

# Antenna Design Note

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# About the Document

## History

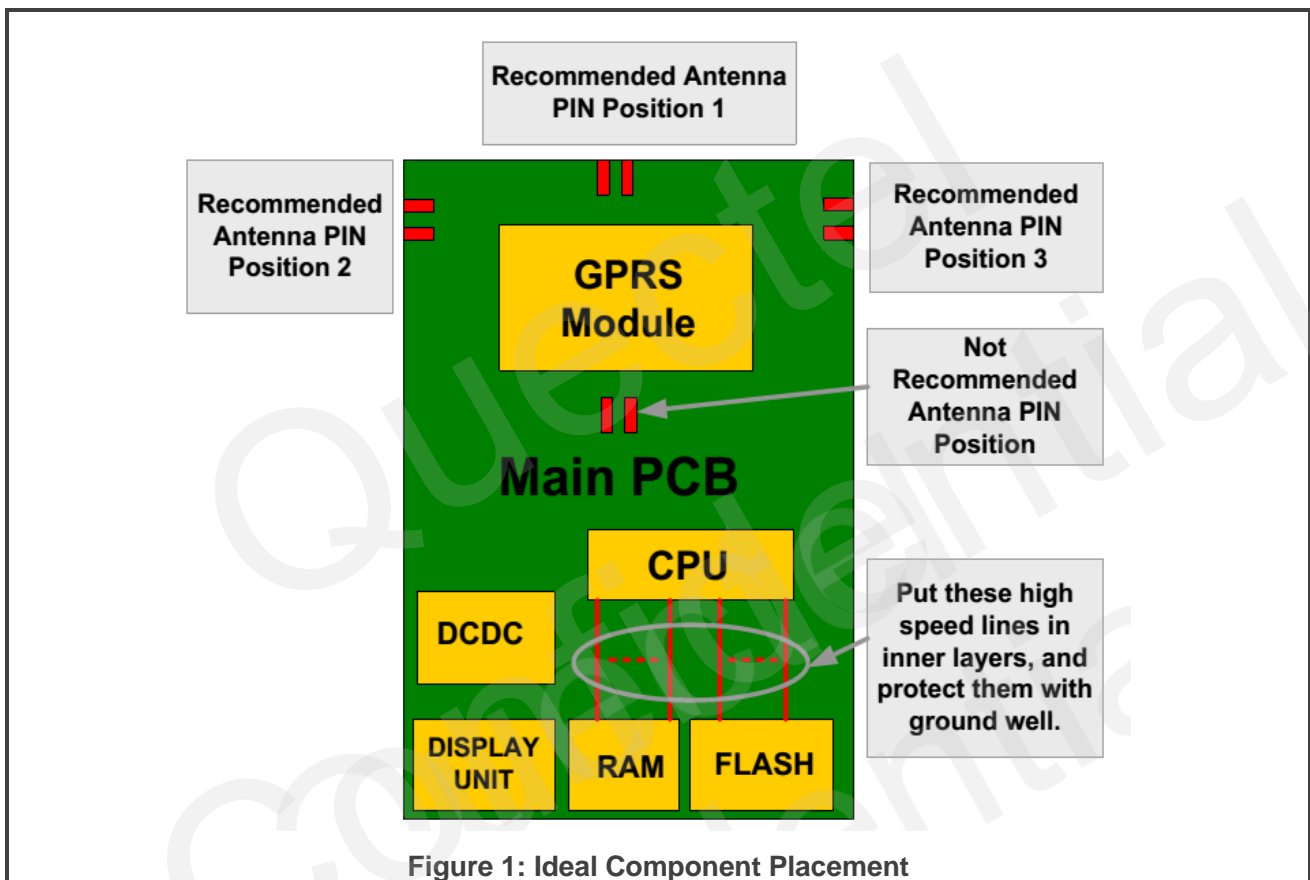
Revision	Date	Author	Description
1.0	2012-06-09	David WEI	Initial
1.1	2012-06-15	David WEI	Modified Figure 1
1.2	2012-08-01	David WEI	Added contact information for antenna manufacturers: Antenova and Pulse Electronics
1.3	2012-11-21	David WEI	Added contact information for GLONASS antenna manufacturer INPAQ
1.4	2013-07-10	David WEI	1. Added ceramic chip antenna 2. Updated contact information
1.5	2014-11-21	Jackie WANG	Added the antenna performance and LDS antenna
1.6	2015-04-11	Jackie WANG	Added applicable modules
1.7	2016-01-06	Mark ZHANG	1. Added external PCB antenna 2. Added contact information for antenna manufacturer SAINTENNA and JINGHONG
1.8	2016-06-01	Mark ZHANG	1. Updated the contact information of antenna manufacturer JESONCOM 2. Updated the address and contact information of antenna manufacturer Antenova

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# 1 Recommended Component Placement of Main PCB

This document is applicable to all Quectel modules.



## Notes:

1. It is suggested to keep the RF ports on the outer side of PCB when displaying the module.
2. Put antenna pin at the edge of the main PCB, not in the center.
3. Keep antenna as far away from CPU\FLASH\DCDC\DISPLAY FPC as possible. It is preferred to place the antenna in the different side of CPU\FLASH\DCDC\DISPLAY CONNECTOR.
4. Keep the high speed lines between CPU and DISPLAY as short as possible, put these lines in inner layers and protect them with ground as well as possible. Add some EMI filters in the lines if necessary
5. Put CPU\FLASH\DCDC\DISPLAY ZIF in shield case.

## 2 Basic Parameters and Requirements of Antenna

### 2.1. Basic Parameters of Antenna

**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:

$$\text{dBi} = 2.15 + \text{dBd}$$

**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.

**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:

$$\text{EIRP} = P * G \text{ (Here } P \text{ is radiation power, } G \text{ is antenna gain indicated in dBi.)}$$

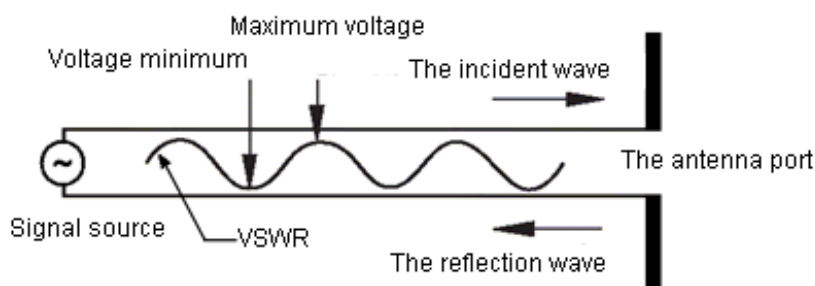
**PEIRP (Peak Effective Isotropic Radiated Power):** The peak value of EIRP.

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

$$\text{EIRP} = P * G \text{ (Here } P \text{ is radiation power, } G \text{ is antenna gain indicated in dBd.)}$$

**VSWR (Voltage Standing Wave Ratio):**

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



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

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

VSWR(K)	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 Antenna

Table 1: Basic Requirements of Antenna

Type	Requirements
Frequency Range	According to the operating band of device
VSWR	$\leq 3$
Gain (dBi)	$\geq 1$
Max Input Power (W)	50
Input Impedance ( $\Omega$ )	50
Polarization Type	Vertical linear polarization (GSM/WCDMA CDMA2000 TD-SCDMA/LTE) Right hand circular polarization (GPS)

# 3 Embedded 2G/3G/4G Antenna

## 3.1. PIFA Antenna with FPC Form



Figure 2: Example of FPC PIFA Antenna with Welding Pads and Feed Points

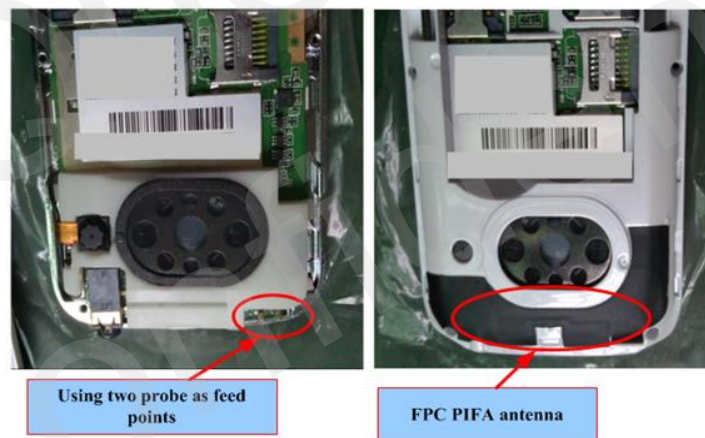


Figure 3: Example of FPC PIFA Antenna with Spring Probes as Feed Points

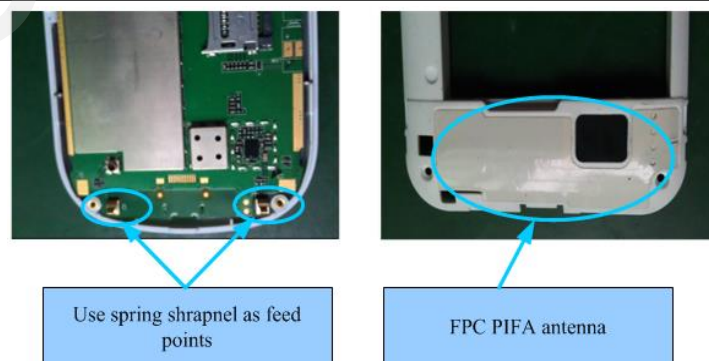


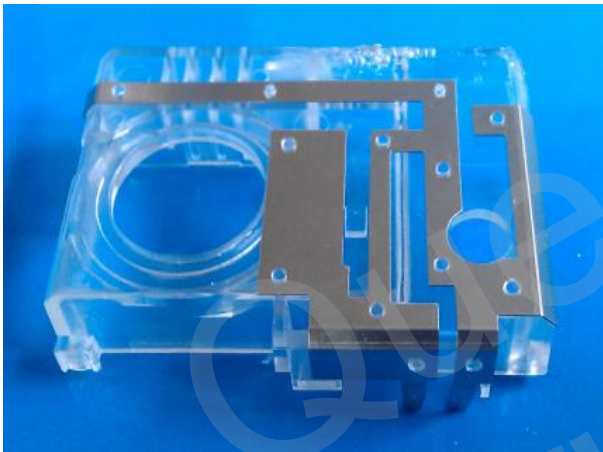
Figure 4: FPC PIFA Antenna with Spring Shrapnel as Feed Points



**Notes:**

1. FPC PIFA antenna can be pasted in the casing, which can save space especially for PDA and vehicle device.
2. Keep the distance between antenna and main PCB at least 5 millimeters.
3. Ground copper is required under antenna area in the main PCB.
4. Feed points can be designed as spring probes, shrapnel, welding pads. For more reliability, some melted plastic leg can be designed inside the device casing.

### 3.2. PIFA Antenna with Plastic Bracket



**Figure 5: PIFA Antenna with Plastic Bracket**

**Notes:**

1. This kind of antenna needs 2 or 3 pins, one is for RF pin and the other (two) is for ground.
2. Ground copper is required under antenna area in the main PCB.
3. For dual band, antenna projected area "A" is no less than 500 square millimeters, the height "d" is no less than 7mm.
4. For quad band, antenna projected area "A" is no less than 600 square millimeters, the height "d" is no less than 9mm.

### 3.3. Monopole Antenna



Figure 6: Example of FPC Monopole Antenna



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

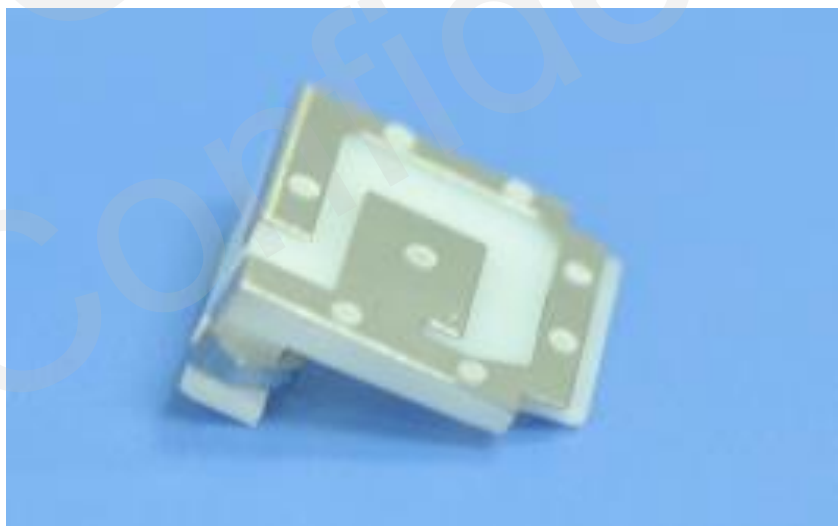


Figure 8: Monopole Antenna with Plastic Bracket

**Notes:**

1. This kind of antenna only has one feed point.
2. A certain clearance area in all layers under antenna of host PCB is required.
3. For dual band antenna, the height of the bracket is more than 6mm and the clearance area in PCB

should be more than 360 square millimeters. For quad band, the height and clearance area should be 8mm and 400 square millimeters respectively.

### 3.4. FPC Dipole Antenna



Figure 9: Example of Dipole Antenna with FPC Form

**Note:**

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

### 3.5. PCB Antenna



Figure 10: Example of PCB Antenna



Figure 11: Example of Practical Applications of PCB Antenna

**Notes:**

1. This kind of antenna can be fixed to plastic box and does not need any host PCB area. It will be better if the antenna is mounted in suitable notch.
2. There should be no metal material around antenna.
3. Antenna can be connected by RF connector or welding pad.

### 3.6. Chip Antenna

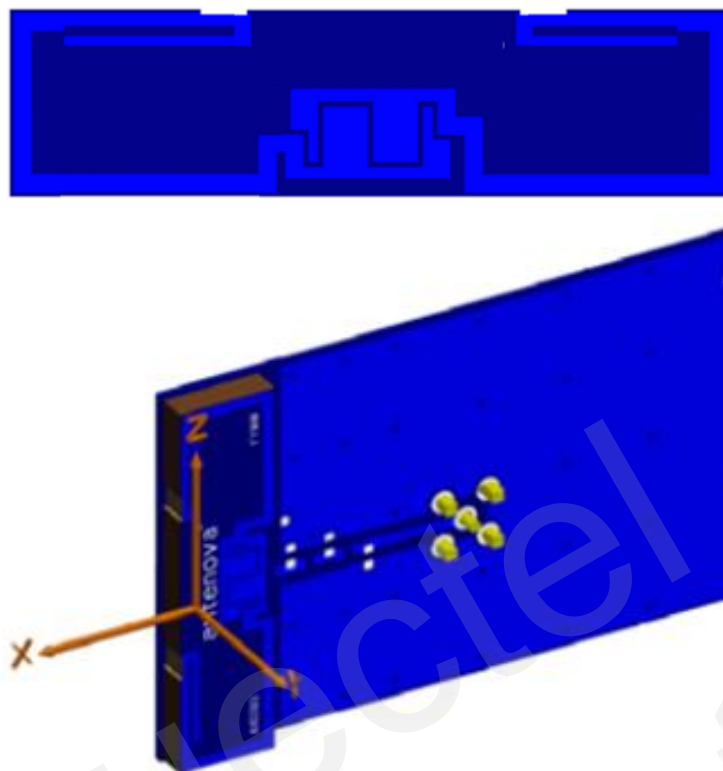


Figure 12: Example of Ceramic Chip Antenna

**Notes:**

1. This kind of antenna needs enough main PCB size.
2. There should be no metal material under antenna.
3. This kind of antenna should be placed on the edge of main PCB and can be packaged in SMT type.

### 3.7. Laser Direct Structure Antenna



**Figure 13: Example of Laser Direct Structure Antenna**

**Notes:**

1. The performance of the antenna is stable and has good consistency and high precision. Manufacturing cycle is short. There is no need of circuit graphics mould. And it is the green product as well.
2. The antenna is radiated on the mobile phone shell to prevent the interference of mobile phone internal components, thus the signal is stable.
3. It is easier to make the device smaller and thinner.
4. The cost of LDS antenna is higher than common type because of the complex production process.



## 4 External 2G/3G/4G Antenna

### 4.1. Dipole Antenna

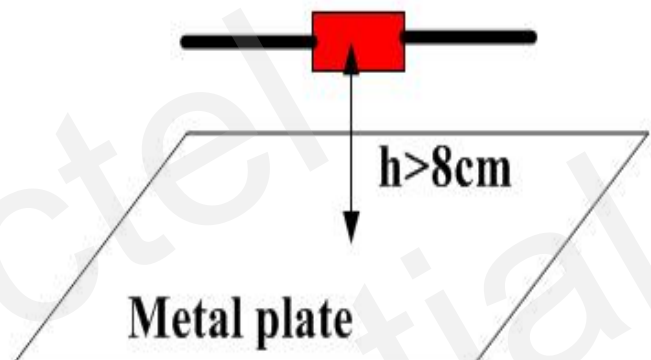


Figure 14: Example of Dipole Antenna

**Notes:**

1. The height between antenna and main metal board "h" should be more than 8 centimeters.
2. The length of cable should be as short as possible. The shield copper wire net of the cable should be as dense as possible. The quantity for surround copper lines used to shield signal should be no less than 32.

## 4.2. Monopole Antenna



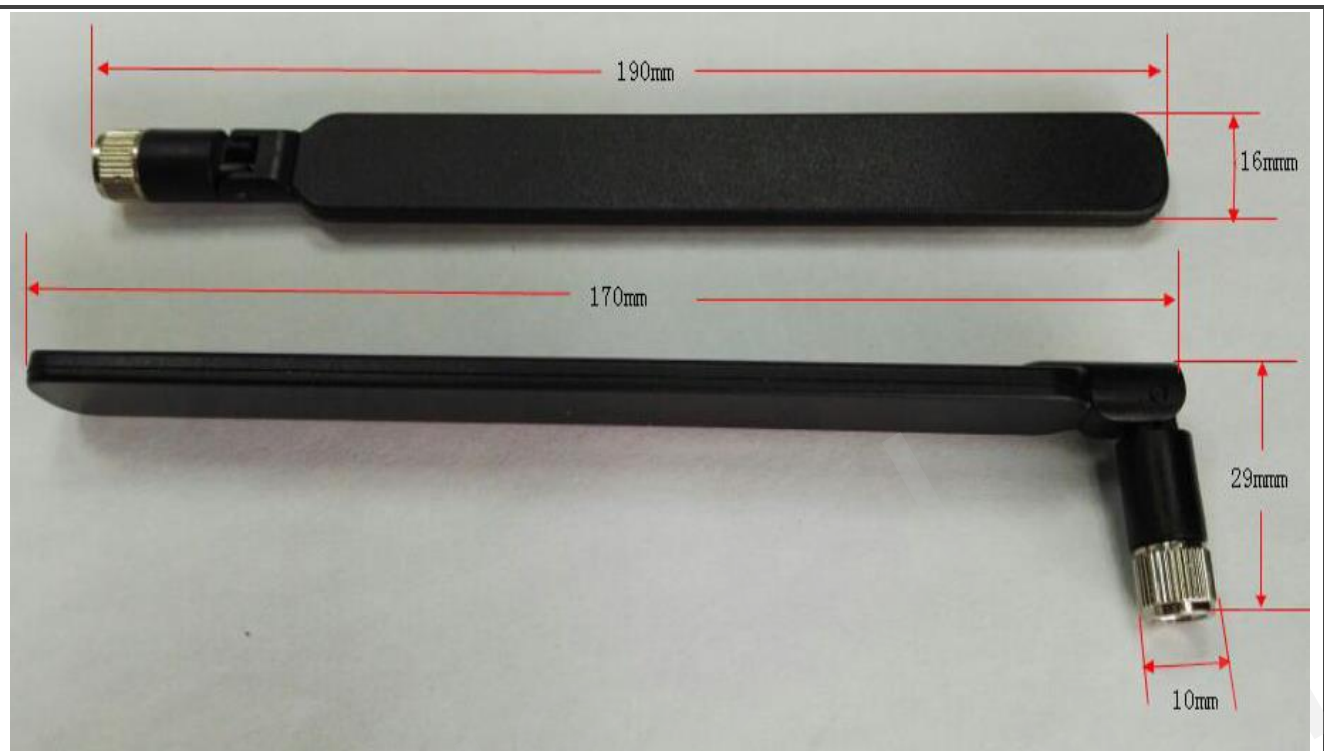
**Figure 15: Example of Practical Monopole Antennas**

**Notes:**

1. There should be no other metal pole 200 millimeters around 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. The quantity for surround copper lines used to shield signal should be no less than 32.



### 4.3. PCB Antenna



**Figure 16: Example of PCB Antenna**

**Notes:**

1. The performance of the external antenna is stable and superior.
3. Keep antenna perpendicular to the ground and avoid being surrounded by metal objects.
4. As two branches of LTE antenna, the main antenna is responsible for sending and receiving signals and the diversity antenna is only responsible for receiving signals. Diversity antenna mainly resists multipath fading and fast fading. Considering the receive gain of diversity antenna is much worse than main antenna, the gain of diversity antenna should be controlled under 3dBi.
5. Attention should be paid to the relative position between main antenna and diversity antenna, the overall performance would be better when isolation is less than 10dB between antennas in view of distance and polarization isolation.
6. The multi-antenna technology (MIMO) has the ability to transmit high-speed data and resist interference in the future.

# 5 Embedded GPS Antenna

## 5.1. Example of Embedded GPS Antenna with RF Connector



**Figure17: Example of Embedded GPS Antenna with RF Connector**

**Notes:**

1. Keep antenna radiation side towards open sky during practical application.
2. Be sure the height of metal component nearby is lower than antenna radiation side.
3. Square shape is RHCP polarization, rectangle shape is linear polarization, and the former is preferred.
4. Keep RF cable line as short as possible.

## 5.2. Embedded GPS Patch Antenna with Welding Needle

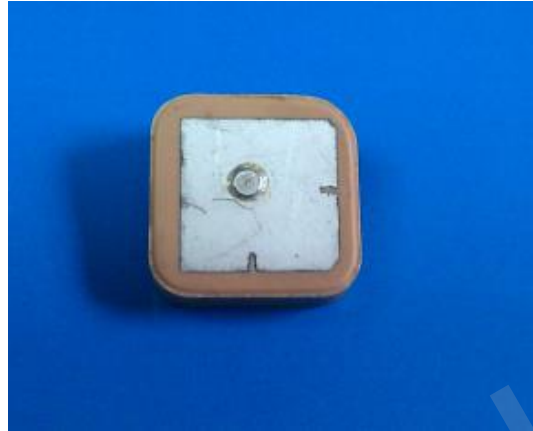
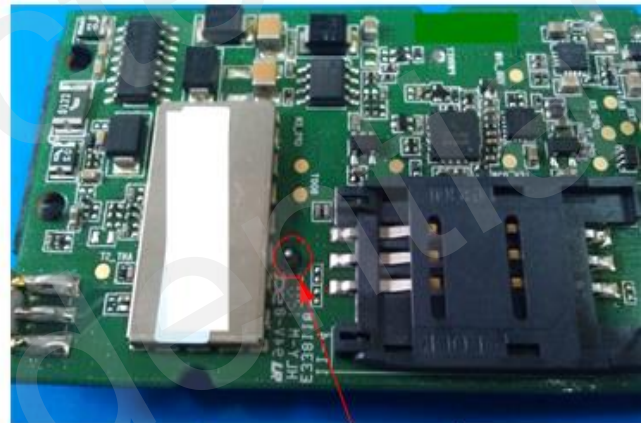


Figure18: Example of Embedded GPS Patch Antenna with Welding Needle



GPS patch antenna

**Top side**



GPS patch antenna  
feed point

**Bottom side**

Figure 19: Example of Practical Application of GPS Patch Antenna with Welding Needle

**Notes:**

1. Keep antenna radiation side towards open sky during practical application.
2. Be sure the height of metal component nearby is lower than antenna radiation side.
3. Square shape is RHCP polarization, rectangle shape is linear polarization, and the former is preferred.

# 6 External GPS Antenna

## 6.1. External GPS Antenna



**Figure 20: Example of External GPS Antenna**

**Notes:**

1. Keep antenna radiation side towards open sky during practical application.
2. Be sure the height of metal component nearby is lower than antenna radiation side.
3. Square shape is RHCP polarization, rectangle shape is linear polarization, and the former is preferred.
4. Keep RF cable line as short as possible.

# 7 Antenna Suppliers Information

Antenna Manufacturer	Address	Contact Information			Main Products
GSM Antenna Manufacturer					
SAINTENNA	2nd Floor, 8th Building, No.611, Baoqi Road, Baoshan District, Shanghai	Robin Yu	Fax	+86-21-36307757	All kinds of embedded and external antenna which supports LTE, WCDMA, EVDO, GSM etc.
			Mail	<a href="mailto:robin.yu@saintenna.com">robin.yu@saintenna.com</a>	
			Phone	+86-21-36307732 +86-13817683329	
JINGHONG	Room 501, 9th Building, No.518 XinZhuan Road, Caohejing Development Zone, Shanghai, China	Daniel Ding	Fax	+86-21-37632209	JINGHONG offers all kinds of antennas suited for GSM and CDMA, 3G, 4G, LTE, GPS and Wi-Fi.
			Mail	<a href="mailto:daniel.ding@wireless-sh.com">daniel.ding@wireless-sh.com</a>	
			Phone	+86-21-67766362 +86-13818493259	
			Web	<a href="http://www.jinghong-sh.com">Http://www.jinghong-sh.com</a>	
JESONCOM	No.358, Liuyuan Road., Baoshan District, Shanghai, China	Yuegang Zhang	Phone	+86-18101816628	All kinds of embedded and external antenna which supports WCDMA, EVDO, GSM, GPS/GLONASS etc.
			Fax	+86-21-66276923	
			Mail	<a href="mailto:Alex.zhang@shjesoncom.com">Alex.zhang@shjesoncom.com</a>	
			Web	<a href="http://www.shjesoncom.com">www.shjesoncom.com</a>	
Antenova	2nd floor, Titan Court, 3 Bishop Square, Hatfield, Herts AL10 9NA, United Kingdom		Fax	+44 (0) 1223 810650	Antenova's broad range of antennas and RF solutions are ideally suited for GSM and CDMA, 3G, 4G, LTE, GPS, Wi-Fi®, Bluetooth®, WiMAX™, WiBro, ZigBee®, FM, Mobile TV and M2M applications.
			Phone	+44 (0) 1223 810600	
			Mail	<a href="mailto:sales@antenova-m2m.com">sales@antenova-m2m.com</a>	
			Web	<a href="http://www.antenova-m2m.com">http://www.antenova-m2m.com</a>	

Pulse Electronics	European Headquarters Automotive Headquarters Zeppelinstrasse 15 71083 Herrenberg Germany		Fax	+49-7032-7806-12	Pulse Electronics is a leading global supplier of LTE; WLAN, 3G / 4G, Navigation, and M2M fixed and mobile solutions.
			Phone	+49-7032-7806-0	
			Mail	<a href="mailto:prodinfo.antennaseurope@pulseelectronics.com">prodinfo.antennaseurope@pulseelectronics.com</a>	
			Web	<a href="http://www.pulseelectronics.com">http://www.pulseelectronics.com</a>	
GPS&GLONASS Antenna Manufacturer					
INPAQ	No. 1800 Zhongshan West Road, 4th Floor, Zhao Feng Universe Building Block D, Xuhui District, Shanghai, China	Berry Zhou	Mob.	+86-18621809429	INPAQ offers all kinds of GPS/GLONASS antenna such as patch antenna, active antenna, chip antenna and customized antenna.
			Phone	+86-21-64400398*26812	
			Mail	<a href="mailto:berryzhou@inpaq.com">berryzhou@inpaq.com</a>	
			Web	<a href="http://www.inpaq.com.tw">http://www.inpaq.com.tw</a>	
Note: If the salesmen listed above cannot be contacted for some reason, please visit their web site and get the products and contact information.					