A CommScope Solution

Uniprise™

Strength through integration

# *LC VERSUS MT-RJ CONNECTORS: WHICH IS THE BETTER PERFORMER*

Author: Rodney Casteel

*Fiber Applications Specialist*

A CommScope Solution
Uniprise™
Strength through integration

When fiber optic connectors were first developed, performance was the key design issue. But now that fiber is the first choice for telco networks and a growing presence in private data LAN/WANs, another issue has gained prominence - connector size. Shelf space in central offices and telecommunications rooms is becoming scarce through the use of bulky ST and SC connectors.

SFF (Small Form Factor) connectors were developed to put more fiber connections into the same space. They also took advantage of advances in design and materials to deliver levels of performance beyond that of those first-generation connectors.

Two styles of SFF connector have found favor in the marketplace - the highly-promoted MT-RJ and the workmanlike LC. Both address the need for high density and low insertion loss. But despite the hype, there are solid reasons that the LC is the preferred connector for high-performance networks.

## History

The MT-RJ is a variation on the MT ribbon fiber connector developed by Nippon Telephone and Telegraph. In its original design, the MT could hold as many as 12 fibers. The connector manufacturer AMP adapted the MT design to hold only two fibers in an inexpensive rectangular plastic ferrule. The MT-RJ was aggressively marketed upon its introduction as THE small form factor connector. MT-RJ design was later standardized in EIA/TIA-604-12 and is now offered by several other manufacturers.

The LC connector was developed by Lucent Technologies as a response to the need by their primary customers, the telcos, for a small, low insertion loss connector. The LC is a single fiber connector that borrows a cylindrical ferrule (usually ceramic) and split-sleeve construction from its predecessor, the larger SC connector. Two LCs can be easily yoked together into a duplex assembly that occupies the same area as a single SC (some manufacturers offer a true duplex LC). The primary customers were the public telcos who have specified Lucent (formerly BellCore) components for decades. The LC design was standardized in EIA/TIA-604-10 and is offered by several other manufacturers.

## How The Connectors Connect

The version of the MT-RJ connector used to terminate cable is male, with two steel alignment pins that fit into the female receptacle. The connector is locked into place with an RJ45-style clip. Fiber is cleaved and placed in the ferrule where it is mechanically held in place.

An LC connector terminates in an adapter and meets a similar connector face-to-face. The connectors are held in the adapter with an RJ45-style clip. The fiber is inserted into a ceramic ferrule that is then polished. An interesting feature of the LC is that the ferrule can be 'tuned' or rotated with a special tool after it has been assembled. This offers a considerable performance advantage as will be shown below.

## How Design Effects Performance

The MT-RJ is a complex mechanism. Proper function requires that four items be precisely positioned; the two alignment pins (and their holes) and the two fibers. Assuming 3$\mu$m manufacturing tolerance for the pin/hole positioning/diameters and a 2$\mu$m tolerance for the fiber placement reveals a worst-case scenario of as much as 5 $\mu$m of offset.

But is that truly worst-case? Remember that the MT-RJ has a plastic body and it is difficult to maintain a 2$\mu$m tolerance in plastic molding. There is a chance that the offset could be much greater. And when fiber concentricity is figured into the equation, the offset could be enough to cause a significant power loss. By attempting to consistantly align two fibers at once, the MT-RJ opens itself up to some potential problems.

The beauty of the LC connector is due to an inherently simple design; everything revolves around a single axis - a single fiber core. When clicked into the adapter, the ferrule (with the fiber positioned to within 1.4$\mu$m of its center) is placed inside a receiving bore that aligns it with another connector. Assuming a manufacturing tolerance of 3$\mu$m for the bore, there is very little opportunity for 'wiggle.' Even in a worst-case scenario, the maximum offset would be 4.4$\mu$m in the core-to-core interface at the adapter.

The difference is easily shown in the measured performance of the multimode versions of the connectors; average insertion loss from a factory installed MT-RJ is 0.3dB, but for an LC is 0.2dB.

For single-mode connectors, the tolerances must be even tighter because of the narrow fiber core. The LCs ceramic ferrule allows tolerances of down to 1.4$\mu$m. While the tolerance for the diameter of the metal pins in the MT-RJ can be tightened, the features molded into the plastic ferrule cannot. Using materials such as semiconductor-grade silicon for the ferrule have been tried, but that drives up the cost considerably. The average measured single-

mode performance for a factory installed tuned LC is 0.08dB and average return loss of greater than -55dB, while the MT-RJ has an average factory insertion loss of .4dB with a typical reflection of -40dB.

## How Installation Effects Performance

The MT-RJ is positioned as a craft-friendly connector, a claim that is based on the fact that no polishing is required. Fiber is stripped, cleaved and placed so that it is flush with the pre-terminated fiber in the tip of the ferrule.

However, a problem arises during the cleaving stage; it takes a good bit of practice and a good cleaving tool to achieve a clean flat cleave of less than 1° of perpendicular. If the cleave is angled more than that, it can create an air space that could cause crippling attenuation and reflection loss.

The flat face of the MT-RJ accentuates this air space reflection loss. The fiber must be installed so that it is absolutely flush with the front of the connector. Installing the MT-RJ incorrectly will open up a gap that will cause reflection loss. These factors are easily seen in the average reflection loss figures for the connector types; a typical single-mode LC has only -55dB of loss (and an even lower -75dB if angled) while the typical single-mode MT-RJ only achieves a -40dB of reflection loss performance.

A third problem is the mechanism that holds the fiber in place. The clamp that holds the fiber may introduce stress that results in additional loss through micro bending. It should be noted that the clamp does not provide as much tensile strength and fiber support as the ferrule of the LC.

A fourth problem caused by the 'two-fibers-at-once' philosophy of the MT-RJ is fiber polarity; an installer may accidentally reverse the position of the tx and rx fibers. Fortunately, some MT-RJ connectors are re-enterable and the problem is fixable, but not without some effort. This two-fibers-at-a-time approach creates another inherent problem. With a two fiber connector, if only one fiber gets damaged, two fibers still have to be reterminated. However, with the LC, if one fiber gets damaged only one fiber has to be reterminated. This means less labor and material cost.

Even the best of craftsmen run into problems such as fiber that has an eccentric core. However, the LC addresses this post-installation with its 'tune-ability.' Using a special wrench, an LC connector can have the ferrule rotated in 60° increments that helps align core mismatches.

## Testing

While the concept of "two fibers" at a time sounds good in theory, it poses yet another problem in the field, which is testing. According to the TIA/EIA-568-B.3 standard, the recommended test method is a one jumper reference. However, the current hand held test sets are not capable of testing a two fiber connector utilizing a one jumper reference.

To test a two fiber connector with current hand held test sets, two composite jumpers are needed and a minimum of a two jumper reference (and in some cases a three jumper reference). A two and three jumper reference test may not reflect the actual loss of the system as accurately as a one jumper reference.

Incontrast, the LC connector having only one fiber per ferrule is much simpler to test. Many of the hand held test sets today are available with the LC interface and can take advantage of a one jumper reference, which will better simulate the actual performance of the fiber network.

## Conclusion

Sometimes simple is better. The classic one-fiber-at-a-time approach of the LC connector coupled with its tunability makes it the right choice for the low-loss, high performance SFF connector of the present and the future. For these reasons many of the electronic manufacturers are standardizing on the LC as the connector interface of choice for higher speed networks. While the MT-RJ was popular for a while with some electronic manufacturers for their low speed 10/100 systems, they have discovered that the complexities, expense and poor performance of the MT-RJ make it an unfavorable connector for their higher speed electronics; therefore they are switching to the more simplified and cost effective LC connector.

A CommScope Solution
Uniprise™
Strength through integration

CommScope®
1100 CommScope Place SE Hickory, NC 28603
P: 800.544.1948 828.459.5000 F: 828.459.5099
www.uniprisesolutions.com