Antenna Development Report

3M – Electronic Ankle Bracelet Monitor GEN3.9

SFB000060

Revision	Author(s)	Description	Date	Approved By
1.0	Dustin Morris	Update with alpha PCB measurements	06/28/2013	George Kellerman

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2 Electromagnetic Simulations

Electro-magnetic (EM) simulations offer a great starting point for custom antenna designs. Depending on the model and simulator accuracy; results can be very close to actual measurements. Antenna simulations offer three main parameters of interest: return loss, radiation pattern and antenna efficiency. Return loss signifies the amount of power that actually flows into the antenna, and not reflected back to the power amplifier. Multiple band antennas may have much lower return loss performance than single band antennas due to practical bandwidth limitations of resonant antenna structures. The 3D far-field pattern represents the power radiated by the antenna as a function of angle from the antenna. Antenna efficiency represents a ratio of the power radiated from the antenna versus the power driven into the antenna. Because an antenna is reciprocal in nature, identical characteristics can be expected when used as a receive antenna.

2.1 Electromagnetic Model

The chosen antenna topology for the cellular and ISM antenna is a planar inverted-F antenna (PIFA). PIFAs will be used to maximize antenna efficiency and bandwidth. An electromagnetic model is built for the 3M tracking device. The model includes plastics (teal), PCB ground plane (brown), FR4 dielectric, antennas (yellow), foam (blue), and human tissue (pink).

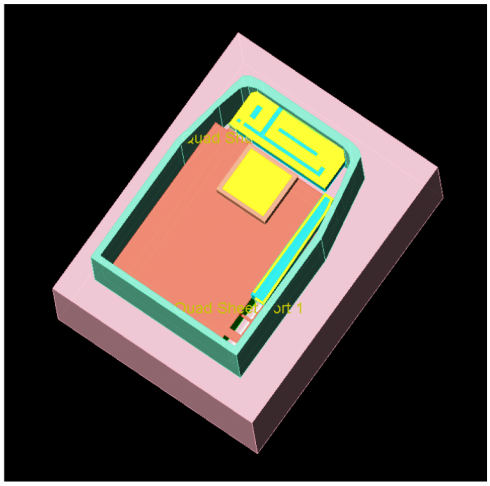

Figure 2 – Electromagnetic model

2.2 Antenna Impedance

The cellular antenna return loss and Smith chart are given below.

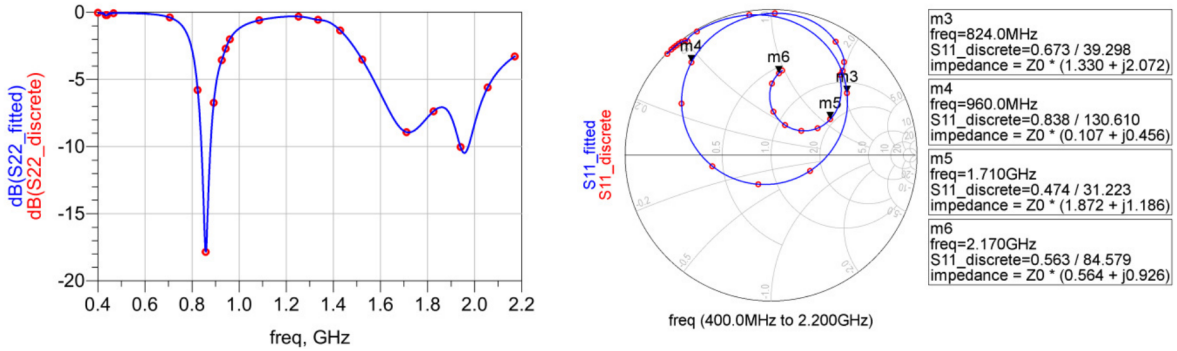

Figure 2 – Return loss magnitude (dB) and Smith Chart

2.4.3 ISM (433MHz)

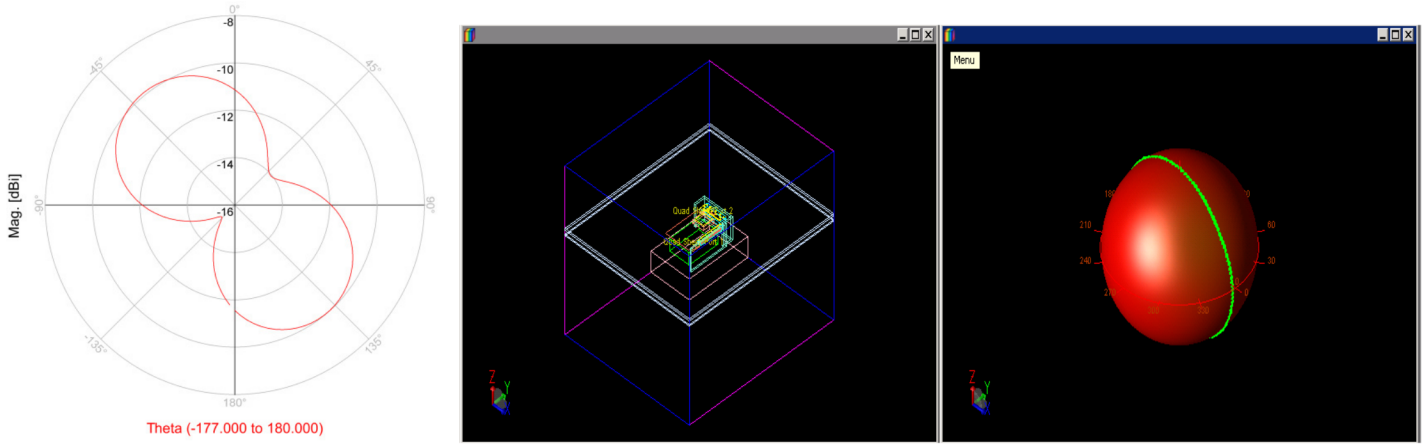

Figure 12 – Phi=0°

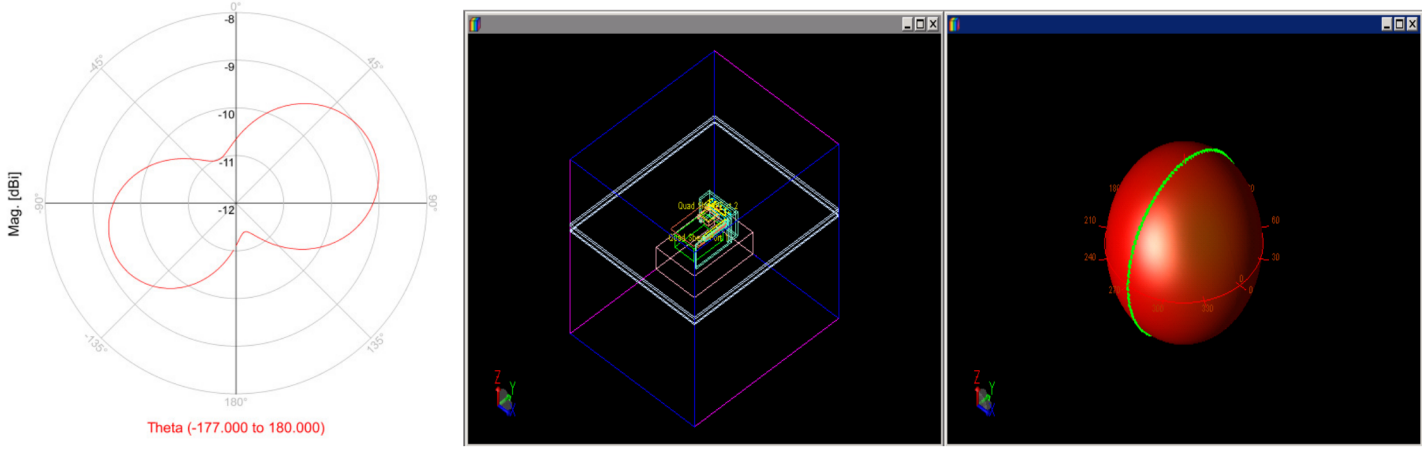

Figure 13 – Phi=90°

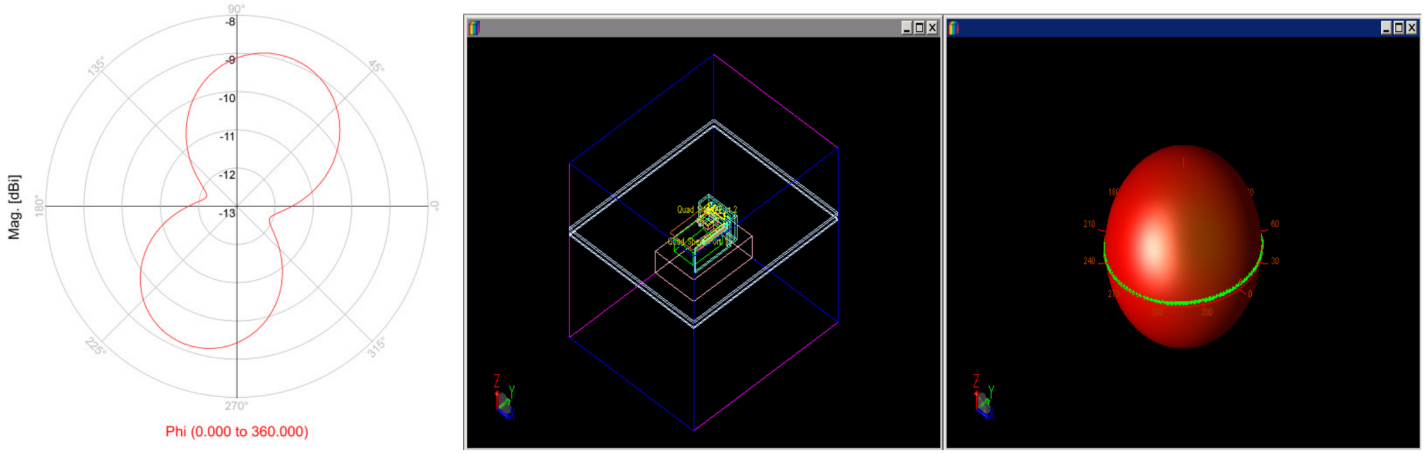

Figure 14 – Theta=90°

2.5 Antenna Efficiency

Removed OLD Cellular Antenna Data

2.5.2 ISM

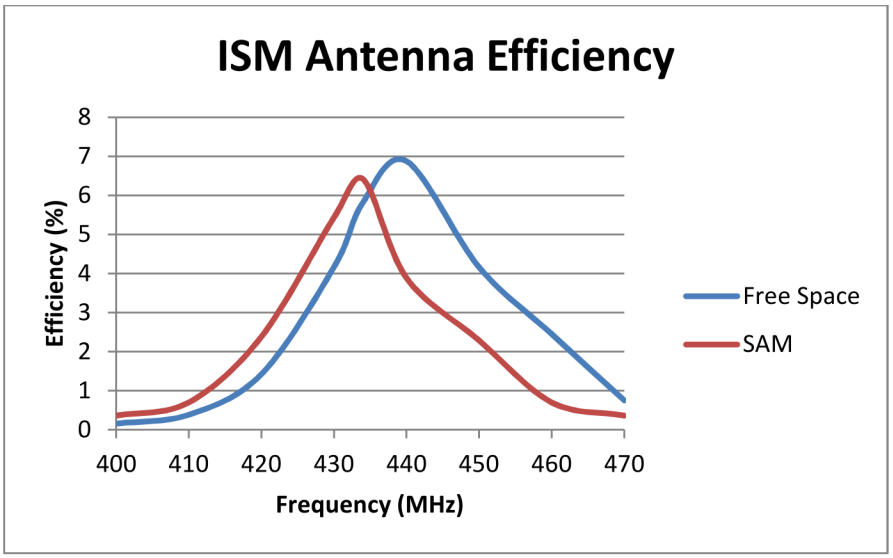

Figure 16 – ISM antenna efficiency

3 Prototype Measurements

Prototypes of the antenna and ground plane were manufactured. Prototypes are a starting point for the physical implementation of the antennas. They provide accurate predictions of how the antenna will perform when integrated with the PCB ground plane, electronics, battery, plastic enclosure, etc.

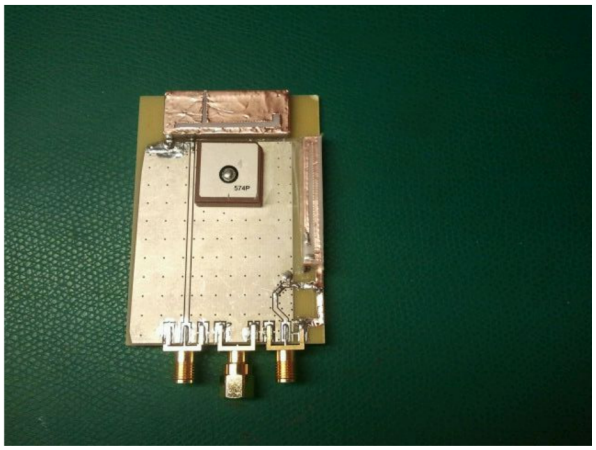

Figure 17 – Photograph of prototype antennas and PCB

3.1 Antenna Impedance

Simulations and measurements will always differ due to insufficient modeling and simulation inaccuracies, therefore the antenna prototype must be tuned and/or matched to be resonant at the desired frequency bands. This means the return loss of the antenna is minimized at the desired frequency bands. Return loss (RL) signifies the reduction in signal power caused by reflections due to the transmission line/antenna impedance discontinuity. A RL of -10dB signifies 90% of the energy driven into the transmission line reaches the antenna terminals and is considered good antenna design. A -10dB or better RL is easily attainable for single band antennas; however, multi-band antennas often have much poorer RL at the band edges. This is due to the finite impedance bandwidth of a resonant antenna structure. RL measurements for the cellular antenna and ISM antenna are given below.

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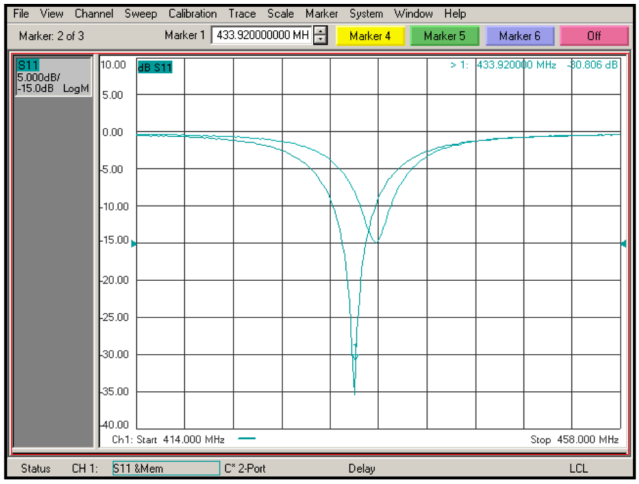

Figure 19 – ISM antenna return loss

The ISM antenna return loss plot includes free space and on-body measurements. The presence of meat has a loading effect on the ISM antenna which reduces the resonant frequency slightly. The return loss at 433.92MHz is -7dB in free space and -30dB on the body. Again, the return loss measurements are very similar to simulations.

3.2 Radiation Pattern: 2D Far-Field Cuts

The prototype antennas were sent to a 3rd party lab (Satimo) for official antenna range measurements. Satimo is a premiere antenna measurement system manufacturer and performs calibrated antenna measurements regularly as a service. Far-field radiation and antenna efficiencies are measured in free space and on a SAM wrist. Antenna measurements include integration of PCB ground plane, ABS plastic and Li-Ion battery. Measurements do not include rigid-flex PCB that is part of the electronics design.

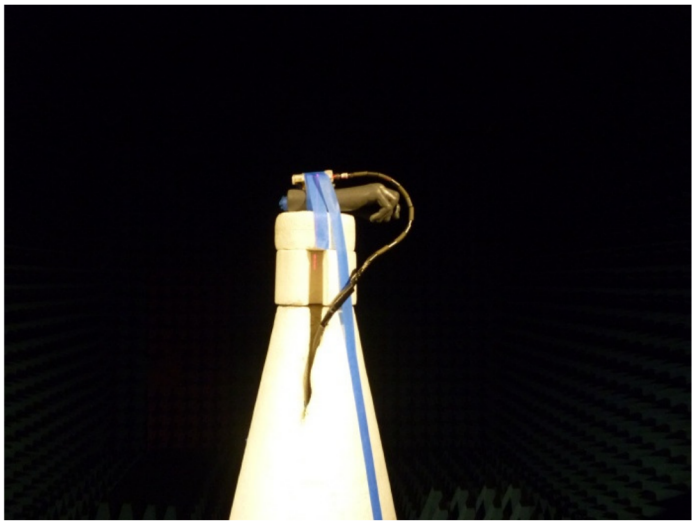

Figure 20 – Far-field test setup with SAM hand inside Satimo's SG64 antenna range

3.2.1 Cellular

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