

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

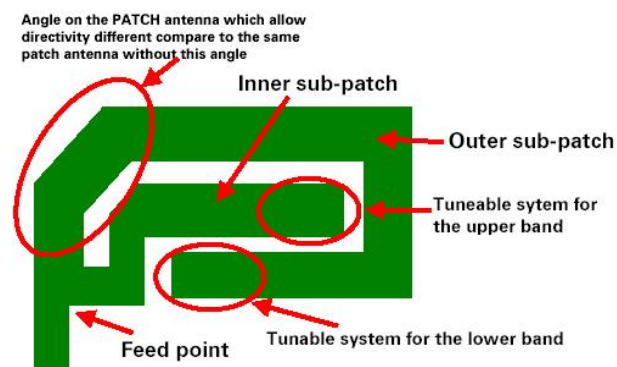
- Possible PCB Antenna printed on the main PCB
- Low cost and fast development
- Frequency bands supported: GSM 850 MHz and PCS 1900 MHz only

5 Application Environment

The printed antenna can be used for GSM Class 4/PCS 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 24.5mm x 41.0mm, being reserved to the PCB antenna that the application must follow.

6 Geometry

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



There is restricted area being reserved for the PCB antenna that the application must follow. The dimension of the restricted area is 24.5mm long and 41.0mm wide.

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

7 Test Result

As an example, the internal antenna implemented on 11 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.

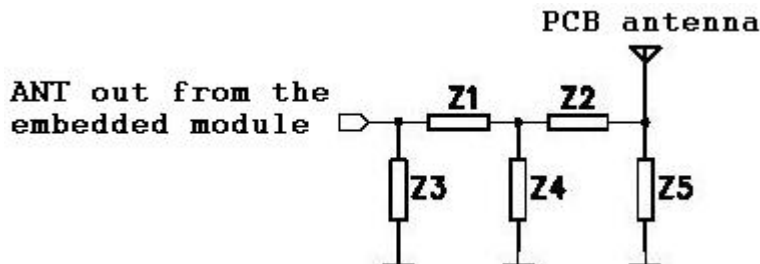
Orientation	Max. Antenna Gain (dBi)	
	GSM850, channel 190	PCS, channel 661
in azimuth	-0.7	0.5
in elevation front	0.6	0.6
in elevation side	-0.3	1.9

In addition, the directivity of the PCB antenna used by Antenna Evaluation PCB is found to be quite omni directional.

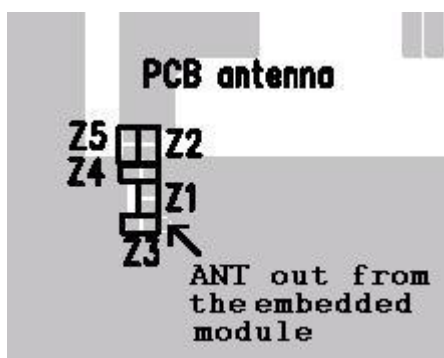
7.1.1 Caution

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:



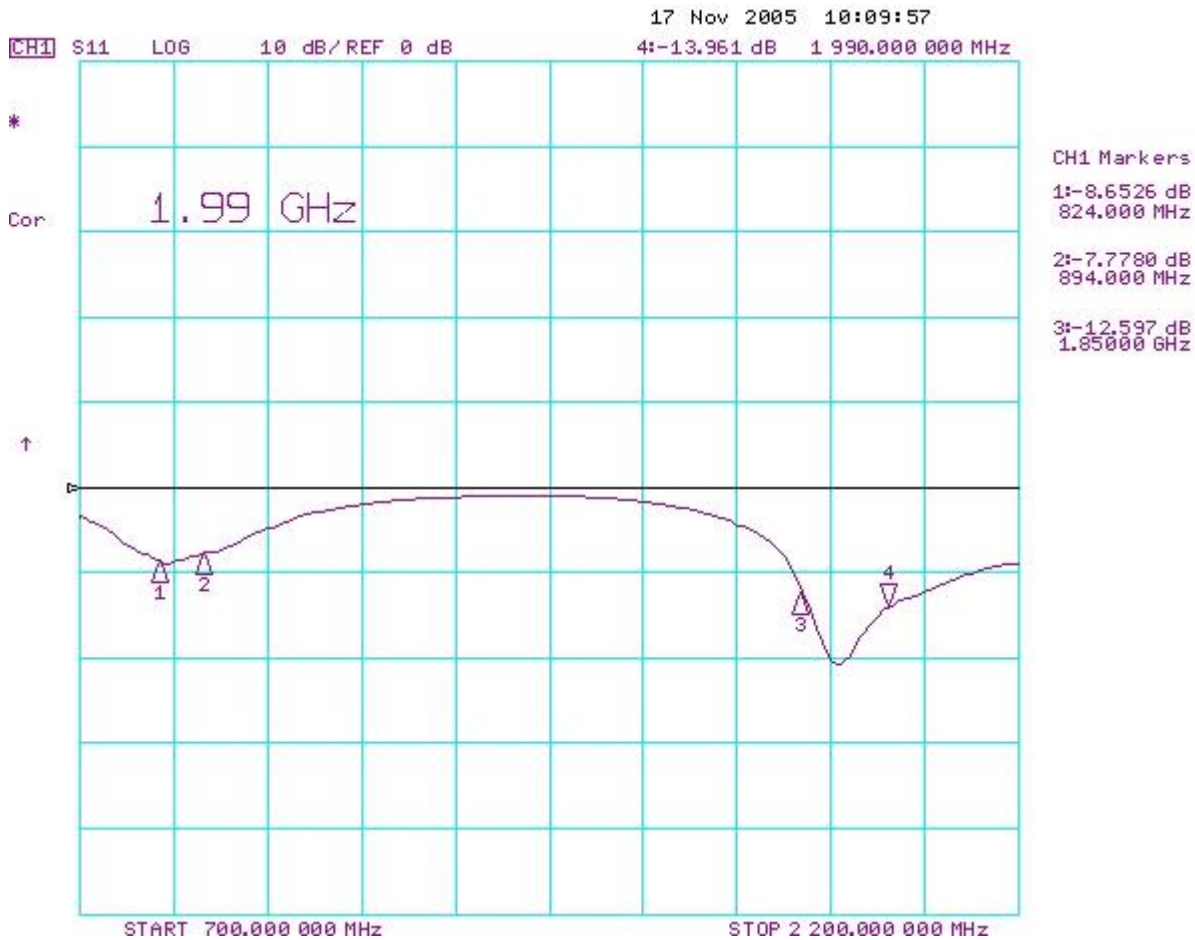
Refer to the following PCB layout for the recommended matching circuit:



The value of Z1 to Z5 will be adjusted depending on each application. At first, test will be done with Z1 = Z2 = 0Ω and Z3 = Z4 = Z5 = Not used.

7.2 Performance on Return Loss, S11

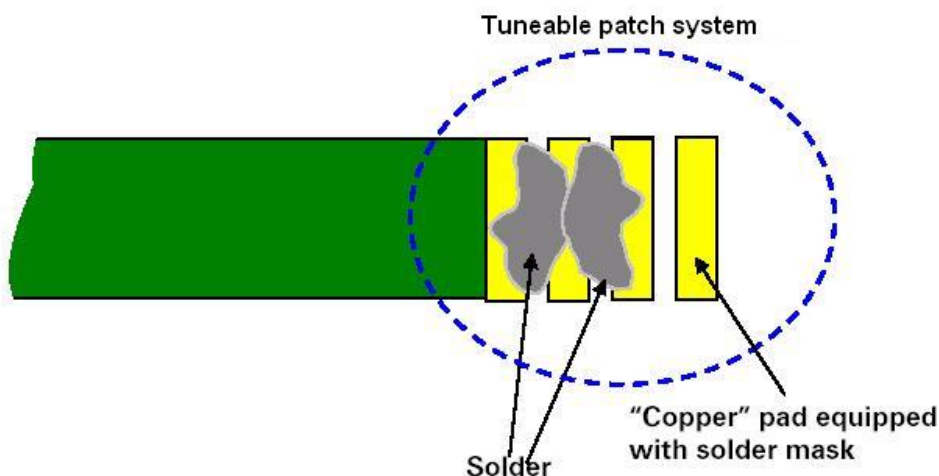
The return loss, S11 in log magnitude is recorded as shown below. From the result, it is found that within the operating band of both GSM850 and PCS, return loss better than -7.5dB can be achieved.



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.



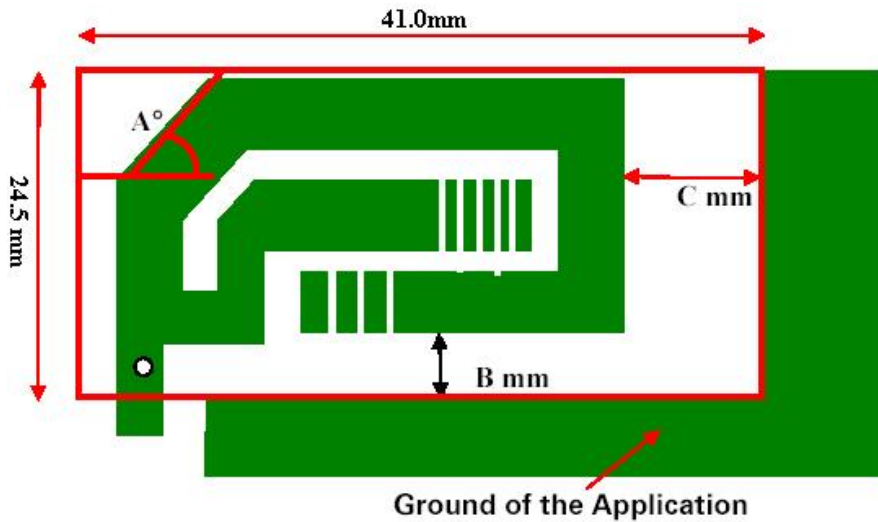
At the end of the inner and outer sub-patch, there are copper pads equipped with solder mask. Hence, the length of the sub-patch can be adjusted by shorting the adjacent copper pad by simple soldering. Increasing the length of the sub-patch will shift the operation frequency to lower side for both bands.

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 24.5 mm x 41.0 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 summarized 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 850		PCS		Limit when Effect Insignificant
		Operating Band	Return Loss	Operating Band	Return Loss	
PCB Substrate						
Thickness	↑	←	↓	←	↑	--
Metallic Plate Distance						
Upper	↓	←	δ	←	↓	≥ 8 mm for Aluminium ≥ 12 mm for Copper
Left	↓	δ	↑	→	↑	≥ 15 mm for Aluminium ≥ 20 mm for Copper
Bottom	↓	δ	↓	←	↓	≥ 20 mm for Aluminium ≥ 30 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 ↓	←	↑	≥ 2 mm
Grounding Width						
Right	↓	δ	↓	→	No conclusion	--
Left	↑	→	δ	→	degraded	--
Shielding Distance						
C*	↓	←	↓	δ	↑	≥ 7.0 mm
B*	↓	Slightly ←	↓	→	δ	≥ 8.0 mm
Right 7.0mm + Lower 8.0 mm	--	δ	δ	δ	δ	Just out of restricted area of internal antenna

Legend:

↑:Increase/Better

↓:Decrease/Worse

←:Shift left

→:Shift Right

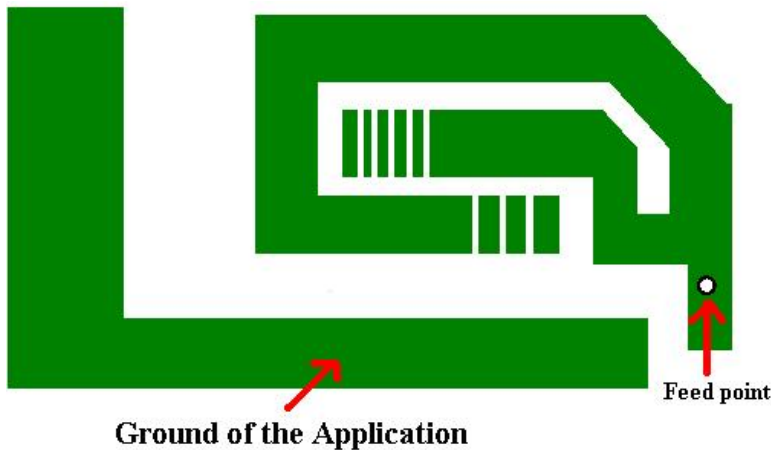
δ:Insignificant change

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

Test condition: Test done on the Reference Hardware (Antenna Evaluation PCB) for which antenna is located on the upper left corner (no grounding on the left side of the antenna).

9 Antenna Placement

As the table above has shown, it is not recommended to have ground in the right hand side of the antenna. Otherwise, PCS band resonance will be degraded. So, it is suggested that the antenna should be placed in the upper left corner of a PCB. If the customer really wants to place it in the right upper corner, the antenna needs to be mirrored horizontally as follows.



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

10 Comparison of European and US GSM Band Antenna Application

In order to tune the antenna from a European GSM band (900MHz/1800MHz) (refer to application note Tuneable PCB Antenna (900/1800MHz) to US GSM band (850MHz/1900MHz), follow these steps.

1. Increase the path length of the outer sub-patch.
2. Decrease the path length of the inner sub-patch.
3. Increase the distance to ground below the outer sub-patch in order to improve the matching of GSM band. That is the value of B.

11 Reference Hardware

Antenna Evaluation PCB is used as the reference application. All the tests result in this application note are based on the Antenna Evaluation PCB only.

12 Package Deliverables

This application note is delivered as a single document:

Filename	Description
Application Note for Tuneable PCB Antenna 850 and 1900MHz – Rev3.0.pdf	Tuneable PCB Antenna (850/1900MHz) Application Note

13 Support

For direct clients: contact your Sierra Wireless FAE

For distributor clients: contact your distributor FAE

For distributors: contact your Sierra Wireless FAE

14 Document History

Version	Date	History
001	November 23, 2005	Creation
002	March 31, 2010	Reformatted to the rebranded SWI template.
3.0	January 10, 2012	Added SL6087. Reformatted to new document template.

15 Legal Notice

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