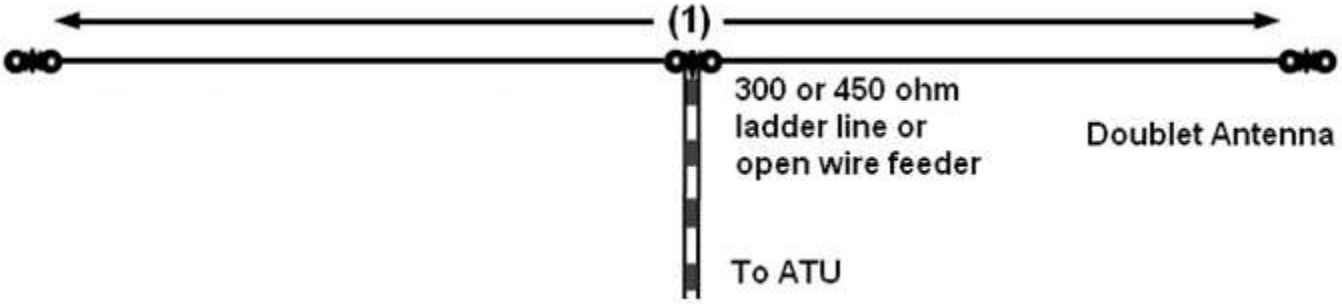
Multi Band Doublet Inverted V Wire Antenna

By John Fraser - 4F3EW / GM4DKO

Looking for an antenna to operate on as many bands as possible with only the one antenna length, I decided to install the doublet antenna, simple to install for multiband operation but the doublet being a balanced antenna needed ladder line or open wire feeder and a balanced ATU to match the antenna to the transceiver 50 ohm unbalanced output.

The space available at this qth would govern the number of bands that I could operate on; I found that I could install an inverted V doublet wire antenna which would require one main center support and two side supports.

I have a 46ft wall which is 8ft high running on one side of the garden and at the wall end the house roof apex is 18ft high, half of which is open between the wall and the house roof apex, the area under this part covered part of roof is used as the car port. I could erect a mast using the wall and the apex of the house to support the mast. Installing a mast at 29ft would make the top 11ft of the mast unsupported and the wall would support the end poles.



(1)The doublet antenna is not cut to resonate at any particular frequency (unlike the half-wave dipole), and any length may be chosen to suit a individual location subject to…. a minimum of 1/4λ to 1/3λ on the lowest frequency of operation will work but with reduced effectiveness, a guide is to make the doublet at least 70% of a half wave at the lowest band you want a good performance on.

The doublet antenna is a balanced antenna fed with 300 or 450 ohm ladder line or open wire feeder and is connected to the transceiver via a balance antenna tuning unit.

Advantages: Can fit into the space available with a minimum cost, easy to make and install with low maintenance, allows multiband operation without the need for loading coils, traps, baluns or any ladder feeder plus coaxial cable combinations etc and can operate on a wide range of frequencies (bands).

Disadvantages: Requires balanced feeder and a balanced antenna tuning unit.

When using a manually balanced ATU, when changing bands the ATU has to be re tuned.

Ladder line: Advantages, less lossy than coaxial cable, does not suffer from high losses at high SWR, so may be effectively used to feed an antenna that may, at various frequencies, present the feed-line with any SWR from 1:1 to ~12:1….With ladder-line we can completely forget about resonance and SWR until we get to the transceiver where we can use a balanced antenna tuner to match the transceiver unbalanced 50Ω by adjusting the length of the ladder feeder.

The ladder line feeder is able to operate with high levels of standing waves, the feeder effectively becomes part of the antenna and ladder line doesn't radiate

Ladder line: Disadvantage with wet weather, the ladder feeder SWR increases, which means that the ATU has to be (slightly) re tuned during wet weather and when the feed line dries out, the tuner reset to the original settings.

Ladder feeders have a tendency to catch a lot of wind which causes it to whip around, this could be somewhat curtailed if distance insulators are used as supports for the ladder line on the main mast when antenna installed as an inverted V.

When using open wire feeder, the SWR barely alters during wet weather, 600 ohm open wire feeder can be bought or homemade.

With balanced feeder, it is important to keep the line clear of metal objects and avoid sharp bends; I haven't found this to be the case, keeping the ladder line feeder say 1" away from a metal window frame when feeding the feeder into the operating room.

For the doublet antenna I could buy the feeder and the antenna wire for the lengths that I needed, the center piece and end insulators can be bought or can be home made, there was also the cost of the center mast and antenna end supports.

My best option to operate on as many bands as possible with the one top antenna length in the space available was using the doublet antenna as an inverted V.

Inverted V installation….Inverted V efficiency is less than a horizontal dipole of similar height, but the radiation pattern is more omni-directional.

Used as an inverted V with the one main support, the center of the doublet antenna would not sag in the middle if it was strung between two masts and the ladder line can be attached to the mast using a distance insulator to help it stop swaying in the wind.

Antenna Support: It is best to have as high as possible or at least 1/4 wave length above ground, for example, a 40 meter antenna is best if the center feed point is about 36′ above ground, in my case the best height I can achieve is having the center feed point at 28ft above the ground.

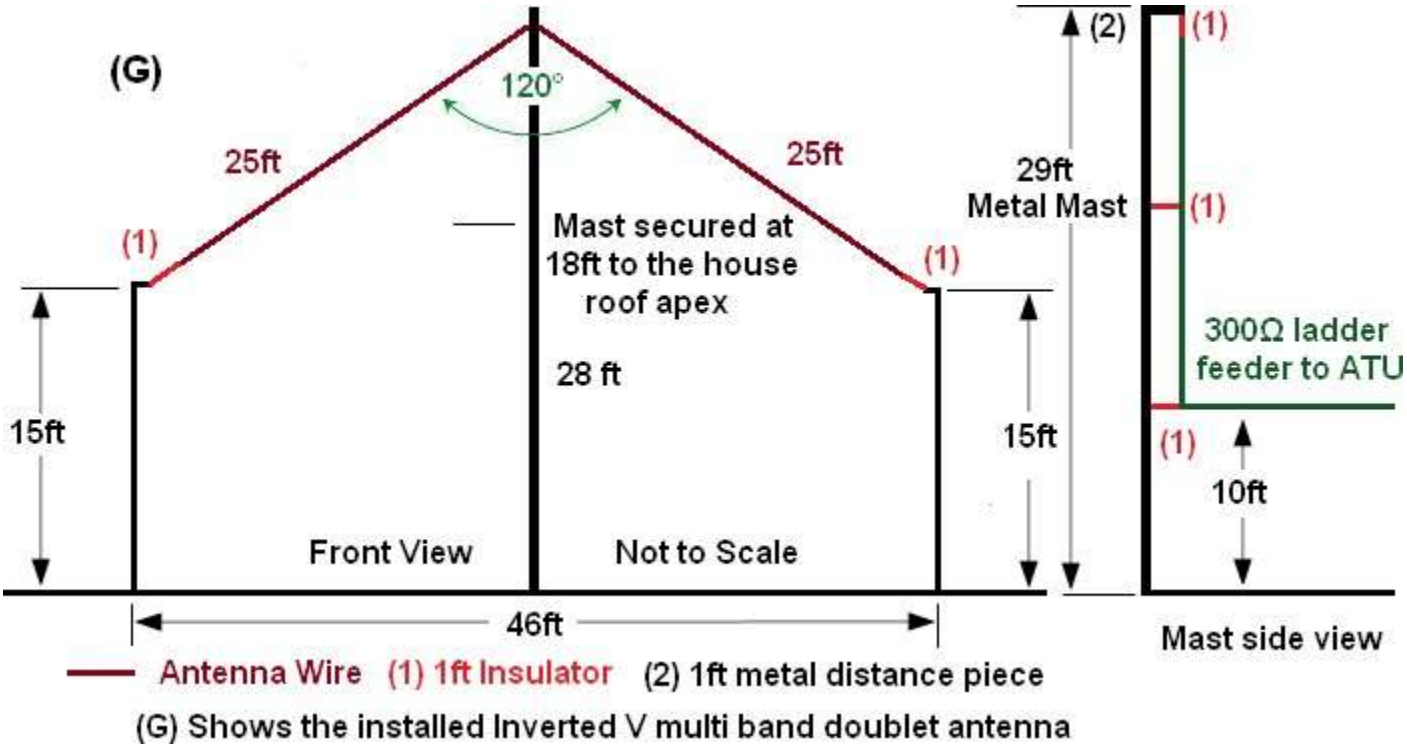
The limiting factor on how many bands I could operate on with the inverted V antenna doublet antenna depended on the total top length of antenna I could erect which in turn depends on how high is the center of the doublet and the total distance between the antenna ends which also governs the angle between the sloping wires.

The antenna center height would be 28ft and the total distance between the antenna end support poles to 44 ft, apart from these the only thing that is variable is the height of the end support poles, which in turn governs the total length of the antenna and also governs the angle between the sloping wires.

As a guide I read that the angle between the sloping wires should be between 90° to 120° or more and to make the doublet at least 70% of a half wave at the lowest band I wanted to operate on will depend on the space available.

The mast center would be at 28ft with 44ft between the ends, I scaled down these figures onto a piece of paper and using a protractor and found that for the angle 120° I could use 15ft end support poles and each leg would be 25ft for a total top length of 50ft, the higher the support poles the greater the angle and the shorter the total antenna length and vice versa. The 50ft is 75% of a half wave on 40 meters.

It would be possible by adjusting the length of the ladder feeder to operate on 40-30-20-17-15-12-10 meters.



(G) Shows the installed Inverted V multi band doublet antenna

I used 2 x 20 ft metal slotted tubes (29ft) for the main mast and 2 metal tubes for the end supports (15 ft), to keep the ladder feeder 1ft away from the mast got a 1ft metal distance piece welded to the top of the mast (A) I could have used a metal elbow.

Made a vertical 1ft insulator (C) to connect the antenna center piece, added 6" metal distance tubes to each of the 15ft tube end supports (D1) and for the 1ft end insulators used the tensioning rope or braided garden string connected to the antenna ends.

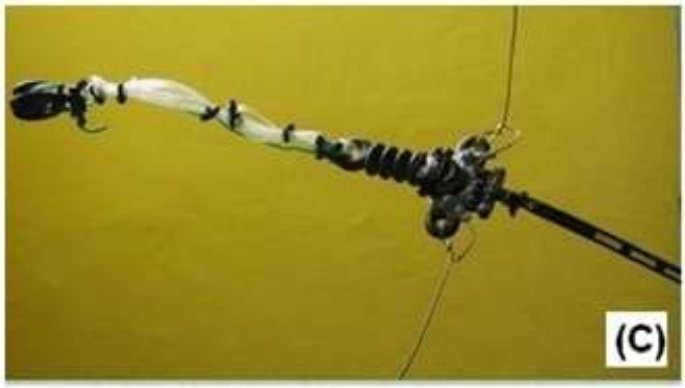
I needed….Antenna wire 60ft….Ladder feeder 120 ft of 300 or 450 ohm ….center insulator, egg and ribbed insulators….plus the metal tubes.

I have a security fence rail running across the top of the wall, I made 3 x 8” metal distance pieces (E) and used 3 x empty paint tins (F) to be filled with cement for the base of the mast and support tubes.

Made a 1ft insulator (B and C) to use vertically between the top of the 29ft mast 1ft distance tube and the antenna center piece by multi braiding fishing line together a few times, I think garden string braided a few times would have been better, I added elbows and 6” distance tubes to each of the 15ft tube end supports (D1).

(A) Shows the 1 foot distance piece welded to the top of the 28 feet mast with an insulator added.

(B) Shows the 1 foot insulator made from fishing line braided together a few times.



(D1) End support pole

(D2) Center mast

(E) Shows the distance piece used to secure the mast and end supports to the wall security fence.

(F) Using empty paint tin filled with cement at the base of the mast and the end supports.

Raised the 29 ft mast with the center piece and ladder feeder and installed the end support tubes, secured both the mast and end supports to the garden wall fence with (E), the bases (F) and secured the mast at the roof apex 18ft and tensioned the antenna wire at the end supports using braided garden string (D1)

I made 1 ft insulator from a plastic tube and secure it with a U clamp to the mast at 19ft to use as a distance piece between the mast and the vertical 300Ω ladder feeder to help prevent the ladder feeder from swaying in the wind.

Another 1 ft insulator was secured to the mast at 10ft to hold ladder feeder in place, the 120 ft feeder was then taken across a 12 ft air gap to the side of the house, along the house wall and into the house via a metal window frame avoiding a 90° angle and keeping the ladder feeder at least 1" from the frame, I routed the feeder inside the room "ceiling cornice" to the transceiver ATU, total feeder length to the ATU was say 80ft.

The doublet multiband antenna using ladder line is required to operate on multiple HF bands which don't always have the lowest SWR on each and every band, the 50 Ω unbalanced (coaxial) output of the transmitter has to be adapted (matched) to the wide range of frequencies covered by the doublet antenna using a balanced ATU.

On many modern transceivers, one side of the transmitter output is at the chassis-ground potential. This is said to make the output "unbalanced whereas a balanced antenna has symmetry about the feed point, for example a dipole.

For maximum power transfer, the impedance of the source and load must be the same. If this is not the case, then not all the available power can be transferred.

If there is a mismatch between the transceiver and the antenna, then not all the power that is available is able to be transferred. As power cannot just disappear, the power that cannot be transferred has to go somewhere, so it is reflected back along the feeder, setting up voltage and current standing waves. Standing Wave Ratio (SWR)

The Antenna Tuning Unit (ATU) matches the impedance of the antenna system to the impedance (50Ω) output of the transceiver via the antenna feeder to improve power transfer between transceiver and antenna. The ATU is also like a one way valve stopping any reflected power from entering the transceiver.

The Antenna Tuning Unit (ATU) could be called the Antenna Matching Unit (AMU) because the ATU matches the antenna impedance to the transmitter.

When using an ATU, the impedance of the actual antenna system does not change and the ATU will not…

1) Tune the antenna to resonance.
2) Remove any standing waves that may appear on the transmission line.
3) Eliminate the loss of signal within the transmission line due to standing waves.

Commercial antenna tuners apart from having inputs for coaxial cable, for use with balanced feeder they can have a built-in 4:1 or 1:1 baluns….They can also have a roller inductor or a multi-tapped coil using a selector switch for antenna tuning.

While such ATU configurations can work well with some ladder line antennas they are not always the best antenna tuner system to use with the balanced doublet and ladder feeder which has a wide range of varying impedances over its frequency range where best matching is achieved using a balanced ATU, the same could be said for automatic and internal transceiver ATU's.

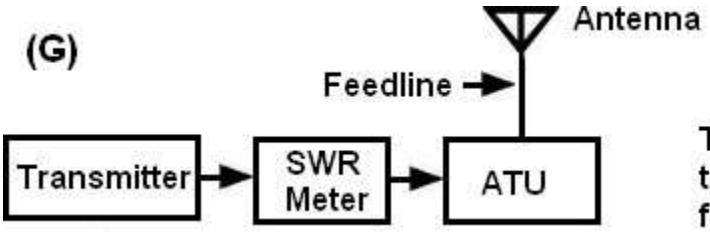
When using a manual ATU with the doublet antenna plus ladder feeder, the operator is in control of the adjusting the manual ATU for the antenna matching.

The ATU can have power limitations, the frequency coverage is usually the HF bands and some also cover 6 mtrs and they can have different impedance matching ranges.

The best type of antenna tuner to use with the multiband doublet is one with a configuration that naturally has an unbalanced input, to accept the transceiver's coaxial cable and a balanced output.

Instead of buying a commercially made ATU, the choice would be to find a second hand Z match ATU or build one myself as it happens for many years I have used and still use the KW E-Zee match with the doublet and 300 ohm ladder feeder, the KW E-Zee was sold separately or in my case it is the tuner section of the KW-107 Supermatch.

The KW E-Zee ATU power limit is 400 watts SSB and covers 80-10 meters including the WARC bands. It has two variable capacitors with one being double ganged and two sets of fixed coils with one coil over the other x 2. Resistive load between 15 ohms to 5,000 ohms. There are published variations of the Z match.

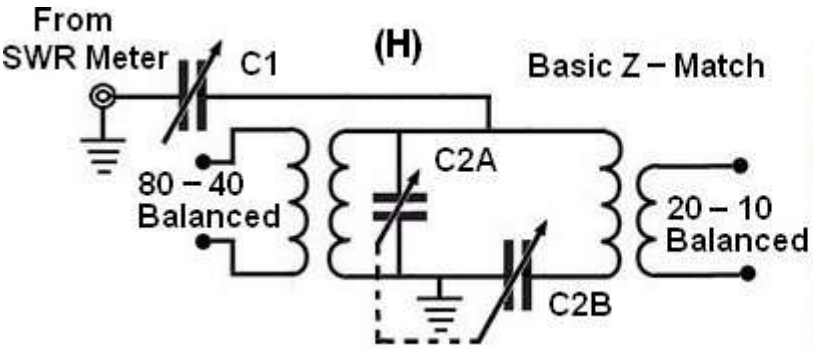


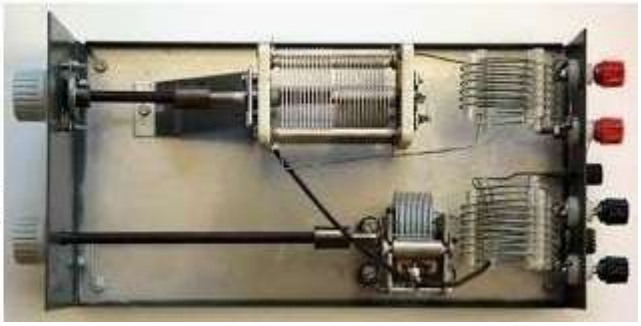
The ATU is an impedance matching device that matches the impedance of the antenna/ feeder to the 50 ohm output of the transmitter

Z match advantage there is no need for coil changing or switching over a wide (8:1) frequency range…..Easy to tune…..Matches balanced loads without the use of lossy baluns.

Disadvantage, the tuning is usually narrow and can be sometimes a bit touchy to tune. High voltage can develop across the variable capacitors, even at 100 watts often resulting in arcing….As a result the operator is forced to either reduce power or play with feed line lengths.

Instead of the Z match, there are several circuits that can be used to build a balanced antenna tuner, each having its own attributes example T network, L network, SPC Transmatch, Pi section.





By using a suitable length of 300 ohm ladder feeder I can use the Z match 80 – 40 balanced terminals to operate on all the bands between 40 – 10 meters. On some bands the Z match needs careful adjustment to obtain the minimum SWR indication, the reflected SWR reading was sensitive when adjusting C1 and the ganged C2 to get the minimum reflected SWR meter indication.

Having run the 120 ft of 300 ohm ladder feeder to the ATU, the next step is to match the antenna impedance on the different bands to the transceiver via the ATU.

Matching the antenna impedance via the ATU is achieved by cutting the 120ft ladder feeder at the ATU terminals, the result will be a "fixed ladder feeder length" from the ATU terminals to the antenna center at 28ft, additional ladder feeder can be added to this fixed length to bring the varying antenna impedances to within the range of the ATU impedance on the different bands.

As I operate on cw I wanted the ATU to match the ladder feeder and antenna for operation on the cw sections of the HF bands.

As a guide, connected the newly cut feeder to the ATU terminals and adjusted C1 and C2 while listening for noise on an empty space on say the 20 meter band…. Hearing noise adjusted the C1 and C2 to the loudest part of the noise, this will help in the rough tuning of the feeder.

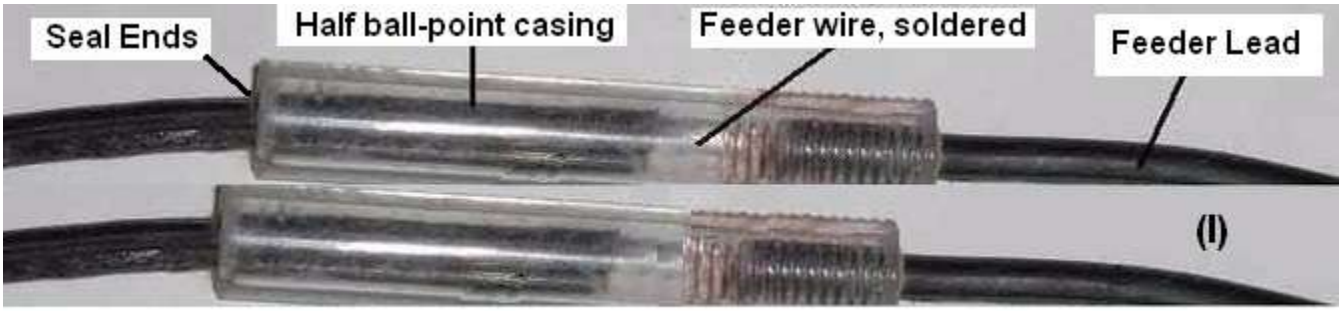
Did the same on the other bands if no noise is heard on some bands, add say 6ft or more of feeder and repeat the process, at times adding or cutting of the feeder length as may be necessary to ensure that the loudest noise can be heard on each band. I ended up adding 10ft to the "fixed ladder feeder length" at the ATU. Afterwards this extra 10 ft can be inserted into the ladder feeder outside in the garden.

Back to 20mtrs adjusted C1 and C2 for the loudest noise, transmitted on low power say 5 to 10 watt continues tone and adjust the SWR sensitivity in the forward position, switch to reflected power, adjusted the C1 and C2 to fine tune for the minimum SWR indication.

Made a note of the ATU adjustment settings and proceeded to the next band, repeated with the rest of the bands, making note of the ATU adjustment settings is useful when changing bands or if there is a problem.

When changing bands, adjusted the ATU for the noise associated with that band, lower the transceiver output 5 to 10 watts and fine tune C1 and C2 for the minimum reflected SWR indication.

If wanting to use the antenna on 60 and or 80 meters try adjusting the length of the feeder (make the feeder longer).



(I) Shows one way of connecting two ends of a ladder feeder together.

All this as well worth the effort to allow me to operate my transceiver on as many bands as possible with the limited space available using the one antenna top.

The article is only a guide and no responsibility can be taken for any errors.

Amateur radio is a hobby, wishing the reader lots of enjoyment with the hobby

73 de John (age 77) GM4DKO / 4F3EW – 17 May 2020