



40GBASE-SR4 & URM-Infrastructure Verification with BER-T and OTDR

White Paper



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Executive Summary

Fiber-optic multi-fiber connector systems will play an important role in the transition towards 40G Ethernet. Technical evolution in transceivers permits transmitting and receiving 4x10G with a single module. The necessary high density of 8 optic fibers cannot be realized with a common LC(dx). Up to now, only MPO patch connectors are used for the purpose.

However, the MPO patch connector has several technological disadvantages due to its design. In MPO there are 12 fibers in one plastic ferrule, making it impossible in the production process to polish the fibers individually but in a bunch. This leads to rather high signal loss. In addition, the fibers of an MPO patch connector cannot be cleaned separately, leading to insecure results.

In contrast, URM is based on reliable, separately polishable ceramic ferrules with excellent loss properties. The fibers can be cleaned separately and securely on site.

The URM system is, thus, a more than valid alternative for MPO.

In order to prove the quality with regard to the high technical demand, this White Paper describes the test setup and the measuring analysis of an URM cabling structure.

URM-System

URM means “You Are Modular”, describing a modular, flexible and easy cabling system.

The core component of the URM system is the 8-fold adapter “K8” for the patch panel. The picture shows that the adapter can be used with either one 8-fold connector “P8” or 4 duplex connectors “P2”.

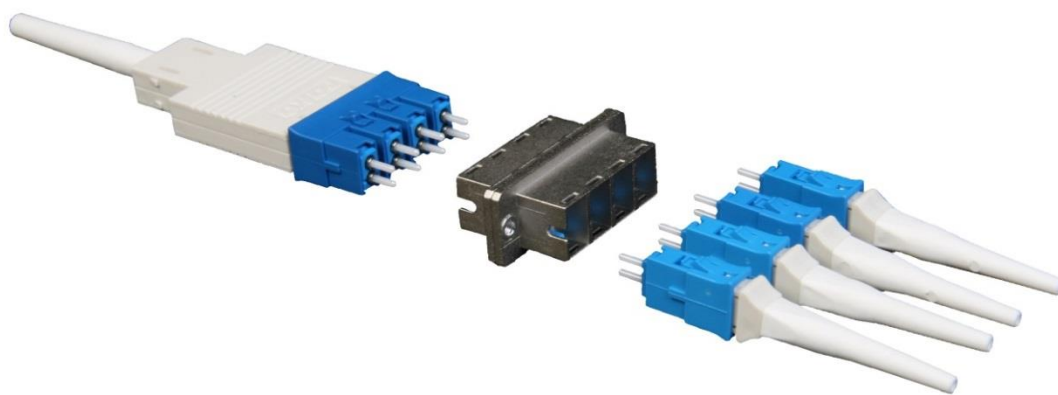


Figure 1: URM System

The following table compares the available cabling systems based on multi-fiber connectors to illustrate the modularity of the URM system.

	URM System	MPO System
Ferrule	Ceramic 1,25 mm (SFF)	Plastic
Number of fibers in a connector	2, 8	Up to 24
Connectors	P2 (duplex) P8 (8-fold)	MPO xx female MPO xx male (with pins)
Polarity reversible	Yes (P2)	No
Adapter	K8 (8-fold)	Type A (key up, key down) Type B (key up, key up)
Compatibility	Yes P8 <-> 4 x P2	No MPO 12 <-> MPO 24
Patch cable duplex	Yes	No
Patch cable to LC(dx)	Yes LC(dx) to P2	Indirect MPO Cassette or MPO Fanout
Patch cable MPO to Multi-fiber connectors	Yes MPO to P8	Yes MPO to MPO

Table 1: Comparison of cabling systems

URM trunk cabling enables easy switching between LC(dx) and MPO based active devices at any time by simple replacement of the patch cables, whereas an MPO based trunk cabling needs additional connectors and cassettes to link LC(dx) active devices.

Technical Background

The high standard for the passive infrastructure is reached due to the following points:

Abutting face geometry:

The geometry of the polished ferrule is critical for the repeatability of a plug connection and the insertion loss and return loss of fiber-optic connectors. Minimum loss values for every plugging process can only be reached if, the fibers glued into the connector are pressed together in ideal alignment and without air gap.

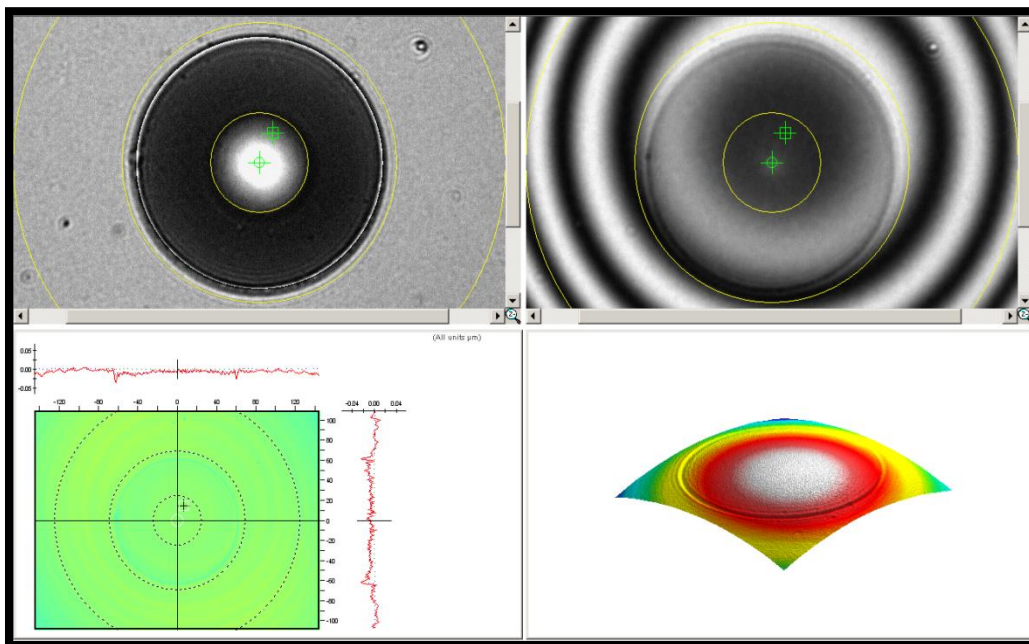


Figure 2: Interferometric measuring of a ferrule of a P2 connector.

This can be reached with high-precision ceramic ferrules, a convex polishing of the abutting faces as shown in Figure 2 and an additional angle for APC connectors. The angle is necessary to reduce return reflection to a minimum.

Insertion Loss (IL):

Any plugging connection causes loss at the connector face, where both fiber ends abut. Scratching, dirt, misalignment and air gaps increase the loss. Such defects disturb the optical signal path through the fiber and cause a reduction of signal power at any transition point due to offset coupling, scattering, absorption and reflections.

Return Loss (RL):

In addition to the Insertion Loss, parts of the signal are reflected back to the transceiver at any plugging connection. The defects mentioned for Insertion Loss not only increase the loss but also increase back reflection.

In order to drastically decrease this reflection, the abutting surfaces of the ferrules are angled at 8° in APC connectors. The reflected part of the optical signal is, thus, sent back into the fiber at an angle greater than the acceptance angle. Therefore, no total reflection occurs at the core-cladding transient surface (singlemode fiber) because the reflected optical signals are lead out of the fiber. Faultless abutting face geometry is critical for that purpose.

Summary:

The effects above mentioned are critical for signal loss in a fiber-optic plugging connection.

URM solves these problems by guiding every single ceramic ferrule in a slit ceramic sleeve. Additionally, the ferrules in the connector are separately spring-loaded and polished, hence using the established principle of LC connectors.

In MPO, the plastic ferrule with all fibers is polished only as a bunch, only the complete connector is spring-loaded and the ferrule is guided with two lateral metal pins. It is extremely difficult for manufacturers to ensure the high quality needed for 40G links for all 12 fibers of an MPO connector.

In addition to loss, modal dispersion plays an essential role in multimode fibers for the maximum length of the signal path. High quality plugging connections in particular do not by far exhaust the loss budget recommended by the manufacturer of the transceiver. Here, modal dispersion is the limiting factor.

Verification

A 40G Ethernet connection with a maximum link distance of 150 m with OM4 fibers, specified for the QSFP-40G-SR4, is to be verified; IL an RL are to be evaluated. The test setup is monitored with an OTDR manufactured by JDSU. Subsequently, the capacity of the built test link is determined with a BER test by JDSU.

Measuring Instruments and Setup

JDSU MTS-4000 OTDR

MM Module 850nm
3 ns Pulse
8 cm Resolution

JDSU MTS-8000 BER-T

40GE Transport Module
QSFP-40G-SR4 (Max. link distance 150 m, loss budget 1,5 dB)

The following basic conditions were assumed for the measuring setup. They are very similar to standard data center fiber-optic links and indicate the maximum distance according to norm IEEE 802.3ba.

- 40G via 8 fibers OM4
- Trunk cabling with URM system
- At least 4 plugging connections
- Link distance: minimum 150 m
- OTDR test setup
- BER test setup including patch cable MPO to URM P8

Realized configurations of the measuring and channel setup:

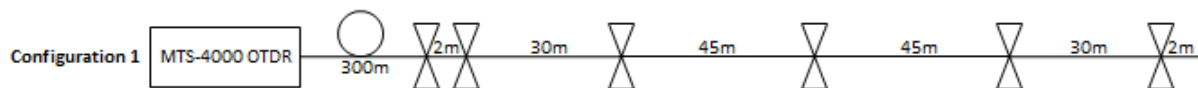


Figure 3: Measuring setup Configuration 1

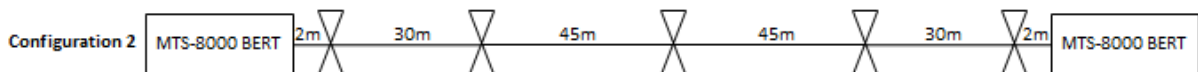


Figure 4: Measuring setup Configuration 2

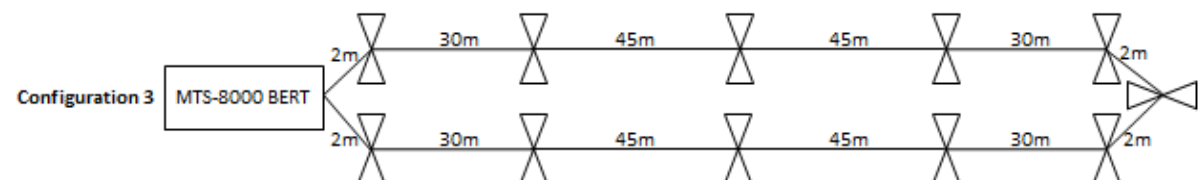


Figure 5: Measuring setup Configuration 3

Summary of Results

Configuration 1: Loss budget and return loss

Checking of the URM channel with an OTDR, the expected high quality of the components of the URM cabling system could be verified. Together with JDSU, every fiber was measured in both directions in order to determine the respective loss. The average values and the according standard deviations are shown in table 2. The last transition to the patch cable and the subsequent open end were not considered in the evaluation.

Measuring setup	
Connector transitions	5
Number of fibers	8
Link distance	155 m
Measuring results	
Average link loss	0,48 dB
Standard deviation	0,06 dB
Average Connector loss including fiber loss	0,1 dB
Average return loss	48 dB
Standard deviation	6 dB

Table 2: OTDR measuring results for URM trunk cabling

The following figure 6 shows a magnified view of the OTDR measurements with the greatest loss gradient over distance. It has an overall loss of 0,57 dB.

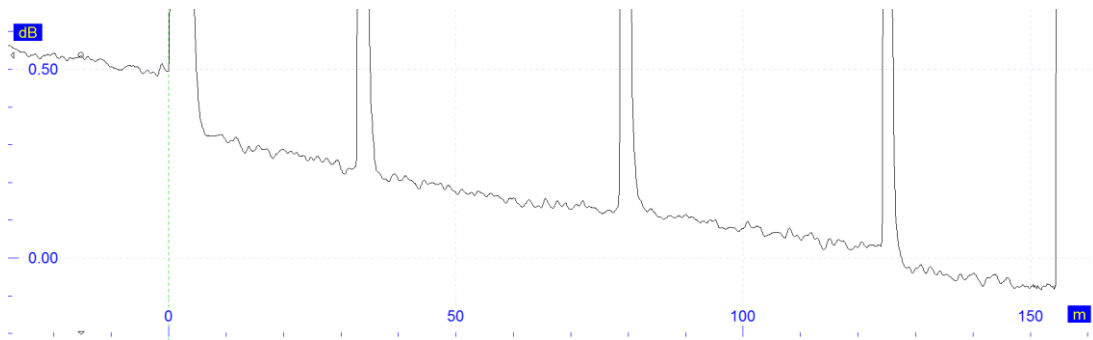


Figure 6: OTDR Loss gradient of one fiber of a URM link

The first peak is the patch cable after the launch fiber. It contains 2 plugging connections. Apart from reflection, all other transitions can hardly be distinguished from the normal cable loss, illustrating the high quality of the URM cabling system.

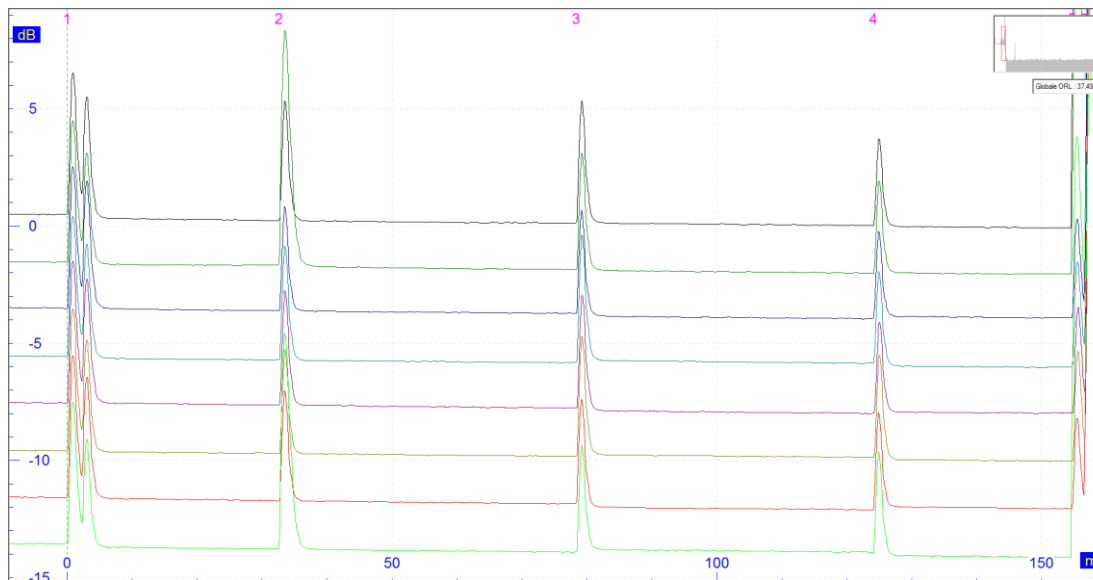


Figure 7: OTDR Loss gradient of all fibers in the URM link

For further verification, the links were set up again in-house at Sachsenkabel and measured with the JDSU MTS-6000 OTDR. The results showed similarly excellent loss values.

Configuration 2: BER-Test

The bit error rate was measured over a period of 30 minutes. Not a single bit error could be determined. The result corresponds with the expectations, particularly, because the channel attenuation is clearly below the required loss budget and the link distance of 155 m is only slightly above the transceiver specification.

Configuration 3: BER test over 308 m

In this configuration the 40G channel was measured as loop with a JDSU MTS 8000 platform. This resulted in the double link distance of 308 m. In sum, the channel contains 11 plugging connections. The one additional transition comes from the patch cable required to form a loop.



Figure 8: Measuring setup

With an average path attenuation of 1 dB, only 2/3 of the available loss budget are used. There is sufficient reserve for future upgrading.

The following Figure 9 shows the result of the BER test in configuration 3:

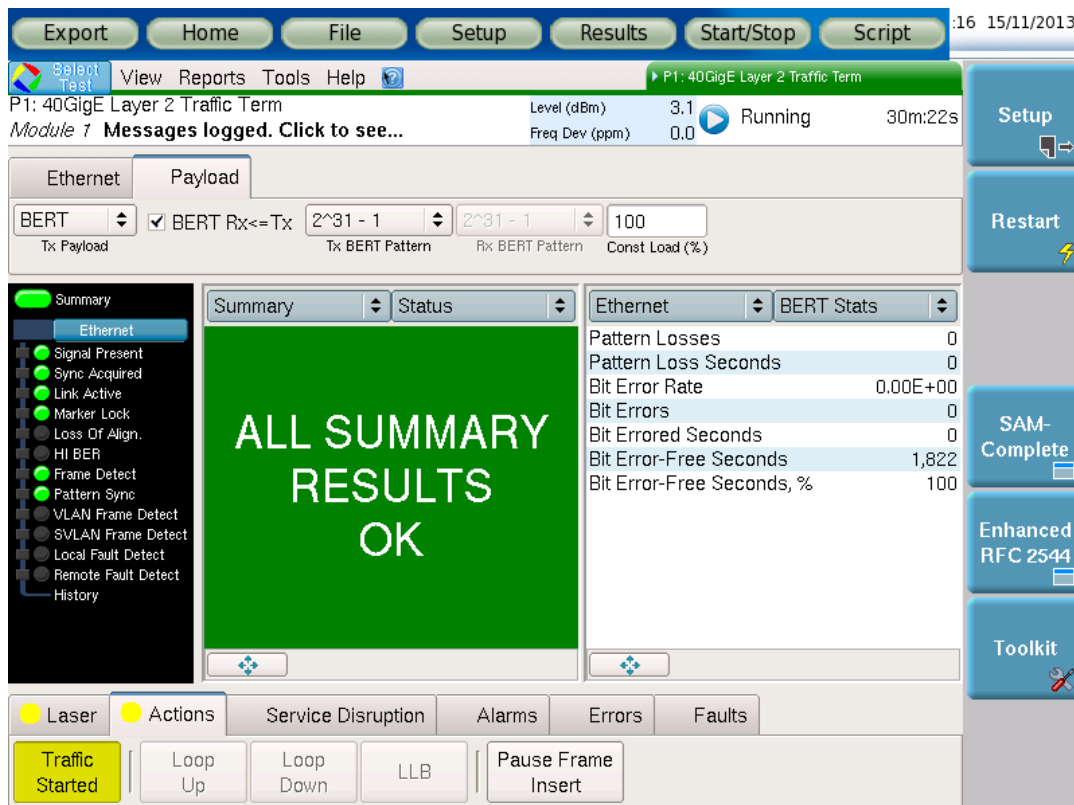


Figure 9: Results of the BER test in configuration 3

Against all expectations, the BER test showed an error free result even for a link distance of more than 300 m. The link distance is clearly above the specification of the transceiver. So it was expected that an error free data transmission at the highest rate of 40G is impossible due to modal dispersion.

Conclusion

Loss budget:

An average link loss of 0,48 dB offers sufficient budget reserve of more than 1 dB. This opens the opportunity to plan and install a fiber-optic infrastructure for 40G Ethernet and other applications with great freedom and appropriate security.

Return loss:

An average return loss of 48 dB enables stable and secure operation of the channels and ensures a low error rate for the operator. Insufficient return loss in a fiber-optic link may interfere with the transceivers, causing higher bit error rates. This is particularly disadvantageous for the operation of fiber channel systems, or causes problems, if the loss and the distance of the link are bordering the specified parameters of the transceivers.

Skew:

Possible differences in the signal propagation speed caused no errors during the BER test of the URM system. The maximum allowed time difference according to IEEE 802.3ba is 79 ns between two fibers in one channel.

Considering the signal propagation speed in an optic fiber, 79 ns mean a maximum allowed length difference of the eight separate fibers of approximately 16 m. The length difference of single fibers in one channel in the URM system, however, is in the millimeter-range.

The URM system clearly exceeds all requirements for trunk cabling with multi-fiber plugging connectors.

High-quality ceramic connectors enable a multitude of transitions without exceeding the tight loss budget. With the use of high-grade components in the URM system, the links will work even if the recommended distances are exceeded. This means security and reserves for future development and upgrading in data centers.

Consequently, the URM system offers a technologically superior alternative to MPO systems.

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Company Profiles

LWL-Sachsenkabel GmbH has been among the biggest manufacturers of fiber-optic cabling solutions in Germany for more than 20 years. Nationally and internationally, Sachsenkabel develops and produces high-quality serial products as well as custom-made solutions for network providers, data centers, industry and media broadcast. Learn more about Sachsenkabel on <http://www.sachsenkabel.de/en>.

JDSU develops and produces testing and measuring solutions as well as optical products for data communication and telecommunication. With its devices and solutions, JDSU makes sure that the ever-growing data streams, up to complex video broadcasts, reach the users' laptops, or smartphones without time delay and at the highest quality. Learn more about JDSU on www.jdsu.com and follow us on [JDSU Perspectives](#), [Twitter](#), [Facebook](#) and [YouTube](#).

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