LPFM Antenna Applications and Engineering Guide

We have received a lot of questions from new **LPFM** station operators about how to get the best coverage for their station. We have answered some of these questions in the last 8 or so issues of our monthly newsletter AntennaSelect™ in late 2013 and early 2014.

We are pleased to release this **LPFM** Antenna Applications and Engineering Guide, to help new broadcasters get the best coverage possible. In this guide are reprints from some of our newsletter articles along with additional **LPFM** tools and tips. If there more questions that come up about **LPFM** antennas, please give us a call or email us. Put our many decades of design and applications experience to work.

The picture to the left shows a single bay of our popular **FMP** series antenna. The **FMP** antenna produces an excellent omni-directional circular polarized (C/P) pattern. The weight and wind load from this antenna is quite low.

MICRONETIXX COMMUNICATIONS

LPFM Antenna Applications and Engineering Guide

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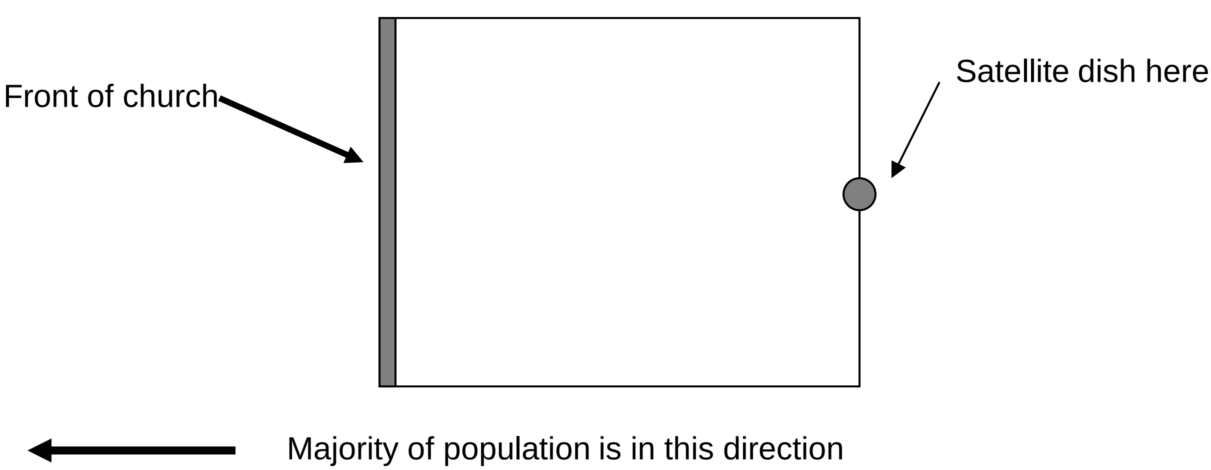
LPFM antenna mounting tips – part 1

With **LPFM** (Low Power FM) becoming a long awaited reality, we are getting numerous applications questions on how to best mount the FM antennas. Because **LPFM** will be limited in range, the transmitter sites will be close into the population they serve. That translates to many more antennas being mounted on top of buildings rather than towers.

Let’s take a look at a few cases. The first case is a church that is building their radio station and is in a building that formerly housed a supermarket. They on top of a hill that looks down on the majority of the population they hope to serve. The roof is about 200 feet (61 meters) wide, by 250 feet (76 meters) deep, and is about 20 feet (6.1 meters) above street level. Going up 40 feet (12.2 meters) above the street level will put them at their maximum average height above terrain of 30 meters (98.4 feet).



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On the back wall of building there is a satellite dish (no longer used) that is pole mounted. The mounts according to the church's contractor could with some additional support take the loads from 30 feet (9.14 meters) of pipe above the roof, plus the two bay Micronetixx **FML** antenna they are planning to use. Will this work well ?

With the center of radiation being 20 feet (6.1 meters) above the roof, the bottom bay will only be 15 feet (4.6 meters) above the roof. At 20 feet (6. meters) that is less than 2 Lambda or wavelengths from the roof. The roof may be constructed with steel, which is excellent to cause reflections.

If you were able to climb up the support pole to where the center of radiation was, you would not be able to see most of the parking lot in front of the church. The front edge of the roof would only be at a depression angle of -4.5 degrees from the front of the antenna. With 25 Lambda of reflective roof surface between the antenna and listeners, there is bound to be signal impairment. Remember there are only 100 Watts to work with on LPFM's

What could we do to make the signal better to the listeners ? Two quick options come to mind. One is to locate the antenna at the same height as close to the front of the church's roof as possible. If that is not possible, mount the antenna 50 feet (15 meters) or so above the roof top at the back of the building. You would need to reduce your ERP slightly, and file for an amended CP, but your signal would suffer much less Fresnel disruption from the roof.

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Your consulting engineer can run the numbers for you. The farther and clearer your antenna can see will help improve coverage.

One other tip. Your new support mast may well become the building lightning rod. Bond that support mast to the frame of the building (if steel construction) and if possible add ground rods.

Water Towers In many towns the water tower is the highest structure around, and many are in the range of 100 to 150 feet 30 to 45 meters) tall. Quite a few water towers already spout other antennas, ranging from public safety to TV translators. We got a call from a client in Florida who uses one of our UHF slot antennas mounted on a water tower . Now they are planning for an FM station, how far away from the slot antenna does the FM antenna need to be?

The slot antenna in question is mounted on the walkway railing that goes around the tank. The slot antenna is a very high front to back cardioid – so the tank has little influence on the directional azimuth pattern. The FM antenna however is omni-directional and operates at a frequency that is about 6-1/2 times lower than the slot antenna.

The water tank will greatly disrupt the azimuth pattern of the antenna and possibly cause to detune. There are two solutions. One is to mount the antenna so the bottom bay is more than 2 Lambda (20 feet) above the top of the tank. Be sure to bond the support pole to the water tower – your support pole becomes the new lightning rod.

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The second solution is to mount the antenna below the tank. Again about 2 Lambda (20 feet) from the tank bottom to the top bay of the FM antenna will work. Outrigging the antenna off one of the legs a few feet will generally help reduce azimuth pattern interference as well. If questions come up, send them along to us with some pictures of the mounting location.

LPFM antenna mounting tips – part 2

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Many of the new **LPFM** broadcasters have limited options on where to put their antenna. With only a maximum power of 100 Watts, there is no power that can go to waste. So let's look at a few cases and see what can be done to ensure the best possible coverage. In a number of cases, just moving the antenna by a few feet or a meter can make a big difference. Let's look at a few examples of how to optimize placement of the antenna.

The first example is a two bay C/P antenna mounted on an office building. The building has an elevator penthouse that is 17 feet higher than the roofline. Could the antenna be mounted on one side of the penthouse ? There are two problems with this approach.

First the two bay antenna (using 98 MHz as an example) needs 240 inches (20 feet or 6.1 meters) of free vertical space. That would put the end of the bottom bay just a foot or so off the roof.

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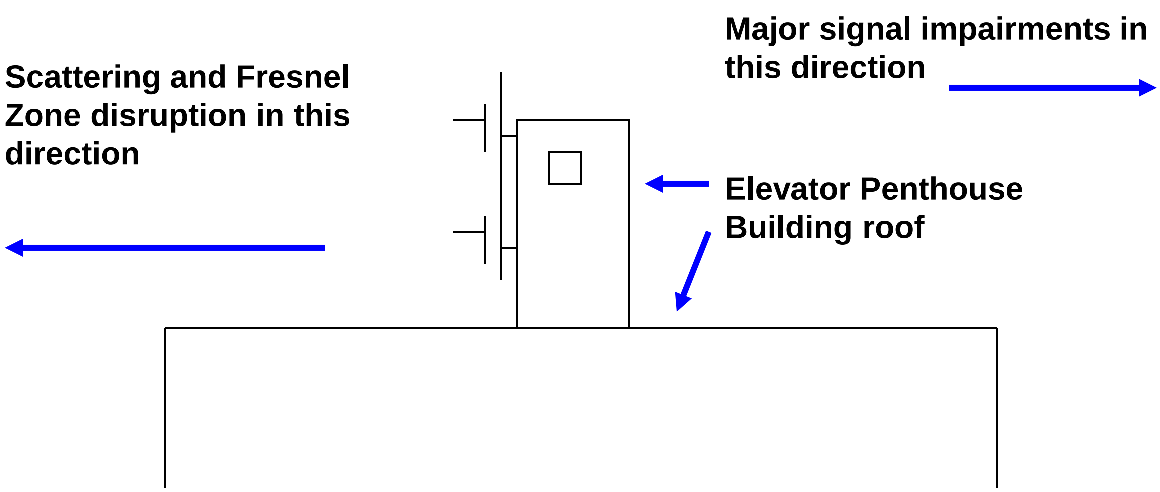
The antenna would most likely be de-tuned. Also being that close to the roof the antenna would not be able to launch a good C/P signal, and the Fresnel zone disruption might reflect the signal above the radio horizon, the one place where the listeners are not.

The second problem is the Omni-directional characteristics of the antenna now resemble a very scattered cardioid antenna. Attenuation of 20 dB or more to the rear of the antenna would be likely. Scattering in the forward direction can easily be as much as 10 dB. This translates into having an ERP of only a few Watts in some azimuths and maybe not even below the radio horizon.



A second option would be to mount the antenna on a monopole away from the elevator penthouse. The monopole should be as faraway from the penthouse as possible. The bottom tip of the bottom bay of the antenna should be 1-1/2 wavelengths - 180 inches (15 feet or 4.6 meters) above the roofline if at all possible.

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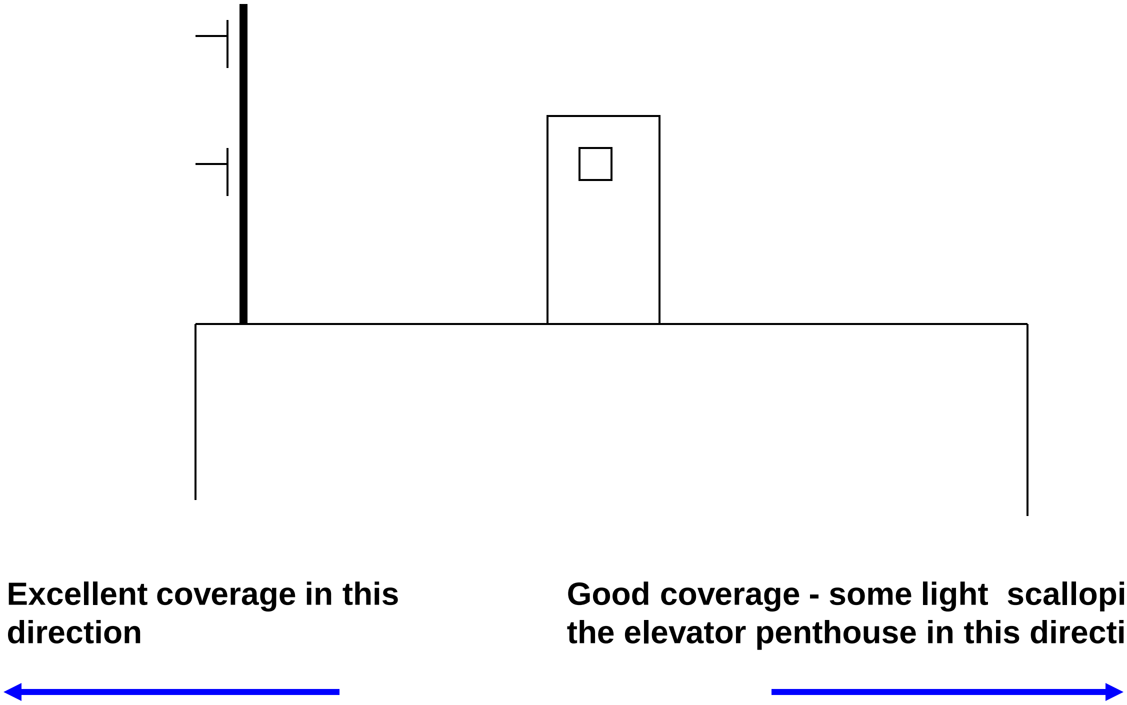
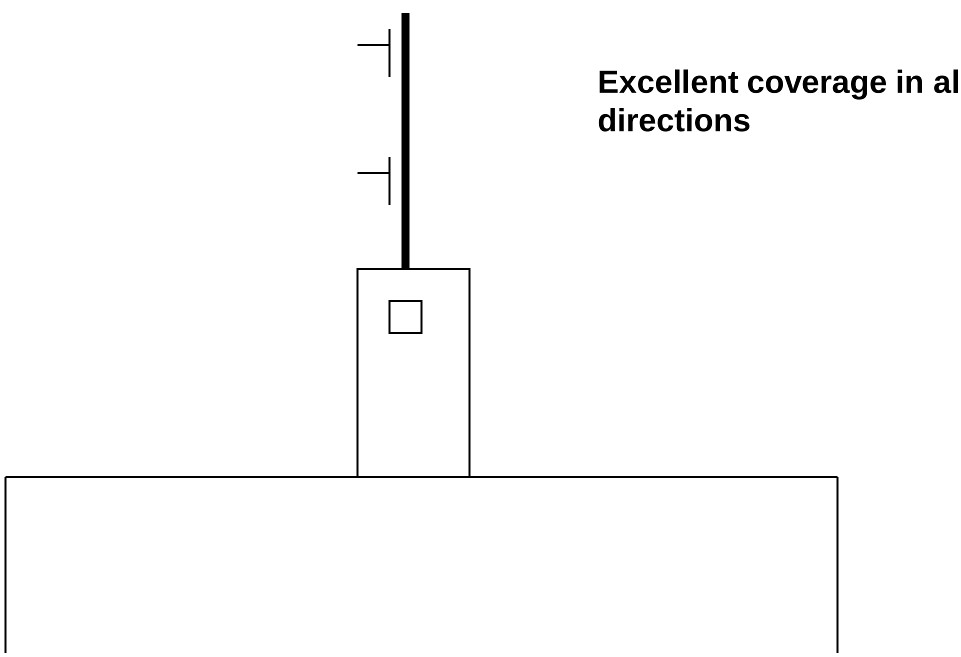


If the majority of the population is in one direction from the building, try to mount the antenna on that side of the roof.



The antenna can be mounted above the elevator penthouse, as depicted above.

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If the antenna is mounted to the top of the elevator penthouse, ensure that the bottom bay of the antenna is at least 10 feet (3 meters) above the roof of the penthouse. If there is more than a 2 meter higher difference in height from what you CP says, you will have to file for a modification. Most important in rooftop installations is to have the support mast and cable well grounded to the buildings lightning protection system. Also the transmission cable should be grounded where it enters the building. Contact a licensed electrical contractor or tower installer for more details. Proper bonding and grounding of your antenna is money well spent.

Another question that has been asked is, can the antenna be mounted on the church steeple ? One reader pointed out they already had several cell service antennas in place above the roofline and below the steeple.

Mounting the antenna to the steeple is very much like the issues we looked at on the previous two pages, where the antenna was going to the be mounted on a roof of the building with an elevator penthouse.

Cell phone antennas are directional and only emit 3 to 10% of peak energy off the back side of the antenna. They can be mounted to a number of types of structures will minimal azimuth pattern disruption.

LPFM antennas are Omni-directional and emit the same amount of energy in all directions. Hence mounting them on the steeple will cause the same sort of pattern distortion as the elevator penthouse did in the previous example.

A much better way to mount the antenna, is to use a monopole or small face width tower. A two bay C/P antenna such as our **FML** series weighs about the same as a consumer TV antenna. We looked at one application where the church had a ridged roof that was 40 feet above street. The antenna needed to be mounted 30 more feet above that to get the licensed 30 meter or 98 foot average height above terrain.

Solution ? A 70 foot small face tower will be installed at the rear of the church and attached to the building. This will ensure excellent coverage, much better than if the steeple had been used. There will be a little scalloping caused by the steeple, but overall coverage should be excellent.

Mounting LPFM antennas on cell towers

Most **LPFM** stations will be installing their transmitting antennas very close to where their listeners are. Many stations will choose to install their antennas on existing cell towers. There are two main types of structures, monopoles and lattice towers. These structures will have some effect on coverage to the rear of the transmitting antenna. If there are multiple towers at a site, try to choose the one with the smallest pole diameter or face width. If a majority of the population you are trying to serve is in one direction from the site, installing the antenna so there is no tower between your antenna and the population will provide the best coverage.

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Let’s look first at using a cell monopole to host an **LPFM** antenna. The monopole will scatter the azimuth pattern mainly to the rear of the LPFM antenna. To minimize the effect of the monopole, using an outrigged pole to mount the antenna on will give the best results. The optimum distance from the monopole to the outrigged pole is 3 feet or about 1 meter. Normally a 2 to 3 inch pole is used to mount the antenna bays. The tower company or your installer can determine the pole size and wall thickness needed for your location.

Other antennas on the monopole can effect the azimuth and elevation pattern of your antenna. For a 2 bay FM antenna 240 inches (20 feet or 6.1 meters) is needed to ensure minimum pattern distortion. There should also not be any antennas mounted at the same elevation on the monopole on the opposite side.

If you are lucky to be able to install your new **LPFM** antenna on a small monopole extension above the existing tower, the bottom of the lowest LPFM antenna bay should be at least 5 feet above any cell antennas mounted below. Also the monopole should extend a minimum of 5 feet above the mounting bracket of the top bay of the **LPFM** antenna.

A lightning rod and good bonding to the cell tower help minimize damage from lightning. Also ground the transmission line to both the monopole extension and the existing monopole with a grounding kit.

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A second type of cell tower is a lattice like structure. The face of the tower will scatter the azimuth pattern to the rear of where the antenna is mounted. The optimal mounting location for your **LPFM** antenna is off one of the legs of the tower. If there is one general direction where most of your listeners are located, mount the antenna to the tower leg that has the closest azimuth.

If you are locating at a multi tower site try to use the tower that has the smallest face width. Also try to use a tower that has no obstructions (another tower) in front of your **LPFM** antenna.

The optimal way to mount your **LPFM** antenna is by using an outrigged pole that is 3 feet or about 1 meter off the tower leg. 20 feet or 6.1 meters of clear vertical space on the tower will ensure the best performance of your antenna. As with the outrigged pole used in the monopole example, the diameter of the pipe should be 2 to 3 inches

If questions come up about mounting your new **Micronetixx LPFM** antenna, please let us know. Pictures and tower drawings are very helpful to us to advise the optimal mounting configuration. **LPFM** antennas are quite different than the antennas most cell tower installers are used to. The **LPFM** antenna is omni-directional and operates at a much lower frequency (about 8.5 times) than a cell phone antenna. The cell antennas are very directional and are mounted in clusters to achieve the desired azimuth pattern.

Why Circular Polarization (C/P) is better

We are getting a number of questions about Circular Polarization (C/P). Is it really much better ? Are there tradeoffs or pitfalls in going C/P ? What kind of increased range will I get over using just a simple whip or vertical dipole antenna ?

We will answer the question on increased range of the station using C/P first. The answer is C/P will not increase the theoretical 60 dBu contours of the station. What it will do is greatly enhance the chance that there will be a useable signal within that contour.

We took a call from a gentleman who was looking at using a vertically polarized folded dipole mounted on a small pole that extended 15 feet above an elevator penthouse. To get the 100 Watt ERP requires a transmitter output of 120 Watts due to the feedline loss.

How well would this installation work ? Would going C/P help ? Here are three answers to the question. First let's take a look at the azimuth pattern of the folded dipole antenna. These antennas are often marketed as being omni-directional, but are they ?

The folded dipole when mounted to a support pole begins to act like a two element Yagi. On the next page is the azimuth pattern of the dipole.

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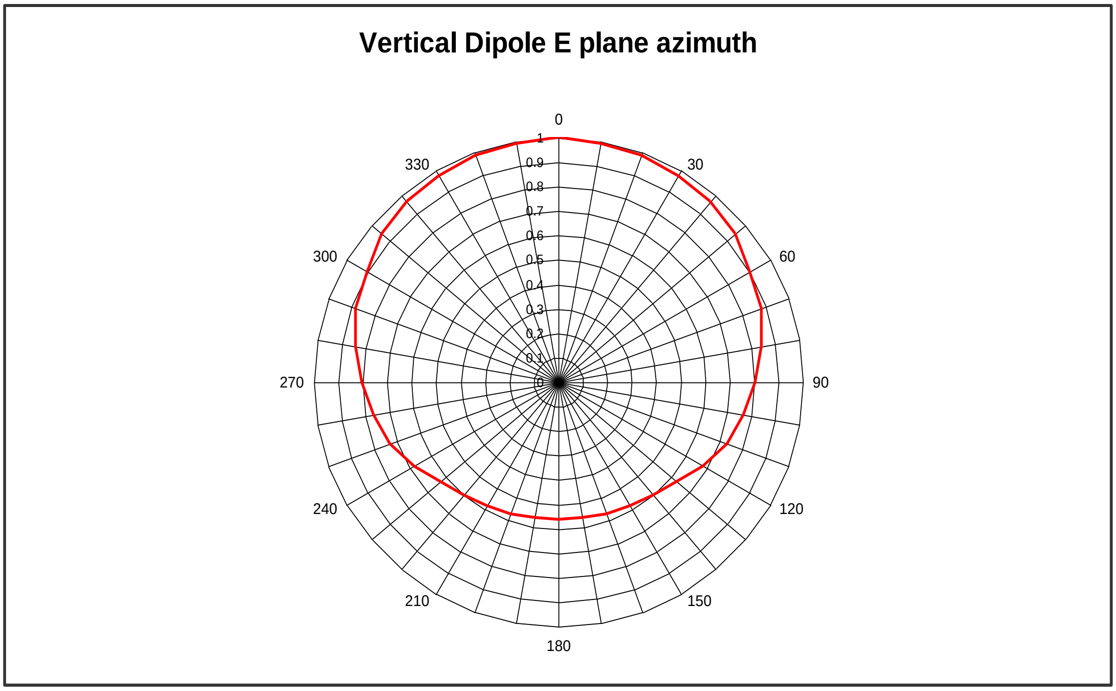

The vertical dipole antenna has a 4.7 dB front to back ratio. With an ERP of 100 Watts, the ERP at the 180 degree azimuth point would only be 33.6 Watts. So maybe the dipole is not the optimal solution.

The second part of the answer deals with the signal loss from cross polarization of the receive and transmit antenna. In the case of the vertical dipole we are only transmitting in one electrical plane – in this case the vertical plane.

If the listener's antenna happens to be horizontally polarized, in the case of an outdoor TV/FM antenna, or an in-glass vehicle antenna, a signal loss of up to 20 dB may occur due to that antenna being horizontally polarized.

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A 20 dB cross polarization loss is like only having an ERP of 1 Watt. So a listener who is on the fringe area of a **LPFM**, may well not get a good signal even with putting up a good FM antenna. In the case of the station using the vertical dipole, a simple whip antenna at the receive site would have worked better.

C/P on the other hand launches a right hand spiraling signal that has nearly identical signal levels at every angle. With a C/P signal there is little or no cross polarization loss for many types of receive antennas. Going C/P could deliver up to 20 dB more signal to the listener who installed a good FM antenna hoping to receive the new **LPFM** station.

The third part of the answer discusses Faraday Rotation and Fresnel zones. To those new to radio imagine being able to go up where your transmitting antenna is mounted. Take out a pair of binoculars and look off in the distance where your listeners are located. Do you get a clear view of where they are ? Or are buildings or even a small hill or two blocking their view ? If you have a clear view of where your listeners are, the signal path or Fresnel zone will have little or no impairments.

If you are transmitting a vertically polarized signal (from the folded dipole), your listeners will be getting a high percentage of the signal vertically polarized at their location. If your transmitting antenna does not have a clear signal path to your listeners, the signal will likely suffer from Fresnel zone impairments.

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When a signal has a Fresnel zone impairment, the signal can change polarization due to Faraday Rotation.

Faraday rotation occurs when the signal strikes the side of a building, the side of a steep hill, or simply the earth's magnetic field surface. Faraday rotation is not constant. A vertically polarized signal might be received in a given location as horizontally polarized, or it might come in at a 45 degree angle.

The Faraday rotation of the received signal can change every few inches, or remain constant for more than 100 feet, then change back. As the signal path is more impaired, more signal rotation can be expected. Since the C/P signal was launched with energy in all planes, a Faraday rotation of that signal greatly ensures that a signal will be received at the proper polarization to the receive antenna. With C/P there will be much fewer dead spots, where reception is difficult. In car and pedestrian reception will greatly improve with C/P operation.

A high quality C/P FM transmitting antenna, such as the **Micronetixx FML**, or **FMP** series of antennas has an excellent V to H ratio of under 1.5 dB, with a nearly omni-directional pattern. C/P can help to deliver up to 20 dB more signal to a given listener's location as compared to a single linear polarized signal. With only 100 Watts to work with, get all the coverage you can.

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The only down side to C/P is the need for additional transmitter power. Instead of the 120 Watts needed for a single polarization antenna, 240 Watts are now needed. There are some excellent 300 Watt transmitters with audio processing and full remote capabilities on the market that have great specs and a very affordable price tag. Go for C/P !, you will love the solid coverage.

How many antenna bays are best ? – Part 1

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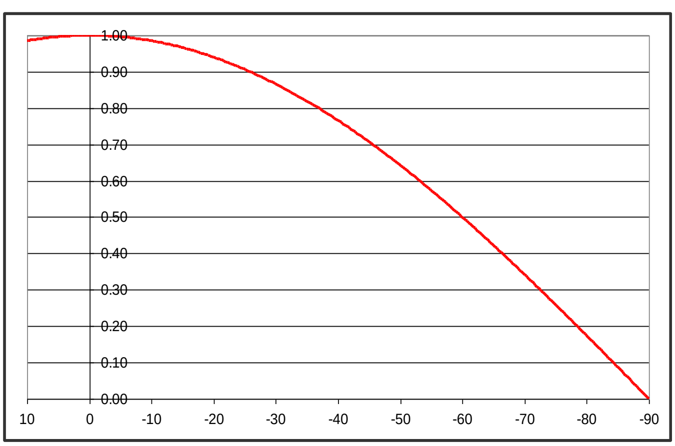
To answer the question we will show the elevation patterns of several bay counts of our **FML** series FM antennas. Unlike higher power FM stations that may have antennas 300 or more feet above ground, **LPFM** services are generally kept to maximum of 98 feet (30 meters) above ground. So what advantages or disadvantages are there with single versus multi-bay antennas ?



The plot above shows the elevation pattern of a single bay FM **Micronetixx FML** series antenna.

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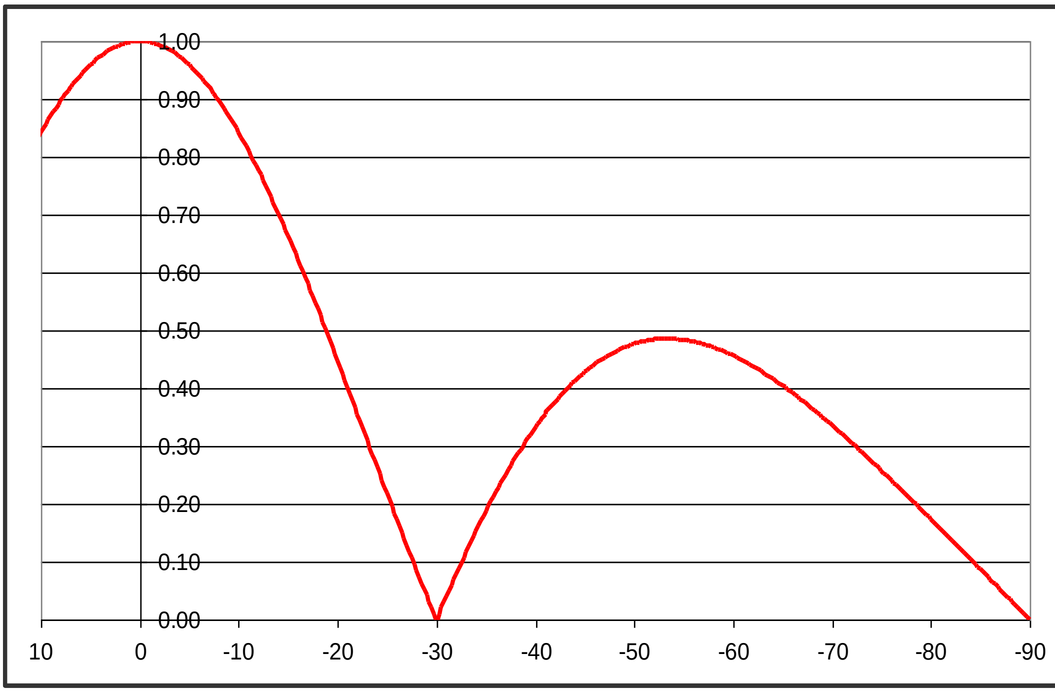
A single bay **FML** series antenna has an elevation gain of -0.48, or -3.20 dB. When the antenna is mounted 98 feet from the ground, the signal level 98 feet from the tower will be at a depression angle of -45 degrees, At 3 miles from the tower the beam from this antenna will be at -0.36 degrees .



Here is the elevation pattern of a two bay **FML** series antenna. It has an elevation gain of 1.00 (0.00 dB). When mounted 98 feet above the ground the first null will fall 171 feet from the tower at a depression angle of -30 degrees. Even where the first null falls there will be plenty of signal for your listeners. Most of your listeners will be located between the radio horizon (0 degrees) and -2 degrees below the horizon.

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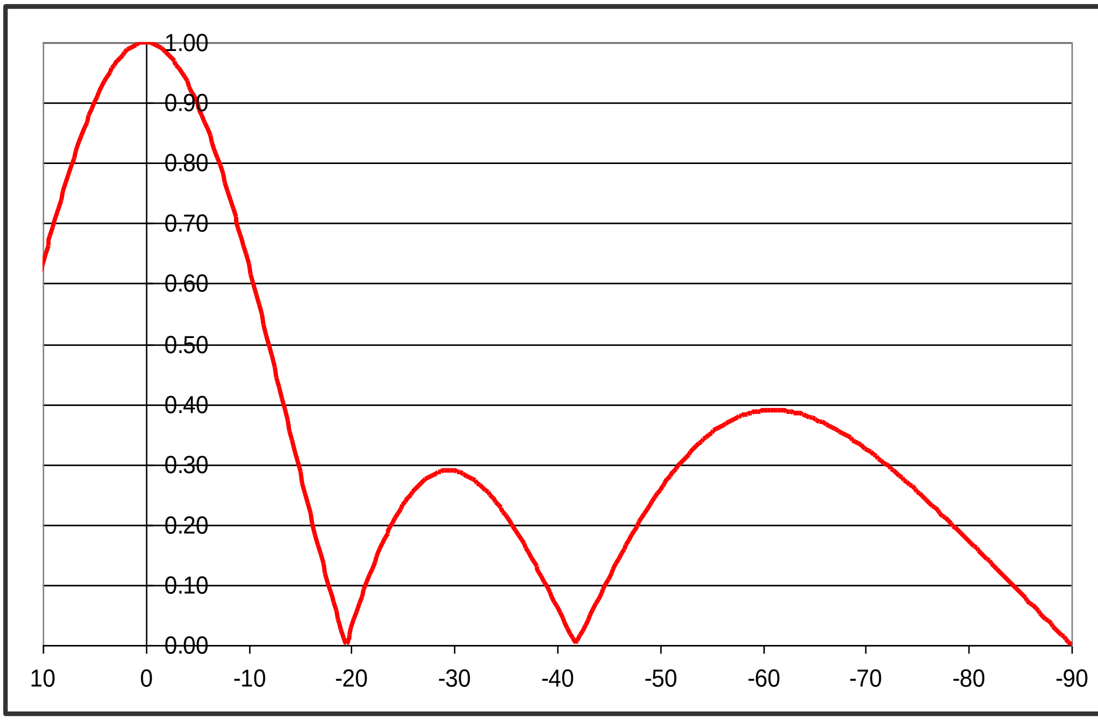

Here is the elevation pattern of a 3 bay **FML** series antenna. This antenna has an elevation gain of 1.52 (1.84 dB). When mounted 98 feet above the ground the first null is located at a depression angle of -19.50 degrees, which is 278 feet from the tower. The second null. located at -42.00 degrees is located 109 feet from the tower.

Which of the three patterns would work best for an LPFM ?

All three elevation patterns would work equally well for an LPFM station. The nulls found on the two and three bay patterns are not a problem since they are so close to the tower. There would be enough signal level at those locations to receive a great signal.

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So coverage being equal, what are the tradeoffs between the three elevation patterns we have looked at ?

There are two tradeoffs to look at when comparing the three elevation patterns. One is the amount of room or space you have to mount the antenna, and the second is the amount of transmitter power needed to make your 100 Watt ERP.

Here is a comparison of the amount of space needed to mount a single bay antenna, a two bay model and a three bay model. We will assume that the station is on 98.1 MHz and needs a 120 foot (36.6 m) long piece of transmission line. We will model LDF4-50A flex line, which has a loss of -0.784 dB (83.5% efficient). The ERP is 100 Watts, and we are running circular polarization.

Single Bay FML antenna

Minimum Vertical space needed: 120 inches (3.04 m)
Optimal Vertical space needed: 150 inches (3.81 m)
Transmitter power needed: 249.5 Watts

Two Bay FML antenna

Minimum Vertical space needed: 240 inches (6.09 m)
Optimal Vertical space needed: 360 inches (9.14 m)
Transmitter power needed: 120 Watts

Three Bay FML antenna

Minimum Vertical space needed: 360 inches (9.14 m)
Optimal Vertical space needed: 480 inches (12.19 m
Transmitter power needed: 79 Watts

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Each of the three antenna solutions we have looked at will produce excellent coverage for your new station. The difference are the amount of space you have to mount the antenna and the size of transmitter you want to run. If there are LPFM antenna questions, please call us at (207) 786-2000 or email us at: info@micronetixx.com. We will be glad to share our many decades of antenna engineering knowledge with you to make your new LPFM station shine.

How many antenna Bays are best – Part 2

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After reading How many antenna bays are best ? Part 1 in the March 2014 issue of **AntennaSelect**, more questions came up. Some readers did not realize how much vertical real estate was needed for a multi-bay antenna. A few others wondered about other inter bay spacing options, like half wave or 0.875 wave would offer them.

In **Part 1** we modeled a station with the antenna at 98 feet or 30 meters above. Lets look at several more antenna options.

On the next page is the elevation pattern of two **FML** series antenna bays spaced a half wave apart. This pattern has an elevation gain of 0.68 or -1.67 dB. The radiation from a half wave spaced antenna goes to near zero in the -80 to -90 degree depression angles. If the antenna is mounted near a roof top or occupied area, this design greatly lowers NIR levels.

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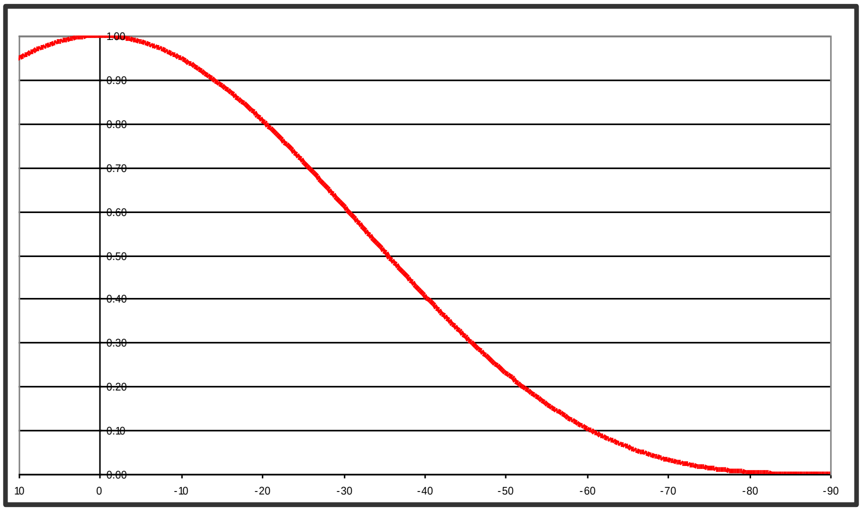
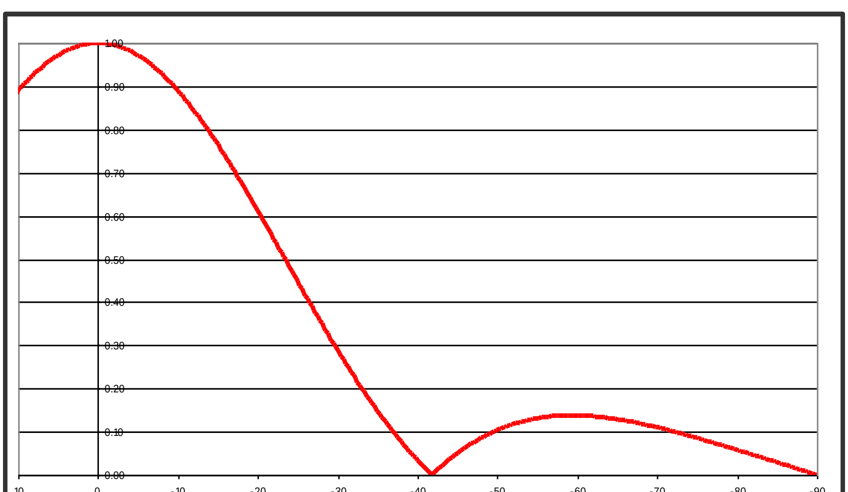
Two bay ½ wave spaced elevation pattern



Below is the elevation pattern of a three bay **FML** series half wave spaced antenna. It has an elevation gain of 1.00 (0.00 dB). When mounted 98 feet (30 meters) above the ground the first null will fall 43 feet from the tower at a depression angle of -43 degrees.



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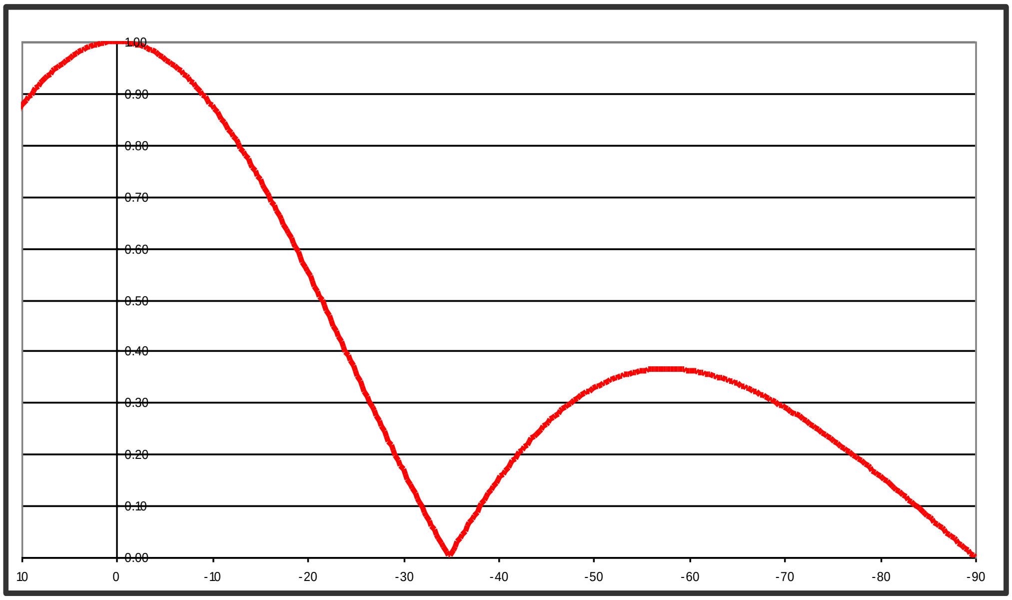

Above is the elevation pattern of a 2 bay **FML** series antenna, with a bay spacing of 0.875 Lambda or 315 degrees.. This antenna has an elevation gain of 0.92 (-0.36 dB). When mounted 98 feet above the ground the first null is located at a depression angle of -35.00 degrees, which is 140 feet (42.6 m) from the tower.

Which of the three patterns would work best for an LPFM ?

As with the patterns we looked at in part 1, all would work equally well for an LPFM station. The null found on the two and three bay patterns are not a problem since they are so close to the tower. There would be enough signal level at those locations to receive a great signal. If NIR at the site is a problem, a half wave spaced pattern will work much better.

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So coverage being equal, what are the tradeoffs between the three elevation patterns in part 2 we have looked at ?

There are two tradeoffs to look at when comparing the three elevation patterns. One is the amount of room or space you have to mount the antenna, and the second is the amount of transmitter power needed to make your 100 Watt ERP.

Here is a comparison of the amount of space needed to mount several antenna configurations: 1) two bay ½ wave spaced 2) two bay 7/8th wave spaced 3) three bay ½ wave spaced. To calculate TPO. we will assume that the station is on 98.1 MHz and needs a 120 foot (36,6 m) long piece of transmission line. We will model LDF4-50A flex line, which has a loss of -0.784 dB (83.5% efficient). The ERP is 100 Watts, and we are running circular polarization.

Two Bay ½ wave spaced FML antenna

Minimum Vertical space needed: 95 inches (2.41 m)
Optimal Vertical space needed: 135 inches (3.43 m)
Transmitter power needed: 176 Watts

Two Bay 7/8th wave spaced FML antenna

Minimum Vertical space needed: 210 inches (5.33 m)
Optimal Vertical space needed: 315 inches (8.00 m)
Transmitter power needed: 130.5 Watts

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Three Bay ½ wave spaced FML antenna

Minimum Vertical space needed: 150 inches (3.81 m)
Optimal Vertical space needed: 185 inches (4.70 m)
Transmitter power needed: 120 Watts

As with the patterns we looked at in part 1, any of the three patterns above will work well. If there is an NIR problem or excessive RF power density at the site, the half wave spaced patterns will lower NIR by 6 to 14 dB as compare to full wave spaced bays. If there are other scenarios you would like help with, please give us a call and we will crunch the numbers for you.

How the FML series FM antenna works

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The Micronetixx Communications FML Circularly-Polarized FM Broadcast Antenna is designed to launch a true circularly-polarized system of electromagnetic fields from the transmitting site to the listeners in the field. The advantages of circular-polarization are many. Major among them is a compensation for what is known as **Faraday Rotation**. Electromagnetic Fields, of which radio waves are a subset, have both en electric and a magnetic field component. Both are known as vector fields, (meaning that they have both a magnitude, or strength, and, that they point in a specific direction).

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By convention, if the electric field component of a radio wave is oriented to that it points up and down, (perpendicular to the ground), that radio wave is said to be **vertically-polarized**. Conversely, if the radio wave has its electric field component oriented so that it is pointing from side to side, (parallel to the ground), in that case, the radio wave is said to be **horizontally-polarized**. In both of these cases, since the electric field oscillates back and forth, and has a specific linear orientation, the radio wave, (and by convention, as well as the antenna that transmits it), is said to be **linearly-polarized**.

Most antennas are linearly-polarized, meaning that they are designed to receive or transmit radio waves with their electric fields oriented in a specific orientation. That situation is fine as long as both the transmitting and receiving antennas are oriented so that their polarizations remain aligned.

However, there are many cases where the orientation, (polarization), of the electric field in a propagating electromagnetic radio wave, can be altered by external, (mostly magnetic), fields that are present in regions through which the radio wave is propagating, while on its way to your receiver. In this case, the wave has undergone **Faraday** rotation; the polarization of the propagating wave has been rotated from its original orientation by the presence of external fields. (These can be from large iron deposits in geological formations, or from other sources in the environment.

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If the radio wave encounters the receiver's antenna in an orientation that is not aligned with the polarization of the radio wave, the strength of the received radio signal can be severely reduced. This can cause fading of an analog radio signal, or drop-out periods if the signal is digitally modulated.

A good solution to this problem is to transmit a radio wave whose electric field orientation actually rotates smoothly from, say, an initial horizontal orientation, at relative time equal to zero, to a vertical orientation at a time one-quarter of a period later. Then it rotates smoothly back to a horizontal orientation at a time equal to one half of a period later, (now pointing in the opposite horizontal direction, compared to its initial horizontal orientation), then smoothly to vertical again three-quarters of a period later, (opposite in direction from the vertical orientation at one-quarter period). Finally the polarization rotates back to its original horizontal orientation from which it began, one full period earlier. (A Period is the length of time necessary for the electric or magnetic field in a radio wave to move through one complete cycle). Here, the radio wave is said to be **circularly-polarized**, or simply, **C.P**.

The best, and most practical way to develop and transmit a C.P. radio wave is to design an antenna which is actually two antennas in one. One section of the antenna would be, horizontally-polarized, and the second section vertically-polarized.

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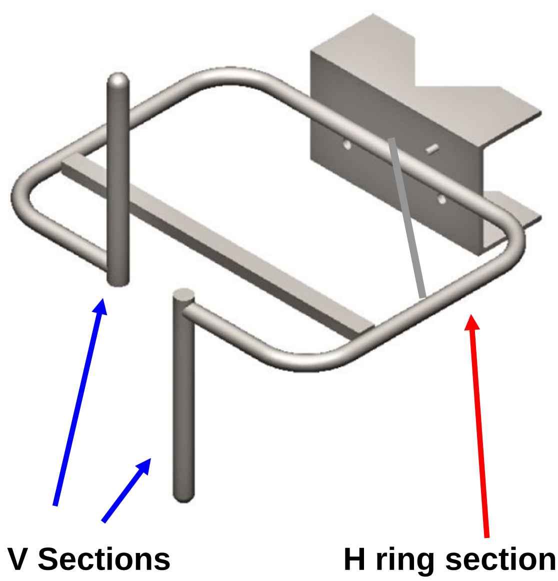
If the antenna is designed so that its horizontal and vertical radiating sections are physically spaced, or electrically-phased such that they are exactly one quarter wavelength apart, a circularly-polarized radio wave results.

The **Micronetixx FML** Antenna is designed so that it will emulate that exact scenario. The **FM**L antenna contains a ring-like horizontal section, specifically located at a region on the antenna where the impedance is lowest, (meaning that more of the electromagnetic energy from the transmitter is expressed in conduction currents in the horizontally-oriented ring section of the antenna), from the "Right-Hand Rule for Magnetic Fields", a magnetic field results from these conduction currents in that horizontal section of the antenna, that is oriented up-and-down, perpendicular to the ground.

The second half of the Micronetixx FML antenna is a vertical section, connected to the terminating ends of the horizontally-oriented antenna section that is oriented vertically, as shown in the picture to the right.



Continued on page 29

Since each of the two halves of the horizontal ring section of the antenna shown above is an approximate electrical one-eight wavelength long, at any given instant in time, the two ends of the horizontal ring section are approximately 90 degrees out of phase, relative to one another. Each of the two ends of the horizontal ring structure is then connected to a vertically-oriented conducting section, completing the antenna. These two vertically-oriented sections are positioned at the high-impedance portion of the antenna, (meaning that a large percentage of the energy from the transmitter is now expressed in the electric field).

Since the horizontal section of the **Micronetixx FML** Antenna radiator produces a vertically-oriented magnetic field, and then, exactly 90 degrees, (one quarter-period), later, the vertical section of the antenna produces a vertically oriented electric field. Since these two fields are coincident and their relative phases remain at approximately 90 degrees, we have successfully launched a nearly perfect circularly-polarized radio wave

Which transmission line is best for LPFM ?

For LPFM applications high power transmission lines are not needed. There are two types of cables, solid outer jacket and braid style outer conductor.

Continued on page 30

The braided jacket cables have between 80 and 95% coverage of the outer conductor. They have a braided inner conductor. Cable types like RG-8 and RG-213 fall into this category. The diameter of these cables are typically 0.405 inches (6.27 mm). They have more than enough power handling capacity even using a 300 Watt transmitter. Both of these cables have fairly high losses at 100 MHz.

A 120 foot (36.6 m) long run of RG-8 on the average has a 2.16 dB loss. If the transmitter is putting out 200 Watts, the transmission line will only deliver 122 Watts – 78 Watts will be lost.

RG-213 cable has even a higher loss of 2.10 dB per 100 feet. The same 120 (36.6 m) foot long run of line would have a loss of 2.52 dB. The transmission line would only deliver 112 Watts -88 Watts would be lost.

To protect against lightning strikes, transmission lines should be grounded several places before entering the building. Braid type cables are much harder to ground due to the ability of the outer braid to separate.

A second type of cable uses a corrugated copper outer conductor and a solid inner conductor. A popular cable type used is LDF4-50A. It has a outside diameter of 0.50 inches (12.6 mm) and a tough Polyethylene outer jacket.

Continued on page 31

The LDF4-50A line also has a much lower line loss than the braided cable types. Using a 120 foot run of line at 100 MHz, the total line loss is 0.793 dB, which is less than half of the loss of the braided cables. With 200 Watts going into the line, 166 Watts will be available at the output of the line – a loss of only 34 Watts !

There are other advantages of a solid outer conductor cable. First is the mechanical crush strength. When using even a simple mounting system like Tie Wraps on braid style cables can cause the cable to distort slightly. Having this distortion repeat itself a number of times can alter the impedance of the line. Solid outer cables have a much higher crush strength and mounting clips are available that do not distort the cable.

Another advantage of solid outer conductor cable is the connectors when installed properly have a much better electrical connection. The inner conductor is also solid and tightly nests into the inner conductor socket of the connector. The connectors also seal much better from water ingress than braided line connectors.

The last advantage is grounding. Because of the much greater crush strength of the outer conductor and 100% outer coverage, grounding this type of cable is much better. Grounding kits are available. Good grounding is your best insurance against lightning damage.

My choice for LPFM ? Solid corrugated transmission lines – a little more expensive upfront, but much more durable !

How do I calculate the transmitter power needed ?

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For LPFM, most stations will be running at an ERP of 100 Watts and using a fairly low gain antenna system. The math to calculate the transmitter power needs two things – the gain of the antenna and the loss of the transmission line to be used.

So let's model a single FML series antenna bay and 120 feet (36.6 m) of LDF4-50A cable. The frequency of operation will be at 99.9 MHz.

Gain of the antenna:	-0.48 (-3.20 dB)
Loss of the transmission line:	-0.793 dB
Efficiency of the transmission line:	83.3% (.833)
ERP of station C/P:	100 Watts

Our first calculation is to see how much power needs to go into the antenna. We divide the 100 Watt ERP by the antenna gain (100/0.48). The answer is 208.3 Watts. Now we need to know how much power the transmitter needs to be set at. The transmission line has an 83.3% efficiency. If we divide (1/.833) we get 1.20. Multiply that number by the power needed at the input to the antenna (208.3 Watts) and the answer is 249.96 Watts. Now what if you only have a 200 Watt transmitter. Lets recalculate the power needed by moving up to a two bay antenna.

Continued on page 33

The gain of the two bay **FML** antenna is 1.00 (0.00 dB). Using the same format as on the previous page we substitute the gain of the two bay.

Gain of the antenna:	1.00 (-0.00 dB)
Loss of the transmission line:	-0.793 dB
Efficiency of the transmission line:	83.3% (.833)
ERP of station C/P:	100 Watts

Since the gain of the antenna is 1, we divide (1/100) and the result is 100 Watts needed to feed the antenna. We then take the 100 Watts and divide that by the efficiency of the transmission line (100/.833). The answer is 120 Watts of transmitter power needed.

Now what if it turns out that you needed a slightly longer transmission line ? Most transmission line manufacturers list loss of a cable by frequency at 100 foot (3.05 m) lengths. For the LDF4-50A the loss is -.661 dB at 100 feet. To figure out the loss of a 160 foot (48.8 m) run of line, multiply the loss of 100 feet of line -661 by 1.6 (a 160 foot run is 1.6 times as long as a 100 foot run), the answer is -1.057 dB). If you have a calculator with a 10^x function it is a breeze. The formula is 10^x(-1.057/10) which calculates to 0.7839. Multiply that and you get the percentage (78.39%) of efficiency. Substitute that number for the .833 used on the 120 foot (36.6) long line. The new TPO would be 127.5 Watts.

Grounding LPFM antennas

Many more **LPFM** operators are planning their station transmission systems. We are getting some questions as to how to effectively ground the antenna and transmission line to prevent damage from lightning. Preventing damage is the main goal of a good ground system – lightning is unpredictable and even the best engineered systems can be damaged. So what are some of the steps a new **LPFM** operator can do to lessen the chance that lightning will damage their facility ?

The first thing is selecting an FM antenna that has all it elements held at DC ground. Both of our **LPFM** antennas, the **FML series** and **FMP series** meet this criteria. All elements are stainless steel and are welded in place to the mounting bracket.

The second thing is coming up with a good grounding system for the antenna, antenna support system and transmission line. If you are moving into a existing multi user site, the tower is most likely well grounded and there are usually a number of grounding opportunities for your transmission line as it enters into the building. The key here is to keep the DC potential between the mounting structure as low as possible between the tower or mounting structure if lightning hits. A well grounded tower will have a much lower DC resistance than a run of ½ inch foam flex line, so grounding the line at multiple locations to the tower is the answer.

Let's look at the first case – a new **LPFM** antenna that is mounted on the side of a cell phone tower. The cell tower is about 160 feet (48.7 meters) high and the new **LPFM** antenna will be mounted at 98 feet (30 meters) above the ground. The new antenna will be installed on an outrigged pipe off the leg of the tower.

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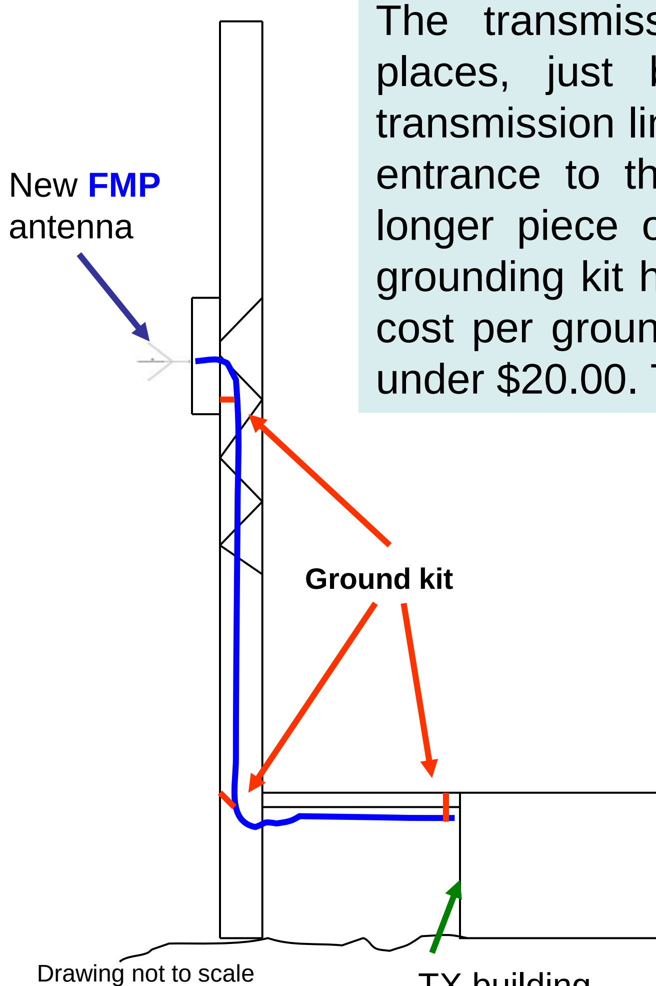

The transmission line is grounded in three places, just below the antenna, where the transmission line enters the ice bridge and at the entrance to the building. If you are running a longer piece of transmission line an additional grounding kit half way up is not a bad idea. The cost per ground kit for ½ inch LDF4-50A line is under $20.00. That is cheap insurance.

If the transmitter site is in very lightning prone area, you might want to also consider additional bonding of the outrigged pole system to the tower. The tower site manager and tower riggers can be a great source of information as to past tower operations.

Next let's look at several scenarios where your new **LPFM** antenna is going to be mounted at the top of a structure or support monopole. Antennas mounted at the top of these structures are more likely to get a direct strike of lightning. So good grounding techniques become even more important.

Once example of an **LPFM** tower top mounted antenna uses a 90 foot high Rohn 25 series tower and a top mounted 12 foot pole. The LPFM antenna is placed on the pole at the 98 foot level. The pole is held in place by a bolt that pushes it against the mounting stem. The pole should be electrically bonded to the tower with a ground strap. The transmission line should have a grounding kit installed at the top of the tower and at the bottom of the tower. Another grounding kit should be

Continued on next page

Installed where the transmission line enters the building. A licensed electrician can design and install an effective ground system for the tower, and transmitter building.

The antenna in this example is mounted 4 feet below the top of the support pole. Increasing the height of the pole another 5 feet or so will reduce the chance that if lightning struck, it would strike the pole and not the antenna. Also consider using a heavier wall pipe to support the antenna. If there is a lightning strike, the thicker wall pole would have a lower DC resistance. A set of lightning rods can also lessen the chance that the antenna would be hit directly.

Some tower crews and engineers swear by the use of static dissipation devices, claiming that they reduce the chance of the tower getting hit and the intensity of the strike. These stainless steel bristle like dissipation devices are mounted on the top of the support monopole and in some cases on the side of the tower near the top. Some are quite inexpensive, coming in less than $100. Two of the installers we work with in the South use them on every project.

To sum up **good grounding** is the best insurance you have for protecting you station from damage. Consulting with a licensed electrician and tower installer to come up with an effective plan will save you money down the road and help keep you on the air.

We hoped you enjoyed the Micronetixx **LPFM** applications guide. When you have questions about LPFM antennas, please let us know. Put our many decades of engineering experience to optimize your station. Brochures for our **FML** and **FMP LPFM** antennas start on page 37.

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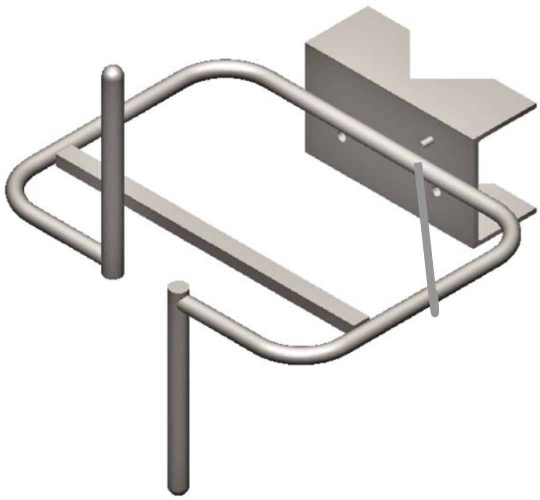
FML C/P FM Antenna

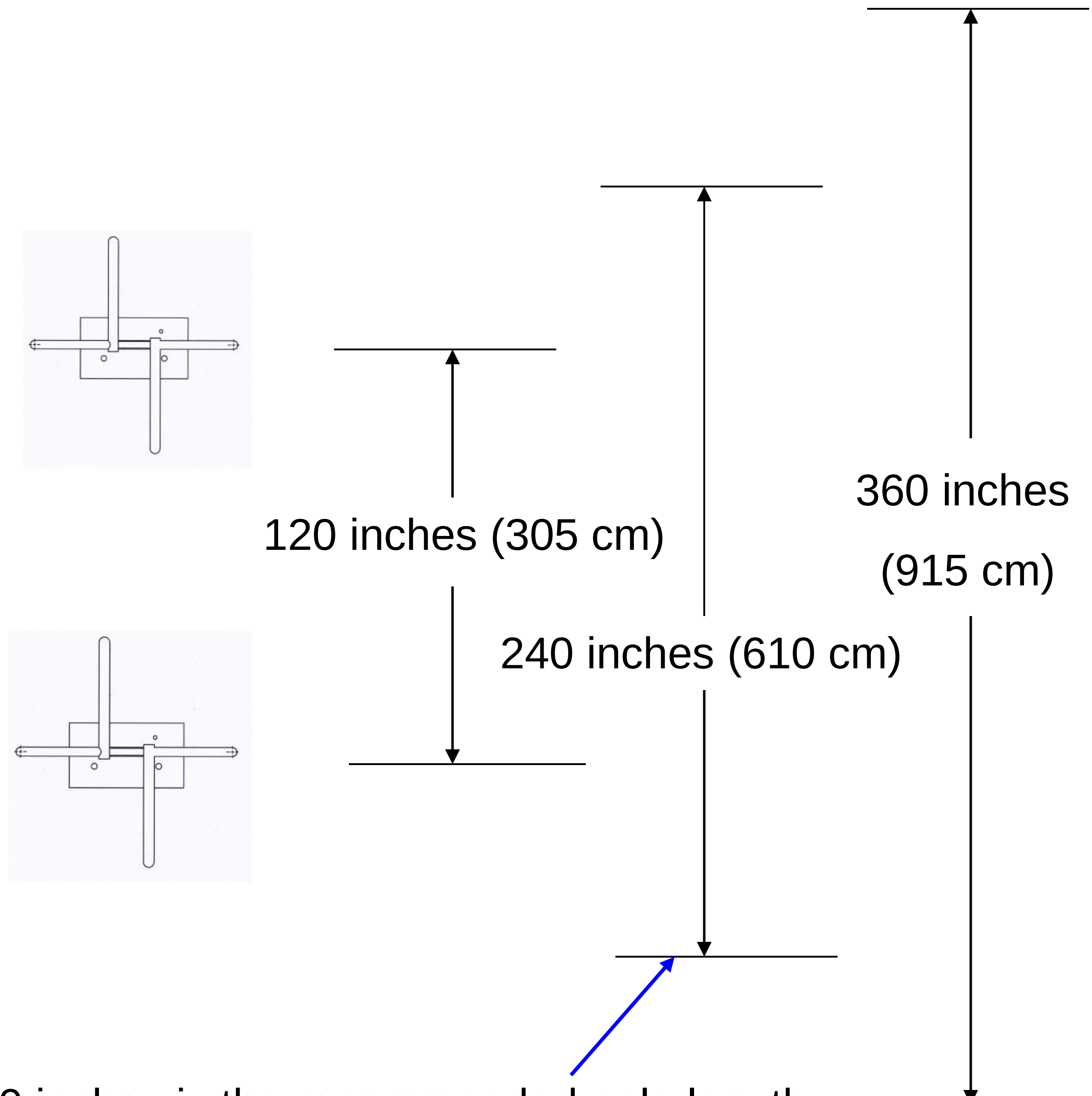


- Right hand C/P Polarization
- Low wind load area
- Up to 1 kW Rating per bay
- Omni-directional
- Up to 8 kW input per array with power divider options

The **FML** series of antennas are narrow band C/P FM (Band II) antennas. They are an excellent solution for LPFM, plus standby and translator applications. The **FML** has outstanding horizontal to vertical circularity, with an Omni-directional pattern. The input rating per bay is 500 Watts via an “N” input connector, 1 kW with a 7/16” DIN input. Higher power options use an input power divider that has an input rating of 8 kW, and produces a maximum ERP of 34 kW (FML-158-8). The light weight, but rugged stainless steel design weighs less than 5 lbs. (2.27 kg.) per bay. The antenna mounts to a 2.375 inch (6 cm) to 3.50 inch (8.9 cm) support pole supplied by others.

The gain of a single bay **FML** bay is 0.49 (-3.09 dB), a two bay model FML-2 has a gain of unity, based on a 1λ bay to bay spacing. The polarization is right hand circular. V.S.W.R is 1.10:1 over +/- 100 kHz.

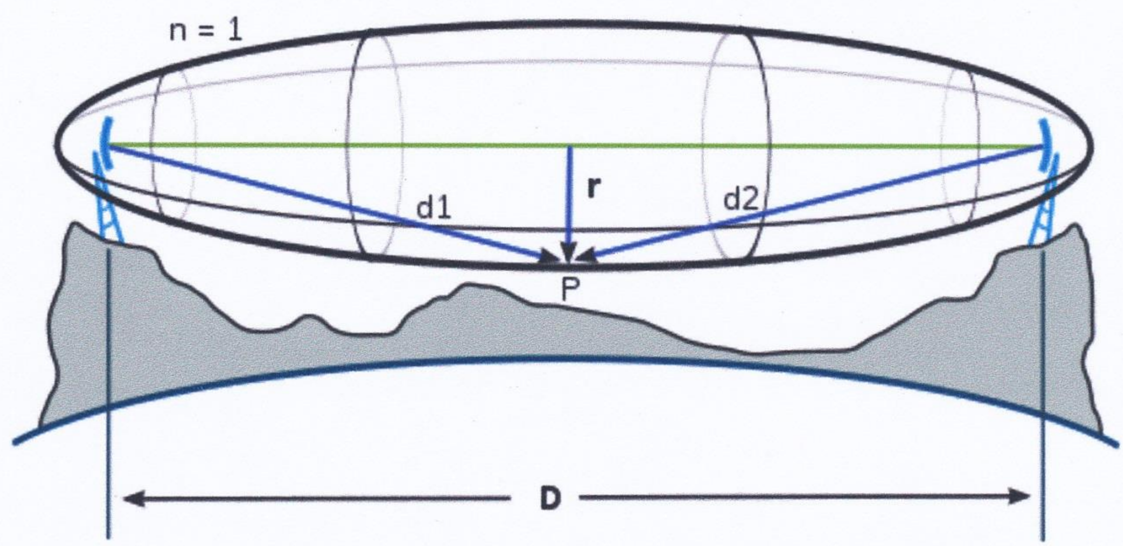
The FML antennas are easy to install and are pre tuned at the factory. The diagram below depicts a two bay antenna (FML-2). The antennas will produce the best radiation pattern if mounted to a small support pole, and installed with free space above and below the antenna. The numbers provided are for operation at 98 MHz.



240 inches is the recommended pole length,
360 inches is the recommended free space area

Why it is best to transmit a C/P signal ?

LPFM and translator signals are low power and the antenna is usually not mounted at a great height. That limits line of sight coverage and a clear Fresnel zone. When the Fresnel zone is disrupted by buildings, or terrain, the polarization of the signal can change due to Faraday rotation. If a signal is transmitted in only one polarization, that polarization can differ at a given reception spot.



Fresnel zone: *D* is the distance between the transmitter and the receiver; *r* is the radius of the first Fresnel zone (n=1) at point P. P is d1 away from the transmitter, and d2 away from the receiver.

The above diagram shows a depiction of the Fresnel zone. If there is a impairment in the zone, Faraday rotation can occur, once or many times along the signal path.

If we for example transmit a horizontally only polarized signal, at impaired reception points the received signal with rotation can be vertically polarized, or at a slanted angle. Depending on the orientation of the receive antenna, Faraday rotation can cause a loss of up to 20 dB in received signal. If your station had a power output of 100 Watts, that impairment could be equal to only having a 1 Watt ERP at given spot.

With Circular polarization, your station is transmitting a signal in all polarities. If there is Faraday rotation at a given location, there is a 99% chance that there always will be a full signal at the orientation of the receiving antenna.

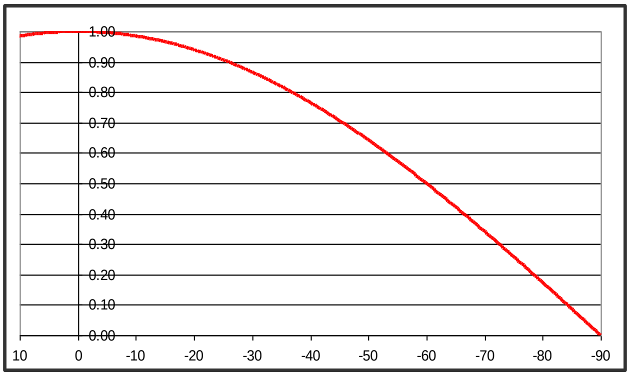
Why is the FML Antenna Superior ?

The **FML** antenna has excellent azimuth pattern circularity, ensuring a nearly identical vertical to horizontal ratio. Many less expensive models have fairly good horizontal patterns, but the vertical azimuth patterns are more figure 8 like, which increases the chances of dead spots in your coverage area.

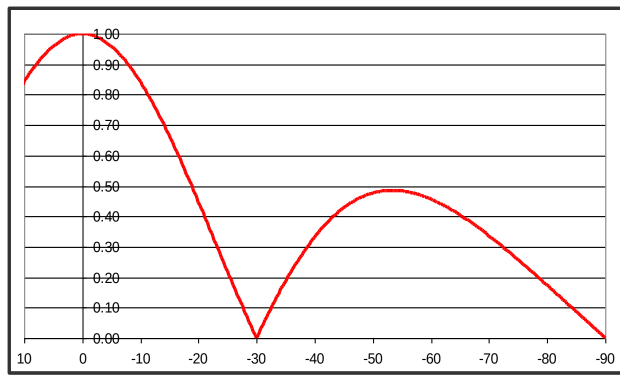
The **FML** antennas are cut to frequency. Multi-bay models have cut-to-frequency feed systems to ensure accurate elevation patterns. Each antenna array is fully tested for proper phase and amplitude relationships. Many competitors do not array test their antennas with the feed system in place.

The all stainless steel design is very rugged and will stand up to rough weather conditions. The elements are all DC grounded to ensure maximum protection from lightning and to minimize possible damage to the transmitter in case of a strike.

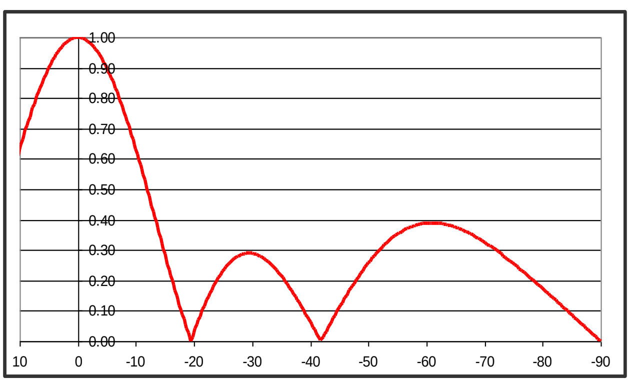
FML Antenna Elevation Patterns



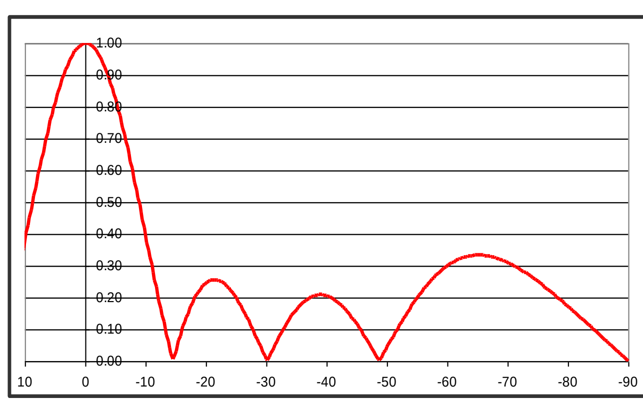
FML-1 Bay
Gain: -0.49 (-3.20 dB)



FML-2 Bay
Gain: 0.99 (0.00 dB)

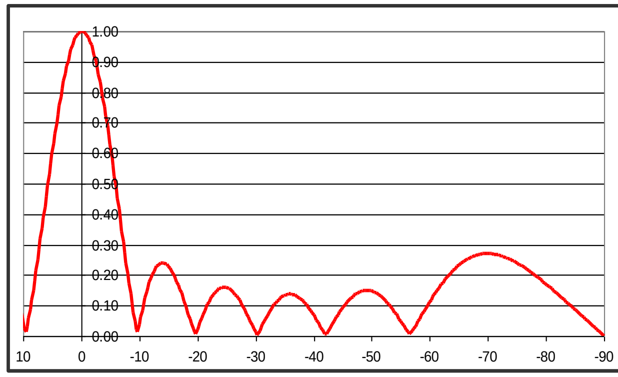


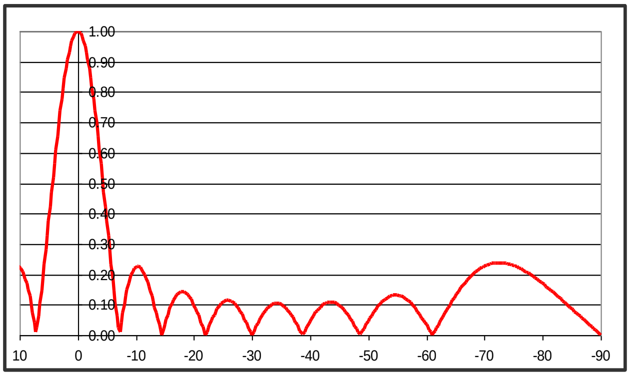
FML-3 Bay
Gain: 1.50 (1.76 dB)



FML-4 Bay
Gain: 2.10 (3.22 dB)

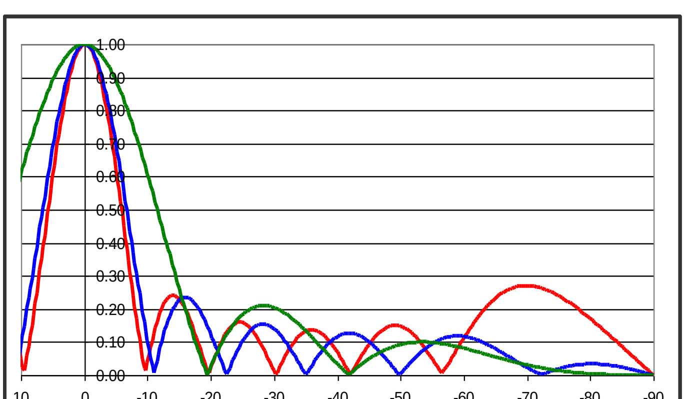
FML-6 Bay
Gain: 3.28 (5.16 dB)





FML-8 Bay
Gain: 4.35 (6.38 dB)

The **FML** antennas are available in a number of bay to bay spacings. If there is limited space on the tower going from 1 wavelength to a 7/8th or 315 degree spacing will save some vertical space and only decrease gain slightly . The plot below is 3 different spacings of a 6 bay **FML** antenna. The **RED** plot is 1 wavelength, the **BLUE** plot is 7/8th spaced, while the **GREEN** plot is ½ wave spaced. The gain is 3.28 for the full wave spaced, versus 3.15 for the 7/8th wave spaced model.



For sites that have RFR constraints, the 7/8th and ½ wave spaced antennas lower high angles of radiation. We can also engineer special spacings for minimizing second adjacent problems.

Full Wave Spaced
FML Antenna Mechanical Information and C/P Gain/ Input Power

Model Number	Number of Bays	Antenna Length	Reccomended tower space	Radiation Aperture	Antena Weight	Antenna Load Area	Antenna Gain	Input Power	Maximum ERP
FML-1-N	1	10 ft. (3.04 m)	20 ft. (6.08 m)	7 ft. (3.04 m)	5 lbs. (2.3 kg)	0.2 ft^2 (0.02 m^2)	0.49	0.5 kW	250 Watts
FML-1-DIN	1	10 ft. (3.04 m)	20 ft. (6.08 m)	7 ft. (3.04 m)	5 lbs. (2.3 kg)	0.2 ft^2 (0.02 m^2)	0.49	1	500 Watts
FML-2-N	2 CF	15 ft. (4.57 m)	30 ft. (9.14 m)	10 ft. (3.04 m)	12 lbs. (5.5 kg)	0.5 ft^2 (0.05 m^2)	0.99	1 KW	1 kW
FML-2-DIN	2 CF	15 ft. (4.57 m)	30 ft. (9.14 m)	10 ft. (3.04 m)	12 lbs. (5.5 kg)	0.5 ft^2 (0.05 m^2)	0.99	1.5 kW	1.5 kW
FML-3-N	3 EF	25 ft. (7.62) m)	40 ft. (12.19 m)	20 ft. (6.08) m)	17 lbs. (8.0 kg)	0.7 ft^2 (0.07m^2)	1.50	1 kW	1.5 kW
FML-3-DIN	3 EF	25 ft. (7.62) m)	40 ft. (12.19 m)	20 ft. (6.08) m)	17 lbs. (8.0 kg)	0.7 ft^2 (0.07m^2)	1.50	1.5 kW	2.25 kW
FML-4-N	4 EF	35 ft. (10.67 m)	50 ft. (15.24 m)	30 ft. (9.14 m)	22 lbs. (10.0 kg)	0.9 ft^2 (0.09 m^2)	2.10	1 kW	2 kW
FML-4-DIN	4 CF	35 ft. (10.67 m)	50 ft. (15.24 m)	30 ft. (9.14 m)	22 lbs. (10.0 kg)	0.9 ft^2 (0.09 $m^{2)}$	2.10	1.5 kW	3 kW
FML-4-78	4 PD	35 ft. (10.67 m)	50 ft. (15.24 m)	30 ft. (9.14 m)	40 lbs. (18.2 kg)	2.9 ft^2 (0.27 $m^{2)}$	2.10	4 kW	8 kW
FML-6-N	6 CF	55 ft. (16.76 m)	70 ft. (21.33 m)	50 ft. (15.24 m)	33 lbs. (15.0 kg)	1.4 ft^2 (0.13 m^2)	3.28	1 kW	3 kW
FML-6-78	6 PD	55 ft. (16.76 m)	70 ft. (21.33 m)	50 ft. (15.24 m)	52 lbs. (23.6 kg)	3.4 ft^2 (0.32 m^2)	3.28	4 kW	12 kW
FML-6-158	6 PD	55 ft. (16.76 m)	70 ft. (21.33 m)	50 ft. (15.24 m)	53 lbs. (24.1 kg)	3.4 ft^2 (0.32 m^2)	3.28	6 kW	18 kW
FML-8-DIN	8 CF	75 ft. (22.86 m)	90 ft. 27.43 m)	70 ft. (21.33 m)	44 lbs. (20.0 kg)	1.8 ft^2 (0.17 m^2)	4.35	1.5 kW	6 kW
FML-8-78	8 PD	75 ft. (22.86 m)	90 ft. 27.43 m)	70 ft. (21.33 m)	62 lbs. (28.2 kg)	3.8 ft^2 (0.35 m^2)	4.35	4 kW	17 kW
FML-8-158	8 PD	75 ft. (22.86 m)	90 ft. 27.43 m)	70 ft. (21.33 m)	63 lbs. (28.6 kg)	3.8 ft^2 (0.35 m^2)	4.35	8 kW	34 kW

Notes: EF = End Fed CF = Center Fed PD = Power Divider. Gain shown is with out beam tilt or null fill. -78 models have a 7/8" EIA input, -158 models have a 1-5/8" EIA input. The **FML** arrays can be provided in 1/2 to full wave spacings. Also directional models of the **FML** antennas are available. Contact us for the details. Mechanical data is taken for a antenna tuned to 98.1 MHz.

The **FML** is a low power antenna that can produce much higher ERP levels when used with a power divider. On our 4 Bay **FML**, we offer an option with a 7/8” EIA input. This produces a maximum ERP of 8 kW. The 6 bay models have both 7/8” and 1-5/8” input options, which can produce a maximum ERP of 12 and 18 kW. The 8 bay antenna with a 7/8” input can produce 17 kW, while the 1-5/8” model can produce 34 kW.

The light weight and low load areas of these antennas allow for installation on many smaller structures. The **FML** makes a great primary or standby antenna. Give us a call today.

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FMP Series Medium to High power FM C/P Antenna

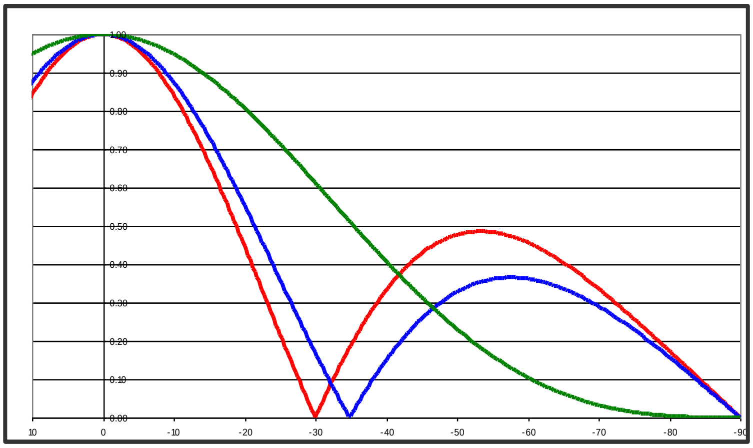
- **Wide Bandwidth**
- **Rugged construction**
- **Omni-directional**
- **End or Branch fed**
- **1.10:1 V.S.W.R +/- 100 kHz**

The **FMP** Series of FM antennas from Micronetixx features an excellent H to V ratio, and Omni-directional azimuth pattern. The rugged antennas are built with stainless steel for a long service life. Two versions of the **FMP** antennas are available – an end fed version with a tapped feedline or a corporate fed model using a power divider. The bays can be spaced at full wavelengths, half wave, or 7/8th wave intervals.

The input power rating per bay is up to **5 kW.** The antenna has an excellent bandwidth and is available in a frequency range of 54 to 108 MHz. The **FMP** antenna has enough bandwidth to be used as a single channel low band VHF (Band I) antenna.

FMP series sample elevation patterns

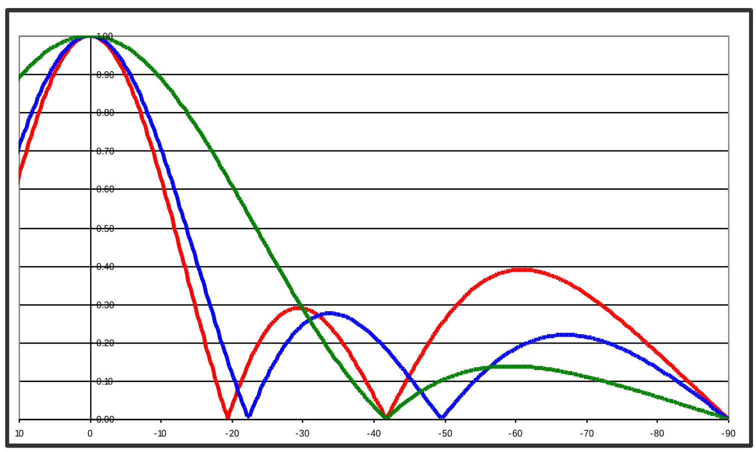
Two Bay



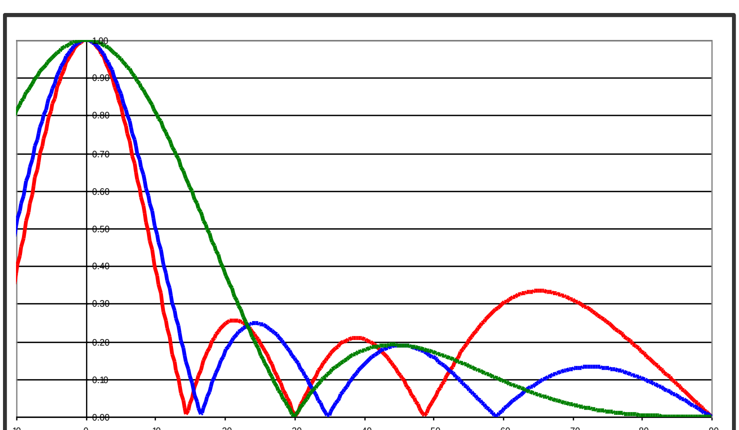
---1 λ (gain 0.99)
---7/8th λ (gain 0.92)
---½ λ (gain 0.68)

Three Bay

---1 λ (gain 1.50)
---7/8th λ (gain 1.46)
---½ λ (gain 1.00)



Four Bay



---1 λ (gain 2.05)
---7/8th λ (gain 1.95)
---½ λ (gain 1.30)

FMP series end fed and corporate fed options

The FMP series of antennas are available in two versions, an end fed antenna with a hardline inter bay feed system and a corporate fed model with a power divider.

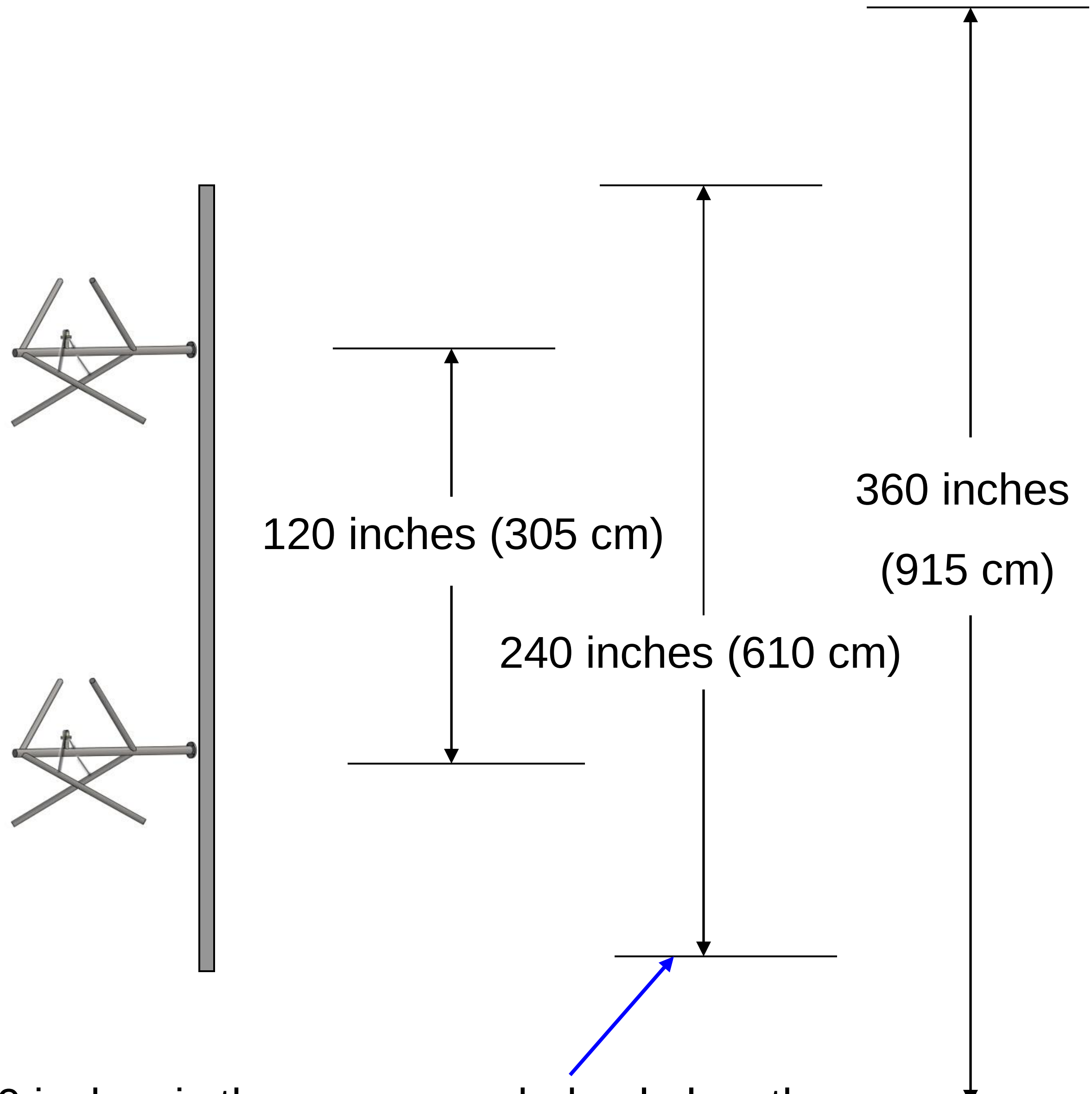
The end fed versions of the antenna use hardline inter bay feed lines. The inter by feed lines are either 1-5/8” or 3-1/8” inch depending on the desired power handling needed. The feed line sections are made of Aluminum and bolt to the antenna bays.

The corporate fed FMP models use a single pancake style input power divider and flex or semi flex feed lines that go to each bay. The outputs of the power divider can be furnished with N, 7/16” DIN or 7/8 inch EIA flanges depending on the power handling needs

Rugged stainless steel elements and mounts

The rugged FMP antenna is constructed from stainless steel for a long dependable service life. The mounts for the FMP are also made of stainless for rust free operation on your tower.

The **FMP** antennas are easy to install and are pre tuned at the factory. The diagram below depicts a two bay antenna (**FMP-2**). The antennas will produce the best radiation pattern if mounted to a small support pole, and installed with free space above and below the antenna. The numbers provided are for operation at 98 MHz.



240 inches is the recommended pole length,
360 inches is the recommended free space area

FMP Mechanical Data and Options

Model	Weight	Wind Load Area
FMP-1	20 lbs. (9.1 kg)	1.0 ft^2 ($0.09m^2$)
FMP-2	48 lbs. (21.8 kg)	4.7 ft^2 ($0.43m^2$)
FMP-3	76 lbs. (34.5 kg)	8.4 ft^2 ($0.78m^2$)
FMP-4	104 lbs. (47.3 kg)	12.1 ft^2 ($1.12m^2$)

The data above is for a 98 MHz antenna, please contact us for other frequencies. The weight and wind loads are for the antenna only and are assume a 3-1/8" inter bay feeder. Basic wind speed rating is 125 M.P.H. (200 km/h)

✓3 bay and above models can be configured with beam tilt.

✓A four bay **FMP** antenna with a corporate feed system can have an input power rating of up to 20 kW

Need some assistance or advice in planning your station's antenna ? Our engineers have decades of experience in antenna design and applications. Give us a call and we will help to design the best system for you. And after it is up and working we will love to hear from you how great the coverage area is.

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