ASSOCIATION OF ENGINEERS, ARCHITECTS AND GRADUATES IN TECHNOLOGICAL SCIENCES IN ISRAEL

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The Institute of Electrical and Electronics Engineers

SCE
SHAMOON COLLEGE OF ENGINEERING

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Antenna topologies in IoT Circuit

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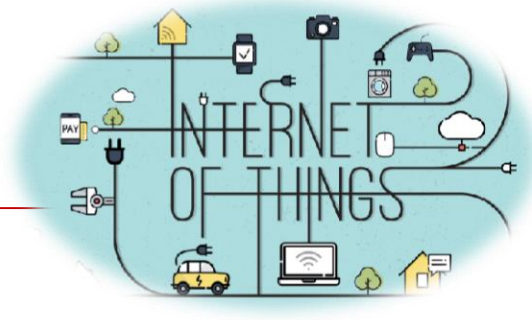
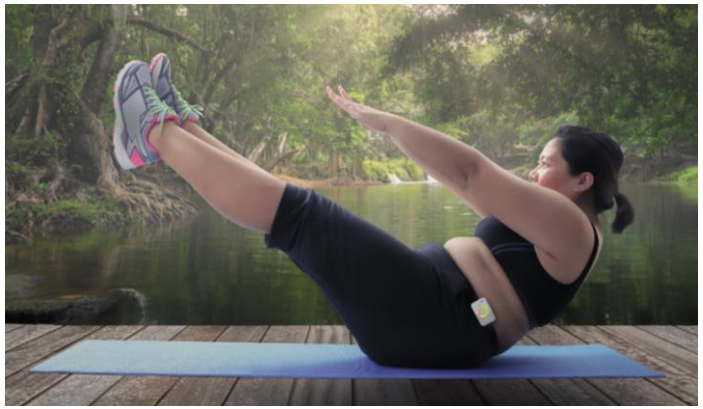
IoT Definition



IoT Can be defined as an extension of the internet or other network connection to different sensors/device …… or “things”

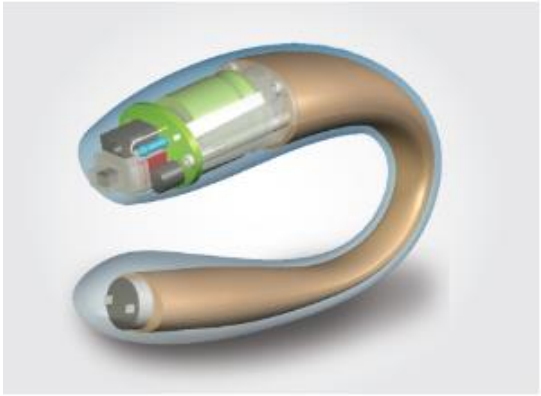
IoT Devices

Wireless RFID pediatric patient security bracelet



wearable fitness monitor

Know if your kid leaves their room at night



Adult Toys

smart watches

Personal air pollution sensor

DoorBell Cam

IoT within refrigerat

It is Written……

For every living person on earth, there will be between two and six connected things by 2020, according IoT Analytics.

75% of new cars will include a built-in IoT connectivity by 2020. (Business Insider)

15.4 billion – the number of devices that are going to be connected by 2015. This figure is expected to grow to 30.7 billion and 75.4 billion in 2020 and 2025, respectively. (IHS Inc.)

The majority of people (87%) have not heard of the term 'Internet of Things'.

ATMs are considered some of the first IoT objects, and went online as far back as 1974.

The Issue

- The Small scale integrated IoT Device, increases the EMI problem from the product itself to sensitive circuits on board. This is called "**Platform Interference**"

- One of the major malfunction in those device is communication sensitivity de-sensing.

- There are few main mechanism [noise source-coupling path-victim circuit] that cause sensitivity de-sensing

Webinar Focus

How antenna topology influence the performance, regards to conducted noise from SMPS.

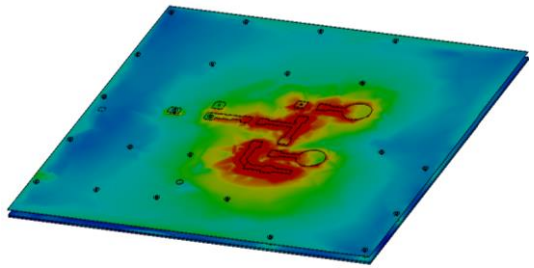
IoT Antenna Considerations

- Real Estate
- Frequency
- Band Width
- Efficiency
- Radiated Pattern

- **What About EMI considerations ????**

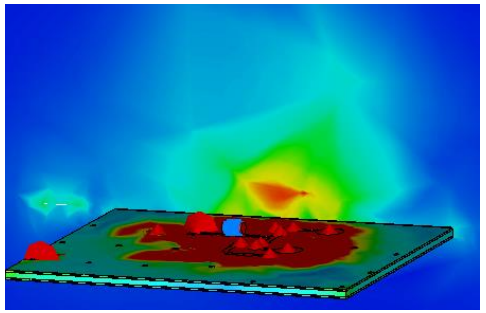
Electromagnetic Sources Coupled to Antenna

Ground Bounce on the Attached GND Plane

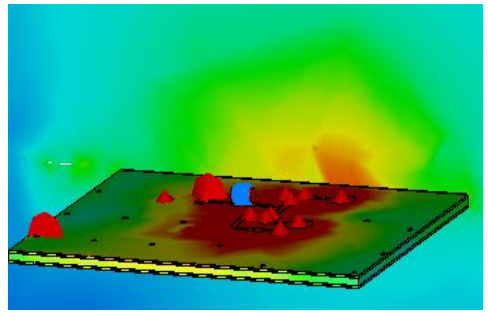


Surface Current

Radiated Electromagnetic Interference EMI



E-Field



H-Field

Radiated Mechanism of SMPS

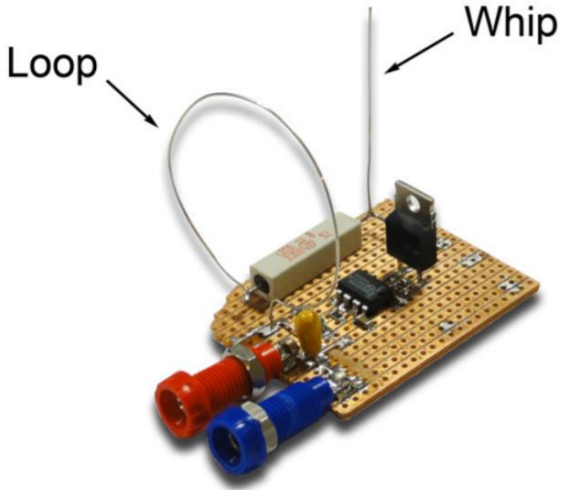
- High switching current $\frac{di}{dt}$ (magnetic source) flowing in small current loops
- High switching Voltage $\frac{dV}{dt}$ (electric source) flowing on small conductive trace
- The relationship between electric field and magnetic field is function of the distance from the source

Near Field max radiation from Infinitesimal magnetic dipole

$$|\hat{H}_r| = j\frac{\hat{I}\cdot A}{\lambda_0}\left(\frac{1}{D^2} - j\frac{\lambda_0}{2\pi D^3}\right)$$

$$|\hat{H}_\theta| = j\frac{\pi\cdot\hat{I}\cdot A}{{\lambda_0}^2}\left(\frac{j}{D} + \left(\frac{\lambda_0}{2\pi D^2}\right) - j\left(\frac{\lambda_0}{2\pi D^3}\right)\right)$$

$$|\hat{E}_\phi| = -j\frac{120\pi^2\cdot\hat{I}\cdot A}{{\lambda_0}^2}\left(\frac{j}{D} + \frac{\lambda_0}{2\pi D^2}\right)$$



Near Field max radiation from Infinitesimal electric dipole

$$|\hat{H}_r| = j\frac{\hat{I}\cdot A}{\lambda_0}\left(\frac{1}{D^2} - j\frac{\lambda_0}{2\pi D^3}\right)$$

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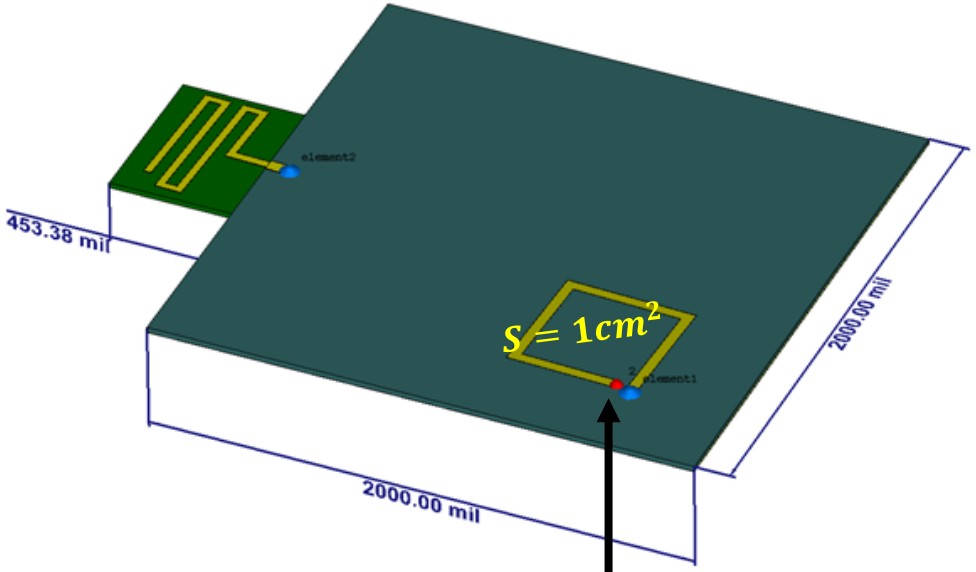
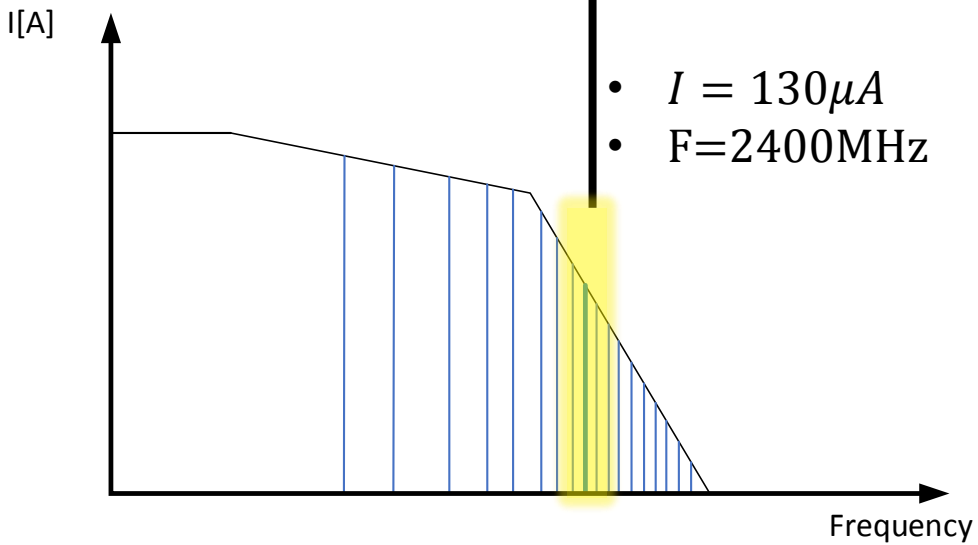
$$|\hat{E}_\phi| = -j\frac{120\pi^2\cdot\hat{I}\cdot A}{{\lambda_0}^2}\left(\frac{j}{D} + \frac{\lambda_0}{2\pi D^2}\right)$$

Example





- $I = 130\mu A$
- F=2400MHz

Wifi Sensitivity

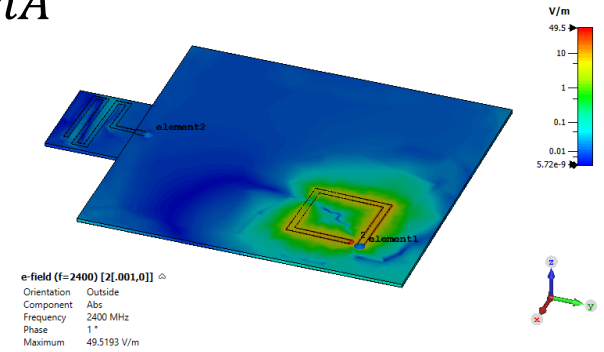
$$Noise\ Floor \cong P_{Sens} - SNR$$

$$Noise\ Floor \cong -90 - 7 =$$

$$\text{-97[dBm]} = 1.99 \cdot 10^{-13}[W]$$

$$I\big|_{@50\Omega} = 63\text{nA}$$

$$I_{ANT\_Simulated} = 64.5nA$$

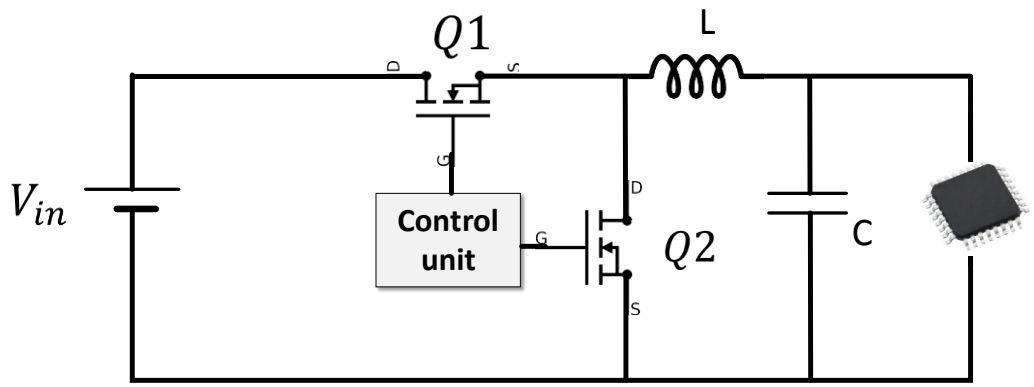


Loop Area $1cm^2$ triggered by $130\mu A$, will DE- Sense WIFI receiver sensitivity

Antenna Comparison Regard To Ground Bounce

The EMI source

- DC/DC - Buck Convertor 4.2V to 2.4V ; I=400mA

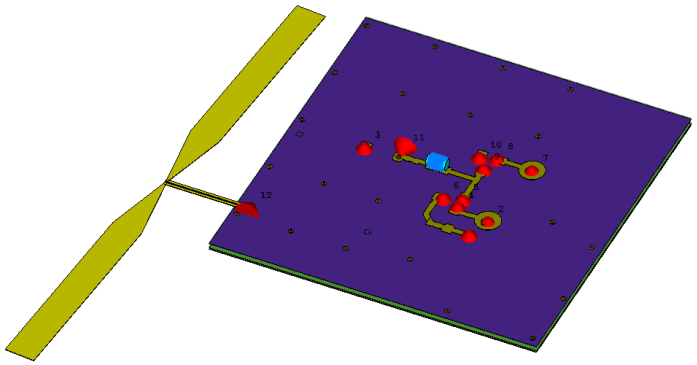


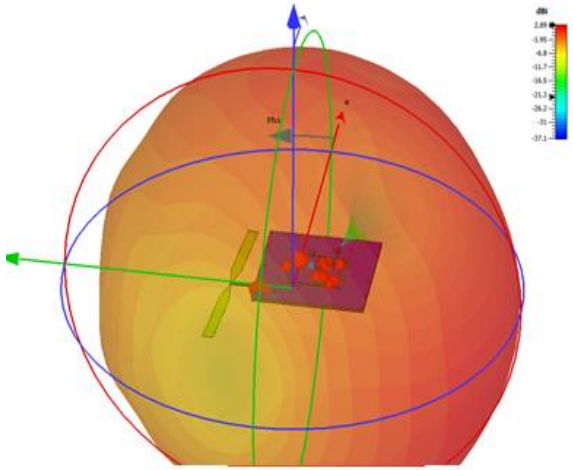
The Sensor

- Monopole Vs. Dipole

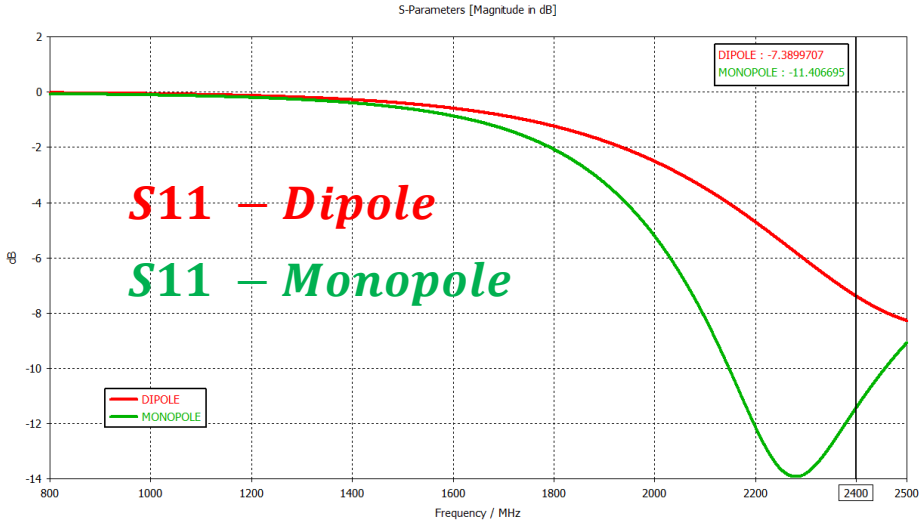
Antenna Parameters Comparison

Diploe Antenna



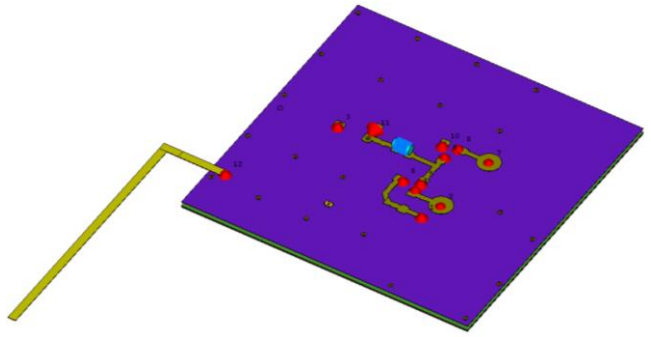


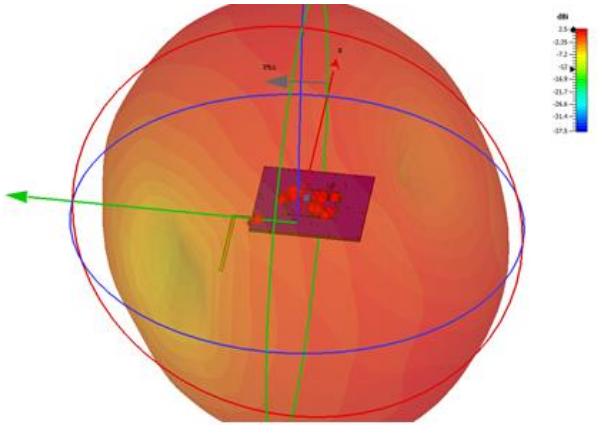
$R_{lzd}.GAIN = 2.89dBi$



- Similar far field radiated pattern
- Similar power efficiency $\sim 0.5dB$

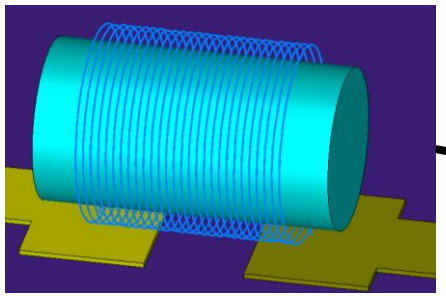
Monopole Antenna

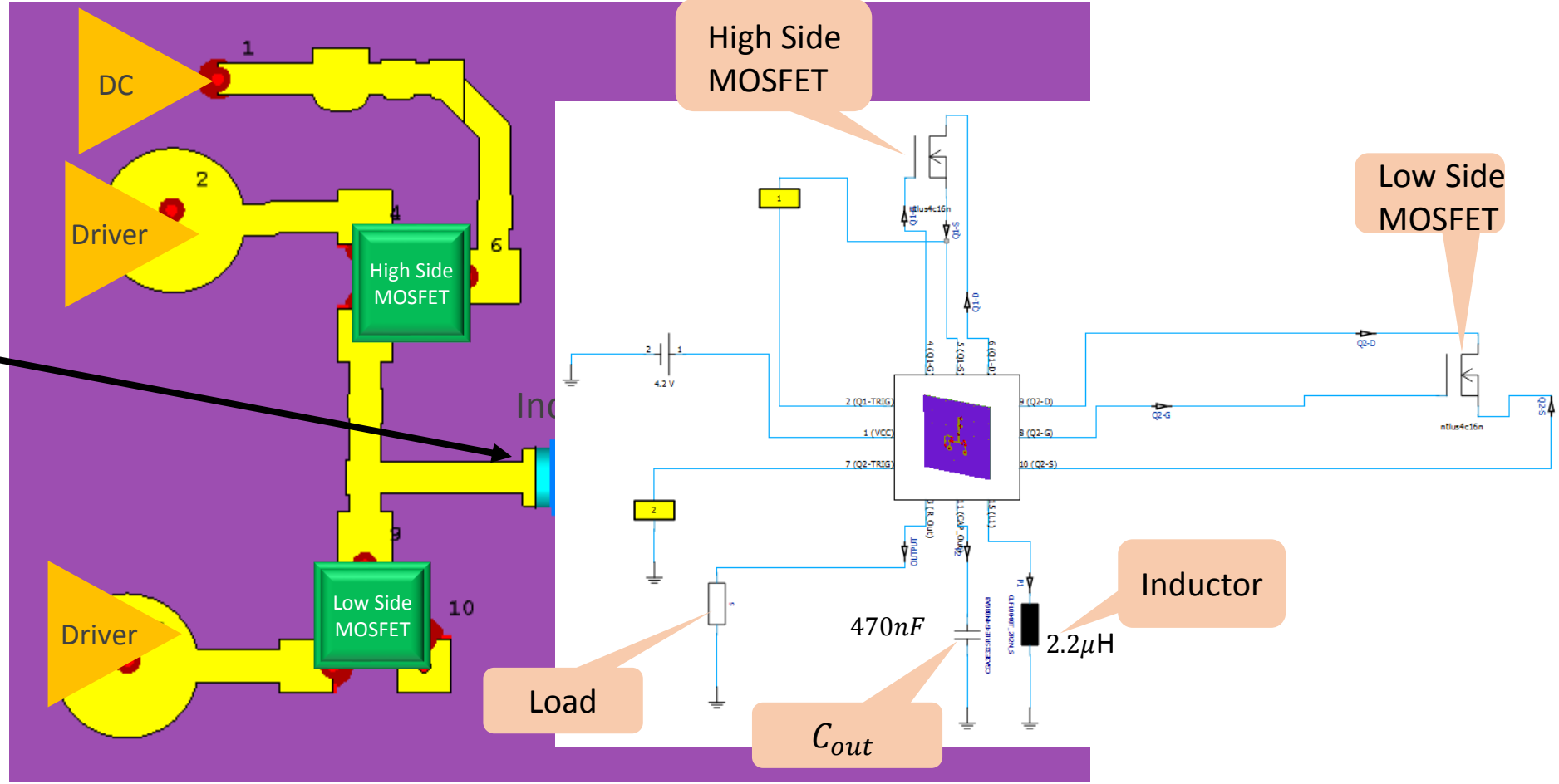


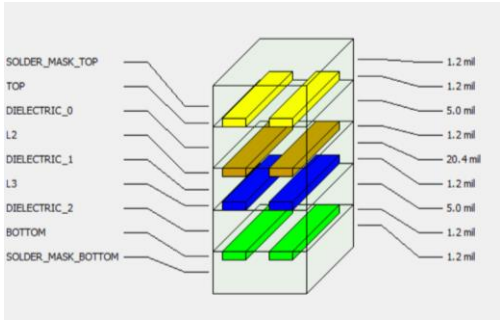


$R_{lzd}.GAIN = 2.498dBi$

Our EMI Source – Buck Converter



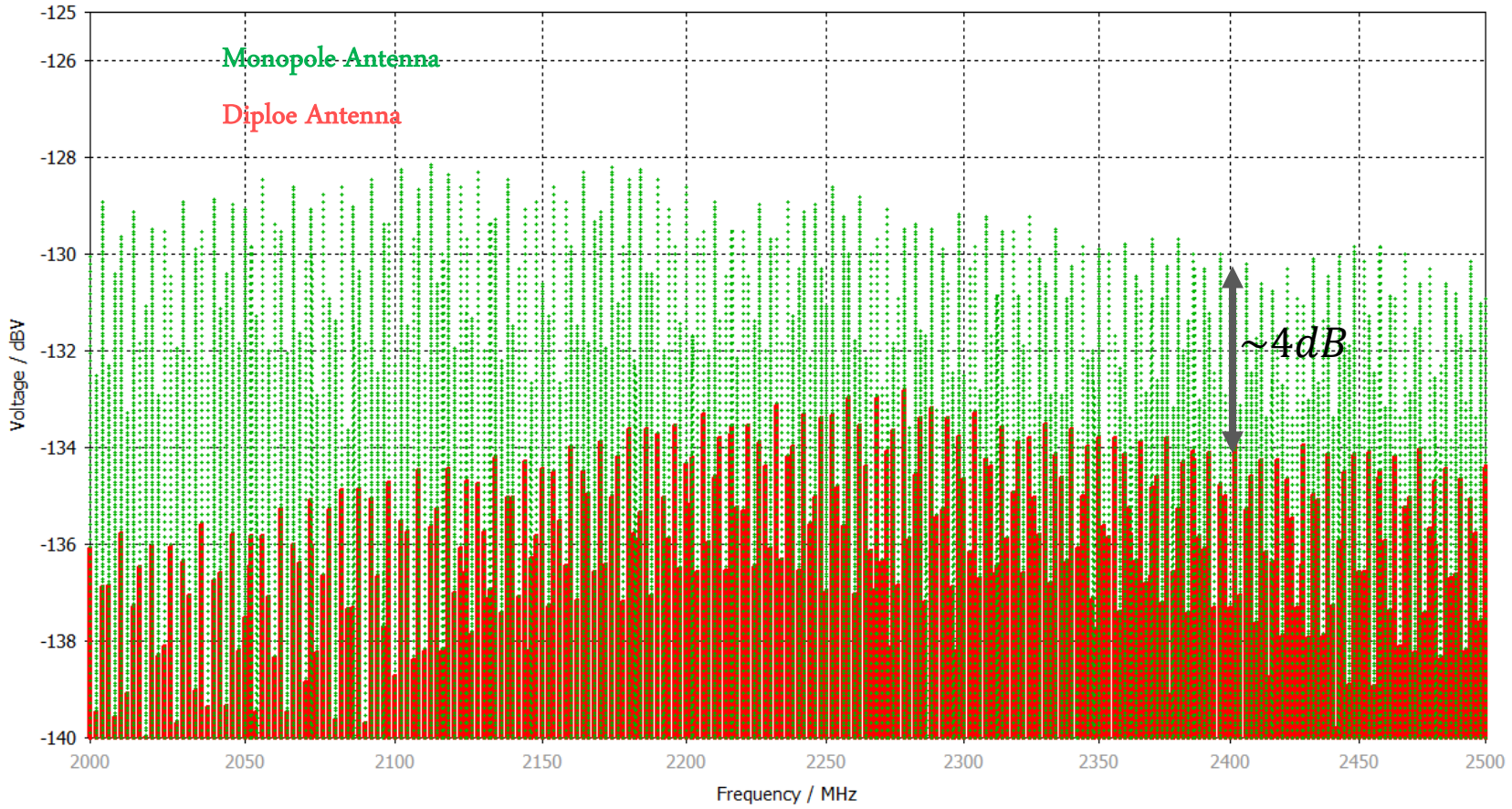




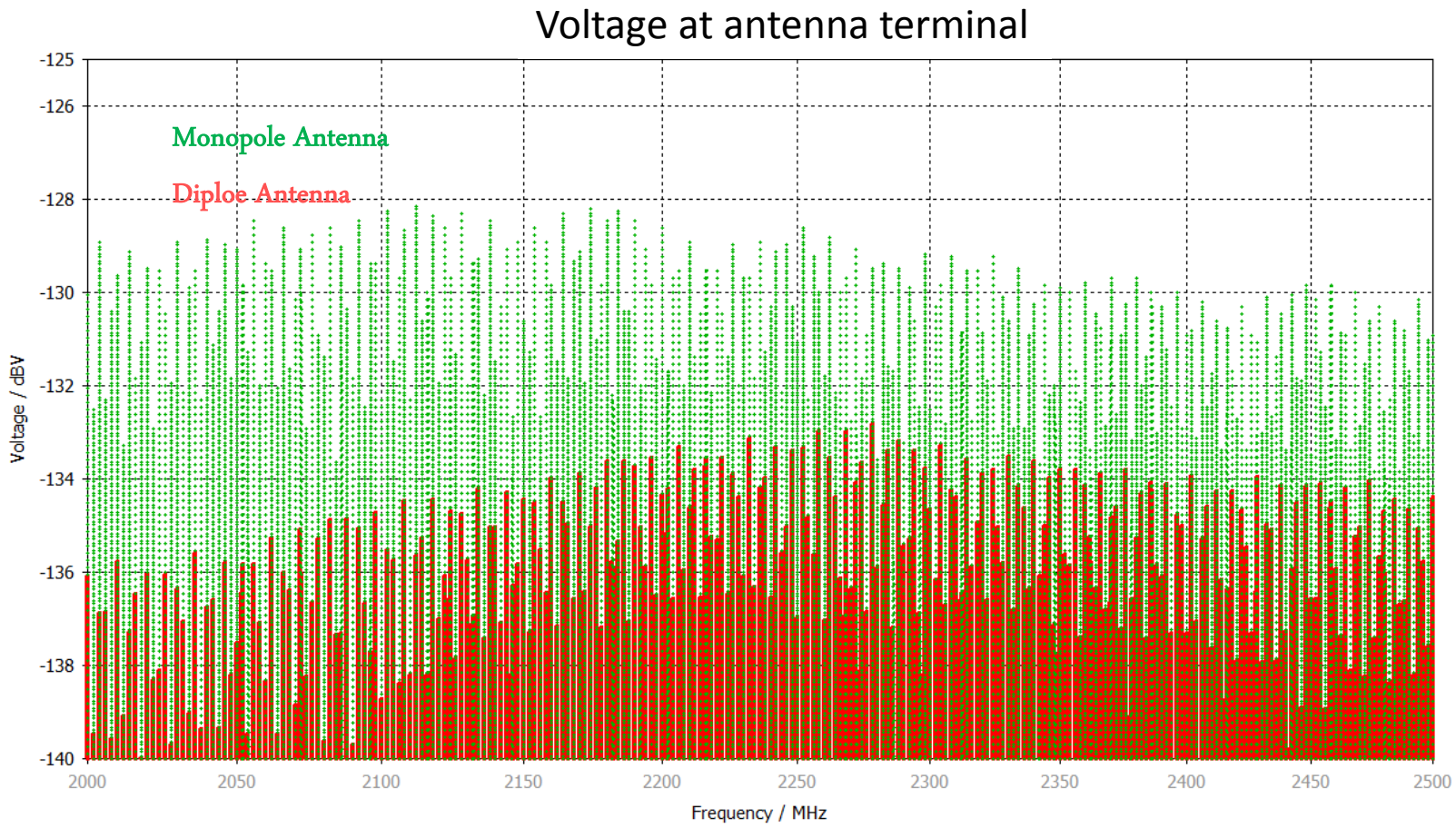
$$f_{sw} = 2MHz\ ; t_{rise} = 30nsec; duty\ cycle = 50\%$$

Reference case – Antenna Terminal

Voltage at antenna terminal



Reference case



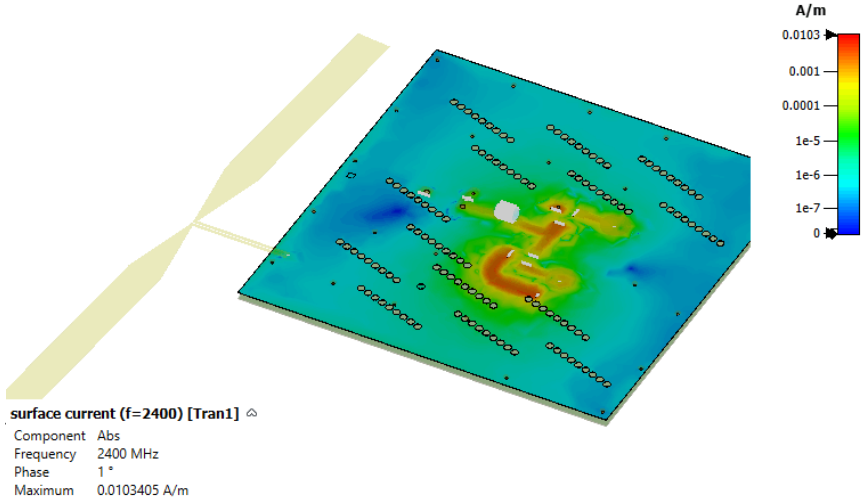
Wifi Sensitivity

$Noise\ Floor \cong P_{Sens} - SNR$

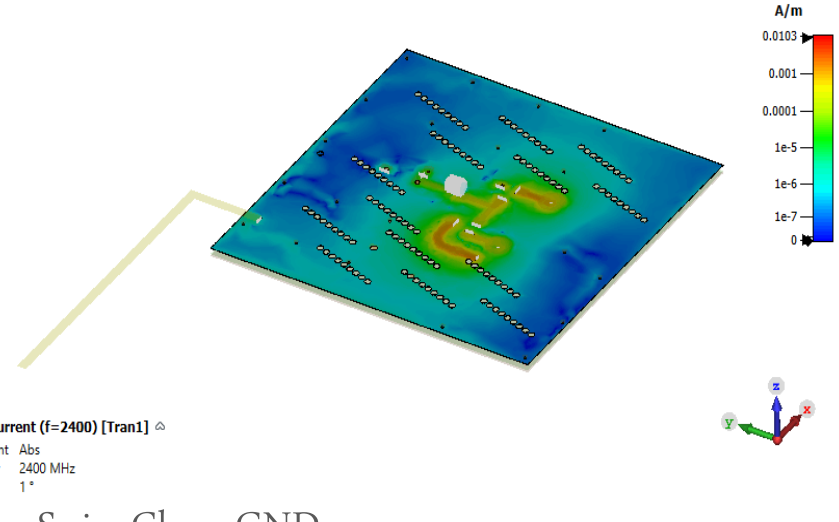
$Noise\ Floor \cong -90 - 7=$
-97[dBm]=$1.99 \cdot 10^{-13}[W]$

$Vnoise_{@50\Omega} = 3.15\mu V = -110dBV$

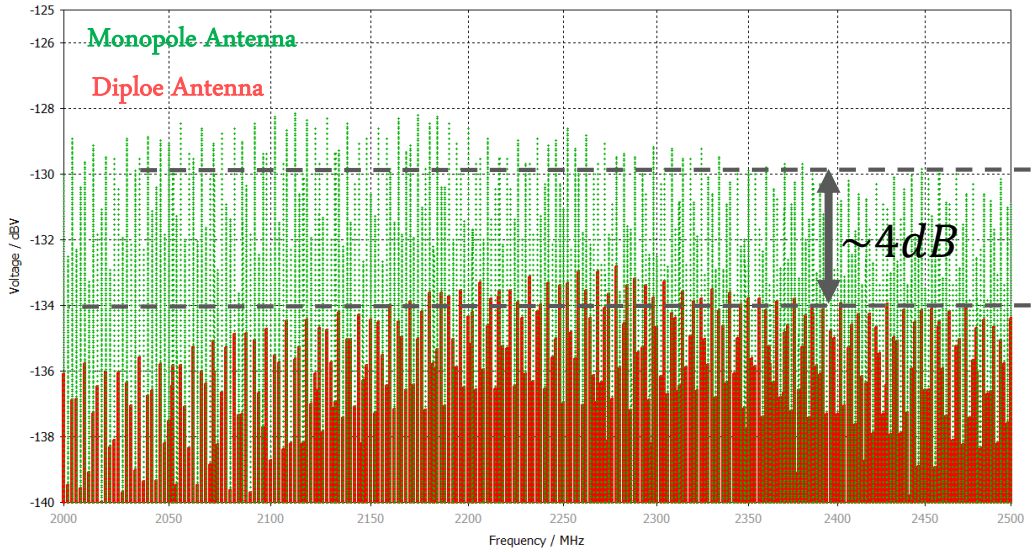
Swiss Cheese GND

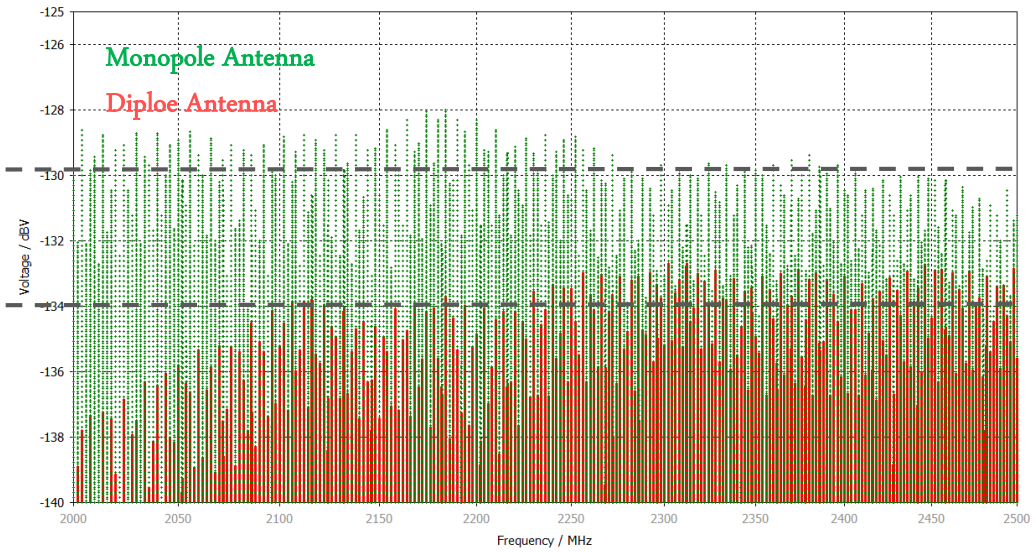


Reference Case

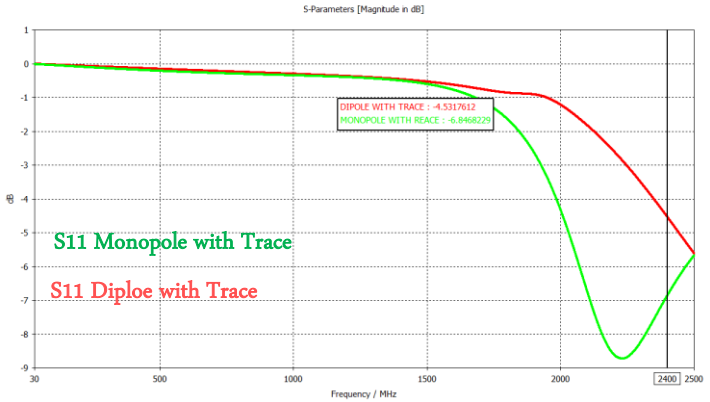


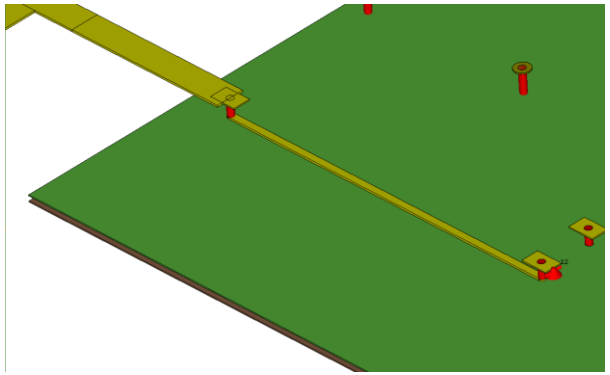
Swiss Chees GND

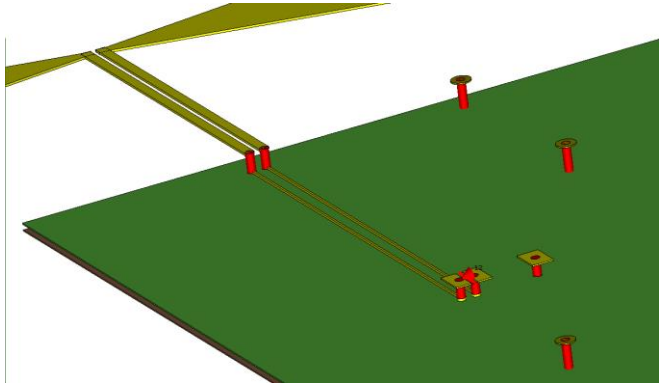




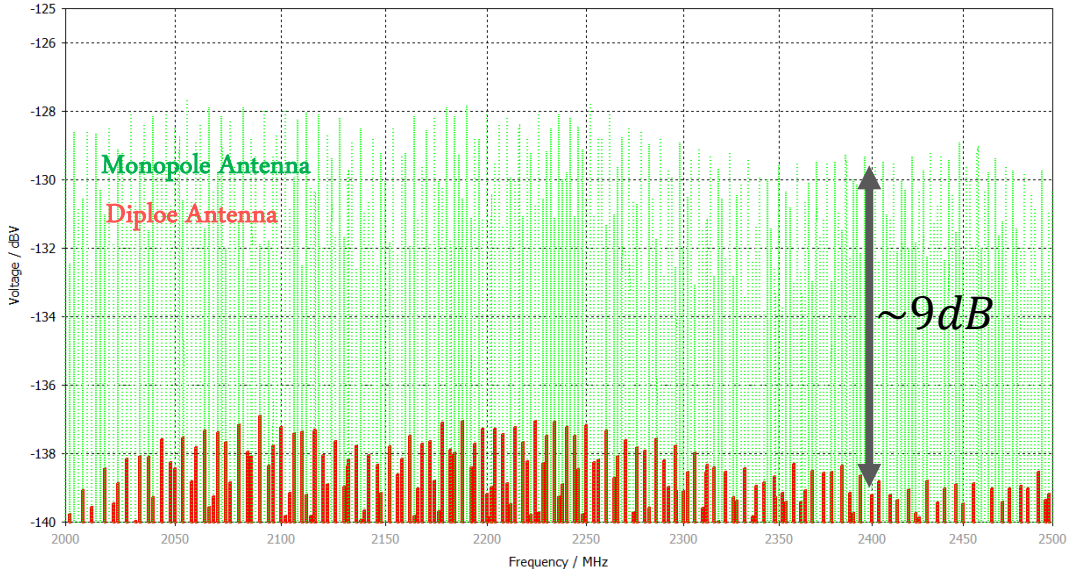
Reference Case……With Routing







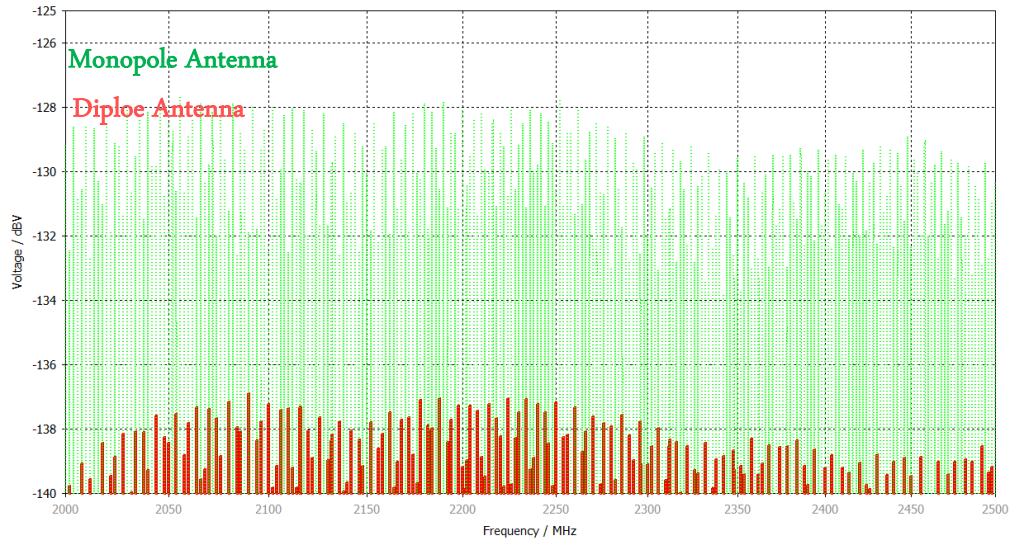
Voltage at receiver ports



The monopole noise increased by 0.5dB
The Dipole noise decreased by 5dB

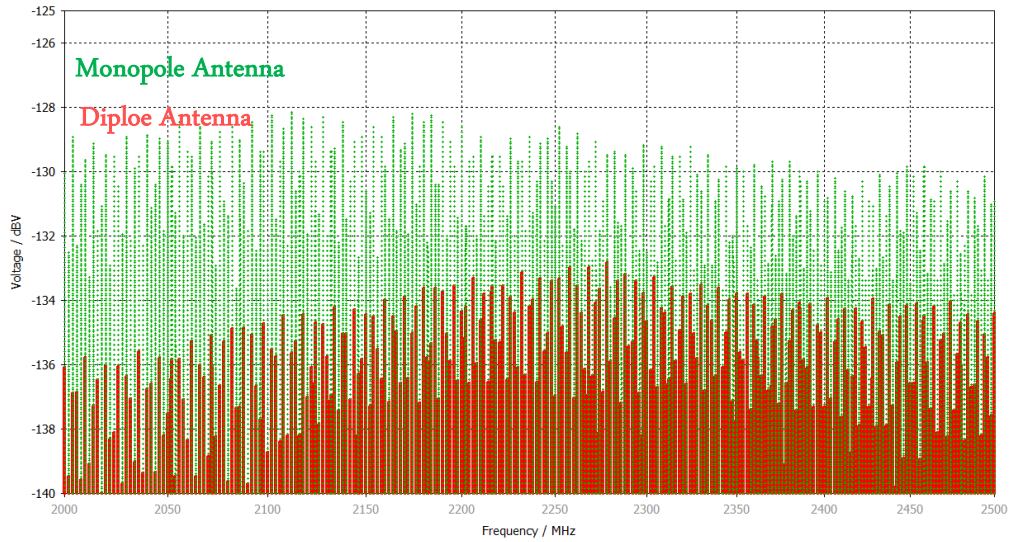
Tracing to Receiver Ports Vs. Antenna Terminal

Voltage at receiver ports



With Routing

Voltage at antenna terminal



Terminal Port Only

Conclusion

- Acoording to the our issue
  - Buck converter as source of EMI $[f_{sw}, DC, Duty\ Cycle, t_{rise}]$
  - Size and Distances
  - Antenna Specifications

Monopole Antenna is more sensitive to EMI than Dipole Antenna With/Without routing.

Thank You

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