SPACE RAD. LAB. INTERNAL REPORT #1

NOTES FROM READING

HANDBOOK ON RFI VOL 3 FREDRIK RES. CORP 1962

MARTIN ISRAEL

GENERAL:

- SOLID COVER MUCH BETTER THAN MESH
- FOR HIGH FREQ SHIELD MUST BE ALMOST WATERPROOF
- USE MULTIPLE SHIELDING + FILTERS FOR ALL LEADS
- BELOW 1 MG COPPER MUST BE VERRY THICK FOR MAGNETIC SHIELDING; BETTER TO USE HIGH Mg MATERIAL
- ELECTROSTATIC SHIELDING IMPORTANT FOR HIGH VOLTAGES

REFLECTION & ABSORPTION LOSSES IN SHIELDS

1) PLANE WAVE ON INFINITE PLANE SHIELD NORMAL INCIDENCE (WORST CASE)

\( P_{3-11} \) TOTAL LOSS (dB) = \( 3.34 \sqrt{\frac{\mu_n \sigma_n}{\mu_0 \sigma_0}} \) + 10 \log \frac{\sigma_n \mu_n}{\sigma_0 \mu_0}

WHERE
- \( f_m = \) FREQ IN Mhz
- \( \mu_n = \) REL. PERM. (\( \mu_n = 1 \) FOR NON-MAGNETIC)
- \( \sigma_n = \) REL. CONDUCTIVITY (\( \sigma_n = 1 \) FOR COPPER)
- \( S = \) SHIELD THICKNESS IN MILS

AT FREQUENCIES \( \geq 1 \) MG, MAGNETIC MATERIAL IS BETTER THAN COPPER

(But even 5 mils of Cu give 125 dB)

FOR 5 MIL Cu ABSORPTION DOMINATES FOR \( f > 40 \) MG

FOR 5 MIL \( \sigma = 0.1 \) MG = 1000 \( \cdots \cdot \cdot \cdot \)

\( f > 0.2 \) MG

2) CYLINDRICAL SHIELDS ABOUT LINE OR LOUD SOURCE

FOR ONE POLARIZATION, REFLECTION PRODUCES LITTLE LOSS

- CONSIDER ONLY ABSORPTION LOSSES

PLANE WAVE EQN GIVES GOOD APPROX.

(NOTE, AT ALL FREQ ABSORPTION LOSS FOR TYPICAL MAG SHIELD IS BETTER THAN Cu, *

BUT FOR 5 MIL Cu, ABSORPTION IS FAIRLY LARGE REASON:

5 MIL Cu:

<table>
<thead>
<tr>
<th>( f (\text{MHz}) )</th>
<th>1</th>
<th>10</th>
<th>100</th>
<th>1000</th>
<th>10000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abs. Loss (dB)</td>
<td>10</td>
<td>50</td>
<td>160</td>
<td>380</td>
<td>**</td>
</tr>
</tbody>
</table>

* BUT FOR TYPICAL MATERIAL

\( \sigma_n (\text{STEEL}) = 0.03 - 0.16 \)

\( \sigma_n (\text{Al}) = 0.61 \)

\( \sigma_n (\text{Cu}) \geq 1.0 \)

\( \mu_n (\text{STEEL}) = 1000 \)

\( \mu_n (\text{Cu}) = 1 \)

** FOR ABSORP. ADVANTAGE/WEIGHT (\( \mu_n \sigma_n \) STG) \( \frac{\text{absorption}}{\text{weight}} \)

DENSITY OF STEEL \( 7.8 \)

DENSITY OF Cu \( 8.9 \)

STEEL BETTER FOR FM \( < 200 \) MG

**
SHIELDING MATERIALS

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Material} & \text{Al} & \text{Brass} & \text{Cu} & \text{Ag} & \text{Steel} & \text{Sn} \\
\text{Thickness (in)} & 13 & 20 & 10 & 10 & 25-55 & 26 \\
\hline
\end{array}
\]

*Assuming \( \mu = 1 \)

**Principal shielding of mesh is due to reflection (absorption much lower than for solid shield)**

**Total loss of solid wall increases with freq.**

**But if... mesh decreases...**

(For mesh, reflection = solid reflection)

**50% open = 60 strands/wavelength, permanent electr. contact at intersections**

(3-24)

**Holes**

For dimensions of hole small compared to wavelength, leakage small, proportional to hole area. Many small holes better than one large hole

\[ \text{Note: } 10 \text{ KMc} \leftrightarrow 3 \text{ cm, wavelength } \leftrightarrow 7.03 \text{ msec rise time} \]

**Protruding sleeves around holes act like waveguide provided length \( \geq 3 \times \text{diam} \) \( \text{or } 3 \times \text{longest xsectional dimension} \)

\[
 f_c = \frac{5900}{L} \quad f_c = \frac{6920}{d} 
\]

**Cutoff for Rectang.**

\[ f_c \text{ in Mc, } \quad L \text{ = longest dimension in inches, } \quad d \text{ = diam. in inches} \]

**Note:**

- 1" diam \( \Rightarrow f_c = 6.9 \text{ KMc} \)
- 0.2" diam \( \Rightarrow f_c = 3.5 \text{ KMc} \)

For \( f < 0.1 f_c \) attenuation (db/in) = \( \frac{27.3}{f} \) or \( \frac{32}{f} \)

\[ \text{So } 1\" \text{ diam } \times 3\" \text{ long } \Rightarrow \]

**Note: If a conductor runs inside the "waveguide" then a TEM mode of propagation is possible. This mode has no lower freq cutoff. (i.e. you can transmit dc down a coax)**
Joints: Knitted mesh is good [e.g., Meter, Technit] (Also lists other possibilities & considerations)

Solder has conductivity \( \approx 0.12 \) of copper

[Compare: Al \( \approx 0.61 \)] so even a good solder joint is not as good as a weld.

\[(P.3-44)\] Conduit: Rigid conduit \( \frac{0.22}{\text{in}} \) Al = 57 dB absorption at 1 Mc

570 \( \ldots \) \( \ldots \) 100 Mc

Flexible conduit not as good

Tightly woven braid over flexible conduit gives

\( \approx 45 \) dB additional attenuation (at most freq)

\[(P.6-8)\] Misc: Ground cable shields, coaxial feed throughs, \& filters

At shields at point of exit or point of entry

At high freq a GND lead which has length which is an odd multiple of \( \frac{1}{4} \) wavelength may have very high impedance to GND.

And high impedance in GND lead may be caused by sudden changes in configuration, as when leaving a metal duct or otherwise changing the electrical relationship to metallic bodies. Such changes produce serious reactive mismatches.