EMI Analysis

The Statement of Work states that our system must abide by the US CFR Title 47 Part 15 subpart B regulations for Class A digital equipment. Going to the FCC documentation, we discover the following information: 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:

<table>
<thead>
<tr>
<th>Frequency of emission (MHz)</th>
<th>Field strength (microvolts/meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–88</td>
<td>90</td>
</tr>
<tr>
<td>88–216</td>
<td>150</td>
</tr>
<tr>
<td>216–960</td>
<td>210</td>
</tr>
<tr>
<td>Above 960</td>
<td>300</td>
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</tbody>
</table>

For our system, the source that will create the greatest amount of EMI will be our 4 MHz oscillator found on our backend board and boat board. Based on analysis for an ideal square wave, the amplitude of the odd harmonics are given by: \( A_n = \frac{2}{n\pi} \). So, looking at the closest harmonic of our 4 MHz oscillator which falls into the 30MHz or greater FCC category, we find that the 9\(^{th}\) harmonic falls at 36 MHz.

\[
A_9 = \frac{2}{9\pi} = 0.07073553
\]

Taking the length from the 5V, 4MHz oscillator to ground to be 1mm, the electric field created by the 9\(^{th}\) harmonic of the oscillator is \( \frac{(5\ \text{V})(0.07073553)}{5\ \text{mm}} = 70.7355\ \text{V/m} \). This field strength decreases as a factor of \( \frac{1}{r} \) as we move away from the oscillator. Using the following equation:

\[
100\ \text{μV/m} = \frac{70.73\ \text{V/m}}{2^x}
\]

where \( x \) is distance in meters at which we meet the EMI intensity requirement

We see that we hit the 100 \( \text{μV/m} \) at 19.43 meters, nearly twice the distance as required by FCC. Therefore, we propose an EMI enclosure that reduces the electric field strength. Our current strength at 10 meters is \( \frac{70.73\ \text{V/m}}{2^{10}} = 0.069077\ \text{V/m} \) and we need to get down to 100 \( \text{μV/m} \). Therefore, we need shielding on our backend board and boat board of:

\[
20\log\left(\frac{0.069077}{100 \times 10^{-6}}\right) = 56.79\text{dB}.
\]

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1 Equation for harmonics found in: Signal and Power Integrity - Simplified, 2nd Edition by Eric Bogatin