Several Universal ATUs for the Whole Amateur HF Band

By Igor Grigorov, VA3ZNW

It is not difficult to build an Antenna Tuning Unit (ATU) for any amateur HF band. Such device could be done with usual coils and capacitors. However the real problem is making a simple and effective ATU without lots switching and tuning that could work over a broad range of frequencies. Below there are given several different ATU that work effectively over all amateur HF bands from 160-10 meters, easy to do and easy to tune and easy to match antenna with transmitter. The ATU was tested with transmitters having for working 50 and 75 Ohm output.

Universal ATU

Figure 1 shows schematic of simple and universal ATU that can capable of working on all amateur HF bands. Design of the unit is based on ATU made by Peter Linsley (G3PDL), **Reference 1**. I repeat the schematic with some changes and found to be very effective this one. This ATU is capable of matching the transmitter final stage of 50-75 ohms output to an antenna load of 20 to 300 ohms in the frequency range of 1.8-32 MHz with an SWR of no higher than 2:1.

How it works:

In the 1.8 to 4-MHz range, the circuit consisting of L1, C2.1, and C2.2 is tuned to resonance with the input signal. Capacitor C1 is used for fine-tuning of the matching circuit with transmitter final.

7 to 32 MHz: For operation in the range of 7 to 30-MHz range, the circuit consisting of the lower section “A” of coil L1 and variable capacitor C2.3 is tuned to resonance and the middle section “B” serves as a coupling coil for section “A”. C1 also provides the fine matching with the final amplifier stage. In the higher frequencies the upper part of the coil L1 acts as an RF choke and does not interfere with part “A” and “B” sections of the coil.

For both ranges, the coupling coil L2 is a compromise for coupling to the antenna. By adjusting C1 and C2, satisfactory matching to the antenna can be achieved in both frequency bands. This ATU does not cover the new amateur band at 5 MHz. To use the ATU in the new band, a tap at 3.5 turns in section “C” of coil L1 needs to be added as shown in **Figure 2**.

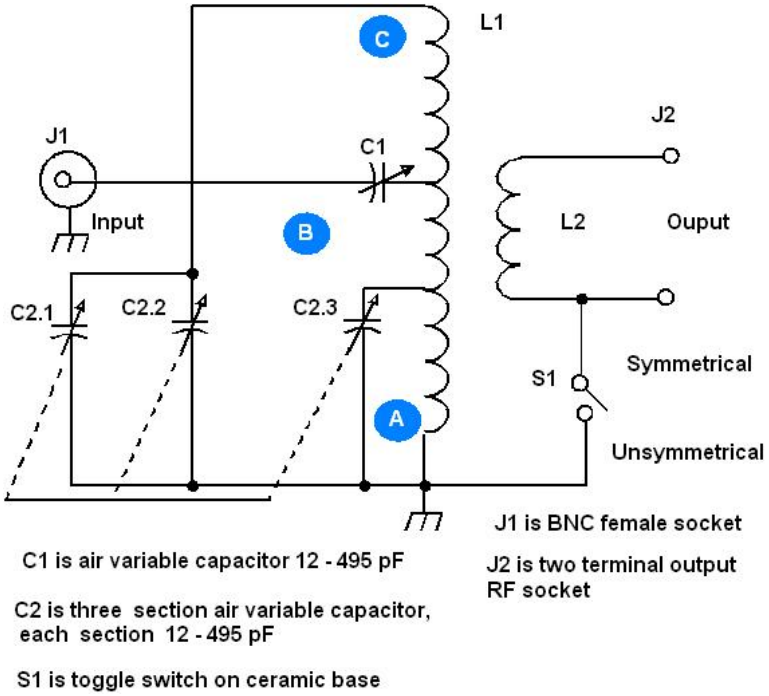

Figure 1 Universal ATU

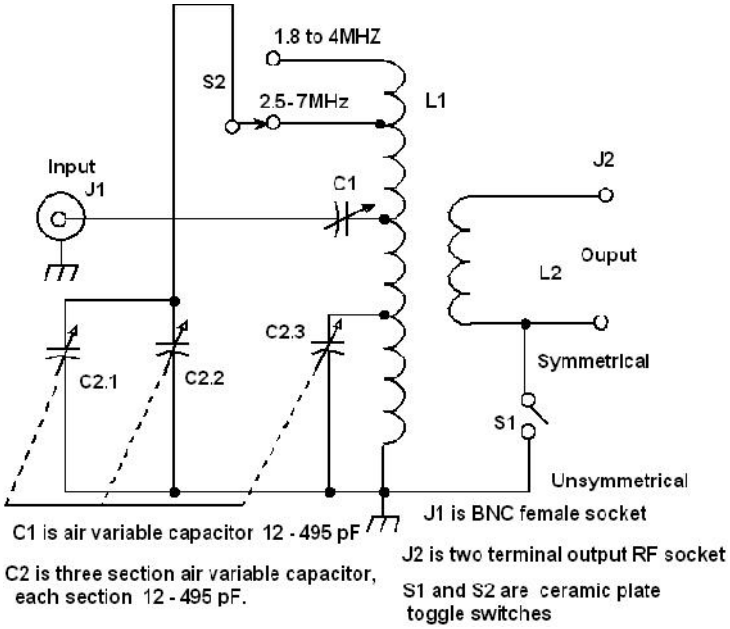

Figure 2 Universal ATU Covers 5- MHz Band

The effectiveness of this ATU mostly depends on the quality of parts and proper design. This is a resonant ATU and, therefore, on coil L1 and capacitor C2 there is a high RF voltage during the transmission time. These components must be of a high quality due to the high voltage present otherwise you have got burnet stuff inside ATU box…

The coil L1 is wound on a form with an OD of 55 mm. Each winding consists of:

1. Section “A”: 7 turns covering 40 mm length section of the coil form
2. Section “B”: 3 turns covering 15 mm length section of the coil form
3. Section “C”: 7 turns covering 30 mm length section of the coil form

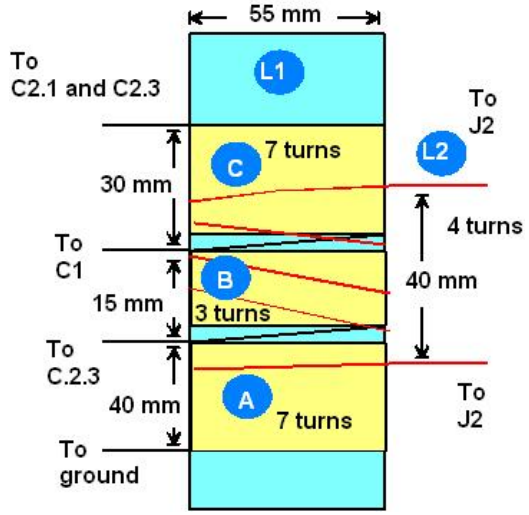

Fig. 3 Design of L1 and L2

The coil form must be of a high quality material, RF ceramic will do the job. The wire used for L1 should be no less than 1-mm diameter (#18 AWG). The winding L2 is four turns and it is wound in the middle part of L1 and covers 40 mm. L2 can be wound using either stranded wire or solid wire with a diameter of 1.5-2 mm (#17-#12 AWG). Insulation tape with high- voltage capability should be used between L1 and L2. **Figure 3** shows design of the coils.

Next step to improve the ATU was my attempt to build an ATU that could match load (in this case antenna) with reactive component, particularly if the reactive component was no more the value of the active component of the load. C3 was added to this ATU to compensate the reactive component of the load (antenna). The diagram of this modified ATU is shown in **Figure 4**. For the entire frequency Band from 1.8 to 32 MHz, the addition of C3 allows the SWR to be no worse than 1.5:1 with an antenna having such above mentioned reactive component. SWR of 1.2:1 in the HF Band from 1.8-7 MHz can be achieved if antenna has any resistive component of 20-300 ohms and has no reactance or little one.

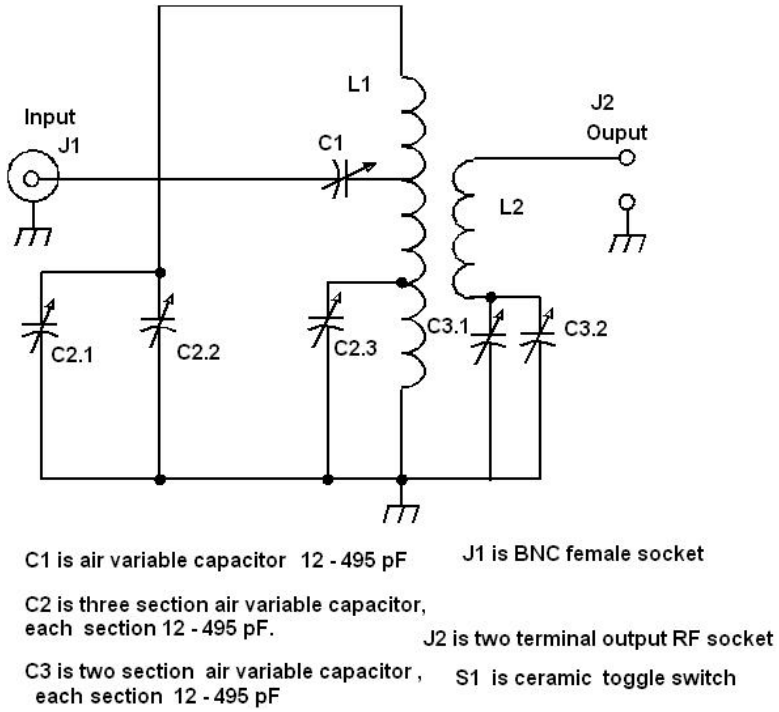

Figure 4 Modified Universal ATU

Further improvement of the ATU was made for upper HF Bands 18- 32 MHz. L3 is an additional coupling coil that is added and only works in these ranges. This coil increases the value of matching loads (as loads having only active resistance either having complex impedance with active and reactive component). The diagram for this ATU is shown in **Figure 5**.

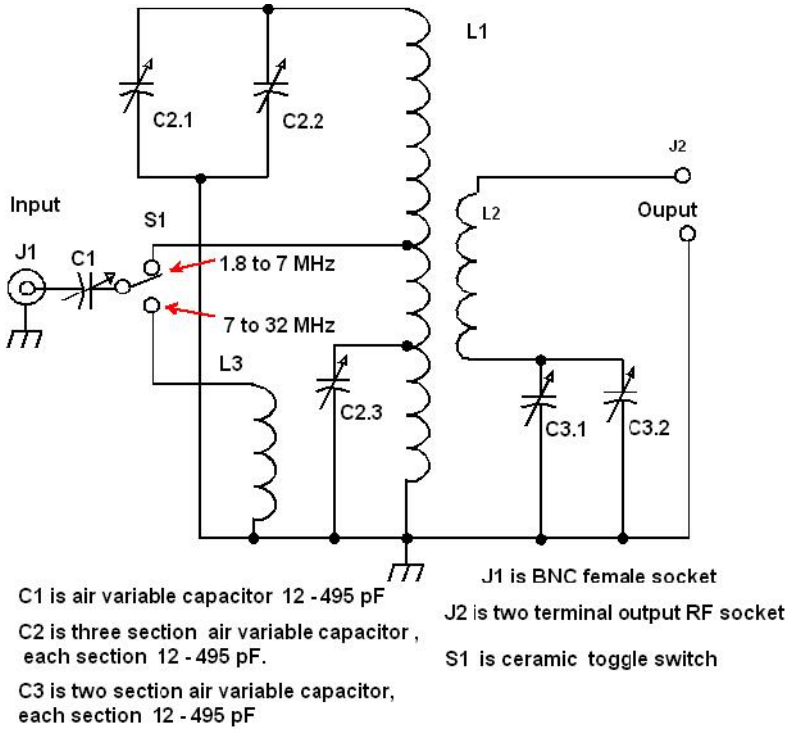

Figure 5 Schematic of Universal ATU with Improved 18-32 MHz Band

The coil has 3 turns of strand wire with a diameter of 1.5 mm (#17 AWG). It is wound above coil L1 as shown in **Figure 6**. In the range of 18-32 MHz, the coupling coil L3 allowed tuning of the SWR down to 1.2:1 with lots of my experimental antennas. The ATU shown in **Fig. 5** is a true simple and effective universal ATU. It has only one switch, S1 that could be a simple toggle switch at power up to 100 W and three variable capacitors with clear tuning.

To check matching for the antenna feeding through a coaxial cable a SWR meter should be installed between the ATU and transmitter as it is shown in **Figure 7**. In this case we know that the antenna matched with transmitter output stage with help ATU but the SWR in the coaxial going to the antenna may have any value. So with antennas having high SWR it should be used coaxial cable that could be capable stand high SWR in it. ***Do not forget initial tune the ATU at low power to prevent damage of final stage of your transceiver.***

It is a bit easy to check the matching antenna that is fed through a two wires open line.
In this case an RF voltmeter on the ATU output terminals would show matching of the antenna with transmitter. **Figure 8** shows the tuning. By the way usual neon lamp with a serial capacitor (1- 2 pF) may serve like the RF voltmeter. At maxima RF voltage on the output terminals the SWR at transmitter output would be low.

Since all ATU capacitors are working in the resonance mode they need a large gap between the plates because of the high RF voltage that is present when operating. If the spacing is too close, arcing is likely to occur.

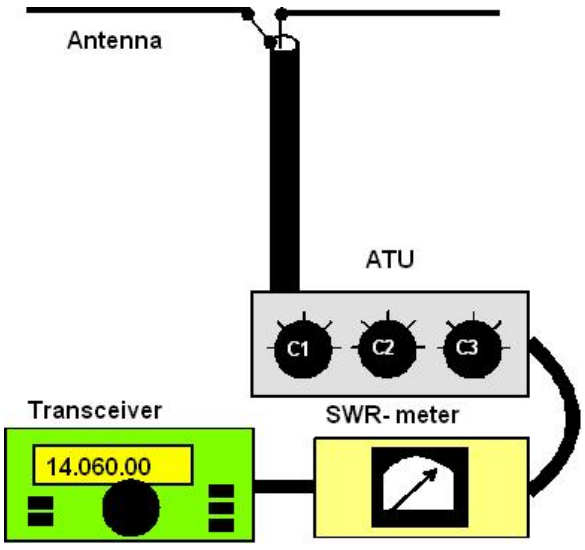

Figure 7 System Transmitter- SWR Meter- ATU- Antenna

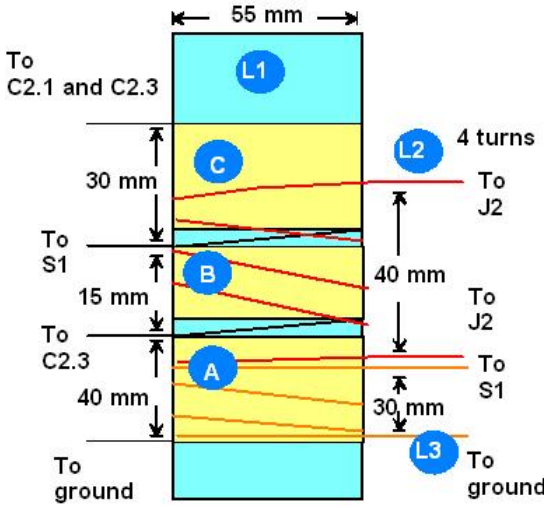

Figure 6
Placement of L3

Spacing should be no less than 0.5 mm for 50 watts going to the ATU. If they do break down on transmission, it may be necessary to avoid tuning the capacitors to total resonance. However, this will reduce the effectiveness of the ATU. It is also necessary to use high-quality variable capacitors with good contacts on the rotor. This is important to the usage of the ATU on the upper amateur HF ranges. An air variable high-voltage capacitor, C2, may be used with the capacity range of 10 to 200 pF for the ATU. It allows the reduction of the dimensions when the ATU is constructed. In this case it becomes necessary to use a two-pole three-position switch instead of the S1 toggle switch. The schematic for this ATU is shown in **Figure 9**. In this ATU the C4 and C5 should be selected for operation in the ranges of 3.5- 1.9 MHz. For 5 MHz band should be added additional pole on the switch.

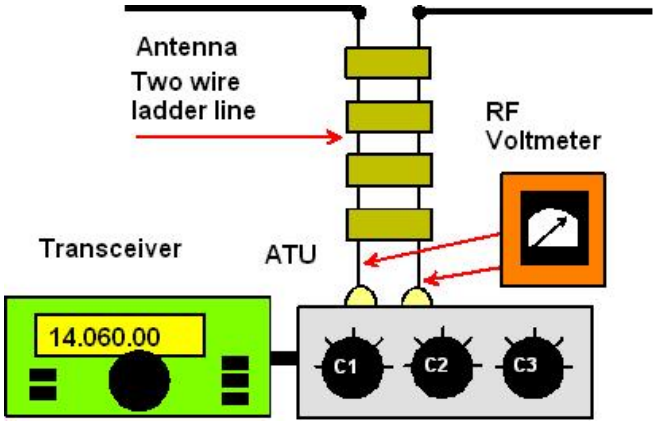

Figure 8 Adjusting the universal ATU with Antenna Feeding through Two Wires Line

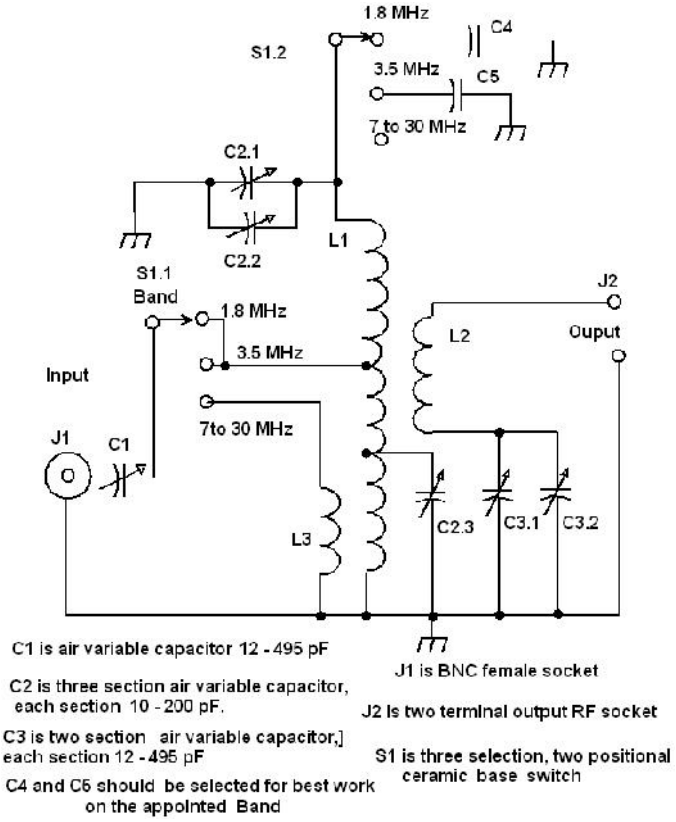

Figure 9 The universal ATU with 2-pole 3-position switch

The “C” part of L1 should have up to 15 turns for more effective ATU work on 1.9 and 3.5 MHz. To match antenna in most effective way it needs vary the tap from L1 to C1. This tap should be tapped from 5 to 10 turns from ground as it shown in **Figure 10**.

Any of the ATUs do good matching job. However, the ATU selected for operation on the ham radio station will depend on the matching requirement for the Band of operation chosen and the antenna used. The most universal ATU is shown in **Figure 10**.

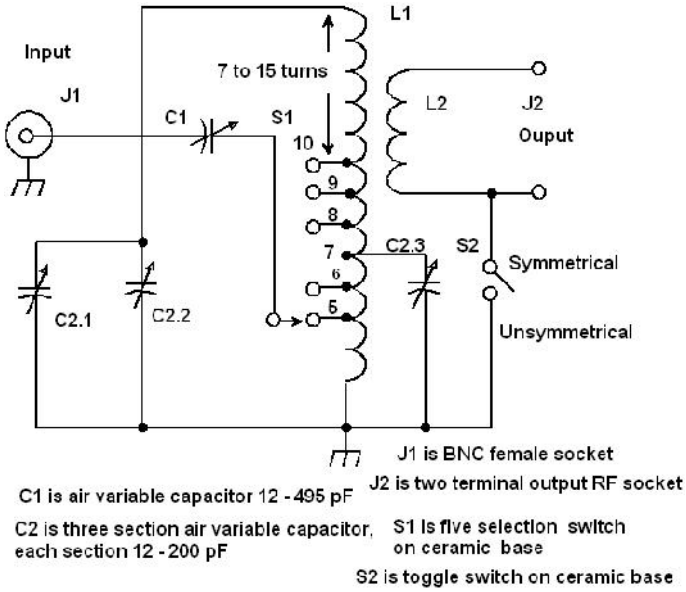

Figure 10 Universal ATU

If one wants to operate with a symmetrical two wires feed line then it will be wise to use a two isolation section variable capacitor on the ATU output as is shown in **Figure 11**.

The capacitor allows compensate reactance in the two wires line. However the capacitor is hard to find part and the installation is nice but not necessary…

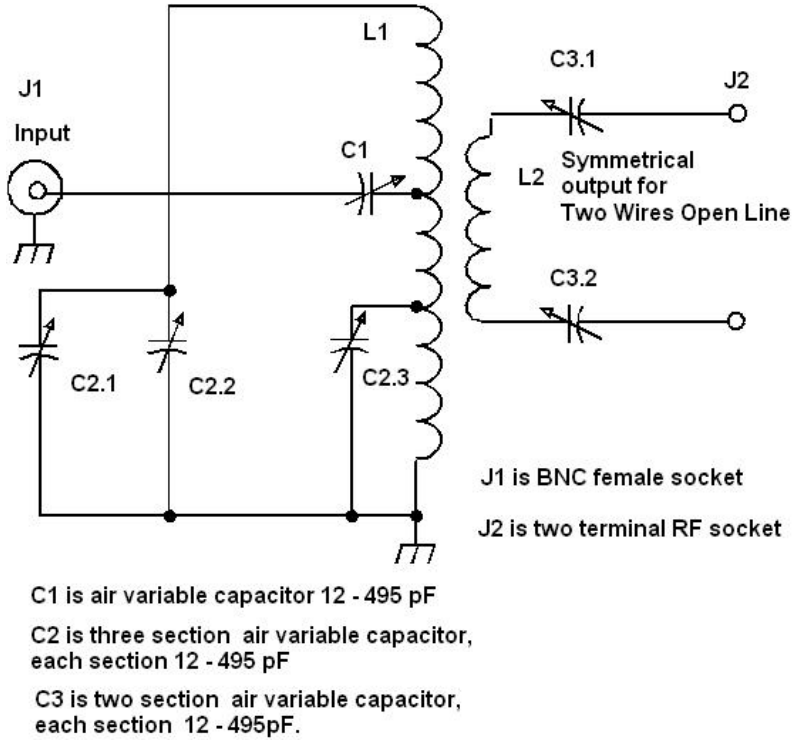

Figure 11 Universal ATU with Symmetrical Output for Two Wires Open Line

Simple all HF Band matching device

The Universal ATU that is described hereinabove is simple but has lots parts and sometimes is not so obviously in tuning. However it is possible make a simple all band ATU that is clear in tuning and has small quantity of parts. The schematic of simple ATU is shown in **Figure 12**. However the simple ATU is not so effective on the high HF bands (compare to the previous ones). As can be seen from the diagram, this ATU is a conventional LC-tuned tank. With switch S3 and capacitor C1, it can be tuned on frequency of any selected amateur band. Switch S1 allows adjustable coupling with the transmitter's final stage. S2 provides the variable coupling to the antenna. By using S1, S2, S3, one may match just about any transmitter's final amplifier to any antenna. The matching network works well in the HF range from 1.8 to 30 MHz with nearly all antennas. But, I should repeat, in the higher ranges above 14 MHz to 32 MHz, the efficiency is low.

For the coil form for L1, I used a glass jar (it was empty jar from mustard) with an OD of 55 mm and a metal screw-on lid.

L1 consists of 30 turns of copper wire with a diameter of 1.5 mm, (#14AWG). The coil was wound over a 50-mm length on the jar. The first and last turns were held in place by using automobile epoxy. The first, second, and third taps were placed at 2, 3 and 4 turns. Then the next turns 3, 4, and 5 were placed at 6, 8 and 10 turns. Taps 6 and 7 are at 13 and 15 turns. Then the turns are uniform for four turns. Then, tap 8 is at 19 turns, tap 9 at 23 turns, tap 10 is at turn 27 and tap 11 is at end of the coil- 30s turn. Capacitor C1 is a two section air variable capacitor from an old tube broadcast receiver. Such kind of capacitor may be used at power up to 100 watts going to this ATU. The ATU also improves reception because selectivity of the LC- circuit.

To tune the ATU, an LED D1 is used. The ATU is tuned for maximum brilliance from the LED. The LED is located in the winding of the current transformer T1. The current transformer is wound on a ceramic ring with the OD of 22 mm. I used a ceramic ring from an old tube socket. All the leads and center metal clamp was removed. Another type of ring (ceramic, plastic or ferrite) for the current transformer may be used everything is depend on the scratch box and experience of amateur.

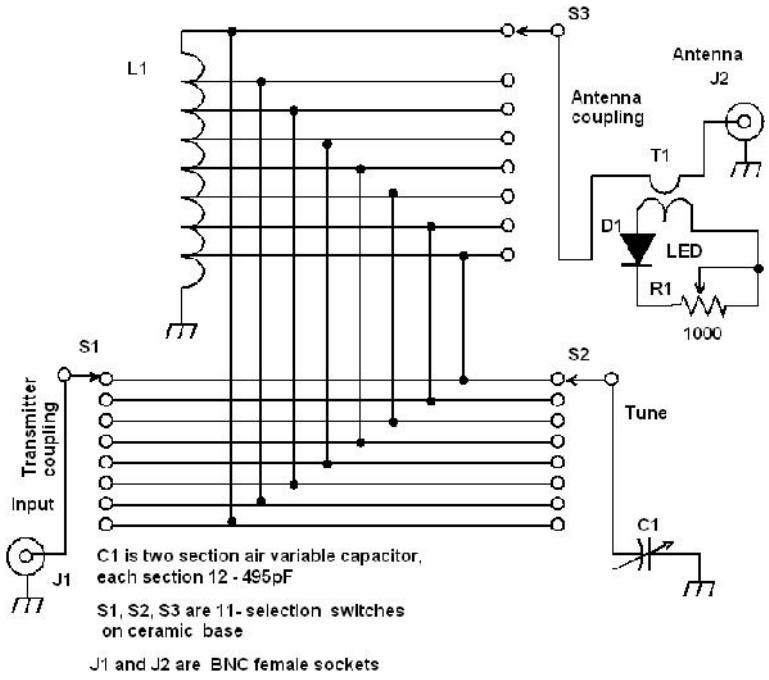

Figure 12 Simple ATU

The first winding of my transformer is contained 3 turns and the second has 30 turns. The first winding is wound with wire from L1 coil. The second winding is wound with wire of 0.3 mm (#27-#25 AWG). However the second wire is depend on the design of the coupling transformer, RF power going in to the antenna and for characteristics of the LED. Design of the ATU is shown in **Figure 13**. The front view is shown in **Figure 14**.

The coil wound on the mustard jar L1 is fastened to the case of the ATU using the metal cap as the base mount. From L1 the tap wires go to the switches. It is necessary to keep the length of the wires going to the switches as short as possible.

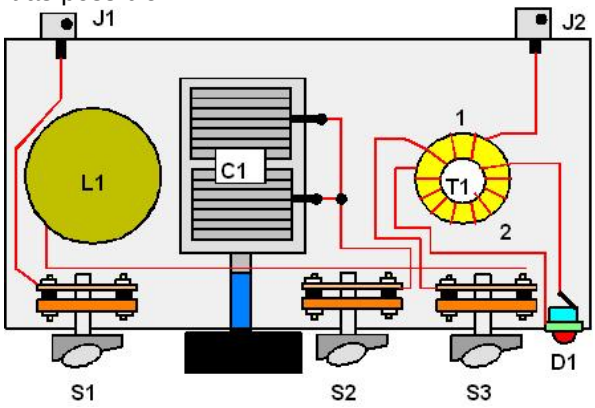

Figure 13 Design of Simple ATU

The capacitor C1 is behind the switch and its calibration is located on the front panel.
Because the capacitor has a short in length adjusting shaft, it was lengthened with help of an old ballpoint pen.

Credit Line:

1. Igor Grigorov. Universal ATU for the HF Bands, Radiolubitel KV and UKV, October 1999, p. 29
2. Igor Grigorov. Universal ATU for the HF Bands, Radiolubitel, November 1993, p. 43
3. Igor Grigorov. Antennas: Tuning and Adjustment, Radiosoft, Moscow 2002,270 pages.

References

[1] Peter Linsley (G3PDL) : HF SINGLE COIL "Z-MATCH" ATU // SPRAT p.76. AUTUMN 1993

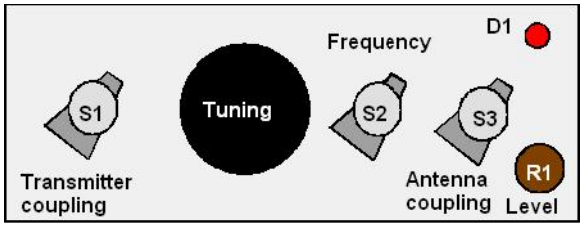

Figure 14 Front View of Simple ATU