Problems and Best Practices in Protecting Data Lines Against HEMP

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Abstract—This paper discusses the unique design problems associated with protecting data lines with passive filters against a HEMP event. In today's intercommunicated world, much of the electronic communication takes place over data channels, more specifically data wires. These wires can carry data in a myriad of formats and speeds. Some of the data could be Ethernet, others could be control signals such as RS232 or RS485. Each of these could be passing data at different speeds. For example, we have RS485 protocols that can send data at 78 kbps or at 115 kbps. In addition, data signals can carry encoded voice messages, or can carry proprietary sensor information to a control center. A control center could be a HEMP hardened building where it would be necessary to have all these data transmission wires protected against an EM pulse. Many HEMP protection standards recommend that data signals should be converted to fiber in order to safely pass this data during a HEMP event. But the recommendation begs the question as to why that is. Thus, this paper will discuss the nature of the data that is to pass through, the pulse that data wires need to be protected against, and the filter characteristics that make protection with passive data filters problematic. Finally, some recommendations on protecting sites according to well-established commercial and military standards are provided.

I. THE HEMP FILTER AND ITS IMPLICATIONS

A. *The Data to Pass Through*

On the one hand, a data signal consists of a train of pulses or a square wave. Fourier Transformation of a complex wave tells us that a square wave is actually made up of multiple sinewaves as shown in Fig. 1. Any complex wave can be broken down into sine waves that when added together give the original complex wave.

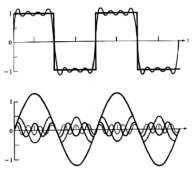

Fig. 1. Complex waves can be broken down into sine waves

Thus, a data filter must be able to pass all the composite sine waves in order to be able to reproduce at the other end the same square wave without loss of fidelity to the signal, without loss of the shape, and thus without loss of information as it passes through the filter. These multiple sine waves are actually at multiple frequencies. When a square wave is seen in the frequency domain, it looks as shown in Fig. 2. A filter is typically a passive device that would allow, up to a certain cut off, frequencies to pass. In filter terminology, we say that the passband of the filter must be wide enough to allow for all these composite sine waves to pass through.

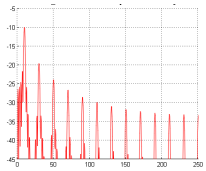

Fig. 2. Frequency domain view of a complex waveform

But this wide passband is also the Achilles' heel of all passive data filters used for HEMP protection.

B. *The HEMP Waveform*

The HEMP waveform or pulse shape is given in various well-known standards. This is essentially a double exponential pulse with an established rise time as shown in Fig. 3.

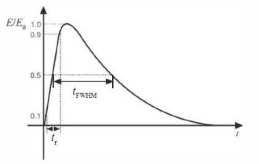

Fig. 3. Typical HEMP waveform

The composition of a signal like this shows that the pulse's rise time contributes to a multiple frequency component that can be shown by Fourier analysis. It is accepted that the typical HEMP waveform would generate frequency components from a few kHz to about 300 MHz.

C. *Data Filter Passband*

A typical data filter is a low pass filter that has a passband, or 3dB cut off point at several MHz in order to allow the data to pass without degradation. In addition, the stop band is further removed at several MHz because passive components do not have a sharp or instantaneous cut off at 3dB. Thus most of the energy of a HEMP event will be in-band or pass right through the filter, with only some lesser energy passing through the skirts of the filter's response. This would typically result in greater power residuals (or transients) appearing in the data line which could still damage the system that the filter was intended to protect.

D. *HEMP Protection of Data lines*

Because of the foregoing, data wires should be converted to fiber as recommended in commercial and military standards. Exceptions could be made if the data wires have a slow transmission rate, probably below 9.6kbps. But even in such cases, it would be prudent to inquire of the filter manufacturer if a given data filter meets a given protection standard.