HOW TO CHOOSE AN ANTENNA

How a radio antenna works

The antenna is a transducer and as all the transducers converts one physical quantity into another. In this case the conversion is between "electric current" and "electromagnetic field". Every antenna can work as Transmitting and Receiving.
The transmitting antenna converts the electric current generated by the transmitter into an electromagnetic field that is radiated wile the receiving antenna converts the received magnetic field into an electric current that the receiver can uses extract the information it contains.

What is the purpose of an FM antenna

All the antennas are used to transmit music, pictures, voice and data by radio waves.
We see antennas every day, they are in our cell phones, on our cars, on our homes, over the roofs, etc.
Antennas come in many different shapes and this depends if they are suited to receive or transmit, of the working frequency, on the rating power, etc.

What does a Radio Antenna compare to?

The operation of the antenna is less intuitive than other transducers but we can compare with a speaker converts electrical current into acoustic energy or sound waves. We are used to listening to music at different volumes, like the low power necessary for an headphone or the high power necessary in a concert where are used many thousands of watts! The antenna does the same thing as the speakers, only it converts the signal not to acoustic energy but to electromagnetic energy.
There are antennas connected to transmitters of few of watts and antenna systems connected to transmitters of thousands of watts.

What kind of antennas are there?

A radio station uses an FM antenna to transform the radio frequency produced by the transmitter into electromagnetic waves and transmit its signal over long distances
The transmitting antenna must handle high power, must direct the waves in the area of interest, must be mounted at a height that allows it to reach as far as possible.
Three characteristics of antennas are particularly important: directionality, gain, bandwidth and polarization.

Directionality

Antennas are divided into two types: omnidirectional and directional.
The omnidirectional antennas radiate equally in all directions and the typical model is the Dipole, the most widely used. Directional antennas can be of different types: multiple element antennas, logarithmic antennas, yagi antennas and panels.
Each of these types have different values of directionality and concentration of the electromagnetic beam in one direction.

Gain

The gain of an antenna is related to its directivity and therefore the more the signal is concentrated in a limited portion of space, the more gain will be obtained.
Usually is used a parameter to define antenna gain, defined as the ratio of the power radiated by the antenna in a specific direction to the power radiated by a hypothetical isotropic antenna that is instead radiated in all directions. In a transmitting antenna, gain describes how much the antenna converts incoming power into radio waves radiated in a specific direction. Also with dipole antennas (Omnidirectional) is possible increase the gain and consists to increase the number of antennas.
A two antenna system has twice the gain of a single antenna. A four antenna system has twice the gain of a two antenna system, etc. In this case the gain increase because with more antennas we reduce the amplitude of the vertical lobe

Bandwidth

Every antenna has a typical bandwidth and outside this working band the antenna is mismatched. The matching parameter defines how much the antenna shows itself to the transmitter as a pure load resistor of 50 Ohm. In a mismatched antenna part of the power is reflected, and sent back to the transmitter in the form of VSWR.

This produces two effects:

1. Not all the Power is radiated so coverage decreases
2. The transmitter don't work well because it has to handle the power it is transmitting plus the power that is being sent back and this overload can damage the transmitter.

There are two types of antennas: wide band and tuned.
The wide band FM antennas work well in all 20MHz of the FM band.
Tuned antennas are adapted only in a small band around the frequency to which it was tuned. The FM bandwidth is 20MHz, design an antenna that has a consistent matching throughout this band requires special attention and skill in design.
Broadband antennas are always preferable to tuned ones even if they cost more.
These models allow you to easily change frequency and can accept multi-frequency systems

Polarization

Polarization is the direction in which the electromagnetic fields produced by the antenna and define the plane in which the energy travels and is received by a receiving antenna. This plane is conventionally called the "E-plane".
Polarization can be Linear (vertical, horizontal) or Circular. A horizontally polarized antenna will not communicate well with a vertically polarized antenna and vice versa.

Linear Polarization

Linear polarization refers to an antenna system that operates with polarization in a single plane of radiation then vertical or horizontal. Thus, a vertical antenna receives and emits vertically polarized waves, and a horizontal antenna receives or emits horizontally polarized waves. These are the most used polarization because are also the more simple

Circular Polarization

In circular polarization the direction in which the energy is radiated changes continuously with a circular motion. This means that vector of the E-plane continuously rotates and gradually passes through all intermediate variants from vertical to horizontal. It is as if the power were being radiated on both planes at the same time then the power on the single vector then becomes half.

Choosing the polarization type

The choice of polarization type depends on the regulations in force in the country of use of the antenna. For the FM band the most used globally is the vertical polarization and only in few countries horizontal polarization is used.
In the United States and Latin America is preferred circular polarization is used but the choice of polarization type is in part political and in part technical.
Circular polarization is used in the belief that this improves reception, mainly in cars or in large cities where can exist multi path, signals that bounce off buildings.

Antenna for FM transmitter

The type of antenna a broadcaster needs depends on many factors as the area they need to cover, rural, city, mixed, flat or mountainous terrain, etc.
There are many types of antennas, directional, omnidirectional, yagi, logarithmic, circular polarization, broadband, tuned, etc. Depending on the needs of the broadcaster, it is possible to identify antenna systems that meet their coverage needs. Below is a description of the main features of antenna systems and a guide to choosing the appropriate model.

These are some common requests:

- How to decide how much power I need for an FM transmitter?
- What is the best antenna system and cable to use?
- How much Power need a radio station to cover a determinate area?

For these questions is necessary professional advice from industry experts to decide which option is the best.

Factors that determine the coverage of an FM transmission system

The coverage of a transmitting system depends on the power of the transmitter, the antenna system, the height at which the antennas are mounted and the type of area to cover. The best advice Label Italy can give you is to build the system with a good transmitter but don't overlook the type of the antenna and the height of the installation point. If you look at the horizon with binoculars, the maximum distance we can look at is called the "Line of sight". The FM signal does not go beyond this distance.
For this reason the height of the antenna is so crucial.

These are therefore in summary the parameters:

- The Effective Radiated Power (ERP)
- The antenna Height
- The shape of the Terrain
- The area to be covered; Rural, Urban or Large town.

To calculate ERP you need to know the following factors:

- The output power of the transmitter
- The losses of the coaxial cable used to connect the transmitter to the antenna and his length.
- The type of antenna system: dipole vertical polarization, circular polarization, single antenna, systems with 2 or more antennas, etc.
- The gain of the antenna system in dBb.

The ERP formula is this:

ERP = TX power in Watt x 10^((Gain of the antenna in dBb – cable loss) / 10)

Example:
Power of the FM Transmitter = 1000 Watt
Example antenna = 4 bay dipole vertical polarization, gain of 8 dBb
Feeder cable = Cellflex 1/2”
Cable Length = 30 meters
Attenuation of the cable = 0,69dB
ERP = 1000W x 10^(8dB - 0,69dB)/10 = 5382W
So the system described on the formula would effectively provide approximate 5 times the transmitter power

Once we know the ERP there are many other factors to consider:

- The height of the antenna above the area to cover.
- The height of trees in the area around the antenna
- The height of buildings around the antenna
- The type of terrain flat or hills
- The near frequency stations or other radio stations broadcasting in the same frequency and can be interfering.

The C.C.I.R. says the minimum level of signal needed to have a good reception on the different areas is as follows

Rural areas = 48 dBµV

Urban areas = 60 dBµV

The follows table illustrate the approximate coverage in Kilometers of a rural area with different values of ERP

Watts in ERP	Kilometers Rural area
10	8
30	13
50	17
100	24
300	42
500	54
1000	76
2000	108
4000	152
6000	187
10000	241

The follows table illustrate (taking count of the terrestrial curve) the distance covered with different heights of the antenna system.

Height (meters)	Distance (km)
3	6
10	11
20	16
30	20
60	28
100	36
300	62
500	80
1000	113
2000	160
3000	196

The FM signal will propagate as far as there is optical visibility.

Example of coverage of same FM Transmission system installed at different height levels
If we compare two different radio station using a 1000 Watt FM transmitter: one of them with a 20 meter tower in a flat terrain will cover 16 kilometer while the other with the antenna on a 500 meters hill will cover 80 kilometer.
We must be known that we can be only estimate the range and can not guarantee results until after a given system has been tested in real practice.
In conclusion, to know the effective coverage of a transmission system we must assume all this factors but mainly the Effective Radiated Power, the Antenna height from the terrain and the type of area to cover: Rural, Urban, Towns or Large Towns.