AntennaSelect

Micronetixx's Antenna Technology Newsletter

Welcome to AntennaSelect™ Volume 37 – April, 2018

Welcome to Volume 37 of our newsletter, AntennaSelect™. Every two months we will be giving you an "under the radome" look at antenna and RF technology. If there are subjects you would like to see covered, please let us know what you would like to see by emailing us at: info@micronetixx.com

In this issue:

- **A Discussion of Slot-Style Antennas**
- **Higher Power THV VHF High-Band Antennas**

Standing-Wave vs. Traveling-Wave Antennas

MICRONETIXX COMMUNICATIONS

In the previous issue of AntennaSelect, we took a relatively qualitative overview of Slot-Style Digital Television Broadcast Antennas. In this second section, we will begin to highlight the actual difference between Standing-Wave and Traveling-Wave Pylon Antennas.

Most of us are quite familiar with the term VSWR. The term stands for Voltage Standing Wave Ratio. When your transmitter is connected to your antenna, depending on how well matched your antenna is to the characteristic impedance of the transmission system. (This is usually 50 ohms. Some television antenna systems still may use 75 ohms.

Continued on next page

However, most modern transmission systems utilize the 50 ohm system characteristic impedance.) If the antenna is extremely well-matched to the transmission system characteristic impedance, then nearly all of the RF power from the transmitter will be radiated and transmitted properly to your viewing audience. However, in the real world, nothing is perfect, and therefore, even though a good antenna that is well matched to the impedance of the transmission system will transmit most of the RF power from the transmitter, there will usually be a small percentage of the RF power that will not be transmitted by the antenna.

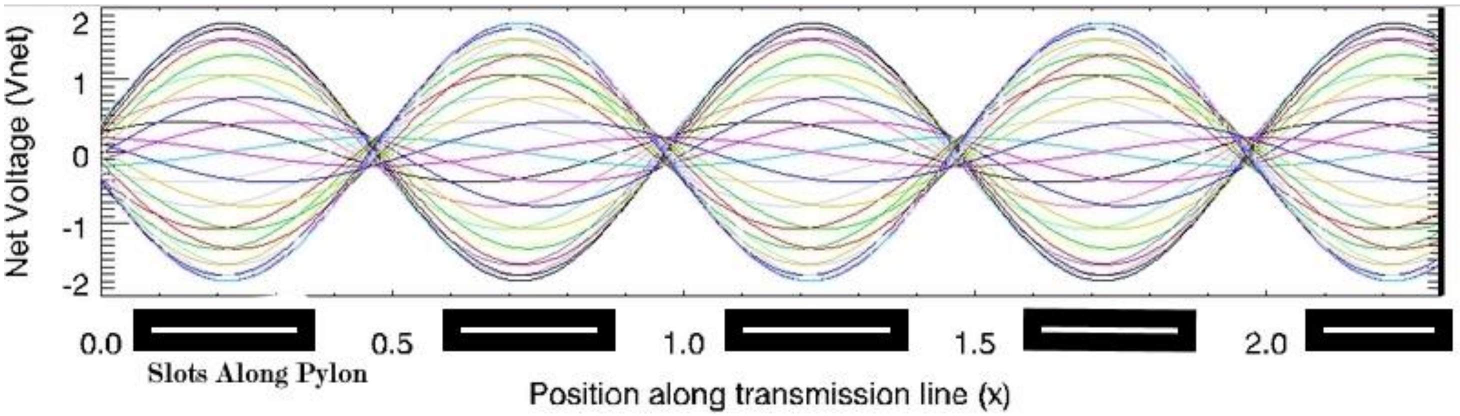
That small percentage of RF power that is not transmitted will be reflected by the antenna and then be sent back down the transmission line to the transmitter. Since that reflected power that is not used by the antenna is phase-related to the RF power originating from the transmitter, (because it is an actual portion of that same incident power), the RF waves that are traveling up the transmission like from the transmitter will then interact with the waves that are reflected back from the antenna.

That interaction will cause what is known as an "interference pattern" inside of the transmission line. (That interference pattern is the result of the interaction in the line of the superposition of the two traveling waves; one traveling toward the antenna from the transmitter, and the other traveling in the opposite direction; reflected from the antenna and traveling back down toward the transmitter.) That interference pattern is in the form of "Standing Waves". Standing waves are the interference pattern that is set up from the two systems of traveling waves; one from the transmitter traveling toward the antenna, and the second reflected from the antenna and traveling back down toward the transmitter. So in order for there to be any standing waves on a transmission line, there must be an incident wave from the transmitter interacting with a reflected wave from the antenna.

Continued on next page

Because of this interaction, the standing waves that are set up in the transmission line, as one moves along the line will have alternating maximum voltage regions along the line, and maximum current regions along the line also. In a system of standing waves like this, the maximum voltage points and maximum current points along the transmission line are stationary, (standing), and will repeat themselves every half-wavelength at the transmitter frequency. In addition, the standing wave voltage and current maxima are displaced along the line by one quarter wavelength at the operating frequency. It is important to note that the magnitude of the standing-waves is dependant on the percentage of the power from the transmitter that is reflected back by the antenna. The larger the percentage of reflected RF power, the larger the relative magnitude of the variation of voltage and current along the transmission line.

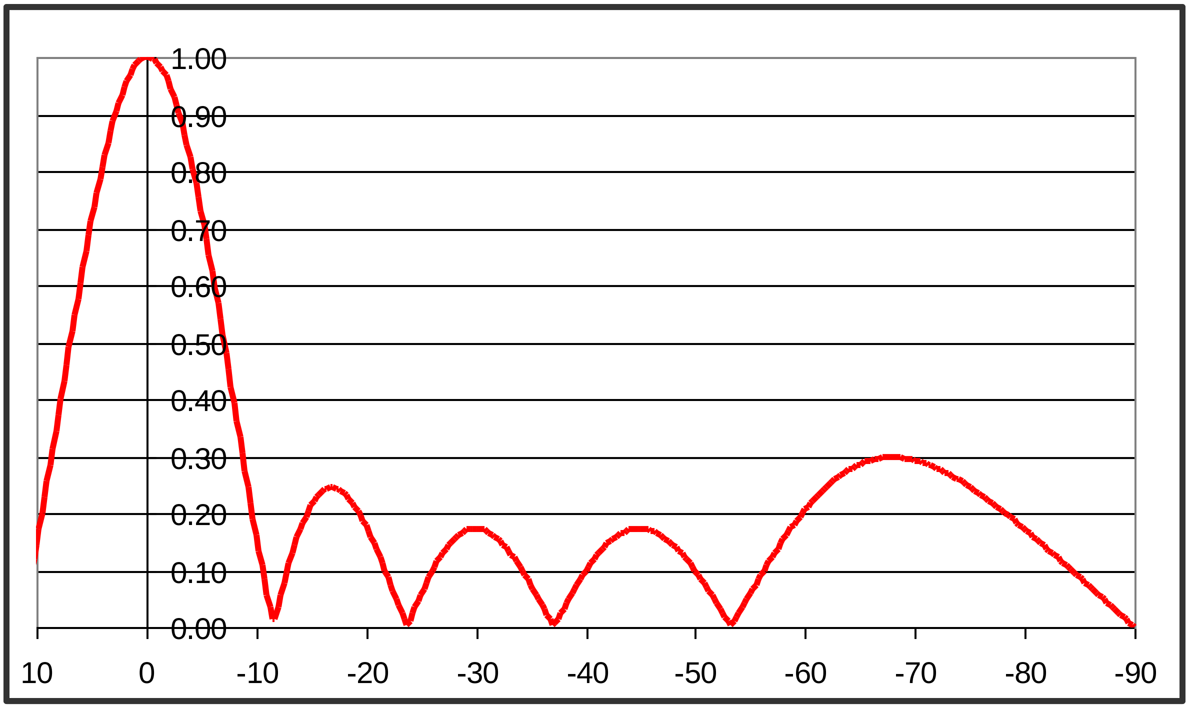
The Figure below depicts the pattern of standing-waves, along an RF transmission line with relatively high VSWR due to reflected RF power.



Note that in the diagram of the Standing-Wave Pylon antenna above, the radiating slots are placed along the pylon where the actual standing-wave voltages are at their peak. Notice that the size or magnitude of the standing-wave voltage levels along the pylon is relatively uniform from slot to slot. This is in order to drive each slot uniformly. Here, each slot contributes nearly the same radiation moment to the array pattern profiles.

Continued on the next page

As a consequence of this, if one were to measure the relative electric field magnitude from 0° to 180°, (where zero degrees is a position directly under the antenna as it is mounted on a tower, 90° is actually at the horizon, and 180° is directly above the antenna), the pattern would look something like this, below:



Five bay slot antenna elevation pattern

It is important to note that, if the percentage of reflected power from the antenna is nearly zero, then, in that case, there is virtually no reflected wave from the antenna to interact with the incident wave from the transmitter and therefore there will be virtually no standing waves on the transmission line. The only wave present is the one traveling wave system from the transmitter. If there is no reflection from the antenna, then there are only traveling waves present in the transmission line.

As mentioned earlier in this article, the VSWR is a quantitative measure, and is calculated using the ratio of the voltage in the forward traveling wave, (forward voltage), to the voltage in the reflected traveling wave, (reflected voltage).

Continued on the next page

The Mathematical Definition of VSWR is:

$$\text{VSWR} = \frac{[(1+(\text{reflected voltage/forward voltage}))]}{[(1-(\text{reflected voltage/forward voltage}))]}$$

Considering the above equation, one can see that if the antenna is well-matched to the transmission line, then the reflected voltage will be nearly zero. That is the desired situation for a TV or FM Radio broadcast transmitter. In that case, the VSWR expressed as the ratio in the above equation will be nearly 1:1.

If you look at this equation, you can see that if all of the forward voltage from the transmitter is reflected back toward the transmitter, (such as is nearly the case when there is a burned-out transmission line, or if no antenna or dummy load is connected to the line), then the forward voltage will be nearly equal to the reflected voltage. In that case, looking at the denominator of this VSWR equation, the forward voltage divided by the reflected voltage will be one, (1). Since the denominator is 1 MINUS that ratio, then that denominator would be 1 minus 1 or ZERO. A zero in the denominator here will be an infinite VSWR. NOT GOOD!

On the other hand, let's consider now that we have a perfect dummy load connected to the end of the transmission line then the reflected power is nearly zero. In that case, the VSWR equation is:

$$\text{VSWR} = \frac{[(1+0/\text{forward voltage}))]}{[(1-0/\text{forward voltage}))]} = \frac{[1+0]}{[1-0]} = 1{:}1$$

PERFECT!

But what, you may ask, exactly is a "standing wave"? A standing wave is actually a combination or superposition of two **traveling** waves from the same source; one wave traveling FORWARD and the other, (reflected) wave traveling backwards toward the transmitter.

Continued on the next page

In a transmission line system, in most cases, in order to have reflected power, the electromagnetic waves that are traveling away from the transmitter in the transmission line will encounter or "bump into" something in the line that is results in an electrical disruption to the system of traveling waves. In a coaxial transmission line, this can be an abrupt change in the ratio of the outside diameter of the inner conductor to the inside diameter of the outer conductor. (This is called an abrupt discontinuity.)

This changes what is known and the Characteristic Impedance of the transmission line. In that case, a portion of the electromagnetic wave system that is traveling away from the transmitter will be turned around and reflected back toward the transmitter. (The percentage or portion of the forward traveling waves that are turned around and reflected back toward the transmitter, in this case, will depend on the size of this abrupt discontinuity.) In the case of a short, (or open), circuit, nearly 100 percent of the traveling waves that are propagating in the coaxial line are turned around and reflected back toward the transmitter.

As stated earlier, the superposition of these two systems of traveling waves, (the initial, forward traveling wave from the transmitter, and the reflected traveling wave from the short or open circuit), will result in an interference pattern inside of the coaxial line that takes the form of a system of standing waves.

In order for there to be standing waves inside of a coaxial transmission line, there must be a discontinuity inside of the line that causes a reflection of the forward traveling waves to be reflected back toward the transmitter, and result in standing waves inside of the coax line. In a standing-wave pylon antenna, this discontinuity is a specifically positioned short circuit that is located at the end of the standing-wave pylon antenna, furthest away from the end of the antenna that is connected to the transmitter.

Continued on the next page

This short circuit will reflect nearly all of the forward traveling waves that encounter it, setting up an intentionally-created standing-wave pattern inside of the coaxial pylon antenna. If you consider the magnitude, (or strength), of the electric and magnetic fields inside of the pylon as you move from the short circuit at the far-end of the pylon antenna along its length, the magnitude of these fields will increase and decrease periodically, (repeating every half-wavelength at the channel or transmitter's operating frequency), as you move axially along the pylon from the short circuit toward the end that is connected to the transmitter.

The radiating slots along the pylon outer conductor are then positioned at specific locations, relative to the short circuit, such that they extract a portion of the signal power that is present in these standing waves. The slots are positioned such that the repeating periodic magnitude of the standing waves is extracted by the slots and radiated away to the viewing audience. All along the length of the pylon, the relative magnitude of the voltages and currents, (resulting in electric and magnetic fields), is nearly uniform or the same all along its length.

In that case, if all of the slots are designed to couple to the standing waves inside of the pylon equally, then each slot will radiate along the axial length of the pylon and contribute almost the same amount of power to the total radiated signal that is launched from each of the slots in the slot array of the antenna traveling toward the viewing audience. In this case, all of the radiating slots in the array are uniformly driven or illuminated. That is basically how a standing-wave pylon antenna operates. The contribution of each slot in this array along the pylon’s lenght then results in the desired far-field radiation pattern.

So what is a TRAVELING-WAVE antenna? In a traveling wave antenna, there is a profound difference. In this case, a traveling RF wave in the coaxial pylon antenna does not have the reflecting short circuit placed at the far end of the pylon, thereby not establishing a standing-wave pattern in the pylon, as in the standing-wave pylon.

Continued on the next page

In the case of a traveling-wave antenna, the waves that are traveling along the coaxial pylon antenna do not encounter the abrupt discontinuity, as they did with the short circuit at the far end of the standing wave pylon antenna. In this case, the forward traveling waves are not reflected back toward the generator end, and therefore, do not create the superposition of the two systems of traveling waves, resulting in the standing-wave pattern, described earlier in this article.

In this case, each slot is designed to extract a small portion of the energy in the traveling wave as it passes along under the slot, and radiate that energy out to the viewing audience. In the case of the traveling-wave antenna, the slots are designed so that they do not present any discontinuity, and hence, reflecting little or no portion of the traveling wave at all, and therefore, do not result in the formation of any standing waves due to reflection of any portion of the **forward traveling wave inside of the coaxial pylon. As the traveling wave system passes along the coaxial pylon antenna, and a portion of the signal is extracted by the slot and radiated away, the overall magnitude of the electromagnetic fields are reduced as the waves pass each slot, on their** way down the length of the coaxial pylon.

Because the magnitude of this traveling wave is reduced at each slot as it passes, the magnitude of the radiated signal from each successive slot is reduced exponentially, relative to the radiated magnitude of the slot before it in the array. At the far end of the pylon, instead of a short circuit reflecting the all of the energy in the wave traveling down the pylon, there is a set of final slots that couple to and radiate all of the remaining energy in the coaxial pylon. All of this remaining energy is then extracted and radiated away. In this case, the slot array is said to be **"exponentially-illuminated"**, as opposed to the case for the standing-wave pylon, where all of the slots in that array are **"uniformly-illuminated".**

Continued on the next page

Because of the exponentially-illuminated slot array profile of a traveling-wave antenna, the contribution from each successive slot in the array, to the overall array pattern and gain of the antenna as the wave passes along, is reduced, as the system of fields travels down the antenna aperture from the input end to the far end of the antenna. In that case, the overall gain and therefore aperture efficiency of the antenna is greatly altered for the same number of slots that may be present in a standing-wave pylon antenna.

In the next article, we will look at some precise numbers regarding antenna aperture efficiency, gain and radiation pattern profiles. We will also examine some of the advantages of the new technology designs embodied in the efficient standing-wave pylon antenna as opposed to the older traveling-wave antenna design.

Higher Power THV – VHF High Band Antennas

MICRONETIXX
COMMUNICATIONS

We have had a number of you wanting a more compact and robust VHF High Band option for interim and standby services. With the open translator window, a number of stations will need to look at the VHF High Band as an option. We now offer a higher power version of our THV VHF High Band antenna. The original THV antenna had an input rating of 500 Watts per bay. Our newer higher power version has an input power rating of 2 kW per bay. Depending on the number of bays and the desired ERP level, the THV bays are fed by a power divider with either a 1-5/8” or 3-1/8” EIA input.

Each THV bay is built with rugged schedule 304 stainless steel. The bays may be customized to have a basic wind speed rating of 150 M.P.H. The THV Antennas are available in two to 10 bay counts and are half-wave spaced. Each bay, including mounts, weighs under 20 lbs and has a very low wind load area.

Continued on the next page

THV Antennas Electrical Specifications

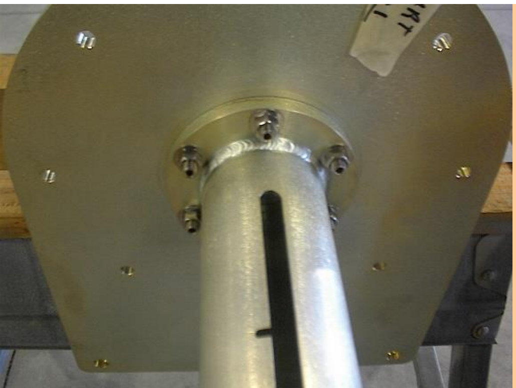
Number of Bays	Antenna Gain (C/P)	Antenna Max Input Power	Maximum ERP
2	0.69 (-1.61 dB	4 kW (6.02 dBk)	2.76 kW (4.41 dBk)
4	1.30 (1.14 dB)	8 kW (9.03 dBk)	10.4 kW (10.17 dBk)
6	1.90 (2.78 dB)	12 kW (10.79 dBk)	22.8 kW (13.58 dBk)
8	2.50 (3.98 dB)	16 kW (12.04 dBk)	40 kW (16.02 dBk)
10	3.10 (4.91 dB)	20 kW (13.01 dBk)	62 kW (17.92 dBk)

The new THV Antennas come in array sizes of two to ten bays. A 6-bay antenna, can produce an ERP of up to 22.8 kW – with full Onmi-directional C/P performance. For low power operators looking at an ERP of 3 kW, the 6 bay antenna would only require a TPO of 1.58 kW, (plus power to make up for line loss).

The THV Antennas come array-tested with cut-to-frequency feed harness systems. Beam tilt and null fill can be added to 4 bay or larger arrays. With the light-weight an low wind load, they can be mounted on a small diameter monopole system or side mounted on a tower. Since the THV bays are spaced a half wavelength apart, they produce 15 to 25 dB less radiation, (RFR), at high depression angles, as compared to competitors models.

With a move to VHF looking more likely, or stations needing a low cost interim antenna solution, the THV antenna is the perfect solution.

Be on the lookout for the next volume of AntennaSelect$^{\text{TM}}$ coming out in June



MICRONETIXX COMMUNICATIONS

70 Commercial St. Lewiston ME 04240 U.S.A.
V 207-786-2000 www.micronetixxantennas.com