Antenna Application Note

Prestta™ Standard Penta-Band Cellular Embedded Antenna

Applications:
M2M
Automotive
Automatic Meter Reading
Healthcare
Point of Sale
Tracking

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PROPRIETARY INFORMATION
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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 Cellular Product Line

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.

Part Number	Frequency	Application	Size
P522303	850/900/1800/1900/2100 MHz	Cellular	42.5 x 12.7 x 8.1 mm
P522303-01	850/900/1800/1900/2100 MHz	Cellular	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.

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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.

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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

Product Selector Guide

Antenna PN	Application	Type	Typical Deliverable
P522303	Cellular	• Partial Ground • Flexible antenna placement	SMT metal antenna on plastic carrier
P522303-01	Cellular	• Demo Board	Metal antenna with plastic carrier on PCB board

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) .

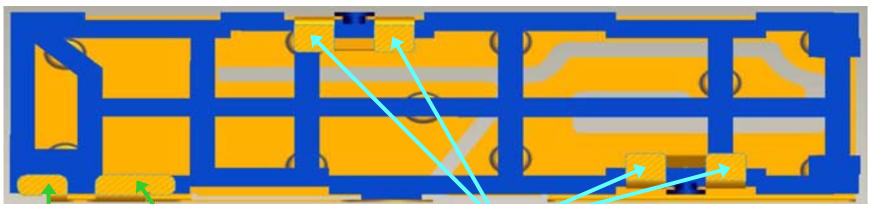

Figure 1

- **Maximum Dimensions**: 42.5 x 12.7 x 8.1 mm
- **RF Mounting**: RF Feed and Ground pads are SMD attached to the main PCB
- **Mechanical Mounting**: Antenna Assembly is SMD attached to the main PCB

3.3 PCB Land Pattern

Two PCB land pattern options can be used with the antenna. The first configuration has the antenna matching circuit within and closer to the footprint of the antenna itself for space saving reasons. The second configuration places the antenna matching circuit outside the antenna footprint for ease of re-work. Both configurations will provide similar performance.

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

Figure 2

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Figure 3 below shows the PCB Land Pattern layout (top view) when the Matching Circuit is located outside the antenna footprint.

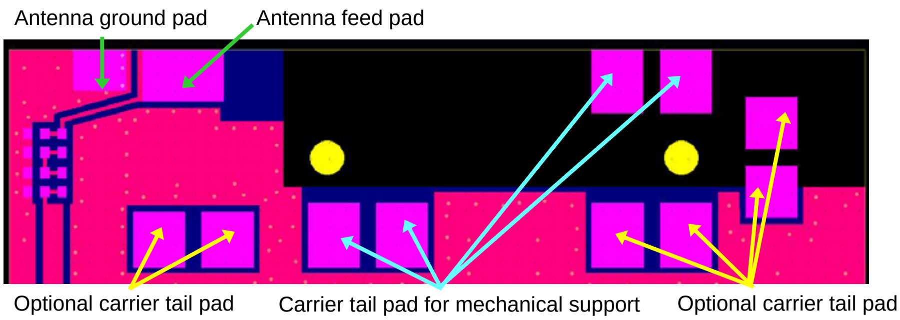

Figure 3

3.4 Antenna Location

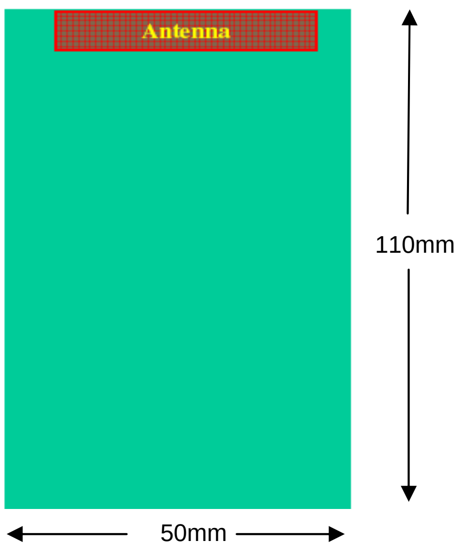

Figure 4

1. Figure 4 shows a typical landing location of a Prestta Penta-Band Embedded Cellular Antenna.
2. Ethertronics recommends full or partial clearance under the antenna for optimum performance.
3. Top edge is the recommended location.

3.5 Measured Efficiency vs. Ground Plane Length

Figure 5

1. When the width is held constant, varying the length of the PCB will change the performance.
2. Results are shown in Figures 6, 7, 8 and 9.

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Figure 6, below, shows the effect on low band Efficiency when the ground plane length is decreased.

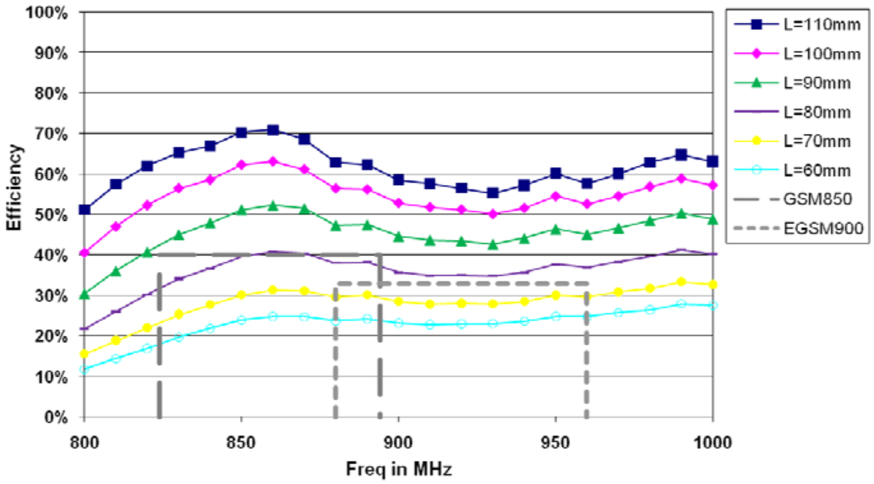

Figure 6

- Low band efficiency decreases uniformly as the length reduces.
- A length of 110mm provides the best results.
- When the length is at least 100mm, efficiency is 50% or more
- When the length is greater than 90mm, efficiency is 40% or more

Figure 7, below, shows the effect on high band efficiency when the ground plane length is decreased.

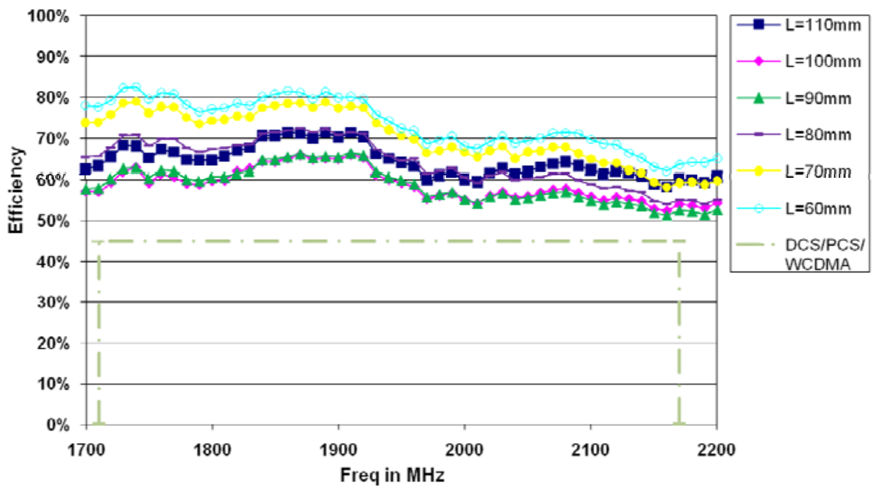

Figure 7

- High band efficiency is not affected significantly by increasing the length.
- For the high band, efficiency is above spec regardless of PCB length

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Figure 8, below, shows the effect on low band Efficiency when the ground plane length is increased.

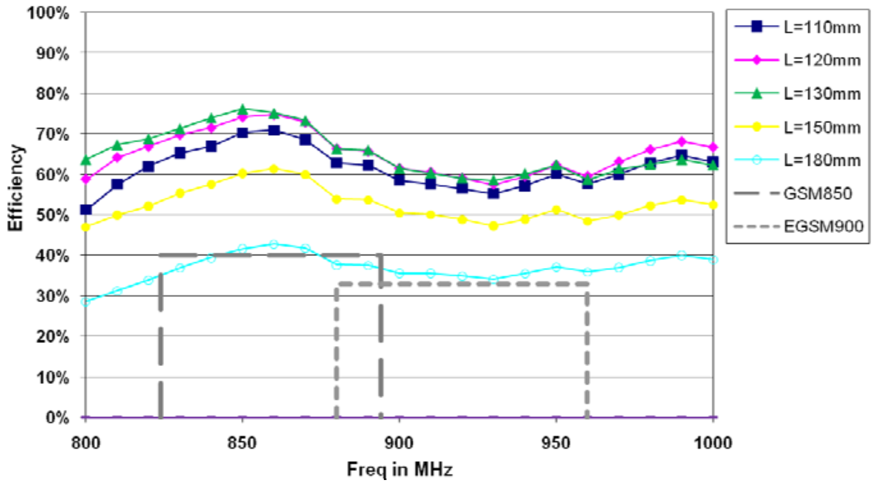

Figure 8

- Low band efficiency first stabilizes as the length increases and then starts decreasing again.
- A length of 130mm provides the best results.
- When the length is no more than 150mm, efficiency is 50% or more

Figure 9, below, shows the effect on high band efficiency when the ground plane length is increased.

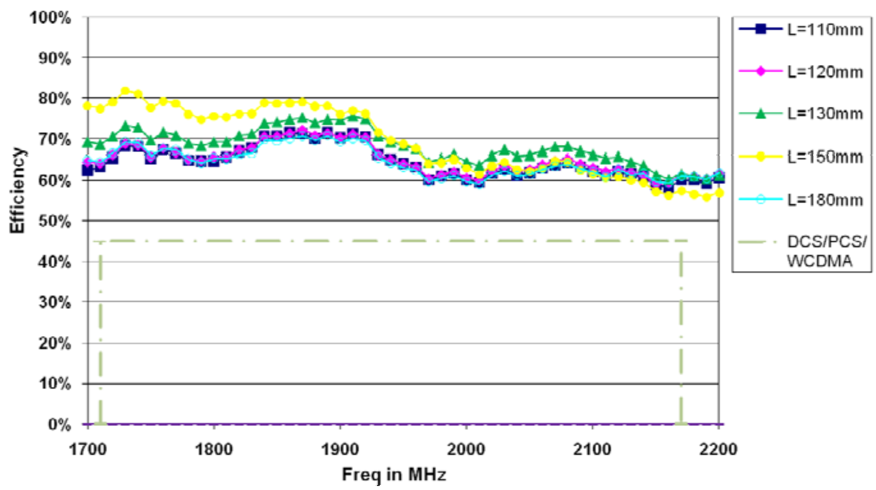

Figure 9

- High band efficiency is not affected significantly by increasing the length.
- For the high band, efficiency is above spec regardless of PCB length

3.6 Matching Circuit Tuning Guidelines

The matching circuit can be tuned to improve performance. 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. Nevertheless, the trend should remain.

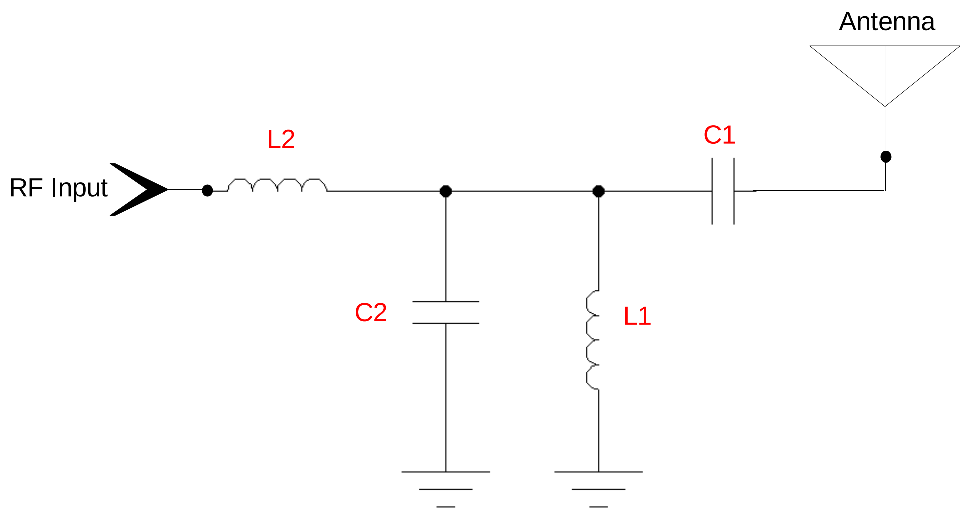

Figure 10

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Measured Return Loss vs. Matching Component C1

Performance can be changed by changing the value of C1 (Figure 11), as shown in Figures 12 and 13 below:

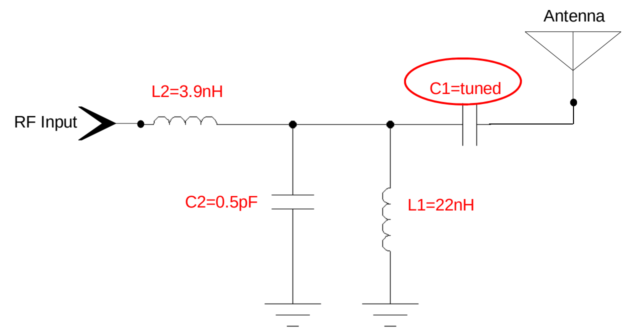


Figure 11

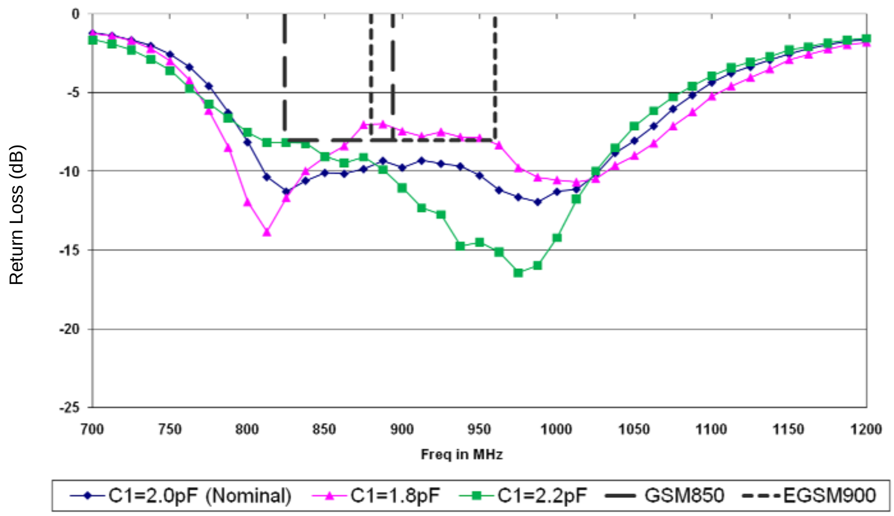
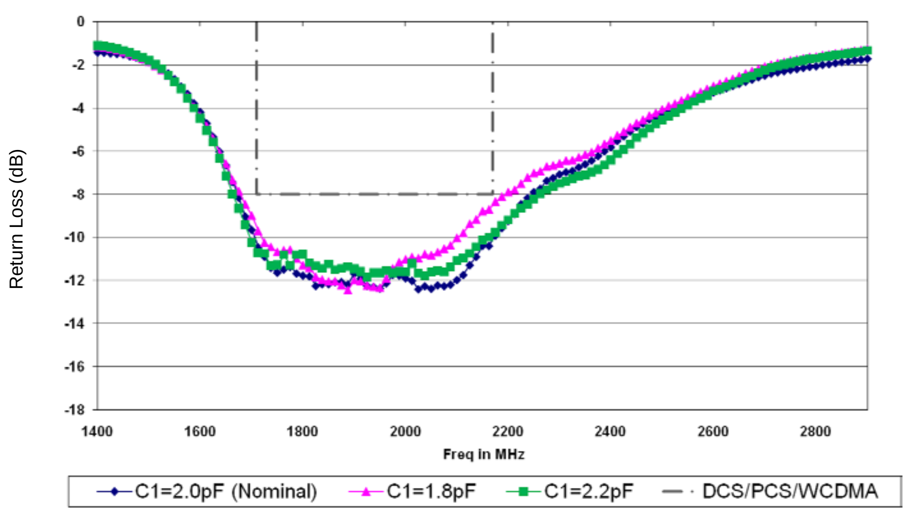


Figure 12

Low band consists of two resonances.

- When C1 is equal to its optimum value, two resonances are properly positioned and a maximally flat in-band response appears.
- When C1 deviates from its optimum value, the two resonances split.
- When C1 decreases, matching at lower resonance improves, but degrades at higher resonance. The opposite occurs when C1 increases



- High band is not affected significantly.

Figure 13

Product specifications subject to change without notice.

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Measured Return Loss vs. Matching Component L1

Performance can be changed by changing the value of L1 (Figure 14), as shown in Figures 15 and 16 below:

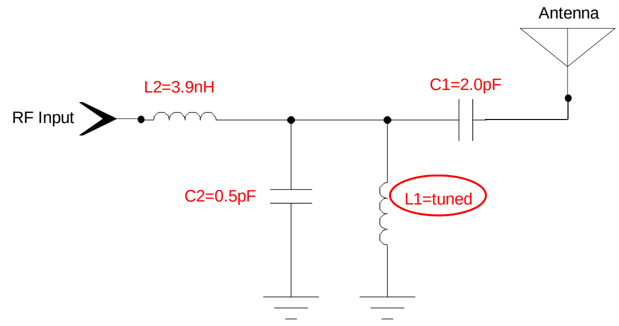

Figure 14

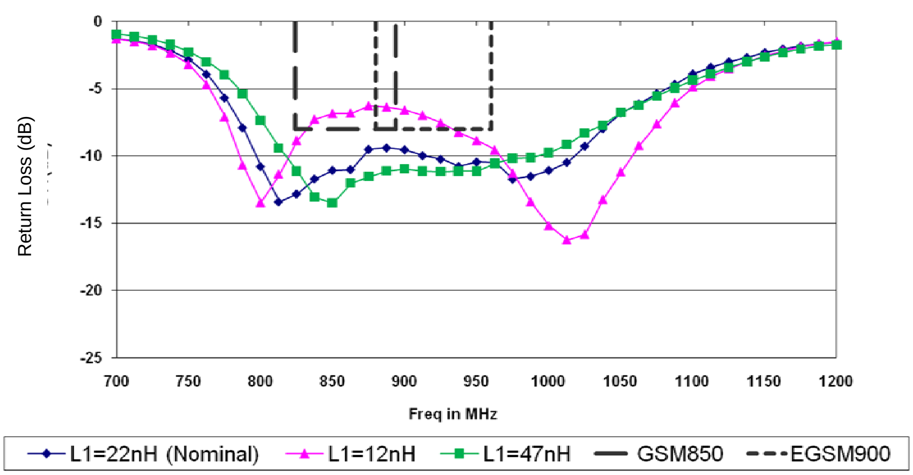

Figure 15

The smaller L1 is:

- The larger the bandwidth
- The worse the matching becomes
- Eventually it splits into two resonances

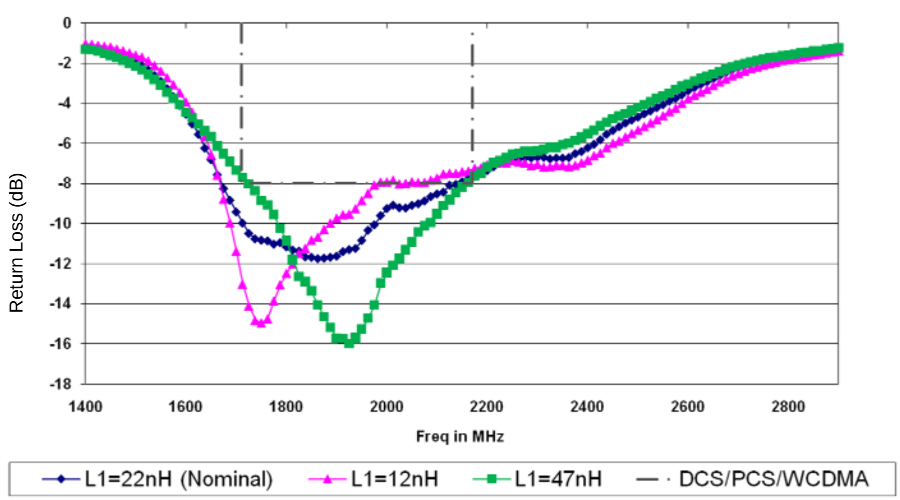

Figure 16

- High band bandwidth degrades as L1 deviates from its optimum value.
- The smaller L1 is, the lower the high-band resonating frequency.

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Measured Return Loss vs. Matching Component C2

Performance can be changed by changing the value of C2 (Figure 17), as shown in Figures 18 and 19 below:

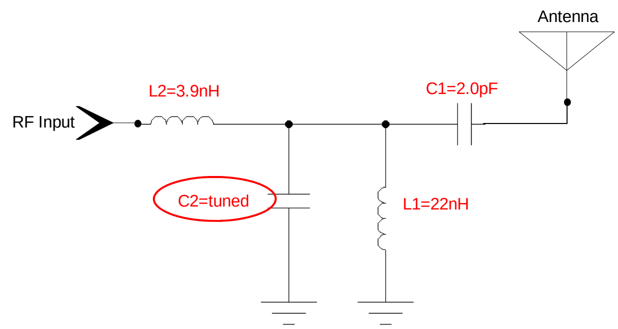

Figure 17

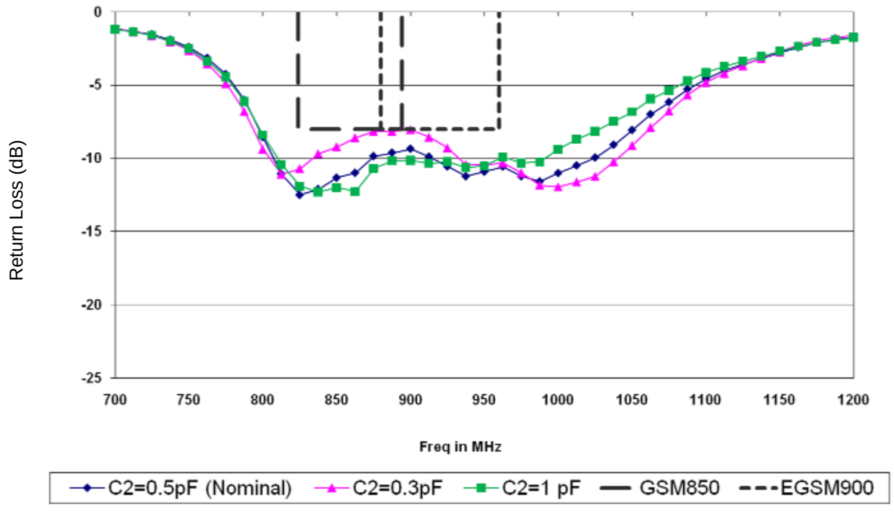

Figure 18

- Low band is not affected significantly

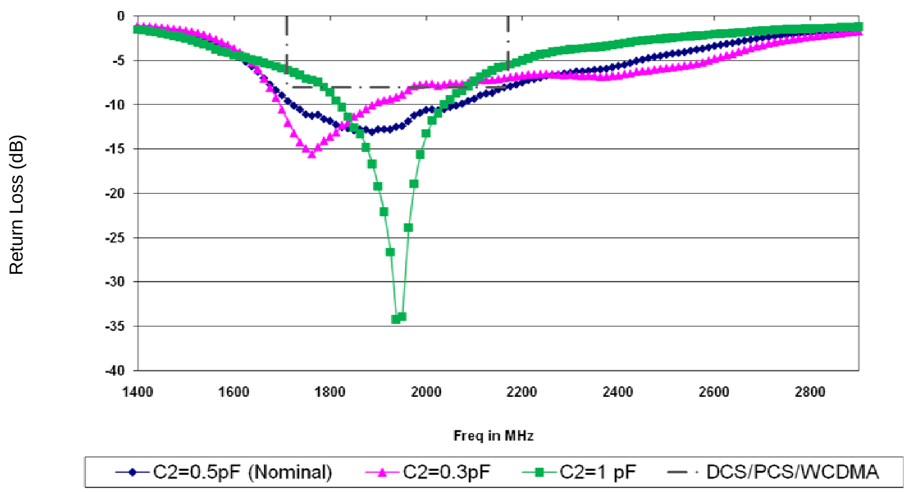

Figure 19

- High band bandwidth degrades as C2 deviates from its optimum value.
- The smaller C2 is, the lower the high band resonating frequency.

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Antenna Application Note

Measured Return Loss vs. Matching Component L2

Performance can be changed by changing the value of L2 (Figure 20), as shown in Figures 21 and 22 below:

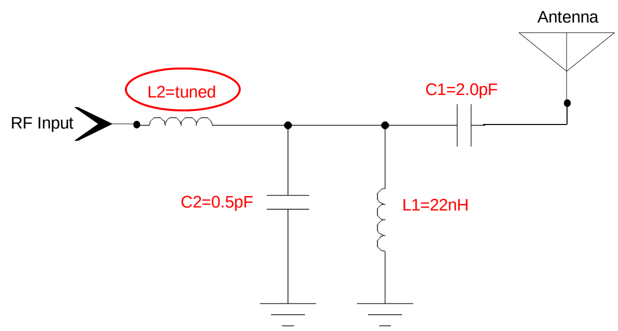

Figure 20

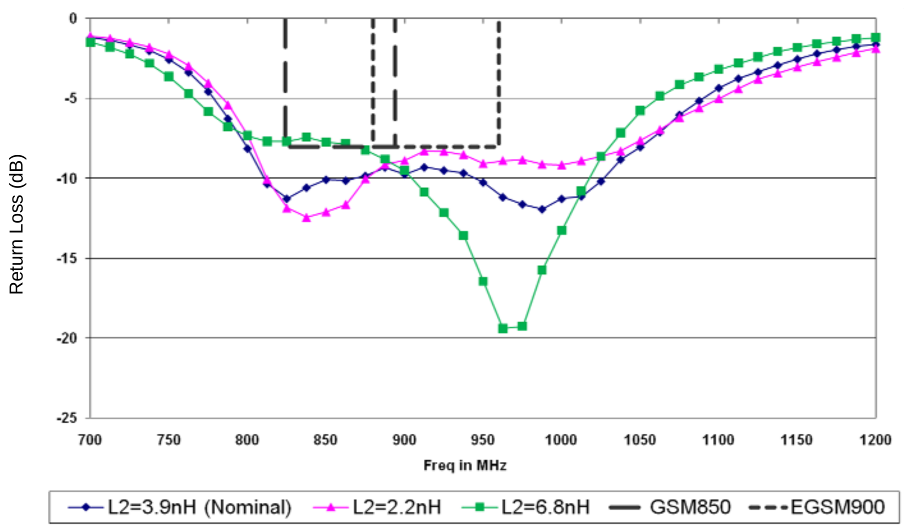

Figure 21

Low band consists of two resonances.

- When L2 is equal to its optimum value, two resonances are properly positioned and a maximally flat in-band response appears.
- When L2 deviates from its optimum value, the two resonances split.
- When L2 decreases, matching at lower resonance improves, but degrades at higher resonance.
- The opposite occurs when L2 increases

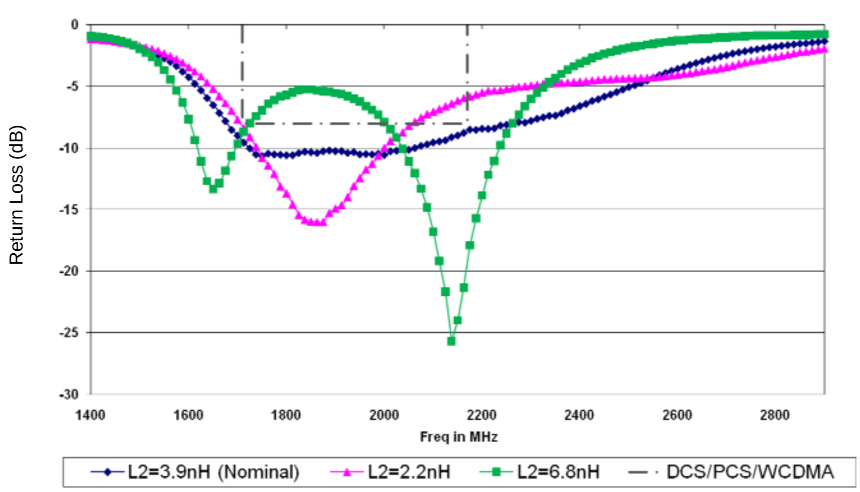

Figure 22

The larger L2 is:

- The larger the bandwidth
- The worse the matching becomes
- Eventually it splits into two resonances

Product specifications subject to change without notice.

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									
Murata Elect	L1	MLK1005S22NJ	22nH	+/- 5%	445-1471-2-ND	Yes	-55 ~ 125	200	
TDK Corporation	L1	MLG1005S22NJ	22nH	+/- 5%	445-3063-2-ND	Yes	-55 ~ 125	350	
Susumu Co	L2	HPL1005-3N9	3.9nH	+/- 0.2NH	408-1007-2-ND	Yes	-55 ~ 125	620	
Taiyo Yuden	L2	HK10053N9J-T	3.9nH	+/- 5%	HK10053N9J-T-ND	Yes	-55 ~ 85	500	Temperature range smaller than other products
TDK Corporation	C1	C1005C0G1H020B	2PF	+/- 0.1PF	445-4862-2-ND	Yes	-55 ~ 125		
Taiyo Yuden	C1	UMK105CG020CW-F	2PF	+/- 0.1PF	UMK105CG020CW-F-ND	Yes	-55 ~ 125		
TDK Corporation	C2	C1005C0G1H0R5B	0.5PF	+/- 0.1PF	445-4851-2-ND	Yes	-55 ~ 125		
Taiyo Yuden	C2	UMK105CG0R5BW-F	0.5PF	+/- 0.1PF	UMK105CG0R5BW-F-ND	Yes	-55 ~ 125		
Extra components for tuning									
Wurth Electronics	L1	744765127A	27nH	+/- 5%	732-1735-2-ND	Yes	-40 ~ 125	400	
Murata Electronics	L1	LQW15AN27NJ00D	27nH	+/- 5%	490-1151-2-ND	Yes	-55 ~ 125	280	
Murata Electronics	L1	LQW15AN18NJ00D	18nH	+/- 5%	490-1149-2-ND	Yes	-55 ~ 85	370	
TDK Corporation	L1	MLK1005S18NJ	18nH	+/- 5%	445-1470-2-ND	Yes	-55 ~ 125	250	
Susumu Co	L2	HPL1005-4N3	4.3nH	+/- 0.2NH	408-1317-2-ND	Yes	-55 ~ 125	550	
Murata	L2	LQW15AN4N3C00D	4.3nH	+/- 0.2NH	490-1138-2-ND	Yes	-55 ~ 125	750	
Taiyo Yuden	L2	HK10054N3S-T	4.3nH	+/- 0.3NH	587-1510-2-ND	Yes	-55 ~ 85	500	Temperature range smaller than other products
TDK Corporation	C1	C1005C0G1H1R8B	1.8PF	+/- 0.1PF	445-4860-2-ND	Yes	-55 ~ 125		
TDK Corporation	C1	C1005C0G1H2R2B	2.2PF	+/- 0.1PF	445-4864-2-ND	Yes	-55 ~ 125		

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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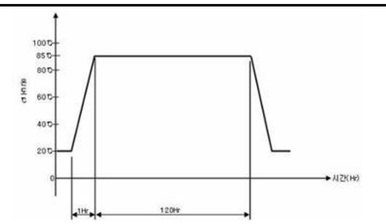
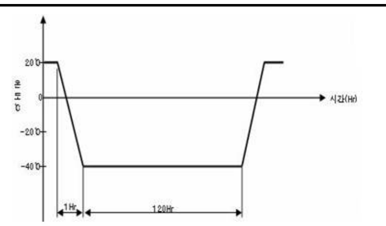
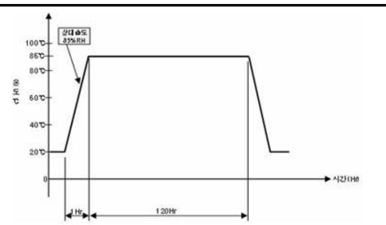
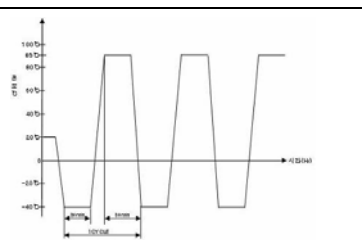
5. Material Specifications

Item	Material
Metal Element	Various (C5210, SUS301, SUS304 and others)
Contact Finish	Ni and selective Au standard
Plastic Carrier	LCP or similar

6. Product Testing

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		Thermal shock	-40°C±3°C/30min, 85°C±3°C/30min, 32cycle		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

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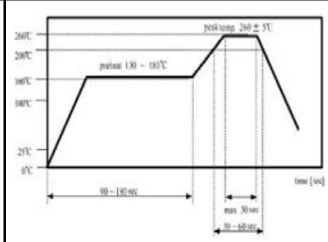
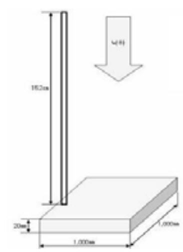
NO	Test Type	Items	Test condition	Test method	
6	Reflow test	Reflow test	Pre Heating **200°C±5°C** 30~60sec Peak Heating 260°C±5**°C** 30sec Max		Step 1: Put it in REFLOW Step 2: Test it like this picture which explains temp. Cycle by EV board
7	Mechanical Test*	Vibration*	-Frequency:10~500hz -Acceleration:10*9.8㎧(G) -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.	
8		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 with carrier 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 a tray.
- A fixture tray is provided for transferring parts for use in Pick and Place machines.
- Instructions for proper transfer of parts to the fixture tray will be provided.

Metal Component Handling Recommendations

Ethertronics' metal 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.

(**NOTE:** Normal oxidation may result in a slight discoloration of the gold nickel surface. This has no effect on the performance of the antenna.)

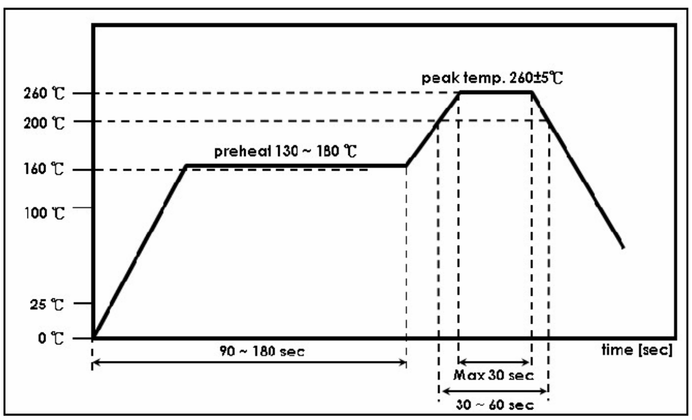
Paste Stencil Recommendation

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 ceramic 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. 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. 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

Trays

PN	Box Dims	Tray Dims	# Parts/Tray	# Trays/Box	# Parts/Box
P522303	420x240x320 mm	410x225x14 mm	88	25	2200

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. P522303

Electrical Specifications

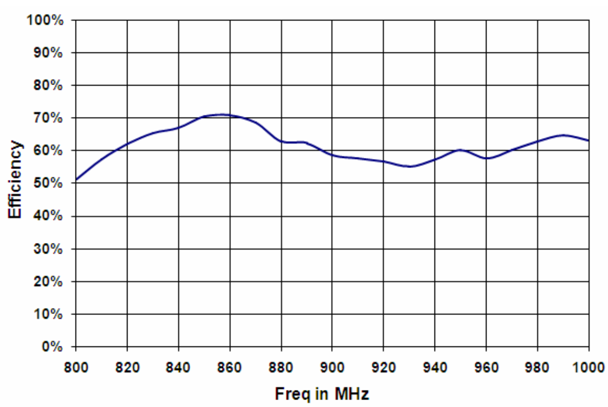
Typical Characteristics
(PCB: 50 x 110 mm)

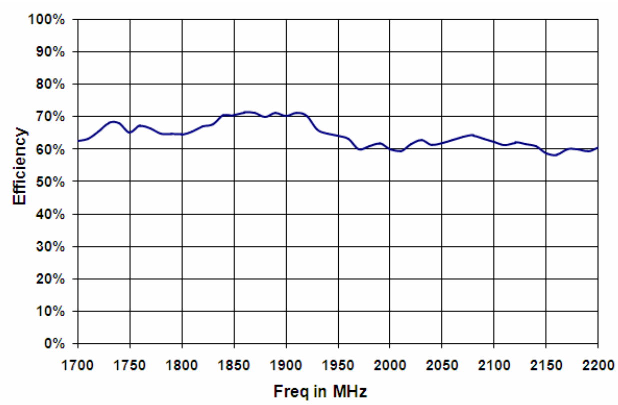
Cellular Antenna	824-849, 869-894	880-915, 925-960	1710-1785, 1805-1880	1850-1910, 1930-1990	1920- 1980, 2110-2170
Peak Gain	1.7 dBi	1.9 dBi	3.0 dBi	2.8 dBi	2.6 dBi
Average Efficiency	62%		66%		
VSWR Match	2.0:1 max (GSM/EGSM); 2.2:1 max (DCS/PCS/WCDMA)				
Feed Point Impedance	50 ohms unbalanced (other if required)				
Power Handling	2Watt CW				
Polarization	Linear				

Mechanical Specifications

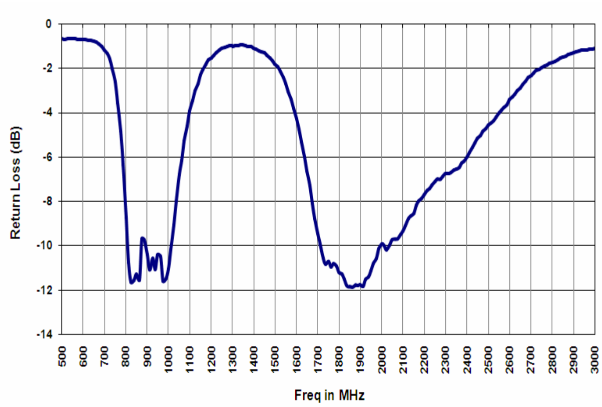
Maximum Dimensions	42.5 x 12.7 x 8.1 mm
Mechanical Mounting	Metal on plastic carrier. Antenna Assembly is SMD attached to main PCB.
RF Mounting	RF and Ground feed pads are SMD attached to main PCB.

Efficiencies

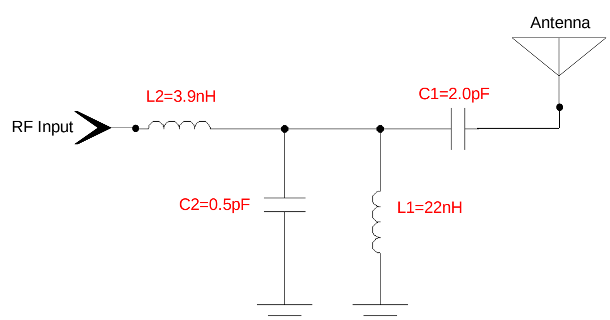




Typical Return Loss



Matching Network



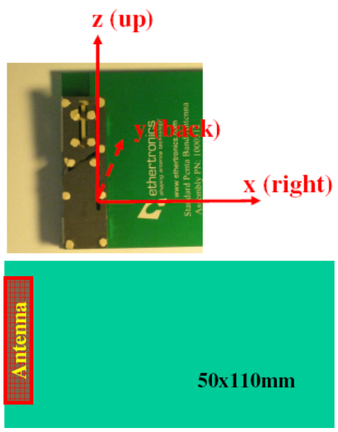
Antenna Application Note

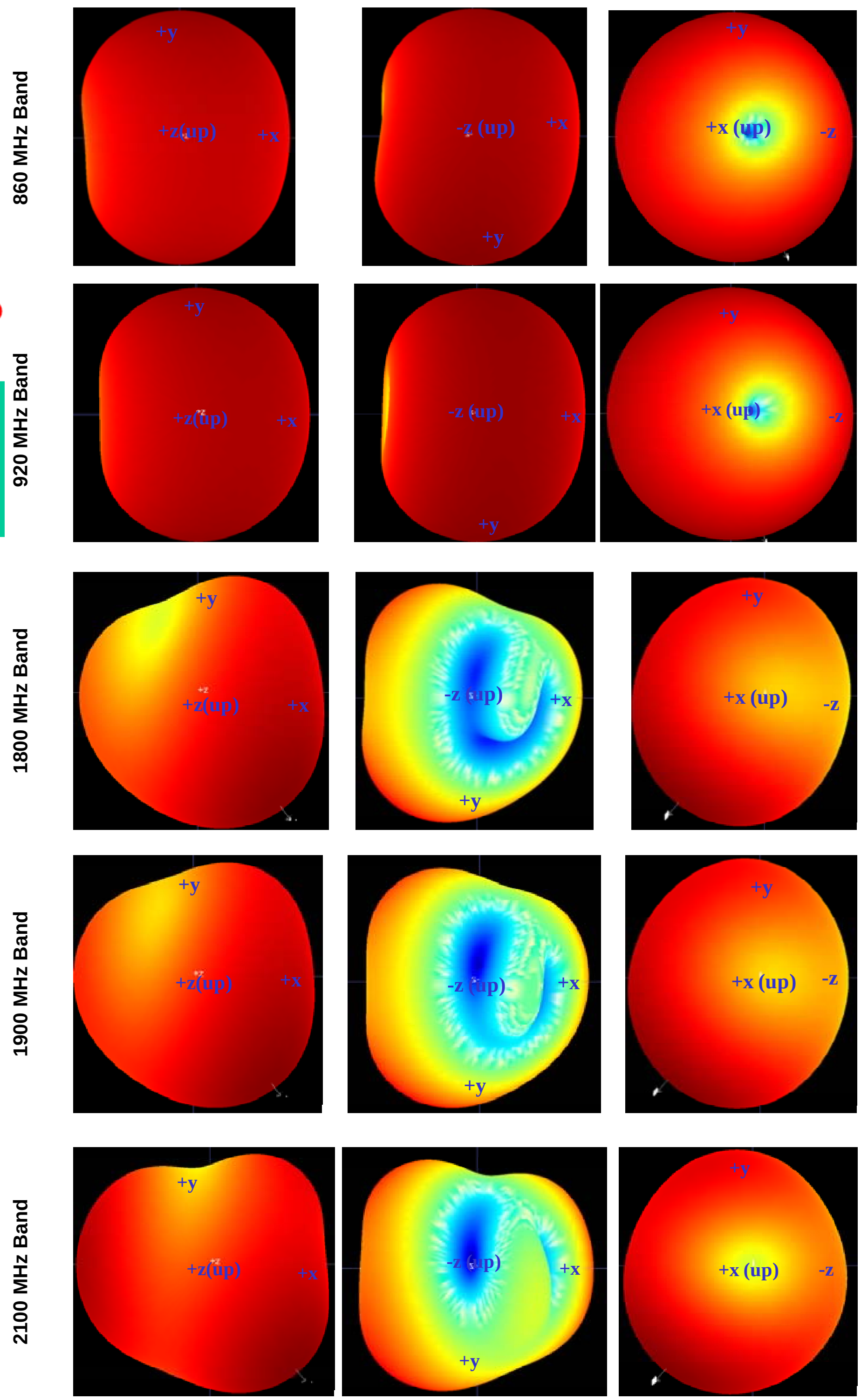
Appendix 1
Summary of Prestta™ Antenna Part No. P522303

Antenna Radiation Patterns

Typical Performance

Ethertronics' Test Board
PCB: 50x110mm

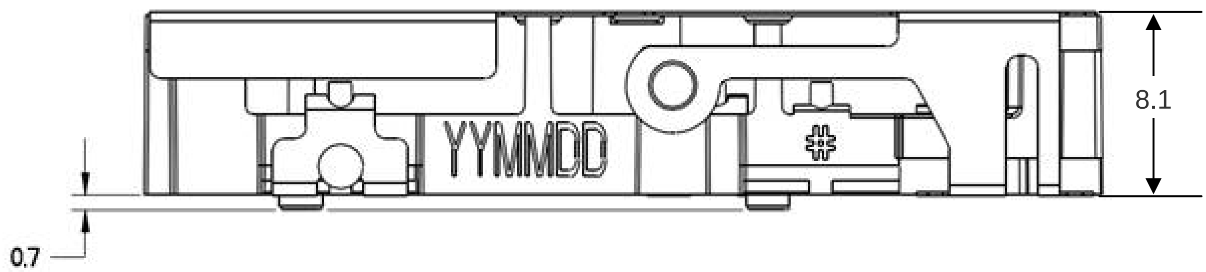


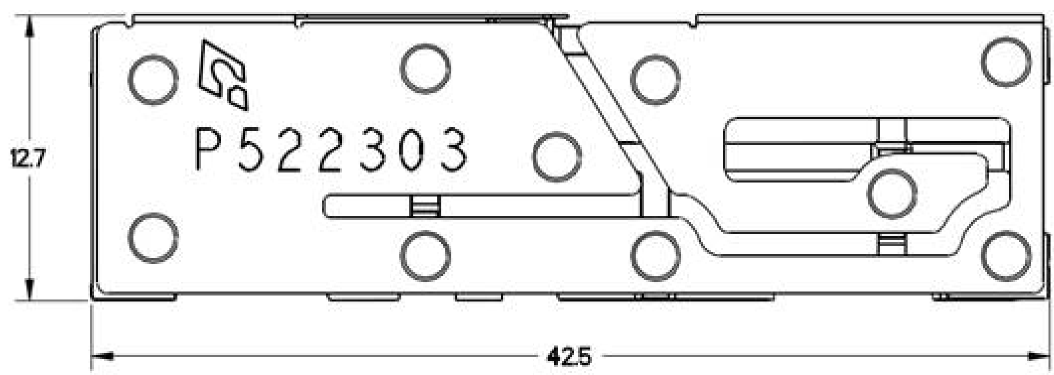


Antenna Application Note

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)



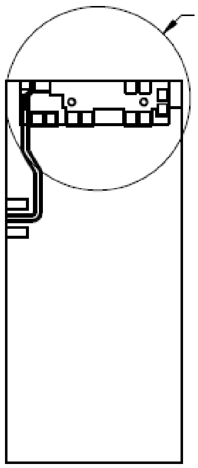


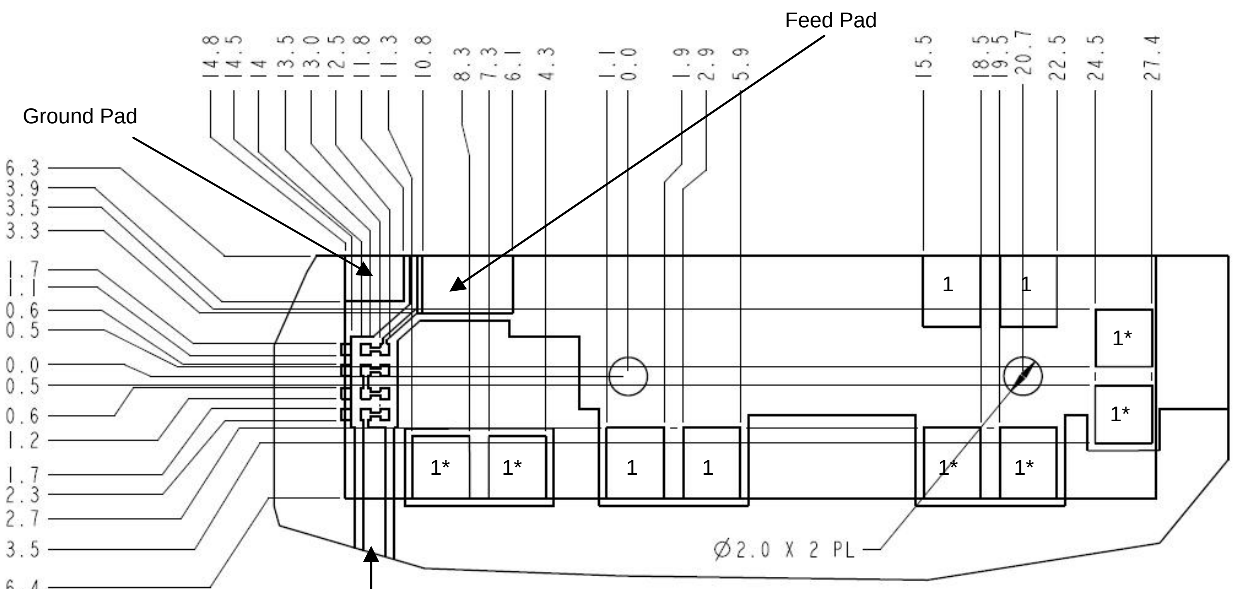
Antenna Application Note

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.





50 ohm line

1—Tail Pad (Dummy)
*Extra Tail Pad (not currently used)

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 outside the antenna footprint.