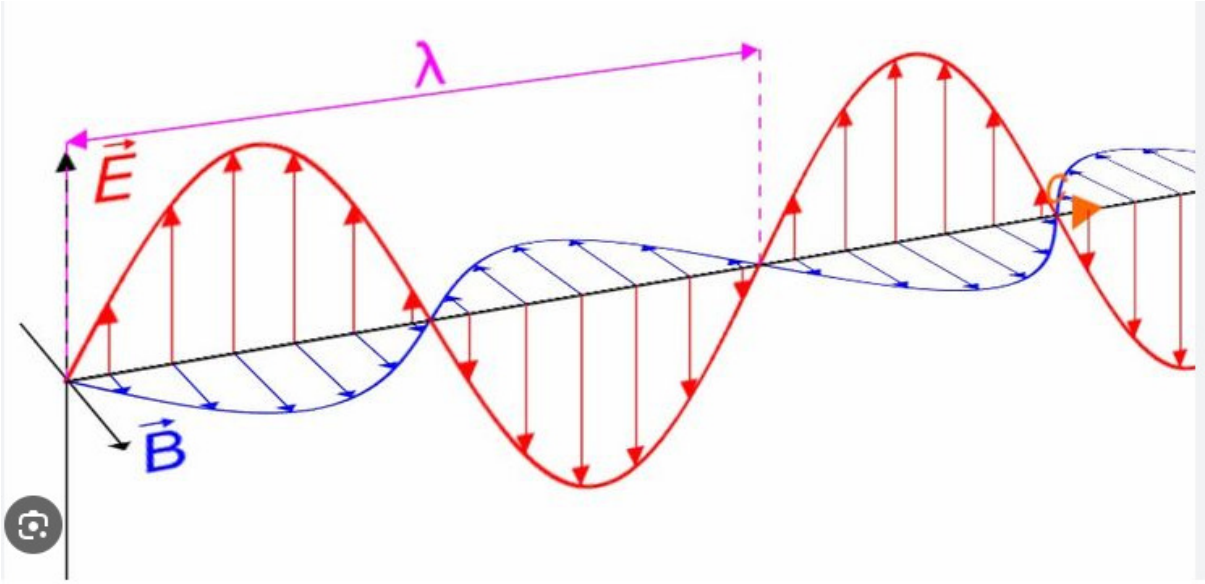
UHF Vertical dipole phased stack

VK2JMJ August 2024

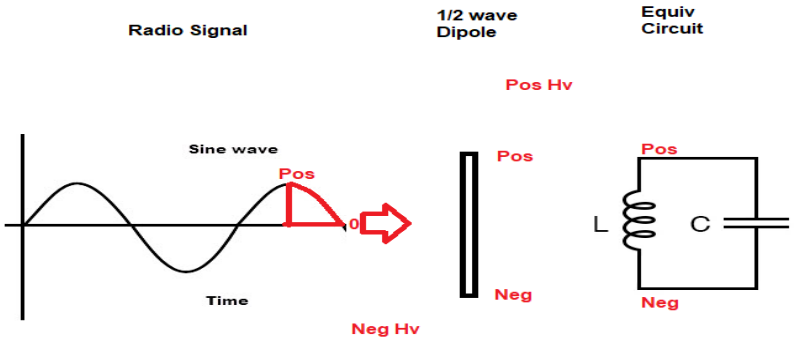
Concept: Experiment with the design concepts and theory of the high gain vertical for UHF. A dipole is a 1/2 wave.

Theory:

A radio frequency energy is the same as light energy, travelling in a magnetic and electrical wave shape, 90 degree separated. Visible light is all the frequencies within the visible light spectrum. Lower in frequency is Infra Red, much lower is UHF.

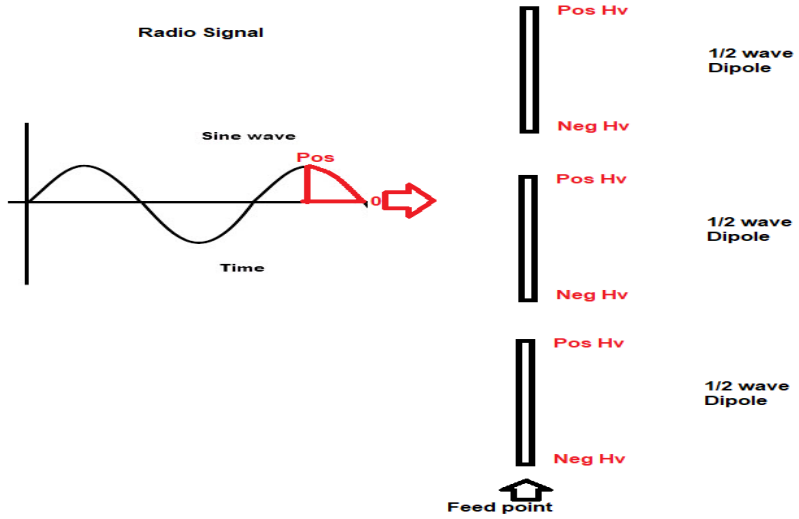


Radio waves will energise the antenna elements from a distance. Voltages are induced into the antenna elements. The length of the element determines a resonate frequency. At resonance, the equilivant circuit is an inductor and a capacitor.



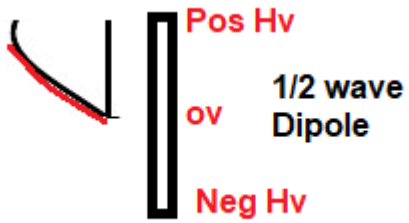
For the 1/4 wave of the incoming radio signal, it energises the diople

Consider a vertial with many elements



Being in a vertical structure, each of the elements are energised in the same direction. The red section shows the first 1/4 wave shape of energy. If all the 1/2 wave segments are joined in series, then the length would no longer be at a 1/2 wave, so each vertial element must be joined so that the induced values add to provide higher gain, but without being physically connected.

Each of the dipoles can be considered as having a "zero volts" (0v) centre and the positve and negative swings can be shown as a vertical sin wave. This example is showing the first 1/4 wave of the induced signal.



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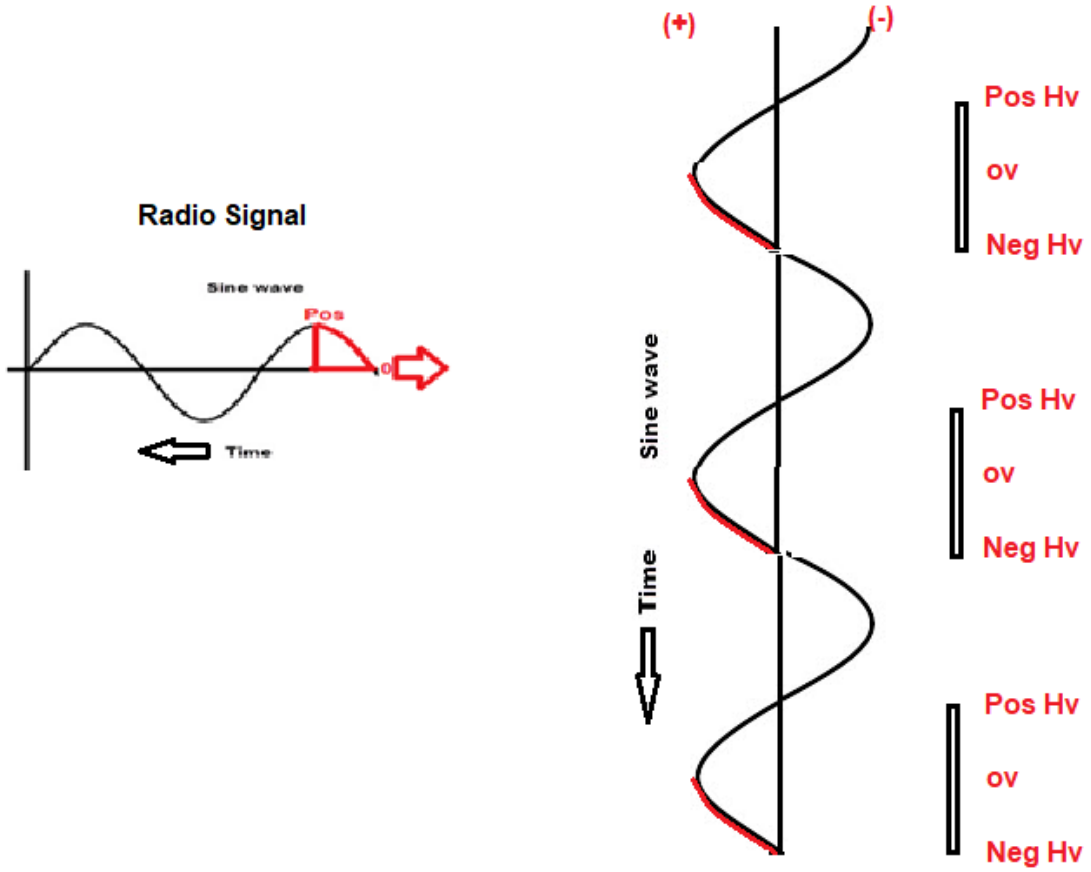
Consider the arriving 1/4 wave energy that has been induced into the element. Consider the equilivant circuit comprising of the inductor and the capacitor. The 1/4 wave energy has energised the element as a whole lenght of element during the 1/4 wave. This now makes it possible to visualise that all the elements in the stack have all been energised by the same arriving 1/4 wave of energy.



The vertical structure can be shown with a vertical wave shape towards the feed point to visualise how the the enegry from each of the stacked elements progresses to the feed point.

During the positive portion of the wave shape, the induced voltage rises for the first 1/4 wave and reaches a maximium, then reduces during the second 1/4 wave of the radio signal. The polarity of the elements reverse during the remaining 1/2 wave cycle.

The question remains, "how to join each of the element's energy into one" but without physically connecting them together. Connecting each will just make a longer element, thus altering the physical lenght and altering that natural resonance in that length.

Consider Time

The radio signal arriving has a frequency and one cycle has a wave length. Thus one full wave arrives over a fixed time. The signal is induced to all the elements and the same frequency will travel towards the feed point at the same rate that the signal is arriving.

By considering the time taken as the signal travels down the stack, the elements can be joined. A linking conductor that is 1/2 wave length long can control the time between the elements. The only requirement is that length of joining wire does not get energised by the arriving signal energy.

Stack the elements with a 1/2 wave shielded conductor

Visualise the top element's lower end being the Neg HV travelling down the stack via a joining shielded conductor. By the TIME the neg HV has arrived to the top of the next lower element, that lower element's voltage has changed to Neg HV by the arriving signal. All the energy from all the elements are now added because they are in phase with each other as that energy moves down the satck towards the feed point.

Shield or not to shield

A straight length of wire has an inductance and will resonate on it's length. That same length formed into an air coil has a greater inductance as thus it will resonate at a different frequency. The electrical length of the air coil conductor remains the same. This means that the same delay required (being a 1/2 wavelength of time) can be created from an un-sheilded wire that has been formed into an air coil. The natural resonance of the air coil is not at the arriving frequency, so it will not be energised.

This means that the linking 1/2 wave delay wire between the elements can be a simple air coil of unsheilded wire.

Feed Point to the stack of dipoles

The stack of 1/2 wave dipoles are separated by a 1/2 wave delay line. Each end of the 1/2 wave dipoles is a HV point. The stack needs to be fed with a HV point created at the base of the antenna (ie the driven element).

The tip of 1/4 wave ground plane is a HV point.

The upper tip of a bottom fed 1/2 wave dipole is a HV point.

The upper tip of a J-POLE is a HV point.

Any resonate feed point that has a HV point can be used to appy to the stack of phased dipoles.

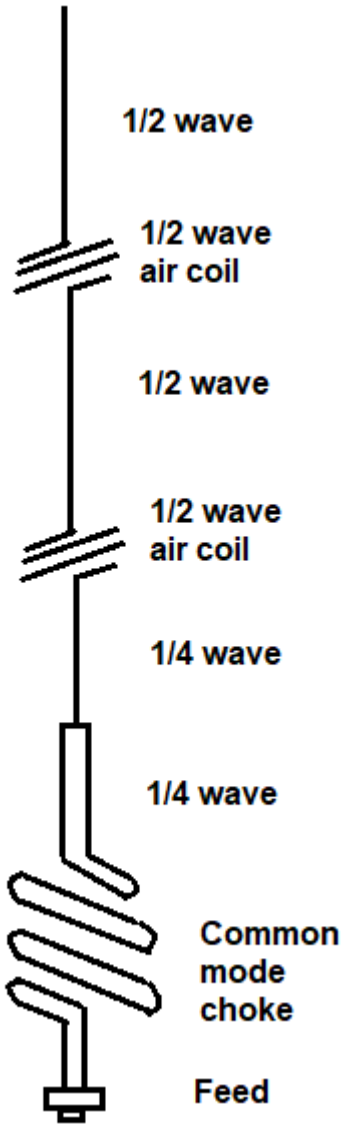
The Build

The driven element is constructed from RG59AU coax. The diople is formed by a 1/4 wave of exposed centre conductor and the lower section 1/4 wave of the dipole is formed by the outer sheild. To define a length of the 1/4 wave of the outer sheild, a choke is required to block the energy flowing down the outer sheild. The RF energy is blocked by the inductance of the turns on the choke, thus the 1/4 wave of outer sheild becomes the 1/4 wave of the dipole.

The choke is 5 turns of the coax on the tighest radius that the coax will allow.

Use a NanoVNA to find the electrical length of a 1/4 wave of internal coductor amd build the driven element. It is difficult to get a good SWR at UHF as it requires very fine adjustments in length. VKJ2JMJ found that the VNA can get it close and then use RF power and a SWR meter to it get closer to perfect.

Use the VNA to get the electrical 1/4 wave length of the air coil wire and the stacked elements. VK2JMJ used wire from the junk box. Double that length for the 1/2 wave lengths. Complete the stack one element at a time, trimming the 1/2 wave using the RF power and SWR meter. Complete a higher stack. Complete as many as required for the vertical stack.



Conclusion:

This UHF vertical worked very well. The theory was created due to a pervious project build using Coax Collinear that failed badly. The theory presented here could be easily applied to the next attempt at the coax collinear. The hardest task was making the driven element resonate.

(END) Create by VK2JMJ August 2024, To understand why a coaxial collinear build failed, suffering a pool drenching.