Antenna Design Considerations

Introduction:

In Low Power Wireless Systems, good Antenna design is required to realize good range performance. Without an antenna it is impossible to transmit data over a long distance range. Undeniably, of all the elements in a wireless systems, the Antenna is the most difficult to design and optimize.

In addition, an antenna's performance is closely dependent on variables such as the dielectric constants, proximity to other components, and materials properties.
Finally, antenna measurement and characterization requires sophisticated and expensive test equipment, which may not be readily available.

This Application Note illustrate the most popular antenna's type utilized in Low Power Wireless Systems, and should help to achieve effective antenna design.

1 – Whip Antenna

The simplest antenna is the "Whip" antenna. These antennas are commonly used in applications where range is important and are also very easy to design and tune.
Whip antenna is a quarter wavelength straight wire or rod (Fig.1) connected directly to the Antenna pin of RX/TX. The length of a resonant quarter wavelength whip antenna may be calculated from the following formula:

L(cm) = 7500 / Freq.(MHz)

At 433.92 MHz, one quarter of wavelength is 17cm..

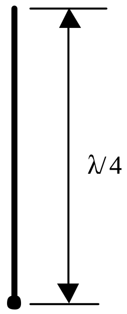

Fig.1

This formula is only a starting point since the length may be shorter if the whip is overly thick or wide, or have any kind of coating. It may need to be longer if the ground plane is too small.
These antennas are easy to tune, simply by slight changes in length.
If the antenna is installed remotely from the Receiver/Transmitter module, a 50Ω coaxial cable can be used (Fig.2).

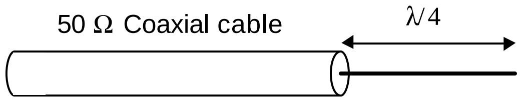

Fig.2

The shielding of the cable should be soldered to the ground near the antenna pin.
The whip can be made also as a trace on a PCB Board (Fig.3).

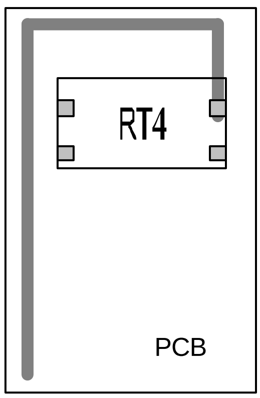

Fig.3

The length of the trace may be 10% to 20% shorter than calculation, depending on the dielectric and the thickness of the board. If the unit is to be handheld, the antenna can be made a little shorter, to compensate for the effect of the hand.

Keep the antenna trace away from other circuitry and ground (5mm or more).

2 – Helical Antenna

A helical antenna is a wire coil usually wound from steel, copper, or brass (Fig.4).

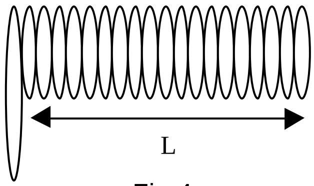

Fig.4

Because a helical has a high Q factor, its bandwidth is very narrow and the spacing of the coils has a pronounced effect on antenna performance.
The number of turns on the coil will depend on wire size, coil diameter, and turn spacing. The numbers of turns can be determined empirically by taking a excessively long coil and tuning it by clipping until it is resonant at the desired frequency. The coil can be fine tuned by spreading or compressing the length of the coil.
For 433.92 MHz use 17 turns of 1.0 mm enameled copper wire close wound on 5.0 mm diameter former, L = 30 mm

The big problem with this antenna is that it can be easily detuned by nearby objects, including a hand, so it may not be good for handheld use.

3 – Loop Antenna

Loop antenna find application mostly at the transmitter, especially where ruggedness, size, and ease of construction are required.
The loop antenna is a PCB track: one end is grounded and the other and is connected to TX/RX via a capacitor (Fig.5). The capacitor is used to tune and match the antenna.

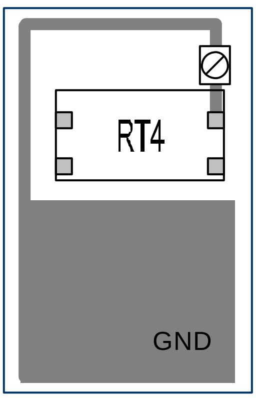

Fig.5

One advantage is that the loop is not easily detuned by hand effects and is not ground plane dependent. For these reasons, loops are very common in handheld transmitter such as garage door openers, car alarm, etc.
When you design the loop antenna, make the loop as large as possible, because small loop have poor gain and have a very narrow bandwidth. This makes the tuning extremely critical. Tuning is often done with a variable or a fixed capacitor.

4 –Comparison of Antenna Types

To summarize, whip antenna are physically larger structures, intended for applications which demand the best range. Whip antennas are also by far the easiest antennas to design and apply.

Helical antennas are a good compromise, especially where small size is important. The resulting assembly generally can be completely enclosed, and made quite compact. Helical antennas are more difficult to set up and optimize than whip antennas, since the antenna's characteristics are strongly influenced by nearby objects.

Loop antennas provide the poorest range of the three antenna considered.

Comparison Table:

Parameter	Loop	Helical	Whip
Design Simplicity	★	★★	★★★
Range	★	★★	★★★
Size	★★	★★★	★
Immunity Proximity effects	★★★	★	★★
Overall Performance	★	★★	★★★

★★★ = Best Relative Performance
★ = Worst Relative Performance