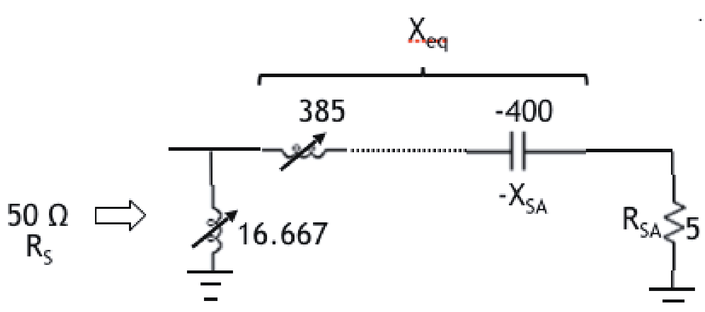
$R_a := 5 \ \Omega \qquad x_a := -400 \ \Omega \qquad R_p := 50 \ \Omega$

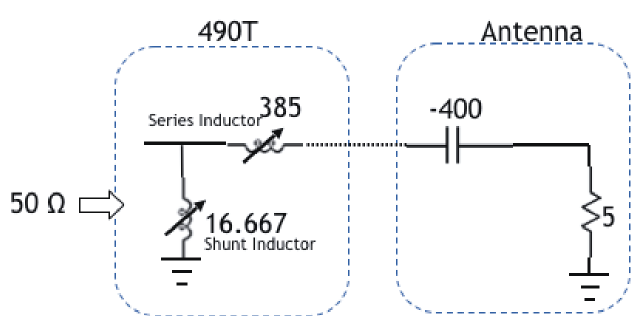
$$x_{ls}^2 + 2 \cdot x_a \cdot x_{ls} + x_a^2 + R_a^2 - R_a \cdot R_p \text{ solve}, x_{ls} \rightarrow \begin{bmatrix} 385 \\ 415 \end{bmatrix} \Omega$$

There are wo possible solutions. We select the first since it produces a capacitive residual, to satisfy the 490T architecture.

if Xs is 385 Ω, Xp is:

$$x_{lp} := \frac{R_p \cdot \left(x_a + 385\right)}{\left(R_a - R_p\right)} \qquad x_{lp} = 16.667 \quad \Omega$$





Smith Chart Method

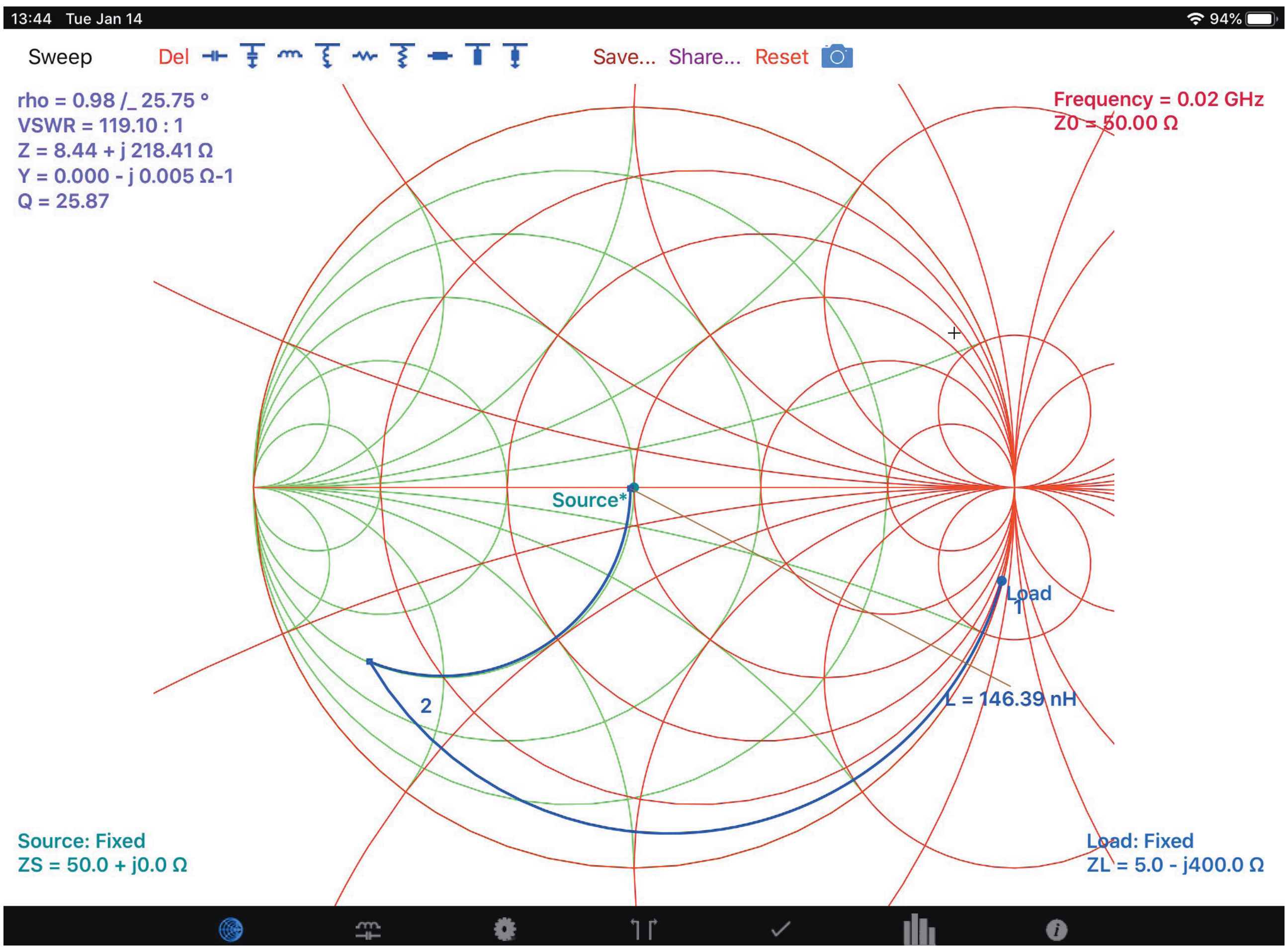
Example 1

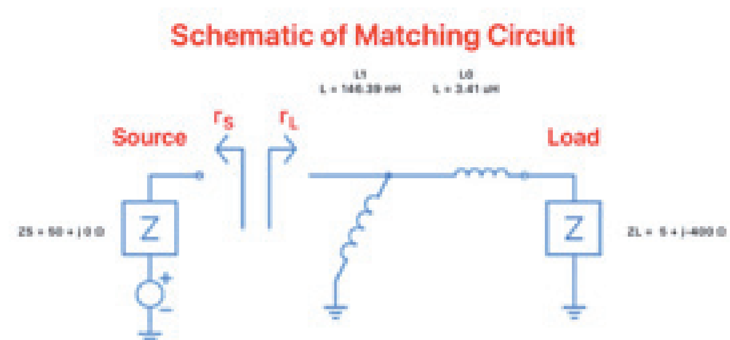
The Smith chart below shows the tuning process described above. Point LO 1 in the antenna impedance 5 – i400 Ω.

Point 2 is the impedance after the series inductor, before the shunt inductor is applied. Source is the transmitter impedance 50Ω. When the shunt inductor is added, the impedance of the antenna with the series and shunt inductors matches the transmitter impedance.

The Smith chart application used for this example is available for Iphone and Ipad for about $5 (Smith Chart for Iphone and Ipad). Think about all the fun you can have for $5! Another highly recommended Smith Chart design too is JJSmith from Tonne Software, and it is free.

First, input the antenna impedance, such as 5-j400Ω. Then select the series inductance symbol. This will create a CW circle. Next, put the crosshair on the circle where it intercepts the constant 50Ω circle. By doing this, we have the value of the series inductor. Now, select the shunt inductor. This creates a circle that intercepts the source impedance. Put the crosshair there, and the circle will terminate at 50Ω. Yes, you have designed a matching circuit for your antenna. Select the schematic symbol, and voila' you are done! The tool provides the values of the components, based on the selected frequency.



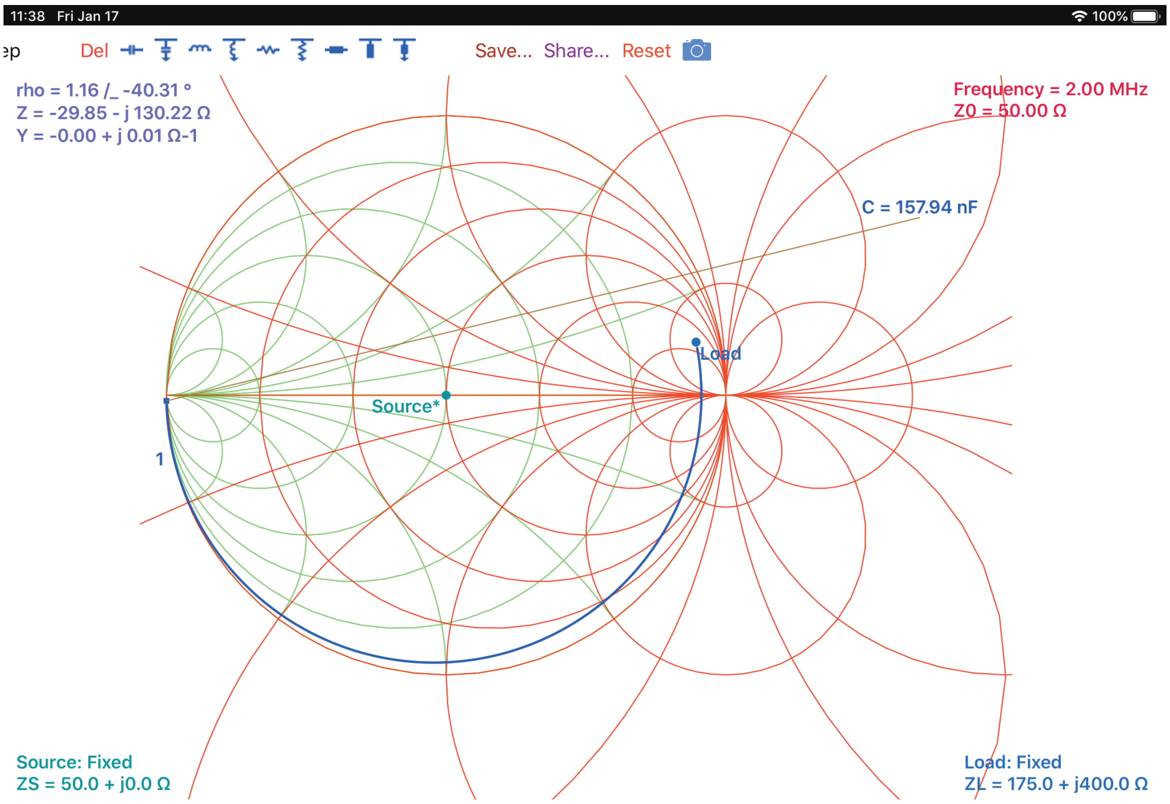


Smith Chart Method

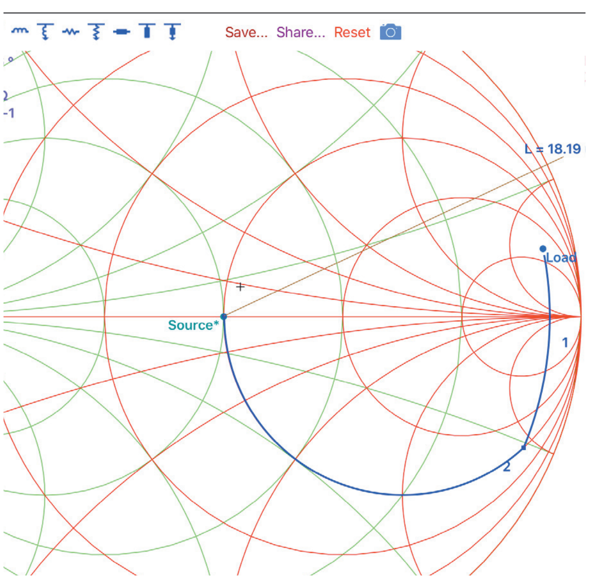
Example 2

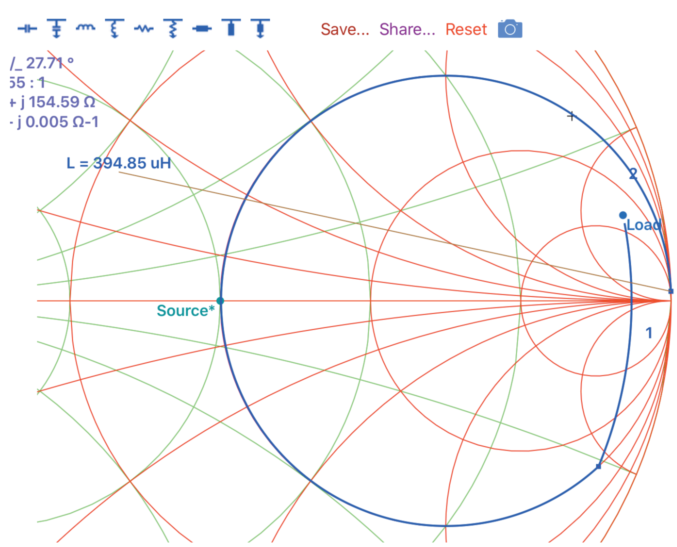
For this example, we are going to consider an antenna with impedance 175+j400Ω. This impedance has been chosen to show how a shunt capacitor can be used to lower the resistance of the antenna to 50Ω.

First, we add a shunt capacitance. This will both change the resistance and reactance of the antenna. We can see that the CW circle intercepts the constant 50Ω circle.

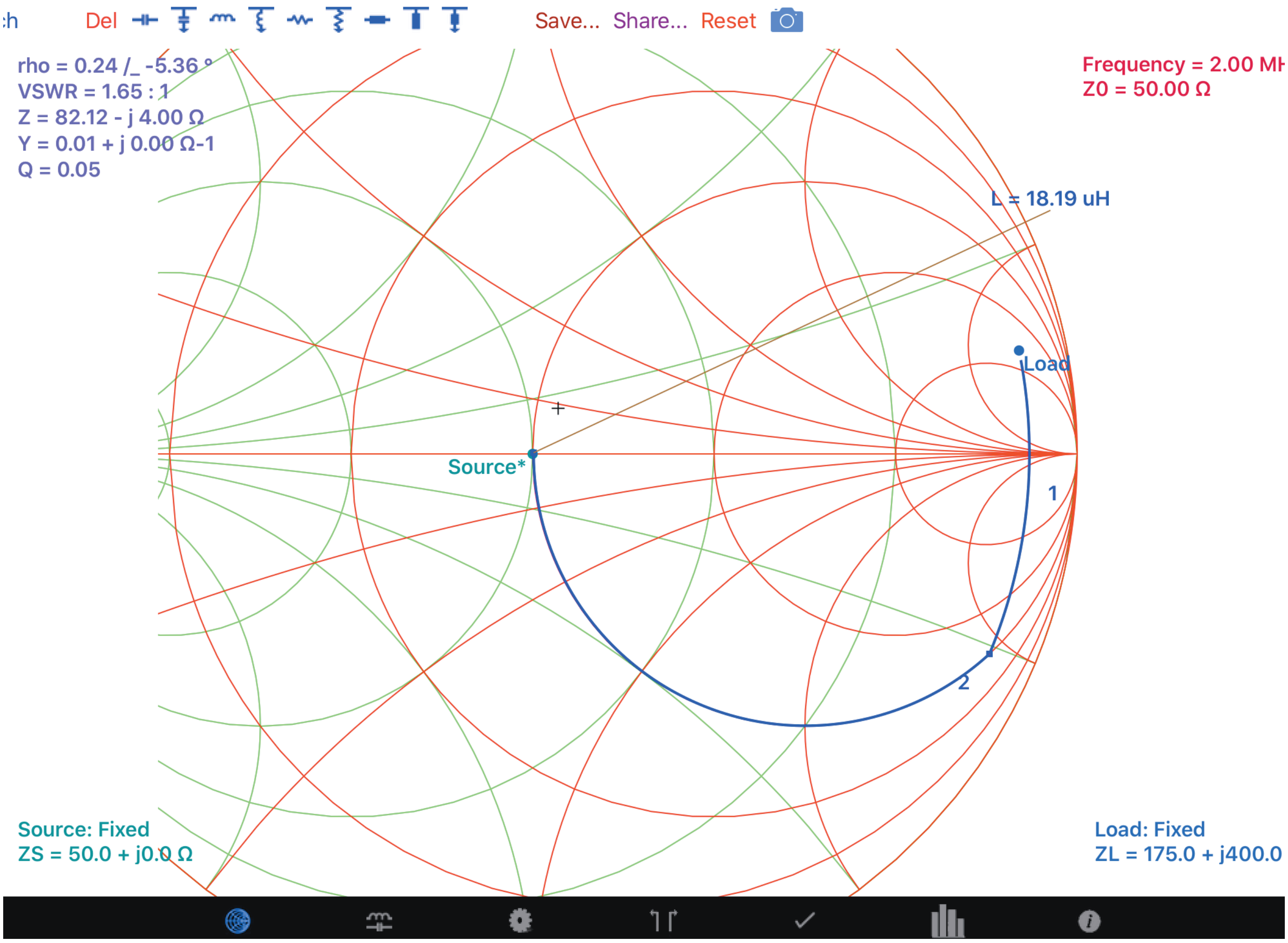


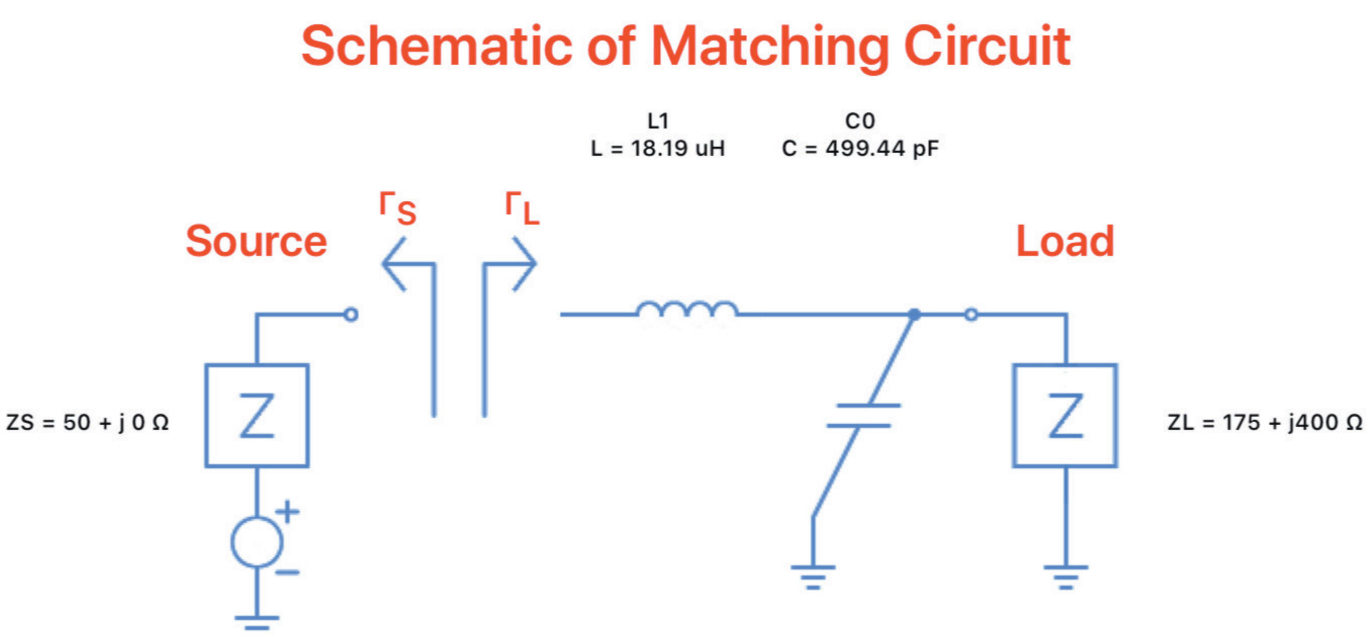
As in the previous example, we put the crosshair at 50Ω intercept point. Now, we select a series inductance, and we have a circle that crosses the 50Ω point.





Put the crosshair there, and the circle will terminate at 50Ω. Select the schematic symbol, and you are done!



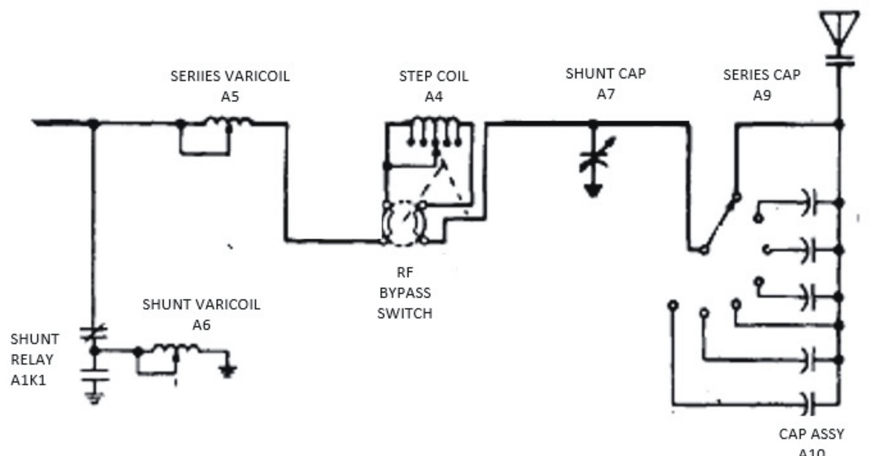


The Collins 490T-x Antenna Coupler

The 490T- Antenna Coupler matches the effective input impedance of an antenna to the output impedance of a transmitter. This effective input impedance includes the impedance of both the antenna and the antenna coupler and will be subsequently referred to as the effective antenna network impedance. The transmitter is designed for a 50 ohm load. Typically, within 3 seconds, the 490T Antenna Coupler automatically matches the effective antenna network impedance to this 50-ohm value. This section describes the tuning network, the tuning process, and the basic tuning sequence for such a matching capability. Most Collins antenna couplers have similar configurations.

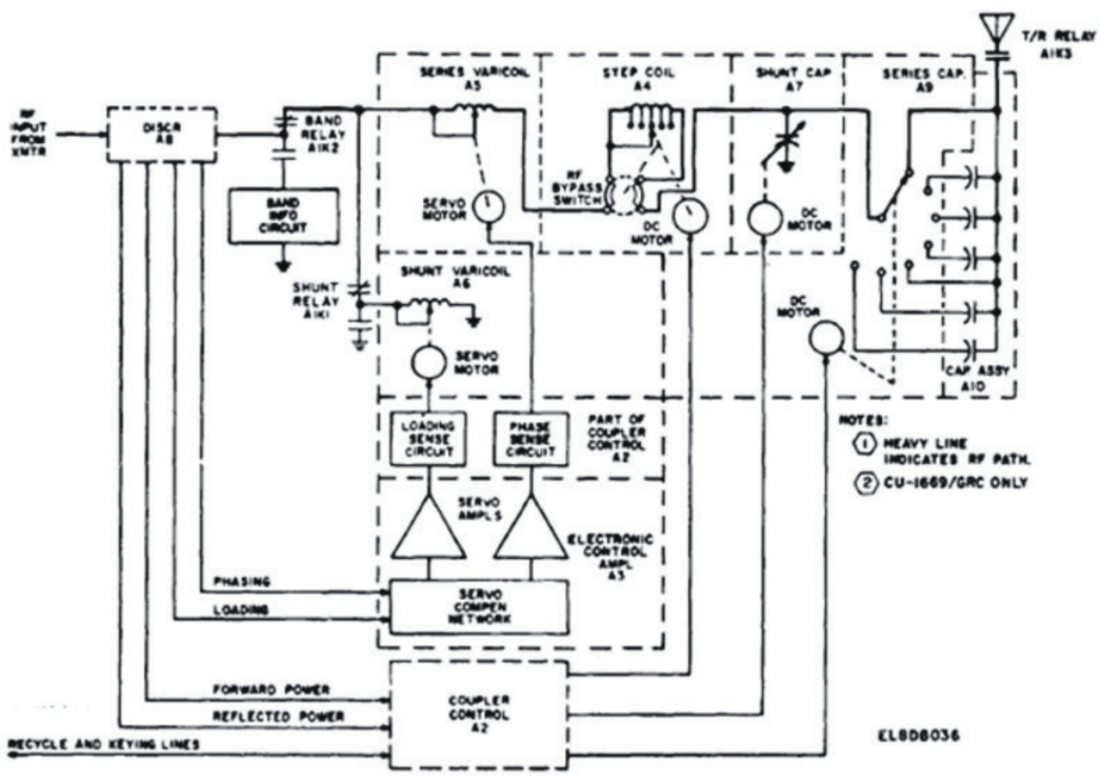
Tuning Network

The 490T Antenna Coupler tuning network includes a discriminator circuit, shunt and series varicoils, shunt and series capacitors, and a step coil. Servo motors position the varicoils. Dc motors position the variable capacitors and the step coil.



490T Building Blocks

Please, refer to picture below to follow the description.

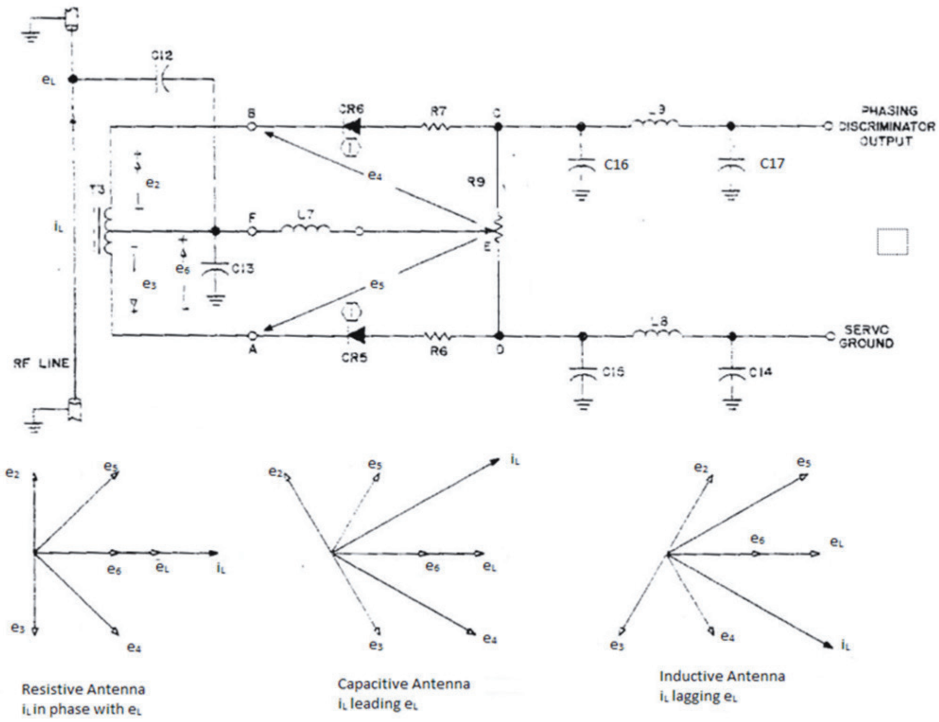


Antenna Coupler, Block Diagram.

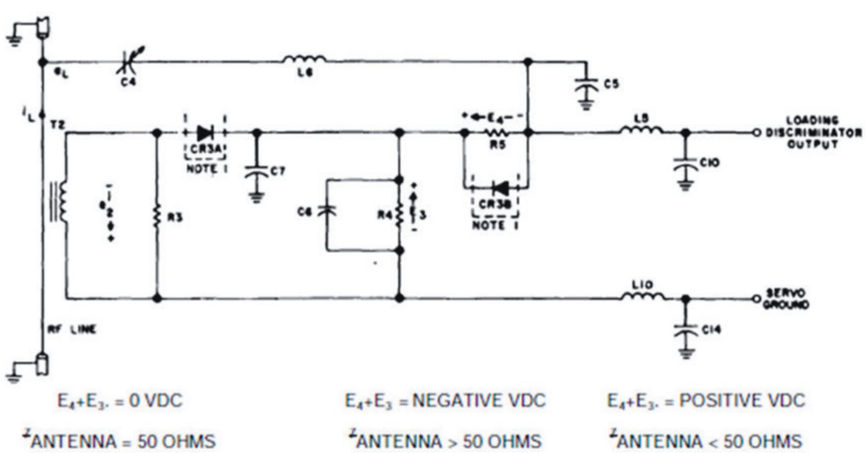
A8 Discriminator Module

The A8 module information drives the tuning solution. It provides DC signals to the Coupler Control with DC signals related to Phasing, Loading and SWR measurements. Phasing is used to measure the reactive component of the load. Loading is used to measure the real portion of the antenna impedance. VSWR is used to determine the need for tuning.

Phasing: When the RF is applied and the antenna is resistive, the RF line voltage eL and line current iL are in phase (see diagrams below). When the antenna is capacitive, the line current leads the line voltage and the error signal is negative. When the load is inductive, the line current lags the line voltage and the error signal is positive.

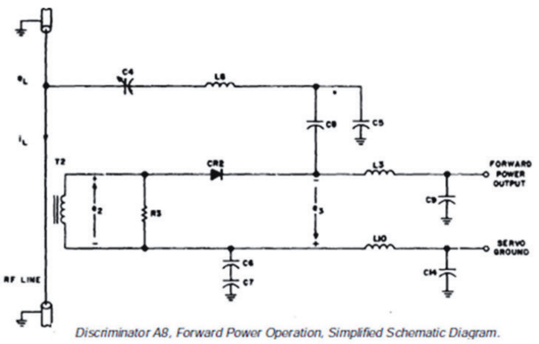


Loading: The Loading signal is dependent on the difference between the impedance of the RF circuit and 50 ohms. When the impedance of the RF circuit is 50 ohms, there is no error signal developed. When the RF circuit impedance is greater than 50 ohms, the error signal is negative. When the RF circuit impedance is less than 50 ohms, the error signal is positive.

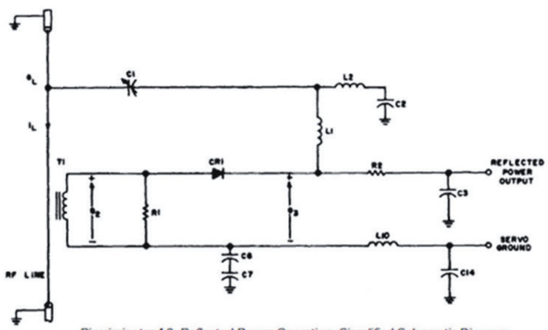


Discriminator A7, Loading Operation, Simplified Schematic Diagram.

Forward Power: The Forward Power is proportional the Current iL in phase with eL.
Reverse Power: The Forward Power is proportional the Current iL out of phase with eL.



Discriminator A8, Forward Power Operation, Simplified Schematic Diagram.

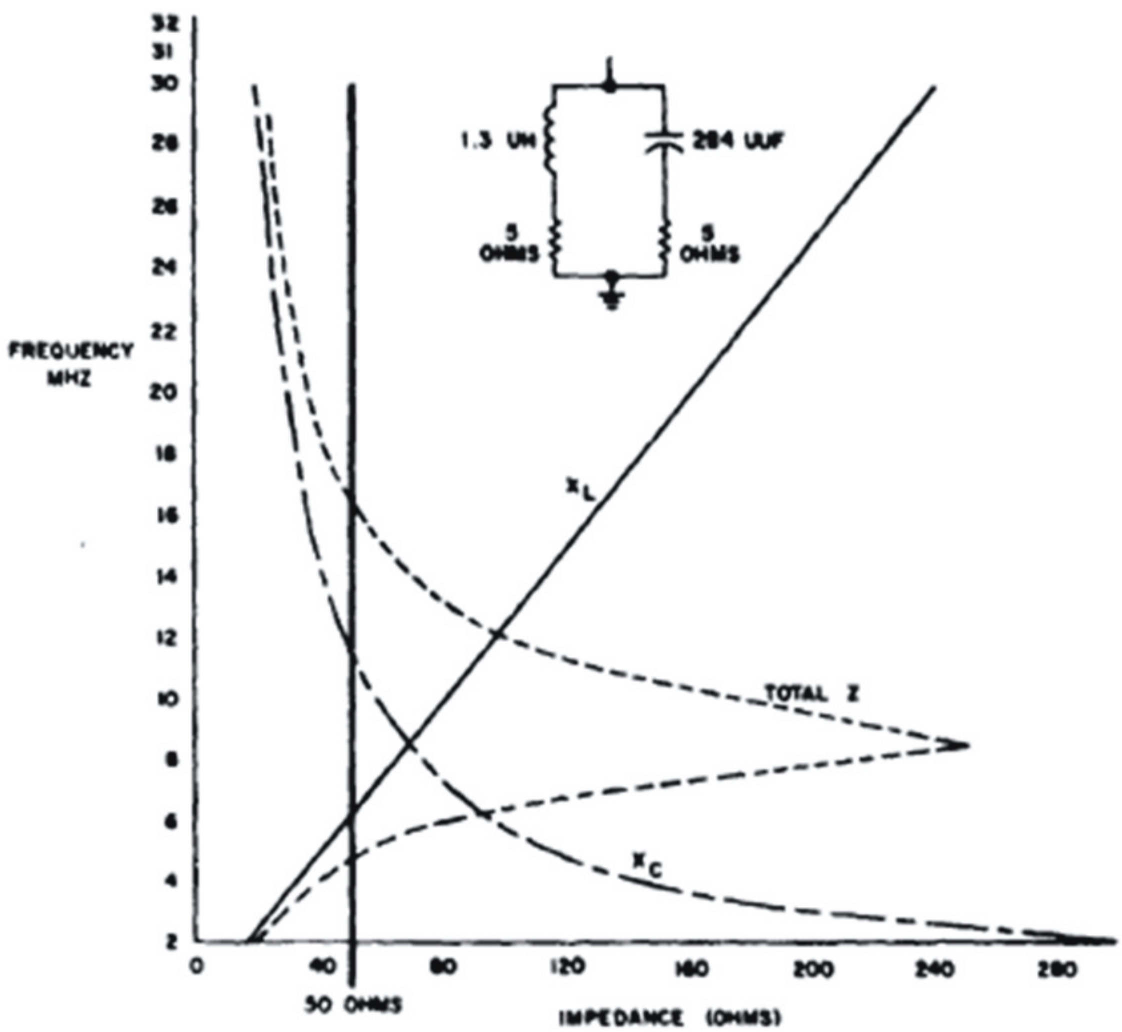


Discriminator A8, Reflected Power Operation, Simplified Schematic Diagram.

Band Information Circuit

To quickly achieve a tuning solution, the 490T needs to know the approximate frequency of the incoming RF signal. This information is used to pre-tune the tuning elements. This pre-tuning gives speed to the coupler and avoid possible resonant tuning. In previous couplers, this information was provided by the transmitter with additional wiring.

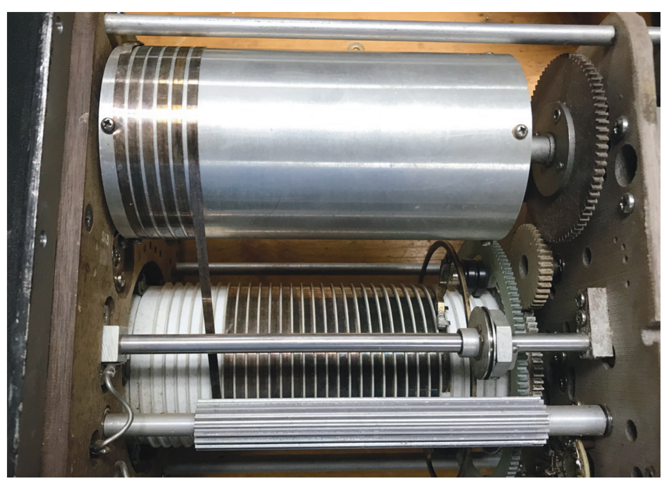
The 490T has a frequency band information circuit that consists of a parallel-tuned network that resonates at approximately 8.5 MHz This circuit is used as a transmitter dummy load for a short time after RF power is applied before tuning can start. When the frequency of the receiver-transmitter is above or below 8. 5 MHz, discriminator A8 uses the band information circuit to develop dc error voltages that are applied to the servo-amplifier and used to set the band sense circuits. The band information is used to limit the travel of the tuning elements. If the transmitter is operating in the 2 to 16-MHz band, capacitance is limited to three steps. In the 16 to 30-MHz band, capacitance is limited to five steps. When operating in the 2 to 16-MHz band, shunt capacitance is added if the series capacitor reaches its maximum limit, and the antenna is not yet capacitive and greater than 50 ohms.



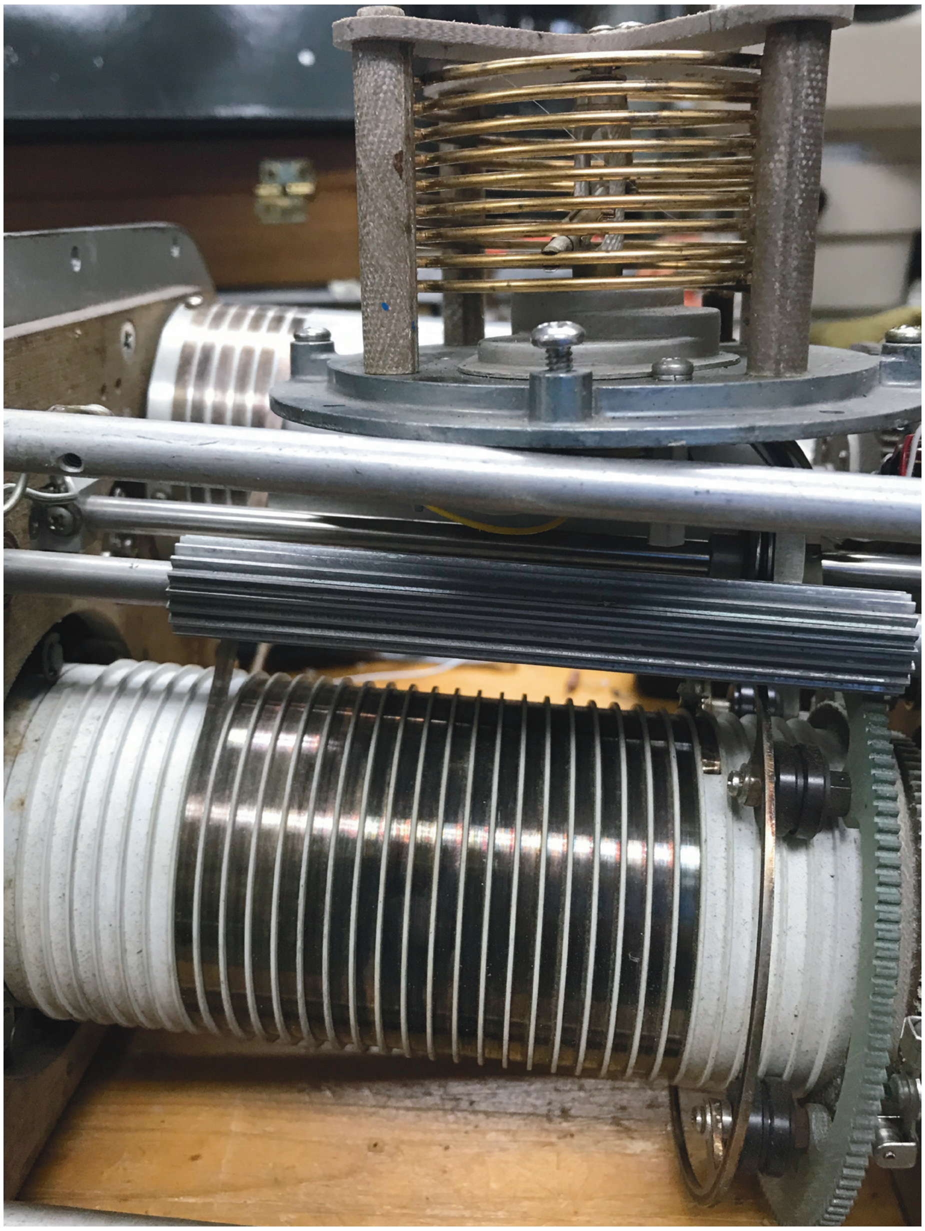
Tuning elements

The tuning elements are: A5 - Series Varicoil, A6 – Shunt Varicoil, A4 – Step Coil, A7 – Shunt Cap, A9 – Series Cap and A10 – Cap Assy. The picture below shows one of the varicoils.

The varicoil was very innovative and simple compared to the previously adopted solution. It was small, light, inexpensive, and with only the pickup stick being the only rotating element. This allowed for fast tuning, small motors and low sensitivity to acceleration. On the right is a picture of the variable inductor used on the Collins 180R-6 coupler. This older solution had two large rotating cylinders that spooled and unspooled a long silver flat wire.



The picture below shows the 490T varicoil with the older 180R-4 variable coil.



A3 – Control Amplifier

This module consists of 2 servo amplifiers. These include solid state 400Hz choppers to convert the input DC signal into 400Hz signals to drive the AC servomotors of the applicable tuning elements. The 400Hz of the generated signal is dependent upon the polarity of the input DC signals. The Control Amplifier also keeps memory of the Band Information.

A2 – Coupler Control

The coupler control is the "heart" of the system. It is an electromechanical computing device that sequentially controls and tunes the coupler. In engineering terms, it is called a "State Machine". Electronic Control Amplifier provides AC signals, derived from Phasing and Loading measurements, to drive the Shunt and Series Varicoils.

About the coupler Control

I will attempt to explain a state machine by using an example: the actions required for any of us to take a commercial flight: drive to airport, park car, get the boarding pass, go through security, walk to gate, board plane. Let's assume that each action is a state; we all know that we cannot walk to gate until we go through security or get to the airport. Basically, a state machine performs actions in a preset and logical order. Only when the current action is completed, the following action can be executed. In the case of our 490T, the Coupler Control does know how to tune the coupler in logical steps, and will not proceed to the next step until the current step is successfully completed.

The Coupler Control implements a State Machine with relays, silicon-controlled rectifiers (SCR) and diodes. The antenna coupler tune cycle starts when RF power is applied to discriminator A8 and ground is applied momentarily to the key circuits in coupler control A2. The schematic of the Coupler Control is very criptic and will not yield much of its secrets. At least for me, I can't look at that schematic and figure out its logic. In these days and age, a simple microcontroller would be executing the state machine.

Back to the A2 Coupler Control, be aware that there are a few known versions of the Coupler Control. These are CPNs 528-0465-000, 608-9500-001 and 608-9500-002. They are functionally equivalent but they have different internal layouts. I believe that CPNs 608-9500-001 and 608-9500-002 have the same schematics. From a functional point of view, any schematic version can be used, as the relay numbers are the same. The US Army TM 11-5985-326-35 manual has the schematics of both types.

How does the coupler work?

Home

The first step is the Homing step. This is a preparatory step and sets the tuning elements to known initial positions. The controller A2 positively confirms that all tuning elements are home before going to step 2. During the Homing step, RF power is NOT applied. Without achieving a positive Homing, the 490T will not enable RF power on and will not attempt to tune any further.

A Homing is initiated anytime the corresponding 618T is retuned or powered on. The 618T exercises the Recycle line to command the 490T to Home (J1-F on the 490T-1).

A positive Homing step is followed by an RF-ON. RF is applied by the 618T, and it can be seen on a Power Meter between the 618T and the 490T. An indication of a failed Homing step is the Tune and OPR lights being off and the 490T sitting there and doing nothing. Any failed step following "Home" will light both the Tune and OPR indicating a failed tuning cycle.

Step 2 – RF On
Step 2 is initiated when the operator pushes the PTT or CW key. When voice any voice mode is selected, keying is accomplished by depressing the push-to-talk switch of the microphone. The RF from the 618T is enabled by the 490T. From this point on the 490T takes control of the transmitter Key Line, until completion of the tuning or tuning time out (About 8 seconds). During the tuning cycle, the 618T is forced into AM mode. The Tune light turn on. The A1K2 relay momentarily applies RF to the Band Information Circuit, and the A8 Discriminator module provides corresponding Forward and Reflected Power, Loading and Phasing measurements.

Band Information Pre-Tuning
A pre-tuning of the tuning elements is done after determination of the frequency band of the incoming RF signal. The band relay A1K2 allows the RF signal to be fed to the band information circuit. The band information circuit presents the same load to the transmitter each time it is tuned to a given frequency. When the VSWR is larger than 1:3:1, the readings from the A8 discriminator, determine the initial position of the tuning elements. Relays A3K1 and A3K2 are set in this step to indicate the band selected.

Band in MHz	A3K1	A3K2
2 to 4	ON	ON
4 to 8	ON	OFF
8 to 16	OFF	OFF
16 to 30	OFF	ON

Antenna Tuning
The antenna can be
- Capacitive
- Inductive
- Above 50 Ω or below 50 Ω

The coupler logic adjusts the tuning elements to find a tuning solution. Forward power and reflected error signals greater than 1.3: 1 will start a tuning cycle. This action lights the TUNE indicator lamp. If the VSWR is less than 1.3:1, the antenna coupler will skip the tuning cycle. The OPR indicator lamp lights when tuning is completed.

After homing is completed, depressing the receiver transmitter key applies a momentary ground to operate key relay A2K7. A circuit internal to the 490T keeps the 618T keyed while the antenna coupler is tuning. This is done by connecting together the Interlock Pins S and L on the 490T J1.

Series and Shunt Varicoils Error Circuits
The series varicoil phasing sense circuit compares the output of the series servo-amplifier with a 400-Hz reference voltage to determine whether the antenna circuit is capacitive or inductive. If the antenna circuit is capacitive, the series varicoil maximum sense circuit is activated, adding additional inductance. If the antenna circuit is inductive, the inductance is reduced to match the antenna system. During the tuning operation, the series varicoil sense circuits, in conjunction with the loading sense circuit, controls the positioning of the tuning elements.

The shunt varicoil sense circuit determines if the resistive component of the antenna system is above, equal to, or below 50 ohms. The sense circuit is activated when the antenna system is equal to or greater than 50 ohms.

Initial Tuning
Antenna circuit is inductive or less than 50 ohms
The antenna coupler adds series capacitance until the series capacitor reaches its maximum limit. If the antenna circuit is still inductive, the shunt capacitor adds capacitance until the antenna circuit is capacitive and, if required, greater than or equal to 50 ohms magnitude.

Antenna Resonated With Resistance Less Than 50 Ohms.
Discriminator phasing error voltage drives series varicoil A5 from minimum toward maximum. If series varicoil A5 reaches maximum limit, step coil A4 inserts increments of inductance until the antenna becomes resonant. If the antenna is not resonated when step coil A4 reaches the maximum limit, shunt capacitance is added. When step coil A4 inductance or shunt capacitance is added, the series varicoil A5 will run to maintain a phased antenna. Fault condition will occur after approximately 10 seconds if shunt capacitor A7 reaches its maximum limit.

Resistance greater than 50 ohms after resonance.

If shunt capacitance is added during this loading operation, series varicoil A5 is decreased in inductance to maintain the antenna circuit at resonance. If series varicoil A5 reaches minimum inductance before resistance is decreased to 50 ohms the following occurs:

- From 2- to 8-MHz Step coil A4 decreases inductance.
- From 8- to 16-MHz Series capacitance is added.

Antenna coupler will fault if series or shunt capacitors reach maximum limits and resistance is not equal to or less than 50 ohms.

Loading if Resistance is Greater Than 50 Ohms

Shunt capacitance is added if the resistance of the antenna circuit is equal to or greater than 50 ohms after the circuit is resonant. Shunt capacitor A7 continues to operate until the antenna circuit is less than 50 ohms or maximum capacitance is reached. During this loading operation, series varicoil A5 inductance is decreased to maintain the antenna circuit at resonance. Series capacitance is added if series varicoil A5 reaches minimum inductance before the resistance is decreased to less than 50 ohms. The antenna coupler faults in approximately 10 seconds if series capacitor A9 reaches the limit or shunt capacitor A7 reaches maximum capacitance and the resistance is not 50 ohms or less. When the resistance is less than 50 ohms, the antenna coupler circuits advance to the tune B mode of operation.

Final Tuning

During the Final Tuning (Tuning B), the shunt relay A1K1 restores connecting shunt varicoil A6 into the antenna circuit. The series and shunt varicoils are tuned to adjust for the phasing and loading impedance mismatch introduced by the inductance of shunt varicoil A6. The operation of shunt capacitor A7 is controlled by series varicoil A5 sense circuit and shunt varicoil A6. Shunt capacitance is added when shunt varicoil A6 reaches maximum inductance. Shunt capacitor A7 continues to operate until shunt varicoil A6 is moved from the maximum inductance position opening. Tuning of the antenna coupler is now controlled by the reflected power error signal. When the reflected power is decreased to a 1.3:1 VSWR, the antenna coupler tuning is complete.

Operate and Demand Surveillance

After the Final Tuning, the servosystem is turned off but the antenna coupler continues to monitor forward and reflected power. If the reflected power rises above a specific level, the demand surveillance system takes over. The demand surveillance system activates the antenna coupler tuning circuits causing retuning. The initial tuning of the coupler is from the home position. In the demand surveillance mode, the coupler is tuning with the elements starting from a position determined by the previously tuned antenna impedance. With the elements starting from a position other than the home position, the new antenna impedance may be outside the tuning limits of the coupler. For instance, the series and shunt capacitors do not reverse in the tuning mode. If in the demand surveillance mode the new impedance requires a reversal of either of these two elements, the coupler will not retune. The antenna coupler goes back into the Final Tuning step.

Fault

If the antenna coupler does not tune in 8 to 10 seconds, the fault circuits disable the tuning circuits and both the OPR and TUNE indicators illuminate.

Troubleshooting

From an operational point of view, the 490T is very stingy about providing information to the users to troubleshot a "dead" or failed 490T. When failed, the 490T either does nothing or tries to tune and later lights its TUNE and OPR indicators. The operator and owner is often left without any hints on how to proceed or how to investigate. Of course, if you happen to have access to a Collins 978L-x test set (also known as AN/ARM-109), your life may be a little easier, but there are cases in which the test set can't help you.

How to Check for Home Condition

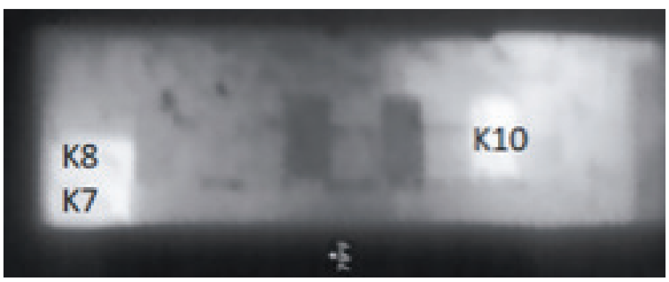
If the Coupler applies RF-ON, the homing step was successful! Therefore, most likely you have a bad A2 module. All the 490Ts I worked on had one or more tuning elements "frozen" and unable to home properly after sitting idle for years. I was able to free them by using a small plastic stick to move the varicoils and the gears of the step coil and capacitors.

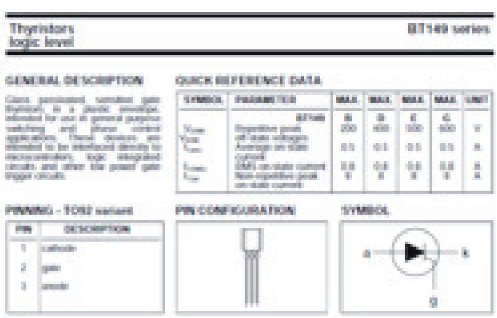
To identify which element is not homing, retune your 618T and monitor the recycle line. This should be momentarily grounded during the recycle. Turn the system off and disconnect the power source. Remove the A2 Coupler control to gain access to connector J4 and J5. Follow these steps to figure out which tuning element is not homing.

Step Coil A4 @ Home – Minimum inductance and bypassed
– Step Coil A4 is home, when A4 P1-22 and 23 or J4-1 and J4-2 are shorted.
Series Varicoil A5 @ Home – Minimum Inductance
-Series Varicoil A5 is home, A5 P1-11 and P1-13 or J4-23 and J4-14 are shorted.
Shunt Varicoil A6 @ Home – Maximum Inductance and removed from the RF circuit.
-Shunt Varicoil A6 is home, A5 P1-11 and P1-13 or J4-23 and J4-14 are shorted.
Shunt Capacitor A7 @ Home – Minimum capacitance
– Shunt Capacitor A7 is home, when A7 P1-5 and P1-15 or J4-2 and J4-14 are open.
Series Capacitor A9 @ Home – Bypassed
– Series Capacitor A9 is home, when A9 P1-5 and 15 or J4- and J4-15 are open.

Other troubleshooting hints

For this particular type of product, I find that a low-cost IR camera can be quick and non-intrusive to figure out the status of the relays. The US Army TM 11-5985-326-35 gives guidance about the status of the relays at the divergent tuning steps. An inexpensive IR camera can also find components under temperature stress like old capacitors My camera is the Seek Thermal and costs about $150. It can do miracles when working a "new" Collins radio or boat-anchor. In a couple of minutes overworked components can be identified; leaking capacitors wave at us, well before they fail. With an IR camera, there is no need to be smart!





CB1018 SCR

A note about the SCRs. The 490T makes great use of a custom SRC (CB1028). The CB1028 is pretty much unavailable or very pricey. Through some experimentation, I discovered that a "common" BT149 is a good replacement for less than $0.50 each!

Special thanks for the preparation of this article go to Loney Duncan W0GZV, Scott Johnson W7SVJ and Don Jackson W5QN for their suggestions, advice, and editing.

New Board Members

Loney Duncan, W0GZV

Loney Duncan joined Collins Radio, Cedar Rapids, in 1957. He served in engineering development and line management, becoming a division director of HF Equipment and High-Power Transmitters. This division developed the paradigm shift avionics 718U HF transceiver and 651S receiver. Additionally, it developed the 821A-2 second generation 250 kW shortwave broadcast transmitter and the TACAMO 200 kW airborne VLF (17-30 kHz) transmitter and trailing wire antennas.

In 1976 he joined the corporate engineering staff of Rockwell International who had purchased Collins. He became VP, Electronics Technologies and Processes, reporting to the Chief Engineer of Rockwell. Loney retired in 1998 after almost 41 years with Collins and Rockwell.

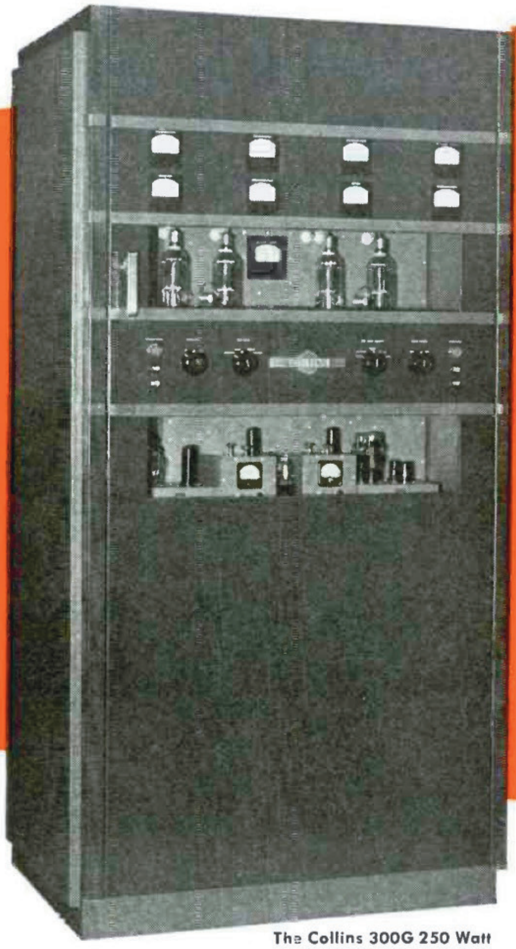
Loney (LEFT) is seen in the photo on the top right working on Fifi.

Dennis Kidder, W6DQ

My interest in amateur radio began in 1964 following the Alaska earthquake. My neighbor was Bob, W6QJU, and he gave my dad and I a tour of his ham shack while on a break from handling emergency traffic out of the disaster area. I was hooked, and my interest was peaked when I started my quest for a Novice license. Before I could get my ticket, Bob moved away. It was not until I got to high school that I hooked up with the school's radio club and became friends with one of the members, then WN6MRM, Sid, now K6AF. Sid introduced me to his father, Harrison, W6PM (SK), who helped me get my Novice license in December of 1969, WN6NIA. Through Sid and his father I met two other local hams, Bill, W6DR (SK), and Chek, W6DQ (SK). They became my Elmers and they all had one thing in common: Collins S-Line gear. W6QJU first introduced me to Collins (he also ran an S-Line) and had given me a catalog (that I still have) and told me, "When you get your license, this is the gear you want to have." Truer words were never spoken. My parents truly supported my ambitions and for accomplishing the grant of my license. For Christmas that year, they took me to Henry Radio in West LA, from which I came home with a used 75S-3 and a new 312B-3 to go with it. Those two pieces of gear are now sitting on one of my operating positions and in use every week. I've added a lot more since then. In 2006, I was thrilled to receive the grant of my former Elmer Chek's call, W6DQ.

Since that first 75S-3 my passion for collecting vintage radios has grown, and I have amassed a substantial collection of Collins amateur, commercial and military equipment, with representations of each decade that Collins produced amateur products as well as commercial. Amateur pieces such as the 4A and 30FXR transmitters represent those early years. I have examples of almost every A-Line product including a KW-1 with a matching 75A-2. Into the sideband era, two sets of Gold Dust Twins, a KWM-1, two S-Lines and KWM/2(A)s. I round out the amateur products with a KWM-380. On the commercial side I have two broadcast transmitters, a 550A-1 and a recently obtained 820D-2. At last count there were over 100 pieces of equipment having the Collins brand. All of this will soon be housed in a 1500 sq ft "ham shack," nearing completion, in the center of our 5 acre antenna farm named "Faraday Fields" that my wife, Lisa, KF6QNG, and I own near the tiny burg of Inyokern, California.

Today, I serve on the CCA Board as secretary, and am the Net Manager for the CCA's West Coast Friday night 75 meter sideband net. In the wake of our major earthquakes in our region, I recently received an appointment from the ARRL as an ARES Emergency Coordinator for Eastern Kern County. I have capabilities at Faraday Fields on almost all bands between 160 meters and 24 GHz (soon to include 122 GHz). And in case anyone was wondering, I do own modern radios as well, the primary being a Flex 6700 coupled with an Alpha 87A, several other Flex Radios, and several requisite Yaesus and Icoms. What can I say? I have a passion for radios. To honor my Elmers fifty-plus years later, I do all I can to give back to the amateur community as they did for me. Over the past 20 years I have been a speaker/presenter of many topics at radio clubs, conferences and conventions throughout California. I entered retirement from the aerospace industry in 2012 and promptly co-authored, with Jack Purdum, W8TEE, Arduino Projects for Amateur Radio, published by McGraw-Hill. In the end, Sid and I are still close friends and speak with each other regularly on 75 meters ... another one of the many joys of being a radio amateur!



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