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Connector Selection: Looking Upstream from the OEM Equipment

By Dale Reed
Trompeter Electronics

This tutorial article discusses connector considerations beyond the edge of the p.c. board or enclosure, emphasizing mating connectors, cables, installation procedures and quality

There is more to the selection of connectors than simply selecting a standard type and mounting configuration. Good OEM designers consider all aspects of the mated jack/plug pair in their specific application environment, looking beyond their "local" selection to understand the implications of that selection on the end user. Input/output port connector selection is just one part of a larger process that involves the OEM "box" and its interconnection to the rest of the system via wires.

Figure 1 · This "octopus" assembly takes signals from a p.c. board multipin connector at one end and splits them into multiple coax connectors.

Design Considerations—
1. Signal characteristics

One set of criteria that the OEM design engineer should consider when selecting a connector for getting a signal on or off of a pcb is the properties of the transmission line involved. In particular, the designer must know the required frequency response.

RF signals are straightforward, but if the signal is digital, data rate must be translated into frequency, since high frequency transmission requires appropriate cables and related interconnects. For example, Fast Ethernet is largely supported by Category 5 unshielded twisted pair (UTP) technology. The corresponding frequency bandwidth is relatively low and the impact of S-parameters, such as return loss, is small.

Higher data rates need better answers, even with forward error correction coding in place to "solve" network performance problems by retransmitting corrupted information.

Increased error correction results in lower effective data rates, a point well documented by Anixter during their early work with Category standards in cable assemblies. As Gigabit Ethernet and faster data rates are deployed, we must assure that transmission lines are up to the assignment—at full bandwidth and without errors.

In another area, deployment of high definition television (HDTV) offers similar challenges. In studio and post-production applications, the coaxial line used for uncompressed HDTV needs to handle 1.485 Gbps. At this data rate, signal integrity is at risk without connectors specifically designed for high frequencies.

Low frequency interconnect assignments can be inexpensively handled by multi-pin connectors such as the common D-sub series. High frequency interconnect assignments require RF connectors with full ground shielding properties. Fully-shielded RF connectors are also required in applications that must have low egress emission (leakage), such as telco central office equipment hook-ups.

2. How is the other side of the mated connector pair installed?

The equipment side of the mated pair is typically a pcb-mounted jack (in the case of an RF connector) or a header-type set of interconnect pins. If the header type is used, the mating side is usually some sort of flexible circuit or a set of individual wires. In the case of the RF connector, typically coaxial cable is used, with its center conductor and braided shield.

If you choose to use both coax and a multipin approach to capture the density advantages of the pcb, a new choice is now emerging. Called by one supplier "the octopus" (see Figure 1), this solution effectively moves the network connectivity side of the connector off the pcb and to the rear of the network rack that the OEM equipment is bolted to. This is a viable solution for sub-GHz networking needs like DS3 data rates.

3. Impact of the cable on connector selection

The type of cable involved is quite significant. If the required frequency response is 100 MHz, as in the case of 100BaseT Ethernet applications, category 5 twisted pair is normally sufficient. Coax is usually the preferred choice for applications that involve higher data rates or where shielding is important to minimize crosstalk, radiation and/or other induced current effects.

4. Is power available for field installation?

Another issue related to "thinking upstream" that is often overlooked has to do with the physical working conditions of the installer. For example, new installations commonly do not have electricity available, and as a consequence, crimp connector technology would be preferable over soldering. Small format connectors like the SMA are usually soldered on the plug side, which is one reason why they are rarely used for field deployments.

Figure 2 · An improved F connector with captive center conductor and gold plating.

5. What legacy product is the installer base accustomed to?

Custom and tradition matter in some industry segments. Consider why low cost/low reliability F connectors are used in the wiring of a million dollar home. The answer lies with the history of the CATV industry. When this hybrid-fiber-coax network initially deployed their service, the product was residential home entertainment. Overall network quality, signal integrity and service levels were fairly low. The return path was non-existent and delivery was one way.

Today, with SOHO (small office/home office), telecommuting workers, home banking, home shopping and home security over the Internet, the importance of reliable signal integrity in the interconnection of a cable modem is vastly different from early cable TV. Yet the low-end F connector is still used wholesale, partly because the specifier in that market is the installer, not the design engineer.

Regardless of technical merit, the CATV industry will continue to use F connectors for coaxial connectivity and is unlikely to undertake a change. As manufacturers, it falls to us to develop an improved F connector that combines the strengths and convenience of that series with the signal reliability benefits of a fixed center pin, thick gold plating design (Figure 2).

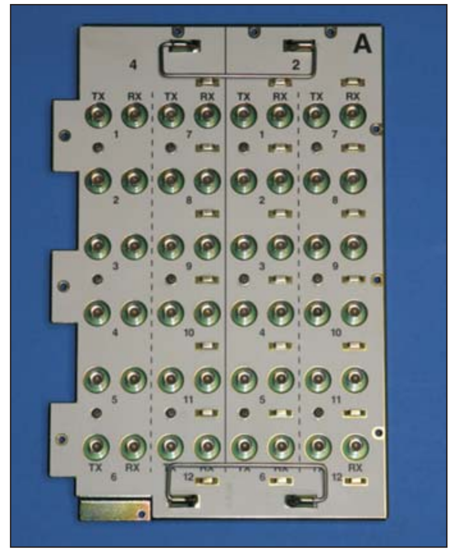

Figure 3 · PSTN distribution panel with full size 75-ohm BNC jacks.

Another example of end user/installer considerations driving a connector choice involves the public switched telephone network (PSTN), aka telephone service providers. This network was born in AT&T where methods and practices of network deployment were guarded for decades. For example, in the central office where coax was employed, the BNC connector was the only permitted interconnect hardware. Further, that particular BNC came to be known as "telco grade" in that it was different and superior to consumer grade BNCs. The 75-ohm impedance version was selected for technical reasons of attenuation and distance. Despite the low frequency of the application (only 44 Mbps), coax was selected to provide signal shielding and reduce crosstalk in this high line count environment. A crimp/crimp version of the BNC was then implemented since telco installers sometimes worked in locations without electricity, or where soldering methodology was not common practice. This set of conditions created the need for, and the extensive use of, the telco grade BNC connector that is used today throughout North America (including Canada and Mexico).

Figure 3 illustrates a traditional approach to connecting the network side of an OC48 fiber link to the PSTN, using a distribution pcb with many BNC jacks, mounted behind and parallel to the motherboard of the box.

6. Cable management issues and their impact

Network equipment connectivity can take up a lot of space, particularly when it is DS3—central office, outside plant, enterprise wiring. This line type is coaxial and the braid-

Figure 4 · 90-degree and 45-degree angled connectors help route cables away from the box in a orderly manner.

shielded cable is relatively thick. Put the output of an OC48 on the back of a box and you have 96 coax lines to deal with in connecting to the next network element. This bulk of cable hanging from the equipment can impede the natural airflow that designers rely on for heat dissipation.

Understanding this, the thoughtful design engineer will select a connector with a plug side (attached to the cable) that can be rotated 90 degrees so that the cables can be routed to the edges and up into the cable ladders without blocking airflow or other access to the rear of the equipment. An even better answer is a rotatable 45 degree plug connector (see Figure 4) that can help solve cable management issues by conveniently nesting the cables at the point of interconnect to the equipment. The orderly routing of cables also simplifies inspection and troubleshooting.

7. Equipment activation issues and quality inspection of the installation

When installers complete their work and turn over their job site to an inspector for quality and conformance inspection prior to activating that portion of the network, several

Installation Requires Proper Tools and Training

Figure 5 · High quality, reliable field installation of connectors requires a set of the manufacturer's installation tools, plus training in their proper use.

The OEM design engineer generally selects a jack connector that is soldered onto a pcb in a factory. This jack side is handled like other pcb components, installed in a production environment and examined at final inspection with appropriate testing and precision inspection equipment. This is not true of the plug on the mating side of the connector, which is often installed in a dark, crowded space with hand tools, little supervision and a cursory follow-up inspection.

Connector field installation warrants special attention. The highest quality installations will be obtained with connectors that are supported with the proper tools and training. The design engineer should consider installation when specifying the plug side, even by brand name, since only a few companies have a commitment to tools and training: providing both assembly and inspection tools (see Figures 5 and 6), offering installer certification and maintaining mature ongoing installer training programs.

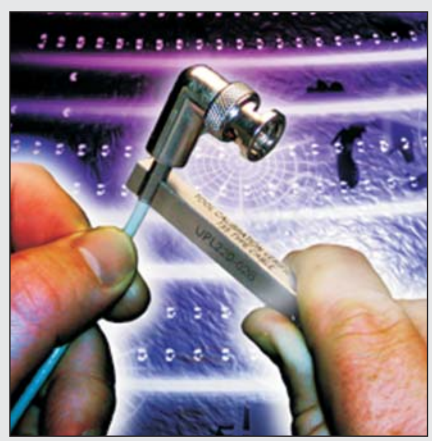

Figure 6 · Installation tools include calibration devices to verify that the connectors were installed according to the manufacturer's specifications.

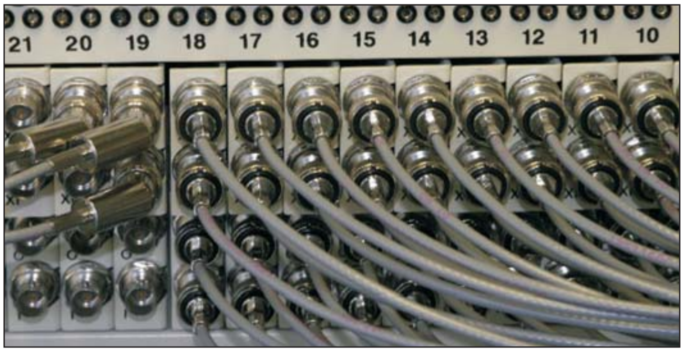

Figure 7 · A new type BNC connector has a notch that indicates when the plug is fully rotated onto the lugs of the jack.

aspects of the inspection process come into play. For example, in the case of the PSTN DS3 line, one supplier's BNC connector can now be inspected visually by virtue of a "notch indicator" feature that is in the coupling sleeve of the plug connector. This small notch is aligned with the J-slot, providing a visual confirmation that the coupling sleeve is fully rotated onto the lugs of the equipment jack, as shown in Figure 7. The black contrasting washer makes it easy to distinguish the position of the notch for visual verification of engagement. This kind of attention to detail is fully two steps "upstream" from the designer's decision to use a BNC jack on the network side of the equipment.

The Future

Design engineers can help increase the attractiveness of their product to the customer by considering the issues important to their success. This article explored several illustrations. Ideas that may help this agenda are welcome, and will be considered for inclusion in the company's network connectivity products. Interested readers may contact the author directly.

Author Information

Dale Reed is Vice President of Sales and Marketing for Trompeter Electronics and Semflex. He has been active in high frequency issues, particularly involving microwave printed circuit board design, and is the author of several articles on design, fabrication, quality and management issues. Mr. Reed earned his BA from Trinity College in 1970 and an MBA from Georgia State University in 1979. He can be reached by e-mail at dale.reed@trompeter.com.