Antenna Application Note

Prestta™ Standard Penta-Band Cellular Embedded Antenna P522304

Applications:

M2M
Automotive
Automatic Meter Reading
Healthcare
Point of Sale
Tracking

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PROPRIETARY INFORMATION

Preliminary Release May 4, 2010
Product specifications subject to change without notice.

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RESTRICTED PROPRIETARY INFORMATION

Copies of documents that are referenced in this document or other Ethertronics literature may be obtained by calling (858) 550-3820, email at USASales@ethertronics.com or the website www.ethertronics.com .

Contact your local sales office or manufacturers' representative to obtain the latest specifications.

Antenna Application Note

1. Purpose

This document provides information for incorporating Ethertronics' Prestta™ standard embedded cellular antennas into wireless products. Specifications, design recommendations, board layout, packaging and manufacturing recommendations are included.

This document is divided into two parts: a main section and appendices. The main section addresses points and issues common to all products. The appendices provide product-specific information.

2. Overview

The Prestta Standard Penta-Band antenna, listed below, represents a new category of internal IMD antennas. Ethertronics antennas utilize proprietary and patented Isolated Magnetic Dipole (IMD) technology to meet the needs of device designers for higher performance; providing greater than 50% average efficiency across all five bands. Standard, off-the-shelf, antennas lower total costs, enable quicker time-to-market and work with a variety of designs.

Product Selector Guide

Antenna PN	Application	Type	Typical Deliverable Size
P522304	Cellular 850, 900 MHz 1800, 1900 MHz 2100 MHz	• Partial Ground • Flexible antenna placement	• SMT mountable antenna assembly • 35.0 x 9.0 x 3.2 mm
P522304-01	Cellular 850, 900 MHz 1800, 1900 MHz 2100 MHz	• Demo Board	• Antenna Assembly on PCB board • 50 x 110 mm

Additional antennas are under development, please see Ethertronics' Website, or ask your Ethertronics salesperson about additional products to meet your needs.

IMD Technology Advantages
Real-World Performance and Implementation

Ethertronics continues to set the standard for antenna performance with its award-winning IMD technology, which uses patented design configurations to confine the current flow to the antenna element rather than exciting the main circuit board. Other antennas may contain simple PiFA or monopole designs that interact with their surroundings, complicating layout or changing performance with user position. Ethertronics' antennas utilize patented IMD technology to deliver a unique size and performance combination.

IMD technology offers important real-world advantages over other approaches. Please see our white paper and Website www.ethertronics.com for a full explanation.

Feature	Advantage	Benefits
High performance	High efficiency	Meet and exceed design performance specs. Lower design risks. Enhance end-user satisfaction. Potential for additional device sales.
	High isolation	Less interaction with surrounding components. Smallest effective antenna size when component keep-out areas are included. Resists de-tuning due to orientation on circuit board. Lowers design risk and time-to-market. One antenna part number can serve multiple designs. Simplifies design and ordering.
	High selectivity	Eliminates need for additional band-pass filters and other circuitry. Saves cost and space.
Superior RF Field Containment	Virtually eliminates detuning due to device handling during use.	Better performance. Higher end-user satisfaction. Potential for higher sales.

Prestta Standard Penta-Band Cellular Antenna Features and Benefits Summary

Features	Benefits
Cellular	• Eliminates external antennas
High Performance Embedded Solution	• Greater than 50% average efficiency across all bands
Extensive design collateral and apps support	• Speeds development time
Standard “Off-the-Shelf” Product	• Speeds development time and reduces costs since reduces NRE and custom development time
Small Form Factor & Ground Clearance Requirements	• Can be used in a variety of custom form factors and applications
Cost Effective & Rugged Design	• SMT, Pick and Place, enable lower manufacturing costs

3. Design Guidelines

3.1 Introduction

The Prestta Penta-Band Embedded Cellular Antenna can be designed into many wireless product types. The following sections explain Ethertronics' recommended layouts to help the designer integrate the antennas into a product with optimum performance.

3.2 Antenna Pad Layout

Figure 1 below shows the Prestta Standard Penta-Band Antenna pad layout (bottom view) .

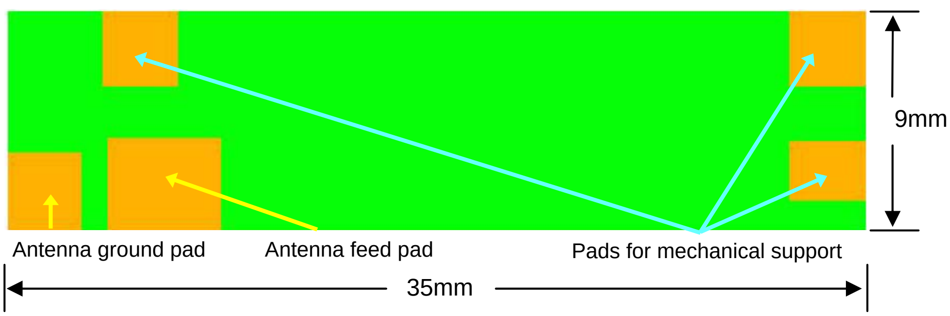

Figure 1

- **Maximum Dimensions**: 35.0 x 9.0 x 3.2 mm
- **RF Mounting**: RF Feed and Ground pads are SMT attached to the main PCB
- **Mechanical Mounting**: Antenna Assembly is SMT attached to the main PCB

3.3 PCB Land Pattern

The PCB land pattern places the antenna matching circuit outside the antenna footprint for ease of re-work.

Figure 2 below shows the PCB Land Pattern layout (top view) when the Matching Circuit is located outside the antenna footprint.

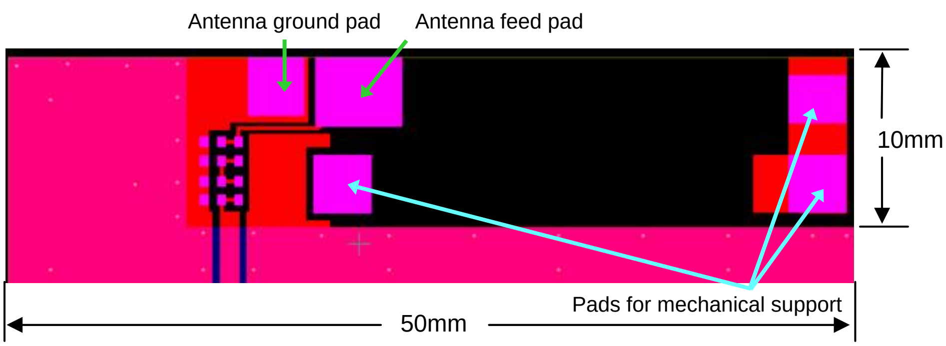

Figure 2

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3.4 Antenna Location

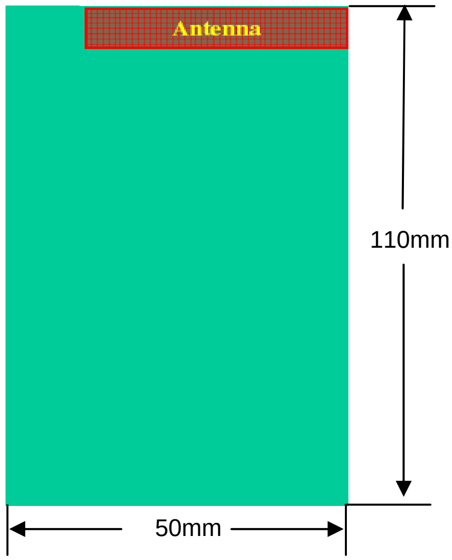

Figure 3

1. Figure 3 shows a typical landing location of a Prestta Penta-Band Embedded Cellular Antenna.
2. Figure 4 below shows the Matching Circuit. Components used are listed below:
   - C1 = 2.0pF
   - L1 = 15nH
   - C2 = 1.2pF
   - L2 = 3.9nH

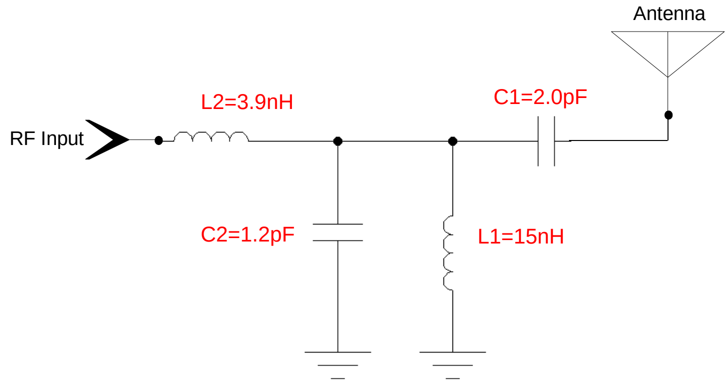

Figure 4

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Figure 5, below, shows the typical VSWR performance of the GSM/EGSM bands when using a standard 110x50mm demo board.

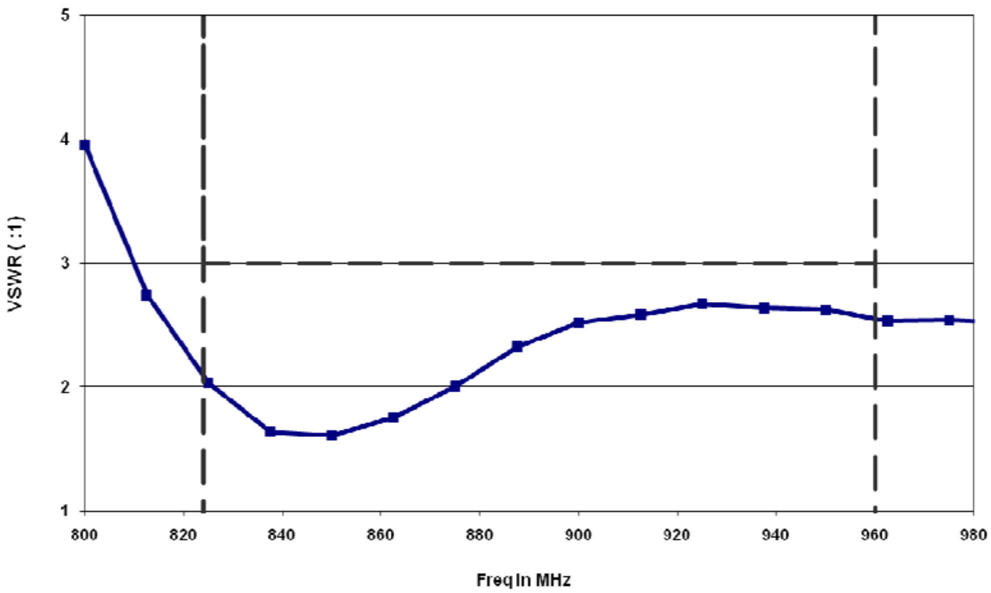

Figure 5

Figure 6, below, shows the typical VSWR performance of the DCS/PCS/WCDMA bands when using a standard 110x50mm demo board.

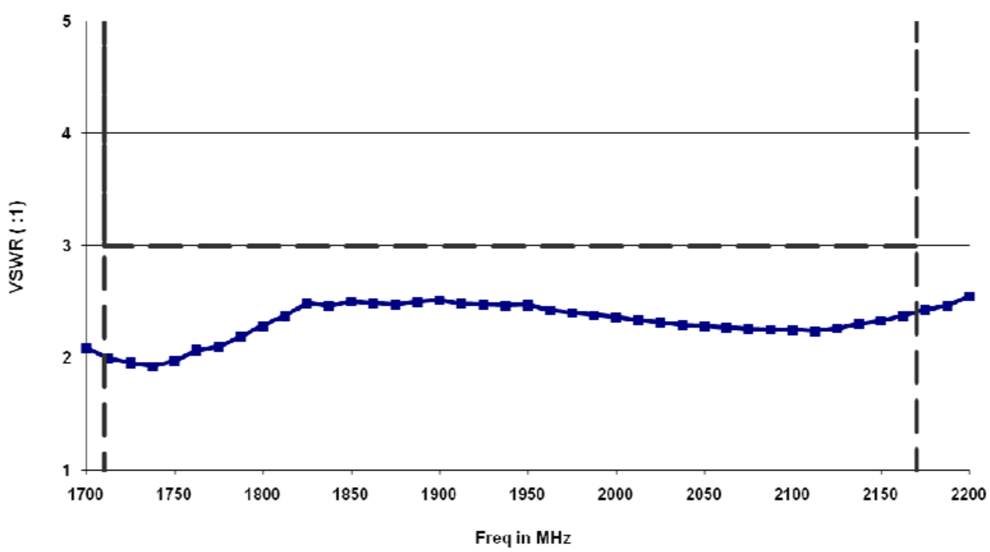

Figure 6

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Figure 7, below, shows the typical Efficiency performance of the GSM/EGSM bands when using a standard 110x50mm demo board.

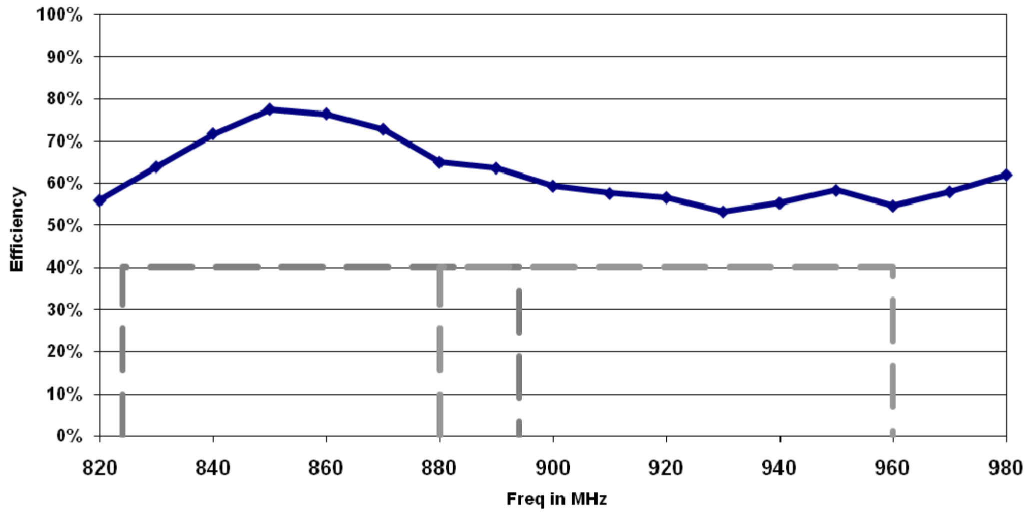

Figure 7

Figure 8, below, shows the typical Efficiency performance of the DCS/PCS/WCDMA bands when using a standard 110x50mm demo board.

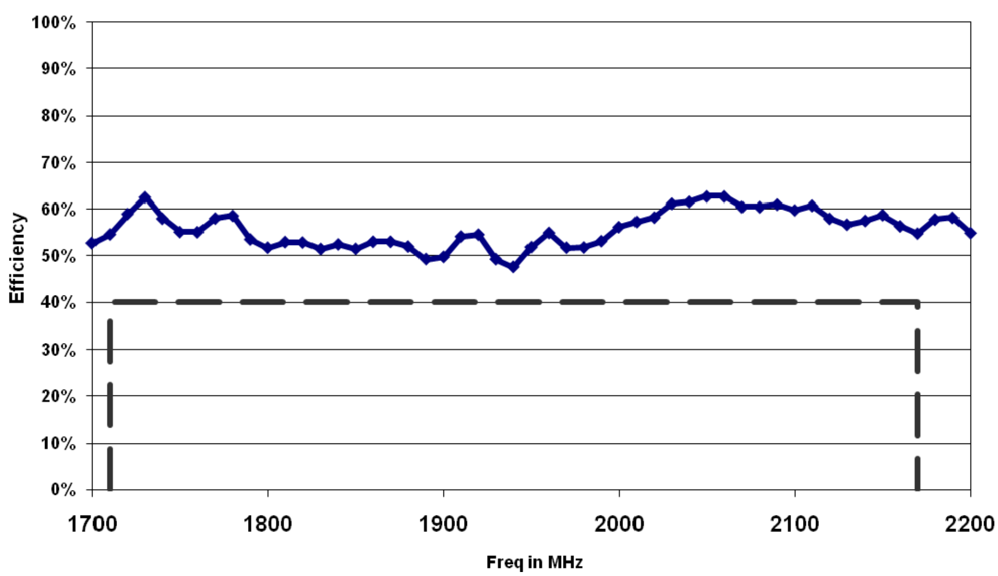

Figure 8

Shield Can and Housing Effects on Performance

Additional testing was done to simulate the effects of a shield can and an antenna with a housing. Below are examples of the shield can and the antenna in a housing. Figure 9, below, shows the test set-up for a shield can with a height of approximately 2.7mm. Figure 10, below, shows an antenna touching the housing; simulating the worst case.

Figure 9

Figure 10

The results shown below use tuning to optimize the performance through the PCB tuning pad and matching components. See section 3.5 for more detailed information.

Figure 11, below, shows the typical Return Loss performance when using a shield can and housing on a standard 110x50mm demo board.

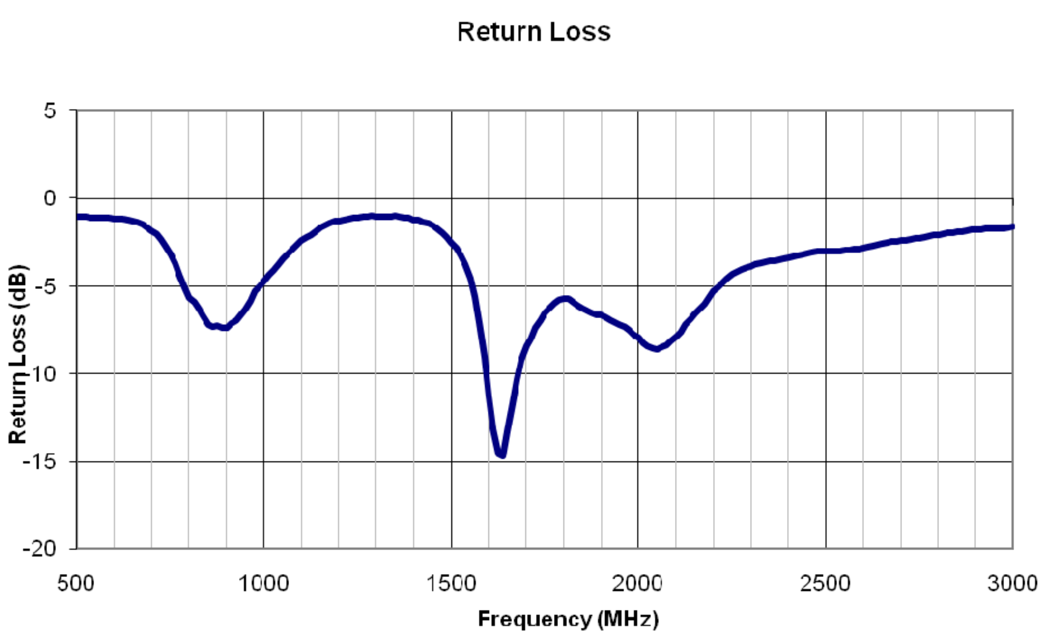

Figure 11

Figure 12, below, shows the typical Efficiency performance of the GSM/EGSM bands when using a shield can and housing on a standard 110x50mm demo board. Note that the efficiency is still over 50% in the bands of operation despite the shield can housing.

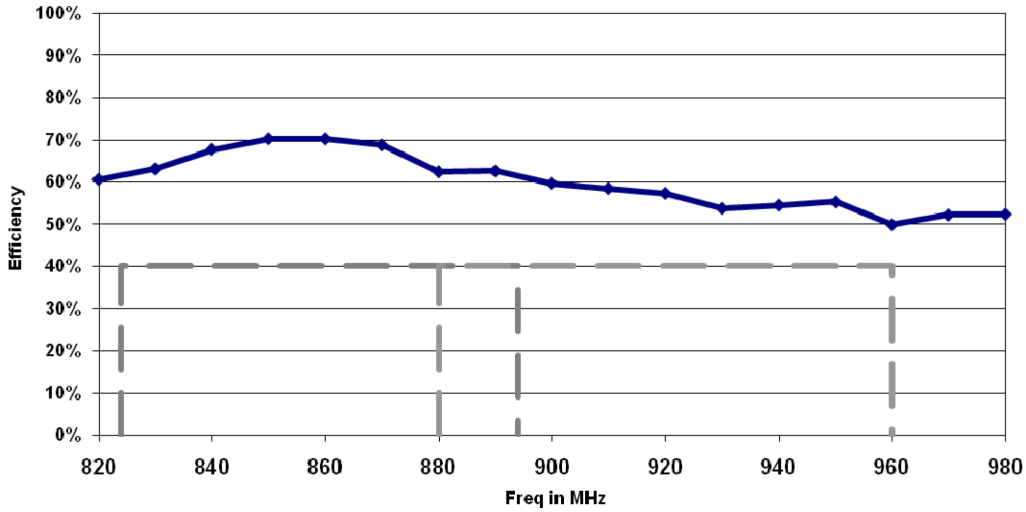

Figure 12

Figure 13, below, shows the typical Efficiency performance of the DCS/PCS/WCDMA bands when using a shield can and housing on a standard 110x50mm demo board. Note that the average efficiency is still nearly 50% in the bands of operation despite the shield can and housing.

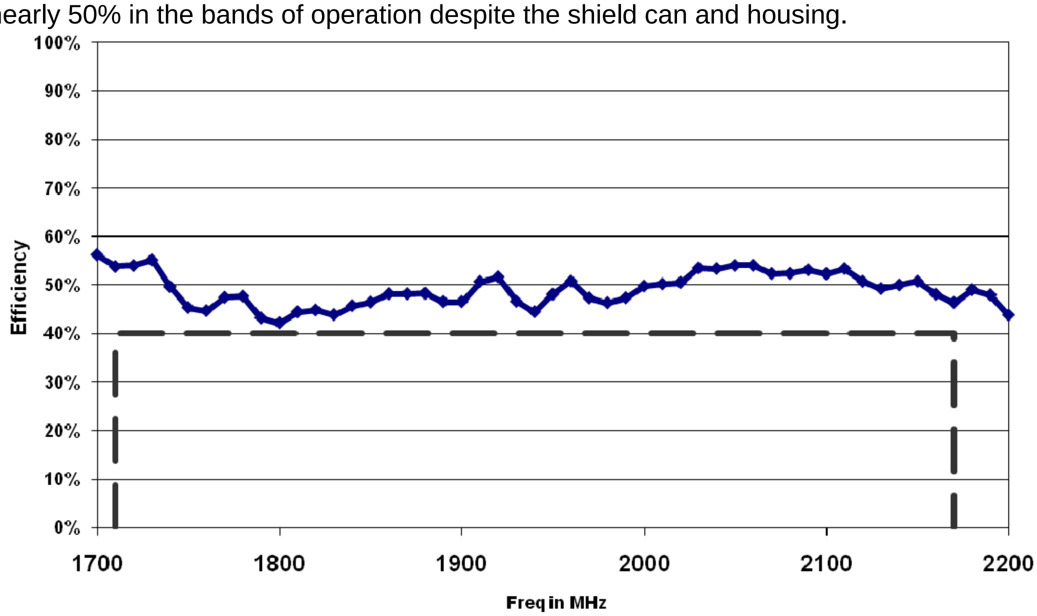

Figure 13

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3.5 Antenna Tuning Guidelines

All tuning is done through the PCB layout and/or matching instead of the antenna. There are three ways to tune through the PCB:

1. Major tuning through the tuning pad printed on the PCB
2. Minor tuning through the matching network
3. Bandwidth tuning through ground clearance.

Major Tuning Through the Tuning Pad Printed on the PCB

An effect of shield cans, housing and other close by components is low-band frequency shift. To offset the detuning effect, the PCB includes a printed Tuning Pad for improving performance. Figure 14, below, shows the Return Loss for different Tuning Pad sizes. In general, the low-band frequency can be tuned higher by approximately 200 MHz.

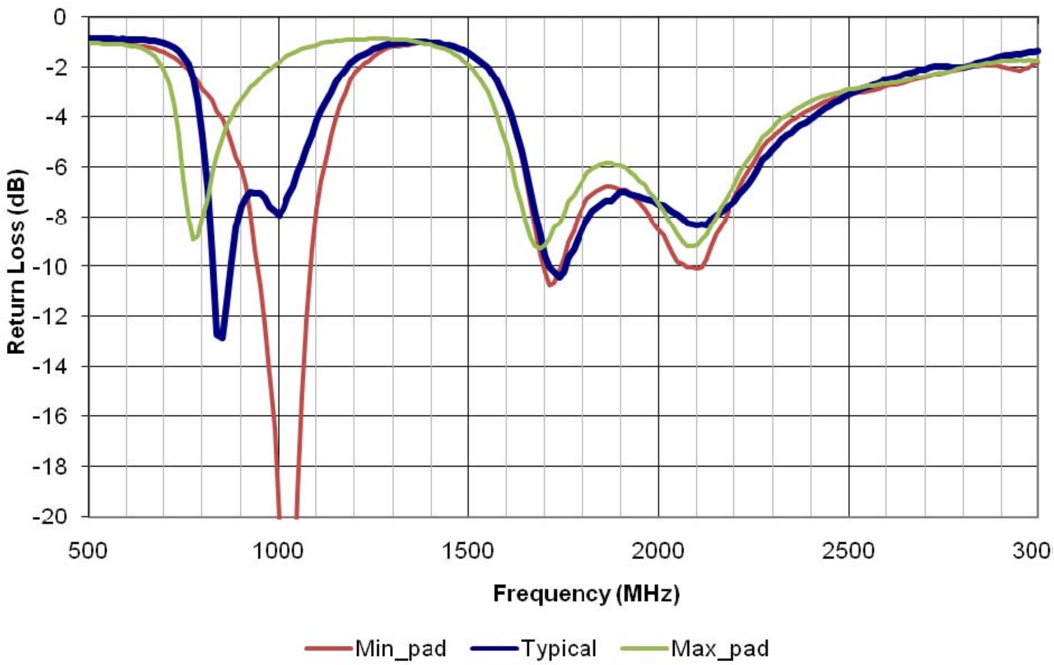

Figure 14

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Figures 15 (Minimum), 16 (Typical) and 17 (Maximum) below show the Tuning Pad sizes.

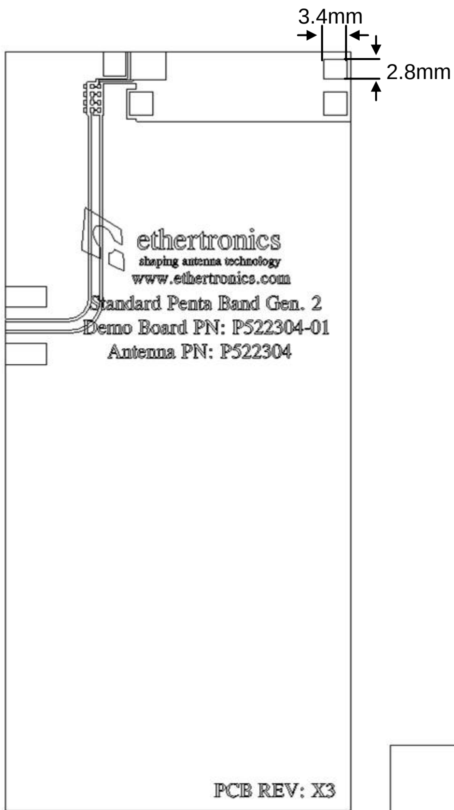

Figure 15

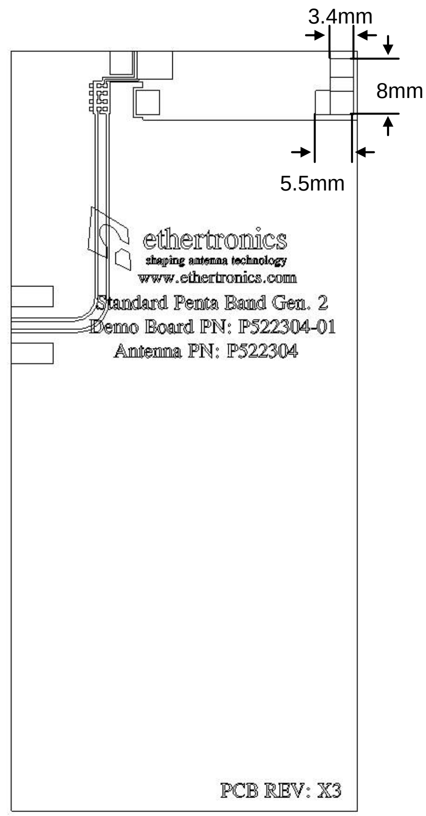

Figure 16

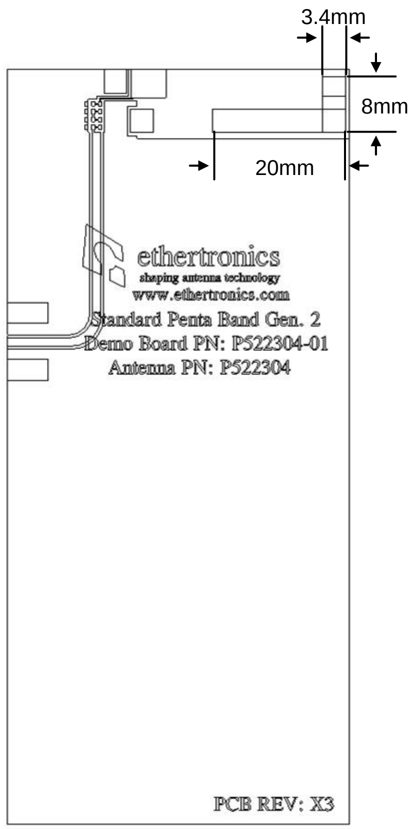

Figure 17

Product specifications subject to change without notice.

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Matching Circuit Tuning Guidelines

Performance can be improved by tuning the matching circuit. In general, low band resonance is mainly affected by L1 and C1, while high band resonance is mainly affected by L2 and C2.

Optimum matching values vary with different boards and environments. In the following pages, the optimum values are for the demo board.

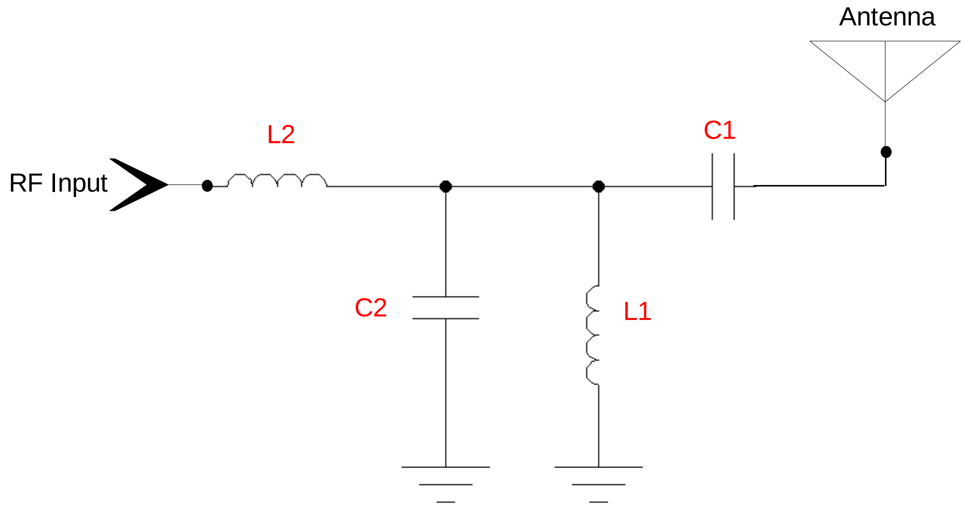

Figure 18

Bandwidth Tuning Through Ground Clearance

When the board length is shorter than 90mm, bandwidth will be decreased. Increasing the ground clearance will increase the bandwidth.

3.6 Varying The Board Size

In applications where the board size less than 110x50mm, antenna performance may degrade. In general, the smaller the board size, the lower the performance. Nevertheless, antenna performance can be improved through increasing ground clearance, modifying the tuning pad and optimizing the matching components accordingly.

Following are examples using an 80x50mm and 65x50mm board lengths.

80x50mm Board

Performance can be optimized by changing the components in the matching circuit, changing the tuning pad and increasing the ground clearance. Figure 19, on the right, shows the test board set-up. Below are the components used in the matching circuit for the test results on the following pages:

- C1 = 2.2pF
- L1 = 18nH
- C2 = 1.2pF
- L2 = 3.3nH

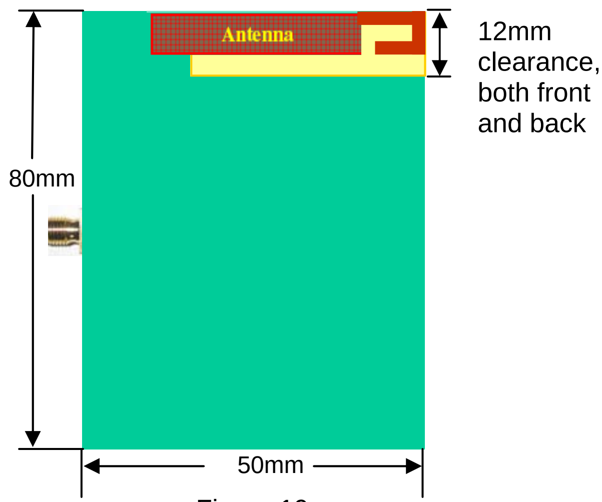

Figure 19

Figure 20, below, shows the typical Efficiency performance of the GSM/EGSM bands.

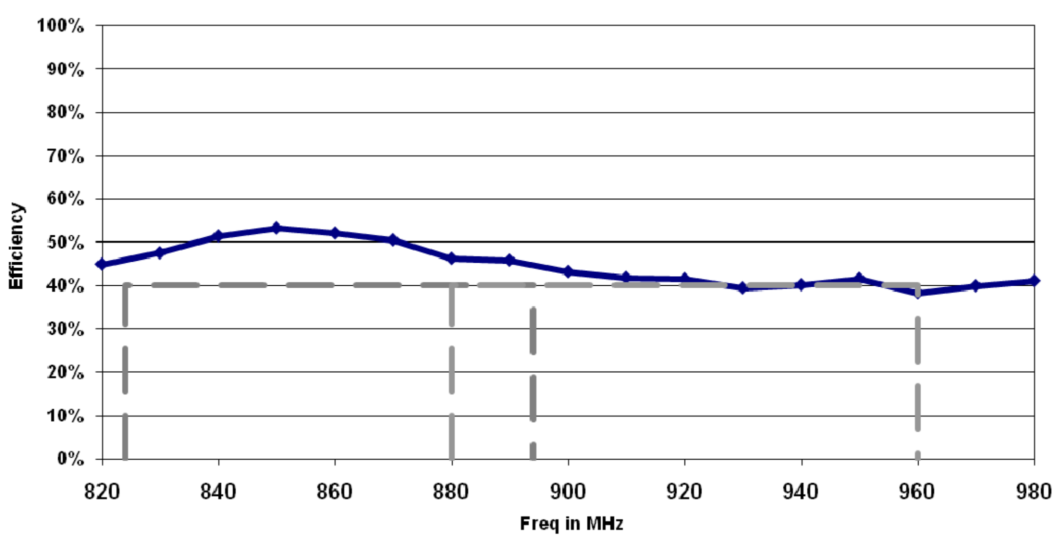

Figure 20

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Figure 21, below, shows the typical Efficiency performance of the DCS/PCS/WCDMA bands.

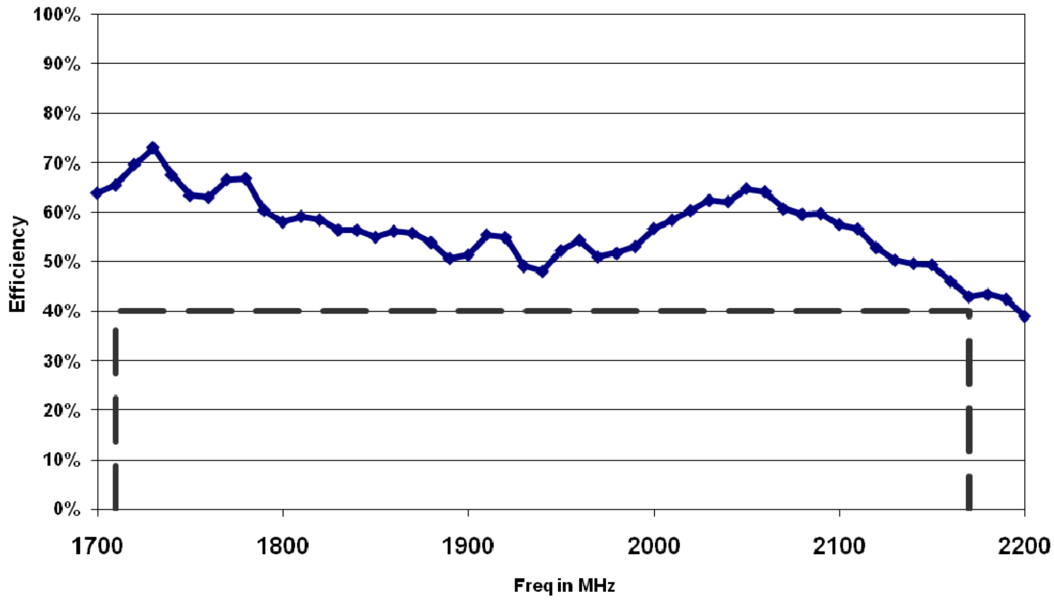

Figure 21

Figure 22, below, shows the typical Return Loss performance.

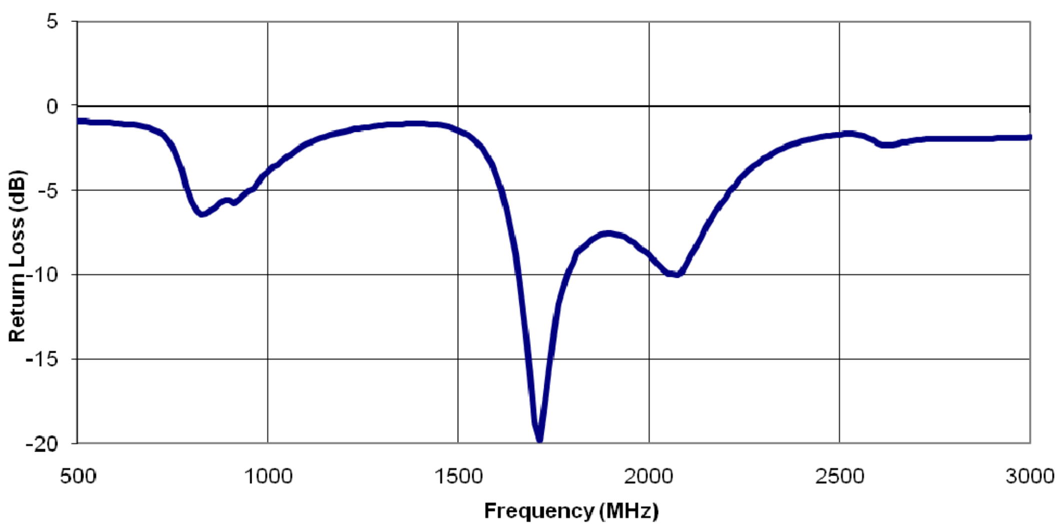

Figure 22

Product specifications subject to change without notice.

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65x50mm Board

Performance can be optimized by changing the components in the matching circuit, changing the tuning pad and increasing the ground clearance. Figure 23, on the right, shows the test board set-up. Below are the components used in the matching circuit for the test results on the following pages:

- C1 = 1.8pF
- L1 = no component
- C2 = 1.0pF
- L2 = 3.3nH

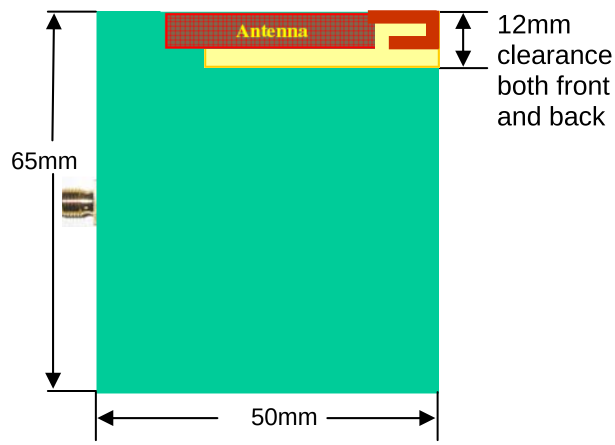

Figure 23

Figure 24, below, shows the typical Efficiency performance of the GSM/ EGSM bands.

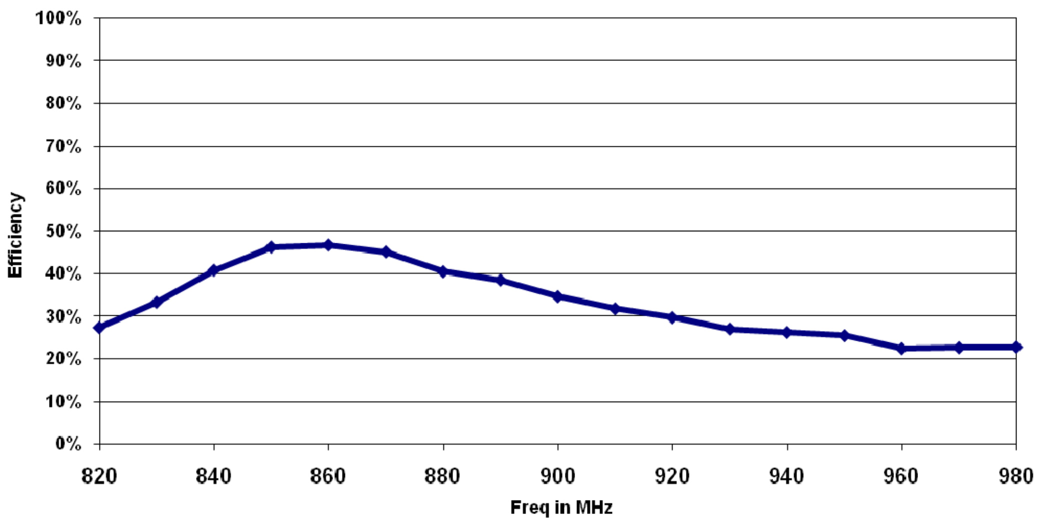

Figure 24

Figure 25, below, shows the typical Efficiency performance of the DCS/PCS/WCDMA bands.

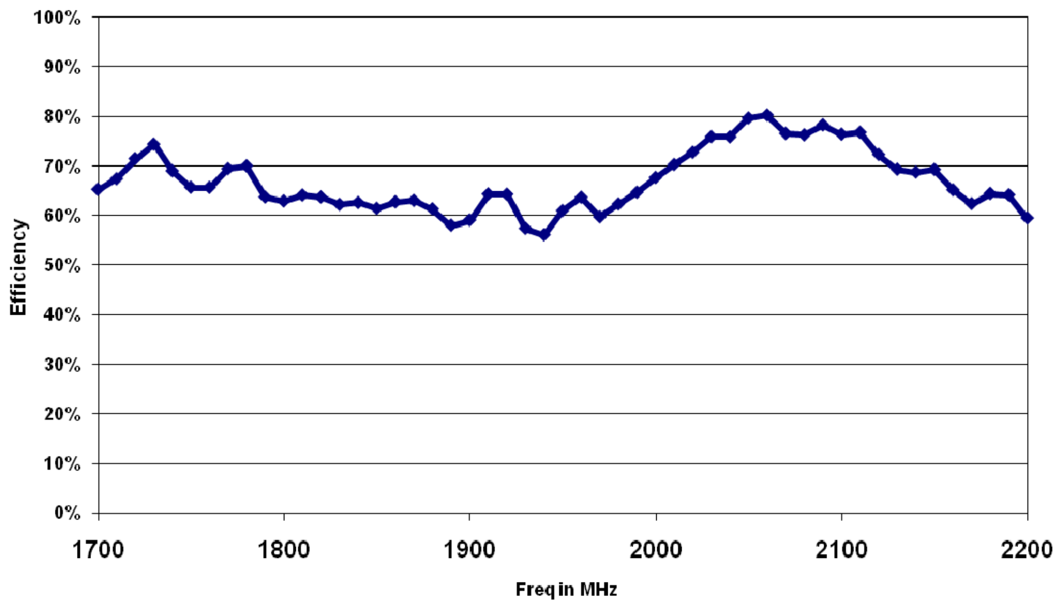

Figure 25

Figure 26, below, shows the typical Return Loss performance.

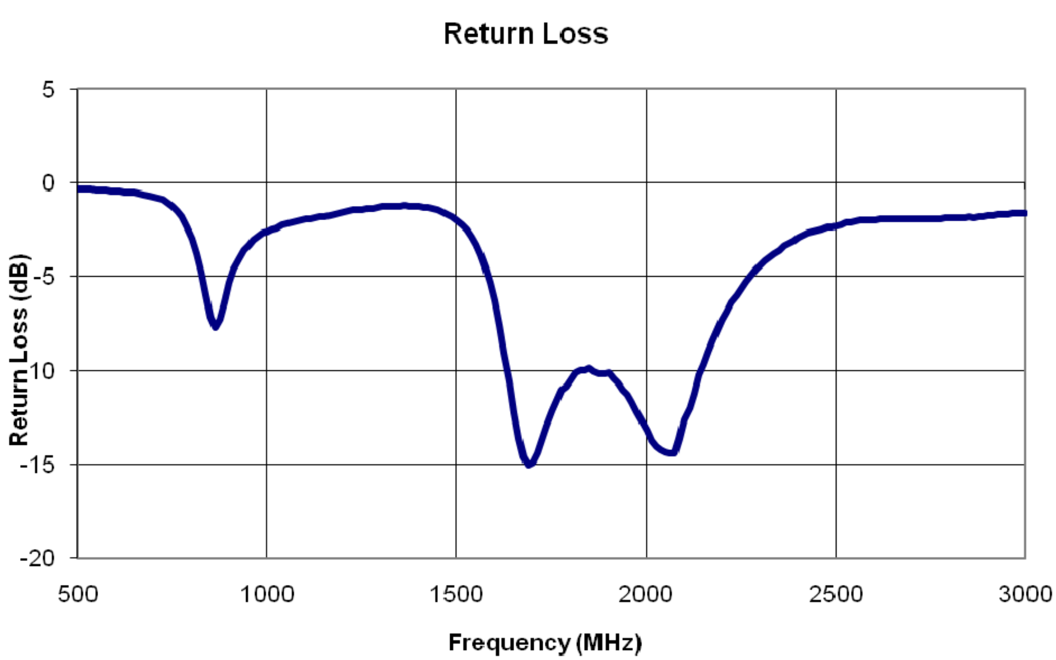

Figure 26

4. Antenna Matching Circuit Component Information

Manufacturer	Component	Manufacturer's PN	Value	Tolerance	Digi-Key PN	ROHS Compliant	Temperature (deg C)	Current (mA)	Comments
Recommended Components									
TDK Corporation	L1	MLK1005S15NJ	15nH	+/- 5%	445-1469-1-ND	Yes	-55 ~ 125	250	
Taiyo Yuden	L2	HK10053N9S-T	3.9nH	+/- 0.3nH	587-1509-1-ND	Yes	-55 ~ 85	500	Temperature range smaller than other products
TDK Corporation	C1	C1005C0G1H020B	2pF	+/- 0.1pF	445-4862-1-ND	Yes	-55 ~ 125		
TDK Corporation	C2	C1005C0G1H1R2B	1.2pF	+/- 0.1pF	445-4856-1-ND	Yes	-55 ~ 125		

Components listed above are for reference. Other components can be substituted provided they have the same value and the same or smaller tolerance.

NOTES:
1. Industrial temperature ranges from -40 to +85 deg C. Please see the following references for industrial temperature range:
http://www.interfacebus.com/Logic_Prefix_Temp_Range.html
http://www.compulab.co.il/all-products/html/industrial-temp.htm

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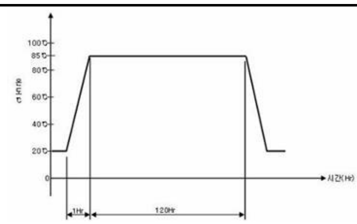
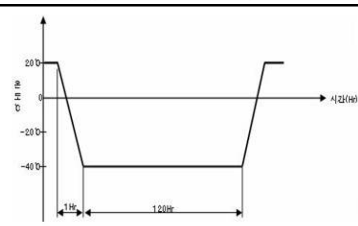
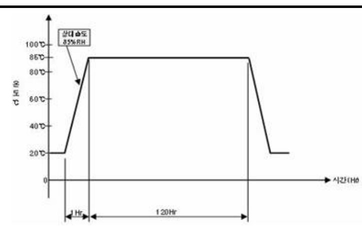
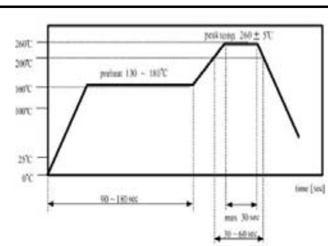
5. Material Specifications

Item	Material
Antenna	FR4
Contact Finish	Hot Air Solder Level (HASL) or Au

6. Product Testing

Ethertronics' antennas comply with RoHS directives. Ethertronics' antennas undergo product qualification testing as part of the product development process. The following are the core tests used to qualify the Prestta™ cellular antenna.

NO	Test Type	Items	Test condition	Test method	
1	Environment test	High Temp .	85**°C**±3**°C** 120hr ±2hr		Step 1: Test VSWR by jig. Step 2: Put it in the chamber. Step 3: Test it like this picture which explains temp. cycle. Step 4: Test VSWR after 1hr in normal Temp. & normal Humidity
2		Low Temp.	-40**°C**±3**°C** 120hr ±2hr		Step 1: Test VSWR by jig. Step 2: Put it in the chamber. Step 3: Test it like this picture which explains temp. cycle. Step 4: Test VSWR after 1hr in normal Temp. & normal Humidity
3		High Temp. & High Humidity	85**°C**±3**°C** RH=85% 120hr ±2hr		Step 1: Test VSWR by jig. Step 2: Put it in the chamber. Step 3: Test it like this picture which explains temp. cycle. Step 4: Test VSWR after 1hr in normal Temp. & normal Humidity
4		Salt Spray	Nacl 5%, 35**°C**, 72hr	Step 1: Test VSWR by jig. Step 2: Put it in the chamber. Step 3: Start test. Step 4: Wash the samples. Step 5: Test VSWR after 1hr in normal Temp. & normal Humidity	
5	Reflow test	Reflow Test	Pre Heating **200°C±5°C** 30~60sec Peak Heating 260°C±5**°C** 30sec Max		Step 1: Put it in REFLOW Step 2: Test it like this picture which explains temp. Cycle by EV board

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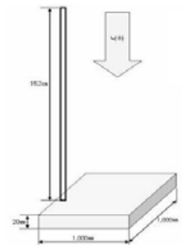
NO	Test Type	Items	Test condition	Test method
6	Mechanical Test*	Vibration*	-Frequency:10~500hz -Acceleration:10*9.8m/s^2(G) -Sweep time15min -X.Y.Z each 5times	Step 1: Solder antenna on EV board. Step 2: Assemble EV board (+antenna) on set. Step 3: Test it.
7		Drop*	-From 1m height, drop the sample to the bottom 18 times per one test by drop jig. (each 3 times on 6 surfaces) -Jig: using the plastic jig (120±20g) -Floor Material: Linoleum	 Step 1: Solder antenna on EV board Step 2: Assemble EV board (+antenna) on set. Step 3: Test it like this picture which explains how to do it.

*Mechanical Tests are for Assemblies only (antenna on a PCB). The Mechanical Tests do not relate to antennas nor antennas with carriers only.

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7. Manufacturing and Assembly Guidelines

Ethertronics' Prestta Standard Cellular Penta-Band Antenna is designed for high volume board assembly. Because different product designs use different numbers and types of devices, solder paste, and circuit boards, no single manufacturing process is best for all PCBs. The following recommendations have been determined by Ethertronics, based on successful manufacturing processes.

The antenna solution is designed for automated pick and place surface mounting. However, as with any SMT device, Ethertronics antennas can be damaged by the use of excessive force during the handling or mounting operation.

Component Handling Recommendations

The following are some recommendations for component handling and automated mounting:

- Ethertronics Standard Penta-Band antenna ships in tape and reel.

Component Handling Recommendations

Ethertronics' antennas are not moisture sensitive and the antennas meet the requirements for a Level 1 classification of J-STD-020A (moisture/reflow sensitivity classification for non-hermetic solid state surface mount devices from the Institute for Interconnecting and Packaging Electronic Circuits). Nevertheless, as a precaution to maintain the highest level of solder ability, Ethertronics antennas are dry-packed.

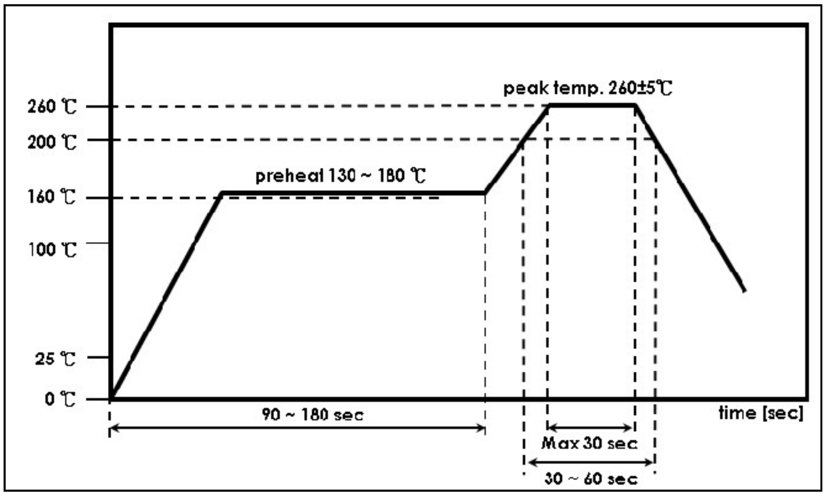
Paste Stencil Recommendation

Ethertronics recommends application of paste stencil to a thickness of 0.1 to .125mm, applied to within 0.05 mm of the solder mask surrounding each exposed metal pad on the PCB. PCB layouts for each antenna are provided below.

Soldering Recommendations

The recommended method for soldering the antenna to the board is forced convection reflow soldering. The following suggestions provide information on how to optimize the reflow process for the antenna:

- Adjust the reflow duration to create good solder joints without raising the antenna temperature beyond the allowed maximum of 260° C.



Cleaning Recommendations

After the soldering process, a simple wash with de-ionized water sufficiently removes most residues from the PCB. Most board assembly manufacturers use either water-soluble fluxes with water wash, or “no clean” fluxes that do not require cleaning after reflow.

Acceptable cleaning solvents are CFC alternatives, Isopropyl Alcohol (IPA), and water. If the application uses other types of solvents, please consult with Ethertronics.

Cleaning processes that should be avoided are ultrasonic cleaning and any abrasive techniques, such as scrubbing with an abrasive material.

Rework & Removal Recommendations

There may be a need to rework or remove the antenna from the PCB. Although Ethertronics’ antennas are designed for ease-of-use, use care when separating them from the PCBs. Careless heating or removal of the antenna can cause thermal, mechanical or lead damage. These degradations may render the antenna useless, impeding any failure analysis and preventing the reuse of the device. Therefore it is recommended to observe the following precautions:

- The component can be reworked and soldered by hand using a soldering iron and non-corrosive flux. However care should be used so the temperature does not exceed 260°. The soldering iron should not touch the composite material while soldering the leads of the antenna.
- The component can be reworked and soldered using a hot air rework station and non-corrosive flux. However, care should be taken to ensure that the temperature does not exceed 260° C.
- Once the solder on the PCB is sufficiently heated, use a vacuum pen to lift the antenna straight up off the PCB. Avoid twisting or rotating the device while removing it.

Packaging Specifications

Product will be shipped in Tape and Reel packaging; specs are forthcoming.

8. Glossary of Terms

For a complete list of terms, please visit the Ethertronics Web site at www.ethertronics.com/resources/glossary/, or enter http://files.ctia.org/pdf/Telecom_Glossary_of_Terms.pdf into your browser.

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Appendix 1
Summary of Prestta™ Antenna
Part No. P522304

Electrical Specifications
Typical Characteristics

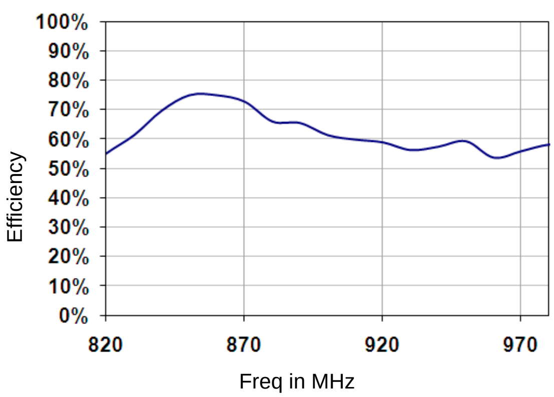
Measurements taken with a matching circuit on a 50 x 110 mm ground plane.

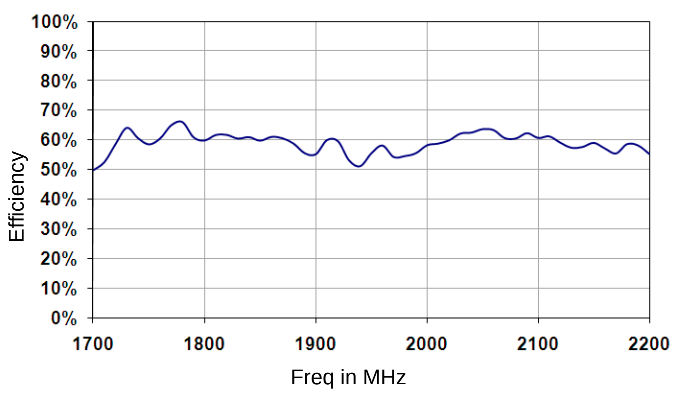
Cellular Antenna	824-849, 869-894	880-915, 925-960	1710-1785, 1805-1880	1850-1910, 1930-1990	1920- 1980, 2110-2170
Peak Gain	1.4 dBi	1.2 dBi	1.8 dBi	1.1 dBi	2.5 dBi
Average Efficiency	64%		59%		
VSWR Match	2.5:1 max				
Feed Point Imped-	50 ohms unbalanced (other if required)				
Power Handling	2 Watt cw				
Polarization	Linear				

Mechanical Specifications

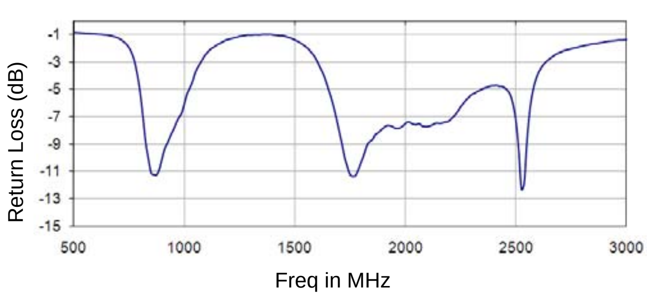
Maximum Dimensions	35.0 x 9.0 x 3.2 mm
Mechanical Mounting	Antenna Assembly is SMT attached to main PCB.
RF Mounting	RF and Ground feed pads are SMT attached to main PCB.

Efficiencies

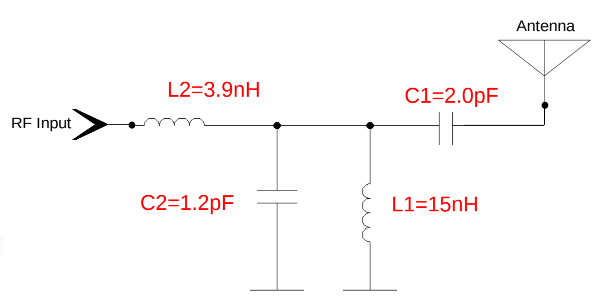




Typical Return Loss



Matching Network



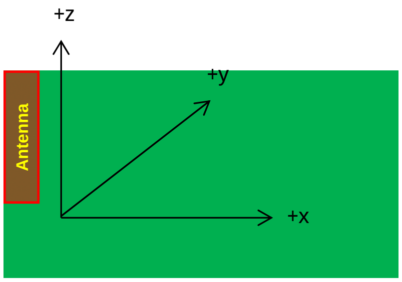
Antenna Application Note

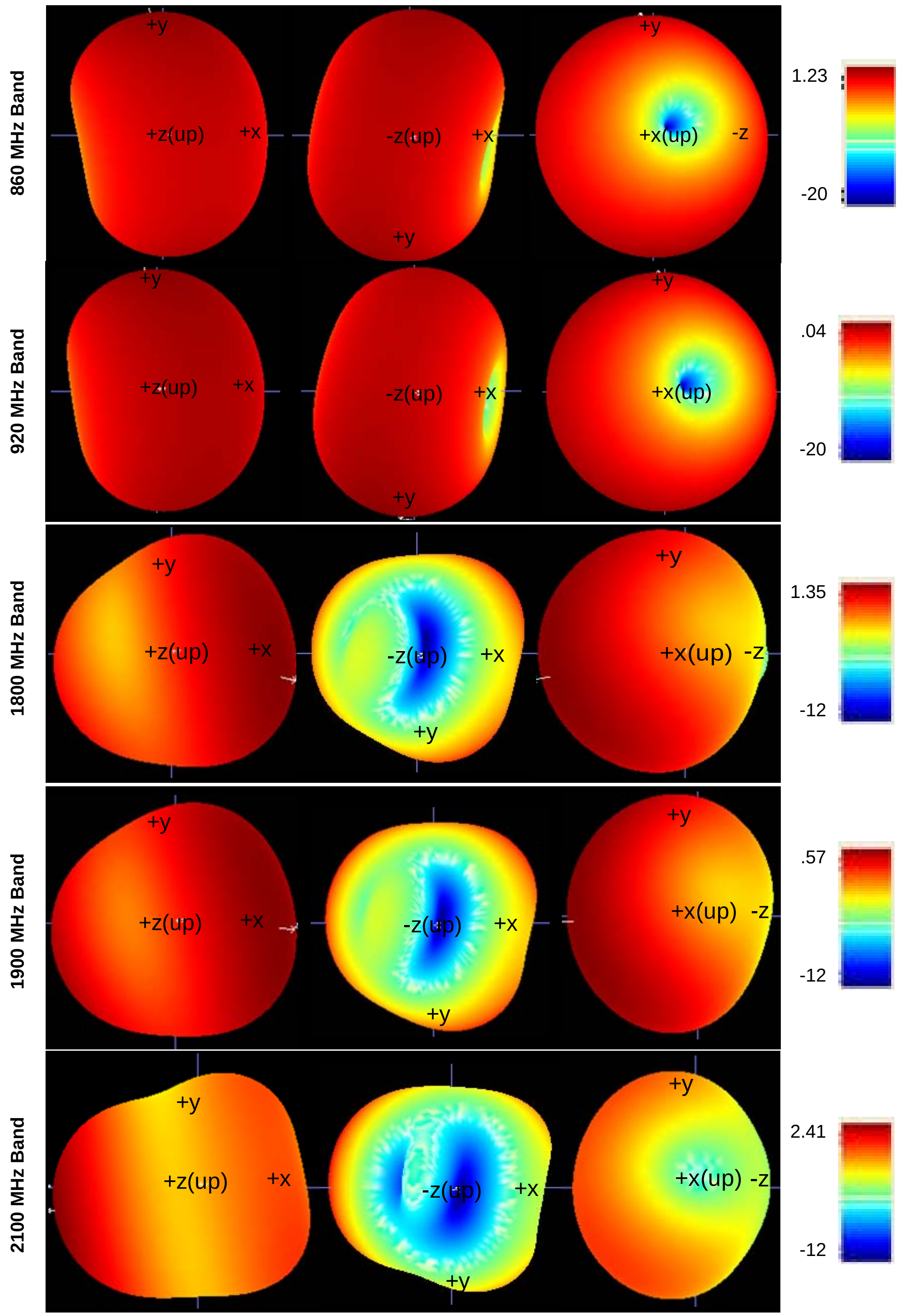
Appendix 1
Summary of Prestta™ Antenna
Part No. P522304

Antenna Radiation Patterns

Typical Performance

Ethertronics' Test Board
PCB: 50x110mm

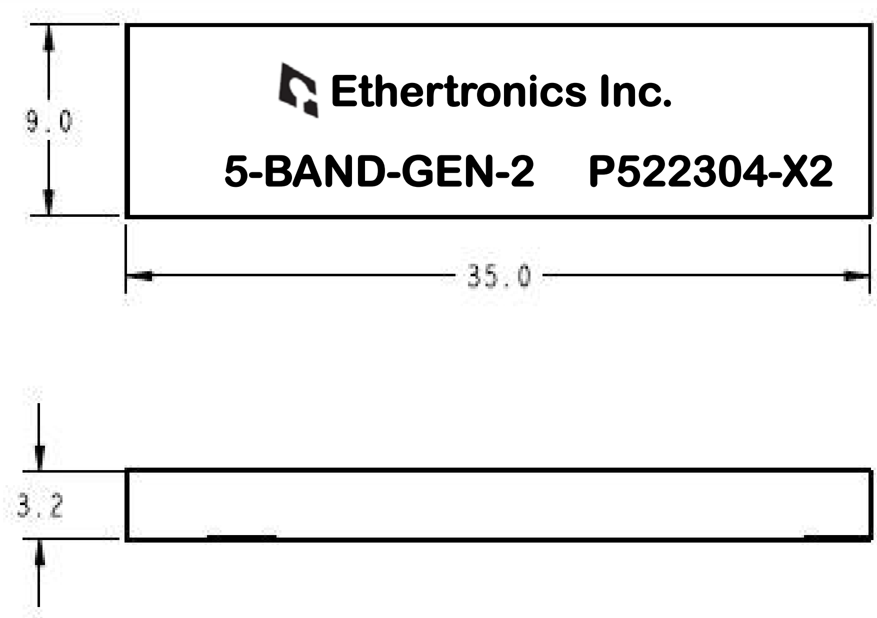




Antenna Application Note

To optimize designs using Ethertronics' Prestta™ Cellular Penta-Band antenna, the PCB should use the recommended land pattern shown in the Figures below.

Antenna Dimensions (mm)



Antenna Application Note

To optimize designs using Ethertronics' Prestta™ Cellular Penta-Band antenna, the PCB should use the recommended land pattern shown in the Figures below.

PCB Layout (mm)

Matching Circuit located inside the antenna footprint.