VSRT MEMO #053

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To: VSRT Group
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Subject: Effect of standing waves on the LNBF cable

The frequency switching used by the ozone spectrometer takes out bandpass structure following the mixer in the spectrometer. Bandpass structure in the LNBF and cable to the spectrometer is not cancelled by frequency switching the spectrometer. Unfortunately the free running local oscillator of the LNBF cannot be controlled and hence cannot be frequency switched to take out the structure in the cable transmission. The dominant structure is the reflection from the spectrometer to the LNBF and back. The bandpass structure is given by

$$\left|1 + ae^{i\phi}\right|^2 = 1 + 2a\cos\phi \quad for\ a << 1$$

where $a = \left|\Gamma_a\right|\left|\Gamma_l\right| A_c$

Γ_a = reflection coefficient at spectrometer

Γ_l = reflection coefficient at LNBF

A_c = oneway cable power attenuation factor

$\phi = 2\pi\ f/F$

f = frequency

F = ripple period = 1 /2-way cable delay

If we expand the spectrum P

$$P = 1 + 2a\cos\left(\frac{2\pi f}{F} + \frac{2\pi\Delta}{F}\right)$$

where Δ = frequency offset

the curvature in the ripple is

$$2a\cos\left(\frac{2\pi f}{F}\right)\left(\frac{2\pi\Delta}{F}\right)^2 (1/2)$$

For example is $\Gamma_a = \Gamma_l = 0.1$

And $A_c \sim 0.3$ and $F \sim 8\ MHz$ for 50' of RG-6 cable then the curvature amplitude is 1.7×10^{-4} for 0.3 MHz offset from the nominal 1322 MHz center frequency where the ozone line appears. While this curvature can be corrected in software it may be time variable and consequently limits the ability of the spectrometer to adequately measure the wings of the ozone line. Reducing the cable length down to 20' reduces the effect of these standing waves by more than a factor of 4.

Several method of reducing the standing waves on the cable are being studied as they may be required at installations for which a long cable cannot be avoided:

a) Improved match at LNBF and spectrometer

The match at both ends of the cable could be improved by adding attenuator at each end. These attenuators have to have 75 ohm impedance and to pass D.C. unfortunately D.C. pass attenuators tested have poor match. Typically these 75 ohm products have no published specifications so these attenuator may not improve the match.

b) Increase cable loss

Going to a lossy cable would decrease A_c and decrease the standing waves. Using RG-58 instead of RG-6 is a possibility but since RG-58 has a 50 ohm impedance the reflection coefficients would increase. Going to a cable which has even greater loss, like RG174, runs into difficulty with the D.C. power transfer as the lossy cables have excessive resistance.

The problem might be solved by adding a separate cable to convey the D.C. power. Also the cable which carries the R.F. could be 50 ohm for which well matched attenuators are readily available.

c) Using an inline amplifier with better match

Tests of various inline amplifiers show that the Terk BIA has a particularly good 75Ω input match and is the best choice for the amplifier at the receiving end of line long RG-6 cable.

The best performance, lowest ripple, is obtained by adding a 10 dB DC pass attenuator (Micro-Ray Electronics MR-20454) to the output of the LNBF (Fortec FSKUV-N) and using the Terk BIA inline amplifier in the ozone spectrometer electronics box.