

Antenna Design Note

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About the Document

History

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| 1.0 | 2012-06-09 | David WEI | Initial |
| 1.1 | 2012-06-15 | David WEI | Modified Figure 1 |
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| 1.9 | 2017-07-14 | Vick YANG | 1. Added description of metal frame antennas in Chapter 3.8 2. Added description of internal Wi-Fi laminated antennas in Chapter 7 3. Updated antenna suppliers information in Chapter 8: <ul style="list-style-type: none"> ● Updated contact information of antenna manufacturers SAINTENNA and INPAQ ● Deleted information of antenna manufacturer JINGHONG ● Added information of antenna manufacturer SHEN XUN |

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1 Recommended Component Placement of Main PCB

This document is applicable to all Quectel modules.

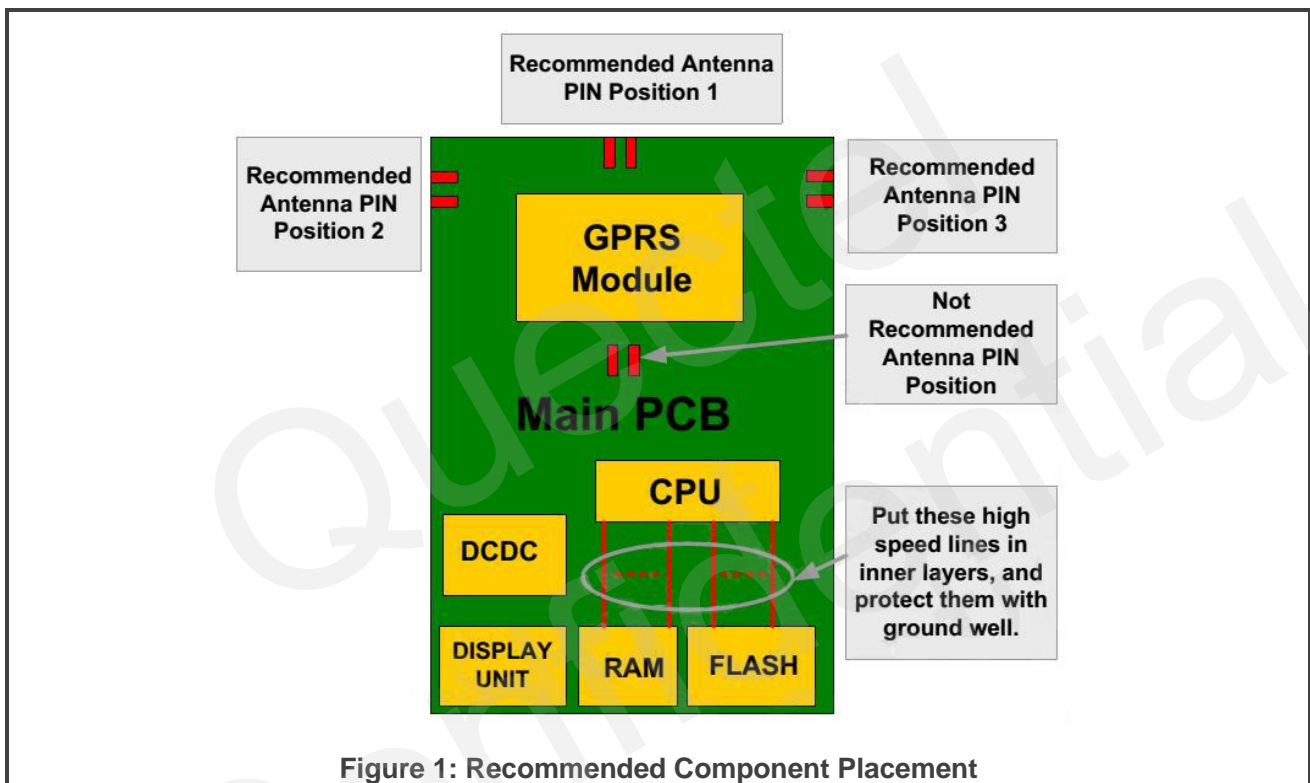


Figure 1: Recommended Component Placement

Notes:

1. It is suggested to keep the RF ports on the outer side of PCB when placing the module.
2. Put antenna feed points at the edge of the main PCB, rather than in the center.
3. Keep the antenna as far away from CPU/SDRAM/Flash/DCDC/Display FPC components as possible. It is NOT recommended to place the antenna and these components on the same layer and same edge of the main PCB.
4. Keep the high speed lines between CPU and SDRAM/Flash/Display FPC as short as possible, and put these lines in inner layers with ground shielding on not only upper and lower layers but also right and left sides. Add an EMI filter on high speed lines between CPU and display FPC if necessary.
5. Put ZIFs of CPU/SDRAM/Flash/DCDC/Display FPC into the shielding case, and copper-nickel-zinc alloy shielding case is preferred.

2 Basic Parameters and Requirements of Antennas

2.1. Basic Parameters of Antennas

Gain (dBi): The ratio of “power of antenna” and “power of isotropic radiation from an ideal current source” in maximum transmitting direction with the same input power. “dBi” is widely used as the unit of antenna gain.

Gain (dBd): The ratio of “power of antenna” and “power of half wave dipole antenna” in maximum transmitting direction with the same input power. One formula indicating relationship between dBi and dBd is given as below: $dBi = 2.15 + dBd$

Directivity: The ratio of “power of antenna” and “power of isotropic radiation from an ideal current source” in maximum transmitting direction with the same radiated power.

Efficiency: The ratio of the antenna radiation power and antenna input power.

$\text{Gain} = \text{Directivity} \times \text{Efficiency}$

$\text{Efficiency} = \text{Output Power} / \text{Input Power}$

APIP (Antenna Port Input Power): The input power to antenna.

EIRP (Effective Isotropic Radiated Power): Compared to isotropic antenna, it is the power obtained in maximum transmitting direction. Its formula is:

$EIRP = P \times G$ (Here P is radiation power, G is antenna gain indicated in dBi.)

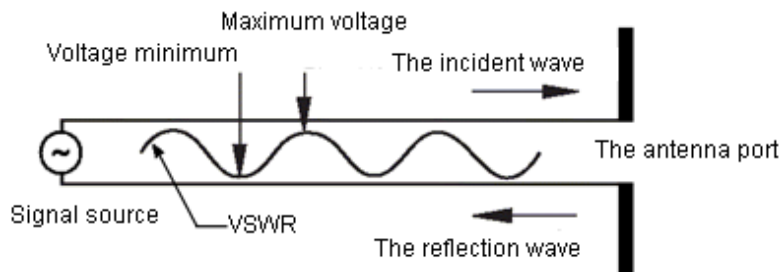
PEIRP (Peak Effective Isotropic Radiated Power): The peak value of EIRP.

ERP (Effective Radiated Power): Comparing to half wave dipole antenna, it is the power obtained in maximum transmitting direction. Its formula is:

$ERP = P \times G$ (Here P is radiation power, G is antenna gain indicated in dBd.)

VSWR (Voltage Standing Wave Ratio):

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$



Voltage standing wave ratio return loss is commonly used in engineering RL (S11), corresponding relationship is shown as the following table:

The corresponding formula: $RL = -20 \lg \frac{V+1}{V-1}$ (dB)

Table 1: VSWR and Return Loss

| VSWR | 1.20 | 1.25 | 1.30 | 1.35 | 1.40 | 1.50 | 2.00 |
|------------------|--------|--------|--------|--------|--------|--------|-------|
| Return Loss (dB) | -21.00 | -19.00 | -17.60 | -16.60 | -15.60 | -14.00 | -9.50 |

2.2. Basic Requirements of Antennas

Table 2: Basic Requirements of Antennas

| Items | Requirements |
|------------------------------|---|
| Frequency Band | According to the operating band of devices |
| VSWR | ≤ 3 |
| Gain (dBi) | ≥ 1 |
| Max Input Power (W) | 50 |
| Input Impedance (Ω) | 50 |
| Polarization Type | Vertical linear polarization Horizontal linear polarization Left/right hand circular polarization |

3 Internal 2G/3G/4G Antennas

3.1. PIFA Antennas with FPC Form

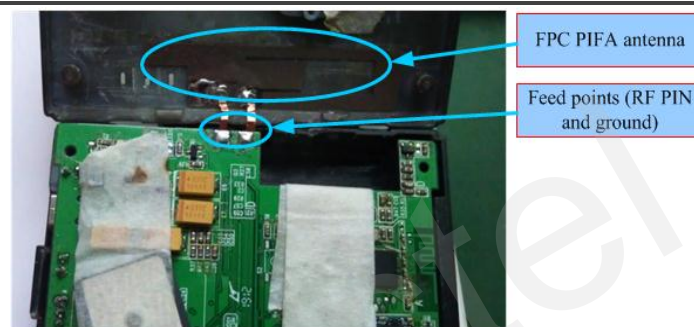


Figure 2: Example of An FPC PIFA Antenna Using Soldering Pads as Feed Points

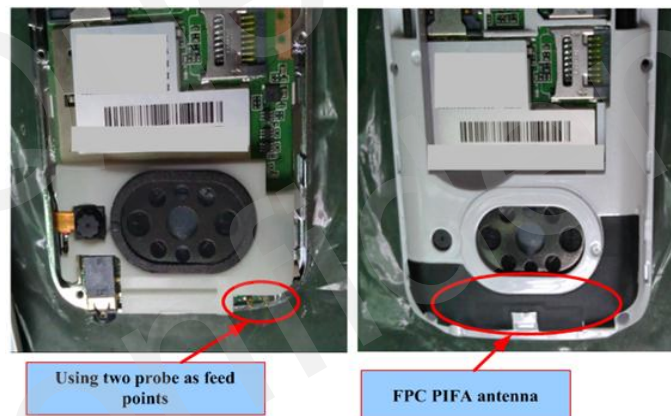


Figure 3: Example of An FPC PIFA Antenna Using Spring Probes as Feed Points

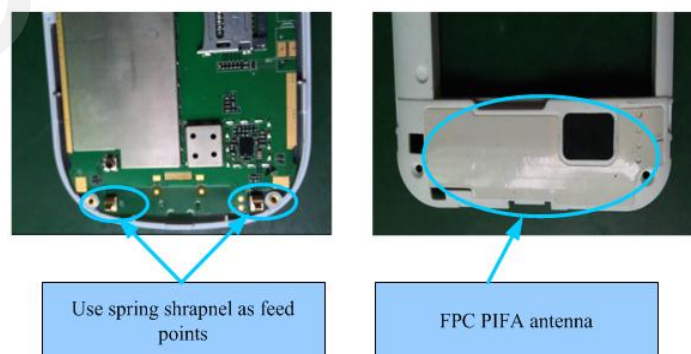


Figure 4: Example of An FPC PIFA Antenna Using Metal Shrapnel as Feed Points

Notes:

1. The FPC PIFA antenna can be pasted in the casing, which saves space especially for PDA and automotive devices. Three feed points will be used on the antenna, the middle one is signal feed point, the other two are ground feed points. When bandwidth of a high-frequency band is not enough during tuning the antenna, one ground feed point will be used to increase the bandwidth.
2. Keep the distance between antenna and the main PCB at least 5mm.
3. Ground copper is required under antenna area on the main PCB.
4. Feed points can be designed as soldering pads, probes or shrapnel. For a higher reliability, some hot melt columns can be designed inside the device casing.

3.2. PIFA Antennas with Plastic Bracket

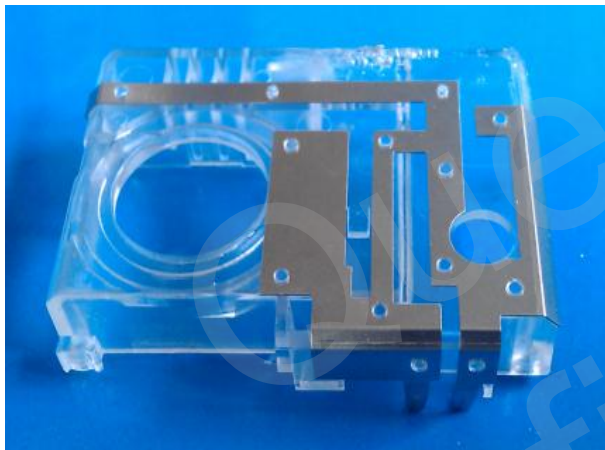


Figure 5: Example of A PIFA Antenna with Plastic Bracket

Notes:

1. The antenna needs 3 feed points, the middle one is signal feed point, the other two are ground feed points. When bandwidth of a high-frequency band is not enough during tuning the antenna, one ground feed point will be used to increase the bandwidth.
2. Ground copper is required under antenna area on the main PCB.
3. For GSM quad-band antennas, the height of bracket (marked as "d") should be about 8mm.
4. For old model of PIFA antennas, clearance area should be no less than 30mm×20mm and the height of bracket ("d") is no less than 8mm.

3.3. Monopole Antennas



Figure 6: Example of An FPC Monopole Antenna



Figure 7: Example of An FPC Monopole Antenna Pasted inside the Casing

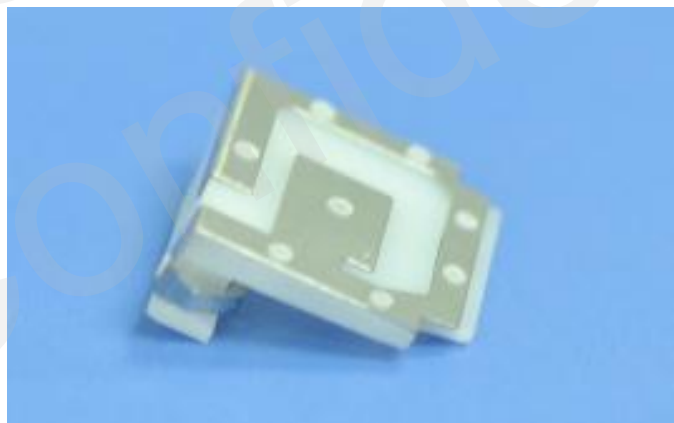


Figure 8: Example of A Monopole Antenna with Plastic Bracket

Notes:

1. Generally, the antenna only has one signal feed point. When bandwidth of a high-frequency band is not enough during tuning the antenna, a ground feed point should be used to increase the bandwidth.
2. A certain clearance area in all layers under antenna of main PCB is required.

3. For GSM dual-band antennas, the height of the bracket should be more than 6mm and the projected area should be more than 360mm². For GSM quad-band antennas, the height of the bracket should be more than 8mm and the projected area should be more than 400mm². Meanwhile, the clearance area should be no less than 30mm×20mm, and the height is recommended to be 7mm.

3.4. FPC Dipole Antennas



Figure 9: Example of A Dipole Antenna with FPC Form

Note:

The distance between inner edge of antenna and the ground of main PCB (marked as “d”) should be more than 8mm.

3.5. PCB Antennas

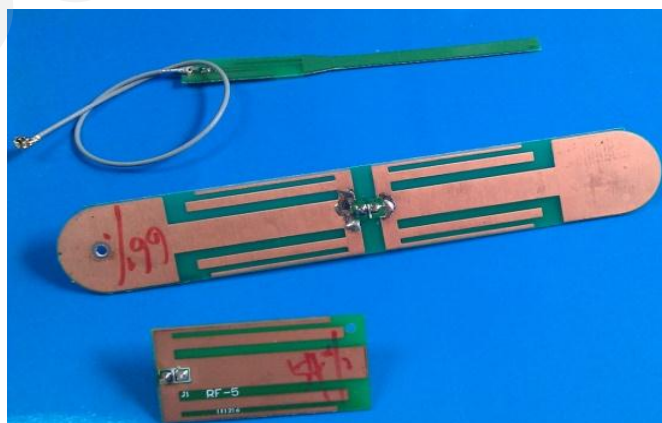


Figure 10: Example of PCB Antennas



Figure 11: Practical Application of PCB Antennas

Notes:

1. The antenna can be fixed to plastic box and does not occupy any space on the main PCB. It will be better if the antenna is mounted in a suitable notch.
2. There should be no metal material around antenna, and keep the antenna at least 8mm away from the main PCB.
3. Antenna can be connected by RF connector or soldered onto the RF output port on the main PCB.

3.6. Chip Antennas



Figure 12: Example of A Ceramic Chip Antenna

Notes:

1. RF performance of the chip antenna mainly depends on the radiation ground on both sides of the antenna, so the antenna should be placed in the middle of the PCB edge, and keep at least 30mm away from the edge of the radiation ground (marked as "d").
2. A certain clearance area in all layers under antenna of main PCB is required.
3. The antenna can be packaged in SMT type.

3.7. Laser Direct Structure Antennas



Figure 13: Example of A Laser Direct Structure Antenna

Notes:

1. The antenna features high compatibility and precision, stable performance as well as simple and environment-friendly manufacturing process.
2. The signals of the antenna are radiated onto a device shell to prevent the interference of the components inside the device and ensure the signal quality of device. Meanwhile, its space-saving design makes the device smaller and thinner.
3. The cost of an LDS antenna is higher than a common one.

3.8. Metal Frame Antennas

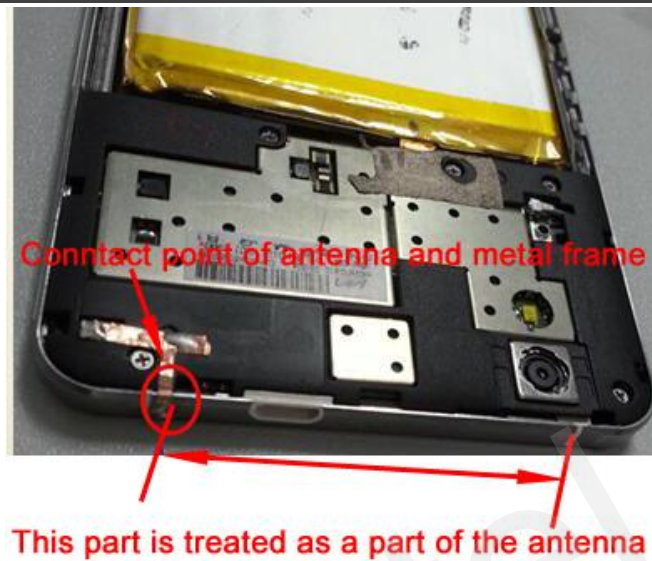


Figure 14: Example of A Metal Frame Antenna

Notes:

1. It is the mainstream 4G antenna, and the metal frame of the device is a part of the antenna. Generally, frequency bands can be switched. There are three feed points on the small main board, the middle one is the signal feed point, the other two are ground feed points in metal shrapnel format. The shrapnel connects the antenna with the metal frame, and the optimal contact point during antenna tuning is the location where the shrapnel is designed.
2. The clearance area in all layers under antenna of the main PCB should be 45mm×10mm, and the height of the bracket should be 7mm.
3. Breaks should be symmetrically designed to isolate the antenna and the metal frame.

4 External 2G/3G/4G Antennas

4.1. Dipole Antennas

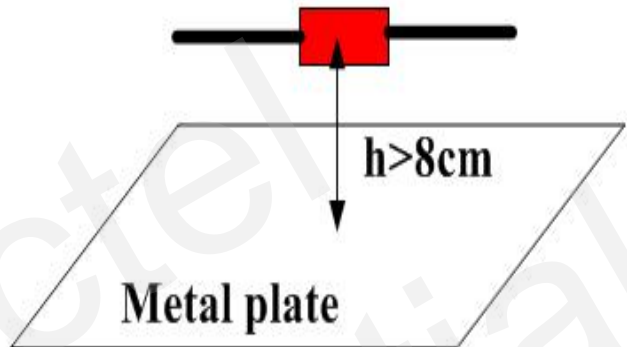


Figure 15: Example of A Dipole Antenna

Notes:

1. The height between antenna and metal plate "h" should be more than 8cm.
2. The length of cable should be as short as possible. The copper wire mesh should be as dense as possible, that is, the quantity for surround copper lines used to shield signal should be no less than 32.

4.2. Monopole Antennas



Figure 16: Example of Monopole Antennas

Notes:

1. There should be no other metal poles within 200mm of the antenna.
2. VSWR for stubby antenna should be less than 4, and VSWR for vehicle with long cable should be less than 2.
3. The length of cable should be as short as possible, and the quantity for surround copper lines used to shield signal should be no less than 32.

4.3. PCB Antennas

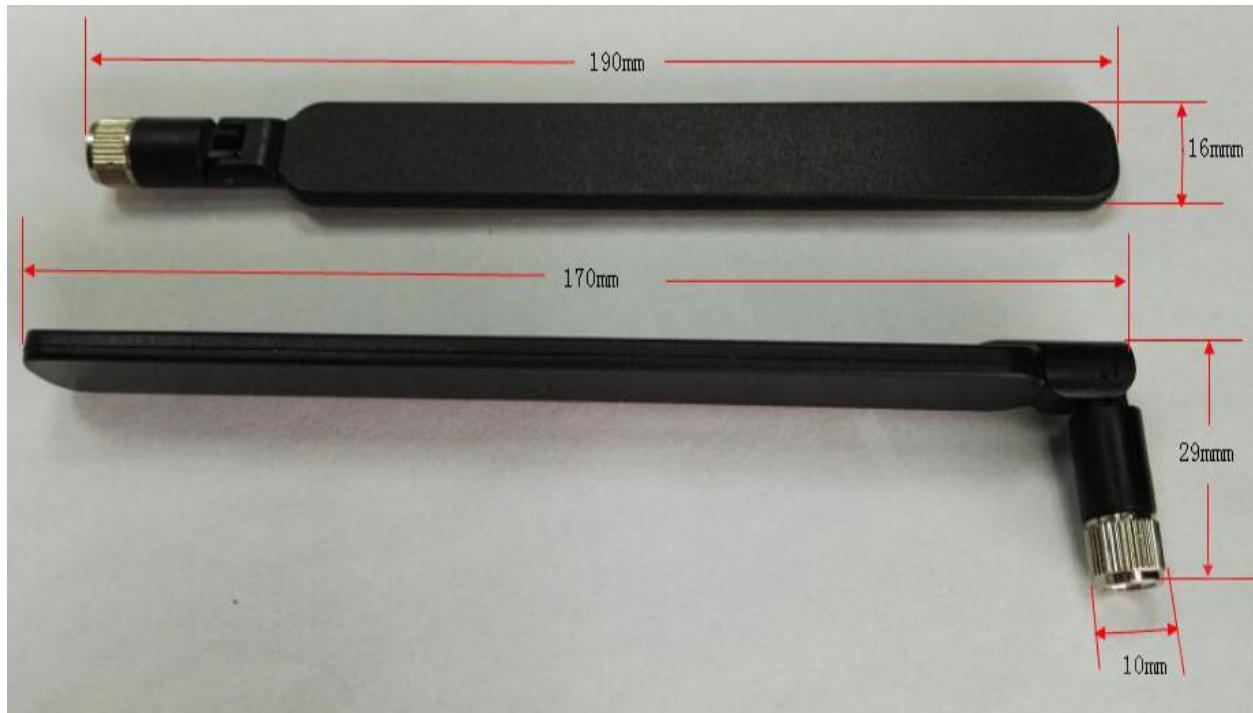


Figure 17: Example of PCB Antennas

Notes:

1. The external PCB antennas feature stable and superior performance.
3. Keep the antennas perpendicular to the ground and avoid being surrounded by metal objects.
4. As two branches of LTE antennas, the main antennas are responsible for sending and receiving signals and the diversity antennas are only responsible for receiving signals. Diversity antennas mainly resist multipath fading and fast fading. Considering the receive gain of diversity antennas is much worse than main antennas, the gain of diversity antennas should be controlled under 3dBi.
5. Attention should be paid to the relative position between main antennas and diversity antennas, the overall performance would be better when distance is larger than 10dB between antennas in view of distance and polarization isolation. And main antennas and diversity antennas should NOT be placed at the same edge of the host.
6. The multi-antenna technology (MIMO) has the ability to transmit high-speed data and resist interference.

5 Internal GPS Antennas

5.1. Internal GPS Antennas with An RF Connector

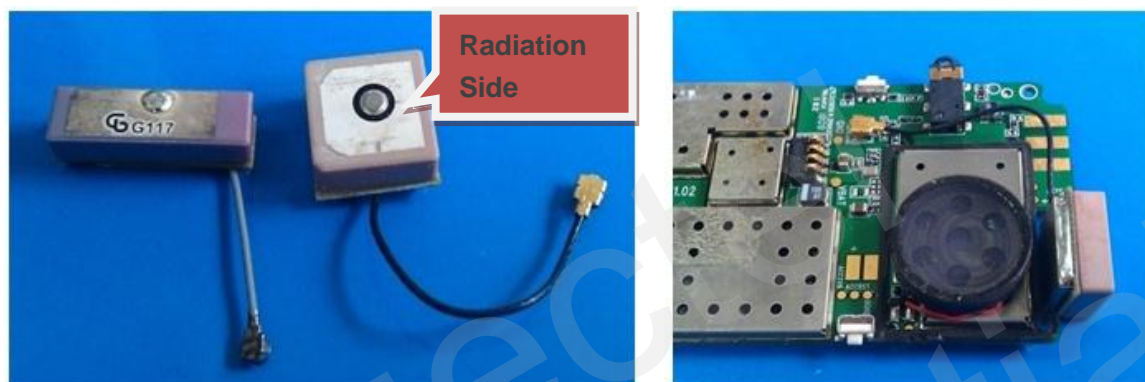


Figure 18: Example of Internal GPS Antennas with An RF Connector

Notes:

1. The antenna has an LNA to improve signal strength, please keep antenna radiation side towards open sky during practical applications.
2. Make sure the height of metal component nearby is lower than the antenna.
3. Square-shaped antenna is right hand circular polarized, rectangle-shaped antenna is linear polarized, and the former is preferred.
4. Keep RF cable as short as possible, and low loss cable is recommended.

5.2. Internal GPS Patch Antennas with A Welding Needle

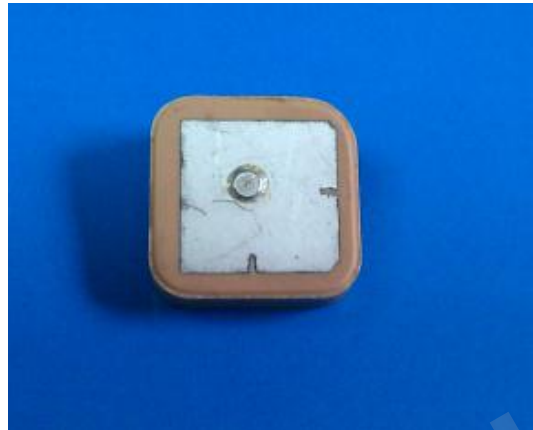
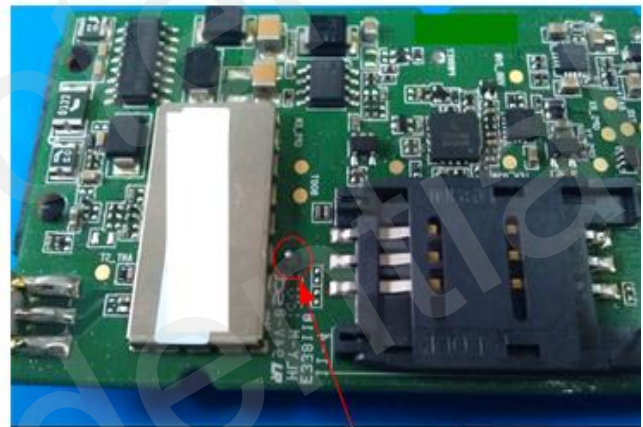


Figure 19: Example of An Internal GPS Patch Antenna with A Welding Needle



GPS patch antenna

Top side



GPS patch antenna
feed point

Bottom side

Figure 20: Practical Application of GPS Patch Antennas with Welding Needle

Notes:

1. The antenna has an LNA to improve signal strength, please keep antenna radiation side towards open sky during practical application.
2. Make sure the height of metal component nearby is lower than the antenna.
3. Square-shaped antenna is right hand circular polarized, rectangle-shape antenna is linear polarized, and the former is preferred.

6 External GPS Antennas

6.1. External GPS Antennas



Figure 21: Example of An External GPS Antenna

Notes:

1. Keep antenna radiation side towards open sky during practical application.
2. The antenna should be placed away from metal components.
3. Square-shape antenna is right hand circular polarized, rectangle-shaped is linear polarized, and the former is preferred.
4. Keep RF cable as short as possible, and the quantity for surround copper lines used to shield signal should be no less than 32.

7 Internal Wi-Fi Laminated Antenna

7.1. Internal Wi-Fi Laminated Antenna



Figure 22: Example of An Embedded Wi-Fi Laminated Antenna

Notes:

1. The antenna adopts 2.4GHz and 5GHz bands, and can realize the best performance to a certain direction. The distance between the antenna and main board is preferred to be 20mm.
2. The antenna should be placed away from metal components.
3. The top patch antenna in green color is for 5GHz, and ceramic antenna in white color is for 2.4GHz, and both of them are designed as right hand circular polarized.
4. Keep RF cable as short as possible and low loss cable is recommended.

8 Antenna Suppliers Information

| Antenna Manufacturer | Address | Contact Information | | | Main Products |
|----------------------|---|------------------------------------|-------|--|--|
| SAINTENNA | 2 nd Floor, Building 8, No.611, Baoqi Road, Baoshan District, Shanghai, China | Wu Xiaofang | Fax: | +86-21-36307757 | Offers all kinds of internal/external antennas and LTE/ NB-IoT/ WCDMA/ GPS/GNSS/Wi-Fi/ GSM antennas. |
| | | | Mail: | wuxiaofang@saintenna.com | |
| | | | Tel: | +86-021-36307754 +86-152-2100-5199 | |
| JESONCOM | No.358, Liuyuan Road., Baoshan District, Shanghai, China | Zhang Yuegang/ Yu Donglin | Tel: | +86-18101816628 +86-18621850533 | Offers all kinds of internal/external antennas and LTE/ NB-IoT/ WCDMA/ GPS/GNSS/EVDO/ GSM antennas. |
| | | | Fax: | +86-21-66276923 | |
| | | | Mail: | Alex.zhang@shjesoncom.com | |
| | | | Web: | www.shjesoncom.com | |
| SHEN XUN | 2nd Floor, Building 3, No. 2710 Fengxiang Road, Jiading District, Shanghai, China | Li Xuanwen | Tel: | +86-135-6499-3005 | Offers all kinds of internal/external antennas and LTE/ NB-IoT/ WCDMA/ GPS/GNSS/EVDO/ GSM antennas. |
| | | | Fax: | 021-69986369 | |
| | | | Mail: | lxw@sh-shenxun.com | |
| | | | Web: | www.sh-shenxun.com | |
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| | | | Web: | www.pulseelectronics.com | |
| INPAQ | 4 th Floor, Zhao Feng Universe Building Block D, No. 1800, Zhongshan West Road, Xuhui District, Shanghai, China | Chen Tiantian | Tel: | +86-134-7249-1553 021-64400398-2681 6 | INPAQ offers all kinds of GPS/GLONASS antennas such as patch antennas, active antennas, chip antennas as well as customized antennas. |
| | | | Mail: | tt.chen@inpaqgp.com | |
| | | | Web: | www.inpaq.com.tw | |

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