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To: Deuterium Array Group

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Subject: Notes on internally generated signals and shielding the D1 receiver box.

1] Fiber optics

One of the strongest signals inside the box is around 1062.5 MHz and is generated by the optical transmitters. This signal can mix with the 4th harmonic of the 278 MHz L.O. to appear in the I.F. at 49.5 MHz. Adequate shielding of the analog electronics is needed to prevent this signal from showing up in the spectrum in an overnight integration with active antennas not connected.

2] Signals related to the 14.31818 MHz Pc clock generator reference.

PCs generate their clock signals from a 14.31818 MHz reference using an IC which has PLLs for frequencies like 48 MHz, 100MHz, 133 MHz etc. The 21st harmonic of 14.31818 MHz is at 300.6818 MHz and is quite strong but is not at a frequency which can get into the output spectrum. However there is a frequency of about 327.46 MHz which is somehow produced from the 14.38 MHz clock (perhaps by mixing of 14.38 MHz with another clock frequency) and is a major source of RFI if allowed to leak out of the receiver box. A fair amount of time was spent trying to identify the exact mechanism for the generation and mediation of this signal which appears at 327.4556 and 327.4686 from the left and right PCs respectively owing to differences in the individual 14.38 MHz crystals. The signal is radiated most strongly from the cables from the motherboard to the disk and from the USB controllers.

3] Shielding notes

a) Ferrite clip-on cores
Ferrite cores are placed on all the USB cables, the Ethernet cables close to the fiber optics converters, and the USB cable from the built-in controller. Ferrite cores are also placed on the a.c. power lines inside the box and on the external cable in addition to the a.c. power line filter.

b) Conductive gaskets
Conductive silicone gaskets are used on the analog module covers. These gaskets have short wires impregnated in the silicon which hopefully contact when the covers are tightened down.

c) Copper tape

Some copper tape (3M1245) is used to ensure a good connection between adjacent analog modules where the L.O. line couples between modules. Copper tape is also used on the internal mesh screen which separates the PCs from the analog and digital receiver boards.

d) Cover screws

Leakage of internal signals to the outside is a serious problem. We need more than 60 dB of shielding from the active antennas. Good low resistance contact is the key to minimizing the transfer impedance of any joints. The radiated power from a seam is by

$$p_t = 2j^2 z\ell \quad \text{(see spira-emi.com)}$$

where p_t = radiated power (watts)
 j = surface current density (A/m)
 z = transfer impedance (ohm m)
 ℓ = length of seam

The importance of the transfer impedance was not fully recognized until paper on the subject started appearing in 1976 and many of the MIL standards for EMI shielding are based on other EMI leakage mechanisms using wave theory and skin depth concepts. We have found empirically that contact resistance is very important and cover screws about every 3 inches were found to be needed on the cover to obtain sufficient contact pressure. In addition to the screws we have added copper tape but have concerns that the contact, especially the contribution from the tape, will degrade with time and temperature cycling.