

Fly-over Technology— When It All Gets Too Fast

Beyond Design

by Barry Olney, IN-CIRCUIT DESIGN PTY LTD / AUSTRALIA

As frequency and rise times increase, SerDes design is becoming more critical. Losses caused by the skin effect, fiber weave effect, surface roughness, vias, and connectors are often too excessive for reliable communications. PCB dielectric materials such as AGC (Nelco) N4000-13SI, Isola I-Speed and Panasonic Megtron 6 are reasonably priced, low loss, temperature stable, moderately flat weave laminates applicable to the 2, 4 and 10 Gbps channels. However, for such applications as PCIe-Gen 4 (16Gbps) and higher, one may need to consider alternatives for stackup construction to meet the higher performance requirements.

So far, we have been able to deal with fiber weave skew, using a variety of physical layout and laminate construction techniques, while still using the more common existing PCB materials. Isola GigaSync material, for instance, was developed in 2013 to specifically

reduce fiber skew, but unfortunately its dissipation factor (Df) and dielectric constant (Dk) are too high for today's serial channels. These homogenous materials try to match the Dk of the polymer to that of the glass, with some boundary modification also being performed where the polymer and fibers contact. This effectively eliminates glass weave skew. Unfortunately, glass is still fairly high Dk when compared to the newer polymers that come in the 2.5-2.8 range. A better alternative is to either use hybrid stackups with mixed woven and non-woven materials to lower the cost or use spread-glass material. Isola I-Speed MS, for instance, is mechanically spread glass, expanded in both the warp and fill direction, which is an improvement especially if two-ply construction is employed.

But as frequency continues to soar, cutting edge interconnects running signals at 28 Gbps

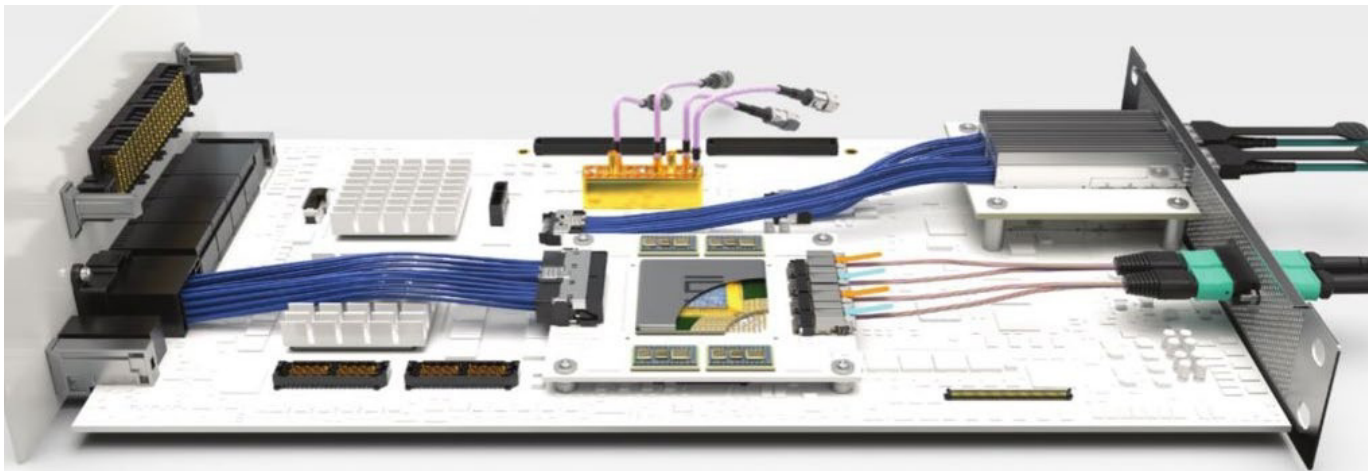


Figure 1: Twinax Cable Flyover™ Technology. (Source: Samtec Inc.)

	FR-4	Megtron 6	Twinax	Optics
10 Gbps	< 250	> 250	> 250	> 250
14 Gbps	< 125	< 250	> 250	> 250
28 Gbps	< 50	< 125	> 250	> 250
56 Gbps		< 50	> 250	> 250
112 Gbps			< 250	> 250

Table 1: Maximum trace length (mm) vs. bandwidth (Gbps).

and beyond require a rethink (Table 1). Or, in the case of Samtec’s solution (Figure 1), a complete rerouting of the signals using Flyover™ cables that remove the signals off the backplane entirely, from chip to off-system connector. They have developed cables and connectors specifically to handle high-speed signals that can pass above and across the board. Using cables for 56 Gbps signals cuts losses by about half compared to PCB traces. This saves PCB cost by reducing the layer count, the material and specification requirements while adding flexibility to high-speed interconnects.

The role of fly-over cables is to isolate signals from the limitations of the PCB materi-

als. As signal speeds increase, the dielectric material’s Df and Dk become an issue, and traces need to be shaped and routed perfectly, without skew, to avoid signal coupling, crosstalk, and electromagnetic compliance (EMC) issues. Fly-over cables are ideal for 28, 56 and 112 Gbps data rate serial links.

Recently, the shift from non-return-to-zero (NRZ) to pulse amplitude modulation 4-level (PAM4) encoding for leading-edge server backplanes has made it extremely difficult to meet jitter and noise requirements over any useful length of board, despite enormous advances in channel characterization and equalization. NRZ is a modulation technique that has two voltage levels to represent logic 0 and logic 1. While PAM4 uses four voltage levels to represent four combinations of 2-bit logic—11, 10, 01, and 00 (Figures 2 and 3).

The goal of these protocols is to transmit data efficiently over co-ax, fiber, or PCB interconnects, but each uses a different method and has its benefits and drawbacks. The well-established NRZ is good for short distance runs, has a throughput of 1 bit per unit interval (UI), minimizes current change, and has a signal and noise ratio (SNR) of 0 dB. On the other hand, PAM4 can transport twice the signal of NRZ (throughput of 2 bits per UI) because it operates on four levels (Figure 3). But this makes reflections three times worse than NRZ, resulting in an SNR of -9.54 dB. Unfortunately, lower-loss cables do not dampen reflections as well as those with higher loss. The increased reflections raise the noise floor, which is critical to PAM4 encoding, especially on shorter cable lengths. However,

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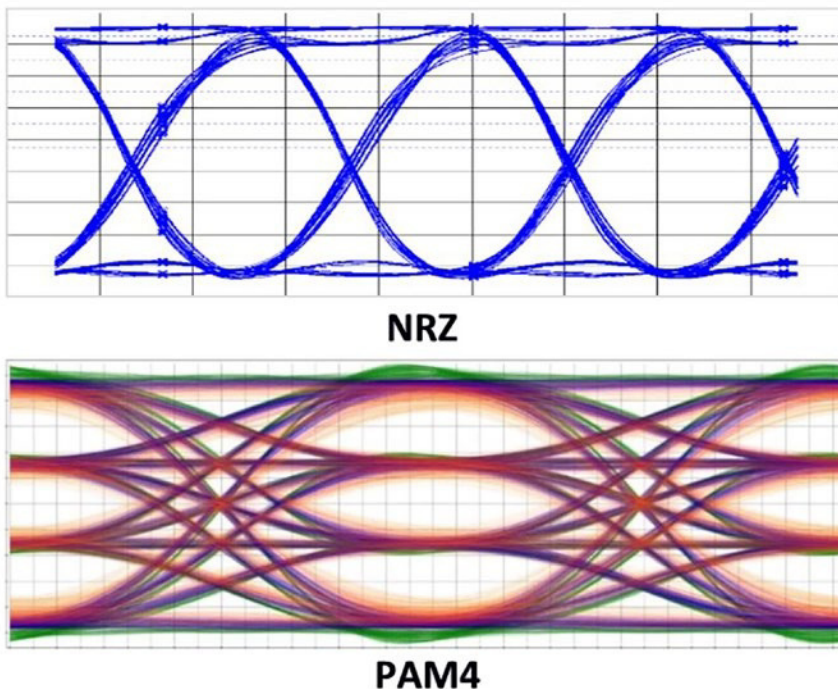


Figure 2: NRZ eye vs. PAM4 eye (Source: Xilinx).

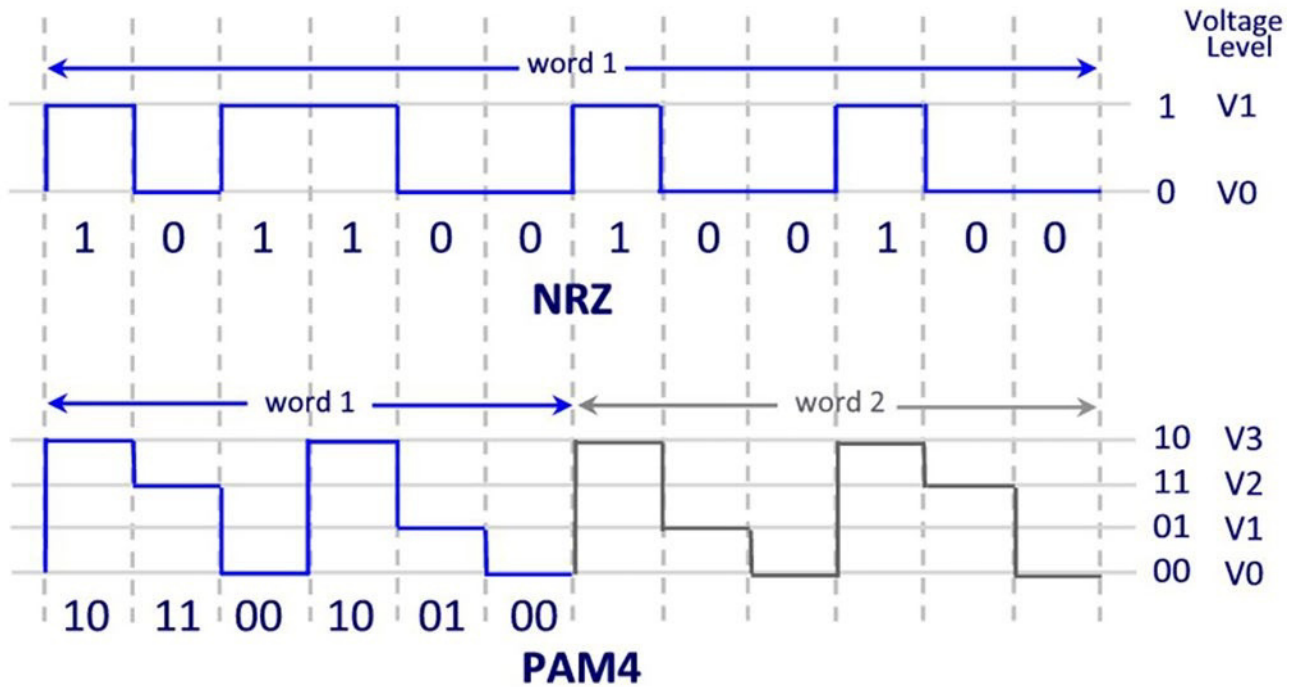


Figure 3: NRZ vs. PAM4 encoding.

NRZ's higher Nyquist frequency (the highest frequency that can be coded at a given sampling rate in order to be able to fully reconstruct the signal) results in higher channel-dependent loss, making PAM4 a more viable solution for high-frequency serial communications.

Using ultra-low skew twin-ax cable to route signals over the PCB is a key performance enabler as signal range and integrity requirements continue to become ever more important in high-speed applications. Fly-over technology provides performance and cost advantages compared to lossy PCBs, with up to 112 Gbps performance at 150 mm cable length. Fly-over also allows designers to go from one board to another as a flexible backplane architecture within a rack, as well as being used as a rack-to-rack interconnect. The traditional backplane architecture is retained, but the system offers lower PCB complexity while achieving higher performance targets.

However, with the growth of 5G data traffic and AI computing, there is a need for faster connectivity to meet the increasing bandwidth. Consequently, serial speed beyond 112

Gbps per lane is now required. If we follow the SerDes technology progression, by doubling the data rate per lane every two years, the next generation I/O data rate will be 224 Gbps. With the signaling rate increasing, electrical channels like PCB traces or copper cable both have bandwidth limitations over certain reach distances. Alternatively, optical fiber cables can be used to transmit high bandwidth data over both short and long distances. Also, there are new emerging technologies such as chiplet and co-packaging optics (CPO) where most of the channel operates in the optical domain.

Key Points

- Applications such as PCIe-Gen 4 (16 Gbps) and higher may need high-performance materials for stackup construction.
- Fiber weave skew has been dealt with using a variety of physical layout and laminate construction techniques while still using the more common existing PCB materials.

- Isola I-Speed MS, for instance, is mechanical spread glass that is an improvement especially if 2-ply construction is employed.
- Fly-over cables remove the signals off the backplane entirely, from chip to off-system connector.
- Using cables for 56 Gbps signals cuts losses by about half compared to PCB traces.
- The role of fly-over cables is to isolate signals from the limitations of the PCB materials.
- Fly-over cables are ideal for 28, 56 and 112 Gbps data rate serial links.
- The shift from NRZ to PAM4 modulation encoding has made it extremely difficult to meet jitter and noise requirements over any useful length of board.
- PAM4 is a more viable solution for high-frequency serial communications.
- Fly-over technology provides performance and cost advantages compared to lossy PCBs, with up to 112 Gbps performance at 150 mm cable length.

- With the signaling rate increasing, electrical channels like PCB traces or copper cable both have bandwidth limitations.
- Optical fiber cables can be used to transmit high bandwidth data over both short and long distances.

Resources

1. Twinax Flyover Cable Systems | System Optimization | Samtec
2. “Flyover Cables: Inevitable, but Not Easy,” by Patrick Mannion
3. “Understanding NRZ and PAM4 Signaling,” by Brian Niehoff
4. SI List, by Scott McMorrow, Samtec

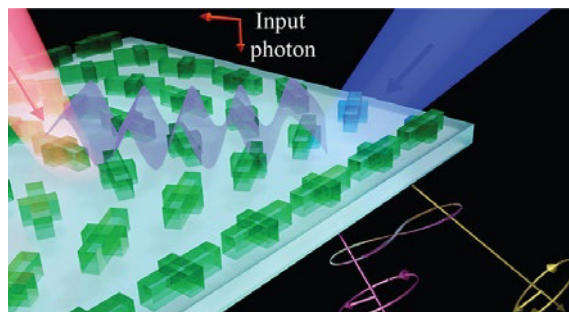


Barry Olney is managing director of In-Circuit Design Pty Ltd (iCD), Australia, a PCB design service bureau that specializes in board-level simulation. The company developed the iCD Design Integrity software incorporating the iCD Stackup, PDN, and CPW Planner. The software can be downloaded at www.icd.com.au. To read past columns or contact Olney, [click here](#).

New Quantum Research Gives Insights Into Mastering Quantum Light

A team of scientists at Los Alamos National Laboratory propose that modulated quantum metasurfaces can control all properties of photonic qubits, a breakthrough that could impact the fields of quantum information, communications, sensing and imaging, as well as energy and momentum harvesting. The results of their study were released in the journal *Physical Review Letters*, published by the American Physical Society.

Metasurfaces are ultrathin structures that can manipulate light in ways not usually seen in nature. In this case, the team developed a metasurface that looked like an array of rotated crosses, which they can then manipulate with lasers or electrical pulses. They then proposed to shoot a single photon



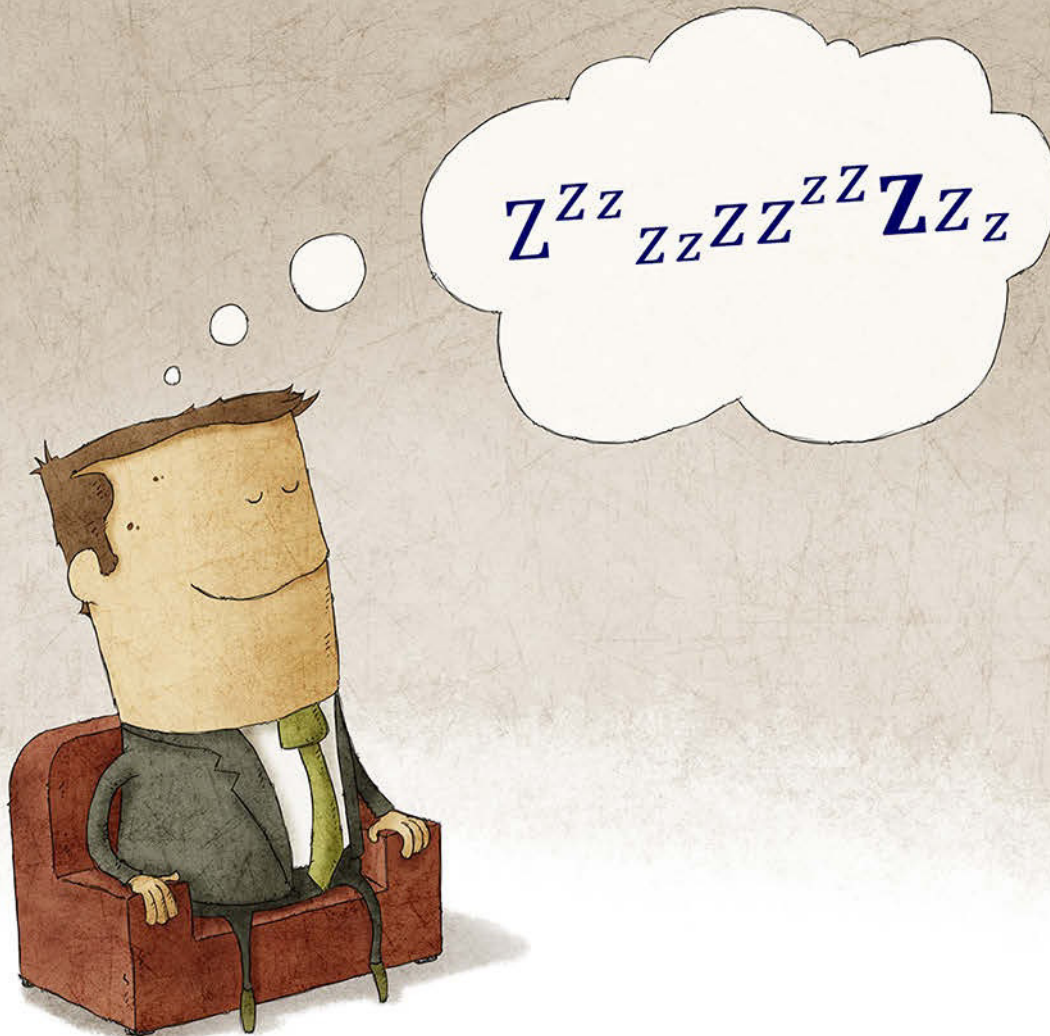
through the metasurface, where the photon splits into a superposition of many colors, paths, and spinning states that are all intertwined, generating so-called quantum entanglement—meaning the single photon is capable of inheriting all these different properties at once.

Harnessing photons that exist in the vacuum and shooting them in one direction should create propulsion in the opposite direction. Similarly, stirring the vacuum should create rotational motion from

the twisted photons. Structured quantum light could then one day be used to generate mechanical thrust, using only tiny amounts of energy to drive the metasurface.

(Source: Los Alamos National Laboratory)

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