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|-------------------------|--------------|--|--|-----------------------------|--------|
| Author: Sierra Wireless | | Date: January 10, 2012 | | | |
| APN Content Level | BASIC | INTERMEDIATE | ADVANCED <input checked="" type="checkbox"/> | | |
| Confidentiality | | Public <input checked="" type="checkbox"/> | Private | | |
| Hardware Compatibility | Product Line | AirPrime | Series | Q26xx, Q26Extreme, Q26Elite | SL6087 |
| | | | | WMPxx | Q24NG |
| | | | | WS2x8 | Q64 |
| Software Compatibility | Series | | N/A | | |



1 Version

Application Notes may be updated over their lifetime. To ensure you design with the correct version, please check the application notes page in www.sierrawireless.com for latest versions.

2 Introduction

This Application Note (APN) is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application note, contact your regional Sierra Wireless Product Marketing Manager.

3 Application Note Description

Printed antenna is designed for Sierra Wireless GSM and GPRS embedded modules in vertical application for which SAR (Specific Absorption Rate) consideration is not required. The radiation pattern is different from helical antenna in handset as vertical application is usually intended to be used at a distance more than 20 cm from the user, hence the consideration on SAR can somehow be ignored.

4 Features Supported

- Possible PCB Antenna printed on the main PCB
- Low cost and fast development
- Frequency bands supported: GSM 900 MHz and DCS 1800 MHz only

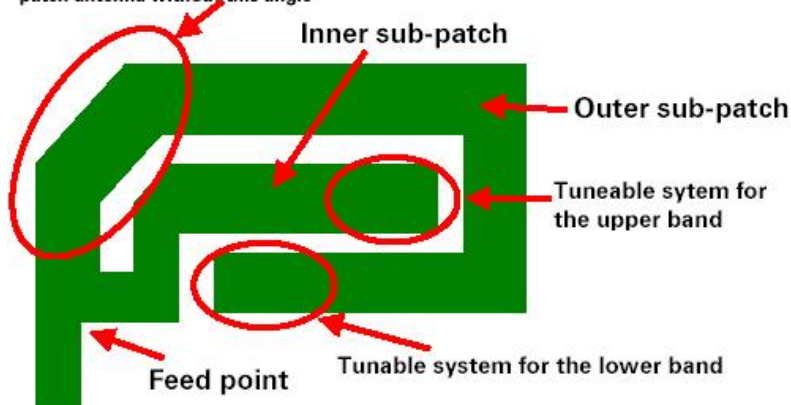
5 Application Environment

The printed antenna can be used for GSM Class 4/DCS Class 1 vertical application for which it is intended to be used at a distance of more than 20 cm from the user. Under these criteria, no SAR consideration is required. Apart from this, there is also restricted working area, with dimension of 22.5mm x 49.0mm, being reserved to the PCB antenna that the application must follow.

6 Geometry

The graph below describes the geometrical idea of the PCB antenna:

Angle on the PATCH antenna which allow directivity different compare to the same patch antenna without this angle



There is restricted area being reserved for the PCB antenna that the application must follow. The dimension of the restricted area is 22.5mm long and 49.0mm wide.

(For the exact drawing of the PCB antenna, please contact Sierra Wireless for details.)

7 Test Result

As an example, the internal antenna implemented on section 9 Reference Hardware is investigated and the test results are summarized in this section.

7.1 Directivity

The radiated performance of the PCB antenna is measured. Three orientations are checked: azimuth, elevation front and elevation side.

Note: GSM conducted output power = 32.5dBm, DCS conducted output power = 29.5dBm

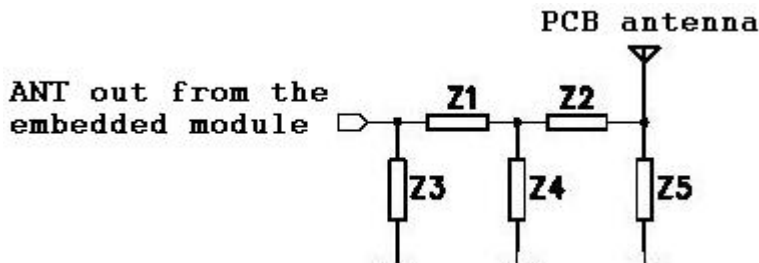
| Orientation | Maximum Radiated Power (dBm) | |
|--------------------|------------------------------|------------------|
| | GSM, channel 62 | DCS, channel 698 |
| in azimuth | 33.3 | 29.7 |
| in elevation front | 31.7 | 30.3 |
| in elevation side | 32.6 | 30.5 |

In addition, the directivity of the PCB antenna used by WLL RDP R2 is found to be quite omni directional.

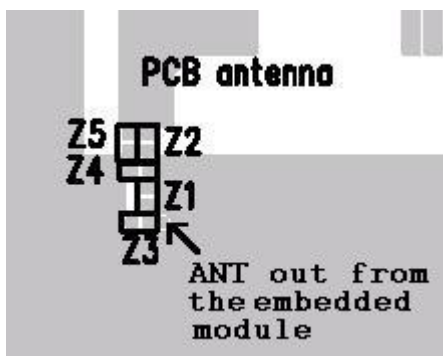
7.1.1 Caution

It is recommended to add the following matching circuit between the antenna out pin of the GSM embedded module and the feed point of the PCB antenna, with recommended PCB layout. Suppression of harmonics in radiated mode can then be achieved.

Refer to the following schematic diagram for the recommended matching circuit:



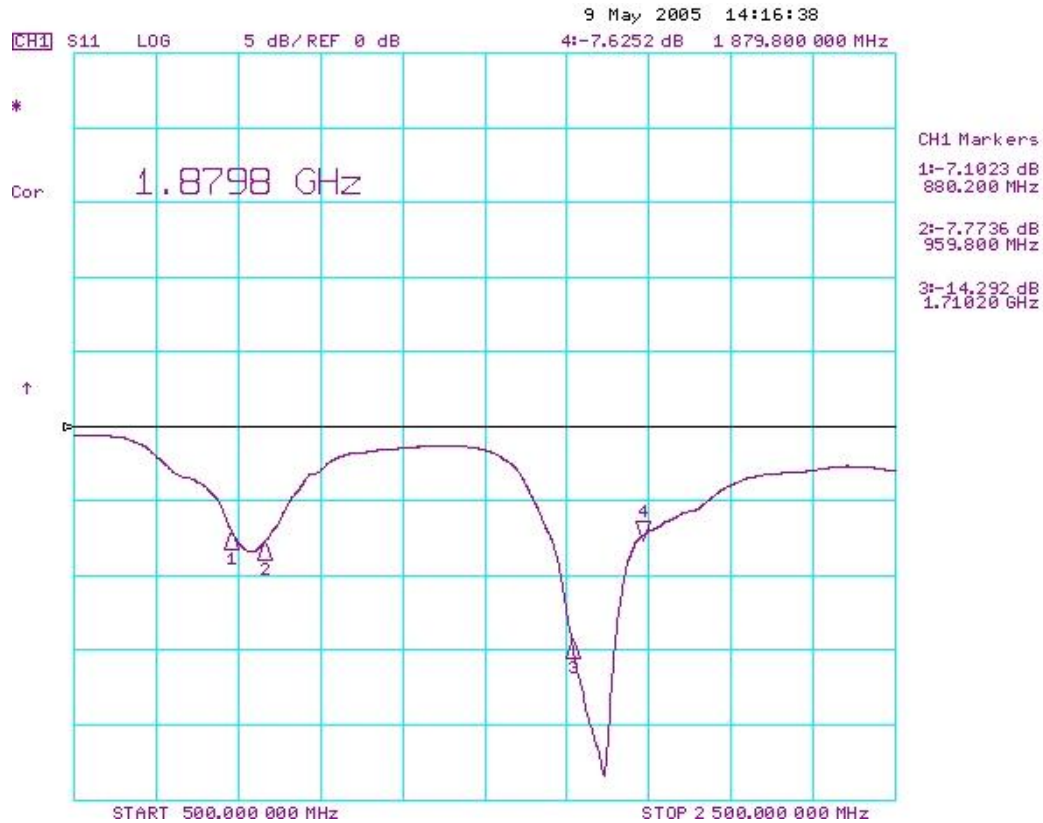
Refer to the following PCB layout for the recommended matching circuit:



The value of Z1 to Z5 will be adjusted depending on each application. At first, tests will be done with $Z1 = Z2 = 0\Omega$ and $Z3 = Z4 = Z5 = \text{Not used}$.

7.2 Performance on Return Loss, S11

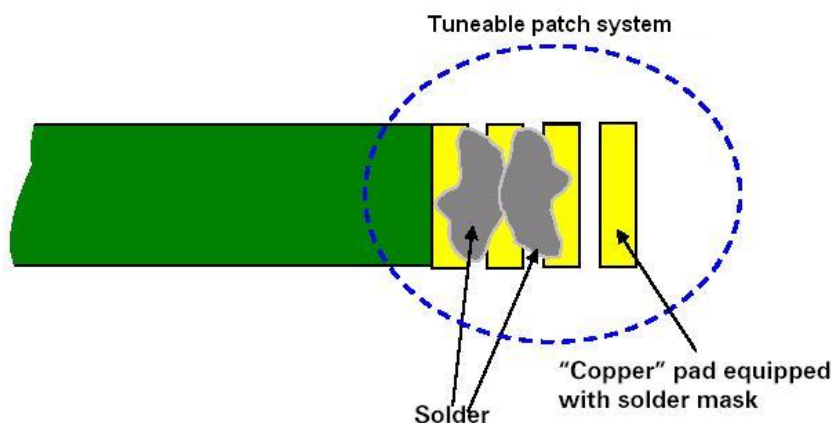
The return loss, S1,1 in log magnitude is recorded as shown below. From the result, it is found that within the operating band of both GSM and DCS, return loss better than 7dB can be achieved.



Note: The measurement above is based on the original PCB antenna without any tuning.

7.3 Tuning

There is a tuning system implemented on the PCB antenna.



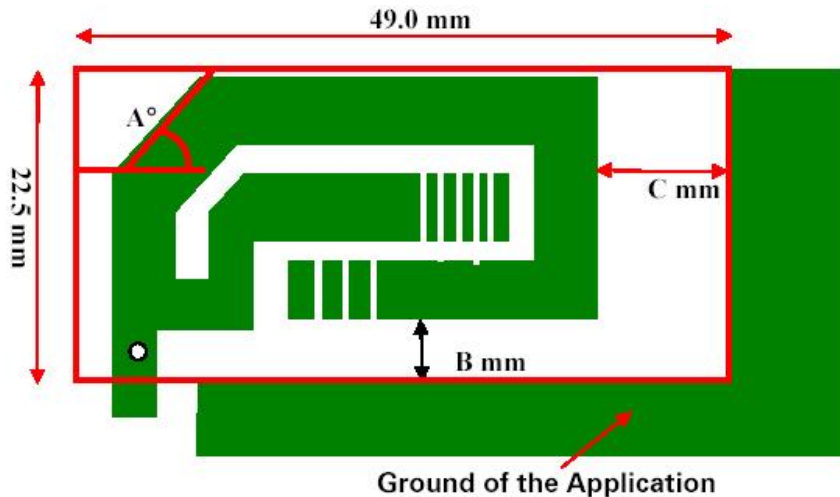
At the end of the inner and outer sub-patch, there are copper pads equipped with solder mask. Hence, the length of the sub-patch can be adjusted by shorting the adjacent copper pad by simple soldering. Increasing the length of the sub-patch will shift the operation frequency to the lower side for both bands.

Once the length is defined with a prototype, the final PCB will be adjusted (inner and outer sub-patch length) accordingly to prevent tuning in production.

8 Environmental Impact

Usually, PCB antenna is very sensitive to environmental change. Therefore, it is interesting to know the impact of such changes to the performance of the PCB antenna. Listed below are items of interest which are more practical and are likely to happen in real life.

- Thickness of the PCB used (substrate thickness)
- Casing material (either plastic or metallic)
- Grounding system on the PCB
- Shielding around the internal antenna



(For the exact drawing of the PCB antenna, please contact Sierra Wireless for details.)

The figure above shows the idea of the test. The 22.5 mm x 49.0 mm rectangle is the reserved area for the PCB antenna. Angle A is used to achieve omni directional radiation pattern. However, in this section of the test, B and C will vary to check the impact on the antenna performance.

The table below summarizes the test results of the impact on various environmental changes. This can provide the antenna designers some ideas on their final PCB antenna, especially on how to tune the PCB antenna on the final product.

Note: The environment provided by the customer application to the "Tuneable PCB Antenna" (mainly items "a" to "d" described at the beginning of this section) may introduce very unpredictable effects to the "Tuneable PCB Antenna" in a way that Sierra Wireless cannot guarantee the radiated performance of a new product using this application note. In particular, following parameters may be impacted:

*Frequency bandwidth,
 Impedance,
 Radiation pattern,
 Transmitter harmonics and
 SAR (Special Absorption Rate)*

In no event shall Sierra Wireless be liable for any loss or damages whatsoever or howsoever caused arising directly or indirectly in connection with this application note.

| Environmental Change | Effect | GSM | | DCS | | Limit when Effect Insignificant |
|--------------------------------|--------|----------------|---------------|----------------|---------------|--|
| | | Operating Band | Return Loss | Operating Band | Return Loss | |
| PCB Structure | | | | | | |
| Thickness | ↑ | ← | ↓ | ← | ↑ | -- |
| Metallic Plate Distance | | | | | | |
| Upper | ↓ | ← | δ | deformed | ↓ | ≥ 5 mm for Aluminium ≥ 10 mm for Copper |
| Left | ↓ | δ | ↑ | → | No conclusion | > 10 mm |
| Bottom | ↓ | δ | ↓ | ← | ↓ | ≥ 22 mm for Aluminium ≥ 20 mm for Copper |
| Plastic Distance | | | | | | |
| Upper | -- | δ | δ | δ | δ | 0 mm |
| Left | -- | δ | δ | δ | δ | 0 mm |
| Bottom | → | δ | δ | Slightly ← | δ | ≥ 3 mm |
| Top | ↓ | Slightly ← | Slightly ↓ | ← | ↑ | ≥ 6 mm |
| Grounding Width | | | | | | |
| Right | ↓ | → | No conclusion | → | No conclusion | -- |
| Left | ↑ | → | ↑ | → | degraded | -- |
| Shielding Distance | | | | | | |
| C* | ↓ | ← | ↓ | ← | δ | ≥ 6.6 mm |
| B* | ↓ | Slightly ← | ↓ | → | δ | ≥ 5.3 mm |
| Right 6.6mm + Lower 5.3 mm | -- | δ | δ | δ | δ | Just out of restricted area of internal antenna |

Legend:

↑:Increase

↓:Decrease

←:Shift left

→:Shift Right

δ:Insignificant change

*B, C:Distance refers to figure shown in section 7 Test Result.

Test condition: Test done on the Reference Hardware (WLL RDP R2) for which antenna is located on the upper left corner (no grounding on the left side of the antenna).

9 Reference Hardware

WLL RDP R2 is used as the reference application. All the test results in this application note are based on the RDP only.

10 Package Deliverables

This application note is delivered as a single document:

| Filename | Description |
|--|---|
| Application Note for Tuneable PCB Antenna (900/1800MHz) - Rev3.0.pdf | Tuneable PCB Antenna (900/1800MHz) Application Note |

11 Support

For direct clients: contact your Sierra Wireless FAE

For distributor clients: contact your distributor FAE

For distributors: contact your Sierra Wireless FAE

12 Document History

| Version | Date | History |
|---------|------------------|--|
| 001 | June 08, 2005 | Creation |
| 002 | March 31, 2010 | Reformatted in the rebranded SWI template. |
| 3.0 | January 10, 2012 | Added SL6087. Reformatted to new document template |

13 Legal Notice

Important Notice

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