Tee and SPC Transmatches

Gary E.J. Bold, ZL1AN Version 2, November 2010

1 Introduction

These transmatches are used to power match between *single-ended* impedances - that is, those where one end of both the source and the load are grounded. This is the case if the source is a modern transmitter, which expects to see a load of 50Ω for optimum operation, and the load is a coaxial transmission line, terminated in the antenna.

If the load is balanced, as for open wire feedlines, a balun can be used at the transmatch output. Baluns can be bought commercially, but they are not hard to wind yourself. I wind them on toroids.

Early single-ended transmatches for tube transmitters were almost invariably pi couplers. There were 2 reasons for this:

- Tube class "C" transmitters generated rich harmonics, which had to be attenuated. Pi transmatches do this, because they are *low-pass* devices, that is, they have a frequency response which falls off very rapidly above the matching frequency.
- Tube amplifiers worked correctly into much higher impedance loads than those specified for modern transistor output stages, usually 50 Ω. When designed for transistor stages, Pi transmatches usually require very large capacitance values to give a match, especially for low value loads, on the lower frequency bands.

Modern Tee transmatches are conventionally constructed as *high-pass* devices. This, their response falls off less rapidly with frequency above the matching frequency. This is acceptable for modern commercial transmitters, which have excellent output low-pass filters already built in. Furthermore, *high-pass* transmatches can be constructed with much smaller values of capacitance. Thus, the majority of modern 3-element commercial transmatches are high-pass tee types, and I use and recommend these myself.

I wrote three *Break-In* articles examining the design and performance of Pi and Tee transmatches in detail. These are references 1,2 and 3. They are a bit theoretical for those who just want to build one, but they do contain all the relevant design and performance equations, most of which I derived myself and have never been published anywhere else.

2 Tee Transmatches

Figure 1 shows the simple tee high-pass transmatch (top) and the SPC (series-parallel capacitor) transmatch. The SPC configuration was devised by Doug DeMaw, W1FB, of the ARRL Headquarters staff, and published in the 1981 ARRL Handbook.

The simple tee is commonly used in commercial transmatches (such as the MFJ series), because it *is* simple. The SPC has slightly better harmonic attenuation, and also enables "reasonably-sized" capacitors to achieve a match on 160 meters. Both require two airspaced variable capacitors and a tapped inductor. The SPC requires a double-ganged capacitor on the output side - that is, two sections which move together on a single shaft, but this is no problem, as salvaged double-ganged broadcast capacitors are at least as common as single ganged types. Capacitors having a maximum value of about 350 pF per section are OK for 80 metres and up. The SPC *always* introduces more loss (power dissipated in the inductor) than the simple tee, given inductors of the same Q. This is

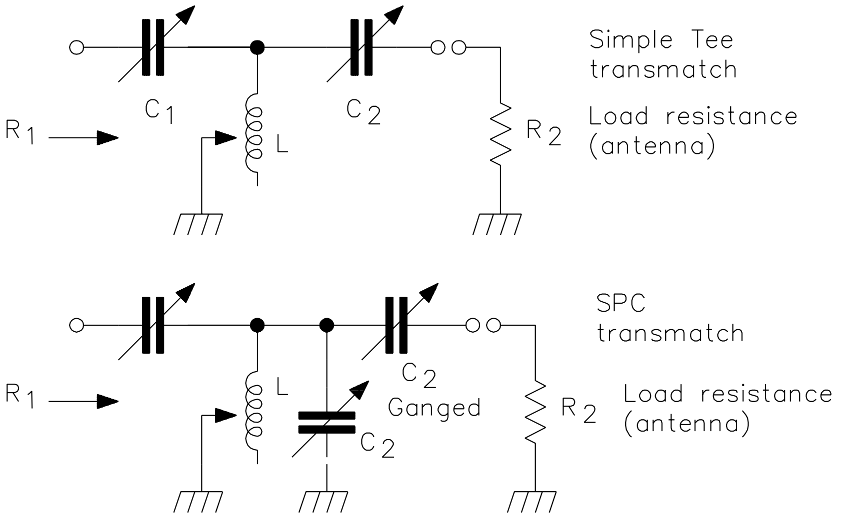

Figure 1: Top: Simple Tee transmatch. Bottom: SPC transmatch

because it is a “more selective” design and the circulating current in the coil is higher. Typical losses are quoted in reference 3. For ZL powers and conditions, the difference is not noticeable.

I also designed an experimental “Bold Transmatch”, which combines the input section of the (now obsolete) “Ultimate” 1970 design of Lew McCoy, W1LCP, and the output section of the SPC. This requires double ganged capacitors at both input and output, and is even more selective than the SPC. However the losses are higher again, and I don’t recommend it for serious use.

The next two sections describe a couple of simple designs which work well. Following this I give their design and performance equations. There is no need to go into all of this, but I include it for completeness.

3 The ZL2QS Version of the SPC

In 1988 Noel Padman, ZL2QS, published constructional details, schematic, and photograph of an SPC transmatch he had reportedly built many times - see reference 4. The only reservation I have concerning his design is the number of tapping points he defines on the coil. He uses only 4, and tells you which bands they should be used on. I would use *more*, since antenna and feedline impedances vary greatly, and I’ve personally found that the tap I use for a particular band may have to be changed if the transmatch is used at a different location. However, he apparently has not found this. His design is as good as any, and if standard double-gang broadcast variables are used, the parts count is the same as for my simple Tee. Try it first.

4 The ZL1AN Simple Tee

I have built several of these, and like Noel’s, they all worked. Here are my thoughts on tees, and my recipe for winding a suitable inductor.

4.1 Selecting Variable Capacitors

Special "wide-spaced" transmitting capacitors are around, but are quite rare. However, "Receiving spaced" capacitors are quite OK for powers up to about 100 Watt, unless the load to be matched has a very high value (several kΩ) or is very reactive. I have found such loads to be unusual. Typically, the plate spacing of receiving variable capacitors is about 0.2 - 0.3 mm, which arc over at about 300 - 500 volt *rms*. Dust, pitting, high spots and high humidity can reduce this.

4.2 Inductors

There is no need to have a continuously variable roller inductor (one where the coil rotates and a small wheel moves along it). Tapped ones are quite OK, if there are enough taps - see later - and will still give a *perfect* match. This is commonly misunderstood, and the need for one is a fiction promulgated by commercial outfits to get you to buy their expensive products. You can easily wind a suitable one yourself.

Inductors should be air-wound, at least double-spaced, if you're going to use them above 3.5 MHz. That is, the wires should be separated by at least one wire diameter. This helps to keep the distributed capacitance down, and also avoids accidentally shorting turns. Wire should be solid copper, around 18 gauge. Either insulated or bare is OK.

When mounted, the inductor should be ideally *at least* one coil diameter away from metal objects such as the sides of the box it's in, or its Q will be lowered. The transmatch will still work fine, but *some* of the power going in will just heat up the box instead of passing through to the antenna. You can check by putting your hand on the box to see if it gets warm. See some observations on this in the review in the appendix.

My "standard transmatch inductor" has 30 turns, is about 2 inches in diameter, and 3.6 inches long, wound with about 18 gauge bare wire. That gives a maximum inductance of about 17 μH. It's tapped every 3 turns, so there are 10 taps. The taps are just pieces of the same wire, 3 cm long, soldered to the coil, bent outwards. These can be taken to a wafer switch, or just clipped onto with a (heavy, clean) alligator clip.

4.3 To Short, or not to Short?

Note that in my diagrams, the unused portion (the bottom) of the coil is *floating*. Commercial and most Ham designs show the bottom of the coil permanently connected to ground. I used to believe that this was bad, since, as the unused portion is shorted, and is inductively coupled to the upper portion, eddy currents will flow in it, eating up some of your power.

However, in 2003 my good friend Villi, TF3DX, a well-known and very knowledgeable CW op from Iceland, counselled the opposite. He said this.

> "For many years I shared your opinion that the unused part of a tapped coil should not be shorted, and snorted at those "stupid" designs of tank circuits and tuners in the ARRL publications that almost invariably included a short.
>
> "I then ran into problems due to resonance in the unused part. As frequency increases, a coil exhibits a succession of parallel and series resonances due to stray capacitance, somewhat akin to a slow transmission line. Considering the 10:1 frequency range of amateur HF equipment, chances are that a large, unused part of a coil may self-resonate at the relatively high frequency one is trying to tune with the smaller part.
>
> "When I came back to DX in 1990, I hooked up a simple tapped L-network at the intake of my LW antenna, using components from an old 80 metre tank circuit, except that I

> increased the pitch of the coil winding in what I assumed to be the right range for 15 metres and 10 metres.
>
> "Tuning up on 15 metres, I immediately spotted a very hot coil end. As I increased the power level further the *nicest corona ever* emerged! That experience made me adopt the ARRL method of *shorting* the unused part, after which it worked perfectly. I surmise that when shorted, the coupling between parts of an air-cored coil is sufficiently low to minimize loss, while eliminating the possibility of an unwanted self-resonance. One can also leave several turns between the tap and the short, thus reducing the coupling further.
>
> "The same story repeated itself when I built a portable tuner some years ago, except that this time a cheap 12-position switch despairingly sent out a smoke signal. Actually, I intended to short it, but just couldn't resist challenging the odds to see what happened. Increasing power ever so cautiously, I thought, until I smelled the molten plastic!
>
> "Again, I wired the short into the circuit and have used that tuner extensively on all bands ever since without any trouble, the barbequed switch still in place!"

Villi went on to analytically compute the coupling coefficient for his coil, and concluded that in his case at least, shorting the coil introduced a power loss of only a few percent. OK, I recant. Short the unused portion.

4.4 Winding the Coil

I wind my transmatch inductors by threading coils through drilled perspex sheets. Do this:

1. Find a broom handle or other cylindrical object which is about 2 inches in diameter. The actual diameter isn't critical.
2. Wind about 35 turns of wire, close-spaced and tight, around this.
3. Release the wire, and let it spring out into it's untensioned shape. The diameter will be slightly greater than the winding form, and now it can be easily slipped off.
4. Measure the actual, resulting coil diameter.
5. Cut a rectangular piece of perspex about a cm longer and wider than the eventual shape of the coil. This is the coil frame.
6. Drill 2 lines of parallel holes, spaced by the actual diameter measured above. These should be slightly larger than the diameter of the wire, so it will pass through easily. I drill 30 holes, 1/8 inch apart.
7. Wind the coil onto the frame through the holes. You should end up with a configuration where all windings are equally spaced.
8. Put a blob of superglue or other adhesive to your taste where each wire goes through a hole, to hold everything tight.
9. Drill whatever mounting holes necessary at the bottom of the frame.

Now you have a coil with free-standing turns where the air can circulate to carry away any heat, and a minimum of supporting dielectric, to reduce losses.

If mounted at least one winding diameter away from metal, this coil should have a Q of about 150 on 80 metres, dropping to maybe 80 on 15 metres. You'll probably need 10 to 20 turns on 80 metres, dropping to 3 to 5 on 15 metres, depending on the lengths of the wires to the capacitors. I also like to mount the capacitors at least a coil diameter away from the coil, but some commercial models have them much closer.

On 20 metres and above, you may find that the taps are not close enough together, and very little of the coil is in use. To get around this, many constructors (like Noel Padman) have included a *second* coil, which is much smaller, connected to the top (ungrounded) end. This might be only 3/4 inch in diameter, have 5 - 10 turns, and be tapped every second turn or so. This can be mounted alonside the main coil, at right angles to it so that the field lines don't interact too much. There's a second coil on my MFJ-945D tuner (reviewed in the appendix) which is a toroid, mounted *inside* the main coil, untapped. Toroids are great for putting inside meatal boxes, since virtually all of the magnetic field is confined inside them. However, you have to use the right grade of toroid. Consult Derek Fortune again.

Make the connecting wires as short as possible. If you don't, stray inductance will cause unpredictable additional resonances and strange effects at higher frequencies. This was (unwittingly) shown in measurements on sample transmatches in the 1981 ARRL Handbook, section 19-12. I entered a long and interesting correspondence with the Technical editor, and this material was withdrawn.

5 Design Equations

If you just want to build a transmatch, it isn't necessary to understand this section, or even to read it. The equations are here for completeness, and are useful if you want to thoroughly investigate different designs. There are other references on my web-page (see the "Software" section) to programs which find suitable values for you.

These are my own design equations. They're different from those given in other references. These are more versatile, because they lead to approximate expressions for other useful parameters such as the inductor power dissipation, which the standard equations can't predict. Design involves specifying the source resistance, R_1 (normally 50Ω) and the load resistance, R_2, which may be anything from a few ohm to several thousand ohm, depending on what the antenna and transmission line look like. R_2 usually has some reactance as well. Normally, however, if you design by disregarding load reactance, a match can be obtained by simply adjusting the value of C_2.

Both procedures start by selecting a value of another parameter R_0, the "characteristic impedance" of the transmatch. This is a "free"parameter, and can have *any* value greater than the minimum values defined below. This means that for each transmatch type, an *infinite* number of designs are possible to match any given load! They differ in selectivity and in the power dissipated in the inductor.

Each procedure finds the value of three reactances (the inductive and the two capacitive reactances) which must then be converted into the values of inductance and capacitance required.

5.1 Simple Tee Transmatch

$$\begin{aligned}
\text{Choose } R_0 &> R_1\ (50\Omega) && (1)\\
\text{and } R_0 &> R_2\text{. Then find} && (2)\\
X_{C1} &= \sqrt{R_1(R_0 - R_1)} && (3)\\
X_{C2} &= \sqrt{R_2(R_0 - R_2)} && (4)\\
X_{L1} &= \frac{R_0 R_1}{X_{c1}} && (5)
\end{aligned}$$

$$X_{L2} = \frac{R_0 R_2}{X_{C2}} \tag{6}$$

$$X_L = \frac{X_{L1} X_{L2}}{X_{L1} + X_{L2}} \tag{7}$$

5.2 SPC Transmatch

$$\text{Choose } R_0 > R_1\ (50\Omega) \tag{8}$$

$$\text{and } R_0 > \frac{R_2}{2}.\ \text{Then find} \tag{9}$$

$$X_{C1} = \sqrt{R_1(R_0 - R_1)} \tag{10}$$

$$X_{L1} = \frac{R_1 R_0}{X_{c1}} \tag{11}$$

$$X_{C2} = \sqrt{R_2(R_0 - R_2)} \tag{12}$$

$$X_{L2} = \frac{X_{C2}}{2 - (R_2/R_0)} \tag{13}$$

$$X_L = \frac{X_{L1} X_{L2}}{X_{L1} + X_{L2}} \tag{14}$$

5.3 Finding the Component Values

The X_L and X_C values are converted into inductor and capacitor values using

$$L = \frac{X_L}{2\pi f_m}\ \text{Henry} \tag{15}$$

$$C = \frac{1}{2\pi f_m X_C}\ \text{Farad} \tag{16}$$

$$\text{where } f_m = \text{matching frequency in Hz} \tag{17}$$

6 Voltage appearing across the Capacitors

Arcing at the capacitors may occur if the voltages across them exceed about 500 volt *rms.*

The *rms* voltages across the series connected capacitors (along the top of the diagrams), V_{c1} and V_{C2}, and the voltage across the shunt connected capacitor in the SPC configuration, V_{C2p} are

$$V_{c1} = \sqrt{P(R_0 - R_1)} \tag{18}$$

$$V_{C2} = \sqrt{P(R_0 - R_2)} \tag{19}$$

$$V_{C2p} = \sqrt{P R_0} \tag{20}$$

$$\text{where } P = \text{Input power in Watts.} \tag{21}$$

These equations assume that the loads are completely *resistive.* These voltages will *increase* if the load is inductive, *decrease* if capacitive. For further detail, see reference 2.

7 Power Loss in Tee Transmatches

If the design parameters R_1, R_1, R_0 and Q_L, the inductor Q are known, we can estimate the power lost, P_L, to within about 5% using

$$\begin{aligned}
\text{Simple Tee: } P_L &= \frac{P_{in}}{Q_L}\left[\sqrt{\frac{R_1}{R_0}-1}+\sqrt{\frac{R_2}{R_0}-1}\right] && (22)\\
\text{SPC: } P_L &= \left[\sqrt{\frac{R_1}{R_0}-1}+\frac{\dfrac{2R_0}{R_2}-1}{\sqrt{\dfrac{R_2}{R_0}-1}}\right] && (23)\\
\text{where } P_{in} &= \text{Power input to the transmatch} && (24)
\end{aligned}$$

These equations are always conservative - that is, they predict slightly greater loss than you'll get. They (correctly) predict that the power lost in an SPC is always a little greater than in the simple Tee - but this is offset by the slightly better harmonic attenuation of the SPC and its smaller component values in equivalent matching situations. The *minimum* power loss (not always obtainable at lower bands with capacitors of 350 pF) is *least* when the load resistance is close to R_1 (50Ω) and increases for both higher and lower values. On lower bands, the power loss for loads less than 50Ω will be unavoidably higher if 350 pF maximum capacitors are used. Typically, a good transmatch will dissipate around 5 - 15% of the power applied to it.

This isn't much - 15% represents a signal loss of 0.7 dB, about a tenth of a nominal (6 dB) S point - but 15 watts dissipated inside a small box may make things warm. You can check by feeling the coil after an extended transmission. It should be only slightly warm to the touch. See the appendix for additional comments on heating.

For *minimum* power loss, design your transmatch using a value for R_0, close to (but greater than) the minimum values given in the design equations. In practice, this means using a matching condition that uses the *largest* value of the *input* capacitor.

I have written an *Octave* program, also on this website, which designs the transmatch and computes the power loss for a simple tee transmatch accurately, and also the voltages across the components for a given load impedance. But to run this, you'll also have to installed *Octave*[1].

8 Some Experimental Hints

All my experimental transmatches were mounted on wooden bases. I use a front panel made from aluminium, with holes drilled through for the capacitor shafts. Make them *big* - a cm or so bigger than the shaft diameter, as we don't want them to touch the panel. Standard variable capacitors have the frame connected to the moving plates. Remember that *neither* side of the tee series capacitors is grounded, so both will be "live".

The shafts *must* have *knobs*, as we want to keep people from touching them. Use big knobs. My rule is "no knob is too big". Vernier dials are unnecessary.

Remember that the SWR meter goes *between* the transmitter and the transmatch. It's the transmatch that's connected to the load (antenna). It's not necessary that the SWR meter scale be accurately calibrated, as we are only seeking a "null" measurement (we just want the meter to read zero). It *is*

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[1] *Octave* is similar to the expensive commercial program *Matlab*, but completely free. Google finds it easily.

important though, that the designated characteristic impedance of the SWR meter is 50Ω - some can cope with either 50Ω or 70Ω, selected by a switch on the back.

9 Tuning a Transmatch

1. Connect as above, and fire up the transceiver. Start on 80 meters, with about half of the coil selected. Swing the capacitors alternately for *maximum noise* on receive. If little variation occurs, try other coil taps until it does. This is a preliminary (but rough) indication that you're in the vicinity of a match.
2. If you have an older, tube transmitter with an output pi coupler, set its "plate" and "drive" controls to the recommended 80 metre "nominal" values - or better still, tune it up into a 50Ω dummy load.
3. If you have a single needle SWR meter, switch to "reflected power" - we want to zero this, to give an SWR of 1. If you have the modern "double needle" type, you'll be able to see both "forward" and "reflected" at once. If the SWR meter has a "sensitivity" adjustment, wind this to maximum.
4. Switch to transmit, on low power. If you can vary the power, apply just need enough to make the SWR needle move reasonably.
5. Adjust the capacitors alternately to *reduce* the reflected power. You will probably find that they interact considerably.
6. If you can get the reflected power down to *zero*, check the "forward power" setting. If this is *not* zero, you're there.
7. If the reflected power goes to a minimum, but will not go to zero, turn the power off and select an adjacent coil tap. If the capacitors are near full-mesh, select *more* coil. If they're near zero-mesh, select *less coil.*
8. Continue adjusting until zero reflected power is obtained.
9. Again, check the *forward* power. There should be some reading. But if this is *also* zero, you have achieved a pathological condition where the transmatch is simulating a short circuit. Switch off and try another coil tap.
10. When the reflected power is zero, and you have a forward power indication, the system is matched. Note the settings.
11. If you have a pi-coupler output transmitter, re-tune its pi coupler for maximum output power.

If the inductor tap you initially selected is too far away from the required value, very little change will be seen when you vary the capacitors. It will be necessary to painstakingly try a variety of taps in turn.

Once you have the transmatch adjusted to a a particular frequency, moving up or down the band will cause a slight mismatch. This can usually be compensated for almost completely by adjusting the *output* capacitor. This is because the radiation resistance of the antenna doesn't change much over a band, but the reactance does change substantially, and it's the output capacitor that "tunes out" the reactance.

If you have an inductor with a large number of taps, you'll probably find that you can achieve a match with several of them, with different capacitor values. For minimum power loss, choose the tap that requires *largest input capacitance.*

10 Design Examples

Here are some typical results for a simple tee matching a variety of load resistances at a frequency of 3.6 MHz. The Q of the inductor is 150, and the input power to the transmatch is 100 Watts.

Load (Ohm)	Inductance, μH	C_1, pF	C_2, pF	Power lost, Watts
10	8	82	163	21
50	8	128	122	9
250	8	182	87	5
1000	10	187	96	3
10	1	1606	1861	2

These values have been computed with my MSDOS computer program TEEBAL, which designs and evaluates simple Tee transmatches. This is available, free, if you send me a disk and SASE.

The first 3 lines show that matching is obtained with reasonable capacitance values with an inductance of 8 μH, but the power loss for the 10Ω load is high, 21 Watts. The last line shows that a much smaller power loss (2 Watts) can be obtained if the inductor is reduced to 1 μH, but at the cost of unnaceptably large capacitor values.

A load of 1000Ω cannot be matched with the 8 μH inductor, but can if the inductor is increased to 10μH.

If the frequency is *doubled*, the value of the required capacitors and inductors are *halved*.

References

1. “A comparison of transmatches, Part 1”, G. Bold, ZL1AN, *Break-In*, May 1982, pages 1 - 11.
2. “A comparison of transmatches, Part 2”, G. Bold, ZL1AN, *Break-In*, June 1982, pages 7 - 19.
3. “Power losses of Pi and Tee transmatches”, G. Bold, ZL1AN, *Break-In*, April 1984, pages 7 - 11.
4. “The SPC Transmatch - Simplified”, Noel Padman, ZL2QS, *Break-In*, November 1988, page 7.

11 Appendix: Review of the MFJ-945D Mobile Transmatch

This is an edited excerpt of what I published in the April 1995 *Morseman* column.

> Recently, Barry, the friendly ZL MFJ agent, sent me this transmatch for review. As I’ve often observed, CW types are usually interested in transmatches, since we operate on the bottom of the bands where commercial antennas often have higher SWR than in the SSB sections. I’ve never owned, and rarely used, a commercial transmatch, so this review was an interesting experience.
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> As befitting a mobile targetted device, it *is* small, as transmatches go, and includes an SWR/power meter. The metal case is black, with a slight crinkle finish, having outside

dimensions 21 cm wide, 15 cm deep, 6.2 cm high. On the back, there are two PL259 female sockets for input and output. On the front, two knobs vary the "antenna" and "transmitter" variable capacitors, and a third operates the 12 position rotary switch selecting taps on the inductor.

The meter is a "crossed-needle" type, optionally illuminated by supplying 12 volts to a 2.5 mm socket at the back. A locking push switch selects alternate full scale forward power ranges of either 30 Watts or 300 Watts (according to the manual, the meter actually says 6 Watts or 300 Watts) Reverse power ranges are a fifth of these. It's rated at 300 watts (although I think this is overly optimistic - see later)

I immediately swapped it with Trev, my large, ugly homebrew transmatch in the shack, to see if it would match the TS520s to the 80 metre end-fed wire, and the trident rotatable dipole, on appropriate bands. Of course, it did, and was easy to null - except that I would have liked larger capacitor adjusting knobs (I am one of those who believe that "no knob is too large").

With a dummy load, I then checked the meter against a Bird Thruline, my reference Standard. The indicated reflected wave zero agreed exactly with Bird on all bands, but the power readings were consistently about 10% high. The 4 page manual includes a large schematic, and this showed me which of the 4 sensitivity pots to adjust. Later, it was easy to set the power correctly. The power reading is not noticeably frequency dependent from 80 to 10 metres.

Reconnecting the antennas, I heard Bruce, ZL1ADF, making exploratory noises on 3521, so I held a 10 minute QSO with him. But being a suspicious type, I put my hand on the top of the case after signing, and found it quite warm. I took the top off.

The circuit is a classic high-pass tee, and with a compact unit like this, I'd expected (probably naively) to discover toroidal inductors inside. But the main coil is airwound, doublespaced, diameter 4 cm, length 4.8 cm, 19 turns, tapped at 11 positions. This is in series with a smaller toroidal one, bolted to the bottom. But since the outside case is only 5.4 cm high, the ends of the (very nice) air-wound coil are only a few millimeters from the metal top and bottom panels. This will decrease the inductance and unavoidably induce eddy currents. Which will heat the case.

What difference *does* the proximity of the case make? Next day, I made measurements on the Department's Marconi Q meter. You can't detach the bottom (everything is bolted to it), but with the top removed, the Q of the combined inductors was about 130 on 80 meters, dropping to around 70 with the top in place. Much the same on 40. On 20, about 75 without the top, 55 with it.

Now it's possible to estimate the losses in the inductor if you know the input impedance of the transmatch (50 Ω), the value of the input capacitance, and the resistive part of the load. I developed and published the equations in 1984 (see the reference. I'll write more extensively on this again, if there's any interest). Plugging in a reasonable value for the antenna impedance, I estimated that the power loss on 80 metres, with 80 watts applied to it, was about 7 watts with the lid off, 15 watts with it on. That seemed reasonable, given the temperature rise I'd felt on the top panel.

That meant that although the top *was* contributing additional losses, the difference in output signal was only about half a dB - undetectable in practice. But case heating is the price you pay for having a small unit, and MFJ obviously consider this acceptable. However, if you don't like losing even *this* much signal, you can readily substitute a piece of thick cardboard or rf immune plastic for the top, which I did. Having done that, there was no detectable heat from any part of the case, and the inductor itself was only very slightly warm even after extended CW overs - which cause more power dissipation than SSB at the same nominal output level.

> The power detector is a toroidal transformer, the primary a single wire feed from the input through its hole, the secondary about 20 turns around it, centre-tapped for the separate forward and reverse detection circuits, mounted on a PCB. These have seperate calibration potentiometers for low and high ranges. Everything looks ruggedly constructed. The variable capacitors are both 208 pF, having plates at 2.33 mm centres, quite adequate to handle RF voltages encountered.
>
> I mounted the trident all-band whip on the Commodore roof-rack, and fired up the FT7B I now use when operating portable. This is a great antenna, and everybody I know who has one enthuses about it. But the SWR of mine rises to about 3:1 at the bottom of 80 metres (even with the 80 metre tuning slug right down), which causes the SWR protected FT7B to close itself down from 50 watts to about 10. This is a power decrease of 7 dB, about a nominal S point, and is worth getting back. The MFJ945D easily brought the SWR down to 1:1 again, and repeated this over all bands. Joy! Full power everywhere!
>
> I wouldn't want to put 300 watts into it with the top case on, but for mobile use, it's small, it's rugged, it's easy to use, it's priced right, and it looks good. In fact, I liked the review unit so much that I never sent it back. I sent Barry a cheque instead.

An aside: While I like MFJ gear, some of their advertising blurb has become pretty wide-eyed and breathless. Their top-of-the-line TEE transmatches use roller inductors, described thus: "A roller inductor lets you tune your SWR down to the absolute minimum, something a tapped inductor tuner *just can't do*" (italics mine). This is just plain wrong. Tapped inductor TEE tuners can and *should* get the SWR down to 1:1. Only for the two-component L match do you need a roller inductor for this. A TEE has three degrees of freedom, and any one of the reactive components can be set in steps.