AMP

EMI and STQ Evaluation of the FireWire/IEEE1394 Interconnect

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General Information

This paper is a brief evaluation of some of the signal transmission quality (STQ) and Electro-Magnetic Interference (EMI) characteristics of the 1394 interface. A more in-depth technical paper covering this topic is scheduled for release at the DesignCon98 Engineering Conference, January 26-29th, 1998.

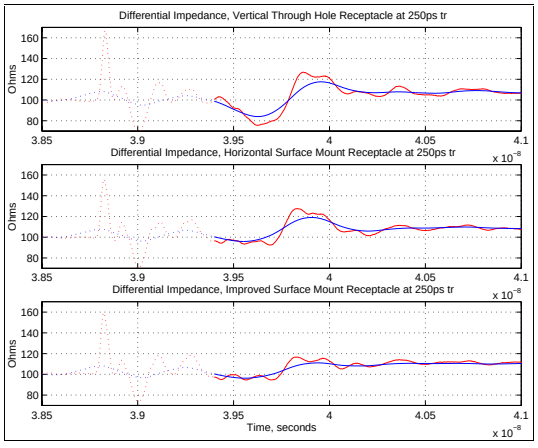
Review of 1394b Goals

The 1394b Working Group has been formed to investigate the capability of expanding the information carrying capacity of FireWire up to 800, 1600 and 3200 Mbits/s while maintaining backward compatibility to 1394-1995 product.

STQ performance

The typical electrical parameters were investigated. The first evaluation was of the signal transmission quality (STQ) performance. This included the evaluation of connector impedance and output eye pattern characteristics. The eye pattern performance is included as it is a good composite test that combines the effects of reflected energy from impedance discontinuities, cable losses, risetime degradation, crosstalk, and other electrical phenomena.

Slide 1, Connector Impedance Characteristic



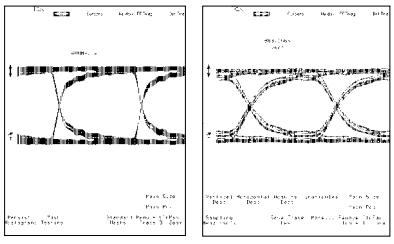
Impedance data is for a typical vertical, through hole mount receptacle and a horizontal surface mount receptacle terminated with an existing cable assembly. The third plot provides the impedance profile of the horizontal surface mount receptacle with an improved performance cable assembly.

Each graph consists of the TDR output and a mathematically generated 250ps risetime impedance profile. The dashed lines are from the fixturing and may be ignored. As can be seen from the impedance profiles, the performance of the existing vertical through hole connector will result in considerable amounts of reflected energy. Though not a problem at the risetimes used for S100 through S400 applications, this will provide potential problems at S800 and above data rates.

Eye pattern data was obtained at the longest standard assembly length of 4.5 meters. The eye pattern data shows that at S400 and S800, there is sufficient margin for this application, and that if necessary, the cable could be increased in length.

Slide 2, Eye Patterns at S400/S800

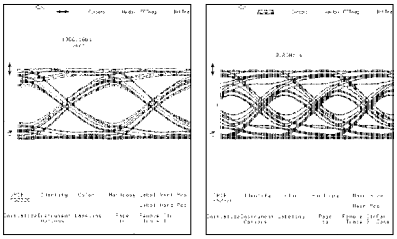
Output Eye Patterns from 2^{23}-1 PRBS Input



S400 Output **S800 Output**

Slide 3, Eye Patterns at S1600/S3200

Output Eye Patterns from 2^{23}-1 PRBS Input



S1600 Output S3200 Output

Slide 4, Summary of Eye Pattern Data

Eye Pattern Summary
S800/S1600/S3200

Cable AWG	S800 983.04Mbd	S1600 1966.1Mbd	S3200 3932.2Mbd
28	0.67/0.94UI Pass	**0.46/0.84UI Fail**	**0.15/0.40UI Fail**
24		0.66/0.90UI Pass	**0.24/0.50UI Fail**

Goal is to exceed 0.66 (Amplitude) /0.40UI (Jitter)

For informative purposes, the simulated eye pattern performance of a cable constructed with a larger signal conductor has been included. Though improving the performance at S1600 rates, the performance is still unacceptable at S3200.

EMI performance

Slide 5

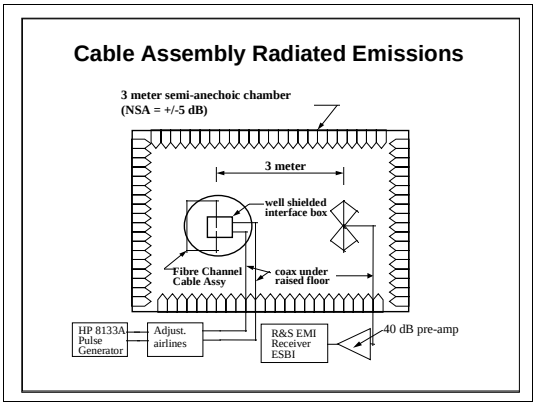
EMI Performance:
Radiated Emissions, Typical S100 Application

- **4.5m Assembly**
- **40 Bit Data Sequence**
- **S100 Data Rate**
- **Right Angle Receptacle with RC or Ideal Termination to Enclosure**
- **330 ps Launch Skew**

The signal chosen was a 40 bit sequence 3EAA2AAAA.

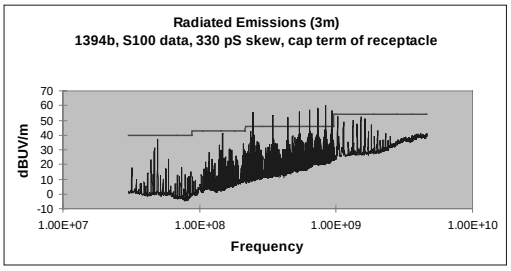
0011 1110 1010 1010 0010
1010 1010 1010 1010 1010

Slide 6, EMI Test Setup



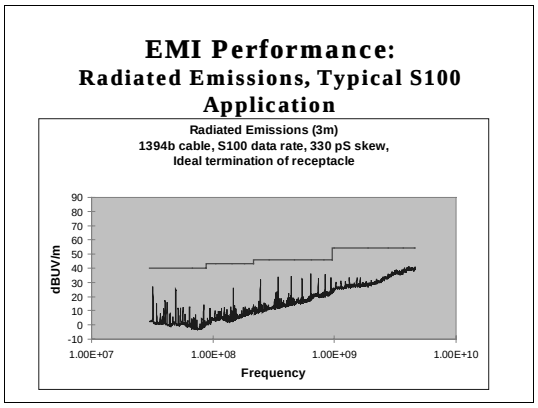
Slide 7, EMI Data, S100, Capacitive Termination

EMI Performance:
Radiated Emissions, Typical S100 Application



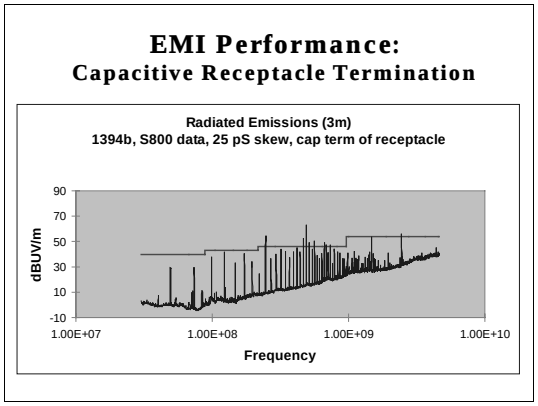
This data was taken using the resistor/capacitor termination that it is favored by many to eliminate DC or 60Hz shield currents. Limit values are for the more stringent FCC Class B requirements for domestic use, and may be relaxed 10 dB for an approximation of Class A testing for the office.

Slide 8, EMI Data, S100, Ideal Termiation

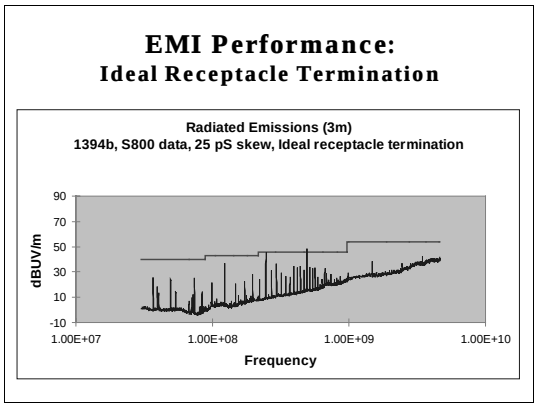


An ideal termination is one with a 360° termination from the receptacle to the bulkhead.

Slide 9, EMI Data, S800, Capacitive Termination



Slide 10, EMI Data, S800, Ideal Termination



When tested at the S800 data rate using an ideal shield termination, performance is marginal for domestic use but acceptable for the office environment.

The S100 data shows that in the presence of either cable or source induced skew, assemblies with an ideal receptacle to bulkhead termination are acceptable for use in both office and residential environments.

To handle the higher data rates, improvements in the existing specification must be made to reduce the proliferation of product unsuitable for high frequency usage.

Summary

The product can be made to work up to the S800 data rates if appropriate steps are taken at this time.

The cable assembly should have the following changes made to assure acceptable performance. Improve the skew performance, add impedance recommendations for the wire termination area, and add a transfer impedance requirement for the plug shield.

The receptacle has the advantage of being under control the OEM. Since the receptacle termination can potentially be the most significant source of EMI, this allows the ability to prevent most problems. If ground loops are not expected to be a problem, a flange mount termination to the enclosure is recommended. If this is not acceptable, multi-point capacitive termination must be used

Though it is possible to produce an assembly/receptacle that is capable of S1600 and S3200 rates and that is backwards compatible, the possibility of EMI problems or inadequate data transfer are quite high. It is for these reasons that it may be necessary to replace the existing interface with a new product or provide keying to assure that low speed product is not used in high speed systems.