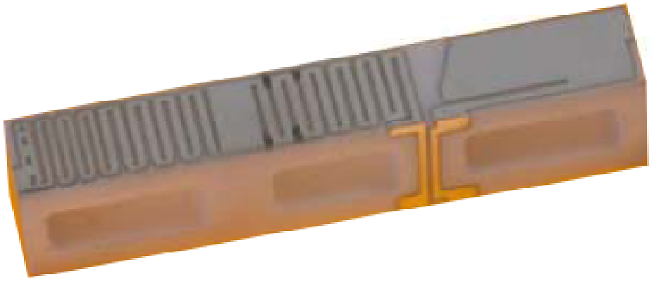
Antenna ANT-GXE475 Design Application Note



1 PIFA Basics

The ANT-GXE475 Planar Inverted F Antenna (PIFA) consists of a rectangular planar element located above a ground plane, a short circuiting plate, and a feeding mechanism for the planar element.
The PIFA is a variant of the monopole where the top section has been folded down so as to be parallel with the ground plane. This is done to reduce the height of the antenna, while maintaining a resonant trace length. This parallel section introduces capacitance to the input impedance of the antenna, which is compensated by implementing a short-circuit stub. The stub's end is connected to the ground plane via the short-circuiting plate on the edge of the antenna, whose function is to extend the bandwidth of the PIFA.

The ground plane of the antenna plays a significant role in its operation.

Excitation of currents in the PIFA causes excitation of currents in the ground plane. The resulting electromagnetic field is formed by the interaction of the PIFA and an 'image' of itself below the ground plane. Its behaviour as a perfect energy reflector is consistent only when the ground plane is infinite or very much larger in its dimensions than the monopole itself. In practice the ground plane area is of comparable

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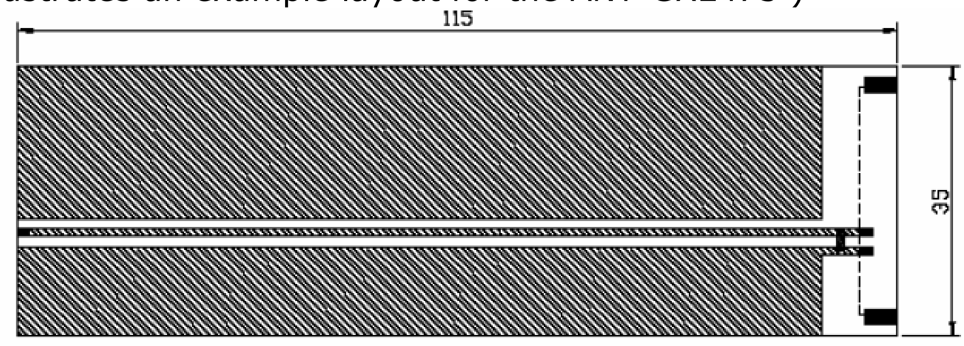
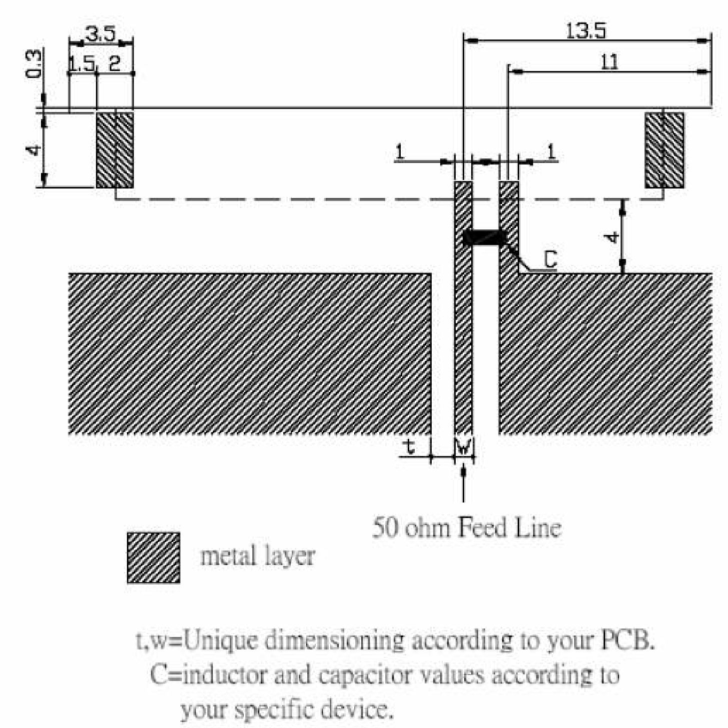
dimensions to the monopole and forms the 'image antenna' which is one half of the dipole. The antenna/ground plane combination will behave as an asymmetric dipole, the differences in current distribution on the two-dipole arms being responsible for some distortion of the radiation pattern.

2 GROUND PLANE SIZE

In general, the required PCB ground plane length should be at least one quarter (λ/4) of the operating wavelength.

- If the ground plane is much longer than λ/4, the radiation patterns will become increasingly 'multilobed'.
- On the other hand, if the ground plane is significantly smaller than λ/4, then tuning becomes increasingly difficult and the overall performance degrades.
- The optimum location of the PIFA in order to achieve an omni-directional far-field pattern and 50Ω impedance match was found to be close to the edge of the Printed Circuit Board. (Drawing below illustrates an example layout for the ANT-GXE475)





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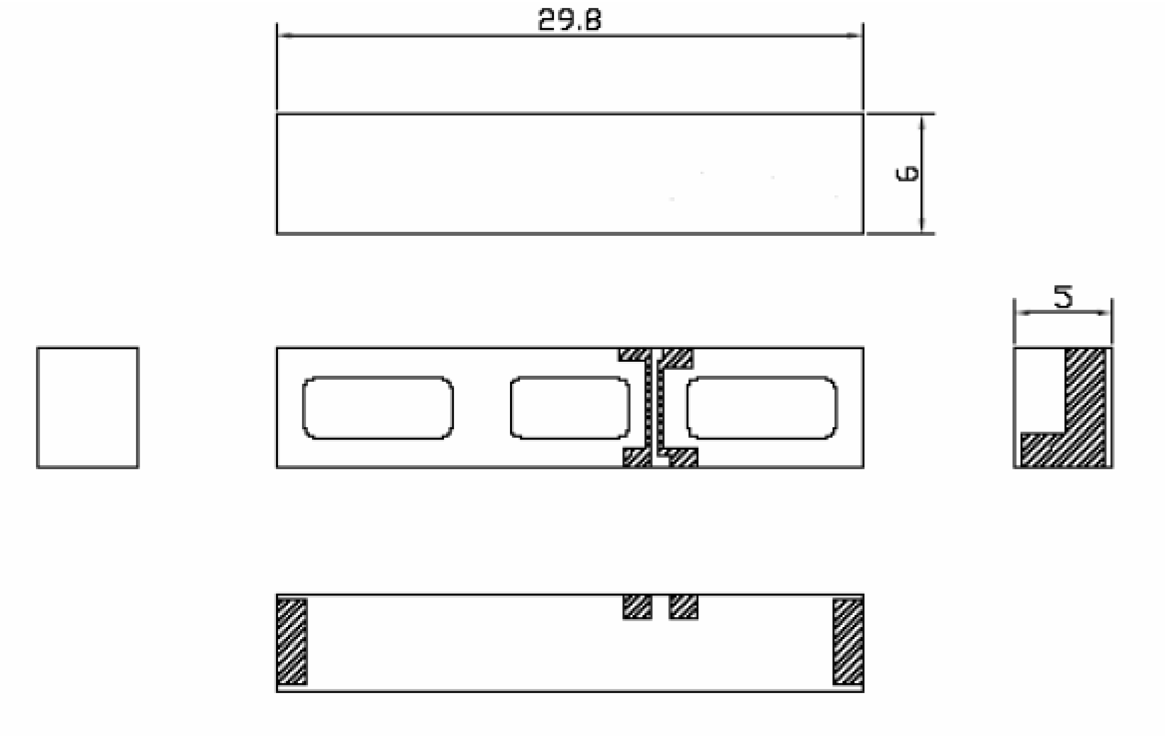
Out line dimensions of ANT-GXE475



3 BANDWIDTH

The bandwidth of the ANT-GXE475 is affected considerably by the size of the ground plane. By varying the size of the ground plane, the bandwidth of a PIFA can be adjusted. For example, a reduction of the ground plane area can effectively broaden the bandwidth of the antenna system. An increase in the bandwidth of the PIFA (and thus a reduced quality or Q-factor), can be achieved by inserting several slits at the ground plane edges, however this is not always practical in real life systems.

4 GAIN

The area of the ground plane will affect the gain of the ANT-GXE475. As explained in section 1, the ground plane of a PIFA is electrically one half of the dipole (known as the image antenna) and thus a larger ground-plane will yield an improved gain.

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5 ADVANTAGES of the ANT-GXE475

- Compact volume, minimum footprint - It can be placed into the housing of the mobile/handheld device, unlike most whip/rod/helix antennas.
- It exhibits a reduction in backward radiation toward the user's head compared to other antenna technologies, thus minimizing the electromagnetic wave power absorption (SAR), which in turn enhances the antenna's performance.
- Achieves moderate to high gain in both vertical and horizontal polarization planes. This feature is very useful in certain wireless communications where the antenna orientation is not fixed and the reflections or multipath signals may be present from any plane. In those cases the important parameter to be considered is the total field strength that is the vector sum of the signal from the horizontal and vertical polarization planes at any instant in time.
- Labor saving SMT – also ensures higher quality yield rate
- No antenna tooling cost for customer
- Robust single block structure.

6 MOUNTING

Follow drawing on specification Mount on non-conductive area close to ground plane ensuring minimum separation distances are obeyed. Best results are achievable when placed close to the edge of the board, see the outline drawing in the specification.

7 ENVIRONMENTAL CONSIDERATIONS

Close proximity to components or housing affects the electrical performance of all antennas. When placed on a non-conductive area of the board, ideally there should be clearance of 4mm in all directions from the board/housing for maximum efficiency. A reduction in the efficiency of the antenna efficiency or a slight shift in tuned frequency will be observed if these clearances are not adhered to. Proximity effects will also have an adverse effect on the radiation pattern of the antenna.

8 TUNING

PIFA antennas are less susceptible to detuning from the close environment than other antennas due to their design. However tuning optimisation can be carried out by option 8.1 to 8.3 .

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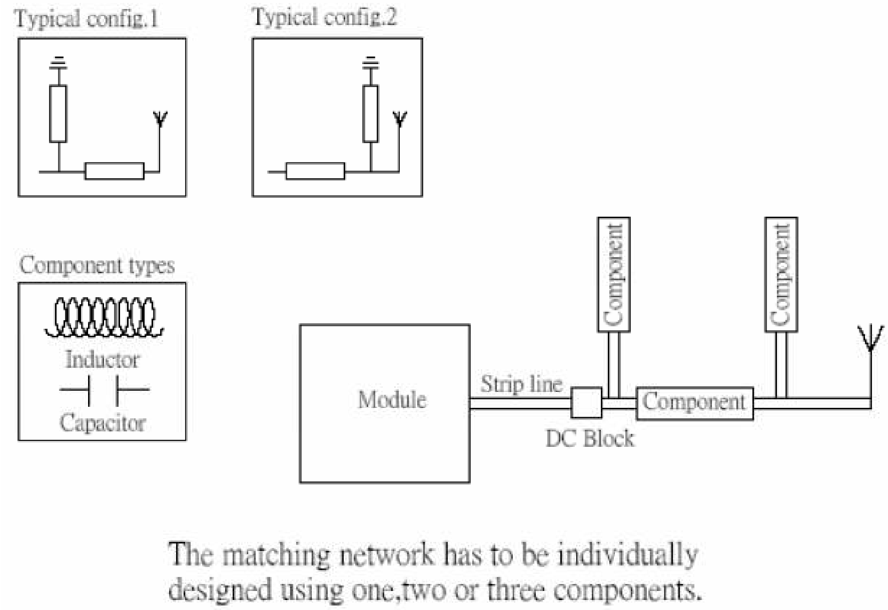
8.1 Appropriate choice of matching circuit

If the customer can give the housing and reference PCB to us then our technical team can carry out the necessary S11 response measurements in both magnitude and Smith Chart format of the complete system. The necessary impedance matching circuit should be designed on the customer side if he/she has access to a software modelling tool which simulates the system. The matching circuit values obtained from this exercise can then be employed and adjusted via trial and error to obtain the optimal 50 Ohm match at the frequencies of interest. It should be noted that the impedance matching can improve the response of the antenna at certain frequencies (or bands of frequencies in the case of wideband matching circuits) but a reduction in the response at other frequencies may be observed.



8.2 Inductor

On the evaluation board it was found that either a 4.7nH or 6.8nH grade chip inductor can be used to obtain a 50 Ohm impedance match across the frequency bands.

8.3 Other Techniques for tuning

8.3.1 Lower Frequency

A. Lengthen distance of PIFA to ground
B. Cutting a bridged meander line on side of antenna will lengthen wavelength and reduce frequency. Would need to be implemented on manufacturing side.
C. Larger surface area on contact pad will lengthen effective wavelength and reduce frequency

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8.3.2 Higher Frequency

New photo mask would be needed on manufacturing side. But this is a very expensive process so we designed the antenna so that in practice the antenna should not need to be tuned to higher frequency.

9 FAQs

9.1 What are radio waves?

Radio waves are waves produced by the interaction of time -varying electric and magnetic fields. More properly they are referred to as electromagnetic waves. With the Wireless Telegraphy Act it was decided that all electromagnetic waves with a frequency below 3,000GHz would be called radio waves.

9.2 What is an antenna?

An antenna converts electrical energy to radio waves and transmits them into the sky as well as collecting radio waves from the sky and converting them to electrical energy.

9.3 What makes a good antenna (1)?

As an antenna serves as the electrical power conversion device between a circuit and the air,
the keys to it’s efficiency are as follows:

- Input characteristics with the contact point on the circuit side
- Radiation characteristics from the contact point to the air

Input Characteristics
Electric power is supplied efficiently to the antenna without reflecting back into the circuit at the feeding point
> If the impedance between the antenna and the feed line is not matched correctly, the signal will reflect back and no power will be supplied to the antenna.

Radiation Characteristics The power supplied to the antenna is not lost within the antenna but is transmitted as a radio wave.
> If the antenna is made of high loss material (conductors and dielectrics), then the power that was supplied to the antenna will be dissipated into heat and lost.

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9.4 What makes a good antenna (2)?

The characteristics of a general antenna are shown below.

9.4.1 Input Characteristics

- **Frequency –Return loss chart**
  Where the return loss is low, indicates that the antenna is well matched at that frequency.
- **Frequency – VSWR chart**
  In the same way as the return loss chart, a low VSWR value shows a good matching of the antenna.
- **Bandwidth**
  The antenna is good to the extent of good matching and the width of the frequency domain.

9.4.2 Radiation Characteristics

- **Radiation Pattern**
  The strength of the antenna emission is displayed. It shows that antennas emit well in their projected direction. It is usually displayed in three planes (XY, YZ and ZX planes).
- **Gain [dBd]**
  Given as a ratio to a standard antenna (half wave dipole). Usually displayed as the average of the three planes (XY, YZ and ZX planes). Designated as a combination of the vertical and horizontal polarity power gains.

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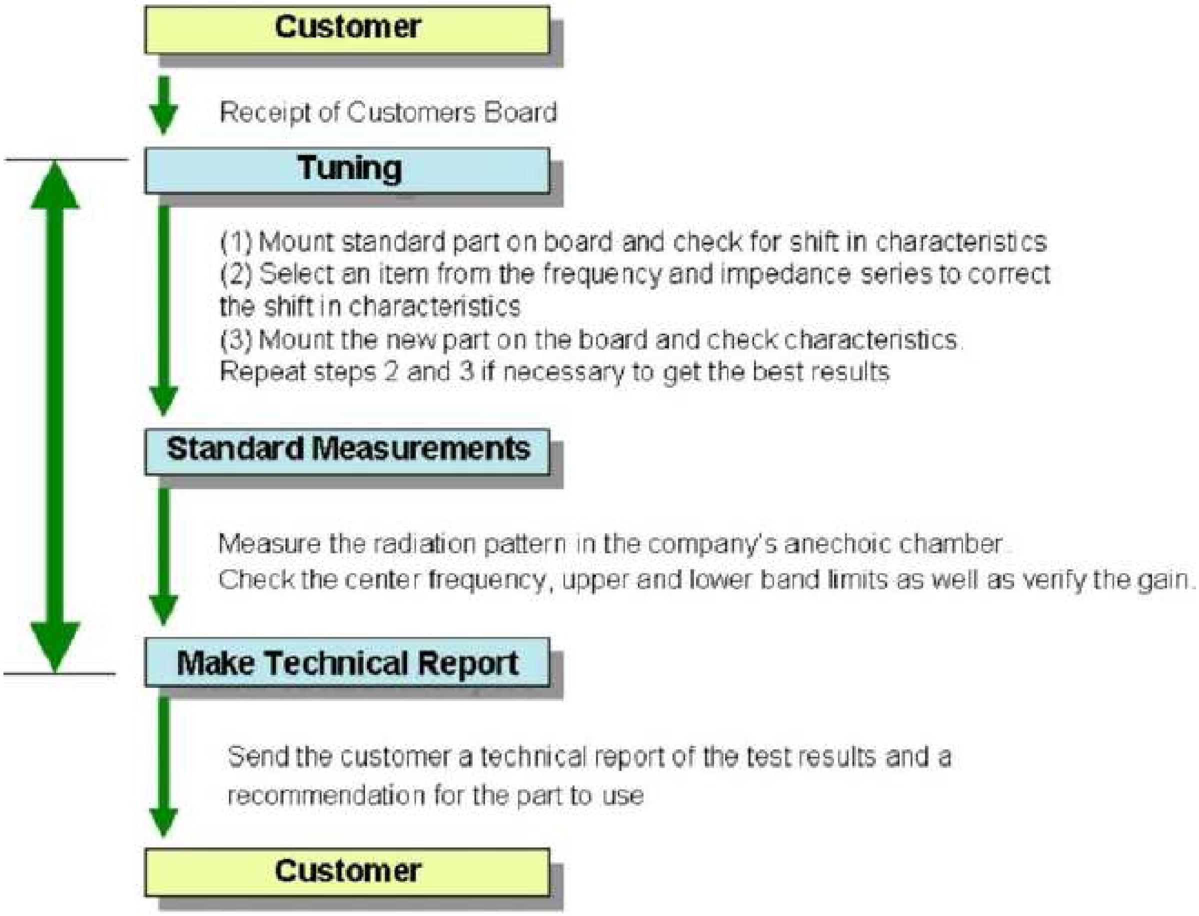
9.5 What is Tuning?

Many parameters, such as the board shape, surrounding components and the case covering the board, can affect the characteristics of an antenna, therefore most designs require customisation of the antenna to compensate for the shift in characteristics. Correcting the shift in the characteristics of the antenna is known as tuning. For this work, having lots of experience from adjusting many items and equipment is where an antenna maker can really show their strengths. This experience can really help the user in getting the help needed for a quick product design.

Tuning work flow



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9.6 *How can we respond so quickly?*

9.6.1 We have anticipated the characteristic shifts and created a series of parts that match those shifts and corrects them.

- **Frequency Series Parts**

When an antenna is mounted, the center frequency will shift due to surrounding elements. These parts will bring that frequency back to the proper center frequency. There are 18 values available in 29MHz steps.

- **Impendence Series Parts**

The impedance of an antenna will appear different depending on the shape of the board and other items surrounding the antenna. Normally in these situations, designers will make a matching circuit by adding capacitors or inductors, we however have created antennas with 3 different impedances values, so a standard antenna can be quickly matched to the design without any modifications to the circuit.

9.6.2 Complete Measurement Environment

Our facilities are complete with a full anechoic chamber and all required test equipment for quick and complete testing.

9.6.3 Standard Data Reporting

Using standardized data forms, the information can quickly be assembled into a report.
** If a verbal reply is sufficient, we can reply within 2 days of receiving the customer's board.*

9.6.4 How to select the correct antenna?

It is important to select the correct antenna for the application.

9.6.5 Important Information about Small Antennas

As for chip antennas, you must consider the ground plane surrounding the area the chip is mounted. When using a small antenna it is often necessary to make a large ground plan to improve the characteristics of the antenna, the result is a larger area on the board for the antenna. Also, since small antennas typically are lambda/4 type antennas, a large GND is also important. In fact if the GND is not large enough, there are some small antennas that will not operate.
> We consider the ground plane area in addition to the area for mounting antenna as a set, and can propose the optimum configuration for both.

Also, if there is room in your design, the larger antenna you can use the better off you will be. (It has been theoretically proven that as an antenna becomes smaller the performance deteriorates.)

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9.6.6 Use Directivity Appropriately

When you know the direction of the transmission, you should choose to use a directional antenna. If you don't, you will scatter the radio waves and the power will be wasted. Also, as seen in the recent case with SAR, directional antennas were best to effectively isolate the body.

> We have both directional and omni directional antennas, so please consider what are best for your application.

9.6.7 Pitfall of Broadband Antennas

For return loss characteristics, the loss amount is a combination of the transmission power and the power lost. Even in the case where the power loss is great and there is no transmission at all, the antenna may be seen as having very good broadband characteristics. To best judge the band, the gain's frequency characteristics should be judged.

> The standard data we submit then is the average gain for the necessary frequency.

9.6.8 Losses for the Matching Circuit

This circuit is used to match the impedance at the feed of the antenna. In actuality, this circuit is also the primary cause of power loss. In addition, this circuit takes up additional space on the board, adding to the total area required for the antenna. If however, the antenna's impedance is matched with the characteristic impedance from the beginning, there is no need for this circuit.

> We do not use matching circuits, but instead have the ability to tune the antenna to match the impedance.

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