Pi-Tee QRP antenna tuner

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Circuit diagram

This tuner has two modes – Pi and Tee which can be switched. It (***Fig.1***) has two variable capacitors and a step-switched coil. The 7 switches are of the simplest on-off type, which allows the inductance to be changed in 128 steps of approximately 0.2 uH. Each subsequent coil must have 2 times the inductance of the previous one (this is how automatic tuners with relays are constructed).

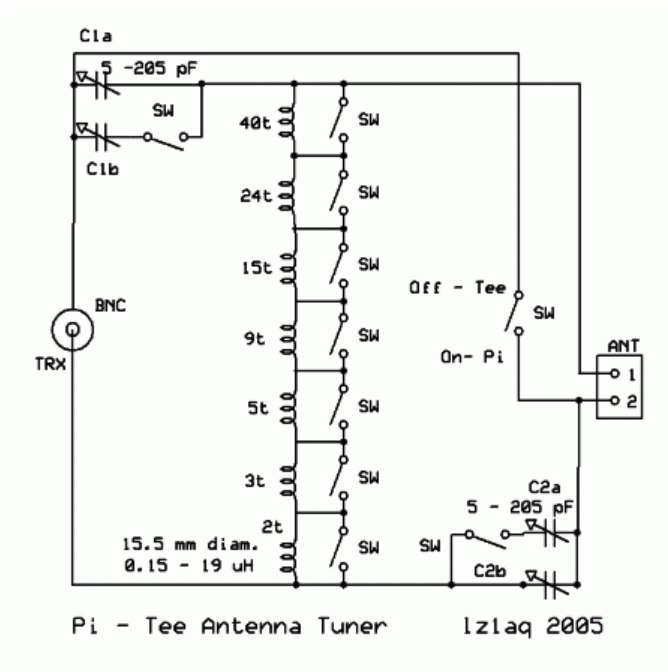


Fig.1

With just one simple on-off switch, the tuner is converted from a *Pi* to a *Tee* type. For some types of antennas (loads), one of them will give better element values and lower losses. With additional switches, the second sections of the capacitors are also included if necessary. In the *Pi* mode, the rotors of the capacitors are connected to the ground of the BNC connector. This tuner has a very wide range and tunes almost everything "that can be tuned" with minimal possible losses *[2].* Note that in the *Pi* mode , *C2* becomes the "first" capacitor (connected to the transceiver), and *C1* appears in parallel with the antenna. This must be taken into account when tuning. In *Tee* mode none of the antenna feeder terminals are connected directly to "ground". When using balanced feeders, balancing with balun will have to be done anyway and the lack of a connection to the "ground" does not matter. In QRP there is no serious problem in treating coaxial feeders in the same way as balanced ones.

Construction

The tuner is mounted in a plastic box (*Fig.2*).

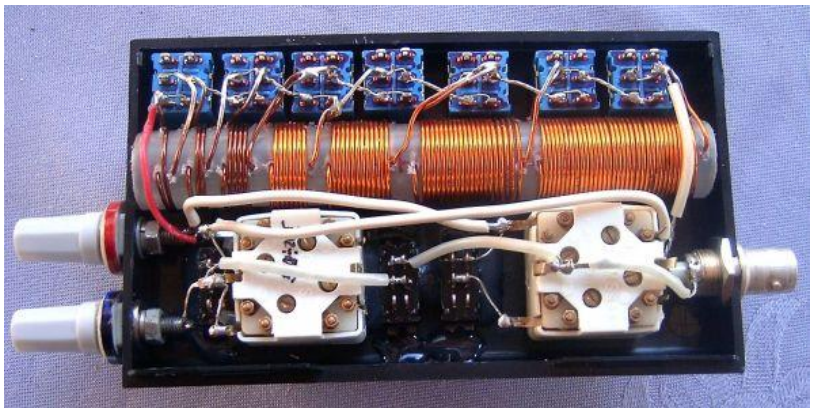


Fig.2

Variable capacitors with solid dielectric from a transistor radio were used. I have noticed that these capacitors start to fail after prolonged use due to frequent rotations - be careful! The switches on the photo are DPDT type since this was available in the local store and I connected them in parallel. The coils are wound on a single body for convenience. The inductances are more or less according to the requirement for doubling each subsequent one. There is some mutual inductance between the individual coils, which is why the measured inductances do not match very well with the theoretically assumed ones. Short-circuiting an adjacent coil changes the inductance from 1 to 3%, so the influence is not particularly large. In practice, the following inductances were obtained: 0.25, 0.36, 0.6, 1.2, 2.3, 4.3, 7.7 uH. The parasitic inductance for all switches shorted is 0.16 uH. Each inductance is measured when the others are shorted. The fact that they are not accurate to the power of 2 is not so important for a manually adjustable tuner. The turns are respectively 2, 3, 5, 9, 15, 24, 40. The diameter of the body is 15.5 mm. The diameter of the wire is about 1.5 mm. The measured range of the coil is from 0.16 to 18.7 uH.

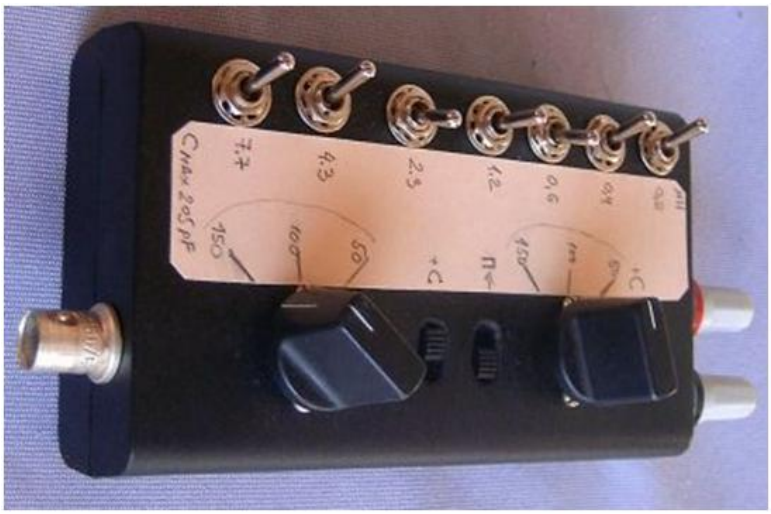


Fig.3

Usage

I use the tuner with a resistive QRP bridge SWR meter which also protects the PA during tuning. A common mode 1:1 balun might be inserted at the output or at the input. Balun at the TX side makes the tuner "floating" but for QRP mode this is not a problem and might be used when symmetric feeders are used. The adjustment is done with successive approximations, knowing that there are many combinations of L and C that give a minimum of SWR. The adjustment that gives lower losses must be chosen. In another article *[2]* I will describe how to find such an adjustment. The design of the tuner allows its use from 3.5 to 28 MHz. It will even tune some loads to 1.8 MHz. I have tried it up to 100 watts, but with antennas with "decent" impedances. Otherwise, up to 10 watts there are no problems with random wires. Usually I start tuning in *Pi* mode. If a good match cannot be found, I switch to *Tee* mode. The *Tee* mode is more universal in the sense that with these values of *L* and *C* it can match impedances in a wider range. It should be borne in mind that with the *Tee* mode it is easier to make mistakes and use settings with low SWR but with quite large losses. Read *[2]* for details.

Tee to Pi transformation

How *Pi* tuner is transformed into *Tee* tuner? ***Fig.4*** below shows how with a single switch this can be accomplished. The successive stages are shown.

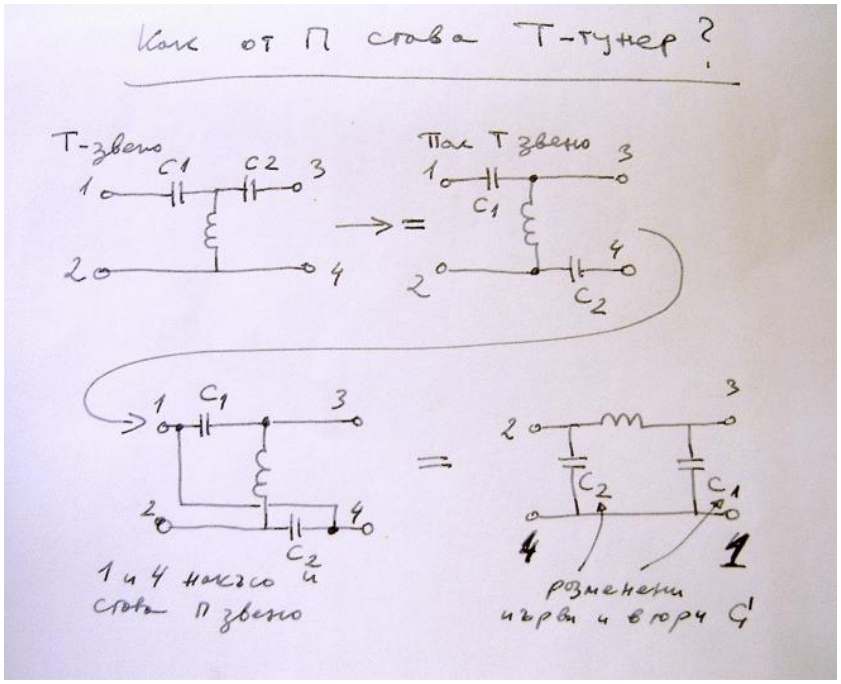


Fig.4 *Tee to Pi transformation. Note that C1 and C2 change their position versus source and load. In Tee mode there is no direct connection between Tx ground and load. The TX side is between points 1 and 2 in both modes.*

Why Pi-Tee tuner is needed? Comparison between Tee and Pi match

Here are three examples of simulations with TLW program which illustrates the need for two modes: *http://www.arrl.org/files/file/Product%20Notes/Antenna%20Book/tlw.pdf* The ranges of *C1* and *C3* are from 10pF to 430 pF, *L* from 0.18uH to 18.7 uH. *Cstray* = 15 pf. Frequency is 7 MHz in both cases.

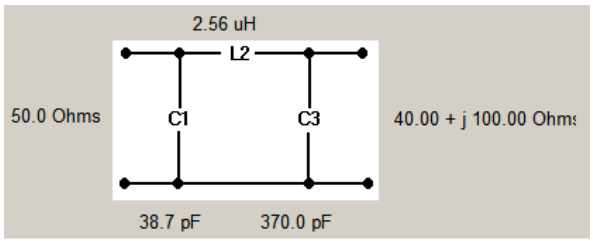
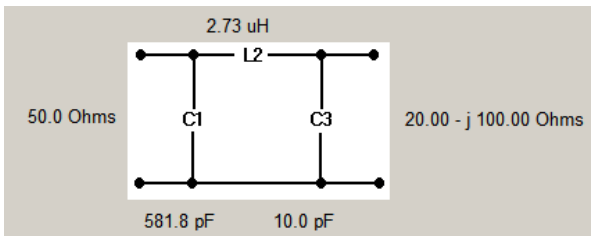


Fig.5 ***Case A:*** *Pi tuner match of Z = 40+j100 ohms., Tee tuner cannot match this impedance within above margins of* ***L*** *and* ***C****.*



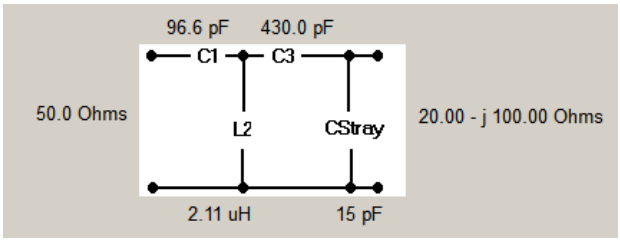
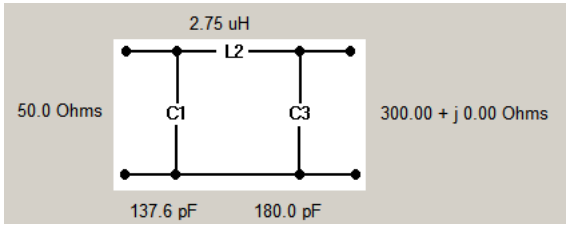


Fig.6 **Case B** ***:*** *Z = 20 – j100 ohms ; Pi tuner C1 is larger than 430 pF when C3 is at minimum possible value and cannot match this load. Tee tuner matches this load easily. C3 value in Tee case is set for minimal losses .*



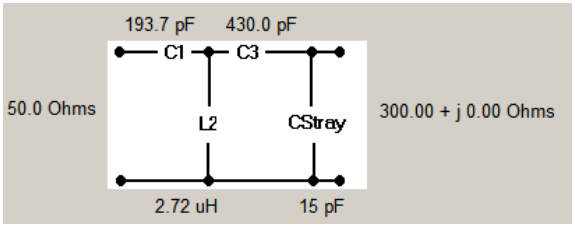


Fig.7 ***Case C****: Z=300 Both tuners match this load with almost the same losses. C3 value in both cases is set for minimal losses .*

Links:

[1] *http://www.arrl.org/files/file/Product%20Notes/Antenna%20Book/tlw.pdf*
[2] Tuning Algorithm for Pi and Tee Antenna Tuners Using Only SWR Meter
http://www.lz1aq.signacor.com/

This article was first published in 2006 in Bulgarian language at
http://www.lz1aq.signacor.com/docs/Pi_Tee_tuner/P-T_tuner.htm
and translated in English on March 2025 with some additions.