EMI/EMC Analysis

A General Project Requirement, and also a necessary step in any design project is the EMI (Electromagnetic Interference)/ EMC (Electromagnetic Conformance) analysis. It is within this document that we will analyze if the LPRDS-ETS-2009 design will meet all US CFR Title 47 Part 15 subpart B regulations for Class A digital equipment. While electronic control systems and power systems utilized by a public utility or in an industrial plant would be exempt from the specific technical standards contained in Part B, due to both specific requirements and safety precautions, an analysis was performed.

Conducted emissions must meet the FCC requirements for our system design. In order to meet these requirements, we must analyze the conducted emissions from all outputs of the system.

The first output of the system is the network connection coming from the SCADA computer. For the SCADA subsystem, our PC will be the Slim-Fit PC. Because we plan to use the PC as intended, and will be unmodified, we can use the companies regulatory certificate. This PC satisfies all Subpart B regulations, as the certificate is shown here (http://www.fit-pc.com/files/fit-PC-Slim-certificate.pdf).

The second output of the system is the main 120 V AC. The requirements for conducted emissions are shown below:

(b) For a Class A digital device that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms LISN. Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dBμV)		Conducted Limit (dBV)	
	Quasi-peak	Average	Quasi-peak	Average
0.15-0.5	79	66	-41	-54
0.5-30	73	60	-47	-60

The two main objects of concern in our design is the buck converter and the H-bridge. The buck converter with be switching at a frequency of 50 MHz and the H-bridge will be switching at a frequency of 10 KHz. Both of these objects are prior to the output low pass filter. In order to meet FCC compliance, we used PSPICE to create a model of the H-bridge followed by the low pass filter. Also in series is the model of the 50 μH/50 ohms LISN.

The results indicate that the projected output of the filter will limit the conducted EMI to meet the FCC Regulations shown. Figure 1 shows the FCC regulation limits, and the conducted emission based on frequencies.

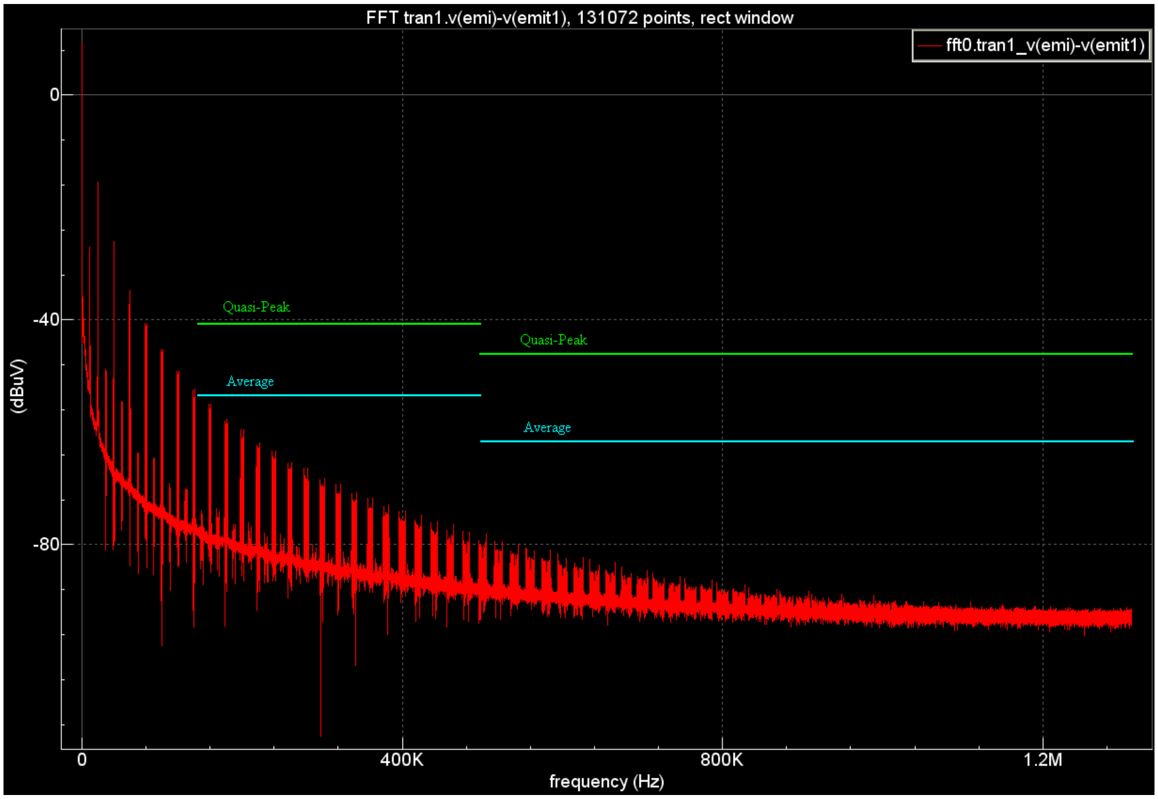

Figure 1

The green line depicts the quasi-peak limit. This term references the spikes shown away from the trend line shown in deep red. The blue line shows the average limit required to be FCC compliant. This line must be higher than the deep red trend line, and is certainly at a safe level. One note worth mentioning is that our simulation software was only capable of simulating up to a frequency of 1.35MHz. Requirements state levels for up to 30MHz. I have assumed that past 1.35MHz, the same trend of the curve will continue, which would be compliant.

The second half of the EMI requirements is the radiated emissions. For unintentional radiators, the FCC has the following regulations to meet:

(b) The field strength of radiated emissions from a Class A digital device, as determined at a distance of 10 meters, shall not exceed the following:

Frequency of Emission (MHz)	Field Strength (microvolts/meter)
30 - 88	90
88 - 216	150
216 - 960	210
Above 960	300

For radiated emissions, our main points of concern are again the buck converter as well as the H-bridge, both switching at high frequencies. This will lead to higher radiation, which cannot thoroughly be predicted, but can certainly be contained. We plan to house all of our major parts within metal casings to reduce the emitted radiation.

While we believe that this will be enough containment in the room to keep the radiated emissions below FCC requirements, we cannot be completely certain until a test has been completed. While the statement of work explicitly states that empirical data is not necessary, if shown to be a problem, we must be able to proceed to a test procedure. If we were to conduct a test, a large antenna able to pick up frequencies of 30MHz+ would be required, along with a spectrum analyzer able to measure in (microvolts/meter). This test, however, would not be done in an EMI chamber, therefore making it a non-compliant test. We would be able to test for a baseline with the system off, and compare to a test with the system running for a general idea of the system, but would be unable to classify the system as compliant.

In the case that the radiation emissions are too large, there are several techniques and approaches we may use to reduce the emissions. One technique is using shielding solutions. We may choose to upgrade to die cast boxes, sheet metal assemblies, conductive polymers, conductive painting and plating, or a molded grid shield. Another option is if the conductive emission is higher than expected, we may add ferrite cores to the end of our cables. These big cylindrical bumps on the cable will reduce the amount of undesired signals.