A Simple Matching Unit

Not all antennas match perfectly on all bands. To counter the problem Stefan Niewiadomski has created a low-cost antenna matching unit for low power transmitters or receivers.

The simplest type of antenna used by a beginner when short wave listening is a random length of wire, this is often called a 'long wire', connected directly to the low impedance input of the receiver. Such a wire tends to have a relatively high impedance compared to the typical 50Ω input impedance of most receivers and this mis-match will result in power loss and a reduction in signal strength.

The best way to cure the power loss is to use an antenna matching unit (a.m.u.) between the long wire antenna and the low impedance receiver input. In this position the a.m.u. will translate the high impedance of the antenna down to a value that's more useful to the receiver. An a.m.u. also provides a high degree of selectivity to the desired signal, helping to reject possible image and other general interference.

The design described here allows a wide range of wire lengths to be matched to the low impedance (usually 50Ω) input of a receiver. The cost of the unit has been kept as low as possible by the minimum use of variable capacitors. Additionally construction has been kept simple by not using a tapped inductor in the impedance matching network.

The design also incorporates a device that allows the unbalanced receiver input (coaxial socket) to be used more effectively on a balanced antena, such as a doublet (often known as a dipole). This 'magnetic' component is known as a balun. In this mode, the unit will accept balanced antenna inputs, which often have impedances in the 400-600Ω range, and match these to the unbalanced low impedance receiver input.

Beginners in the hobby can be put off projects because of the need to wind inductors. So, I've tried to use as many pre-wound inductors as possible and this design needs only two simple inductors and one balun transformer that need winding. With only a few turns, on small toroids, they should present no problems even to a beginner. All the other inductors are off-the-shelf components.

Skeleton Circuit

Have a look at **Fig. 1**, which shows the skeleton circuit of a commonly-used impedance matching network. In commonly available radio literature this is often called a 'transmatch' configuration. By varying C1, C2 and L, a wide range of antenna impedances can be matched to the 50Ω receiver input.

In practice capacitor C1 is usually a single gang tuning capacitor with its frame (and shaft) isolated

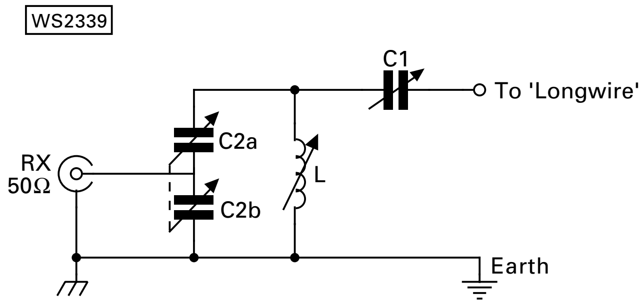


Fig. 1: A simple wide-ranging impedance matching unit. See text for more detail.

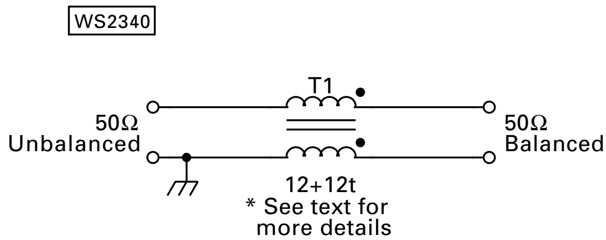
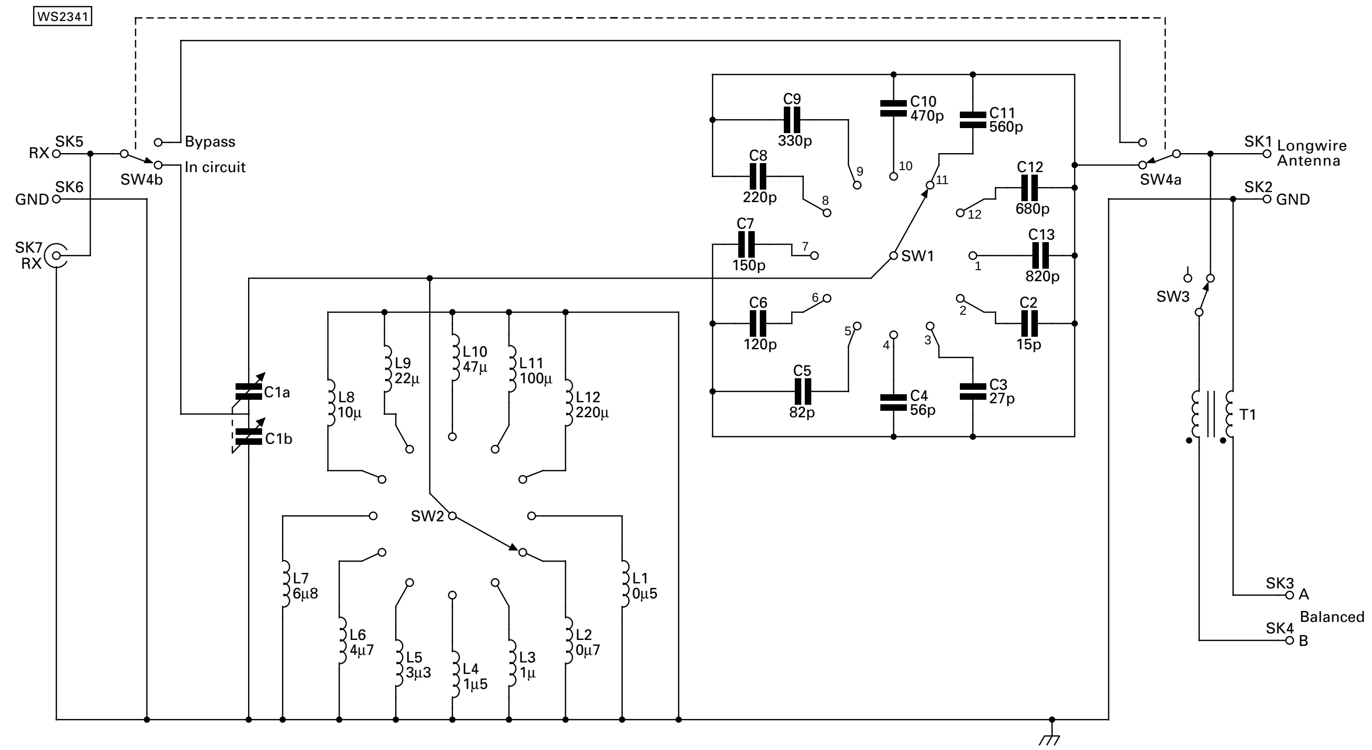


Fig. 2: An in-line Balun with no change of impedance through it (see text).

Fig. 3: The Balun is mounted directly onto the rear-mounted terminal posts. See text for more detail.



from ground. The other variable capacitor, C2, is often a dual gang component, again completely isolated from ground. The variable inductor, L in Fig. 1, may be a 'variable' inductor using a switch to select the tapping points.

Another form of variable inductor is a rotary inductor, often caller a 'roller-coaster', in which a wiper on the wire on the inside of the coil gives a continuously-variable inductance value. It's this variable inductor which usually gives the most problems when constructing a practical a.m.u. not to mention usually costing a great deal of cash!

With the above described difficulty in mind, in the design described here, the variable inductor has been replaced by a switched range of inductors, chosen to allow matching to wire antennas at frequencies from 500kHz to 30MHz.

Reduced Costs

To reduce costs even more, I've dispensed with the single gang tuning capacitor, (C1 in Fig. 1), substituting a series of switched capacitors, that I'm sure will be found in most 'junk-boxes'. If bought new, suitable variable capacitors can also be expensive.

If you want to experiment with balanced feeders and antennas, a balanced-to-unbalanced broadband transformer (usually abbreviated to 'Balun') needs to be used. The skeleton circuit of **Fig. 2** shows how this can be simply implemented with a few bifilliar turns on a ferrite toroidal core.

Using a suitable ferrite material, this type of winding on the ferrite core gives a reasonably broad-band (2-30MHz) transformer that needs no adjustment or tuning over this relatively broad frequency range. The ferrite core and material used for core an FT-50-43, with bifilliar (wound together side-by-side) winding, **Fig. 3**.

The diagram of **Fig. 4** shows the complete circuit of the a.m.u. The long wire antenna connects to SK1. A ground connection, tied to SK2, will help reduce noise. S4 switches the a.m.u. in and out of the signal path from antenna to the receiver that's useful for making a comparison between the signal strength with a direct connection to the antenna and via the matching units. If several antennas are available, then another switch and more antenna sockets could be added to select them without having to fiddle with connections on the rear panel.

The 'variable' capacitor, formed from S1 and its associated capacitors C2-C13, emulates C1 in Fig. 1, but avoids the use of an expensive variable capacitor. If in your junk-box however, you have a 300 or 500pF variable capacitor, then it can be used instead.

Switched Capacitors

If you intend using a variable capacitor in place of the switched capacitor bank, then remember that you need to ensure it is isolated from the metal chassis and case. A piece of insulated material mounting plate and shaft extension should be used.

The switched inductor bank formed around S2 and its associated inductors (L1-L12), **Fig. 5**, emulate L1 in Fig. 1. The range of 0.5 to 220μH allows operation from about 30MHz down to about 500kHz. Only L1 and L2 must be hand wound on small powdered-iron toroids with only a few turns, the other inductors, L3-L12, are Toko pre-wound components. I used Toko 7BS coils because I had them to hand, but Toko 7BA style can also be used, **Fig. 6**.

Fig. 4: The a.m.u. uses switched component 'variables' rather than more expensive real variable ones. See text for more detail.

Variable capacitor, C1a/b is a 500+500pF dual gang unit, which is the most expensive item if you have to buy it. I've found that old valved or transistor radios, that may be picked up cheaply at junk sales, are often a good source of these components. Solid dielectric (sometimes called Dilecon) variable capacitors are also suitable for receive applications.

The Balun, T1 may be switched in and out of circuit by S3 and balances the two feeder lines from the antenna, connected to SK3 and SK4. It performs a 1:1 impedance match making no other impedance changes at the antenna feedpoint. I felt that the Balun winding connected to the antenna terminals might

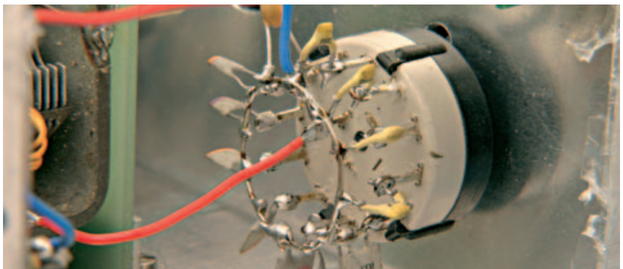


Fig. 5: The switched capacitors are all connected to a common 'ring' at one side. See text for more detail.

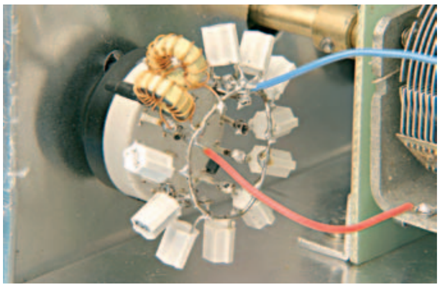


Fig. 6: The fixed value inductors are all connected to a common 'ring' at one side. See text for more detail.

Fig. 7: The back panel showing the BNC socket rather than the more common SO239.

result in signal loss so, I added S3 to enable it to be switched out of circuit. (Using only coaxial feeders, all these components can be omitted.).

The two terminal posts, SK5 and SK6, allow a twisted-pair connection to be made to the receiver's antenna and ground terminals as shown in Fig. 3. Though most often receivers have an SO239 socket antenna input, but my version has a BNC socket, **Fig. 7**.

Winding Coils

Now to winding the various coils and balun, T1, which is wound on an FT-50-43 ferrite toroid. Cut two 150mm lengths of approximately 0.56mm (24s.w.g.) enamelled copper wire (e.c.w.) and twist them loosely together. Then wind 12 turns, of the two wires together, on the toroid. Trim the ends of the wires to about 30mm, to be finally trimmed when mounted in the case.

L1 is 13 turns of 0.56mm e.c.w. wound on a T37-6 (yellow) toroid and L2 is 15 turns of the same sized wire on the same type toroid. Try to keep the windings fairly regular and spread the wire around most of the toroid. Trim the ends to approximately 10mm and remove the insulation and tin the ends before mounting on S2.

With a unit like this, there is no need for a p.c.b. and once the major components have been mounted on the case, they can be wired up point-to-point with insulated wire. If a metal case is used for the unit, then C1 needs to be isolated from the case. I mounted C1 on a piece of single-sided p.c.b. material with all the copper etched off.

The overall layout of my prototype is shown in **Fig. 8**. The balun, T1, is shown suspended between SK2, SK3, SK4 and S3. An earth tag is fixed to the rear panel: SK2 and SK6 and any other grounded connections are soldered to it.

The capacitors, C2-C13, are mounted directly on S1, with the common ends of the capacitors tied together with a ring of tinned copper wire. Similarly, L1-L12 are mounted directly on S2, again with the common ends connected together.

The legends I've used on both the front and rear panel layouts, were created on the computer, printed out and stuck onto the panels. These were then covered with sticky-backed clear plastic. The controls and sockets were then carefully mounted on the panels.

I found the setting of S1 to be fairly uncritical (hence the use of switched capacitors) so I keep it at maximum capacitance (820pF) most of the time. Switch S2 is set so that the inductance in circuit is suited to the frequency range used. As a starting point I found the following settings best for the major Amateur Radio bands. Other frequencies between these bands can be interpolated from the table below:

Band	**Coil**	**Value**
28MHz	L1	0.5μH
21MHz	L2	0.7μH
14MHz	L4	1.5μH
7MHz	L6	4.7μH
3.6MHz	L9	22μH
1.8MHz	L11	100μH
MW band	L12	220μH

Familiar Operation

So, how do you use this a.m.u.? I found the best way to get familiar with the operation of the a.m.u. was to tune to an a.m. broadcast station just outside of the Amateur bands, for example in the 75, 41, 31, 25, 19, 16 and 11m broadcast bands. Because a.m. signals have a continuous carrier they register a steady reading on a receiver's S-meter and so the peaking effect of adjusting C1 and S1 in the a.m.u. is more obvious than with s.s.b. or c.w. signals.

Once peaked on the a.m. signal, you can re-tune to the nearby Amateur band where only a slight adjustment of C1 will be needed to peak the new signals. You will soon get familiar with the settings for the various bands. By switching the a.m.u. in and out of circuit with S4 the effect of the a.m.u. can clearly be heard and seen on the receiver's S-meter. On my set-up the a.m.u. made a couple of S-points difference on most signals. So, it's well worth the effort of building the unit and adjusting it when tuning around.

Transmitter Use

You may ask, can I use the a.m.u. for a transmitter? In reply, I can say that this configuration of a.m.u. is entirely suitable for matching transmitters to random length long wire or balanced antennas. **Note: the only concern is that the components used, particularly C1 and the switched inductors, can handle the power flowing through them** (this is important).

For power levels up to about 20W a receiver-type variable capacitor can still be used for C1, but for higher power transmitters, a capacitor with much wider spaced vanes will need to be used. It's well worth looking for surplus units on junk stalls at exhibitions. When bought new, wide-spaced variable capacitors can be expensive as well as being bigger ... meaning a bigger case will aslo be needed.

The existing toroid-wound L1 and L2 inductors should be changed to T50-6 cores and L3-L12 changed from standard Toko

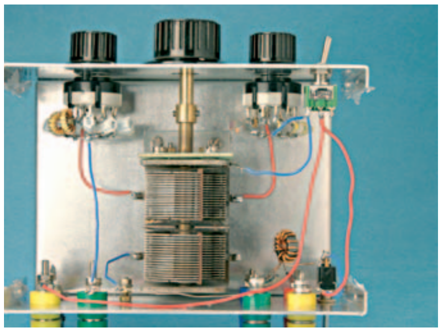


Fig. 8: The overall layout of Stefan's prototype. Care must be taken to ensure that the variable capacitors are isolated from the chassis.

Capacitors		**Inductors**	
C1	Twin-gang 500+500pF	T1	12 bifilliar turns on an FT-50-43 toroid
C2	15pF Ceramic	L1	0.5μH (13t on a T37-6 toroid)
C3	27pF Ceramic	L2	0.7μH (15t on a T37-6 toroid
C4	56pF Ceramic	L3	1.0μH (Toko)
C5	82pF Ceramic	L4	1.5μH (Toko)
C6	120pF Ceramic	L5	3.3μH (Toko)
C7	150pF Ceramic	L6	4.7μH (Toko)
C8	270pF Ceramic	L7	6.8μH (Toko)
C9	330pF Ceramic	L8	10μH (Toko)
C10	470pF Ceramic	L9	22μH (Toko)
C11	560pF Ceramic	L10	47μH (Toko)
C12	680pF Ceramic	L11	100μH (Toko)
C12	820pF Ceramic	L12	220μH (Toko)
Knobs, sockets and other hardware to suit.			

coils to T50-6 (yellow) or T50-2 (red) toroids for transmitter powers up to 20W. The type–6 (yellow) toroid material is suitable for use from 10-30MHz, whereas type-2 (red) material is typically used in the 1-10MHz range. C2-C13 would need to be changed to silver mica types to the powers.

So there you have it, a simple cheap antenna matching unit! **PW**