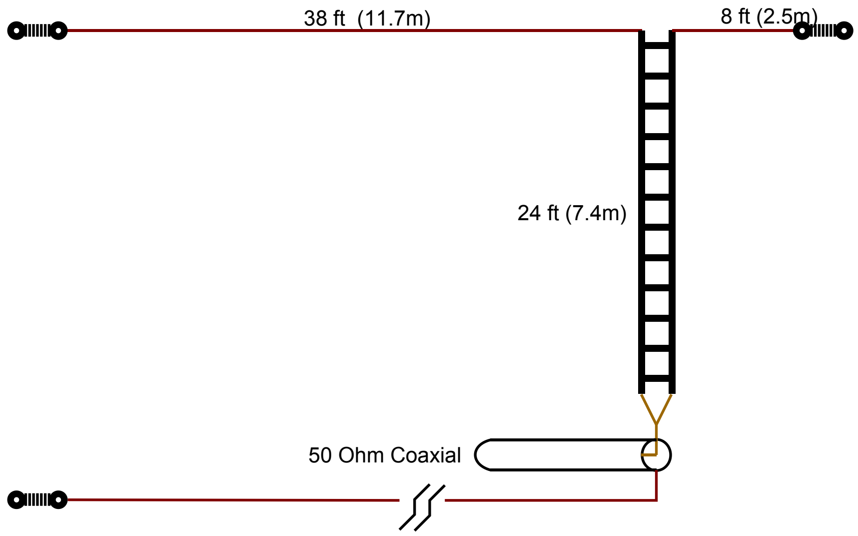
G7FEK Limited Space Antenna

G7FEK Multi-band “Nested Marconi” Antenna - 2008 Version

A 46 ft multi band antenna for small gardens that works well on 80 meters
Main bands (@50 ohm): 80m / 40m / 30m / 17m / 15m / 12m
Other bands (see text): 20m / 10m



This antenna was first conceived as a simple dual band antenna in the mid 1980's, in an attempt to achieve sensible 80m and 40m band operation in a small garden of 14m (45 ft) length. Evolving from a simple end fed Marconi for 80m, the idea was to use the opposing harmonic relationships of two ¼ wave elements so that they could be fed on odd harmonics without mutual coupling. This principle has also been used with nested dipole antennas and other specialist antennas such as the Cobweb but because of technical issues, it’s rarely implemented on vertical wire antennas. With this antenna, interaction and resonance have been turned to our advantage allowing for multi band working with great success, while maintaining a useful radiation pattern on all bands.

The original antenna was built from G5RV leftovers and hence it looks a little like a small, off centre, G5RV. If anyone has tried a G5RV in 45 ft of garden you will know that performance is not that great, and the “½ size” G5RV is completely useless on 80 meters.

During sunspot minimum, putting out a good signal on 80m can mean the difference between operating HF radio or not, as most other bands are not in good shape. This antenna allows anyone to achieve an effective full size 80m antenna in a small garden with excellent low angle DX performance, usually beating a full size dipole installed at the same height.

So what is it ?

G7FEK’s original “Nested Marconi Antenna” was designed in 1988 and comprised two quarterwaves in parallel, fed against ground in inverted L. The original antenna was roughly 50 feet long x 22 feet high and actually worked on 4 bands without an ATU. The difference in feed impedance between elements determined which element is coupled to the feeder and which element appears nearly open circuit, thus automatic band switching occurs without the need for traps. For the higher bands this antenna utilises the odd harmonic resonance of these elements which are also at low impedance. On 30m, the top horizontal section works as an end fed dipole a bit like the Zeppelin antenna, giving a dipole like radiation pattern and a low impedance feed. The dimensions have been carefully optimised for best multi band performance and to maintain a low angle radiation pattern on all bands for best DX working.

This design is very easy and cheap to build and unlike many limited space antennas, it works very well on 80 meters, a band that many Radio Amateurs with restricted space have previously been denied.

Mike, G7FEK is grateful for the feedback received from several Radio Amateurs including: Lee Crocker W9OY for his attempts at modelling the antenna and for identifying how a “Windom-like” effect may be being utilised on some bands, and to Scott VE3SCP for providing such detailed analysis of his own installation, plus details of the many transatlantic contacts he is making with just 100W and this antenna on 80m. User contributions and feedback are helping me gain a better understanding of what is happening with this antenna in different “real world” scenarios and are always welcome.

Build your own.

In this article I have laid out the current recommended design dimensions below. Whatever variation you make from this, one thing that is certain is that this antenna performs extremely well on 80 meters in a small space, and it is very difficult to get it wrong for that band. On tests it has outperformed a full size dipole at similar height for DX working.

Even if you don’t have an antenna analyser or a noise bridge, or you have to compromise a little with installation, at these dimensions this antenna will usually trim up nicely with your ATU on all of the main amateur bands.

Resizing the Antenna

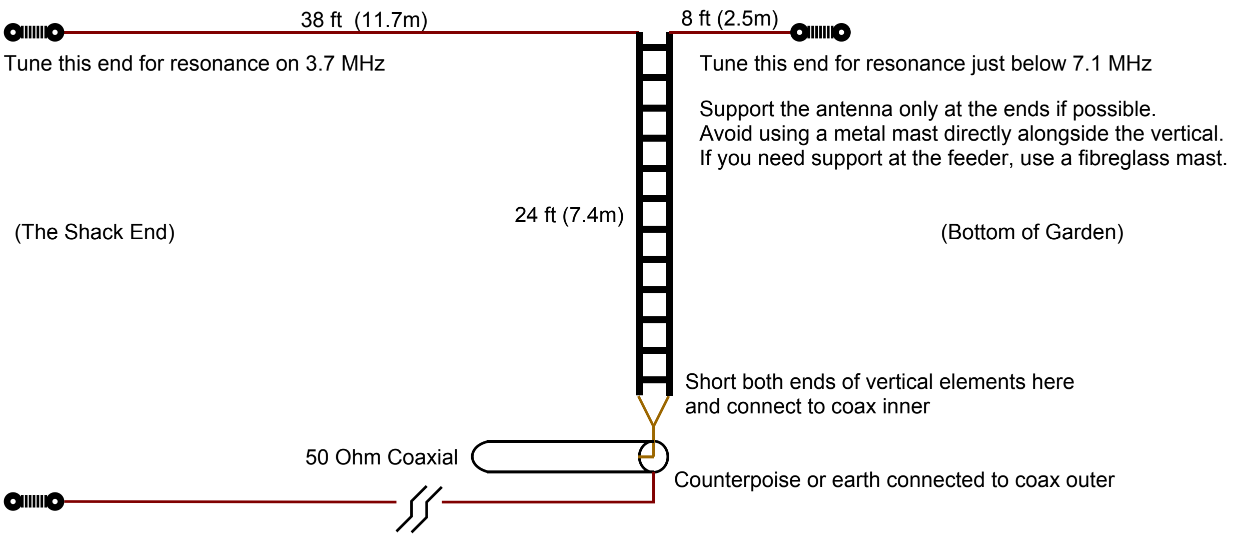
The antenna can be resized within a certain range of dimensions. For each amount of extra height, the same amount must be removed from each end. So if you can get more height you can fit the antenna into an even smaller garden.

There is much scope for experimentation with length vs height. So long as the overall length of each quarterwave element remains intact, (vertical + horizontal extension) the base operating frequencies should not be seriously affected. Remember that unlike a horizontal antenna, longer does NOT mean better. Longer reduces efficiency and bandwidth on 80m by shortening the vertical radiator and increasing loading.

The design dimensions of the 24ft x 46ft version are optimum for best general purpose radiation pattern and space saving and have been proven for proper multi-band use and at a practical height to allow easy installation. Always start with the horizontal elements at least 2 to 3ft (75cm) longer than stated, and twist the wire back on itself to adjust the length to tune the elements.

Resizing the antenna (Dimensions are in feet)

Vertical H	Long ele	Short ele	Total L	
24	**38**	**8**	**46**	Recommended
23	39	9	48	
22	40	10	50	
21	41	11	52	
20	42	12	54	
19	43	13	56	
18	44	14	58	



EARTHING OPTIONS - The minimum requirement for the counterpoise (resonant elevated radial) is a single 65 ft insulated wire (20m) laying in the general direction of the 80m horizontal extension. This can run around a corner to fit in your garden, but keep it just above real ground, and raised at the far end. I also recommend at least one 33ft (10m) counterpoise is also used.

For simplicity and for portable operation, laying two thick insulated wires (2.5mm copper or larger) directly on the ground has also proved effective and easy to match to 50 ohm, provided the last two or three meters are raised above the ground to about 50cm. As a minimum, one of each length (33ft and 65ft) should be used in opposite directions.

If preferred, a more traditional ground of several buried radials can be used. Make these about 30ft (10m) long (any longer is not a big advantage) but you will need at least 4 (and preferably a lot more) for a usable earth. Note that with a good earth and the antenna working close to maximum efficiency, the VSWR will be higher on 80m and the impedance lower (< 20 ohms at antenna). Thus an ATU will be needed. For the best DX, a good earth is preferred over a 1:1 VSWR match because high radiation efficiency is the ultimate goal for antenna design, not lowest VSWR.

Basic Set up Procedure

Step 1 - Impedance matching

Experiment with the counterpoise length & position for lowest impedance somewhere around 3.7 MHz and 7.1 MHz. The exact resonant frequency is not important yet and will be fine tuned afterwards.
(See notes on the diagram above for counterpoise details)

Step 2 - Tune the antenna to resonance

Once you have a low impedance at a nearby frequency, tune the elements to resonance on 3.700 and 7.050 MHz respectively. If you find the SWR dip occurs too low in frequency (say 3.58 MHz), then just shorten the appropriate element end by folding and twisting the wire back on itself (Don't cut it). When you have tuned resonance to 3.7 and 7.05 MHz, the antenna is ready for use. Initially, you might want to make the wires a little longer than shown to allow a wider range of adjustment.

Expected Performance

Most of my recent tests were compared with a 100ft doublet antenna at the same height of 20ft. Most testing was carried out on 80m as this band was the real challenge for a small garden.

My own experiments over the years have shown that the G7FEK (and other similar vertical antennas) are often better than a full size dipole for DX, while comparable to a dipole for medium skip contacts. One thing you will notice is that for very short skip (100 - 200 miles) the G7FEK may be down slightly on a full size dipole of equivalent height, by around 6 to 10 dB (1-2 S points) on 80m. This is due to the lower angle of radiation, but when compared to "straight up" vertical antennas, the "inverted L" style of the G7FEK full size elements still gives rise to useful high angle radiation for short skip contacts.

DX Contacts on 80m

Several users have reported excellent DX results on 80m, even during our present sunspot minimum, with just 100W. In my own tests I have also been able to work good DX on this antenna. When I've worked DX outside Europe on 80m it has always been on this antenna. This is no surprise as it is well known that a low angle of radiation is needed for DX and is delivered by this antenna.

Short Skip and NVIS on 80m

While the 80m band is "open" most "short skip" 100W contacts made with a good dipole antenna at each end, achieve signals of around S9 +15dB. With the G7FEK antenna you can expect the same "short skip" contacts to still be received above S9 under the same conditions. So, although this antenna is low angle on 80m, it still has sufficient high angle of radiation to be useful for short skip. Just for comparison, the signal from a 51ft "half size G5RV" (if you can feed it on 80m) would most likely be well below S7 or, more likely, lost in the noise.

Higher Bands

All the other bands seem to perform about the same as my doublet antenna with very little difference noted, except on 14MHz where the doublet was superior. This was to be expected since the standard G7FEK antenna was not resonant on 14MHz without an additional element (see text). On 14MHz without the element, the antenna was still tunable with acceptable performance, but adding the extra element gives a vast improvement for DX working.

Signal to Noise

I have a low noise floor on 80m with very little interference from man made devices. I find that the G7FEK antenna has a lower atmospheric noise than my doublet. This may be generally true of vertical ¼ wave antennas as most of their signal comes in from the horizon and they may be less sensitive to atmospheric noise from space. I regularly hear weak stations that others cannot hear on 80m.

If you live in a town or City and have a large amount of man made noise (above atmospheric noise floor). You will find there is little difference in noise between this antenna or any other antenna.

QRM

When working very short skip (local contacts) interference from distant stations will be greater on this antenna because of its low angle performance. Generally on 80m, local signals are strong enough to overcome any potential problems.

"Taking up the slack" - This is the feedpoint of Scott's (VE3SCP) version of the G7FEK antenna.

A good tidy G7FEK installation . This neat and tidy job is by Scott, VE3SCP. This is a 24ft vertical section with 8 and 38ft horizontal extensions.

Mike, G7FEK's own installation
Yes, it's another FEK lash up!!

G7FEK Antenna Design Notes and Suggestions

Resizing the antenna: Vertical Height versus Horizontal Length

For practical installations you can vary the antenna height versus length. This may affect multi band operation and an ATU may be necessary.

Don't make the vertical section (twin feeder) longer than the available height. For example, do not be tempted to run 24ft (7.4m) of vertical feeder up your 16ft (5m) fibreglass pole leaving the remainder of the vertical section laying on the ground. Instead, if you cannot achieve the full height, make the antenna vertical shorter and the overall length longer according to the resizing chart. This is because on most bands the radiation comes from the vertical section and none of it should be laying on the ground..

Note: Reducing height also reduces radiation efficiency on 80m to some extent.

Counterpoise / Radials

For optimum DX performance a good earth or radial system is required. However, in tests, we were not able to see a massive difference between multiple radials and a simple double counterpoise arrangement. Unless you are seeking out the weakest DX, you can start off with two counterpoise (radial) wires around the perimeter of your garden running in opposite directions, and you can add to your earthing system at a later date if needed. If you use 4 counterpoise wires (preferred), make sure that two of each length run in both directions. For best efficiency keep the radials above ground and raise the ends higher. Start off with 33ft and 65ft for the radials.

Buried radials, earth rods or any other earthing system can be tried. Earth rods generally do not perform well for RF earthing unless your soil is particularly conductive. More buried radials are needed than resonant elevated radials, but they can be shorter (typically 10m long) and work over a wider bandwidth. Do not use insulated wire for buried radials.

Construction Tips

The easiest way to make a neat antenna, is to use a standard ribbon dipole centre at the top of the feeder and a coaxial dipole centre at the feed point. (Make sure the center of the coax is connected to the vertical section and not to earth!!).

An example of the coax feed point used by G7FEK is shown in the picture on the right >>

A Typical G7FEK antenna feed point before weatherproofing with self amalgamating tape

Support Pole

The antenna can be supported at the ends, leaving the vertical hanging in the clear. The top section will not be flat because the 7MHz end will hang more vertical due to the weight of the feeder, but this is not a disadvantage - remember this is mostly a vertical antenna. If you use heavy duty wire (2.5mm or larger), you can increase the horizontal tension to raise the vertical height and make a tidy installation.

At the top of the feeder, after weather-proofing - not pretty but waterproof!!

If, like me, you prefer to support the antenna with a pole at the feeder, use a fibreglass or wooden pole if possible. If it is more convenient, you can use a metal pole at the bottom and make the top half fibreglass, PVC or wood to insulate it and avoid a resonant length of the metal pole. On my antenna (left) I use a 20ft (6m) fibreglass pole which is attached to a 5ft (1.5m) steel pole with heavy duty cable ties, making it easy for me to take it down and change antennas.

DO NOT INSTALL AS INVERTED-V

Although some downward slope is tolerable, this antenna is not a dipole antenna and will not work properly in a fully inverted-V configuration.

"Plastic on Metal" - Using a PVC extension to a metal mast. Note that the vertical section is kept clear of the mast.

MORE USEFUL NOTES

Add a Choke

When using this antenna without a perfect ground, a feedline choke is advisable to ensure that the RF return path is only via the counterpoise and not via the radio!. A simple common mode choke is made from winding 20ft of the RG58 coax on a 4 to 8 inch PVC drainpipe. Normally added at the coax feedpoint, on this antenna it is can also be used nearer the radio end, at about 55ft down the coax from the antenna. While a little unusual, placing it here allows part of the coax itself to contribute to the grounding effect by working like an additional counterpoise, while still keeping the RF return current away from the transmitter.

RF Feed line Choke used by G7FEK.

Make wires longer to start with

The dimensions given are typical when set up to work on most amateur bands but may vary in different installations. Start with longer lengths to allow for proper tuning of the antenna to resonance.

Keep the vertical in the clear

The vertical section does most of the radiating on the lower bands. Keep it in the clear. ie. don't nail it to a tree or place it right next to buildings.

Using a Metal Pole

While fibreglass is preferred, a metal support pole can also be used. Avoid resonant lengths if possible and extend the pole with a short length of wood or PVC pipe to make up 24ft. Keep the vertical element clear of the pole by sloping it away by a small distance (1 - 2ft).

Build it

With any antenna the best way to test it is to build it, even if its just a lash up for proof of concept. If you have been unable to use 80m because of your garden size, and want a useful multiband antenna for all HF bands, this is a good solution.

Provide Feedback

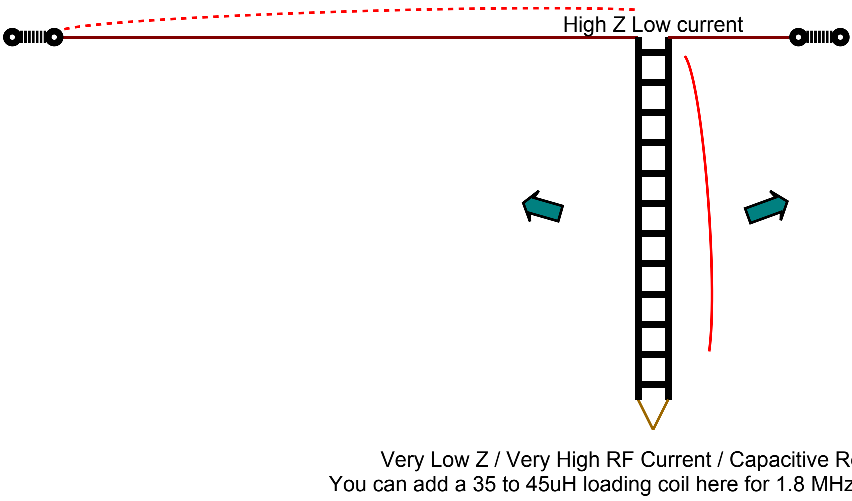
So that I can keep other users informed, please let me know how you get on and if you experience any difficulties. This allows me to provide hints and tips to other users.

Theoretical Modes of Operation

1.8 MHz and below

Below 3.5 MHz the antenna makes good receive antenna for ground wave signals such as Medium / Long wave radio and NDB beacons.

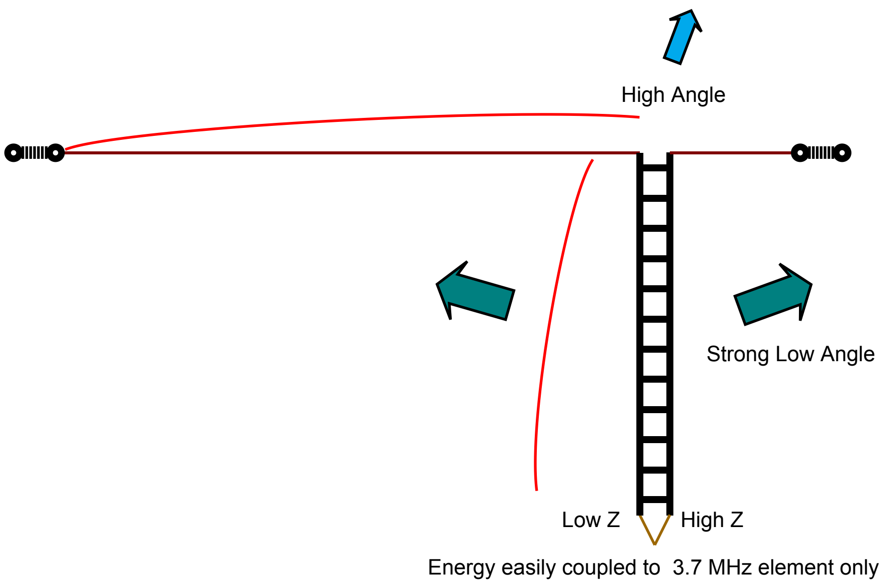
Transmit operation on 1.8 MHz is possible with a very high quality low loss coax and a good substantial ATU, however the addition of a loading coil is advisable to reduce system losses and improve performance. In its present form this antenna was not intended for 1.8 MHz Transmit Use.



3.7 MHz (80 Meters)

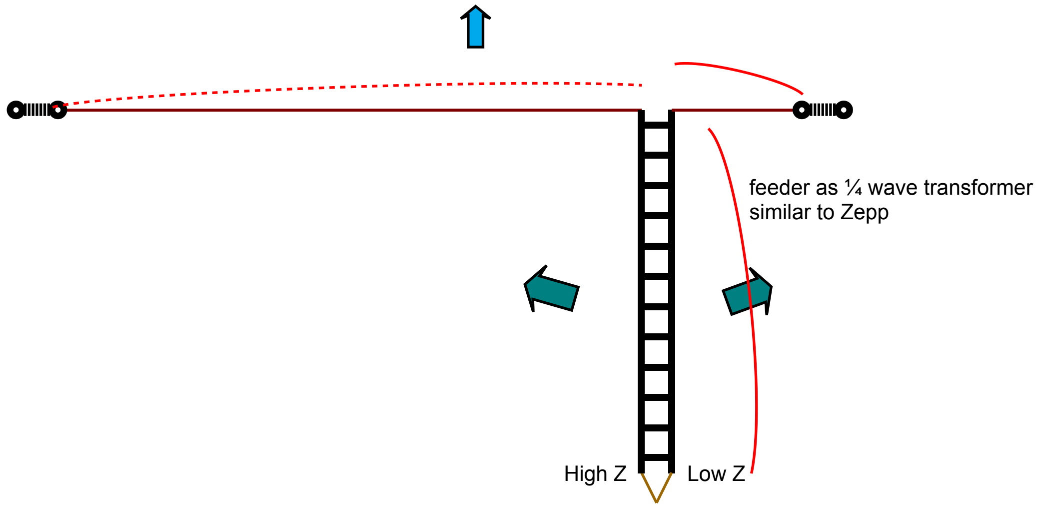
Unlike older designs such as the G5RV, this antenna is designed specifically for the ‘phone section of 80 meters.

On 80m, the antenna is working as a full size quarter wave Marconi in inverted-L configuration. There is some high angle radiation for local (short skip contacts) but the radiation is predominantly low angle and ideal for DX working. With a reasonable earth, this antenna will outperform a full size dipole at the same height on 80m for DX, yet only needs 46 feet of space. (less than a ½ size G5RV). Here this antenna works well and performance on 80m is excellent. This design is optimised for the 80m phone section. 80m in a small garden without the compromise !!.



7.1 MHz (Marconi ¼ wave)

Just like on 3.7 MHz, this is a quarter wave Marconi antenna in inverted-L configuration. There is some high angle radiation for local (short skip contacts) but the radiation is predominantly low angle and ideal for DX working. Some excitation along the top horizontal occurs, especially if the antenna is made too long. This is the second primary band of operation and it should be possible to tune to resonance and low VSWR on this band from the start.

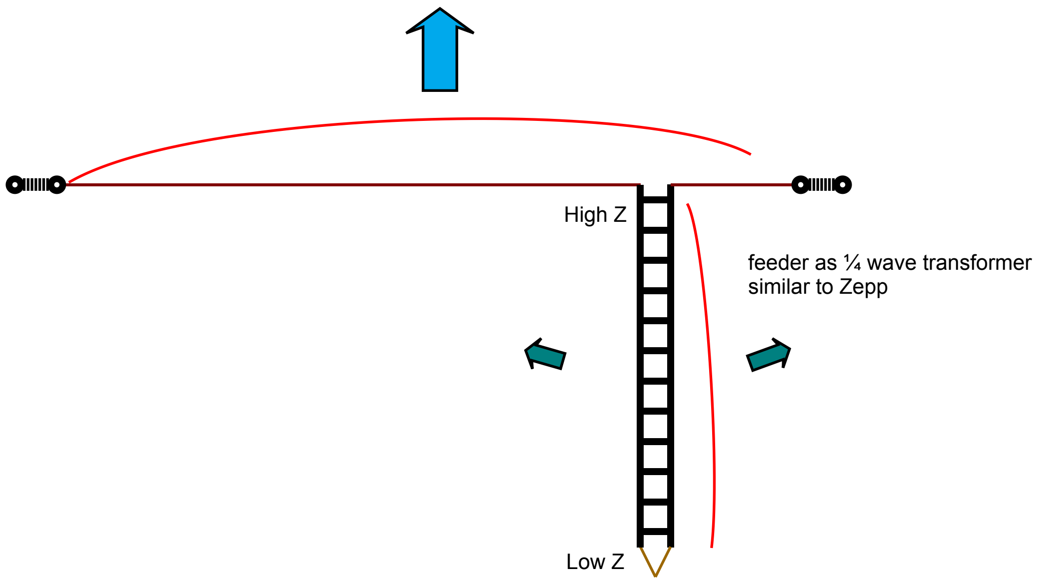


10 MHz (a bit like a Windom and a Zepp)

This antenna also includes operation on the 10 MHz band. Here we take advantage of the horizontal top section. This is resonant on about 10.8 MHz so in band, we will need an ATU to tune out the capacitive reactance and keep the radio happy.

At 24 feet, the feeder length makes a slightly long quarter wave transformer (like a Zepp) to match the end of the horizontal to approximately 50 Ohms. This unusual feed arrangement works a bit like the Windom (off centre feed) but more like the Zepp (Hi-Z - ¼ wave line) on this band.

Radiation is mostly as a horizontal dipole and is high angle. Like the Windom, there is a small low angle vertical component radiating from the feeder.



14 MHz (20 Meters) - optional ¼ wave vertical

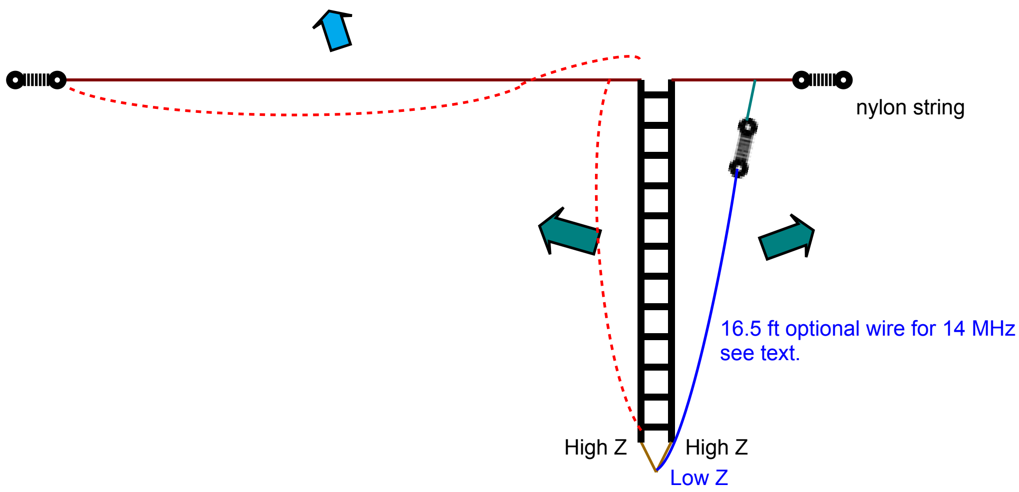
This band is not my favourite and so I didn't make any effort to include this in the original design. I am a regular QRP operator and after patiently breaking pile ups with my 5 watts, I was usually greeted with "Echo Kilo you're five and nine, QRZ"!! What ?, of course I'm not five and nine you idiot. I'm using only 5 watts for heaven's sake and you're using a kilowatt!!. Is that all the conversation I get for my efforts? No thanks old man!!. - So I went for 18 MHz instead, the friendly DX band!!.

You can use the original antenna on 14 MHz. Both the main elements are resonant and in the same phase (a full wave and a half wave fed in parallel) but provide a high impedance to the coax. Having both elements working in parallel seems to make this fairly easy to tune as the impedance is not as high as the end of a single half wave element. Without the additional 14MHz element, expect some loss on this band due to high SWR, especially if you've used RG58, and a higher angle of radiation.

The antenna is easily modified for low angle operation and a very good match on 14MHz

How to add the 14 MHz Element

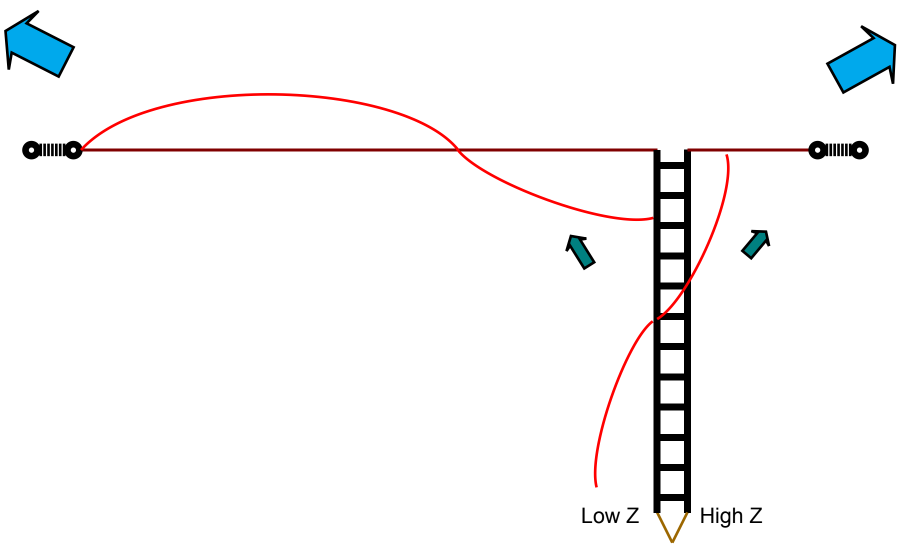
There is a simple fix for 14 MHz if you want to see a good (<1.5:1) match here and achieve a low angle of radiation for DX. Simply connect an additional 17ft length of wire to the feed point and hang it below the 7 MHz section with some string and a cable tie (shown here in blue). This element can be tuned to resonate on 14.18 MHz with very low SWR. This may also excite the main elements to some extent, by parasitic coupling, as they are both resonant and effectively floating with a high Z to ground. This modification has been tested and has proved very effeictive.



Difficult match to main antenna as Hi-Z but energy is easily coupled at 14 MHz with additional Low Z optional element

18 MHz (17 Meters) - Longwire

On 18 MHz the 3.7 MHz element resonates at its 5th harmonic. So the element works like a long wire in inverted-L as a 5/4 wave antenna. Because the horizontal section is resonant on its second harmonic at around 20Mhz, some energy will be coupled and radiate from this section, giving rise to dipole-like radiation. On this band the radiation pattern will contain several lobes towards the end of the antenna. At this height, radiation angle should be fairly low and polarisation predominantly horizontal.

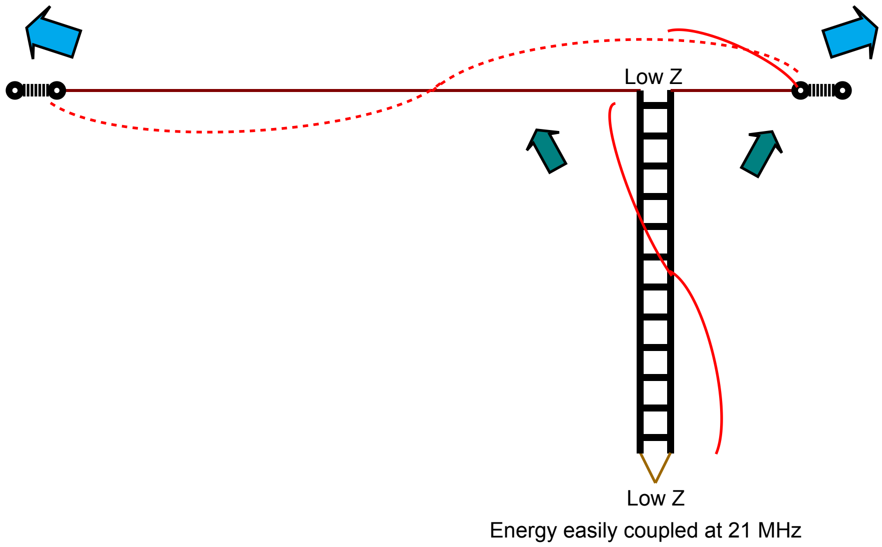


Energy easily coupled at 18 MHz to the 3.7 MHz element

21 MHz (1 wavelength longwire + ¾ wave vertical)

The vertical section is ½ a wavelength at this frequency so the impedance will also be low at the coax and a reasonable match to 50 ohm. Thus the top horizontal section will radiate power as a horizontal longwire with strongest lobes at angles from the ends (dotted line).

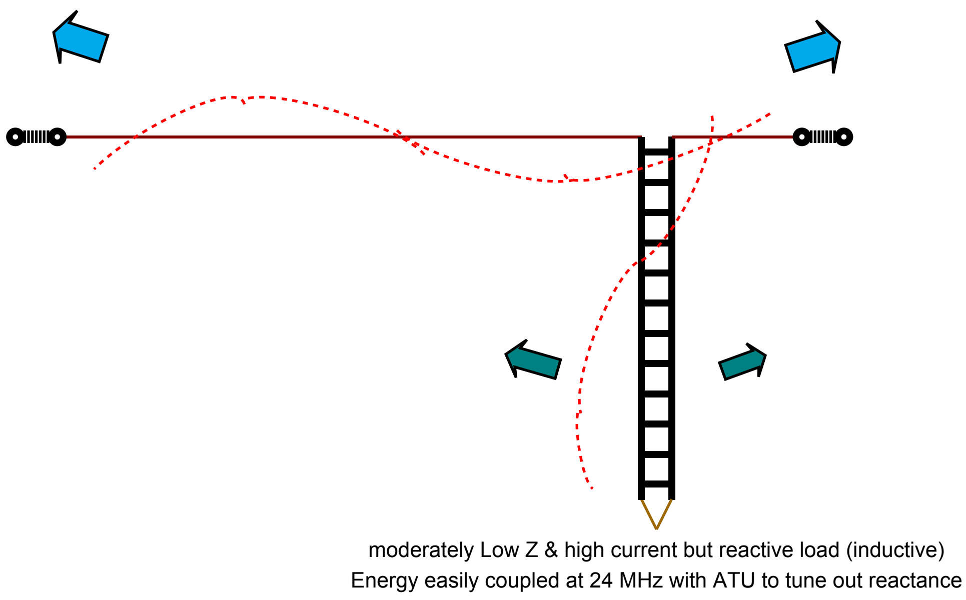
The 7 MHz vertical section is low impedance and a resonant vertical at 21 MHz. So this element absorbs power easily and provides a low impedance match to the coax (solid red line). The current in this element probably also contributes to the excitation of the top horizontal section since the current is in similar phase, while adding some high angle vertical radiation to the pattern.



24 MHz Band

I don't know how this antenna performs here or what the radiation pattern is like but I expect it is similar to 21 MHz. I do know that it tunes up easily with an ATU. Resonance is a little high at just above 25MHz, but it is easy to tune on this band, so it should work reasonably well.

I never use this band. Does anyone use this band? Maybe we need more sunspots before I can evaluate the antenna here!!.

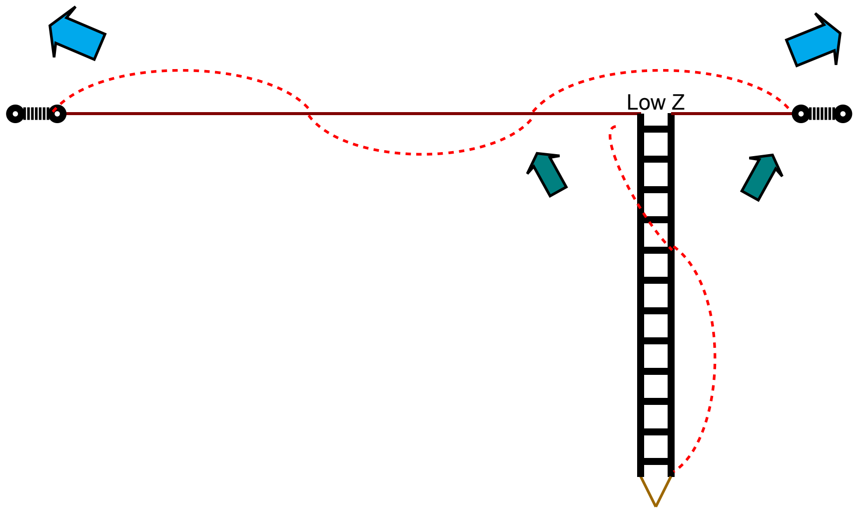


28/29 MHz (3/2 wave horizontal)

On this band the horizontal section is 3/2 wavelengths long. It is resonant and the point at which it is fed is a current node and low impedance. Unfortunately, the length of feeder at 24 feet is ¾ of a wavelength and transforms the impedance up to a high value and no longer 50 ohms. Thus this band does not match well to the low impedance feed of 50 ohm coax. Use an ATU for this band, but expect some coax loss due to the high SWR if you use RG58.

Other solutions for 10m

If you have a small garden it is not too difficult to find a much better solution for this band than a wire antenna, a CB radio 5/8 wave vertical for instance is cheap and effective. It will give much better omni-directional and low angle performance than a wire. Most long wire antennas have highly directional narrow lobes and are not ideal on this band.



Summary

This antenna is very easy to construct and easy to get going on 80/40/30/20/17/15 and 12 meters. Getting a "perfect" system working on all Amateur bands is a little more challenging, as with any multi band antenna, but with an ATU the low impedance feed seen on most of the bands is very easy to trim to a perfect match for your rig, and even if it's not built perfectly, the antenna will work fine in most installations.

If you have been using a ½ sized G5RV dipole antenna, prepare to be amazed at how much better this will work, especially for 80 meters and 40 meter DX. In fact on 80 meters, you will be performing almost as though you had a full sized dipole in your yard, even though this antenna is only taking up 46 feet of space - something that is totally impossible to achieve with the 52 foot ½ sized G5RV.

So have a go and do some experimenting. An antenna analyser will be very helpful, but if you don't have one, just make the antenna to the dimensions given and you will not go far wrong.

Parts

All you need is... Chock Bloc, Cable ties, wire, string. and some 300 or 450 ohm ribbon or ladder line and some 50 ohm coax.

Self amalgamating tape is useful to waterproof things when you have a working antenna.

Good luck and keep experimenting.