= Inverted @-@ F antenna =

An inverted @-@ F antenna is a type of antenna used in wireless communication . It consists of a monopole antenna running parallel to a ground plane and grounded at one end . The antenna is fed from an intermediate point a distance from the grounded end . The design has two advantages over a simple monopole : the antenna is shorter and more compact , and the impedance matching can be controlled by the designer without the need for extraneous matching components .

The inverted @-@ F antenna was first conceived in the 1950s as a bent @-@ wire antenna . However , its most widespread use is as a planar inverted @-@ F antenna (PIFA) in mobile wireless devices for its space saving properties . PIFAs can be printed using the microstrip format , a widely used technology that allows printed RF components to be manufactured as part of the same printed circuit board used to mount other components .

PIFAs are a variant of the patch antenna . Many variants of this , and other forms of the inverted @-@ F , exist that implement wideband or multi @-@ band antennae . Techniques include coupled resonators and the addition of slots .

= = Evolution and history = =

The inverted @-@ F antenna is an evolution of the basic quarter @-@ wave monopole antenna . The wire F @-@ type antenna was invented in the 1940s . In this antenna the feed is connected to an intermediate point along the length of the antenna instead of to the base . The base is connected to ground . The advantage of doing this is that the input impedance of the antenna is dependent on the distance of the feed point from the grounded end . The portion of the antenna between the feedpoint and the ground plane is essentially behaving as a short @-@ circuit stub . Thus , the designer can match the antenna to the system impedance by setting the position of the feed point (RF systems commonly have a system impedance of 50 ? whereas a ? / 4 monopole has an impedance of 36 @.@ 5 ?) .

The inverted @-@ L antenna is a monopole antenna bent over to run parallel to the ground plane . It has the advantage of compactness and a shorter length than the ? / 4 monopole , but the disadvantage of a very low impedance , typically just a few ohms . The inverted @-@ F antenna combines the advantages of both these antennae ; it has the compactness of the inverted @-@ L and the impedance matching capability of the F @-@ type .

The inverted @-@ F antenna was first proposed in 1958 by the group at Harvard led by Ronold W. P. King . King 's antenna was in wire form and was intended for use in missiles for telemetry .

= = Planar implementation = =

A planar inverted @-@ F antenna (PIFA) is used for wireless circuitry implemented in microstrip . The microstrip format is the format of choice for modern RF electronics . It can be used to implement required distributed element RF components such as filters , while at the same time being economical because the same mass production methods are used as for printed circuit boards .

A printed inverted @-@ F antenna can be implemented in the classic inverted @-@ F shape , usually to one side of the circuit board where the ground plane has been removed from underneath the antenna . However , another approach is a modified patch antenna , the shorted patch antenna . In this approach , one edge of the patch , or some intermediate point , is grounded with grounding pins or vias through to the ground plane . This works on the same principle as an inverted @-@ F ; viewed sideways , the F shape can be seen , it is just that the antenna element is very wide in the horizontal plane . The shorted patch antenna has a wider bandwidth than the thin line type due to the greater radiation area . Like the thin line type , the shorted patch antenna can be printed on the same printed circuit board as the rest of the circuitry . However , they are commonly printed on to their own board , or on to a dielectric fixed to the main board . This is done so that the antenna , can be suspended and effectively be in air dielectric , is a greater distance from the ground plane than it would otherwise be , or the dielectric used is a more suitable material for RF performance .

The term PIFA is reserved by many authors (e.g. Sánchez @-@ Hernández) for the shorted patch antenna where the antenna element is wide with the ground plane underneath . The thin line type of inverted @-@ F antennae with the ground plane to one side like A and B in the diagram are just called IFA even if they are in planar format . An author may even call an IFA of this type a printed inverted @-@ F antenna but still reserve PIFA for the shorted patch type (e.g. Hall and Wang .)

A common configuration for a shorted patch antenna is to place the shorting pin as close to one corner as possible with the feed pin relatively close to the shorting pin . In this configuration , the resonant frequency is given approximately by ,

<formula>

where

f0 is the resonant frequency

w , b are the width and breadth of the patch

c is the speed of light

?r is the dielectric constant of the substrate .

This formula only holds if the antenna is not affected by nearby dielectrics , such as the casing of the device .

Another variation that may be encountered is the meandered inverted @-@ F antenna . Where there is insufficient board space to extend an antenna to the full required length , the antenna may be meandered to reduce its height while retaining its designed electrical length . This can be compared to the spiralling of an antenna as found in the rubber ducky antenna .

Inverted @-@ F antennae have narrow bandwidths . A wider bandwidth can be achieved by lengthening the antenna , which increases its radiation resistance . Another solution is to place two antennae in close proximity . This works because coupled resonators have a bandwidth wider than the bandwidth of either resonator on its own . Most of the techniques for producing multi @-@ band antennae are also effective at broadening bandwidth .

= = Multi @-@ band antennae = =

The need for multi @-@ band antennae arises with mobile devices that need to roam between countries and networks where the frequency bands used can often be different . Perhaps the most conceptually simple design , first reported in 1997 , is to nest two PIFA patch antennae one inside the other . Another technique is to insert one or more spur lines into the patch , which has the effect of coupled resonators broadening the band . Other techniques rely on multiple modes being generated , which makes for a more compact design . Examples of this are the C @-@ slot pattern , which is a similar pattern to the interdigital filter , and the tightly meandered pattern shown as , respectively , C and D in the diagram .

= = Applications = =

Inverted @-@ F antennae are widely used in compact hand @-@ held wireless devices where space is at a premium . This includes mobile phones and tablet computers using wireless transmissions such as GSM , Bluetooth , and WiFi . The planar inverted @-@ F antenna is the most frequently used internal antenna in mobile phone designs .

These antennae are also of use for vehicle telematics . Vehicle manufacturers like to use antennae that follow the contours of the vehicle for style and aerodynamic reasons . Multiband PIFAs can be used to combine the antennae feeds for mobile phone , satellite navigation , and car radio .

An R @-@ shaped dual @-@ band PIFA has been proposed for use on military vehicles . The bands to be covered are 225 MHz and 450 MHz . These frequencies are in the same ratio as the mobile phone GSM bands at 900 MHz and 1 @.@ 8 GHz so the design could be used for this application as well if the dimensions were scaled down to suit .