VLBA Electronics Memo No. 54

Interoffice Memorandum

CALIFORNIA INSTITUTE OF TECHNOLOGY

To: A. R. Thompson, L. D'Addario, NRAO   Date: 4 October, 1985

From: Alan Moffet   Mail Code: 105-24   Ext. 4977

Subject: Interference from current loops

I thought it would be worthwhile to calculate the effectiveness of a small current loop carrying digital signals as a source of interference. The necessary theory can be found in Section 8.6 of Stratton's Electromagnetic Theory, among other places.

A current loop of area A carrying peak current I will have a magnetic moment of magnitude $m = AI$. In the approximation that the loop is small compared to the wavelength and that the distance R is large compared to the wavelength, the magnitude of the radiated electric field, in the plane of the loop, is

$$E = mk^2Z/(4\pi R) ,$$

where $k = 2\pi/\lambda$ and $Z = \sqrt{(\mu/\epsilon)} = 377$ ohms. The flux of the radiated wave will be given by the magnitude of the Poynting vector $S = E^2/2Z$.

If the loop carries alternating 1's and 0's at 50 kilobaud, it will have a square wave of current with a fundamental frequency of 25 kHz. Assuming infinitely short rise and fall times, the component of the current at, say, 100 MHz will be reduced by the inverse of the harmonic number, 4000^{-1}. Assuming a peak current of 10 ma and an area for the loop of 1 cm^2, the peak radiated field at a distance of 100 meters would be about 3×10^{-10} V/m, and the flux would be of order 10^{-23} W/m^2 per harmonic, or an average flux density of about 4×10^{-28} $W/(m^2Hz)$. This should be negligible.

There are other considerations, however. There might be a few dozen such loops in the system, and their radiated fields will add coherently, but with random phases, since they will be spread over more than one wavelength in space. Some of the loops will be in the vertex cabin and will be much closer than 100 meters to the feed, however, we have specified 60 db of shielding for the cabin.

The risetime of the current step from the line driver will be finite and is specified as <20 ns. A 20 ns risetime would appreciably reduce the harmonic components above about 15 MHz. A simple low-pass filter consisting of a ten ohm resistor in series with each driver lead, shunted by a 0.01 μf capacitor would have a cutoff frequency of about 1 MHz and introduce 40 db of attenuation at 100 Mhz.

It is true that substantial interference can be generated by digital hardware, such as that associated with personal computers. I believe one of the greatest sources of radiated interference from computers is the ribbon cable often used to drive parallel printers. In such a cable there will be eight digit lines and a few ground lines. Unbalanced currents will flow in these, giving rise to a folded monopole antenna with dimensions of the order of a quarter wavelength at 50 to 100 MHz. This is a very efficient radiator. The key to confining the signals on an RS485 loop will be to keep them balanced and to minimize the dimensions of current loops. I think this can be done with shielded twisted pair cable and with conventional crimp-pin connectors. The savings in cost over twinax cable and fittings will be very substantial.

Interoffice Memorandum

CALIFORNIA INSTITUTE OF TECHNOLOGY

To: A. R. Thompson, L. D'Addario, NRAO   Date: 8 October, 1985
D. Webber, VLA

From: Alan Moffet   Mail Code: 105-24   Ext. 4977

Subject: Interference from Line Drivers

Following up my previous memorandum, I looked at the spectrum of the output from an RS-485 line driver, the AM26LS31. This is not the same one that will be used in the VLBA, but the results should be comparable.

The results are shown on the attached pages. Setup A is the raw output, transformed to 50 ohms by a transformer. It drops more steeply than a pure square wave would, but reaches a threshold of about -34 db at 100 MHz.

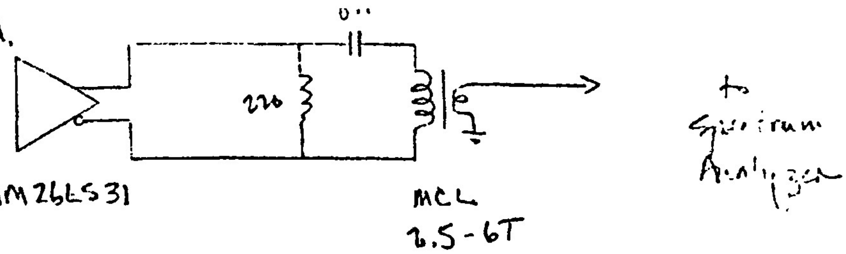
Setup B uses two ferrite beads and two capacitors to ground to filter the higher frequencies. It has an acceptable risetime of 16 ns and drops to -60 db at 100 MHz.

Setup C uses 4.7 ohm resistors and a shunt 0.001 capacitor to filter the line driver output. The risetime is lengthened to 65 ns, but there is still a high threshold above 100 MHz. In setup D, two capacitors to ground are added. These kill off the high frequency noise, which is evidently feed-through signal from the unbalanced input to the line driver.

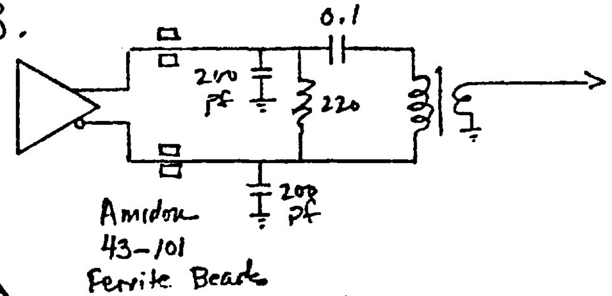
It looks as if something like setup B would be a good choice. The risetime is still within specs for the driver, <20 ns, and yet the high-frequency output is well damped, at least 40 db below that expected for a pure square wave at 100 MHz.

I realize that these results may not perfectly reflect the real world. In particular, the transformer I used would not be present, and it may have suppressed some common-mode noise. The shunt capacitors to ground eliminate most of this, but some further experiments may be needed.

A.



B.



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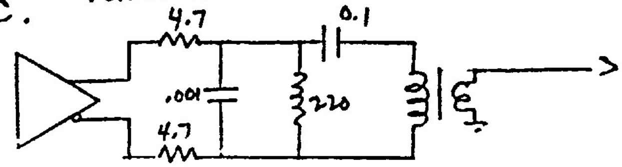

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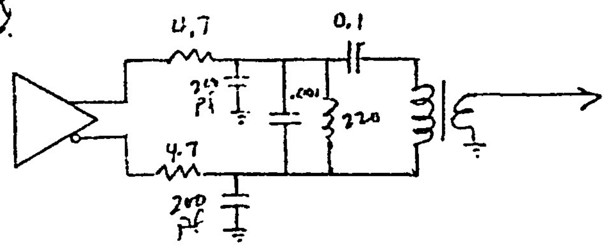

	A	B	C	D
Risetime (ns)	8	16	65	70
Rel. Power @ 100 MHz	-34db	-60	-43	-58

Relative Harmonic Power