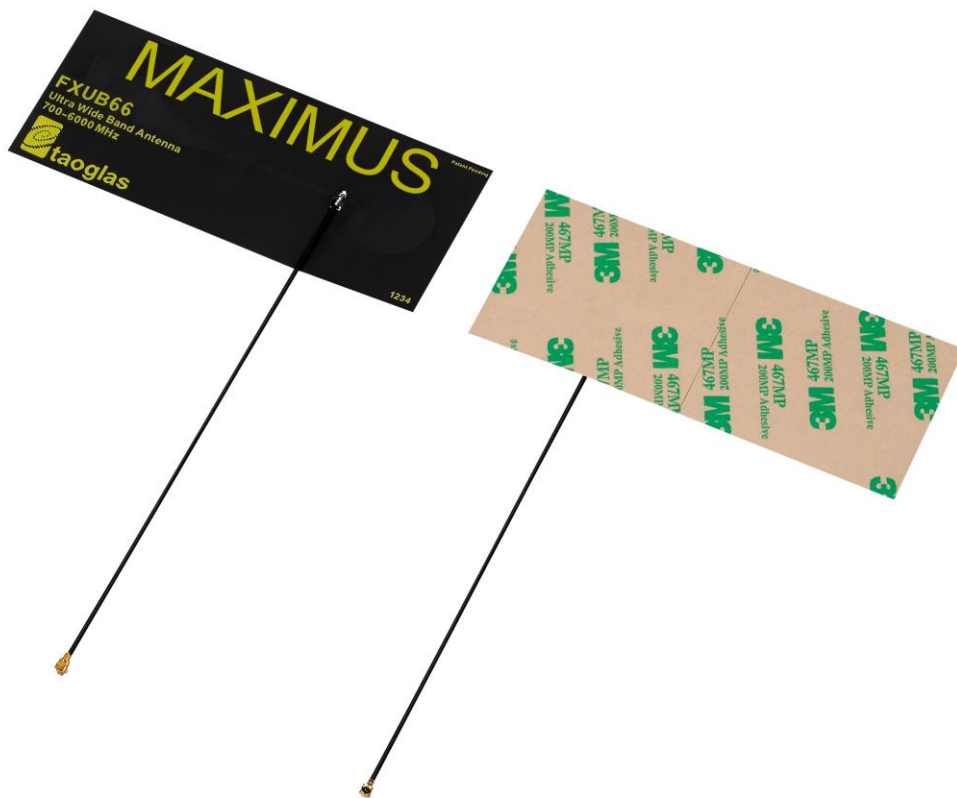


## Flexible PCB Antenna with Cable Integration Application Note





## 1. BASICS

A Flexible PCB antenna with cable is a very flexible, low profile, highly reliable, and economical solution widely used in the wireless industry.

Usually consisting of polyimide flexible PCB (polyimide), a trace is printed on the substrate to get the desired antenna topology. Various antenna types such as monopoles, dipoles, and printed F antennas can be made.

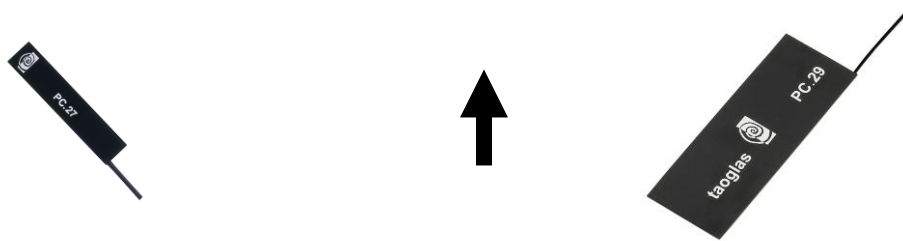
This design application note is intended to help the antenna integrator understand the relevant parameters affecting the antenna performance. Taoglas recommends that the integrator strictly follow the guidelines in this application note. Upon your device prototype completion, Taoglas can provide further optimization by offering custom tuning and testing services for the antenna in your device. (See Section 15 on Page 8 for further info on Tuning.)

## 2. APPLICATIONS

A Flexible PCB antenna with cable is suitable for mobile applications where internal antennas are required, but not much space or volume is available. It is ideally affixed to the plastic housing of a device directly by double-sided adhesive. Taoglas Flexible PCB antennas come in single-band or multi-band solutions starting from 450MHz up to 6 GHz.

### 3. SIZE

The larger the antenna surface area (or volume), in general, the higher the performance in terms of gain and radiation characteristics.



	CLR	GSM	PCS	DCS
Band	824-896	880-960	1850-1990	1710-1880
VSWR	4.76	2.2	2.28	1.89
Min. Return Loss dB	-3.71	-8.49	-8.18	-10.17

	CLR	GSM	PCS	DCS
Band	824-896	880-960	1850-1990	1710-1880
VSWR	1.92	1.65	1.4	1.92
Min. Return Loss dB	-10	-12.24	-15.55	-10.01

### 4. SHAPE AND THICKNESS

A Flexible antenna can be made into any 2D shape for ease of fit into a product.

Flexible PCB antennas are super low profile at 0.5mm.

### 5. GROUND PLANE EFFECTS

The proximity of the antenna to the device ground plane can have a major impact on performance. Radiation efficiency is the ratio of the total power radiated by the antenna to the power accepted by the antenna. If the antenna is too close to the ground plane, the radiation efficiency and radiation pattern can be diminished because the signal is basically getting trapped by the ground plane. In general, we recommend at least a 20mm clearance from the main ground-plane to maintain good antenna efficiency.

## 6. IMPEDANCE

RF circuits in mobile devices should be designed for a 50 Ohm characteristic impedance at the source (RF module), transmission line (PCB trace or coax cable), and load (antenna). In practice, the characteristic impedance of the circuit is not exactly 50 Ohms across all bands. This requires the antenna impedance to be changed to match the actual characteristic impedance of the circuit. This can be done by measuring return loss with a network analyzer or using TRP (Total Radiated Power) and TIS (Total Isotropic Sensitivity) numbers as a guide. See Section 15 for more information on tuning.

## 7. BANDWIDTH

Bandwidth is defined as the frequency band below -10dB return loss.

Taoglas PCB antennas, in general, are rated at a minimum of -7.5dB average return loss for the targeted application bands (for example GSM 850/900/1800/1900). A return loss of below -10dB is targeted for the center of the bands and -5dB return loss at band edges where it rolls off.

## 8. VSWR

VSWR (Voltage Standing Wave Ratio) is a function of the return loss, which describes the power reflected from the antenna. A lower VSWR means the antenna has a better match to the transmission line and more power is delivered to the antenna. A VSWR of 1.0 represents an ideal match. In principle, the target is to be below 1.5. In practice, a VSWR of 3.0 is reasonable for multi-band antennas in challenging environments.

## **9. GAIN**

The gain of the antenna is closely linked to the surface area or volume of the antenna. The larger the surface area or volume of the antenna, the higher the gain. Care must be taken that clearances of at least 4mm are kept from other metal components in the device or metallised substances which will absorb or reflect the electro-magnetic radiation, substantially reducing the gain. The larger the clearance, the better the radiation characteristics of the antenna. We recommend 20mm or more for best gain and radiation efficiency.

## **10. EFFICIENCY**

Antenna efficiency is the ratio of the total power radiated by the antenna to the power accepted by the antenna. Efficiency is a good overall measurement of an omni-directional antenna for mobile communication systems such as GSM and WLAN. A PCB antenna can be designed to have high efficiency (>30% to 50%+) if the antenna surface area is large enough.

It is more difficult to achieve high efficiency for more than two bands or in very compact form factor housings. Efficiency of the antenna directly relates to the TRP/TIS results of a device in OTA testing if the radio module has 50 Ohm impedance.

# 11. POLARIZATION

Polarization describes the orientation of the wave oscillation. All Taoglas cellular and broadband antennas are linearly polarized to most efficiently match with the signals broadcast from the linearly polarized antennas mounted on cellular base-stations and hot-spots. Whether it is horizontally or vertically polarized just depends on how it is mounted from your frame of reference. Standing directly in front of the antenna, the linear polarization is horizontal if the antenna is placed in a horizontal position and vertical if the antennas are placed in a vertical position. In practice, the radiation emitted and received by internal antennas will be cross-polarized due to reflections from the environment and scattering in the atmosphere to some degree.

## Horizontal-Polarization-Position \*



## Vertical-Polarization-Position \*



\*When-standing-directly-in-front-of-Antenna



## 12. ADVANTAGES of Flexible antennas with cable

- Adheres directly to inner shell of plastic housing of device
- No space needed on main-board of device
- Extremely low profile
- Design Flexibility – size, shape, cable, connector all fully customizable with minimum tooling cost
- Quick turn-around time on new designs – 2 weeks to prototypes
- Multi-band frequencies easily accommodated
- Economical pricing

## 13. MOUNTING

Taoglas flexible PCB antennas use 3M 467 double-sided adhesive for the most reliable mounting solution. Ideally, the Flexible PCB antenna is mounted close to the outer housing of the device to allow it to radiate outwards and receive signals without obstruction from internal components in the device. The antenna can be slid into a slot, screwed down, or affixed with double-sided adhesive. The cable exit point can be moved to different locations on the antenna, if needed, please [Contact us](#). Generally, the orientation of the antenna is not critical, as long as clearance from metal components is maintained.



## **14. ENVIRONMENTAL CONSIDERATIONS**

Close proximity to components or housing affects the electrical performance of all antennas. When placed within the enclosure, in most cases, there should be a clearance of 20mm in all directions from other components, metal, and ground plane for maximum efficiency. A reduction in antenna efficiency and a shift in tuned frequency will be observed if these clearances are not maintained. Proximity effects will also have an adverse effect on the radiation pattern of the antenna. Device housings should never be metal or have metal materials when using internal antennas. Most Taoglas flexible antennas are designed to be placed on 2-3mm thick ABS. Slight shifts in tuned frequency may be observed with other housing materials or other thicknesses. Some housing colorants, such as carbon black, have RF absorptive properties and can severely degrade antenna performance. Housing materials that absorb moisture, such as nylon, are also not recommended.

## **15. TUNING**

The frequencies of Flexible PCB antennas with cable are easily shifted when close to other components or if the cable is bent more than 30 degrees. This phenomenon is called "detuning". Taoglas offers Flexible PCB antenna samples to customers on the understanding that they be tested outside the device as a benchmark performance. The actual production antenna will be customized for each customer.

This is why Taoglas always offers a tuning service to its customers at the prototype integration phase. We tune the antenna to its surrounding environment within the customer's device at our lab. Samples are sent back





to the customer within 2 weeks of receiving the device along with a test report showing antenna Return Loss/VSWR, Gain, and Radiation Characteristics in the customer device. Please [Contact us](#) for service pricing.

Further services, such as optimizing the RF performance of the whole device to enable the product to pass network approvals, regulatory compliance, or specific performance targets, are offered as well.

## **16. ISOLATION**

Isolation is a measure of coupling between two different antennas. For example, in a CDMA diversity antenna plan, the target is to get -10dB isolation between the main and the auxiliary antenna. Greater isolation can be achieved by using different polarizations on the two antennas. For example, the main antenna has horizontal linear polarization and the auxiliary antenna has vertical linear polarization. In practice, this is difficult for Omni-directional internal cellular antennas as there is cross-polarization of the waves occurring. The typical solution is to keep the distance between antennas as large as possible.

The antenna cables should not cross over or come close to the other's antenna.

Isolation testing is performed by sending a signal in one antenna and measuring the power of the signal at the other antenna. There should be at least a 10dB difference between the transmit signal and the receive signal. The easiest method is to keep increasing the distance between the two antennas until the target isolation is achieved.



## **17. CABLE & CONNECTOR**

A 1.13mm diameter micro coax cable is preferred in most cellular antenna projects as the most economical solution. Cable loss is not a big factor if cable length is kept below 150mm.

The cable needs a good ground. Try to route the cable as close to the device ground as possible.

The cable should not be looped because it will cause frequency shifts and create magnetic fields which will interact with the main antenna magnetic field.

The cable should be kept away from emitting components such as LCD driver chips or CPUs.

It is preferred to use connectors on the cables for higher connection reliability, as opposed to solder. The most economical connector solution is the IPEX line of connectors which is compatible with Hirose U.FL and W.FL industry standards. Taoglas offers any cable and connector solution for the customer. Taoglas also offers the on-board mating connector and cable jumpers.