Application Note

3Gig Technology Improves Performance

Introduction

To meet the emerging demands of increased resolution for high-definition capture, transport, storage, and production of video images, equipment is being offered with SMPTE 424M compliant physical layer connections supporting 2.97 Gb/s data rates. In fact, NAB 2006 saw a number of companies introduce routing and distribution products incorporating what is currently known as 3Gig (3 Gb/s) technology as demonstrations or product previews.

Now, one year later, many of these products are nearing full production status, but actual usage and operational equipment deployment remains limited. Industry opinions on the need for 3 Gb/s technology vary widely. Some feel that it will not be used outside the origination and limited production. Others see it as being a standard of operation. In Europe, for example, 1080p50 video format is being pushed as a standard of operation. In North America, it seems that many users are utilizing 3 Gig for capture of sports or live events. Certainly, the film and post-production industries, where the large majority of dual-link 1.5 Gb/s circuits can be found, are immediate markets but, even there, it seems that 3 Gig is more suitable for islands than complete facilities. The migration to 3 Gig has been slow because storage and production equipment has not been readily available with SMPTE 424 interconnections.

Many industry analysts are quick to point out that 3 Gig, for the short term, is a niche application, or requirement, much as 1.5 Gb/s technology was in 1998, nearly 10 years ago. However, unlike the initial HD revolution, 3 Gig technology has no legal requirement for deployment in North America. And, although market adoption rates of HD in Europe are running ahead of those in the United States, there is still a time lag — and therefore little market demand — to drive the deployment of 1080p50 production absent governmental regulation or action. Given this, it seems likely that 3 Gig technology will remain a niche market, albeit a growing market, for 2 to 3 years.

Why buy 3 Gig capable routers and distribution equipment? Why spend the extra money associated with more expensive chip sets and related circuitry?

The simple answer is *insurance*. Routing and distribution equipment is the core of any new installation, or facility upgrade. It easily has a ten-year lifetime, and 15-year life cycles are not at all uncommon. When compared to the cost of other equipment in a facility and the installation costs of labor and construction, the additional cost of 3 Gig technology is typically a small percentage of total project cost; often less than 1%. This is very affordable peace-of-mind. But there is an additional advantage: improved plant performance for 1.5 Gb/s and 270 Mb/s signals. This improved performance provides these savings:

- Reduced need for distribution amplifiers used as repeaters,
- Reduce number of fiber circuits because cable runs can be longer,
- More jitter margin, allowing more tolerance for cascades of serial digital signals.
- Smaller initial outlay (simplified plant design, decreased maintenance and service budgets).
- Extended life of capital investments.

NVISION Series Performance

Figure 1 shows a typical 1.485 Gb/s (a.k.a. 1.5 Gb/s) eye diagram using contemporary technology.

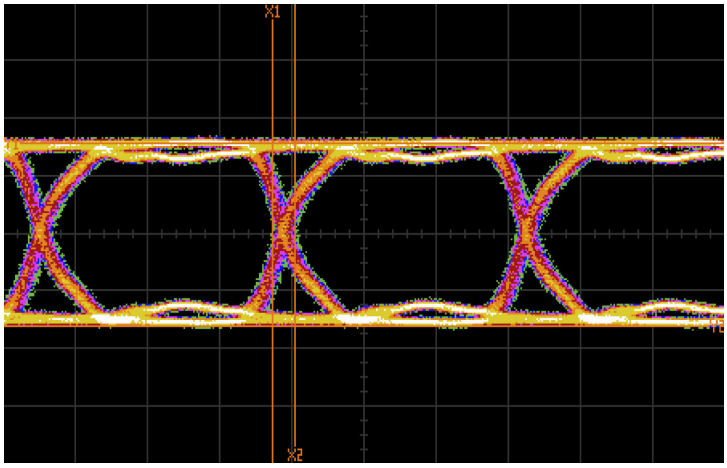

Figure 1. NV8288 Output

This signal is the output of an Miranda NV8288 mobile router. It represents some of the best signal performance in the industry.

Figures 2 and 3 show a typical eye pattern of a 2.97 Gb/s (a.k.a. 3 Gb/s) HD-SDI signal:

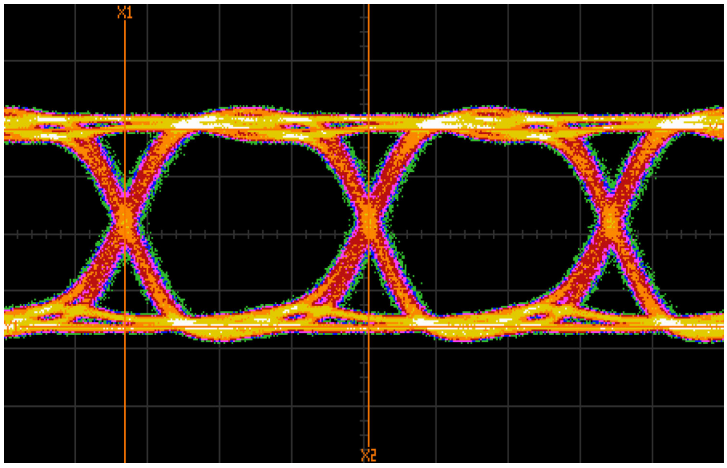

Figure 2. NV8256 Output, 3 GB/s, A

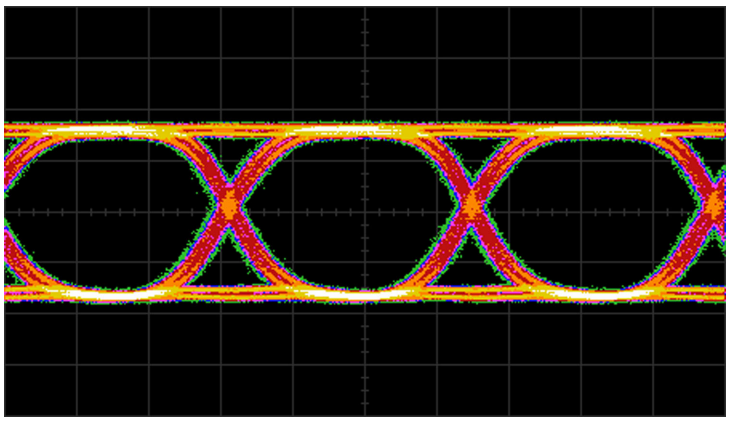

Figure 3. NV8256 Output, 3 GB/s, B

These signals are the output of an NV8256-Plus — the same frames that Miranda has been shipping for nearly 6 years. The NV8256-Plus is probably the only router that is field-upgradable to 3 Gig only by adding cards. Other products capable of 3 Gig require a complete frame replacement and significant re-cabling. It is important to note that jitter and rise-time are both well within the SMPTE 424 specifications.

Figures 4 and 5 show a 1.5 Gb/s signal through the same 3 Gb/s signal path shown previously:

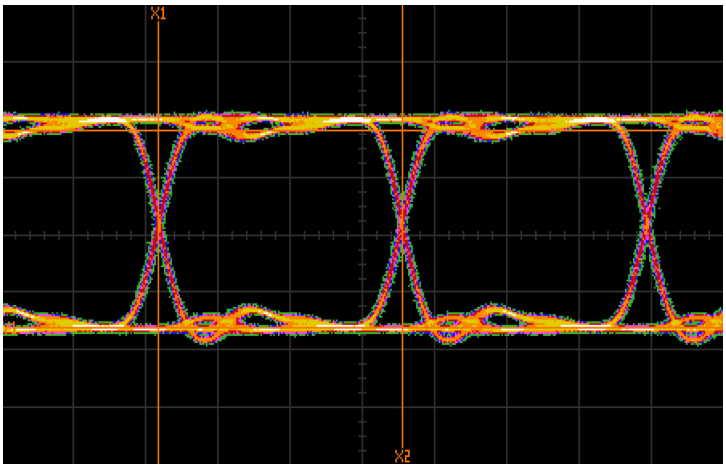

Figure 4. NV8256 Output, 1.5 GB/s, A

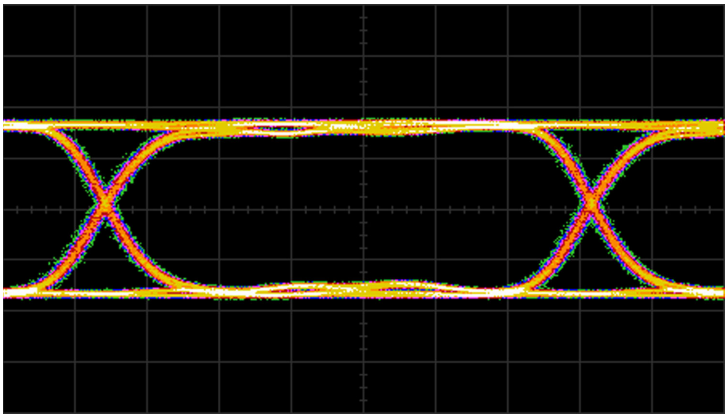

Figure 5. NV8256 Output, 1.5 GB/s, B

The improvement is remarkable. Jitter was reduced from 72 ps to 30 ps and rise and fall times are decreased by approximately 40 ps each. These signal improvements provide increased loss budget, which means that longer cable lengths can be used for signal distribution of a given data rate.

Finally, this last scope shot shows the same signal path, same 3 Gb/s circuitry at a 270 Mb/s bit rate. Simply put, the eye pattern is perfect:

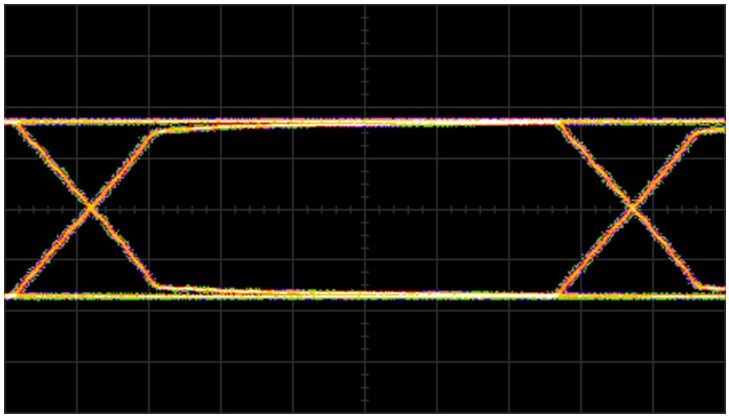

Figure 6. NV8256 Output, 270 MB/s

Again, Miranda is the first—and so far the only—manufacturer to offer 3 Gb/s field upgrades to its existing large-format HD routers. And, Miranda is also providing 3 Gb/s technology in its Synapse modular signal processing frames.

Cabling

Based on manufacturer's data (from Belden and Gennum), Table 1-1 provides a conservative cable length guideline for use of 3 Gb/s and 1.5 Gb/s technology. (All lengths are in meters.)

Table 1-1. Comparative Cable Performance

Data Rate	7731			1694A			18455A		
	Belden Data	3 Gig Chips	1.5 Gig Chips	Belden Data	3 Gig Chips	1.5 Gig Chips	Belden Data	3 Gig Chips	1.5 Gig Chips
2.97 GB/s	110	~110 (calculated)	N/A	82	100	N/A	46	45	N/A
1.485 GB/s	168	> 250 (measured)	> 230	122	215	160	79	125	85
270 MB/s	622	> 250 (measured)	> 230	436	535	370	241	300	210

Notice that the chipset ratings actually exceed the cable length calculations from Belden. The cable receiver sensitivity threshold is based on the CCIR specification. Performance improvements in both cable equalizers and signal re-clockers help explain this. Most facilities include mixed technologies because older equipment uses older chip sets. The older chips have lower sensitivity and jitter rejection. It is important to understand that using 3 Gig equalizers when receiving signals from 1.5 Gb/s cable drivers and re-clockers will allow incrementally more cable distance than using 1.5 Gb/s equalizers with 3 Gb/s cable drivers and re-clockers. This certainly makes sense if you consider the fact that signal loss is proportional to cable length: the longer the cable, the more the loss. Since all sources for SMPTE 259M, 292M, and 424M are standardized at 800 mV nominal output levels, the only way to get longer cable distance is improved receiver sensitivity.

Another key insight is that 3 Gb/s signals propagate as far over Belden 1694A coax, or equivalent, as do 1.5 Gb/s signals using older technology. Put another way, in 1998, 1.5 Gb/s facilities were designed on the premise that 1.5 Gb/s data could travel 100 meters in 1694A. Today, 3 Gb/s signals will travel 120 meters in

1694A. This means that in many cases, an existing facility can be upgraded to 3 Gb/s as the 3 Gb/s equipment is installed, provided core electronic equipment is upgradeable, a feature Miranda products have.

Faster rise and fall times, as well as improved jitter attenuation do improve cable distance too. Consider the zero crossing, or "beak" of the eye. Any uncertainty here increases the chance of error. The more jitter in the signal, the higher the chance there is an error since there is less opening in the "eye". Rise and fall time work the same way, but indirectly. If rise and fall times are slower, then the circuitry which analyzes the zero crossing of the eye, essentially a limiter, will be more susceptible to noise in the signal, noise in the circuit, gain limitations of the circuit and bandwidth of the circuit, or slew rate. Figure 7 shows the effect of decreasing rise time on output jitter amplitude.

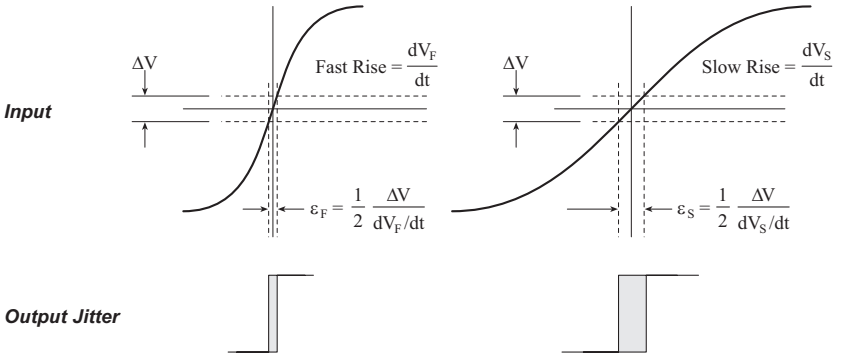

Figure 7. Jitter

When any additional uncertainties are added to the ideal signal, the error will be increased beyond what is shown. If the slew rate is slower, the error will increase too. At 3 Gb/s, circuits typically have higher gain bandwidth and still produce the same output signal levels. Therefore, they have higher slew rate and they introduce less additive jitter into the signal.

Clearly, how far a 1.5 Gb/s or 3 Gb/s signal propagates down a piece of coax depends on many factors: rise time, fall time, receiver sensitivity, additive jitter, receiver jitter sensitivity, cable loss, cable return loss (impedance match), connector quality, cable termination quality, patch bay quality, and bulkhead quality. Essentially, any item in the signal path will contribute to the loss budget. So, items in the path need to be analyzed for suitability of performance.

NVISION Series Routers and Synapse Modular Products

Miranda recommends that you read this note's companion white paper, *Adventures in Return Loss*. It identifies the key issues associated with analyzing and designing a high-speed coaxial data facility.

We has made every effort to insure that the plant infrastructure equipment we manufacture provides the lowest possible loss, and therefore the best possible performance for 3 Gb/s rates. This is true for our routers and our Synapse modules. The NVISION series' NV8256-Plus, NV8288, NV5128, and compact routers are all designed with 3 Gb/s functionality in mind. Upgrades to 3 Gb/s require only module changes, which are easily accomplished from the front of the frame. The Synapse frame system is also designed with 3 Gb/s

upgrades in mind. Figure 8 shows the first Synapse module for 3 Gb/s. It provides dual 1×3 DAs, or a single 1×6 DA, with switching.

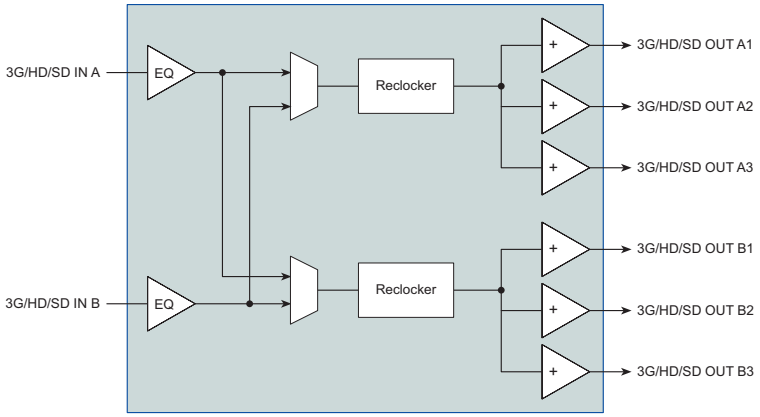

Figure 8. Synapse GDR26

Miranda's NVISION series routing products can be installed in existing facilities, and in most cases, existing 1.5 Gb/s coaxial infrastructure should work without modifications, or costly additions of DAs, particularly where a previous 1.5 Gb/s signal path is being upgraded to 3 Gb/s.

Conclusion

Clearly, 3 Gb/s technology is emerging. But, it is also in production, and will likely be deployed at an increasing rate in the future. In many cases, an existing infrastructure can be used, and with the NVISION series at least, 3 Gb/s upgrades can often be accomplished by upgrading card sets. Additionally, even if 3 Gb/s signals are not in a facility's future, there are the advantages of longer cable lengths and reduced bit error rates when 3 Gb/s technology is applied to lower data rates.