Welcome to AntennaSelect™ Volume 18 – February 2015

Welcome to Volume 18 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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Our newest FM antenna – the FMC 3 element Yagi

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The FMC series of antennas are rugged 3 element Yagi's. They form a single polarization cardioid pattern and have a gain of 4.5 dB. The front to back ratio is between 12 and 14 dB depending on frequency. They can be mounted horizontally or vertically. The FMC is a 50 Ohm antenna.

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The FMC antennas are tuned to a specific channel for lowest V.S.W.R. The V.S.W.R. is under a 1.10:1 over 200 kHz, or a 1.50:1 over a 2.5 MHz span.

The azimuth pattern has a half power beam width of 120 degrees. Multiple FMC antennas can be combined to form a peanut or a wider cardioid pattern, in either horizontal or vertical polarization.

The input power rating of the FMC antenna with an N type RF input is 500 Watts, or 1 kW with an optional DIN input. The feed system and all elements are DC grounded to provide excellent protection from lightning strikes.

The FMC antennas are available in aluminum and stainless steel versions. The aluminum version is finished with a rugged Class 1A chromate treatment.

High tech microwave waveguide tuners

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A look at the inside of the motors that drive the RF plungers used to tune the waveguide. The orange cable is the Ethernet connection to the PLC controller.

In many industrial microwave systems, the material in the application cell can create an ever changing load. Often the power levels in a single cell can reach 30 kW at 915 MHz. Waveguide tuners are used to lower the V.S.W.R. , allowing much better control of the RF energy being applied to the product. We have designed an Ethernet based waveguide tuner that can quickly resolve quickly changing V.S.W.R.

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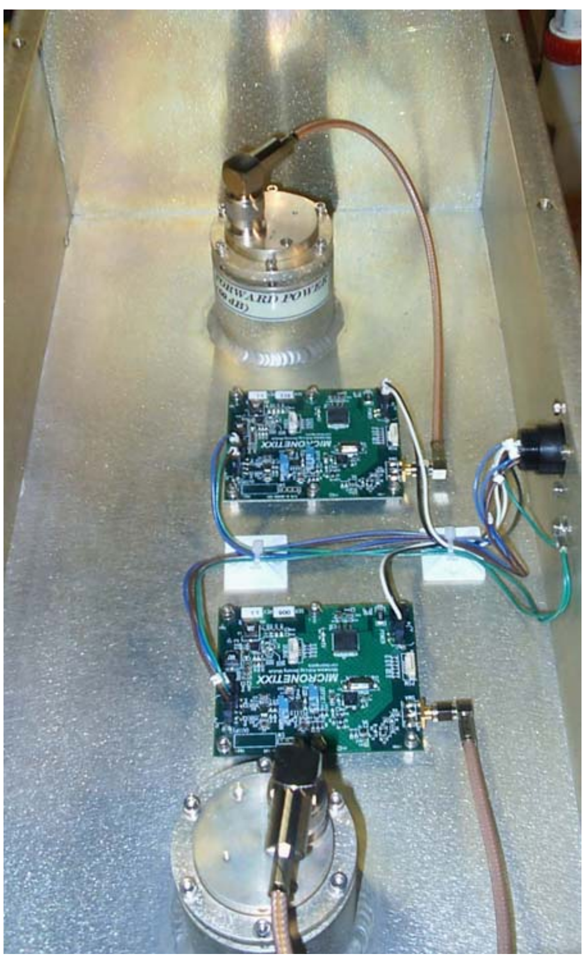
The feed to the application cells is via WR975 waveguide. V.S.W.R. is controlled by placing two inductive structures in the waveguide. These are fixed structures. The variable structures are probes and their up and down movement inside the waveguide changes capacitance. Each of the probes is driven by a bi-directional motor, which is controlled by the PLC control system we have designed.

Depending on the change in V.S.W.R. that the material being processed creates, the motors often will be turning back and forth, many times a minute. The tuner system can resolve V.S.W.R. over an 8 to 1 range. There are mechanical stops on each of the plungers. If the plunger tries to travel up or down too far out of normal tuning range, it will hit a limit switch. This tells the operator that something is out of normal operating range and the system should be looked at.



To get the forward and reverse power levels in the system, a dual directional couplers are used. These couplers have better than 27 db of directivity. The couplers feed a small custom designed PCB that detects and scales the power level into a DC voltage. These DC voltages are read by the PLC and applied to an algorithm that determines the position the two capacitive probes need to be in. These actions are sent via the Ethernet connection to tuner. This correction system is very fast needing only milliseconds to respond.

How far will my LPFM station get out ?

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The FCC defines the coverage area of a full LPFM station at its 60 dBu signal level. With a 30 meter high antenna and 100 Watts, this is a little more than 3 miles. How much farther will the station actually be able to be received ?

First lets look at how much signal it takes for a FM tuner to produce a well quieted signal. Then we will look at several examples of receiving antennas and how they are mounted and connected to a tuner or receiver.

A good high end tuner needs about 25 uV at its input to produce a 50 dB signal to noise ratio (unweighted) in stereo. Most modern tuners have a blend feature that reduces the stereo separation when the signal becomes week. This helps to mask the background hiss and static of weak signals. Radios found in cars can decode a stereo signal down to about 15 uV, before switching to mono or applying maximum channel blending. The signal to noise ratio at the lower signal levels drops to less than 40 dB.

As the station signal gets stronger in the range of 100 uV, the limiting action in the tuner increases greatly, yielding a signal to noise ratio of about 60 dB. Typical signal to noise ratios with an input of 1 mV of signal are 65 to 70 dB, depending on how it is measured.

For the receiving antenna, lets look at three antennas. First there is a indoor antenna that can be simple as a folded dipole made out of 300 Ohm ribbon transmission line. The indoor antenna could also be a rabbit ear type of antenna, or some sort of antenna like a long box or vertical tower.

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Most indoor antennas are somewhat directional, due to the design. Some even claim to have gain higher than a dipole, breaking the laws of physics. Placement in a room can change signal levels by 20 dB or more. Modern construction techniques like wire lath stucco and low E glass windows can turn a room into a partial Faraday shield, quickly dropping signal levels. If there was a 100 uV field outside from a station, the signal level reaching the indoor antenna might be as low as 10uV. The signal would be able to be used in mono, but not stereo.

The next antenna we will look at is a vertical whip mounted outside. Depending on how they are mounted, these antennas have a good omni-directional pattern. Gain is from slightly below unity to as much as 3 dB with longer whips. In the case of the station that produces a 100 uV field, the whip antenna (assuming some line loss), would deliver about 75 uV to the tuner input. That will produce a signal to noise level of 55 to 60 dB – a useable signal. The signal level would also be much more constant as even movement of the occupants inside the house can disrupt reception with an indoor antenna.

The downside to the whip is the signal from the radio station that is desired must be either vertically or circularized polarized to be effective. A horizontal only signal would yield about 20 dB less signal, due to cross polarization loss. Also since the whip is omni-directional, there is no ability to reject any multipath.

The third antenna is a directional FM antenna mounted outside. As of 2015 there is only one low cost consumer FM antenna being manufactured. It has 6 elements, an average gain of 5.5 dB, and a front to back ratio of about 14 dB. If we used this antenna where there was the 100 uV signal across a half wave dipole, we would see about 350 uV of signal at the antenna. Subtracting the line loss and loss from the balun, we would see about 250 uV at the tuner.

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This is a excellent signal providing nearly full quieting. Positioned correctly the antenna can help to mitigate multipath. The down side is if the LPFM station is transmitting only a vertical signal, that 250 uV signal can drop as low as 25 uV due to cross polarization loss. Ouch ! Another reason to transmit a C/P signal. The other downside is the desired stations must be in about a 70 degree arc of each other to get the full benefit of the antenna. A rotor may be needed.

So how far will the LPFM station get out ?

With the indoor antenna 2 to 5 miles.
With the outdoor whip antenna about 12 to 15 miles.
With the outdoor directional antenna about 20 to 25 miles.

And what about in the car ? Many cars use the rear glass windshield as antennas using thin horizontally polarized wires. Very few cars use the fender mounted whips any more. Some cars have short whip antennas mounted on the roof. Of the three antenna styles the in glass antenna is the worst. It is very directional and has the least gain of the three designs. Being horizontal, a vertically only transmitted signal would produce 20 dB less signal. Also it is common that a station you like to listen to might only be useable driving in one direction due to the directivity of the antenna, and Faraday rotation of the signal in some spots. In car reception is best when the station transmits a C/P signal. Mobile range of the LPFM station depending on car antenna type can range from 2 to 10 miles.

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