

Compact Sub-GHz RF Antenna Design

PROJECT OVERVIEW

CUSTOMER	The customer is a leading Wireless SoC company based in Australia, with the cutting-edge Sub-GHz Wi-Fi technology
APPLICATION	IoT / Consumer
SERVICES OFFERED	This was a complete Turnkey Project for Embdes, involving our services such as Feasibility Analysis, RF Simulation, RF PCB Antenna Board Design & Development, Prototyping, RF Characterization & Validation, and Pilot Production
REQUIREMENT	<p>The customer approached Embdes to investigate, design, develop, fabricate, evaluate, and qualify the Sub-GHz RF PCB Antenna.</p> <p>This was a build-to-spec project, where Embdes had to conduct a feasibility study of the possible dipole antenna design options based on RF simulations, design and any changes / improvements in the design had to be discussed and finalized with the customer and then implemented, prototyped, evaluated and then produced in batches.</p> <p>The Sub-GHz RF PCB Antenna Board requirements are as follows:</p> <ul style="list-style-type: none">• Rectangular PCB Antenna• Centre Frequency Fc: 920 MHz• Band of Operation: 890 - 950 MHz• Size: Smaller than 30x100 mm• Termination: Antenna attached with micro-coax cable providing U.FL connector termination
CHALLENGES	Customer wanted Embdes to design a Compact (Smaller than 30x100 mm) Custom Sub-GHz RF PCB antenna with desired performance characteristics around the desired Fc of 920 MHz with the bandwidth of around Fc +/-30 MHz , which was planned to be adopted to their wireless module designs

SOLUTION APPROACH

FEASIBILITY ANALYSIS	<p>Embdes performed detailed feasibility study, simulation and analysis on various possible options of PCB Dipole Antennae, to successfully design and develop the 920MHz PCB Dipole Antenna meeting all the customer requirements and performance metrics as defined and agreed with the customer.</p> <ul style="list-style-type: none">• Simulation Tool: CST Microwave Studio• Feasibility Analysis performed to design and simulate various dipole antenna options<ul style="list-style-type: none">◦ Rectangular Single Band Matched Dipole PCB Antenna
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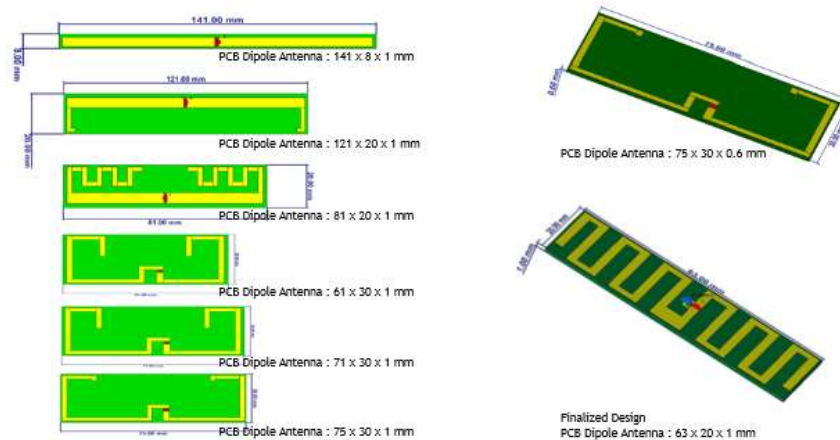
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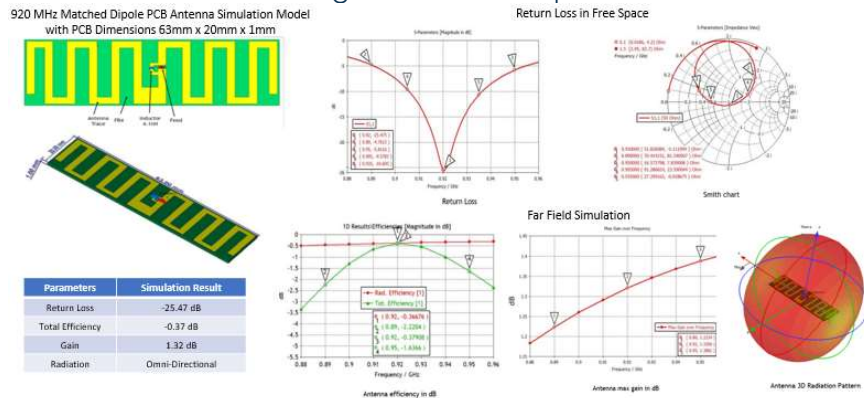
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- Centre Frequency F_c 920 MHz
- PCB Material as FR4 with relative permittivity 4.5 and loss tangent 0.025
- Simulation models varied for different PCB dimensions and different trace antennae for analysis to choose on antenna model Matched for superior performance at F_c 920 MHz
- Performance metrics such as Return loss, Efficiencies, Gain & 3D Radiation Pattern analyzed & documented for different antenna options



- Finalized matched dipole antenna with PCB dimensions **63 x 20 x 1 mm with lumped component inductor of 4.1 nH to match at the 920 MHz** selected for the design based on the performance data.



DESIGN & DEVELOPMENT

Embdes designed & developed the Matched Dipole Antenna based on the investigation report, following the suggested PCB layer stackup as per the simulation data. Also, Embdes provided prototype support, performed proto evaluation against the required performance metrics and released working proto samples to the customer. Following the proto evaluation & acceptance at the customer end, Embdes also successfully supported the customer for the pilot run production activity.

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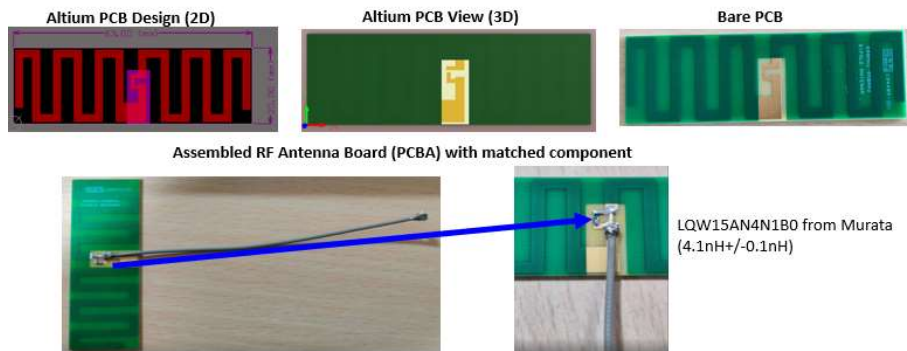
- ECAD Design Tool: Altium Designer 22

PCB Layer Stackup for the Antenna Board

G:\CUSTOMER - STACKUP\embdes\tech\embdes-11YR-1904\2K19-19083.aci Units: Mils

Layer	Stack up	Description	Type	Process Thickness	Isolation Distance (Summed)	Copper Coverage	er	Impedance (Ω)
1		Taiyo PSR 4000 GREEN	SolderMask	2.000	-	100.000	4.400	
2		Imp IT150A 20 mil core 1/1 Incl Cu Foil	FRA	1.260	38.480	-	4.400	

Copper Thickness = 1.260 | Dielectric Thickness = 38.480 | Solder Mask Thickness = 2.000 | Stack Up Thickness = 37.740 | Stack Up Thickness with Soldermask = 39.740



VALIDATION

Embdes supported evaluating the designed antenna for the performance characterization with respect to the customer requirements, using the respective test and evaluation tools.

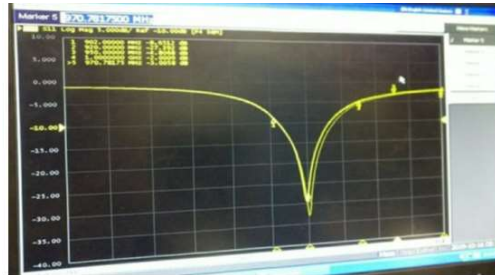
- Test & Measurement Tools:
 - Keysight ENA Vector Network Analyzer E5063A (100 kHz to 18 GHz)
 - ETS AMS 8050 Antenna Measurement Anechoic Chamber (700 MHz- 10 GHz)

Antenna Characterization Measurement Tests

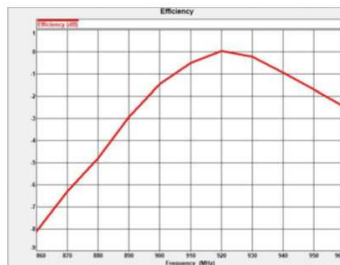
Parameters	Simulated	Measured
Return Loss(Lowest)	-25.47 dB	-27.39 dB
Total Efficiency (Highest)	-0.37 dB	-0.03 dB
Gain(Highest)	1.32 dB	2.07 dBi

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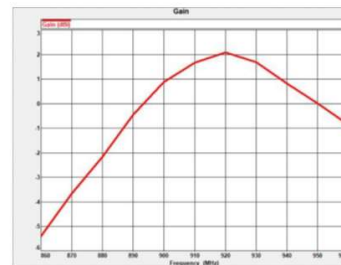
- Test Results:



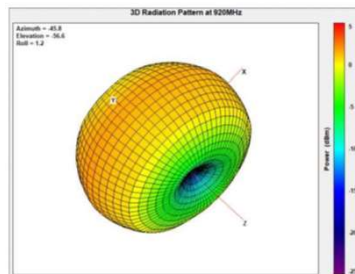
Least Return Loss about -27.39 dB at Fc 920 MHz



Antenna Efficiency in dB



Antenna Gain in dBi



Radiation Pattern at 920MHz

Across 890 to 950 MHz frequency band,
Efficiency better than -2.93 dB
Peak gain better than -0.45 dBi

At Fc 920 MHz,
Best total efficiency is 0.03 dB
Peak gain is 2.07 dBi

Radiation pattern is Omni-directional

Frequency (MHz)	Ant. Port Input Pwr. (dBm)	Tot. Rad. Pwr. (dBm)	Peak EIRP (dBm)	Directivity (dBi)	Efficiency (dB)	Efficiency (%)	Gain (dBi)
890	0	-2.93998	-0.454178	2.4858	-2.93998	50.8162	-0.454178
900	0	-1.46449	0.881652	2.34615	-1.46449	71.3757	0.881652
910	0	-0.494371	1.67394	2.16831	-0.494371	89.2407	1.67394
920	0	0.0310875	2.07657	2.04549	0.0310875	100.718	2.07657
930	0	-0.219016	1.63212	1.91113	-0.219016	95.082	1.63212
940	0	-0.940535	0.814664	1.7552	-0.940535	80.5279	0.814664
950	0	-1.70535	0.00466055	1.71001	-1.70535	67.525	0.00466055

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PROJECT OUTCOME

FEATURES

- **Single Band Matched Dipole Rectangular PCB Antenna**
- Centre Frequency Fc: **920 MHz**
- Band of Operation: **890 - 950 MHz**
- Impedance: **50 Ω**
- Return Loss: **-27 dB** at Fc
- Efficiency: **>50%** across the desired bandwidth
- Gain: **2.07 dBi** at Fc
- Radiation Pattern: **Omni-Directional**
- Compact Design
- Size: **63 x 20 x 1 mm**
- Termination: Antenna attached with **micro-coax cable** providing **U.FL connector termination**

ACHIEVEMENTS

- Successfully delivered functional samples meeting & exceeding the customer requirements in terms of features as well as the performance parameters
- On-Time Project Execution & Product Delivery
- Right Design The First Instance – No design iterations
- Seamless supply of proto samples and pilot run batches
- Zero failure rate

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