STE s.a.s. ELETTRONICA TELECOMUNICAZIONI
Via Maniago N° 15 – 20134 – Milano – Italy
Tel.: +39.02.2153524 / 2153525 / 2157891
Fax: +39.02.26410928
www.stecom.com ste@stecom.com

APPLICATION NOTE AN-B004

Antennas for Short Range Devices

Guido Moiraghi
Chief Technical Director
STE s.a.s.

Introduction

In transmission the antenna allows RF energy to be efficiently radiated into free space.
In reception the antenna intercepts the electromagnetic RF field and sends the resulting weak current to the receiver input : an equivalent capture area is defined for every antenna .
A receiving antenna should capture as much of the transmitted signal as possible and as little as possible of other undesired signals.

There are hundreds of antenna styles and variations that may be employed (dipole, whip, helical, spiral, loop, patch, etc.) but the simplest and most used in "SRD" applications is the quarter wavelenght whip antenna (groundplane antenna).

The ground plane antenna

Basically a groundplane "whip" antenna is a quarter wavelenght wire that stands above a ground - plane.
This antenna is very simple to design and to manufacture, but to be succesfull it is necessary to match two conditions :

1) The wire (the radiating element) must stand right in open space, perpendicular to the ground plane and far away from conductive obstacles (metal parts - walls – etc.).
2) The groundplane must be really "ground" , I.E. it must have enough extension compared to the wavelenght to be really a "zero" equipotential ground.

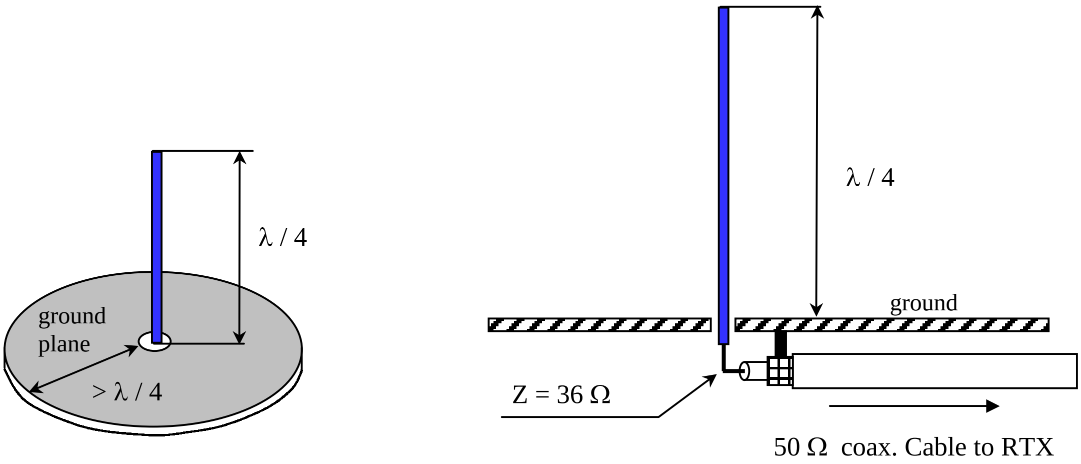
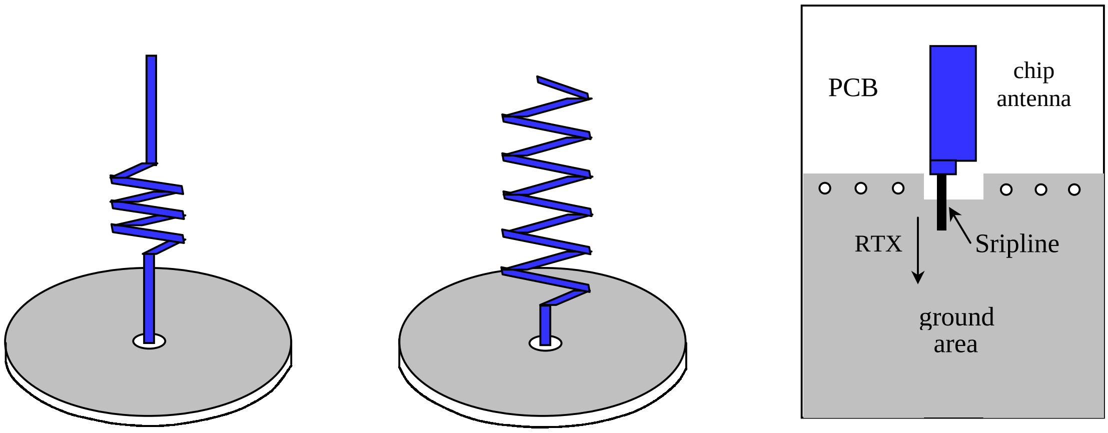


Fig. 1 : Groundplane full size antenna (λ = wavelenght)



a) Shortened GP antenna b) Helical antenna c) Chip ceramic antenna

Fig. 2 : Groundplane (GP) antenna styles

The ground – plane antenna has (at the resonance frequency) a nominal impedance of 36 Ω , which is close enough to the standard 50 Ω impedance.

Radiowaves propagation

The radiowaves propagation is governed by Maxwell's laws which are valid for a concatenated electrical and magnetic field : this concatenation is completely performed some wavelenghts away from the transmitting antenna (at 434 MHz the wavelenght is 69 cm, 34.5 cm at 868 MHz).
Near the antenna the electric and magnetic fields can be regarded as separate (please consider this explanation as an approximate example).
What happens when the antenna is not in free space , but near conductors or conductive grounds ?

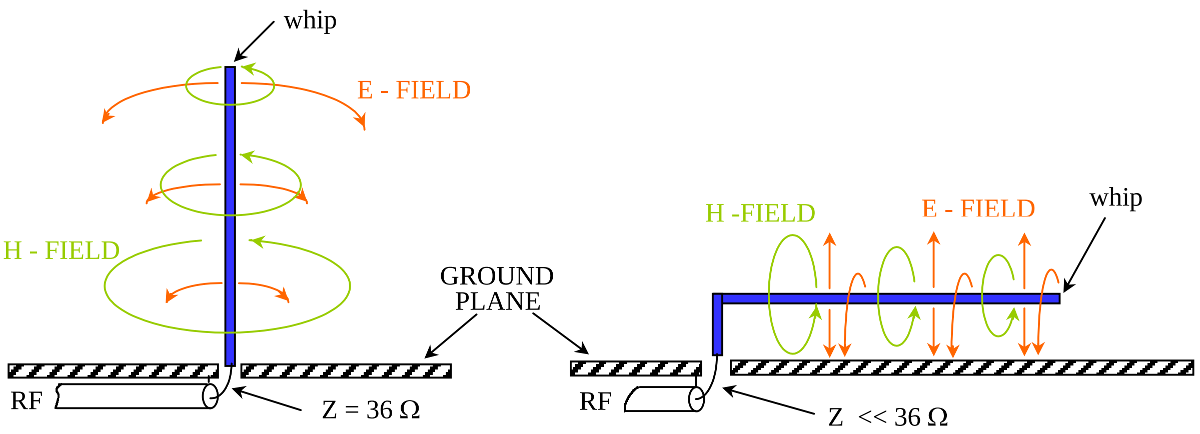


Fig. 3 Electric (E) and magnetic (H) fields surrounding a whip antenna

In fig.3 you can see what happens when a quarter wave antenna is bent parallel to ground : apart from the reduction of the radiating impedance (with a mismatch to the transmitter output opt. impedance), what is more important is the modification of the electric field.
The "E" field is "captured" by the ground killing at the origin the creation of the E&H concatenated electromagnetic field.
What happens in fig. 3 is true for all the "wire" antennas.
Also a "chip" antenna (ceramic or multilayer PCB antenna - fig. 2 C) stops to be an efficient antenna if it is parallel and very near to a conductive object or ground.

The “LOOP” antenna

The “loop” antenna is entirely different from a whip (wire) antenna in that (near the loop) the magnetic (H) field is predominant.

This leads to a relative insensitivity of the radiation efficiency against the presence of nearby conductive objects.

Another advantage is that the “loop” performance is not dependant on the presence of a good return ground.

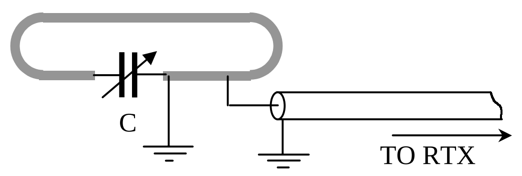


Fig. 4 loop antenna

The “loop” antenna must be designed to resonate to the working frequency with a capacitor (fig. 4).

If the “loop” has a low “Q” (for example a trace on a P.C.B.) it may be pratical to use a fixed capacitor, but the antenna efficiency (gain) is also very low.

If a high “Q” loop is realized with a silver-plated copper conductor (1mm or more diameter) a good radiation efficiency can be obtained.

In this case a variable capacitor must be used : antenna tune is a critical operation which adds to the cost, both parts and labor.

Antenna design and application

A 10 mW transmitter a receiver with two groundplane antennas (fig. 1 – where the whip length is 17 cm on the 434 MHz band and 8 cm on the 868 MHz band) can easily communicate at a free space distance of 1Km.

The received signal level will be around - 90 dBm.

The best system to realize an efficient ground plane antenna is represented in fig. 5.

The metal enclosure must be large enough to represent a good ground plane.

A big advantage of the metal enclosure is the sreeening effect it has to isolate the antenna from the RTX module and from the electronic circuitry.

Especially in reception it is useless to have high sensitivity if the antenna can pick-up noise or interferences from disturbing electronics like fast logic circuits, microprocessor, switching regulators etc.

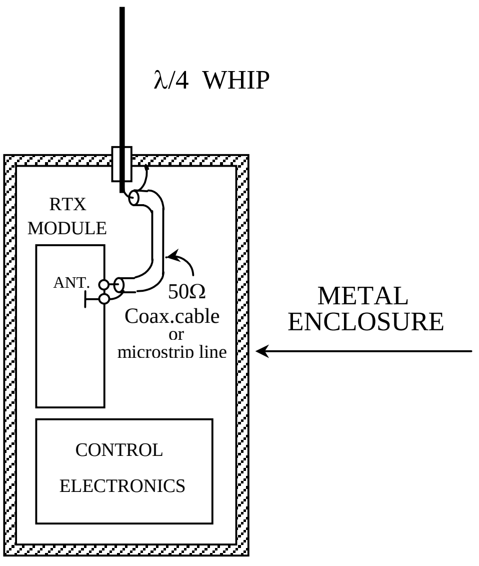


Fig. 5 groundplane antenna on a metal enclosure

Another possible solution is show in fig. 6, where it is represented the employ of an helical antenna.
The metal chassis can also be implemented by the ground side of a P.C.B. , but the best performances are obtained with a solid metal chassis at least ¼ wavelenght long.

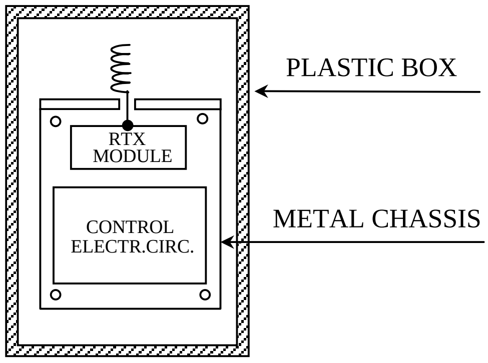
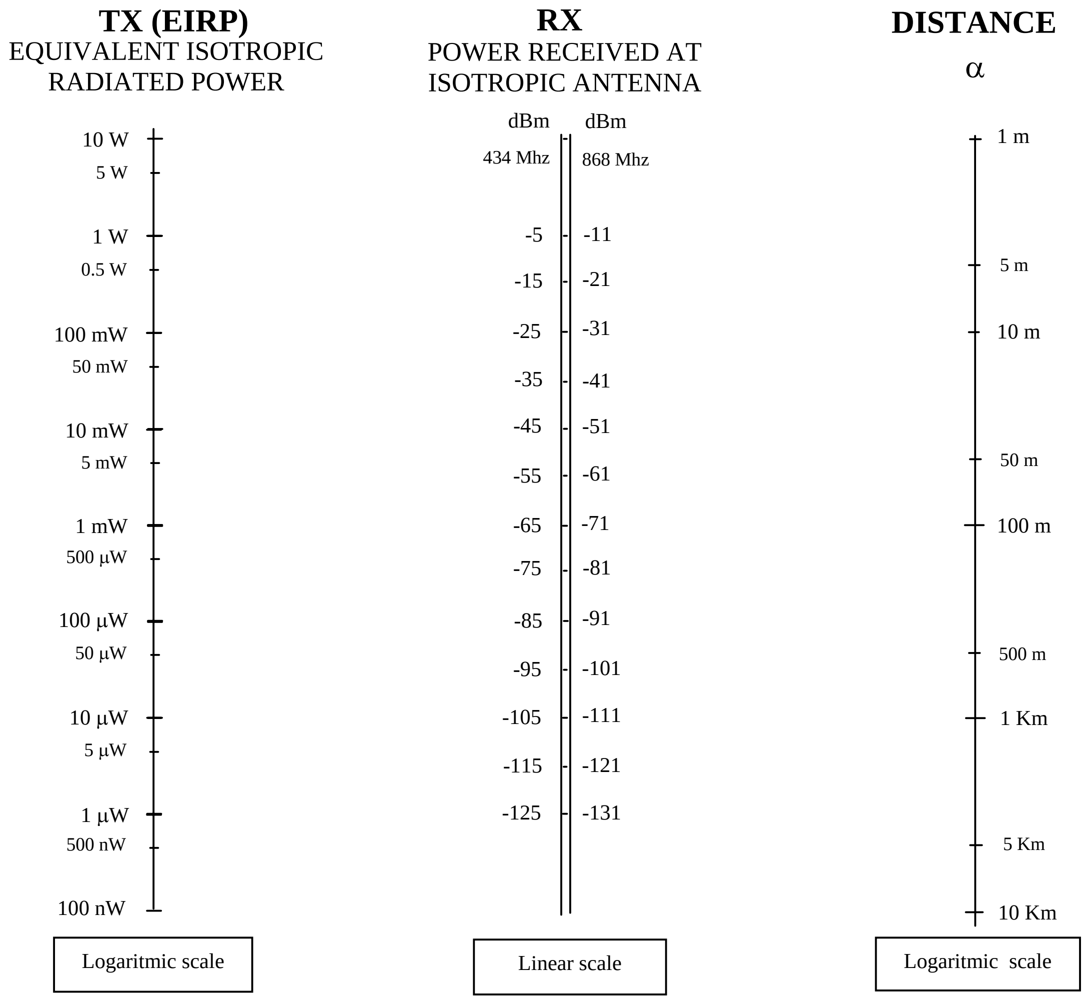


Fig. 6 Helical antenna in a plastic enclosure

FREE – SPACE PROPAGATION NOMOGRAM
434 AND 868 MHz SRD BANDS



TX

dBm / RF power
0 dBm = 1mW

dBm	W
-30	1 µW
-20	10 µW
-10	100 µW
0	1 mW
+10	10 mW
+20	100 mW
+30	1 W
+40	10 W

dBm	mW
0	1
1	1.26
2	1.6
3	2
4	2.5
5	3.2
6	4
7	5
8	6.3
9	8

EXAMPLE:
25 mW=+14dBm

RX

dBm/RF Voltage
0dBm=224mV (Z=50Ω)

dBm	RF V
-30	7 mV
-40	2.24 mV
-50	0.7 mV
-60	224 µV
-70	70 µV
-80	22.4 µV
-90	7 µV
-100	2.24µV
-110	0.7µV
-120	224 nV