AntennaSelect

Micronetixx's Antenna Technology Newsletter

Welcome to AntennaSelect™

Volume 5 – December 2013

Welcome to Volume 5 of our newsletter, AntennaSelect. Each month 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

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Mounting multiple UHF (Band IV) slot antennas

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Tower space in many locations is at a premium. Depending on how your UHF slot antenna is mounted, may make all the difference in performance of your station. We get questions on a regular basis about antenna mounting, so lets take a look at a couple of examples.

The most common question is can you mount two UHF slot antennas at the same height or aperture ? In the majority of cases, yes. Let us take a look a some of the basics of mounting.

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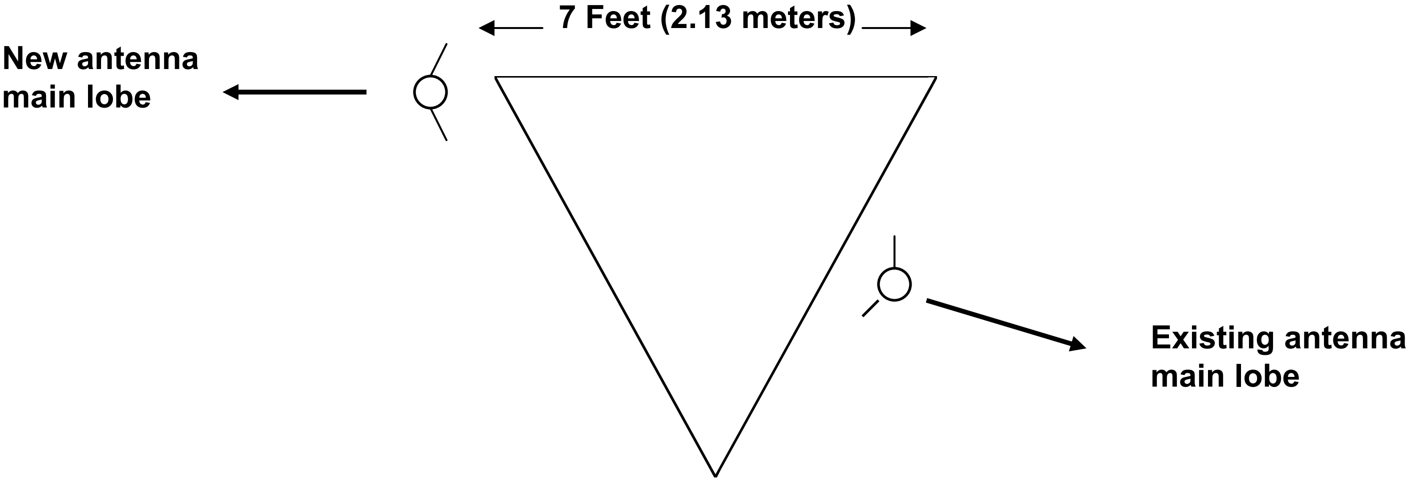
The first example is two cardioid antennas mounted on opposite faces of a tower. The tower has a 7 foot (2.13 meter) face width. Cardioid antennas are a good candidate for this approach as the parasitics that form the main lobe of the antenna, also greatly reduce coupled energy to the support tower



When mounted as depicted by the drawing above, the two antennas will cause minimal pattern disruption to each other. Electrical isolation between the two antennas is between 30 dB and up to more than 50 dB depending on the difference in frequency of operation.

Now lets look at what happens when we use less directional antennas, or even Omni-directional antennas. Since there is 60 to 90 percent more field coming off the back side of the antenna, as compared to a directional cardioid. There are a lot more currents flowing around the back of the antenna that can couple into the mounting structure or tower. Lets look at a pair of Omnioid slot antennas first.

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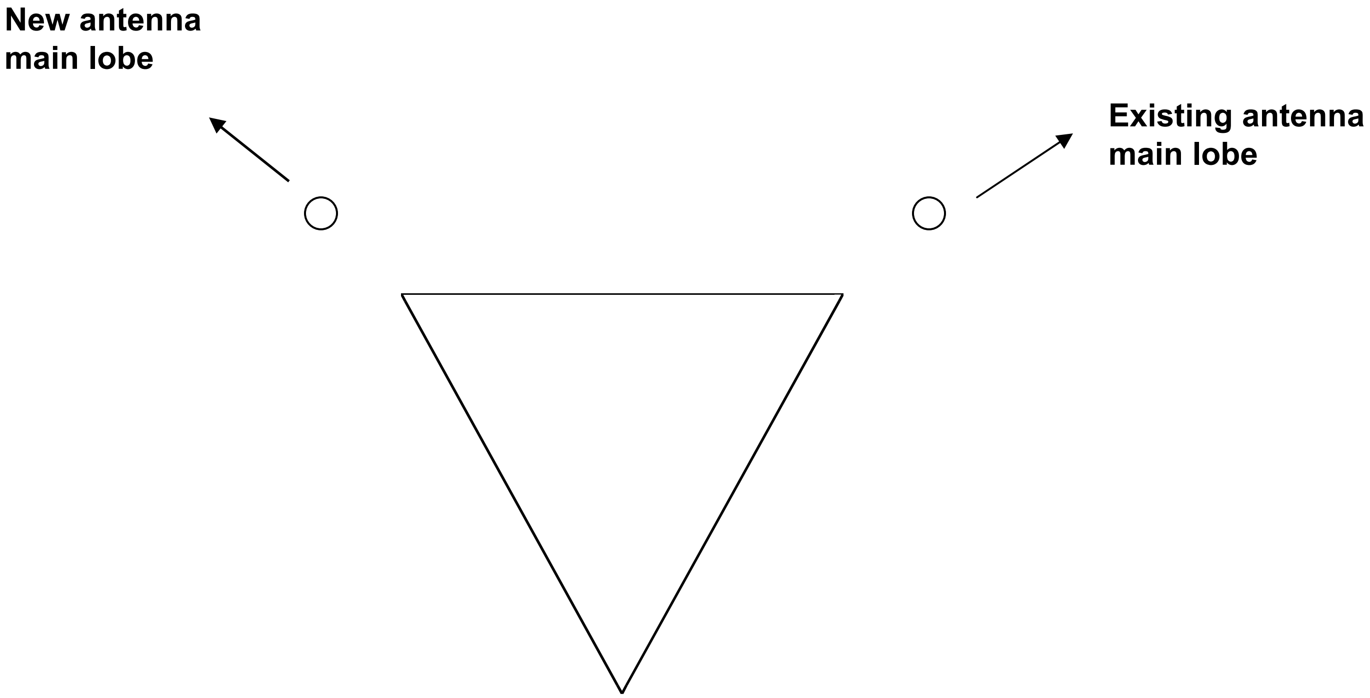
We will use the same 7 foot face tower example for mounting these two Omnioid antennas. The Omnioid antenna produces 100% of field over a 90 degree arc as a main lobe. The back side of the pattern is a little more than 3 dB down, with an average of 66% of field. If the Omnioid is used as a non directional antenna, orientation can be adjusted in the field for best operation. In the case of the Omnioid antenna, mounting it farther off the tower, and off a leg if possible will provide the best azimuthal pattern.



If the Omnioid antenna is going to be mounted on the face of the tower, try to mount it as far as possible away from the tower. A good rule of thumb is a minimum of 1-3/8 Lambda. At 600 MHz that would work out to 27 inches (69 cm).

Lets look at Omni-directional antennas next.

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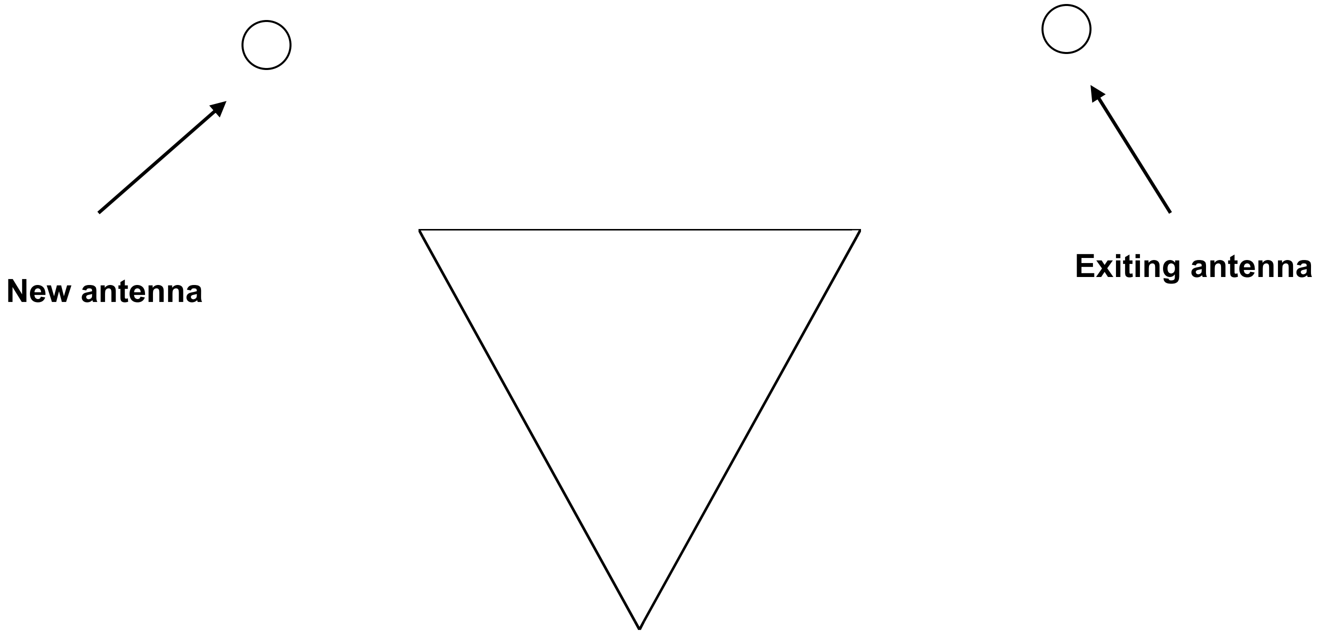
The drawing below shows the mounting position of two Omni-directional antennas off opposing tower legs.



Mounting the antenna off a tower leg is the best way to go. Since the antenna is producing a strong field at every azimuth angle, getting the antenna further away from the tower usually produces the best results. If possible aim for more than 2 Lambda from the tower (at 600 MHz 39 inches or 100 cm).

Antennas are tuned in free space. Mounting them to a tower structure may cause a little detuning. In the depiction above, just rotating the antenna a few degrees may lessen the detuning. A change in return loss of up to 6 dB is not uncommon

We recommend a four port fine matcher for side mounted Omni-directional antenna applications. The fine matcher should be mounted at the antenna input. Planning a new install ? We have tons of experience making multiple antenna projects work.

We make high power RF – 100 kW at a time

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Our customers and friends in the broadcast community know us for our high quality transmitting antennas. But not that many of you know that we build high power transmitters or generators that have an output power of 100 kW at 915 MHz. Transmitters ? Yes transmitters, however they do not put out a modulated signal, just a rock steady source of RF.

High power RF is use in many industrial applications to dry material, separate oils and chemicals, and to sterilize toxic waste. If you think of one of our transmitters having the output of between 90 and 125 home microwave units, cooking and tempering food on a big scale is yet another use.

The transmitters we build only supply the RF energy. The microwave like operation is done in specially constructed cells that product passes through. RF is applied to these cells to heat product passing through them as uniformly as possible. Since the uniformity of the product passing through the application cell changes, it's dielectric properties also change. Specialized PLC controlled auto tuners are used to dynamically keep the loading in the cell as constant as possible. We also design and build these cells and dynamic tuners.

Circular Polarization is a term usually used with transmitting antennas. It is also a term used in industrial microwave. The RF applied to the application cell can be fed with linear polarization, or Circular Polarization. A section of waveguide connected to the application cell launches the RF in a sweeping circular fashion, creating more uniform heating in the cell.

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Here is the view inside of one of the transmitters. A magnetron is used to generate the RF energy. The magnetron is located in the upper center of the photo in a metal case. The RF output is on the right side of the unit, which is a waveguide flange.

Below the magnetron is the high voltage rectifiers. The massive poly-phase transformer is mounted behind the rectifier stack. The PLC controller and control interface are located to the left.

Our engineering staff has decades of high voltage design engineering under their belts. Layout, functionality and ease of maintenance are the design goals they strive for.

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Three completed 100 kW transmitters ready for delivery. One of our customers asked us if high power RF could be used to produce Pizzas very quickly. Well, depending on the toppings probably not. The Pepperoni would come out burnt black and the meatballs would most likely explode. Besides, you would need the power company to build a substation at your site, just to run it. The old brick oven wins out after all.

Precision Measurement of VSWR

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VSWR, (Voltage Standing Wave Ratio), is a measure of the level of RF power that is initially generated by the transmitter, that is reflected back to the transmitter from the antenna and/or other components in the broadcast station's transmission system. The mathematical definition of VSWR is a number expressed as a ratio, computed according to the following formula:

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

A VSWR measurement of 1.0:1 indicates that there is no reflected power at all. This ratio extends all the way to a VSWR of infinity, (∞), if 100% of the transmitter power is reflected. In most passive RF broadcast systems, (such as antennas, coaxial transmission line, waveguide or filters), reflected power is most commonly caused by mechanical variations in the transmission elements' structure that causes a discontinuity in the transmission path. These discontinuities will cause RF power to be reflected. These reflections are vector quantities, meaning that they have both a magnitude, (strength), as well as a direction, (phase), associated with them. The complex power reflection coefficient magnitude is expressed as the ratio of forward to reflected power.

This magnitude can be represented conveniently and accurately on a Smith Chart, (where normalized inductive reactance, capacitive reactance and resistance are quantitatively displayed), or for description here, on a polar chart, where the magnitude is represented by the length of the radius between the center of the chart represents, and its coordinate between the center and the periphery. The quadrant on the chart represents the phase of the complex reflection coefficient.

High levels of reflected power are not desired in antenna and transmission systems for many reasons. Two major reasons are:

1. The reflected RF power can be very damaging to many elements in the station's transmission system, especially the final amplifier in the transmitter, and

2. It is a complete waste of expensively-produced RF power from the station's transmitter.

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In the transmission system in all broadcast stations, the antenna, as well as any other component in the RF path from the transmitter to the antenna, if they are not designed and tuned properly, will cause reflected power. Therefore, all components in the system must be designed and tuned extremely carefully so that it does not generate unacceptable amounts of transmitter power. In most practical DT and FM Radio broadcast transmission facilities, the antenna itself should exhibit a VSWR of no more than 1.10:1 .

Solving the above equation for the ratio of reflected RF power to forward RF power from the transmitter, a VSWR is 1.10:1 is representative of a power ratio of: 0.00227:1 That is; only 0.227% of the transmitter power delivered to the antenna's RF input terminals is allowed to be reflected back toward the transmitter. (This also means that, neglecting small resistive losses in the antenna structure, approximately 99.78% of the RF power is transmitted, resulting in the on-air signal.) Further, other components in the RF transmission system should have a VSWR of only 1.02:1. This translates to approximately only 0.0098% of the incident transmitter power being reflected. Clearly, both of these parameters are **extremely small**. Therefore, accurate and careful measurement of these important characteristics is essential.

Further complicating factors when measuring VSWR involve the fact that these reflections are vector quantities, (as mentioned earlier). These vector reflections will add both constructively and/or destructively along the transmission system in the stations RF system, and can literally "hide" among the other small reflections in the test fixture.

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As demonstrated above, these reflections can be very small. Small levels of reflection coefficient are therefore extremely difficult to detect and eliminate. Therefore, in order to accurately measure and mitigate this unwanted affect, a precise testing method involves presenting the network under test with a known magnitude of reflection coefficient in the test fixture, which also will then rotate the phase of these known reflections in the test fixture through all angles around the polar chart.

The reflections from the device under test will then add both constructively and destructively to the vector reflections in the test fixture. This will generate a vector resultant that manifests in an offset between the center of rotation of the device plotted on the polar chart through the test fixture, and the center of the polar chart itself. In other words, the result is that the difference on the polar chart between the center of rotation of the reflection coefficient when connected to the device under test, and the center of rotation of the phase of the complex reflection coefficient of the test fixture itself is exactly the reflection coefficient of the device under test itself.

This method is extremely accurate, and will allow quite precise measurements of complex reflection of a device under test, down to VSWR accuracies of less than 1.005:1. That equates to a reflected power percentage of approximately only 0.0062%, or a return loss of 52.2 dB, which is extremely small amount of the RF generated.

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The best method of implementing a test fixture where a known level of reflection coefficient can be presented at all phases to a device under test, (DUT), is to connect the DUT to an instrument load, with a known VSWR parameter, through a length of transmission line of known characteristic impedance, that is long enough to so that, when swept over a specific frequency span, the phase of the reflection coefficient rotates through all four quadrants of the polar chart, where the resultant complex reflection coefficient is plotted. The required length, (in feet), of this test transmission line is given by:

Length in Feet={(11803)÷(24*(Δ frequency)}

Editors Note: We will be visiting some of the common test issues we encounter with the testing of transmission systems in future issues of AntennaSelect. As you go up in frequency, especially in the UHF Band (Band IV), the higher the need to have known test components. A single adapter with a V.S.W.R of 1.04:1 will most likely not allow you to test a transmission system and get a V.S.W.R. of under 1.10:1 .

And if you have questions, or suggestions for future articles, please let us know at: info@micronetixx.com

Be on the lookout for the next volume of AntennaSelect coming out in January

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