



Taoglas Guidelines

for achieving highest RF performance and
passing select regulatory approvals for cellular
devices with internal antennas



Just Ask

Please consult with Taoglas BEFORE you begin your product design to;

- Define RF Performance Targets
- Antenna options
- Layout guidelines

Why? We have found people who try to do these themselves FAIL

Before selecting the antenna or antenna design and defining the mechanical specifications for a wireless product the product designer must understand clearly the RF performance targets the product must reach in order to;

- achieve good RF performance in the field to ensure market success and
- pass all regulatory and operator approvals

Performance (The Basic concepts – TRP, TIS and RSE)

For cellular applications such as GSM or CDMA basic RF performance is measured in terms of the product being able to transmit and receive reliably on a network. The scientific way to measure performance is in an anechoic chamber.

The measurements numbers used are outlined here;

TRP – Total Radiated Power

This defines how much power is being radiated from the device and is measured in dBm. The higher this number, the better the device is able to transmit.

TIS – Total Isotropic Sensitivity

This defines how low a signal the device can receive and demodulate. The lower this number (with a minus figure) the better the device can operate in weak signal environments.

RSE – Radiated Spurious Emissions

In practice this is the most difficult test for cellular products to pass from Taoglas’ experience. These are radio waves output by the device which are above the power limit set by regulatory authorities to avoid interference. When a test confirms a radiated spurious emission over the limit either the device or the antenna must be modified to get it below the limit and thus pass certification. Otherwise the device cannot be sold in that country.

Different operators, especially in the USA (such as AT&T, Sprint etc) have specific numbers for TRP and TIS that the device must reach to be accepted on their networks. Other operators do not specifically set any requirements.

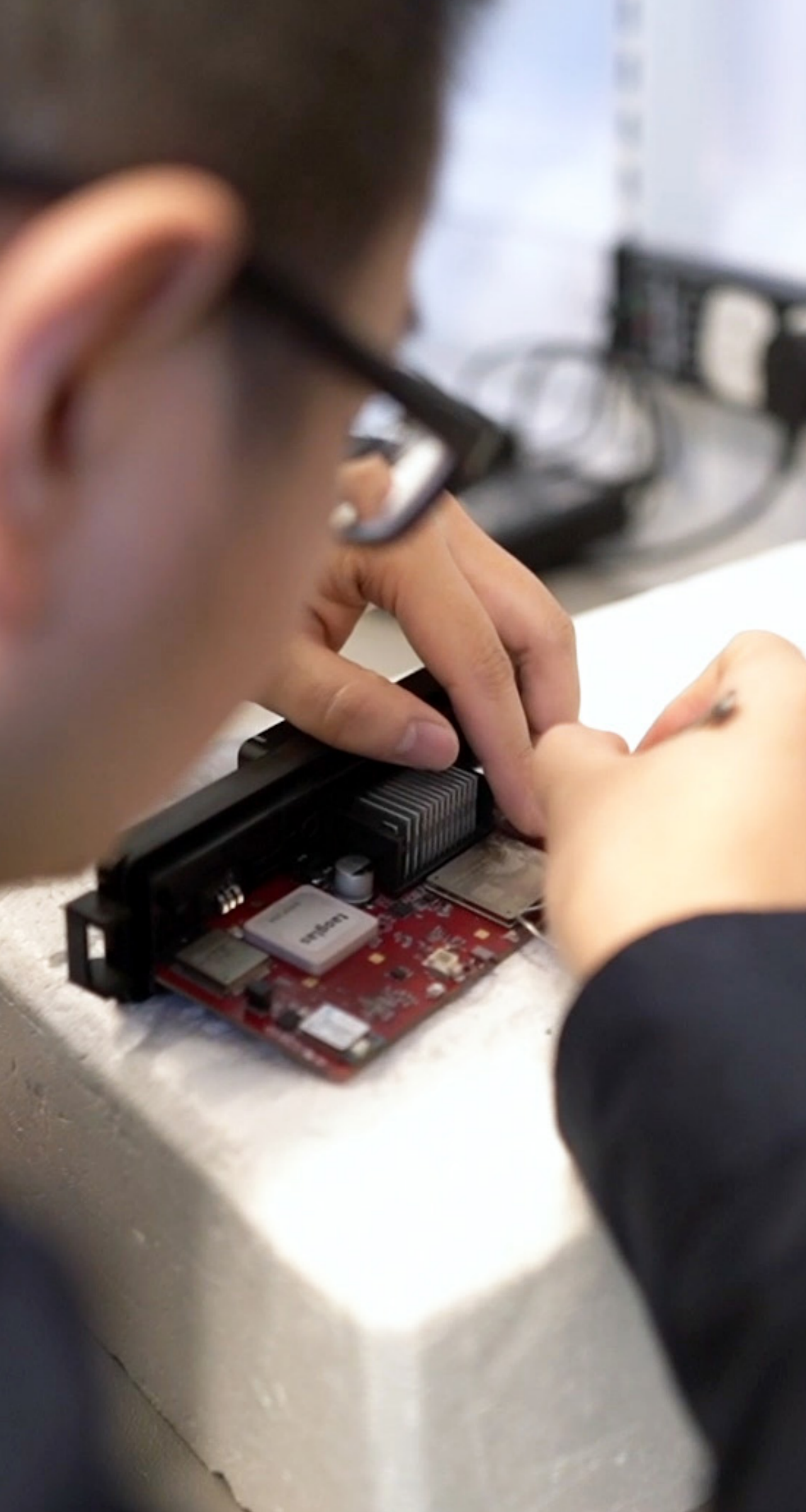
No matter if it is mandatory or not, it is our experience that the wireless products with the best TRP and TIS values succeed in the market. Passing RSE is mandatory for any operator whom requires PTCRB or type approvals. Wireless products are regulated in each country by slightly different standards. Taoglas in co-operation with certified test labs can advise on the exact regulations a product must conform to and provide a test plan.

On the right are targets to reach for passing most but not all operator TRP/TIS approvals. Some operators have specific targets for certain products or applications so you need to confirm individually. In any case these are the numbers any designer should target for their device.

Targets to reach for passing TRP/TIS approval				
	Maximum Conducted Power	TRP	Maximum Conducted Sensitivity	TIS
GSM 850	33	26	-109	-99
GSM 900	33	27	-109	-100
GSM 1800	30	24	-109	-101
GSM 1900	30	24.5	-109	-101.5
UMTS/HSPA/ HSPA+/ WCDMA 850	24	17	-109	-100
UMTS/HSPA/ HSPA+/ WCDMA 1700	24	18.5	-109	-101
UMTS/HSPA/ HSPA+/ WCDMA 1900	24	18.5	-109	-102
UMTS/HSPA/ HSPA+/ WCDMA 2100	24	18.5	-109	-103

Note: All figures in dBm

If your operator does not have a stated standard, or their standard is not mandatory it is advisable to aim for these, or higher, numbers in order to accomplish the best industry standard. Your product can in many cases still function normally below these values, there is no industry set cut-off for operation. It will depend on the actual application environment and your own conditions for what is acceptable in terms of reliability and the outcome of your own product field tests.



How are these TRP and TIS numbers calculated?

TRP

For TRP we have to work backwards from the maximum power allowed from a RF module. For most cellular modules this is capped by the FCC at 33dBm for GSM 850 and 30dBm for GSM 1900.

Let's take a specific example. Usually the module will be set at a slightly lower power rating than maximum allowed. This would mean at GSM 850 with a power level of 32dBm this leaves us 6dB of loss in the device to still pass the 26dBm target. This sounds like plenty of margin but there are a lot of losses in the system.

As the RF signal passes down a cable or a transmission line on the device board it easily loses 4dB or more. 4dB loss is **more than half the loss** of the original power coming from the module.

- When the signal reaches the antenna and is radiated out into the air it will also inevitably lose more.
- So $32\text{dBm} - 4\text{dB} = 28\text{dBm}$, meaning we need to reduce the loss from the antenna side to -2dB or less.
- This -2dB loss is equivalent to saying the antenna has an average gain of -2dB.
- Therefore we need to design an antenna that has better than average gain of -2dB for the device to reach the TRP performance required.

TIS

For TIS a similar calculation can be done. For example knowing that a network operator for GSM 850 has set a signal strength of greater than -99dBm, we can work backwards to what losses are allowed in the device for the device to still operate on the network. The majority of cellular module sensitivity is around -109dBm, therefore the device can sustain another 10dB in loss on the antenna and transmission lines/cable and still reach the operator requirements.

- This means in theory again we can budget for -4dB loss for example in the transmission line (could be less or more).
- It leaves us -6dB in loss for the antenna.
- This is equivalent to the antenna average gain of -6dB which is usually possible for the antenna designer to do.

However, **in real life** TIS is most affected by noise on the board. In many cases this noise will totally overpower the underlying GSM signal. This noise must either be removed from the system, or the antenna placed far enough away from it not to pick it up. Of course either way is very difficult to achieve when the design is complete.

What can Taoglas do to help?

Designing an optimized RF device depends on many parameters, both electrical and mechanical. Fortunately Taoglas can utilize our experienced engineers, unparalleled range of antennas and real industry experience to come out with a solid reliable process to enable a customer's product to succeed.

Antenna Type (including mechanical design and layout)

Below are some simple rules to follow for the mechanical dimensions of a product which can pass the strictest operator TRP/TIS requirements. I am sure you are asking yourself - how come I used mobile phones that clearly violate these guidelines?

Firstly they may not have targeted the above figures for device efficiency but if you look closely, most mobile phones do adhere to the guidelines below. Certain operators negotiate directly with mobile phone companies on lower TRP/TIS standards on their device on a case by case basis. These options are unlikely to be available to M2M devices.

(A) Ground planes < 65mm long

For a ground plane with a length of less than 65mm (and 40mm wide) the only solution is complete custom antenna. The type of antenna material and design will vary from device to device and the process should begin at the start of the product design process

(B) Ground planes > 65mm long

(i) On-board Antenna Solutions - Minimum width needs to be 40mm



PA-25a Ceramic Antenna

- Cleared area needs to be all the way across the short side of the board – see the application note.
- From module side to antenna it requires 10mm clearance to metal.
- Other sides must be completely free of metal.



Custom Metal PIFA Antenna

- Can work directly on ground plane on centre edge of PCB minimum height of elements 10mm, length 60mm, width 25mm.
- Clearance to other metal components ideally 20mm or greater in all directions.

(ii) Off-board Antenna Solutions – Ground plane width of the device needs to be greater than 20mm. Proven example is 80x40mm of ground plane and 20mm of clearance from antenna to metal, but in theory the ground plane of the device can be smaller



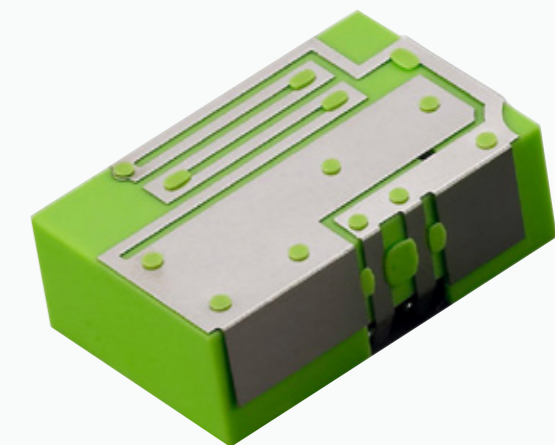
Flexible circuit antennas – FXP14

- Can be mounted to the inner plastic housing of the device.
- Minimum clearance of 20mm from metal in all directions.
- Mount at right angles (perpendicular) to any main-board.
- Cable should be shorter than 150mm but not less than 80mm.
- Place antenna away from noise / activity sources.



Rigid PCB FR4 Antennas – PC.30

- Can be mounted to the inner plastic housing of the device.
- Minimum clearance of 20mm from metal in all directions.
- Mount at right angles (perpendicular) to any main-board
- Cable should be shorter than 150mm but not less than 80mm.
- Place antenna away from noise / activity sources.



PIFA on housing

- Dimensions approximately 60 x 20mm x 10mm.
- 20mm clearance to metal.
- Spring contact can be used for connection.

PTCRB

For cellular wireless products sold in USA and Canada and other regions it is necessary to apply for PTCRB approval from the CTIA wireless association.

A designated lab will test your product to establish if it meets the requirements.

PTCRB itself does not set minimum pass/fail standards for TRP/TIS, but there is a strict RSE standard – higher than the traditional FCC test standard. So you can actually pass RSE and get PTCRB even with compromised device performance (if TRP and TIS are not considered).

Individual operators may specify their own TRP/TIS test standards and even more tests before they will accept your device on their network. Taoglas can assist wireless device designers in meeting these approvals first time around.

Disclaimer: RF design is inherently difficult. Taoglas provides this document as a reference only and cannot be held responsible for errors or omissions in this information or for the performance of devices that use this above information. Users are advised to discuss with a Taoglas representative for a formal solution proposal before proceeding on any design.





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