[HOME] [News] [About Me] [My Station] [My Expeditions] [AMATEUR RADIO] [ANTENNAS] [MODERN ANTENNAS] [SPIDERBEAM] [My Favorite Antennas] [Loop Antennas] [Off-Center Fed Dipole] [VERTICAL Antennas] [Vertical Dipole Arrays] [Wire Beams] [ANTENNA MATCHBOXES] [antenna tuners] [Antenna Tests] [BALUN STUFF] [RF Chokes] [Transceivers] [Chinese Handhelds] [Downloads] [Contest University 2013] [Common Mode Chaos] [CMC TEST] [Ricki-Leaks] [Gallery] [B o B] [TEN-TEC STUFF] [SITE MAP] [LOGIN BELOW] [Rambo.de Domain] [Contact] IMPRESSUM DISCLAIMER Datenschutzerklaerung

{Matchbox or Ant Tuner?}

{Matchbox Needed (?)}

{Matchbox Pwr Ratings}

{Matchbox LOSSES}

{"PERFECT" MATCHBOX}

{Why so many Types ?}

{Symmetric / Asymmetric}

{Asymmetrical Matchboxes}

{Symmetrical Matchboxes}

{* A N N E C K E *}

{ATU POWER RATINGS}

MATCHBOX SHOOT-OUT

MATCHBOX DO's & DON'Ts

HOW TO KILL A MATCHBOX

MFJ MATCHBOXES

SUMMARY / CONCLUSION

(Today = 8/8/2015)

Gemuenden, Germany

Site Search

http://DJ0IP.de
.....(Search on THIS site.)

Antenna Matchboxes

[Antenna Tuners]

NOTE: My web is about my experience, not speculation. I am old-school and prefer manual antenna matchboxes over automatic tuners. These pages are mostly about manual tuners.

TYPICAL ANTENNA MATCHBOX QUESTIONS and TOPICS:

<> WHAT IS AN ANTENNA MATCHBOX ? (on this page, below:)

<> WHAT IS THE DIFFERENCE BETWEEN ANTENNA MATCHBOX AND ANTENNA TUNER?

<> WHEN DO WE NEED TO USE AN ANTENNA MATCHBOX?

<> MATCH BOX POWER LOSSES?

<> THE "PERFECT" MATCHBOX?

<> WHY ARE THERE SO MANY TYPES OF ANTENNA MATCHBOXES?

<> WHAT ARE THE DIFFERENCES? - SYMMETRICAL? - ASYMMETRICAL?

<> ASYMMETRICAL MATCHBOXES: (Unbalanced Matchbox)

<> SYMMETRICAL MATCHBOXES: (Balanced Matchbox)

<> WHICH ONE SHOULD I USE ? (not yet finished - sri)

<> ANTENNA MATCHBOX POWER RATINGS?

WHAT IS AN ANTENNA MATCHBOX ?

An antenna matchbox is a device used in the antenna line for the purpose of matching two different impedances to each other. It is typically used for matching a transmitter (or transceiver) whose impedance is 50 Ohms, to an antenna system (antenna plus transmission line) whose impedance is not 50 Ohms.

Ultimately its job is to transfer as much power to the antenna as possible.

Unfortunately it doesn't alway work that way.

The antenna matchbox may be built into the radio, or be in a separate box.

- The advantage of having it inside the transceiver is, you have everything in one box.
- The advantage of having an external matchbox is, it can be larger, use larger components, and therefore match a broader impedance range. You can also use it with other transceivers.

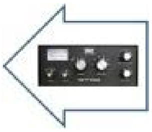
Other names for the antenna matchbox:

- Antenna Tuner
- Antenna Coupler
- Antenna Tuning Unit
- Or simply ATU

What is the difference in all of these?

See the next page...

(NEXT PAGE: ANTENNA MATCHBOX OR ANTENNA TUNER ? >>>)



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Antenna Tuners

"Matchbox" or "Antenna Tuner" ?

WARNING: THIS PAGE IS OPINIONATED !

- **Antenna Tuner?**
- **Antenna Coupler?**
- **Antenna Matchbox?**
- **Antenna Matching Network?**
- **or simply ATU?**
- **Remote Matchbox/Tuner ?**

EFFECTIVELY THESE ARE ALL THE SAME.

They are the names we call the device which enables a transmitter with a specific impedance (usually 50 Ohms) to efficiently transfer its power into a transmission line and antenna which have a different impedance.

NOTE 1: [very important!] Just because the matchbox is able to matcht the antenna and transmission line to the transmitter with a perfect match (SWR = 1.0:1), that does not necessarily mean that all of the power being passed through the matchbox to the antenna.
THERE IS ALWAYS SOME POWER LOSS WHEN USING A MATCHBOX.
THIS IS VERY IMPORTANT TO UNDERSTAND.

NOTE 2: [and also very important!] Just because power is efficiently transferred into the transmission line (with very little loss inside the matchbox), do NOT assume the it effeciently arrives at the antenna! **Don't make that mistake! Transmission lines, ESPECIALLY COAX, can add significant loss to the antenna system.**

Why DJ0IP prefers the term "Antenna Matchbox" or simply "Matchbox"?

The matchbox's job is to match two devices with different impedances to each other. In doing so, we usually are able to transfer more power to the antenna system. The word "matchbox" is descriptive of it's role in the process of delivering power to the antenna.

S NOT 'TUNE' THE ANTENNA! NEVER!
(with one exception)

To do that, the matchbox would have to be located at and be a physical part of the antenna.

AND IF IT WERE PART OF THE ANTENNA, IT WOULD NOT NEED A SEPARATE NAME AND DESCRIPTION!

But it does match the antenna and its transmission line (the antenna system) to the transmitter. Therefore I prefer to say "match" and not "tune".

POSSIBLE EXCEPTION: If you are using a **Longwire Antenna**, where the wire itself begins inside the shack, at the matchbox, then perhaps it can be considered as tuning the antenna (the military calls these Antenna Tuning Units) but in fact it is not changing the electrical/physical characteristics of the antenna. It is just still just matching it to the transimtter.

Most people seem to prefer to call a matchbox an **Antenna Tuner**.
I can't change that and I won't even try.

Just assume that Antenna Tuner means the same thing as Antenna Matchbox.

SOME SAY *"IT TUNES THE ANTENNA SYSTEM"*

This is more of a semantics question.
Is the matchbox itself part of the antenna system, part of the transmitter, or an independent device on its own?
In my opinion a MATCHBOX is an independent device on its own, whose purpose is to be inserted between two devices (the transmitter and the antenna system) and match them together, with the intent of increasing the amount of power that is transferred to the antenna. Unfortunately it doesn't always increase the power transferred to the antenna. Quite often it decreases the power transferred!

THE MATCHBOX IS AN ENABLER

In the presence of a mismatch, it enables the transmitter to deliver more power to the antenna system than it would without a matchbox. On the other hand, if the antenna is already well matched to the transmitter, the internal loss (in every matchbox) actually reduces the power transferred to the antenna.

WHAT DOES "ATU" MEAN?

Some people use this acronym for "Automatic Tuning Unit", meaning an automated device for matching the antenna. Others use the term simply to mean "Antenna Tuning Unit". No sense in taking sides in that arguement. I just accept both as being correct. AND I CALL BOTH "MATCHBOXES."

ANTENNA COUPLER?

Same, same. Just another name for the same thing.

REMOTE MATCHBOX / REMOTE ANTENNA TUNER ?

A Remote Matchbox is a matchbox which is located outside in the open, and it either tunes automatically, or is tuned manually by a remote control head, located in the shack. Functionally, it is exactly the same thing as any other matchbox.

SO WHAT DO ALL OF THESE REALLY DO ?

- **Simple Answer:** They match two devices with different impedances to each other.
- **More Technical Answer:** What tuners do by Steve Hunt, G3TXQ.

REASON "NOT" TO CALL IT A MATCHBOX:

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BAD BALUNS
|

Some people believe that the word "matchbox" is proprietary and belongs to E.F. Johnson. This goes back to the 1950's to the days of the Johnson Viking Matchbox and Johnson Viking Kilowatt Matchbox.

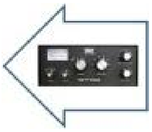
I give credence to this arguement. Other similar devices at the time were referred to as "Matching Network" or "Z-Match" (a specific type). However I was unable to find any proof that E.F. Johnson ever actually trademarked the word "Matchbox".

I PERSONALLY REFER TO THEM AS A "MATCHBOX".

IMO, NO OTHER NAME DESCRIBES THEM BETTER.

YOU CAN CALL THEM WHATEVER YOU LIKE!

[NEXT PAGE: IS A MATCHBOX REALLY NEEDED? }>>



What's Wrong with OCFD

LL-TUNER "S-MATCH" added to my symmetrical tuner page. **HERE**

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Anenna Tuners

WHEN DO YOU NEED TO USE A MATCHBOX?

[Are you sure you even need a matchbox?]

WHEN SHOULD YOU USE A MATCHBOX ?

ANSWER: Hopefully Never! . . . because ALL matchboxes add unwanted losses!

But in reality: In general, you need to use a matchbox whenever the impedance of the antenna and its feedline (the antenna system) does not match the impedance of the transmitter (usually 50 Ohms). For instance:

- On 80m where the band is simply too wide to be covered by a single antenna.
- When you wish to feed the antenna with openwire feedline.
- When using multi-band antennas (generally a compromise).
  - e.g., G5RV, Windom (also called Off-Center-Fed Dipole or "OCF"), multi-band antennas without adjustments for the individual bands, etc.
- When you purchased a transceiver with a poorly designed finals stage, where the power folds back with higher SWR. *** (will be explained below)**
- When you purchased a Linear Amplifier which trips to fault when the SWR exceeds a pre-determined level (which is often too low to be practical). **** (will be explained below)**

WHEN IS IT BETTER NOT TO USE A MATCHBOX ?

TWO ANSWERS:

1. **As often as possible.**
   - ALL antenna matchboxes induce additional loss to the antenna system. With good matchboxes it is less than 10%, but not all matchboxes are good - and NO MATCHBOX is good on every band with every impedance. NEVER BELIEVE THEIR MARKETING. Use 3rd party resources, such as ARRL Lab tests to determine a matchbox's effeciency. (See MATCHBOX SHOOT-OUT for more information)
2. **Whenever you are using monoband antennas.**
   - With monoband antennas, it is usually possible to fix the antenna instead of using a matchbox. This is always the most efficient solution - because ALL matchboxes add additional loss to the system.

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RULES TO FOLLOW:

- **NEVER USE A MATCHBOX IF YOU DO NOT ABSOLUTELY HAVE TO !**
  - **Switch it to "BYPASS" or "THROUGH" when it is not absolutely needed.**
- **IF YOU HAVE TO USE A MATCHBOX, BE SURE YOU USE ONE THAT IS WELL SUITED FOR THE JOB. Remember, different matchboxes have different Sweet-Spots.**
  - **Otherwise you may incur excessive power loss within the matchbox.**

(THE CONTENTS BELOW ARE MY PERSONAL OPINION.)

BAD EXAMPLES:

*** Many Transceivers**, especially those built in Japan, **fold back their output power** in the presence of high SWR to prevent damage to the final transtors.
The question here is, *"what is the definition of high SWR?"*

- **Some transceivers fold back the output power when the SWR exceeds 2.5:1.**
  - This is reasonable but still not good, especially if the SWR problem is just an instantaneous one, due to the antenna swaying in a breeze.
  - GOOD TRANSCEIVERS will operate all day long into an SWR of 3.0:1 without folding back their output power. Personally, I prefer to use a good transceiver, not one where the manufacturer saved a few dollars on the final amplifier stage.
- **Other transceivers fold back their output power by as little as 2:1 SWR.**
  - This is totally unacceptable and a clear indication of an under-dimensioned final amplifier stage.
  - Many people simply accept this as "normal" because the don't realize that there are transceivers which have much better designed final amplifier stages.
  - **Transceivers like these are totally unacceptable to me, but that's my opinion.**

There are good transceivers on the market which will deliver full power, all day long, into an SWR of 3:1. (For instance, any TEN-TEC transceiver). Many other "better transceivers" can also deal with 3:1 SWR. Most of the lower cost transceivers cannot. That's why they are cheaper.
MOST PEOPLE DON'T EVEN REALIZE THERE ARE DIFFERENCES HERE!

Any time you have to use a matchbox in your antenna system, you are inserting additional losses. It is always better not to run a matchbox if you don't absolutely have to.

**** Many Linear Amplifiers** are equipped with **fault monitoring circuitry** which among other things, trips to fault whenever the SWR exceeds a value which is dangerous for the amplifier. Though in principle a good idea, this is not necessary when running a well designed amplifier within legal power limits on the amateur bands. In fact, the protection circuit itself can also cause unnecessary trouble.

Unfortunately most modern amplifiers fall into this category. That's why I personally prefer amplifiers using "vintage" glass tubes, such as the 3-500z. The 3-500z tube is very rugged and most amplifiers using this tube do not have fault (do not need) trip circuitry.

Avoiding amplifiers with fault trip circuitry enables you to avoid the unnecessary need to use a matchbox.

The problem with SWR fault monitoring is, especially in stormy weather with antennas blowing in the wind, you can have instantaneous (non-dangerous) swings in the SWR which will trip the high SWR fault circuitry of many modern amplifiers. In reality these are harmless swings in the SWR because they immediately swing back to normal, and would not damage the amplifier. Never-the-less, the amp goes into fault mode and switches itself into standby position.
For this reason, I prefer to use amplifiers without SWR fault monitoring / warning.

The reason we have SWR fault monitoring in many modern amplifiers is, many modern tubes can blow almost instantaneously under certain over-current conditions. It is simply too dangerous (and too expensive) to run them without SWR fault warning.

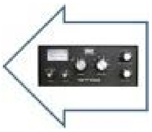
For this reason, I refuse to buy and use one of these modern amplifiers.
MOST PEOPLE DO NOT SHARE MY OPINION.
(They won't buy me a new tube, either.)

In my 50+ years on the air, I have owned 8 linear amplifiers which used the 3-500z tube(s). Knock on wood, (touch wood if you're British) I have never blown the tube(s) in any of these amplifiers. That's why I stick with amplifiers that use the 3-500z.

***** Most Transistor Linear Amplifiers** use fault monitoring / fault warning circuitry which trigger instantly in the presence of high SWR, but there are a few transistor amplifiers that do not. Instead these other amplifiers monitor for excessive heat (which can also be caused by longer periods of high SWR). So they also fault with high SWR, but only if it is for an extended period of time. They don't fault instantly with short swings in the SWR. In my opinion this is good enough. I have had good luck using this type of amp in contests. Unfortunately most transistor linear amps don't work like this. **They fault much too soon!**

IN MY OPINION, most transistorized linear amplifiers are good for normal ham radio use, great for portable use, but a very poor choice for serious contesting.

[NEXT PAGE: MATCHBOX POWER RATINGS }>>



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Anenna Tuners

MATCHBOX POWER LOSS

[ALL Matchboxes have Power Loss]

RULE OF THUMB:

**ALWAYS ASSUME THAT WHEN YOU USE A MATCHBOX
YOU ARE AUTOMATICALLY GIVING UP
AT LEAST 10% OF YOUR POWER.**

YOUR 100w is now only 90w!

(if you are lucky)

Don't be surprised if YOUR matchbox has even more loss!

**THIS IS WHY YOU SHOULD NEVER USE A MATCHBOX
UNLESS YOU ABSOLUTELY HAVE TO.**

MATCHBOX LOSS FACTS:

- **ALL MATCHBOXES HAVE LOSS. SOME HAVE VERY HIGH LOSS.**
  - Power loss can be less than 10% but it can also be 50% or more!
- **THE AMOUNT OF LOSS VARIES BY BAND AND FREQUENCY.**
  - Generally losses are highest on 160m and 10m
  - This is because it is not possible to optimize a matchbox for both ends of the hf spectrum.
- **THE AMOUNT OF LOSS VARIES, DEPENDING ON THE IMPEDANCE OF THE ANTENNA SYSTEM.**
  - Generally losses are highest in all matchboxes at low impedances (less than 20 Ohms).
  - But losses may also be high for high impedances in some matchboxes.
- **SOME TYPES OF MATCHBOXES ARE LESS EFFECIENT THAN OTHER MATCHBOXES.**

- The popular T-Matchbox usually has higher loss than other types, and . . .
- . . . quite often is mis-tuned resulting in even higher losses.
- Yet it is still popular due to its broad impedance matching range. - BUT JUST DON'T USE IT UNLESS YOU ABSOLUTELY HAVE TO!

- **USUALLY, EFFICIENT MATCHBOXES HAVE A LIMITED IMPEDANCE MATCHING RANGE.**
  - By limiting the matching range, we can use components optimized for one specific range.
- **GENERAL PURPOSE MATCHBOXES HAVE A BROAD IMPEDANCE MATCHING RANGE, BUT ALSO HAVE MORE LOSS THAN OTHER TYPES OF MATCH BOXES.**
  - This is the trade-off we often accept in order to have our **"All-in-Wonder Matchbox"**, capable of matching everything from the bedsprings to the Eifel Tower in Paris.
- **IT SEEMS YOU CAN'T HAVE YOUR CAKE AND EAT IT TOO.**
  - If you want to have a good matchbox for all bands and all impedances, you will need to buy or build 2 or 3 matchboxes.

The ARRL has measured Antenna Tuner (matchbox) losses for many common matchboxes. If you want to know how much loss your matchbox has, perhaps it has been tested by them. See MATCHBOX SHOOT-OUT for this.

WHY MATCHBOXES HAVE LOSSES:

FIRST OF ALL, EVEYTHING THAT RF PASSES THROUGH HAS LOSSES, NO EXCEPTIONS!

THE LOSSES INSIDE OF THE MATCHBOX ARE DUE TO:

- **THE SIZE AND QUALITY OF THE COMPONENTS USED**
  - **For the lower bands**, especially 160m, we need a lot of capacitance and especially a lot of inductance. In order to obtain a high Q (to reduce loss), we would need a very large coil. Since a matchbox the size of a washing machine will not fit on our desktop, we use smaller components and accept a compromise. **(slightly exagerated, but you see the point)**
  - **For the 10m band**, we need very small values of capacitance and inductance - typically smaller than the minimum capacitance of the variable capacitor. If we make the variable capacitor smaller, we will have worse efficiency on the low bands. **It's a trade-off.**
- **THE COMPROMISE WE ACCEPTED FOR THE PURPOSE OF ACHIEVING A BROAD IMPEDANCE MATCHING RANGE, RESULTS IN ADDITIONAL LOSSES.**
  - We can improve the effeciency (reduce the loss) by focusing on a smaller matching range and then selecting components optimized for that range. The efficiency goes up, but the usefulness of the matchbox goes down. **As I said, it's a trade-off.**

I will stop there and give you a link where you can read more.

DOWNLOAD: ***GETTING THE MOST OUT OF YOUR T-NETWORK ANTENNA TUNER.***

The following file is also available on the ARRL Web Site as a public download. You do not have to be an ARRL member to download this file.

GETTING THE MOST OUT OF YOUR T-NETWORK ANTENNA TUNER
This document was written by Andrew S. Griffith, W4ULD, and published in the January 1995 issue of QST.
Getting the most out of your T-Matchbox.[...]
PDF-Dokument [406.9 KB]

[NEXT PAGE: THE "PERFECT" MATCHBOX}>>

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Antenna Tuners

THE "PERFECT" ANTENNA MATCHBOX

(ONLY AVAILABLE IN HAM HEAVEN)

.... Joe HAM ....

Most People Expect Too Much from their Antenna Matchbox . . .

EVERY MATCHBOX HAS A "SWEET-SPOT"

(...but no Matchbox can do everything.)

DEFINITION of MATCHBOX "SWEET-SPOT" - The "Sweet-Spot" of a matchbox is the range in Frequency and Impedance where the INTERNAL LOSS of the matchbox when tuned for a good match to the 50 Ohm transmitter, is *LESS THAN 10%.*

Matchboxes can also find a *"good looking match"* outside of their Sweet-Spot. In fact they can usually obtain a *good looking match* to impedances quite a ways outside of their Sweet-Spot. The only problem is, when working outside of their Sweet-Spot, the matchbox internal losses go up. Sometimes WAY UP.

Often internal losses in a matchbox can reach 50% or even higher!

Pictured below is a Loss-Table of a TYPICAL MATCHBOX.

The green area represents its Sweet-Spot, where internal losses are less than 10%. The orange area is where the internal losses are between 10% and 35%. The red area is where the internal losses are greater than 35%.

. . . . . (In reality, most matchboxes are WORSE than this.)

THE REASONS:

- Many people consider the term "Matchbox" (or "Antenna Tuner") as a specific term and believe that all things called that must be more or less the same. **NOT!**
- In reality, the term "Matchbox" is like the word "Car". It can mean just as many different things as "car" means.
  - A Porsche and a Corvette are both great cars.
  - A Mercedes "S-Class" and a Lincoln Continental are both grest cars.
  - Nobody expects the Continental to be able to do the same things as the Corvette, nor do we expect the Porsche to be able to do the same things as the Mercedes.
  - **Yet many people seem to think all matchboxes should be able to do everything! How Silly!**
- Most people don't know or don't stop and think about how different the task of matching a 160m antenna is to the task of matching a 10m antenna.
  - Component values for 160m may be has high as a few thousand pF and 50 uH
  - Component values for 10m may be as low as 10pF and 1 uH
  - **It is virtually impossible to build one single matchbox that can meet both of those requirements effeciently.**
- Most people don't know or don't stop and think about how different the impedance of different antennas might be.
  - Some antennas such as a short 160m vertical might have an impedance as low as 10 Ohms or even less.
  - Yet when trying to load an 80m dipole fed with openwire on 40m, the impedance might be as high as 2K or 3K Ohms.
  - **It is virtually impossible to build one single matchbox that can EFFECIENTLY match such a broad impedance range.**
- **When Joe Ham buys a matchbox and finds it won't match his favorite antenna, the first thing he does is blame the matchbox. He never once considers that he may have bought the wrong size shoes and that's why his feet hurt.**

If Joe Ham really wants to match everything effeciently,

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BAD BALUNS

|

it may be that Joe needs to buy two or three different kinds of matchboxes!

ALL GENERAL PURPOSE MATCHBOXES LOOK SIMILAR TO THE CHART ABOVE.

- Some are better on the higher bands, some are better on the lower bands.
- Some are better at lower impedances, some are better at higher impedances.
- **NO MATCHBOX IS GOOD AT ALL OF THESE.**

THE SWEET-SPOT IS DIFFERENT FROM ONE MATCHBOX TO ANOTHER.

It is wrong to say a matchbox is bad, just because it won't match "your" antenna. That matchbox was probably designed to match something else. You didn't buy a bad matchbox . . . **. . . YOU BOUGHT THE WRONG MATCHBOX !**

*If a **Soccer Mom** can't take her 4 boys to the soccer match becaue they won't fit in her Corvette Stingray, does that make the Corvette a bad car? (It's not the car's fault!)*

THE TRICK:

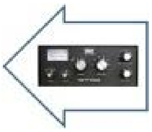
The Trick is to find a matchbox whose Sweet-Spot matches the impedance of the antenna you wish to match, on the bands you wish to use it on.

IF YOU DO THIS RIGHT, THEN YOU HAVE FOUND THE PERFECT MATCHBOX!
(...but it's only perfect for YOU; maybe not for the next guy...)

In this section of my web site, I will try to help you understand what is important for finding the perfect matchbox for your own personal antenna matchbox requirements.

We will use the ARRL's Antenna Tuner test results, which they have published in QST over the years. There is no need to guess at this, or to take chances with a matchbox. Most of the information is available from the ARRL. You only have to read it and use it for your purchase decisions.

[NEXT: Why so many different types of Matchboxes? }>>



What's Wrong with OCFD

LL-TUNER "S-MATCH" added to my symmetrical tuner page. HERE

THIS WEEK:

Noch Nichts

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Matchbox Shoot-Out has been UPDATED

Updated: 16 June 2013

LOTS OF NEW CONTENT IN THE SECTION: ANTENNA MATCHBOXES

MODERN ANTENNAS

WIRE BEAMS

It's time to build antennas! Visit: Spiderbeam Antennas

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{Matchbox or Ant Tuner?}
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MFJ MATCHBOXES
SUMMARY / CONCLUSION

www.dj0ip.de has had 1 Million Visitors! as of TODAY!

(Today = 8/8/2015)

Gemuenden, Germany

Antenna Tuners

Why are there so many different Types of Antenna Matchboxes?

THE SHORT ANSWER:

Because we wish to use so many different kinds of antennas on many different bands.

AND

It is impossible for one matchbox technology to do all of this efficiently!

A DETAILED ANSWER:

WE HAVE A LONG LIST OF VERY DIFFERENT MATCHING REQUIREMENTS:

- **MATCH FULL SIZE ANTENNAS (i.e. DIPOLE) ON THE BAND ENDS**
  - Very easy task. Most matchboxes do this effeciently - except on 160m.
- **MATCH TRAP BEAMS (YAGI's) ON THE BAND ENDS**
  - Very easy task. Most matchboxes do this efficiently.
- **MATCH LONGWIRE ANTENNAS WITH VERY HIGH IMPEDANCE**
  - Many matchboxes, especially those built into the transceivers cannot do this.
  - Many matchboxes that can do this, do so with high internal losses.
- **MATCH PHYSICALLY SHORT ANTENNAS ON 80m AND 160m (VERY LOW IMPEDANCE)**
  - Very common task, but unfortunately most matchbox have very poor effeciency on 80m and fail to find a match at all on 160m.
  - If they do manage to find a match on 160m, then it is usually with significant power loss within the matchbox.
  - The reason for this is the physical size (and cost) of the components that are necessary to do it right.
    - **This is the weakest point of most matchboxes.**
- **MATCH ANTENNAS ON 10M.**
  - The task is easy, but many matchboxes do not have a low enough minimum capacitance

or minimum inductance. As a result they have high power loss on this band.

- **MATCH OPENWIRE-FED ANTENNAS**
    - Most matchboxes are not very good at this.
    - Obtaining a good match on all bands is due more to luck than to the quality of the matchbox. Length of antenna and feedline play a significant role here.
- **AND MORE . . .**

TECHNICALLY, we can solve any of the problems above.
However we cannot do it all with just one matchbox technology;
we need different technologies for different tasks.

IN PRACTICE, IT IS IMPOSSIBLE TO DO IT ALL IN JUST ONE MATCHBOX.

THE BOTTOM LINE:

IN ORDER TO HAVE GOOD EFFICIENCY IN YOUR MATCHBOX,

YOU HAVE TO SELECT THE RIGHT MATCHBOX TECHNOLOGY FOR THE JOB AT HAND.

[NEXT: ASYMMETRICAL MATCHBOXES }>>

BREAKING NEWS:

First Contest Win for Aerial-51 Antenna N1EU/p

Special purpose Aerials:

Ultra-Lightweight antennas for expeditions and stealth applications.

NEW

TUNER BALUNS

ALSO NEW

Simple Multi-Band Vertical on a 12m Spiderpole

160m INVERTED-L on a 12m Spiderpole

80m INVERTED-L on a 12m Spiderpole

Rob Sherwood Test Drives the FLEX 6700 in CQWW DX 160m

+

(other) Transceiver Tests

LATEST UPDATES:

THE RUBBER BALUN
|
BAD BALUNS

Antenna Tuners

SYMMETRICAL vs. ASYMMETRICAL

We tend to clasify antennas as being eithr "Symmetrical" or "Asymmetrical".
(some people call them ballanced or unbalanced)

Examples of Symmetrical Antennas:

- Dipole
- Yagi
- Quad
- Delta Loop

Examples of Asymmetrical Antennas:

- Longwire
- Mobile Whip
- Groundplane
- Off Center Fed Dipole

Like Antennas, Matchboxes come in two flavors:

- Asymmetrical (unbalanced)
- Symmetrical (balanced)

MOST MATCHBOXES AVAILABLE TODAY ARE ASYMMETRICAL.

BUYER BEWARE !

Their manufacturers usually market them for matching both asymmetrical and symmetrical antennas.
They simply include a 4:1 balun and claim the matchbox will match symmetrical antennas. NOT! (at least not very well)

The question is not "if" they can do this but rather "how well" can they do this?

The truth is *"not as well as their marketing would lead you to believe."*

WHAT'S THE DIFFERENCE?

- **The technical difference is easy to understand:**
  - In a Symmetrical Matchbox, everything inside the matchbox is built symmetrically to the two wires feeding the antenna.

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- In an Asymmetrical Matchbox, one line from the antenna goes through the matching circuitry, the other line is connected to ground and passes straight through to the ground side of the coax leading to the transmitter.

- **The practical difference is not quite so easy to understand:**

  If you are running 100w or less, you probably won't see a big difference. The problem emerges when running high power.

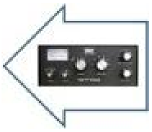
  The problems are caused by **Common Mode Current** (CMC) on the antenna feedline. With an asymmetrical matchbox, we use a balun, typically a 4:1 balun to help match the impedance and hopefully reduce CMC. THIS IS PART OF THE PROBLEM. DO NOT USE A 4:1 BALUN UNLESS NOTHING ELSE IS AVAILABLE. **INSTEAD, USE A 1:1 CURRENT BALUN.**

  REASON: SEE: http://www.karinya.net/g3txq/tuner_balun/

  Unfortunately if the SWR is too high on the balun, it does not function well and you can get trouble with CMC. This is compounded when running high power. This is more predominant in 4:1 baluns than in 1:1 baluns. **The result is "RF in the shack."** You burn you fingers on the key, you burn your lips on the mic, etc. **Worst Case:** some of your equipment may randomly go into FAULT mode.

  With a good symmetrical matchbox, such as the Annecke Symmetrical Koppler or the Johnson Viking Matchbox, you generally have no problems of this sort!

<NEXT PAGE: Asymmetrical Matchboxes>



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Antenna Tuners

ASYMETRICAL MATCHBOXES

(also called "Unbalanced Matchbox")

WHAT IS IT?

An "Assymetrical" or "Unbalanced" Matchbox is a matchbox that was designed to be used primarily with unbalanced (asymmetrical) antennas. These are typically coax-fed antennas but may also be other types.

Examples of Asymmetrical Antennas:

- **Long Wire**
- **Ground Plane**
- **Windom (OCF)**
- **Mobile Whip**

A SIMPLE DIPOLE may sometimes require a matchbox under certain conditions:

- Low band antennas for 160 & 80m (including dipoles) typically do not have a broad enough bandwidth to provide a good SWR across the entire band. An Asymmetrical (Unbalanced) Matchbox is very useful here.
  - A dipole on most bands, 40m and above, is capable of presenting a good enough match (low SWR) to the transmitter across the entire band, so a matchbox is normally not required. (Exception: high end of 10m).
- Sometimes people want to us a coax-fed dipole on another band for which it was not intended. They use a matchbox to match the antenna to their transmitter, obtain a 1:1 match and assume thay have a good antenna for that band. **NOT!**
  - I'm not going to say you should never do this. Sometimes it's a good crutch to help in emergencies, but it is a VERY POOR excuse for an antenna when used like that. Normally you should never use the antenna like that.
  - There is one exception: a 40m dipole is actually a pretty good antenna on 15m, especially with the help of a matchbox it can be very effective.

TYPES OF ASYMMETRICAL MATCHBOXES:

1. LINK-COUPLED MATCHBOX

2. **L-NETWORK MATCHBOX**
3. **T-NETWORK MATCHBOX**
3a. **DIFFERENTIAL-T MATCHBOX**
4. **Pi-NETWORK MATCHBOX**

Although we could use a Pi-Network or Link-Coupled matchbox, with just one exception, you don't find these offered commercially anymore. The simple reason: "cost". The other solutions use components which are not as costly as these two.

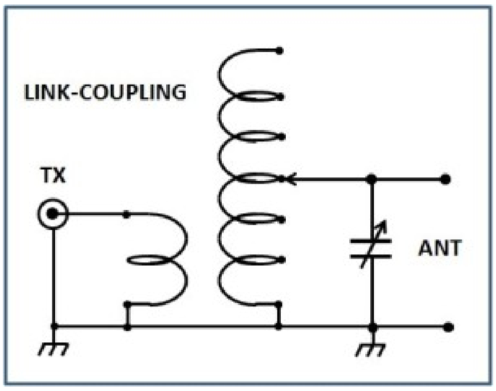
THEREFORE WE WILL LOOK AT THE T-NETWORK AND L-NETWORK IN MUCH MORE DETAIL THAN THE LINK-COUPLED OR PI-NETWORK MATCHBOXES.

- **Commercial only the "T" and "L" are offered.**
- **"T" is by far more popular than "L".**
- **But is it better than "L"? Worse?**

THE SHORT ANSWER IS: EACH HAS ADVANTAGES AND DISADVANTAGES.

WHICH ONE YOU SHOULD YOU USE DEPENDS ON MANY THINGS (described below).

1. LINK-COUPLED-MATCHBOXES:



Link-Coupling is one of the oldest technologies used for matching an antenna to the transmitter. There are many different configurations of link-coupling, from very simple, like the one shown on the right, to very elaborate circuits using differential capacitors.

The efficiency is very good but covering multiple bands can be a challange, especially for the bandswitch.

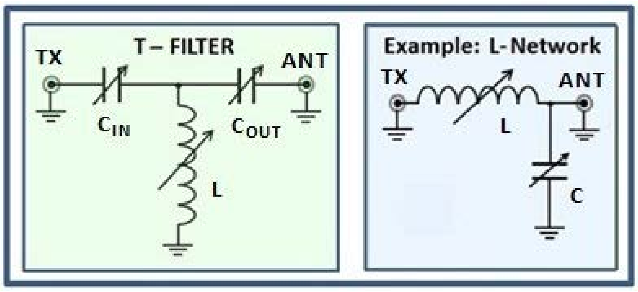
This is probably the main reason that Link-Coupling is not found commercially available.

Although the Link-Coupled matchbox was also use in asymmetrical applications long ago, in the past 50 years it has mostly been used in symmetrical applications. In the meantime there are no more commercial Link-Coupled matchboxes available (that I know of) on the market.

I will cover Link-Coupled matchboxes in more detail under Symmetrical Matchboxes.

The "T-Network" and "L-Network"

[The 2 most popular circuit designs for asymmetrical matchboxes.]



At first glance, the T and L circuits are very similar, with the T having just one more

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BAD BALUNS
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component than the L. There are advantages and disadvantages of both technologies.

T or L ?
Most matchboxes today are **T-Network.** These matchboxes share common routes back to the original "Ultimate Transmatch", described by Lew McCoy, W1ICP (SK) in QST in 1970 (possibly earlier). Their advantage is that they use common components and don't require a lot of fancy switching.

The L-Network appears even simpler, but in practice it is not. It requires more switching and some pretty hefty component values in order to be able to match as broad of a range of impedance as the average T-Network matchbox. Hower when matched, it is always matched at the point of maximum efficiency and generally more effecient (less internal loss) than the T-Network.

For more details, see below..

2. L-NETWORK MATCHBOXES:

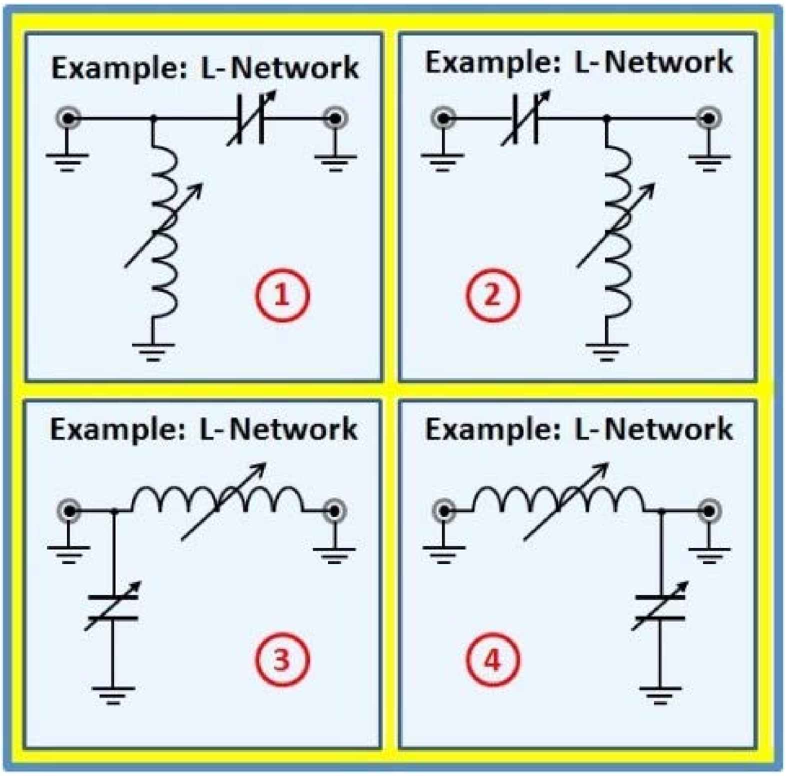
In theory, the L-Network is all you need to match any impedance. As I said, "in theory."

In practice, in order to match a broad impedance range, you need some very large, and very small values of components. In addition, a large variable capacitor capable of matching on 160m is very expensive and would have too much minimum capacitance for use on 10m. As a result, a much smaller variable capacitor is used together with several fixed-value capacitors, switched in when required.

The problem does not stop there. All of the capacitors must be connected to one side of the coil for matching low impedances and connected to the other side of the coil for matching high impedances. As a result, some tricky switching is required if you want to match everything.

There are a handful of L-Network matchboxes on the market but most do not incorporate the complex switching circuit to enable it to match from 10 Ohms to 3000 Ohms. To my knowledge, currently the only L-Network on the market that can do this is the TEN-TEC Model 238, and its successors, the Model 238-A, the Model 238-B, which are only available used. The current Model 238-C is still available new, but it is not cheap.

L-NETWORK CONFIGURATIONS:



Shown above are the 4 "possible" configurations of an L-Network.

Versions 1 and 2 are high-pass matching networks.
Versions 3 and 4 are low-pass matching networks.

In practice, usually only versions 3 and 4 are used for Antenna Matchboxes.

- **VERSION 3** is used whenever the antenna has **LOW impedance** (less than 50 Ohms)
- **VERSION 4** is used whenever the antenna has **HIGH impedance** (greater than 50 Ohms)

Advantages of L-Network:

- **Easy to tune to the optimum setting**
- **Only one setting (per antenna, per band) will yield the optimum SWR**
- **When set for minimum SWR, it always corresponds to maximum efficiency**
- **Fewer components than with a T-Filter (less knobs to tune)**
- **LESS LOSS THAN WITH T-FILTER !!! (BIGGEST ADVANTAGE)**

Disadvantages of L-Network:

- **To cover the same impedance matching range as the T-Filter, it requires some pretty extreme component values, AND. . .**
- **It also requires re-configuration of the inductor and capacitor to all 4 circuits shown above.**
- **In practical applications, achieving the extreme component values needed requires switching the capacitor back and forth between the input and output side of the network, switching multiple capacitors in parallel with the main tuning capacitor, and swapping the positions of the inductor and capacitor.**
- **Without all of the above, its impedance matching range is limited, and not as broad as that of the T-Filter matchbox.**
- **There are very few commercial (manual) L-Network tuners on the market and all of them are relatively expensive. Here are a couple:**
    - **TEN-TEC Model 238/238A/238B/238C** ("C" is the current model)
    - **Viking Nye Matchbox** (only available on the used market)

COMMENTS:

The L-Network is a very efficient, low loss matchbox. Unfortunately it is difficult to design enough hardware into one single matchbox which is capable of matching both low impedances and high impedance across all HF bands.
As a result all L-Network matchboxes are expensive and many have a somwhat limited matching range.

If you are looking for a good matchbox for a specific impedance range, and highest efficiency is your main criteria, the L-Network is the way to go. If you want one that does everything, be prepared to spend a lot of money.

PERSONAL COMMENT: I own a TEN-TEC "Model 238-B" L-Network Matchbox, and it falls into the category, ***"til death do us part".***

3. T-NETWORK MATCHBOXES:

In the past 30 years, the **T-Network** has established itself as the most popular matchbox design found in most ham shacks. It is a simple design that easily covers multiple bands, and it can be built using common, inexpensive components.

The T-Network can easily match a broad range of impedances, making it the ideal matchbox for matching "whatever comes your way". Unfortunately it is not always the most effecient matchbox.

The BIGGEST PROBLEM with the T-Network is its internal loss - power lost inside the matchbox. Through improper tuning by the operator, the losses can be even higher - sometimes 50% or more.

Advantages of T-Network Matchboxes:

- **Simple circuit covers a broad frequency range**
- **Able to easily match a very broad impedance range**
- **Component values and physical sizes are practical**
- **Component costs are reasonable**

Disadvantage of T-Network Matchboxes:

- **Difficult to tune / difficult to find the best setting**
- **Multiple settings "appear" to be optimum (show low SWR), but . . .**
- **. . . when tuned to these wrong settings, these matchboxes heat up, have unnecessary loss, and can even burn up.**
- **VERY OFTEN USED AT LESS THAN OPTIMUM EFFICIENCY SETTING !!!**
- **The operator needs to engage his brain when tuning!**

COMMENTS:

This is probably the best matchbox technology for most hams who are just beginning and do not know yet what they will ultimately need. Selecting this matchbox technology is a low-risk choice, BUT IF YOU DON'T TUNE IT RIGHT, YOU MAY LOSE UP TO 50% OF YOU POWER INSIDE THE MATCHBOX. It is possible to get better solutions for some antenna applications, but at least this matchbox should always find a good match to the antenna. **GOOD STARTER MATCHBOX!**

IF YOU CHOOSE THIS MATCHBOX, YOU MUST LEARN HOW TO TUNE IT PROPERLY!

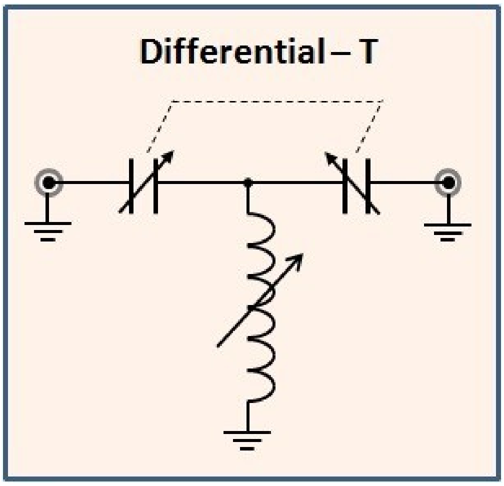
See: Tuning the T-Network

3a. DIFFERENTIAL-T MATCHBOXES:

The " Differential-T " . . . (a good compromise)

- Theoretically it has the same broad matching impedance range as the normal T-Filter matchbox.
- It only finds one setting of L and C which provide the best SWR. This is also the setting with the highest effeciency. This eliminates the possibility of tuning to the wrong position. (nothing can go wrong)
- In theory, slightly more loss than a properly tuned classical T-Matchbox.
- Although it theoretically has a slightly lower effeciency than the standard T-Matchbox, in practical situations it is better because you can never tune it to the wrong settings, so you always have it tuned to its optimum setting.
- BUT, the physical limits of the size of the enclosure prohibits using variable capacitors with as many pF as the standard T-Filter uses; as a result, the impedance range that you can match with the models that are on the market is not as great as the range of a standard T-Filter matchbox.

DIFFERENTIAL-T CIRCUIT:



At first glance, it looks just like the classical T-Filter matchbox.

A closer look reveals the differences:

1. The input and output capacitors are tied together and tuned together.
2. The input and output capacitors are 180 degrees out of phase; when the input capacitor is at maximum capacitance, the output capacitor is at minimum, and vice versa.

These simple changes result in the circuitry finding only one single point of best SWR, and this point always coincides with maximum effeciency. This eliminates the main problem with the original T-Filter matchbox: user error.

In the interest of keeping costs low, istead of using two separate capacitors ganged together, typical commercial units use a single "differential capacitor". This capacitor is a lot longer than a normal variable capacitor, and madates using a much deeper cabinet. To fit it all into a managable size, the maximum value of each half of the capacitor is not as high as the value typicall used for each capacitor in the original T-Filter. As a result, the Differential-T matchboxes currently on the market do not cover as broad of an impedance matching range as the original T-Filter matchbox.

ADVANTAGES OF THE DIFFERENTIAL-T MATCHBOX:

- **Easier to tune to minimum SWR than the classical T-Matchbox**
- **At minimum SWR, the Differential-T is always operating at its most efficient tuning position.**

DISADVANTAGES OF THE DIFFERENTIAL-T MATCHBOX:

- **The impedance matching range of the Differential-T Matchbox is not as broad as that of a classical T-Matchbox.**
- **Their over-sized (long) differential variable capacitor mandates a very deep enclosure, which is often difficult to place on your desktop.**
- **There are very few Differential-T matchboxes on the market. As a result, these tuners are usually more expensive than a classical T-Matchbox. Examples:**
  - **MFJ-986 (rated 1.5 kW)**
  - **Palstar AT-500 (rated 500w)**
  - **Palstar AT2KD (rated 2 kW)**

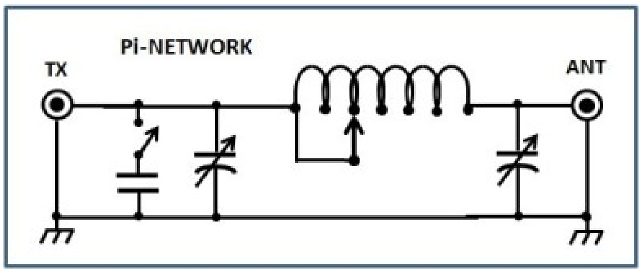
BOTTOM LINE: THE DIFFERENTIAL-T IS A GOOD CHOICE WHEN YOU ARE LOOKING FOR A HIGH POWER MATCHBOX WITH A TUNING RANGE SIMILAR TO THE RANGE OF THE BUILT-IN TUNERS FOUND IN TRANSCEIVERS.

---

4. Pi-NETWORK MATCHBOXES:

The Pi-Network Matchbox, like the

Link-Coupled Matchbox, is more of a device from the past, rather than the present. This is in no way due to its performance, but rather to the cost of the components required to implement a Pi-Network Matchbox capable of matching the required impedances on all HF bands.



The circuit on the right shows an extra capacitor on the input side. In reality there would probably be several capacitors, which are switchable on demand, depending on the antenna's impedance. We do this rather than using a larger variable capacitor because a larger variable capacitor would have too high of a minimum capacitance to be used on 10m.

Although you could build this matchbox with a roller inductor, you usually only see it with switched inductance. The only Pi-Network matchbox still on the market today is a Remote Matchbox and uses switched inductance.

The Pi-Network matchbox has very good efficiency and also has the added advantage of surpressing harmonics. Although this is old technology, it is still a great concept. It's only problem is, it is expensive to implement in a way that it has a broad impedance matching range over the entire hf spectrum.

I know of only one company (HamWare) making and selling Pi-Network Matchboxes today. HamWare is located here in Germany and its products are VERY EXPENSIVE - (and also very good).

ADVANTAGES OF THE Pi-NETWORK:

- **Able to match a very broad range of impedances**
- **Able to match the entire hf spectrum (assuming sufficient switchable components)**
- **Low loss / very efficient (if tuned correctly)**
- **Has excellent harmonic surpression**

DISADVANTAGES OF THE Pi-NETWORK:

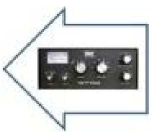
- **High loss when tuned wrong**
- **Requires components with very large and very low values**
- **Components are VERY EXPENSIVE. Much more so than with other matchbox types**
- **Only one commercial source of Pi-Network Matchboxes (HamWare* in Germany)**
  - **HamWare AT615-U (1.5 kW)**
    - **This is a manual remote matchbox with separate matching unit for outside and control unit for the desktop**
  - **HamWare also make two similar Symmetrical Pi-NETWORK matchboxes. More on this under Symmetrical Matchboxes.**

COMMENTS:

The Pi-Network Matchbox is a great technology, with very low internal loss and it also offers good harmonic surpression. Unfortunately the cost of components today has delegated this technology to the history books.

In the past, companies such as R.L. DRAKE marketed Pi-Network matchboxes. In the meantime these have become collectors' items and are difficult to find.

[NEXT PAGE: TUNING THE T-NETWORK MATCHBOX }>>



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Symmetrical Matchboxes

Interest in Openwire-Fed-Antennas is growing in popularity.

The best way to match an openwire fed antenna to your transceiver

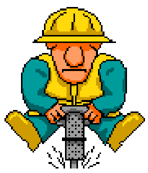
is with a *SYMMETRICAL MATCHBOX* (also called *BALANCED MATCHBOX*).

Unfortunately there is a lot of confusion around the term"Symmetrical Matchbox".

In this section I will explain the different symmetrical matchbox technologies in simple terms and share with you my experience, and misfortunes in working with different solutions to this problem.

On the following pages I will show you some of the matchbox products available on the world market.

FOR NOW, EVERYTHING ON THIS PAGE BELOW THIS POINT IS "WORK IN PROGRESS"



WHY USE SYMMETRICAL MATCHBOXES ?

Symmetrical matchboxes offer the optimum means of matching a symmetrical antenna when fed with openwire feedline. These matchboxes are built symmetrically throughout the antenna side of the matching circuitry.

Once the impedance has been matched symmetrically to 50 Ohms, it can easily be converted to unbalanced using a simple 1:1 balun.

Originally, most symmetrical matchboxes were built using LINK COUPLING. There are additional advantages to this type of circuit. Besides effeciently matching a broad range of impedances, it also adds a significant amount of bandpass selection on transmit as well as on receive. This adds harmonic surpression on transmit and rejects out of band signals on receive, helping to prevent receiver overload. For this reason they are sometimes referred to as "FILTER TUNERS".

Unfortunately Link Coupled antenna matchboxes are complex and expensive to build. There are currently no commercial companies selling this type of matchbox. In fact there are not many cial symmetrical matchboxes on the market at all, of any type.

SYMMETRICAL MATCHBOX TECHNOLOGIES

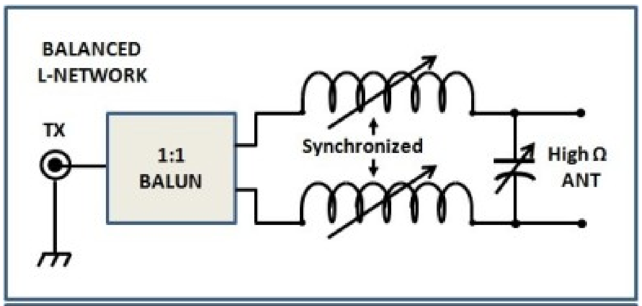
1. **BALANCED L-NETWORK**
2. **BALANCED T-NETWORK**
3. **BALANCED Pi-NETWORK**
4. **LINK-COUPLING**
5. **Z-MATCH**
6. **S-MATCH**

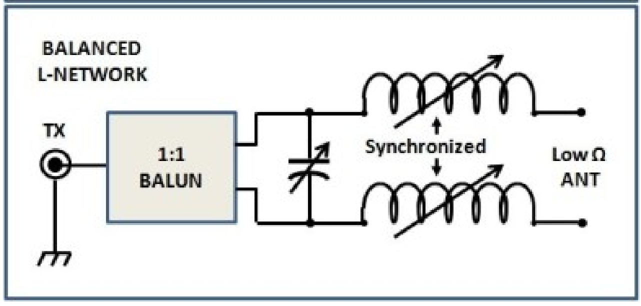
1. BALANCED L- NETWORK

The Balanced L-Network is the simplest traditional way to build a truly balanced matchbox.

It has very good efficiency (very low loss) but it is a bit tricky to implement - both mechanically and electrically. The two roller inductors must be tuned simultaneously, and a means must be found to switch the variable capacitor from the input side to the output side. In addition, in order to match a larger impedance range, additional fixed capacitors must be switched in parallel to the variable capacitor.

A 1:1 Guanella current balun is used on the TX side of the matchbox to convert the 50 Ohms balanced impedance to unbalanced.





BALANCED L-NETWORK ADVANTAGES:

- **Low Internal Loss**
- **Good Efficiency**
- **Capable of matching a broad impedance range "if" implemented properly.**

BALANCED L-NETWORK DISADVANTAGES:

- **Requires two [expensive] roller inductors.**
- **Complex mechanical construction to synchronize the two roller inductors.**
- **Complex switching is required to switch the variable capacitor from one side of the inductors to the other, and to switch additional capacitors in parallel with the variable capacitor.**
- **For matching extremely high or extremely low impedances, additional compensating components would be required.**
  - **I am not aware of any Balanced L-Network matchbox that does this - and I only know of one Unbalanced L-Network matchbox that does.**
  - **As a result, performance (efficiency) drops off with very high or very low impedances.**
- **Usually quite a bit more expensive than Balanced T-Network matchboxes.**

COMMENTS:

Using standard components (e.g. 30uH incuctor and 500 pF variable capacitors), the impedance

Site Search

http://DJ0IP.de .....(Search on THIS site.)

BREAKING NEWS:

First Contest Win for Aerial-51 Antenna N1EU/p

Special purpose Aerials:

Ultra-Lightweight antennas for expeditions and stealth applications.

NEW

TUNER BALUNS

ALSO NEW

Simple Multi-Band Vertical on a 12m Spiderpole

160m INVERTED-L on a 12m Spiderpole

80m INVERTED-L on a 12m Spiderpole

Rob Sherwood Test Drives the FLEX 6700 in CQWW DX 160m

+

(other) Transceiver Tests

LATEST UPDATES:

THE RUBBER BALUN
|
BAD BALUNS
|
What's Wrong with OCFD

LL-TUNER "S-MATCH" added to my symmetrical tuner page. HERE

THIS WEEK:

Noch Nichts

PROGRESSING:

CMC TEST RESULTS

Test results for some of the tests are now posted - including **Two-Core Vs. One-Core 4:1 Guanella Balun**

Matchbox Shoot-Out has been UPDATED

Updated: 16 June 2013

LOTS OF NEW CONTENT IN THE SECTION: ANTENNA MATCHBOXES

MODERN ANTENNAS

WIRE BEAMS

It's time to build antennas! Visit: Spiderbeam Antennas

DISCLAIMER

matching range is somewhat limited.

In order to match a broader impedance range, especially on 160m, several additional 500 pF capacitors will have to be switched in parallel with the variable capacitor. In addition, the capacitors much be switchable to both sides of the coil. Although the concept is simple, the implementation is complex.

The switching arrangement must be capable of handling high voltage and high current. This can be done with relays or with a big switch. Either way is expensive. Add to that the cost of two roller incuctors, and you end up with an expensive matchbox.

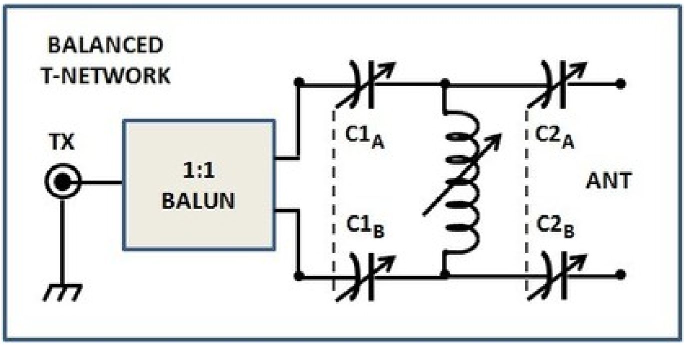
Although the Balanced L-Network is an efficient matchbox, it may not cover the impedance range you require. Be sure to check this BEFORE you purchast that new matchbox!
Check it out; see: MATCHBOX SHOOT-OUT.

2. BALANCED T– NETWORK

The Balanced T-Network is a relatively simple circuit made up of common components.

Physically, there are only 2capacitors to adjust, plus just one roller inductor (total of 3 adjustments).

Tuning is more difficult than with other circuits which have just 2 components to adjust.



ADVANTAGES OF THE BALANCED T-NETWORK:

- **Broad impedance matching range**
- **Common components**
- **Only one roller inductor**
- **No additional switching required**
- **Lower cost than most other circuits**

DISADVANTAGE OF THE BALANCED T-NETWORK:

- **Much higher losses than most other circuits**
- **More difficult to tune than other circuits**
    - **3 knobs to turn instead of just 2**
- **Multiple settings can be found which have a good SWR but all of these settings except one result in additional (unnecessary) losses.**
-
    - **Using the wrong settings can result in upt to 50% loss of power or more in the matchbox!**

COMMENTS:

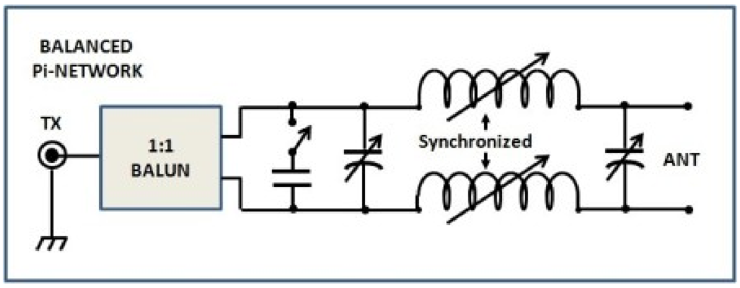
The Balanced T-Network matchbox is the cheapest technology for building a fully symmetrical matchbox. It uses only 3 components - one roller inductor and two double-capacitors. There is no additional complex switching necessary.

Unfortunately it is also the technology which has the greatest internal power loss. In addition, tuning this type of matchbox is not always easy, and often the user tunes it wrong, resulting in additional losses.

Despite all of that, I actually own and use one of these! ("Who's perfect?")
I have an MFJ-974B. I use it often for portable events such as Field Day.
Why? Because it is cheap and will match just about anything you throw at it.
AND also because there is currently nothing else available on the market in the 100w class except the ridiculously expensive remote tuner from HamWare!

3. BALANCED Pi- NETWORK

The Balanced Pi-Network is a symmetrical version of the traditional Pi-Network, which was also known as the Collins Filter.



By switching additional parallel capacitors on the TX side, it is able to match a broad impedance range.

The Balanced Pi-Network's efficiency is similar to that of the Balanced L-Network and much better than that of the Balanced T-Network. Its switching requirements are much simpler than that of the Balanced L-Network.

ADVANTAGES OF THE BALANCED Pi-NETWORK:

- **Broad impedance matching range.**
- **Much simpler switching configuration than the Balanced L-Network**
- **Low loss, high efficiency. (MUCH lower loss than the Balanced T-Network)**

DISADVANTAGES OF THE BALANCED Pi-NETWORK:

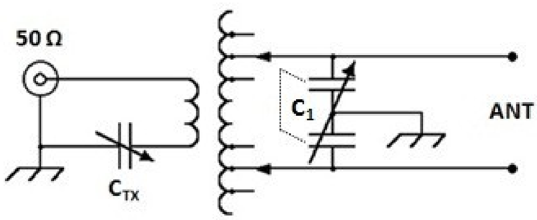
- **Requires two roller inductors (price).**
- **Higher mechanical requirements. (Requires synchronizing the roller inductors).**
- **Available only in Europe. (No known manufacturers in the USA).**
- **PRICE! (VERY EXPENSIVE)**

COMMENTS:

Since there are no commercially available Link-Coupled matchboxes on the market anymore, this is clearly the way to go, **"if you can afford it."** Unfortunately most of us can't afford, or don't want to afford spending that much money on a matchbox. If you happen to be one of the few who doesn't mind spending that much, then take a look at the HamWare AT-615A.

4. LINK COUPLING

This is a simple link coupling circuit. The antenna side of the tank circuit is fully symmetrical.

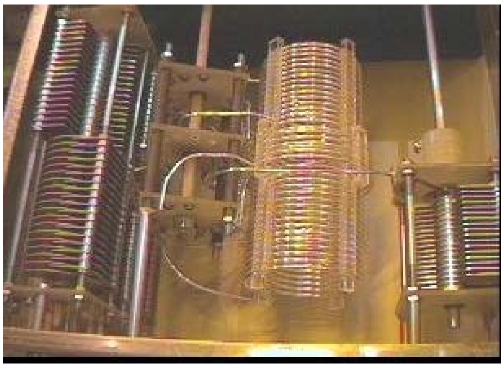


Each half of C1 is identical and tuned symultaneously. It must be able to withstand high voltage (3000 volts), even for just 100w operations.

The variable capacitor on the left helps match the circuit to 50 Ohms. This is a luxury. Older link-coupled matchboxes (i.e. Johnson Viking Matchbox) don't have this capacitor and suffer because of it. If you value performance more than looks, it is easy to add this capacitor to any Johnson Viking Matchbox.

The picture on the right is of an Annecke Symmetrical Koppler. Look closely at the long coil. You will see there is a second, larger coil over the middle of the longer coil. This is the "Link" to the transmitter.

The antenna side is on the left in this picture. The bandswitch is located between the differential capacitor and the two coils. The Annecke circuit also has taps on the TX side of the tank circuit (the smaller Link coil); the Johnson Viking Matchbox does



not, nor does it have the capacitor on the 50 Ohm side of the tank circuit. These two differences make the Annecke circuit superior to the Viking!

The longer coil, which is the antenna side, has taps, equal distance from each end. This maintains symmetry. Simple tuners use alligator clips or bannana plugs for changing bands. A bandswitch is more comfortable but when several bands are required, it becomes very complex and adds significantly to the cost of the matchbox.

This is a simplified circuit. In reality the Annecke and the Johnson Viking are more complex. They use a double-differential capacitor (4 variable capacitors on one shaft) on the antenna side, in addition to C1 shown in the circuit above. The Annecke also has a tapped/switch coil on the TX side and the 3rd variable capacitor. For more on this, see the page **Viking vs. ANNECKE**.

THE IMPORTANT THING TO NOTE HERE:

EVERYTHING ON THE ANTENNA SIDE IS COMPLETELY SYMMETRICAL.

This requires more hardware (more cost) than an assymetrical matchbox or even the other symmetrical matchboxes.

ADVANTGAGES OF LINK-COUPLED MATCHBOXES:

- **Excellent symmetry**
- **Low loss, high effeciency**
- **The Annecke has a very broad matching range**
- **Also adds bandpass functionality, which helps on RX as well as TX**

DISADVANTAGES OF LINK-COUPLED MATCHBOXES:

- **Very high level of complexity**
- **Would be very expensive if we could find someone to build them (nobody does)**
- **Johnson Viking Matchbox has a limited impedance matching range**

COMMENTS:

Unfortunately nobody is willing to build this type of matchbox commercially. The cost of components is just too much. As a result, the only way to get one is either find an old Johnson Viking or an Annecke on the used market, or home-brew one yourself. Most home brew link-coupled projects are for the Z-Match (see below).

Trying to home-brew a general purpose all band link-coupled matchbox is a monumental task, but if you only need one or two bands, it's actually quite simple. I built one for 80 & 40m in a single evening, and it worked great!

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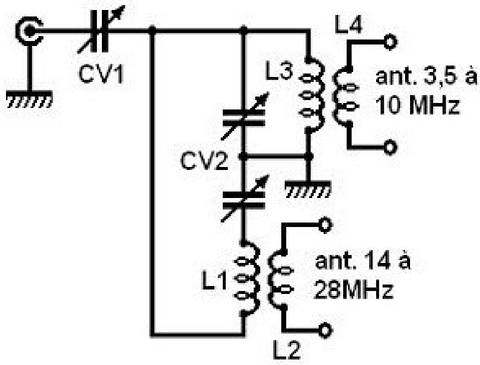
5. Z-MATCH

The Z-Match is an interesting matchbox. Like anything else, it has its advantages and disadvantages. Understanding its strengths and weaknesses is key to obtaining satisfactory performance with this circuitry.

The ORIGINAL Z-Match is shown on the right. It is characterized by two link coupled tank circits and two sets of symmetrical antenna connections, one for 3.5 to 10 MHz, and one for 14 MHz to 30 MHz.



It covers all ham bands from 3.5 to 30 MHz, including the WARC bands WITHOUT THE NEED OF A BANDSWITCH, which saves on complexity and cost. However you do have to manually move the openwire feedline back and forth when switching from high bands to low bands.

The 30m band is a bit tricky. Depending on the antenna characteristics, sometimes it matches better when connected to the low band terminals, and sometimes it matches better when connected to the high band terminals. There is a simple rule of thumb: *"Try them both and use the one which works best."*

No bandswitch means less complexity, a smaller form factor, and it is easier to maintain symmetry throughout the matchbox. It helps keep the cost low. In fact the bandswitch is usually a major cost factor in any matchbox.

Unfortunately, nobody is building these commercially anymore. "Linear Amp UK" was the last company still building these, but they stopped several years ago. In the meantime that company has been sold and I am not sure if the new owners will continue to build any matchboxes or not.

There are plenty of suggestions for building your own Z-Match on the Internet, some with two tank circuits, some with just one. Lots of people have successfully built both types.

ADVANTAGES OF THE Z-MATCH:

- **Relatively simple circuit.**
- **Common, low cost components.**
- **Very easy to tune.**

DISADVANTAGES OF THE Z-MATCH

- **You must manually move the feedline when switching from high to low bands or visa verca.**
- **Although efficiency is fairly good for mid-range impedances, it is much poorer for impedance extremes.**
- **Very high voltage can develop across the variable capacitors, even at 100w, often resulting in arcing. As a result you are forced to either reduce power of play with feedline lengths.**
- **No commercial source for these matchboxes.**

COMMENTS:

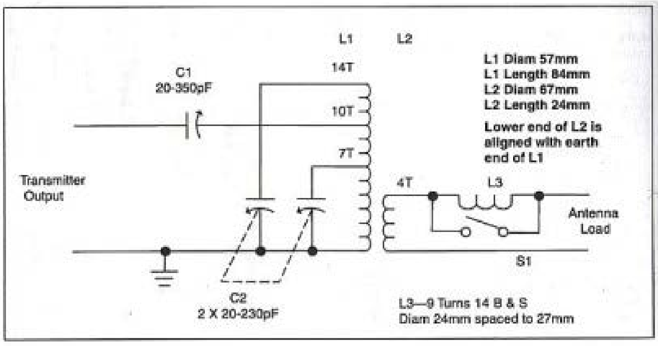
When you read the disadvantages vs. the advantages, you might wonder why anyone would choose this technology. However many people do. The reason is, it is very simple to build one of these, using low cost components. You don't need an expensive bandswitch. In practice, if you put just a little bit of thought into the lengths of the antenna legs and feedlines you use with this matchbox, it is very easy to keep the impedances well within the sweet-spot of the matchbox, where losses are very low.

In Europe you often find used DECCA KW "E-ZEE Match" Z-Match tuners at fleah markets for under $100. It is a great way to get a good symmetrical matchbox at a low cost.
See: **LOW POWER ATU's** for more on this matchbox.

5a. SINGLE COIL Z-MATCH

"No bandswitch" was a great idea. Swapping antenna terminals when changing bands is not a popular procedure. There had to be a better way. The "Single Coil Z-Match" was devised to enable using just one set of connectors for the feedline. I'm not sure who originally developed this idea, but it was best popularized by Lloyd Buttler, VK5BR.

The picture on the right shows the circuitry of the "Single Coil" Z-match. This is perhaps a misnomer, as all Z-matches use Link Coupling (automatically 2 coils) and indeed, this one added a 3rd coil. But at least it did not have two seprated Link Tank Circuits with separate antenna connections connectors. The biggest advanttage here is, it still required no band witch as such, but it enabled having just one single pair of terminals for connecting the openwire feedline.



Perhaps a better name would be the "Single Tank Circuit Z-Match", not the single coil. As you see, it actually has 3 coils, 2 in the Link plus L3.

Could this be the NON PLUS ULTRA SYMMETRICAL MATCHBOX ?

Unfortunately not. Although it functions as well as the classical 2 tank circuit design, it also suffers from the same drawbacks as the classical Z-Match.

ADVANTAGES: See 5. Z-MATCH (above)

DISADVANTAGES: See 5. Z-MATCH (above)

OK, SO WHAT'S WRONG WITH THE Z-MATCH?

ANSWER: OFTEN, NOTHING. BUT . . . with high impedances or very low impedances, the efficiency of the Z-Match drops off rapidly. In these cases you would be much better off with an Annecke Symmetrical Koppler. Of course the real solution is simply, "fix the antenna."

For a detailed description on this, see: T**he Effeciency of the Z-Match** by Lloyd Buttler, VK5BR.

To "Z" or "Not to Z" ? . . . that is the Question.

There is no clear answer. It is up to the user. The bottom line is, if your impedances are above a few hundred Ohms, you will probably have up to 2 dB of loss. On the other hand, this simple, low cost symmetrical matchbox enables you to work up to 8 bands with just one wire dipole, and it offers good preselection for the receiver.

My Personal Opinion: Yes to "Z". (You mileage may vary.)

Especially for portable operations, I find 2dB loss to be a fair trade-off for being able to work so many bands. I still own a DECCA E-ZEE match and take it along often on trips, knowing that it is a quick and easy way to get on multiple bands.

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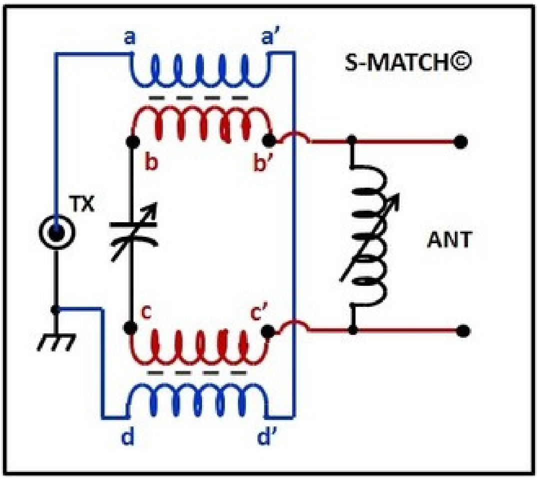
6. S-MATCH©

[New Kid on the Block]

The S-Match© is a creation of Fritz, PA0FRI.

The two transformers are wound on a single Toroid. Thus there are only 3 components: Toroid, Roler Inductor, and Variable Capacitor.

I have no personal experience with this circuit and can only repeat what I have read about it on the Internet.



The concept looks very good to me, but:

DO YOUR OWN DUE DILLIGENCE!

ADVANTAGES OF THE S-MATCH©:

- **Some users have reported a broad impedance matching range**
- **Very few components**
- **Easy to tune**
- **Low cost**

DISADVANTAGES OF THE S-MATCH©:

- **Unable to specify the impedance matching range because it will depend on the components one uses when home-brewing an S-Match©.**
- **Efficiency and loss has not yet been verified by ARRL or other 3rd party.**
- **Sometimes necessary to move the antenna (by unplugging/plugging) to points b & c (directly across the variable capacitor).**
- **[To my knowledge] No commercial source.**

COMMENTS:

The S-MATCH© looks very promising. It certainly is easy enough to build and should be relatively inexpensive. There are plenty of success stories on the Internet, but all of these just speak about the ease of matching the user's own antenna. I have not seen any test results showing measured results or comparisons to other tuners.

I intend to build one of these in the near future and try it. Unfortunately I too can only report on its matching capability. I cannot measure efficiency.

For more information see: http://pa0fri.home.xs4all.nl/ATU/Smatch/smatcheng.htm

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Meanwhile, back in today's Real World . . .

CHEAP WORK-AROUND SOLUTIONS:

- **Nobody is building and selling a Z-Match.**
- **Nobody is building and selling a Link Coupled Matchbox.**
- **Nobody is selling an S-Match, but lots of people are building them (Home Brew).**

SO WHAT IS THE INDUSTRY TYPICALLY OFFERING ?

- **Christian, DL3LAC is offering a "Balanced-L Matchbox" $$**
- **Palstar is offering a "Balanced-L Matchbox" $$$**
- **MFJ is offering a "Balanced-T Matchbox" $$**
- **HamWare is offering a "Balanced-Pi Matchbox" $$$$$$$**

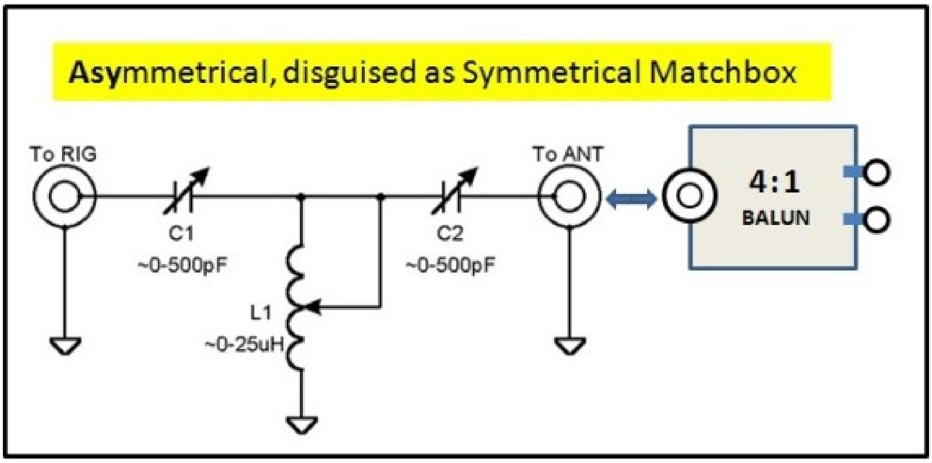
- **Kees, PA0LL is offering a "Balanced-Pi Matchbox"** **$$$$$**

The choice is basically between Balanced-L or Balanced-T, unless you want to spend about $1500 to $2000 on a Balanced-Pi Matchbox. **(ALL OF THESE ARE EXPENSIVE!)**

AND UNFORTUNATELY:

Everyone is trying to sell their cheap work-around solutions to Joe Ham, telling him that an asymmetrical T-Network with a balun is now a symmetrical matchbox. [NOT!]
(See below)

THE PAPER TIGER:



You can fool all the people, some of the time,
You can fool some of the people all the time,
But you can't fool all the people all the time.

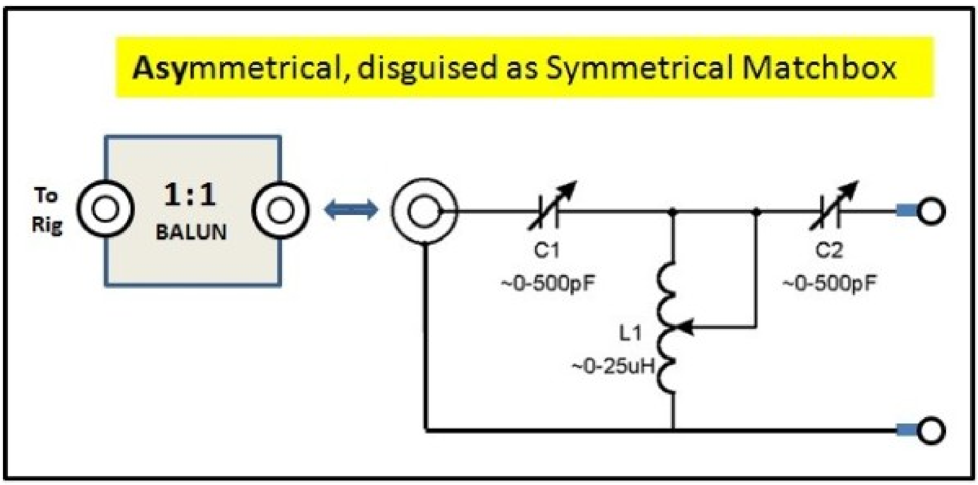
THIS IS NOT A SYMMETRICAL MATCHBOX.

And when running high power you will probably have problems with RF in the shack, especially if the matchbox has a 4:1 balun on the antenna side. **The balun does not properly function as a balun when the SWR is too high.** As a result you will have common mode current in the matchbox and in the shack.

You may notice this by:

- Equipment going into "fault"
- Hot mic or hot key, causing RF burns
- TVI, BCI, etc.

So the next "GURU" said "Do it this way:"



OK, this looks better:

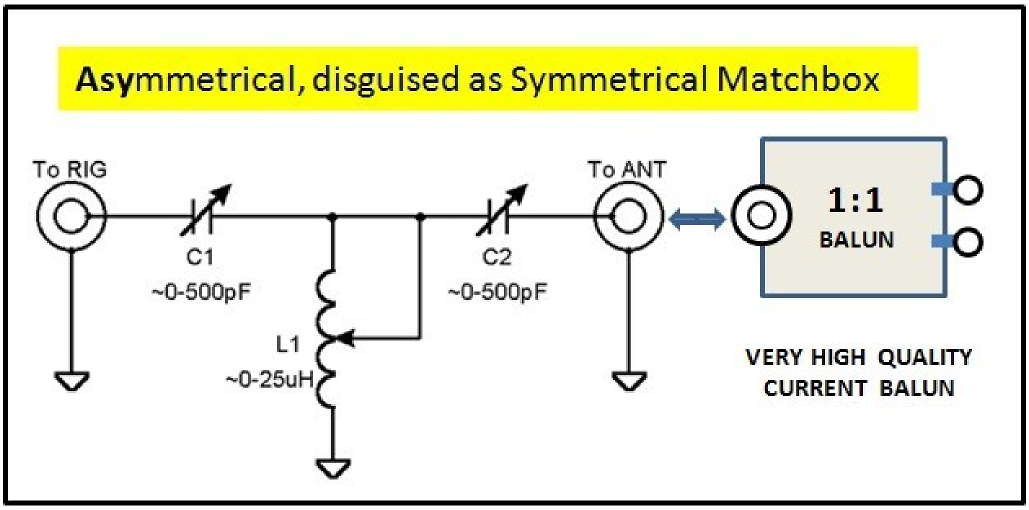
- The enclosure of the Matchbox is now floating above ground; nothing is grounded inside the matchbox.
- The Balun is seeing its design impedance.
- Problem is, in practice it only works just a little bit better than the circuit above.
- In many attempts to perfect this, including trying several different types of baluns, I continued to have problems with RF in the shack when running high power.
- Yet when I replaced this with two different high power [true] symmetrical matchboxes, there were no more problems at all !

Bottom Line, this is better than the circuit above, but still just a work-around with hitches. If this is the best you can do, go ahead. But there are much better solutions.

MORE TECHNICAL DETAIL ON THIS TOPIC, BY W7EL, IS AVAILABLE ON THE FOLLOWING LINKS:

- http://eznec.com/misc/ibalbrf.txt
- http://eznec.com/misc/ibalun.txt
- http://www.eznec.com/Amateur/Articles/Baluns.pdf

THIRD TIME IS THE CHARM: THIS ONE IS NOT BAD:



It's not bad, but it's not great. However with this circuit I was able to run one kilowatt without burning my fingers on the key, or my lips on the mic. A prerequisite for this is, you have to have a good matchbox which has no problem dealing with the high voltage due to the higher impedance when not using the 4:1 transformation in front of it. The variable capacitors should be rated about 6KV or more.

In my specific case, I used a Ten-Tec Model 238B, which is a very good L-Network.

A good T-Network will also work, if the capacitors are of the values shown here and have wide enough plate spacing.

NOTE: although my Ten-Tec Model 238B has a built-in 4:1 balun, I do not use it for the reasons explained above. Instead I use an external home-brew 1:1 current balun.

I have been using this for the past 10 years.
Recent reports from others confirm my experience.

For more explanation on why a 1:1 balun is better here than a 4:1 balun, see also:

- ***"Windom- und Stromsummen-Antennen"*** by Karl Hille, DL1VU, ISBN 3-910159-14-1, pages 106 and 107.
- **Tuner Balun Ratios** by Steve Hunt, G3TXQ

NEED YOU WORRY ? . . . and . . . HOW DO YOU KNOW ?

If you are running low power, up to 100w or so,
you can probably use any of these circuits shown on this page
without incurring any problem.
(Even the cheap work-arounds will work.)

If you have a little problem with RF in the shack, simply insert an RF Choke (beads over coax) in the transmission line between the matchbox and transceiver and your will probably be OK.

IF YOU ARE RUNNING HIGH POWER (500+w)

YES, YOU SHOULD BE CONCERNED.

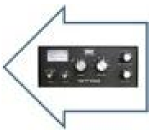
HOW YOU WILL KNOW:

- You may have RF all over the shack.
- Transceivers or Amplifiers may be randomly going to **FAULT** condition.
- You may have interference with other equipment such as televisions or telephones.
- You will burn your lips on your mic and your fingers on your key.

IN THIS CASE YOU SHOULD FOLLOW THESE PRIORITIES:

- Get yourself a good, high power symmetrical matchbox, like a 1KW Annecke Symmetrical Koppler, Johnson Viking Matchbox, MFJ-976, Palstar BT-1500 or AT-2K-BT (BT=Balanced Tuner. It must be the model with "BT", not the previous model).
- If you only need one or two bands, consider home brewing a symmetrical tuner.
- If a symmetrical tuner is not an option at this time, then use the circuit showing a 1:1 current balun on the antenna side of the matchbox.
- Use either of the other two in a pinch, but don't be surprised if you get some **shocking results.** In this case it usually helps to insert an RF-Choke (beads over coax) between the matchbox and the amplifier.

[NEXT: LOW POWER SYMMETRICAL ATU's }>>



[HOME] [News] [About Me] [My Station] [My Expeditions] [AMATEUR RADIO] [ANTENNAS] [MODERN ANTENNAS] [SPIDERBEAM] [My Favorite Antennas] [Loop Antennas] [Off-Center Fed Dipole] [VERTICAL Antennas] [Vertical Dipole Arrays] [Wire Beams] [ANTENNA MATCHBOXES] [antenna tuners] [Antenna Tests] [BALUN STUFF] [RF Chokes] [Transceivers] [Chinese Handhelds] [Downloads] [Contest University 2013] [Common Mode Chaos] [CMC TEST] [Ricki-Leaks] [Gallery] [B o B] [TEN-TEC STUFF] [SITE MAP] [LOGIN BELOW] [Rambo.de Domain] [Contact] IMPRESSUM DISCLAIMER Datenschutzerklaerung

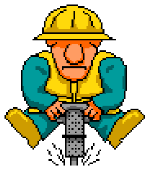
{Matchbox or Ant Tuner?}
{Matchbox Needed (?)}
{Matchbox Pwr Ratings}
{Matchbox LOSSES}
{"PERFECT" MATCHBOX}
{Why so many Types ?}
{Symmetric / Asymmetric}
{Asymmetrical Matchboxes}
<Tuning the T-Network>
<Which one to use:>
{Symmetrical Matchboxes}
{* A N N E C K E *}
{ATU POWER RATINGS}
MATCHBOX SHOOT-OUT
MATCHBOX DO's & DON'Ts
HOW TO KILL A MATCHBOX
MFJ MATCHBOXES
SUMMARY / CONCLUSION

(Today = 8/8/2015)

Gemuenden, Germany

Antenna Tuners

Which Asymmetrical Matchbox should you use?



WARNING: THIS PAGE IS OPINIONATED!

I own and use three designs: L, T, and Differential-T.

So the question for me is not which one should you use,
but rather *WHEN should you use each type?*

ANSWER: Use each type where you can take advantages of its best strengths.

BEST STRENGTHS:

L-NETWORK: Highest Efficiency. I use the L-Network to match antennas which I only use on a couple of bands, and I always want to be sure that I have the highest effeciency. Specifically, I use it together with my low band openwire fed Vertical Dipole when I'm running high power. I use a TEN-TEC Model 238B. Normally I would not use an asymmetrical matchbox for this purpose, but I do not currently own a high power symmetrical matchbox.

Differential-T: Easy to Tune, Good Efficiency. I use this design to match antennas which are "supposed to be" 50 Ohms, but are not quite perfect. For instance almost any dipole, when trying to cover the full 80m band, or with a trap beam when operating towards the ends of the bands. Although this design has more loss than my Model 238 L-Network, the loses in the impedance range where I use it are tolerable, and this is easier to use than the Model 238.

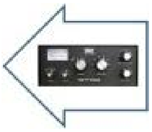
T-Network: Wide Matching Range, Good Efficiency - though not always. I use this type of matchbox for portable use when I don't know what kind of antenna I will have to match at each QTH. I have a tiny MFJ matchbox that has served me well for over 25 years, and it gives me the widest flexibility. It is not the most efficient but it matches most anything I need when operating [illegible]. I would NOT use a T-Network Matchbox for home use. [almost] NEVER!

NORMALLY, I DO NOT USE ASYMMETRICAL MATCHBOXES FOR MATCHING ANTENNAS FED WITH OPENWIRE.

A SYMMETRICAL matchbox is the preferable solution here.

- For most of my portable operations I use an openwire fed symmetrical antenna, so I almost always use my MFJ-974B symmetrical matchbox. As backup I have an old DECCA EZee Match. I've had it for over 30 years.
- For home use, where I sometimes run an amplifier, I would need to use a high-power symmetrical matchbox, but I don't currently own one because they are very expensive and the really good ones are almost impossible to find on the used market.
  - For cases like this, I use an L-Network (Ten-Tec Model 238B) with an external, HIGH POWER 1:1 current balun.
    - This matchbox was chosen after trying most everything else on the market including a Palstar AT-4K and other expensive matchboxes.
    - The reason I chose the Model 238B is for its broad matching range and excellent efficiency, even at impedance extremes.
    - The reason I use a 1:1 current balun and not a 4:1 balun is described **HERE**.

[NEXT PAGE: SYMMETRICAL MATCHBOXES }>>



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http://DJ0IP.de
.....(Search on THIS site.)

BREAKING NEWS:

First Contest Win for Aerial-51 Antenna N1EU/p

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Aerial-51

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NEW

TUNER BALUNS

ALSO NEW

Simple Multi-Band Vertical on a 12m Spiderpole

160m INVERTED-L on a 12m Spiderpole

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Rob Sherwood Test Drives the FLEX 6700 in CQWW DX 160m

+

(other) Transceiver Tests

LATEST UPDATES:

THE RUBBER BALUN

[HOME] [News] [About Me] [My Station] [My Expeditions] [AMATEUR RADIO] [ANTENNAS] [MODERN ANTENNAS] [SPIDERBEAM] [My Favorite Antennas] [Loop Antennas] [Off-Center Fed Dipole] [VERTICAL Antennas] [Vertical Dipole Arrays] [Wire Beams] [ANTENNA MATCHBOXES] [antenna tuners] [Antenna Tests] [BALUN STUFF] [RF Chokes] [Transceivers] [Chinese Handhelds] [Downloads] [Contest University 2013] [Common Mode Chaos] [CMC TEST] [Ricki-Leaks] [Gallery] [B o B] [TEN-TEC STUFF] [SITE MAP] [LOGIN BELOW] [Rambo.de Domain] [Contact] IMPRESSUM DISCLAIMER Datenschutzerklaerung

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MATCHBOX SHOOT-OUT
MATCHBOX DO's & DON'Ts
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MFJ MATCHBOXES
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Antenna Tuners

UNDERSTANDING MATCHBOX POWER RATINGS

Understanding Matchbox Power Ratings is TRICKY, and the manufacturers don't help us much.

JUST BECAUSE GENERAL MOTORS STATES

THAT THE CHEVROLET CORVETTE'S TOP SPEED IS 150 MPH,

THAT DOES NOT MEAN THAT YOU CAN DRIVE IT

150 MPH DOWN EVERY ROAD!

_ _ _ _ _ _ _ _
_ _ _ _ _ _ _ _

MATCHBOX POWER RATINGS ARE SIMILAR

TO A CAR'S TOP SPEED RATING:

JUST BECAUSE A MATCHBOX MANUFACTURER STATES

THAT ITS MATCHBOX IS RATED FOR 1500 WATTS

THAT DOES NOT MEAN THAT YOU CAN RUN IT

AT 1500 WATTS WITH EVERY LOAD!

HERE IS WHAT PALSTAR WRITES IN ITS MANUALS:

BREAKING NEWS:

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NEW

[TUNER BALUNS]

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[Simple Multi-Band Vertical on a 12m Spiderpole]

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[Rob Sherwood Test Drives the FLEX 6700 in CQWW DX 160m]

+

(other) [Transceiver Tests]

LATEST UPDATES:

[THE RUBBER BALUN]

|

[BAD BALUNS]

|

[EXAMPLE: PALSTAR AT-2K]

Power Maximum:

2000 W PEP SSB, 1500 W single tone continuous

Impedance Range:

20 to 1500 Ω 160 m to 10 m (assuming resistive load) -
Reduce power for lower Z range.*

***OK, so what does that mean?**

- Lower Z Range? How low?
- Reduce Power? How much?
- How is the user to know?
- What should the user do

Palstar makes the user aware that its products cannot always be run at maximum power, "no matter what".

Palstar makes no attemt to trick potential buyers by over-stating the power ratings of its matchboxes.

MFJ IS MORE CONFUSING :

[And until recently, has been a bit dishonest in stating power ratings of its matchboxes.]

THERE IS A LOT OF CONFUSION AROUND THE POWER RATINGS OF MFJ MATCHBOXES

- Most people wrongly believe that a matchbox that is rated 1500 watts can handle 1500w of OUTPUT POWER - ALL THE TIME - - - VERY NAIVE!
  - How much power a matchbox can really handle will vary, depending on the frequency in use and the characteristics of the antenna it is attempting to load.
- People who are familiar with MFJ products know their matchboxes cannot always handle anywhere near that amount of OUTPUT POWER that their marketing leads us to believe.
  - They have learned to divide MFJ power ratings by 2.
  - If you do that, then you will probably be happy with your matchbox.
- Up until a few years ago, all MFJ matchboxes were rated with "INPUT POWER" - NOT output power.
  - A couple of their very new matchboxes are rated with "OUTPUT POWER".
  - Another is rated with "Full Legal Power" (no mention of input or output).
  - You have to be VERY CAREFUL when attempting to determine how much power an MFJ matchbox can safely handle.
- READ THE PARAGRAPH (below) SHOWING WHAT MFJ WRITES ABOUT POWER IN MOST MFJ MATCHBOX MANUALS... **It states clearly that you must divide Input Power by 3 to get Output Power.**

IN MY OPINION, PART OF MFJ'S PROBLEM WITH THEIR POOR REPUTATION FOR ANTENNA MATCHBOXES IS, PEOPLE DO NOT UNDERSTAND HOW MUCH POWER EACH MATCHBOX CAN SAFELY HANDLE!

_ _ _ _ _ _ _ _

TYPICAL MFJ MATCHBOX POWER RATINGS:

- **MFJ-945E “Ham Radio’s Most Popular 300 Watt Tuner"**

What's Wrong with OCFD

LL-TUNER "S-MATCH" added to my symmetrical tuner page. HERE

THIS WEEK:

Noch Nichts

PROGRESSING:

CMC TEST RESULTS

Test results for some of the tests are now posted - including **Two-Core Vs. One-Core 4:1 Guanella Balun**

Matchbox Shoot-Out has been UPDATED

Updated: 16 June 2013

LOTS OF NEW CONTENT IN THE SECTION: ANTENNA MATCHBOXES

MODERN ANTENNAS

WIRE BEAMS

It's time to build antennas! Visit: Spiderbeam Antennas

DISCLAIMER

- *"After minimum SWR is achieved, transmitter power may be increased up to 300 Watts."*
- **No mention of whether Input Power or Output Power is meant for this matchbox. ASK MFJ.**

- **MFJ-962D "Compact Tuner for Linear Amplifiers"**
  - *"Handles 1500 Watts PEP SSB amplifier input power (800 Watts PEP SSB amplifier output power)"*
  - **Input / Output = 2**

- **MFJ-986 "KW Differential-T™ Antenna Tuner"**
  - *"3 KW PEP SSB (1500 Watts PEP SSB output power)"*
  - **Input / Output = 2**

- **MFJ-989 "1500 Watt *legal limit* Antenna Tuner"**
  - **"legal limit" must mean 1500w output power**
  - **No mention of Input Power for this tuner**

- **MFJ-9882 "2500 Watts ContinuousCarrier™ Tuner"**
  - *"Handles 2500 Watts continuous carrier output"*
  - **No mention of Input Power for this tuner**

_ _ _ _ _ _ _ _

CAUTION: ALWAYS LOOK FOR THAT ONE IMPORTANT WORD:

"OUTPUT"

If it doesn't say "Output Power",

and it doesn't say "Legal Limit",

then you must assume it is "Input Power".

[divide by 2 for Output Power]

_ _ _ _ _ _ _ _

HERE IS WHAT MFJ WRITES IN IT'S MANUALS:

Understanding Power Ratings

There are no standardized power rating systems for tuners. *The names used (i.e. 3 kW Tuner) carry over from the time when amplifiers were rated by peak power input, and not the true RF power output. For example, the one thousand watt Johnson Matchbox was rated to handle a 1000 watt plate modulated AM transmitter (four kilowatts PEP transmitter input and 3000 watts PEP RF output). The Heathkit SB-220 was called a two kilowatt amplifier, and the rated CW output was approximately 600 watts. Matching tuners were called 2 kilowatt tuners, and these tuners safely handled 600 watts of CW power and 1200 watts PEP SSB.*

The FCC has changed the power rating system of amplifiers, and tuners no longer follow amplifier power ratings. ***Most typical 1500 watt tuners remain able to safely handle 400-600 watts CW, and 600-900 watts PEP SSB.***

Load conditions and control settings also greatly affect the power handling capability of *the tuner. T-networks typically handle more power on higher frequency bands into higher load impedances. The worst operating condition for T-network tuners are low impedance capacitive reactance loads. T-network tuners always handle the least power when operated on 160 meters into low impedance capacitive reactive loads.*

Follow the guidelines in this manual to avoid exceeding the ratings of this tuner.

_ _ _ _ _ _ _ _

Huh? INPUT POWER?

NOBODY ON THE PLANET TALKS ABOUT INPUT POWER ANYMORE!

If you understood that, then you understood more than me!

- If I follow their thought stream correctly, that their 1500w (input power) tuner can run about 400 to 600w (call it 500w) . . .
- . . . then this means we must divide the MFJ INPUT POWER RATING by **3** TO GET THE OUTPUT POWER RATING

- MFJ Marketing (see above) indicates that: Input Power / Output Power = 2.

- Several of their manuals indicate that: Input Power / Output Power = 3.

Therefore, a 200w MFJ Tuner is good for about 70w on CW.

MATCHBOX POWER HANDLING REALITIES:

- **Power Ratings of a matchbox should always be considered to mean:**

  "Maximum Power Ratings"
- Do not think for a moment that you can run the matchbox at maximum power all the time, with any antenna, no matter what.
- How much power you can safely run without causing damage to the matchbox will depend on two things:
  - Frequency being used
  - Antenna Impedance
- In general, a matchbox may be run at full power over a broad range of frequencies and a broad range of impedances.
- This range is referred to as the "Sweet Spot". For more information on this range, see:

  ["The Perfect Matchbox"].
- **You may have to reduce power significantly when:**
  - Operating 10m
  - Operating 160m (sometimes 80m)
  - The antenna has a particularly high impedance (greater than 1000 Ohms)
  - The antenna has a particularly low impedance (less than 20 Ohms)
- **ALWAYS TUNE THE MATCHBOX AT VERY LOW POWER,**
  - THEN GRADUALLY INCREAS THE POWER
  - REDUCE POWER IMMEDIATELY if it begins to make funny noises (caused by sparcs)

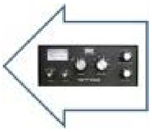
GOOD NEWS: It appears that MFJ has finally realized that "truth in marketing" is a good thing. All of its most recent matchbox products now show "Output Power" or at least state "legal limit" which means 1500 watts PEP SSB Output Power.

DESPITE what I have written above, which sounds pretty bad, 3 of my 7 antenna matchboxes are MFJ products. MFJ makes some good matchboxes, provided you understand how to use them.

IMO, MFJ's bad reputation in the antenna matchbox market is due to users not understanding them and burining them up, etc. I view this as MFJ's Marketing fault, NOT the user's fault.

POSITIVE: All of the MFJ manuals list examples of antennas that can cause problems, thus requiring you to reduce power. MFJ sugests antenna lengths and feedline lengths to be avoided. READ THE MANUAL. It is very helpful.

[NEXT: MATCHBOX SHOOT-OUT}>>



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Antenna Tuners

MATCHBOX "SHOOT-OUT"

[Updated 16 June 2013]

For most people, a matchbox is a matchbox.
Joe Ham seems only interested in how much power does it handle and how much does it cost?

SELDOM DO MANUFACTURERS ADVERTISE THE IMPEDANCE MATCHING RANGE OF THEIR PRODUCTS.

NEVER DO THEY TELL US HOW MUCH POWER IS LOST WITHIN THE MATCHBOX.

For the past 10 years, the ARRL has published several comparison tests of popular matchboxes. They show the matching range, typical SWR and the power loss for the different impedances - all good information that should be considered when purchasing a new antenna matchbox.

PROBLEM: Each test included just 4 or 5 matchboxes. Potential buyers need a way for comparing many different matchboxes and matchbox technologies with each other.

I have created a document showing the results of all of the ARRL test in **one huge Excel Spreadsheet** . If you print it, it is spread out over 6 sheets of paper, which you must cut to size and taped together. The result is a simple, easy to use tool for comparing and evaluating different antenna matchboxes.

If you are an Excel "Power User" and know how to work with split windows and hide rows in Excel, then it is also easy to work on-screen with this document. If you are unfamiliar with this techniques, printing and taping may be the best solution.

MANY IMPORTANT FACTS cannot be shown in a chart or spreadsheet. It is beneficial to use this spreadsheet as a tool to assist in the decision process, but it is not the ultimate answer. Once you have created a short list of your favorite two or three matchboxes, read the original test, read all of the details and weigh that information into your decision process.

Since the tests were conducted by different people over a 10 year period, the reporting method is not always 100% identical from one test to another, though it is close enough to be useful.
EXAMPLE: one test shows power loss of **"less than 10%"** while another shows power loss of **"less than *or equal to* 10%"**. For this chart we will consider both to be the same, although there could potentially be a slight difference.

[IN]ACCURACY: I have typed all of the data into the spreadsheet manually. I am certain there will be a typo or two. **Do your own due dilligence.**

Once you have your potential candidates, double check the numbers for each by reading the original ARRL test.

DOWNLOAD THE SHOOTOUT BELOW:

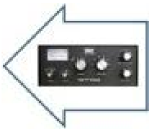
Antenna Matchbox Shoot-Out Ver.1.3

This is an Excel spreadsheet, compatible with Office 97 or later. This is Version 1.3 of the file. As we find and correct errors, we will update the file here.

MATCHBOX SHOOT-OUT V.1.3_e97.xls

Microsoft Excel-Dokument [92.0 KB]

MOST OF THESE ARRL TESTS HAVE BEEN RE-PRINTED IN ***"The ARRL Guide to Antenna Tuners"***,
by Joel Hallas, W1ZR. ISBN: 978-0-87259-098-4.
I highly recommend this book.
Available here: http://www.arrl.org/shop/search.php?mode=search&page=1



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MATCHBOX "DO's" & "DON'Ts"

LONG LIVE THE MATCHBOX!

[IF YOU TREAT IT RIGHT]

YOUR MATCHBOX CAN LIVE A LONG HEALTHY LIFE,

OR DIE A SUDDEN DEATH!

IT DEPENDS ON HOW *YOU* USE IT.

---

10 MATCHBOX DO's:

1. **Understand that no matchbox can match ALL antenna impedances.**
2. **Choose the right matchbox technology for the job at hand.**
3. **Read the instruction manual. Learn how to properly tune your matchbox.**
4. **Always tune your matchbox at low power levels (10 to 20 Watts).**
5. **AFTER the matchbox is properly tuned, increase power slowly until reaching the intended power level, but stop immediately if you hear funny noises (arcing) coming out of the matchbox. In that case, reduce power until it no longer arcs, or fix the antenna.**
6. **Run the matchbox at power levels LESS than maximum rated power level.**
7. **ALWAYS un-key your transmitter before turning the inductor switch.**
8. **NEVER turn the inductor switch with power applied to the matchbox.**
9. **YES, I know #7 and #8 are the same thing! It is VERY IMPORTANT!**
10. **Do not try to match antennas on bands for which they were not**

designed to work.

10 MATCHBOX DON'Ts:

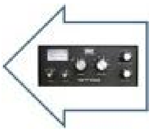
1. **Buy one matchbox, expecting it to be able to match everything.**
2. **Tune the matchbox with high power (more than 20 Watts).**
3. **Use the matchbox on bands for which the antenna was not designed, unless running reduced power.**
4. **Use a T-Network Matchbox without learning how to tune it properly.**
5. **Turn the bandswitch / inductor switch under power. (Nr. 1 Killer!)**
6. **Turn the bandswitch / inductor switch under power. (Nr. 1 Killer!)**
7. **Turn the bandswitch / inductor switch under power. (Nr. 1 Killer!)**
8. **Turn the bandswitch / inductor switch under power. (Nr. 1 Killer!)**
9. **Turn the bandswitch / inductor switch under power. (Nr. 1 Killer!)**
10. **Blame MFJ when you burn it up by doing something stupid.**

By following the Matchbox DO's

and avoiding the Matchbox DON'Ts,

your matchbox will probably live longer than you do!

[NEXT PAGE: HOW TO KILL A MATCHBOX } >>



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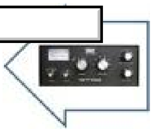

Antenna Tuners

HOW TO KILL A MATCHBOX

[And get away with it.]

Part 1: To Kill a Matching Box

1. **Always tune the bandswitch with power applied.**
2. **Exceed the maximum power rating often.**
3. **Run RTTY at full power rating of the Matchbox.**

Each of these three ways will do it for you!

Part 2: How to Kill a Matchbox (and get away with it):

1. **Do any of the 3 things above.**
2. **When the Matchbox burns up, blame it on MFJ.**

This is one of the most popular ways.

- **Almost everyone will believe you.**
- **Nobody will suspect that you are just another LID who was too lazy to learn how to tune and use his matchbox properly.**

THE NUMBER ONE CAUSE OF MATCHBOX DEATH IS THE OPERATOR.

[NEXT PAGE: MATCHBOX SUMMARY AND CONCLUSION }>>

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MFJ ANTENNA MATCHBOXES

DJ0IP's "OPINION" ABOUT MFJ MATCHBOXES

MFJ is a major player in the antenna matchbox market.
In fact, MFJ is "THE" major player in the antenna matchbox market.
More people use MFJ matchboxes than all other matchboxes from all other manufacturers combined.

Before we continue, please be sure you understand that point.

NOW HERE'S THE NITTY GRITTY:

- The technical level of the average licensed ham is significantly lower than it was 25 years ago.
  - THIS IS NOT NECESSARILLY A BAD THING. I am only stating a fact.
- More people own MFJ matchboxes than all other matchbox manufacturers' products combined.
- It is only logical that more MFJ matchboxes will break in the field than all others. After all there are more of them out there!
- **The single biggest cause of matchbox failure/breakage is operator inflicted.**
- MFJ is not guilty of building poor matchboxes; instead MFJ's MARKETING is guilty of broadcasting confusing messages about their matchbox products. They have consistantely published confusing statements about matchbox power capabilities. For facts on this, see: ATU Power RATINGS.
- As a result of this long-term overstating of the Power Ratings of MFJ matchboxes, customers have been mislead into believing their matchboxes can handle more power than they actually can.
- It is no wonder that many hams have burned up their matchboxes, as a result of

the false expectation level set by past MFJ marketing.

- **THIS IS CLEARLY A MARKETING PROBLEM, NOT A TECHNOLOGY PROBLEM.**
-

  The MFJ matchboxes in general are as good as any other make and certainly worth their price.
- With proper understanding of their power level, and proper use, they will last a lifetime. (My oldest MFJ matchbox is almost 30 years old and still in perfect condition).

IMPORTANT: MFJ HAS CLEANED UP ITS ACT.

Recent products are now advertised showing Output Power ratings instead of Input Power rating.

This will avoid lots of problems in the future.

PERSONAL INFORMATION ABOUT DJ0IP:

- I have owned over 30 antenna matchboxes in my ham radio career.
- I currently own 7 different matchboxes.
- 1 of them is 50 years old. I will keep it for sentimental reasons.
- 6 of my matchboxes are used regularly.
- 3 of the 6 matchboxes are MFJ matchboxes.
- I understand matchbox technology fairly well and know when and where to use each matchbox.
- I am VERY satisfied with these three MFJ matchboxes. They are keepers.

CONCLUSION:

Many people like to brag about their station. If you are one of these guys, well you should probably buy something else. If on the other hand you are looking for a good solution for a fair price, you should consider an MFJ matchbox. If you use it properly, you won't have problems.

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MATCHBOX SUMMARY AND CONCLUSION

The antenna matchbox should be viewed as a necessary evil.

Although it enables us to use an antenna which we could otherwise not use, it also robs us of part of our power. Sometimes the power loss is significant.

There are many different types of antennas that we choose to use, and the impedances they present to the transmitter can be all over the map.

No matchbox on the planet can match everything efficiently.

All matchboxes have a "Sweet Spot" which is a range of frequencies and a range of impedances which they can match efficiently. If you use them within their Sweet Spot, you will be very pleased with them. If you attempt to use them outside of their Sweet Spot, you may incur excessive internal power loss, or even burn them up. If you burn one up, just remember, *it's not the fault of the matchbox!*

The key to efficient performance from a matchbox is to use the correct matchbox technology for each matching task. This will minimize matchbox loss.

Some matchbox types, ESPECIALLY the popular T-Network, have excessive (and unnecessary) loss if they are not tuned properly.

Learn how to properly tune your matchbox.

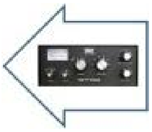
(Read the manual!)

(Today = 8/8/2015)

Gemuenden, Germany

MOST IMPORTANT when choosing a matchbox is NOT to choose the matchbox which most other people are using, but rather to choose the matchbox which is correct for the antenna(s) YOU wish to use it with.

NEVER USE A MATCHBOX UNLES YOU ABSOLUTELY HAVE TO.



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Getting the Most Out of Your T-Network Antenna Tuner

Here's how to adjust this popular tuning circuit so it transfers maximum power to your antenna without going snap, crackle and pop.

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Look into most of today's commercially manufactured antenna tuners, and you'll probably see a circuit that ultimately boils down to one coil and two capacitors. Whether the tuner is a stand-alone unit or one of the "automatic" types built into a current MF/HF transceiver, it probably consists of a *T network*, so named because of how it looks when we draw its schematic (Figure 1). The circuit consists of two variable capacitors, C_{IN} and C_{OUT}, and a variable inductance, L, connected between common and the junction of C_{IN} and C_{OUT}. For the purposes of the discussion to follow, we'll assume that C_{IN} and C_{OUT} can be adjusted from 20 to 240 pF, and that L is a 0.1 to 35-µH inductor.[1]

Especially in automatic tuners, C_{IN} and C_{OUT} may consist of a combination of variable and fixed-value capacitors. In built-in automatic and many manual outboard tuners, L is a fixed inductor with multiple, switch-selectable taps. In upscale stand-alone tuners, L may be a continuously variable *roller* inductor.

[1]Notes appear on page 47.

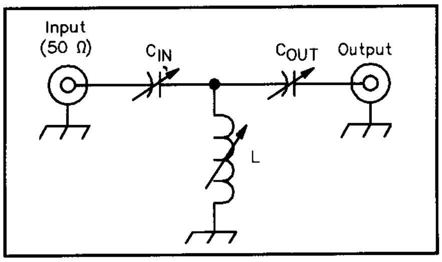

Figure 1— Today's built-in and outboard ham antenna tuners most commonly use this generic circuit, the *T network*. In many automatic tuners, motors adjust the circuit's tuning capacitors (C_{IN} and C_{OUT}), and relays ground various L taps to vary the network's inductance. (Relays may switch in additional inductance or capacitance to extend the network's tuning or matching range.) In manually adjusted tuners, front-panel controls (perhaps labeled **TRANSMITTER** [C_{IN}] and **ANTENNA** [C_{OUT}]) adjust the capacitors, and L may be a front-panel-adjustable roller inductor or a multiply tapped coil teamed with a rotary switch. In exploring the T net's performance, we'll assume that C_{IN} and C_{OUT} can be adjusted from 20 to 240 pF, and that L is adjustable from 0.1 to 35 µH.

Stand-alone outboard tuners often include a 4:1 balun transformer that extends the tuner's matching range and allows it to drive balanced feed lines. The balun's 4× (balanced) side connects to the load, and its 1× (unbalanced) side connects to the tuner output. Some tuners use a 1:1 balun instead.

It's usually possible to find more than one group of **T** network settings capable of transforming a given load to 50 Ω. Some of these values may work better than others; some may even be worth avoiding altogether! Sometimes a **T**-network's components overheat or arc over; sometimes, it seems hard to match a garden-variety load even with a wide-range tuner. Let's see if we can find out why.

T Network Basics

The **T** network is a versatile matching circuit. If its capacitors and inductor can be set to the necessary values, it can match practically any antenna impedance radio amateurs are likely to encounter. What makes this tricky is that, for a given matching problem, an infinite number of C_{IN}, C_{OUT} and L values can achieve a match! We need not endlessly seek a workable set of values, however. Once we set any one of the network's three components to some arbitrary fixed value, we can readily determine the other two values necessary for matching a given load.

For example, say we want to match a 50-Ω transmitter to a 200-Ω resistive load at 3.8 MHz. If we set C_{OUT} to midrange (about 130 pF), C_{IN} must be 233.7 pF, and the inductance must be 5.65 µH.[2] We could preset either of the network's other two variables, C_{IN} or L, instead, and as long as its value is one that allows the network to transform 200 Ω to 50 Ω at 3.8 MHz, we could determine the other two values by experimentation.

If the tuner's inductor is continuously variable, any of the network's variables can serve as the fixed one. If the tuner has a tapped inductor, the inductance is the logical choice for the fixed variable. More than one setting of the inductor switch may allow us to achieve a match within the range of C_{IN} and C_{OUT}.

Matching Range

For purely resistive loads, a **T** network with Figure 1's C_{IN}, C_{OUT} and L values can match loads of about 10 Ω to 3 kΩ from 160 through 15 meters. At 10 and 12 meters, the range narrows to about 10 Ω to 1.5 kΩ because C_{IN} and C_{OUT} cannot be adjusted to less than 20 pF.

When the load impedance to be transformed is reactive, the matching range narrows. Even with reactance present, very few cases should occur in which the antenna cannot be matched with the proper tuning technique. (We'll discuss tuning technique shortly.)

Harmonic Attenuation

The C-L-C **T** shown in Figure 1 is basically a high-pass network. Thus, it can't attenuate harmonics very much. As Figure 2, Table 1 and Table 2 show, making the network tune more sharply somewhat increases its harmonic attenuation, but even at maximum tuning sharpness, the network's attenuation would likely contribute little to improve a transmitter's spectral purity.

This is why this form of **T** network was not used in Amateur Radio circles until recently. Because modern commercial transmitters and amplifiers must meet rigid spurious-emission standards, further harmonic suppression by outboard devices is usually not necessary. If we used variable inductances to replace C_{IN} and C_{OUT}, and replaced L with a variable capacitor, we'd have an L-C-L **T**—a *low*-pass network similar to the familiar pi networks often used in

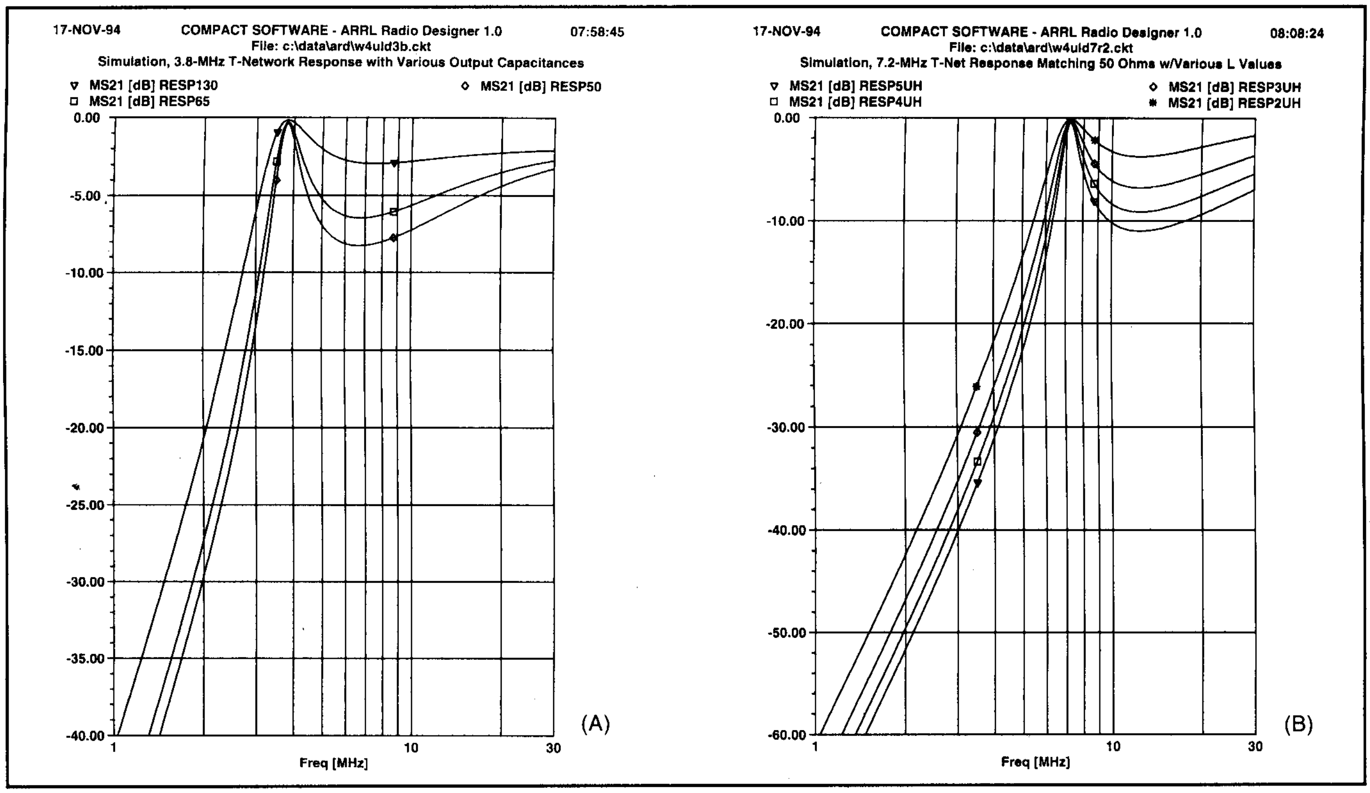

Figure 2—How different sets of T-network C_{IN}, C_{OUT} and L values can vary the network's tuning sharpness for a given impedance transformation. Graph A shows three 200 to 50-Ω transformations at 3.8 MHz, with C_{OUT} as the fixed variable; Graph B shows four 50 to 50-Ω transformations at 7.2 MHz, with L as the fixed variable. (A T network left in line to "flatten" an antenna's modest impedance shifts above and below resonance must be able to "transform" 50+*j*0 Ω to 50+*j*0 Ω as well as transform divergent impedances to 50+*j*0 Ω.) Tables 1 and 2 show the network values and minimum losses associated with these graphs. (*Network simulated, optimized and graphed by WJ1Z with* ARRL Radio Designer 1.0)

Table 1

Simulation, 3.8-MHz T-Network Response with Various Fixed C_{OUT} Values, 200+*j*0 Ω to 50+*j*0 Ω Transformation (Figure 2A)

Curve	RESP130	RESP65	RESP50
C_{IN} (pF)*	233.7	130	103
C_{OUT} (pF)*	130	65	50
L (μH)†	5.65	9.4	11.8
Loss (dB)	0.16	0.31	0.39

*Q=1000
†Q (skin-effect model)=200 at 7.9 MHz

Table 2

Simulation, 7.2-MHz T-Network Response with Various Fixed L Values, 50+*j*0 Ω to 50+*j*0 Ω Transformation (Figure 2B)

Curve	RESP5UH	RESP4UH	RESP3UH	RESP2UH
C_{IN} (pF)*	50.7	63.5	85.7	133.3
C_{OUT} (pF)*	48.2	61	83.1	133.3
L (μH)†	5	4	3	2
Loss (dB)	0.43	0.34	0.25	0.16

*Q=1000
†Q (skin-effect model)=200 at 7.9 MHz.

vacuum-tube RF power amplifiers. However, doing so would add considerably to the cost of a tuner, and its tuning would be more awkward.

Tuner Losses and Power Limitations

Because tuner components are not 100% efficient, some of the RF power applied to a tuner's input turns into heat instead of showing up at the tuner's output. It's often said that these power losses are "not worth worrying about." The truth of this statement depends on how much power your tuner can safely dissipate, and how much loss you *want* to worry about. Power loss in a tuner occurs mostly in the inductor, and is inversely proportional to the inductor's quality factor (Q)—the higher an inductor's Q, the lower its loss. Losses can also occur in a tuner's connectors and balun, but let's neglect these additional losses and assume that the tuner's inductor is good quality, with a Q of 200. A typical tuner task is to extend the range of a dipole over an entire band. Curve C of Figure 3 shows the tuner loss for this situation. At 40 through 10 meters, the loss is less than 0.1 dB—that is, 2.3%. At 160 meters, the loss rises to about 0.32 dB, or about 7%. Even a purist might agree that a loss this low is "not worth worrying about"—but in saying so, we'd be assuming that the tuner components doing the "lossing" can safely dissipate 7% of the power applied. Seven percent of 100 W is 7 W; 7% of 1.5 kW is *105* W. Depending on your transmitter power, and your tuner's loss and dissipation capability, *any* decibel value of tuner loss may be worth worrying about!

At any frequency, T-network loss goes up as the load impedance goes down. As Figure 4 shows, the worst case (for a **T** network with the L and C values shown for Figure 1) is 160 meters, where power losses of *over 20%* can occur *even though the tuner is adjusted for maximum efficiency.* Figure 3's A and B curves show minimum and maximum loss versus frequency with a load impedance of 10 Ω.

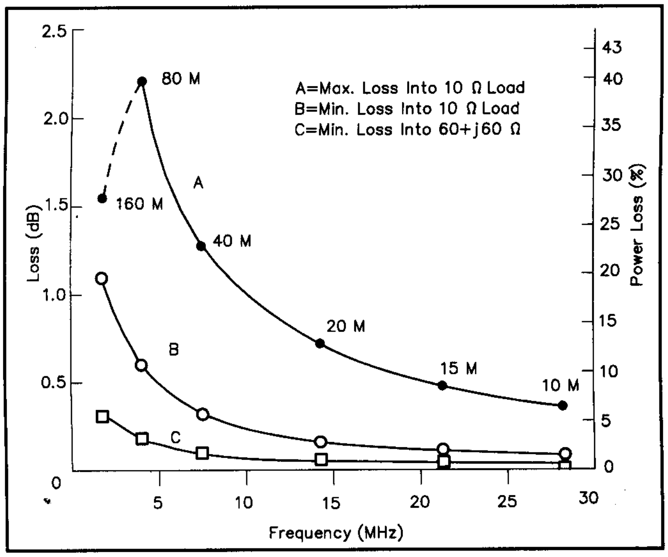

Figure 3—How lossy can a T network be? Curves A and B show the Figure 1 network's maximum and minimum losses when transforming a 10+*j*0-Ω load to 50+*j*0 Ω. Curve C shows the network's minimum loss when matching an 50-Ω antenna slightly off resonance (60+*j*60 Ω). Depending on the transmitter power and tuner type involved, even a network loss on the order of 0.3 dB can cause tuner components to overheat or fail. (*Graph by W4ULD*)

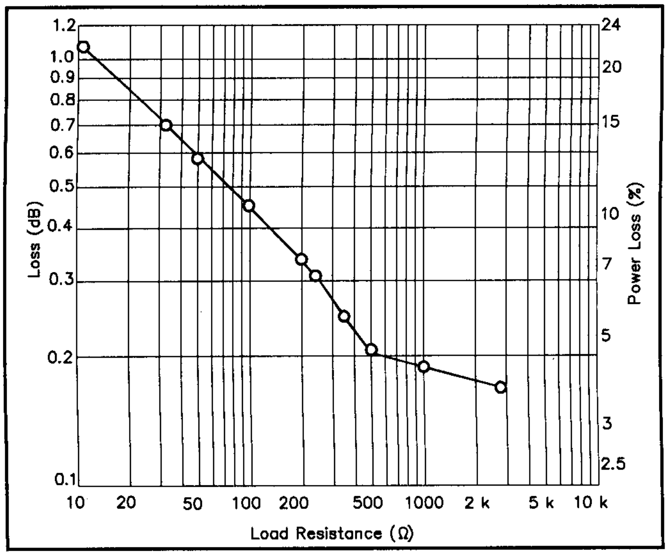

Figure 4—A T network with Figure 1's values can transform a wide range of impedances to 50+*j*0 Ω at 160 meters, but its loss is significant for lower-impedance loads. Using a 500-pF variable at C_{IN} and a 1000-pF variable at C_{OUT} would allow network losses of less than 0.3 dB even when matching 10 Ω, but these capacitors' high minimum capacitances would then restrict the network's high-Z matching ability on higher-frequency bands.

In the **T** network, loss is also proportional to tuning sharpness (the sharper the tuning, the higher the loss). Tuning sharpness is inversely proportional to output capacitance (the lower the value of C_{OUT}, the higher the loss). Figure 3's A curve shows loss versus frequency with the minimum output capacity that allows a match at the desired frequency. We are now talking about losses between *10% and 40%*! The highest losses occur from 40 to 160 meters.

Low load impedances don't just cause high losses; they also cause relatively high voltages to appear across the network's capacitors. When a short circuit occurred in my 75-meter antenna's coaxial feed line, my **T**-network tuner could successfully load the shorted coax at 100 W output. At about 750 W, one of the network's air-dielectric capacitors arced over.

Some tuners switch in solid-dielectric fixed capacitors for more efficient matching on lower-frequency bands. Like air capacitors, these can flash over in response to overvoltage. Unlike air capacitors, however, they can also overheat and fail if subjected to the high RF currents that may occur in some extreme matching situations.

Practical T-Network Tips

What I've covered so far about loss and capacitor flashover suggests two practical hints for **T** networks with C and L values like those of Figure 1:

- To achieve the highest possible efficiency at a given impedance transformation, tune the network with the highest output capacitance that allows a match.
- When matching loads of less than 25 Ω on 80 meters and 160 meters, you may have to reduce your output power to reduce tuner heating or to keep it from arcing. With loads like this, you may not be able to use a legal-limit amplifier even with a tuner specified to handle 1.5 kW.

When operating with high power, take the following precautions:

- Don't feed short (less than 0.3 λ), loaded dipoles with a feed line that's a multiple of ½-λ (electrical) long. Such antennas may have feedpoint impedances of 5 to 9 Ω, and since the input impedance of a ½-λ line section closely mirrors the impedance of its output load, the tuner will also see a very low load impedance.
- Don't operate a 160-meter ½-λ dipole on 80 meters, or an 80-meter ½-λ dipole on 40 meters, with a coax feed line that's an odd multiple of ¼-λ (electrical) long. In this situation, the antenna's high feedpoint impedance will be transformed to 1.5 to 2 Ω at the tuner. To add insult to injury, the feed line loss will be excessive—over 6 dB. *A 6-dB loss wastes ¾ of your transmitter power as heat.*
- Don't use a tuner's 4:1 balun to feed a ½-λ dipole via a ladder line that's a multiple of ½-λ (electrical) long. The tuner may see a load impedance of 12 to 15 Ω. A 1:1 balun would be a better choice in this situation.

A Tried and True T Tuning Technique

I find that a **T** network built with the component values shown for Figure 1 can match most antennas to 50 Ω. Problems in tuning usually result from improper technique.

We commonly adjust roller-inductor tuners by adjusting each control in sequence to achieve a minimum SWR. The problem with this approach is that the minimum SWR combination may be passed each time a single control is adjusted, making the true minimum hard to find. Confronted with this situation, we may think that the best we can do is an SWR of 1.5 or more. With a little practice, the **T**-network tuning technique I'm about to describe should work almost every time.

Practice with low power and a dummy antenna fed via coaxial cable. If a large variable capacitor of about 100 pF is available, connect it in series with the center conductor of the coax at the dummy antenna. By setting this capacitor to various values, you can practice matching reactive loads that produce high SWRs. Instead of driving the tuner with a transceiver, you can use an antenna analyzer.

Remember, if one of a **T** network's three variables is fixed, only one setting of each of the other two variables can provide a match. You can't adjust the tuner's tuning sharpness with a knob, of course; the settings you ultimately arrive at will determine it. Generally, less C_{OUT} translates to sharper tuning. But because efficient tuner operation is more important than a tuner's harmonic reduction, it's more important to remember that more C_{OUT} translates to less loss.

For Roller-Inductor Tuners:

1. Set C_{OUT} at maximum capacitance and leave it there.
2. Set C_{IN} to about half scale.
3. Adjust the roller inductor for an SWR dip. (The dip may be barely noticeable.)
4. Slightly increase or decrease the C_{IN},

and readjust the inductor for a dip.

5A. If the SWR is lower than it was in Step 3, slightly vary C_{IN} in the same direction as in Step 4.

5B. If the SWR is higher than before, adjust C_{IN} in the direction opposite to that taken in Step 4. Alternatively, inch C_{IN} in the Step 4 direction and redip the SWR with the inductor until you obtain an SWR near 1:1.

6. When you've almost reached the match point, the SWR may start to go up as you adjust C_{IN}, but make the change anyway and redip with the inductance.

7. Continue to adjust C_{IN} in the same direction until adjusting the inductor produces a higher SWR than before. Inch the capacitor back to the previous setting.

8. If you cannot obtain a 1:1 SWR, reduce C_{OUT} and repeat the process, beginning at Step 2. If you cannot acceptably minimize the SWR at some setting of C_{OUT}, the antenna impedance is out of range of the tuner.

For Tapped-Inductor Tuners:

The only disadvantage of a tapped-inductor **T** network tuner is that its limited inductance resolution may not let you set C_{OUT} to its maximum possible value at match. With the tapped-inductor tuner, the inductance becomes the fixed variable.

1. Set C_{IN} and C_{OUT} to midscale. Select an inductance switch position, and rotate the C_{OUT} through its range to look for an SWR dip. As before, the dip may be very slight.

2. If you don't find a dip, set the inductance switch to another position and adjust C_{OUT} for an SWR dip.

3. When you find a dip, adjust C_{IN} for minimum SWR.

4. Inch C_{OUT} in one direction or the other, and redip with C_{IN}.

5. If the SWR is lower now than it was with the previous C_{OUT} setting, continue to inch C_{OUT} in the same direction and redip the SWR with C_{IN} until you obtain a 1:1 SWR.

In some cases, an SWR dip can be obtained with two inductance settings. Choose the setting with the lower inductance to get the larger output capacitance.

Summary

Properly configured, a **T** network tuner can match practically any antenna the radio amateur is likely to encounter. Using Figure 1's C and L values, it can transform purely resistive 10 Ω to 3 kΩ loads to 50 Ω, resistive, in the amateur bands from 1.8 through 21 MHz, and it can transform 10 Ω to 1.5 kΩ loads to 50 Ω, resistive, from 24 to 29 MHz.

Because the **T** network is a peaked high-pass network, you should not expect it to provide significant harmonic reduction. Since FCC's Amateur Radio Rules require that acceptable levels of harmonic reduction be built into modern transmitters, we need not expect an antenna tuner to improve it. This lets us design and adjust our tuners for maximum transformation efficiency instead of wasting power in sharply tuned matching networks.

Loss in a **T** network tuner is often less than 0.3 dB, but may be considerably higher. For a given impedance transformation, minimum loss occurs when C_{OUT} is as high as possible when a match has been achieved. The loss in a **T** network that uses Figure 1's L and C values can approach 2 dB when matching load impedances lower than 20 Ω at 40, 80 and 160 meters. Under these conditions, component heating and/or arcing may occur, and the tuner's power-handling capability may have to be derated. With the proper tuning techniques, however, an acceptable impedance transformation—as indicated by a 1:1 SWR—should be obtainable under most circumstances.

Notes

[1]This capacitor-inductor-capacitor (C-L-C) **T** arrangement forms only one of many possible **T** combinations of coils and capacitors. In this article, "**T** network" means the C-L-C circuit, which is the most widely used **T** configuration in Amateur Radio antenna tuners today.—*Ed.*

[2]I determined these values with a GW-BASIC computer program I wrote (and we confirmed and refined them with *ARRL Radio Designer 1.0—Ed.*). This article is about finding **T**-network values by experiment, so it doesn't included the formulas I used to achieve this 80-meter match. If you're interested in experimenting with my program, you can download the file TNETWORK.BAS from the ARRL BBS at 203-666-0578. QST

New Products

FREE SOFTWARE

◊ Although radio amateurs lie in fear that the infamous Murphy (as in "Murphy's Law") will visit their shacks, here's one Murphy you should welcome: George "Murph" Murphy, VE3ERP, has released yet another new, enhanced version of his renowned *HAMCALC* software, a veritable Swiss Army Knife for hams.

HAMCALC does painless calculations for Amateur Radio operators. From the simplest Ohm's Law problem to designing a complete regulated power supply, you can do it all without looking up a single formula or doing a bit of math.

This collection of programs removes the drudgery of mathematics for anyone who dabbles in design, experimentation or general fiddling in the field of ham radio. All the programs are user friendly, self-explanatory and run mostly by menu-driven single keystrokes. The following is a partial rundown of the programs (adetailed index is included in the *HAMCALC* menu):

Designing air-core inductors, attenuators, audio-bandpass filters, an audio tone analyzer, band-reject filters, CCD antennas, coaxial cable traps for multiband antennas, L/C networks, L-pads, mobile whip antennas, voltage regulators, open-wire transmission lines, parabolic antennas, series-section balun transformers, short dipoles for restricted space, toroid antenna traps, trap dipoles, trimmer capacitors, a regulated power supply and a Zener diode voltage regulator; tools for calculating figures for 555 timers, ac circuits, standard and custom-value capacitors, custom-value potentiometers, custom-value and precision resistors, coaxial cable characteristics, series and parallel components, telescoping antenna tubing, copper wire, decibels, Great Circle paths, helical windings, inverted-**V** antenna lengths and dimensions, LEDs, pi-network impedance matching, quad antenna dimensions, RC constants, toroid inductors, transformer ratios and windings, transmission-line losses, sunrise/sunset and SWR; and handy utilities including a calendar, a clock screen saver, a decimal/fraction converter, an equivalents calculator, instant metric conversions, ham shack construction planning, line-of-sight figures, a local repeater data base, a NiCd battery use and charging scheduler, a code practice program, and tools to compute prime numbers, solve triangles and quadratic equations, and measure sag in horizontal wire antennas.

HAMCALC can run in a floppy drive, and menus lead you through all the programs with plenty of onscreen help. Detailed onscreen instructions are included to tell you how to use *HAMCALC* to make backup disks of any size and how to install *HAMCALC* on your hard drive with instructions for removing it from your hard drive. There's also a printer setup program.

The author asks that users read about the Amateur Radio program of the Canadian National Institute for the Blind, included on the first screen that appears when you start *HAMCALC*.

This software is free to use and to copy and pass along to your friends. A bonus is the included *FOTOCALC* software that performs numerous calculations for photographers.

In the true spirit of Amateur Radio, the complete package is free. Contact "Murph," George Murphy, VE3ERP, at 77 McKenzie St, Orillia, ON L3V 6A6, Canada; 705-326-9612.

You can also download the *HAMCALC* ver 8.7 from the ARRL HQ BBS at 203-666-0578, or via Internet, by anonymous FTP from several sites, including oak.oakland.edu. The files on this site include a mirror of ARRL HQ's e-mail information server (info@arrl.org) in the directory pub/hamradio/arrl/infoserver and a number of programs and binary files that accompany *QST* articles in the directory pub/hamradio/arrl/qst-binaries. QST