A Fiber Primer

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A Fiber Primer

Working in the broadcast industry we are all familiar with fiber optic transmission systems, and this technology is commonly used for certain applications. This is typically for long haul applications like moving video signals between distant locations, or hauling distant camera feeds back to outside broadcast units.

Signal distribution within a facility is typically copper coaxial cable, and this has been used in one form or another since the inception of television. However, in the digital domain video bandwidth increased nearly seven fold from 270Mbit to 1.5Gbit with the transition to HDTV, and now this has further increased to 3Gbit. As the bandwidths increase, the reach of copper cable reduces and our world is shrinking rapidly. Cable lengths have dropped from 350m at 250Mbit to 140m at 1.5Gbit, and now it's down to about 70m at 3Gbit. Allowing overhead for cable tray routing and emergency patch panels etc. then 70m (230 feet) cable lengths are imposing serious issues for facility design and expansion.

We now see fiber technology moving within the facility for internal signal distribution to combat this problem. It is unlikely fiber will completely replace copper signal distribution, but it can be used to solve the restrictions of copper for distances exceeding the shrinking boundaries of our copper connected world.

Fiber Technology

As fiber transitions from the few specialized external applications to more of a "utility" role within a facility we all need to grasp the basics of fiber technology. This document will not go into great technical detail but offer relatively simplistic explanations to convey the technology and correct some common misconceptions while also offering some practical solutions using LYNX Technik fiber products.

We all know the basic principle behind fiber technology, light pulses transmitted down an optical cable compared to electrical signals sent down copper cable. Conversion is still required to and from electrical signals each end, which involves the use of fiber converters; namely an optical transmitter and optical receiver. Connect a transmitter and receiver together with some fiber cable, and in its most rudimentary form we have a point to point fiber optic transmission system and our problems are solved….

However, there are some other factors which need to be considered.

- *The bandwidth of the signal*
- *The total distance to be covered*
- *What type of fiber cable and connectors being used*
- *Fiber cable care and routing*

Bandwidth

Fiber cable can transport data at incredible bandwidths, but in terms of video applications the fiber converters selected (and cable) should support the maximum video bandwidth in use today and also the near future. There are solutions available on the market for up to 270Mbit and 1.5Gbit with newer solutions emerging for 3Gbit. The safest bet is to "future proof" and install for 3Gbit, even if you are only using 270Mbit or 1.5Gbit video signals today. Another important consideration is to use reclocking converters. This is good practice, reduces the potential for errors, and ensures a consistent level of quality over the fiber link. LYNX Technik fiber transmitters and receivers support SDI video signals up to 3Gbit and automatically reclock the video at 270Mbit, 1.5Gbit or 3Gbit rates depending on the input signal detected.

Distance

In terms of the maximum distance, this is a function of the optical transmitter and is a combination of laser wavelength, laser power and more importantly the type of cable used. Other contributing factors are the optical receiver's sensitivity and the number of connections and splices in the cable. Most manufacturers (including us) associate a max distance in km with an optical transmitter, (10km, 40km, 80km) which assumes the use of Singlemode fiber cable and the use of the same manufacturer's optical receiver. These are very approximate max distances, as variables in the fiber link itself can greatly influence the achievable distances. These "km" numbers are normally very low estimates and in most cases these distances can be easily reached and often exceeded if using optimum cable and minimal connections and splices. (The need to associate a km figure with a device is driven primarily for marketing to give a ball park indication of the optical transmitter's power – this is far easier to comprehend than "5dBm@1310nm" which is an accurate expression of the power).

At first glance 10Km would appear to be a "cure all" for any application within a facility with more than enough overhead, and usually this is the case, but some care needs to be taken as the type of fiber cable, the number of connections and splices can significantly impact the maximum achievable distance. With lower quality cable with lots of connections and splices, then the reach can potentially drop from many kilometers to hundreds of meters. As there may be fiber cables already in place, which may or may not have splices, some of our choices are limited, so Its good practice to perform some basic calculations to establish an optical link budget from which we can determine the distances which can be achieved given our mix of fixed and variable factors. More on this later.

Type of Cable

Telecommunication marketing to the public touts the benefits of fiber communications as "hundreds of signals simultaneously sent down a signal strand of fiber". While multiplexing many signals into fiber is commonplace, this has caused a little misconception and confusion to those not familiar with the terminology used to describe the different types of fiber cable.

There are two basic types of fiber cable "Singlemode" and "Multimode" the misconception is that Singlemode implies it accommodates one signal and Multimode accommodates many signals. The logical conclusion being Multimode cable is better than Singlemode cable. In fact the opposite is true. Singlemode and Multimode has nothing to do with the number of unique signals which can be carried by a fiber cable. Mode means "path of light" Singlemode means single path of light, and Multimode means many paths of light. In the electrical world a thicker cable means less resistance and therefore fewer cable losses. The opposite is true for fiber cable. The smallest fiber core delivers the most bandwidth and greatest distance.

All fiber cables have a glass core. The core is surrounded with optical cladding (also glass) which stops the light escaping by using the principle of total internal reflection (or refraction). The rest of the cable is a layered mixture of various materials to provide protection from the environment and physical damage.


Fiber Cable Cross Section
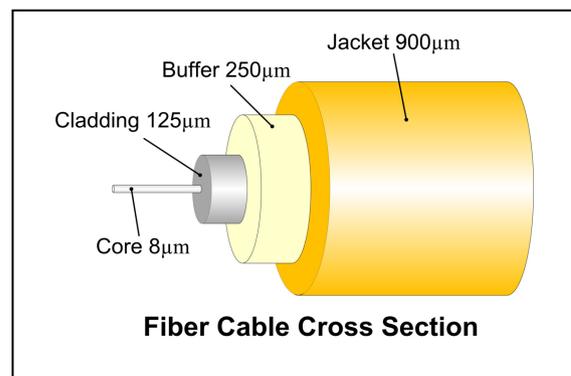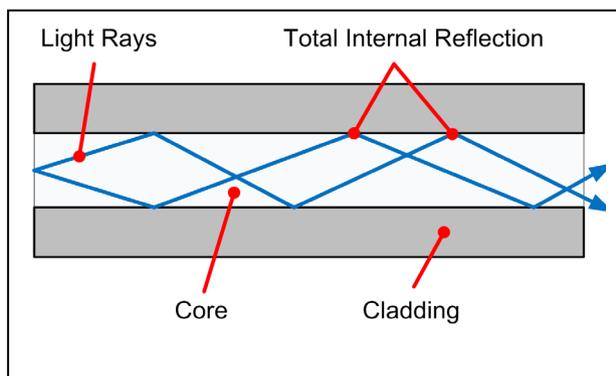
Multimode fiber cable

The core size diameter for Multimode fiber cable is incredibly small physically (about the size of a human hair), but relatively large for fiber at 50 or 62.5 microns. This "large" size means the light is dispersed into many "modes" and the light rays bounce around inside the cable as it moves along. If the angle of incidence is too high then the light ray will not be reflected (or refracted) back into the core and gets lost in the cladding, and light losses occur (attenuation). The many paths of light result in intermodal dispersion which causes an overlapping effect degrading signal recovery in the receiver. The net result is a poor quality output signal. The dispersion effect multiplies with distance and is influenced by signal frequency which is why Multimode cable is only suitable for shorter distances.

There are two basic types of Multimode cable; one is referred to as "Step Index" the other "Graded Index". Step Index cable uses a core and cladding with different refractive indexes so the edge transition is a hard "step". This is only suitable for short distances and lower bandwidths. (Consumer applications, some short distance medical applications and automotive). Multimode Step Index fiber cable should be avoided at all costs as it does not support the laser wavelengths and bandwidths needed for digital video.

Graded Index Multimode uses variations in the composition of the glass core to compensate for different path lengths to reduce the effects of intermodal dispersion. The refractive index value of the glass core is gradually "graded" from the center to the outer edge until it equals the cladding refractive index. This has the effect of slowing down the light paths from the outside to the center of the core shaping the beams and therefore reducing the overall path length differences, this also virtually eliminates light losses in the cladding. Graded Index supports much longer distances and much higher bandwidths than Step Index cable and is the most common type of Multimode cable used.

However, it's not possible to totally eliminate intermodal dispersion and this characteristic is directly influenced by frequency and distance. A 3Gbit video signal is a high frequency, and the effects of this high frequency will have a detrimental impact on achievable distances with Multimode cable.

Multimode: Step Index

Multimode: Graded Index
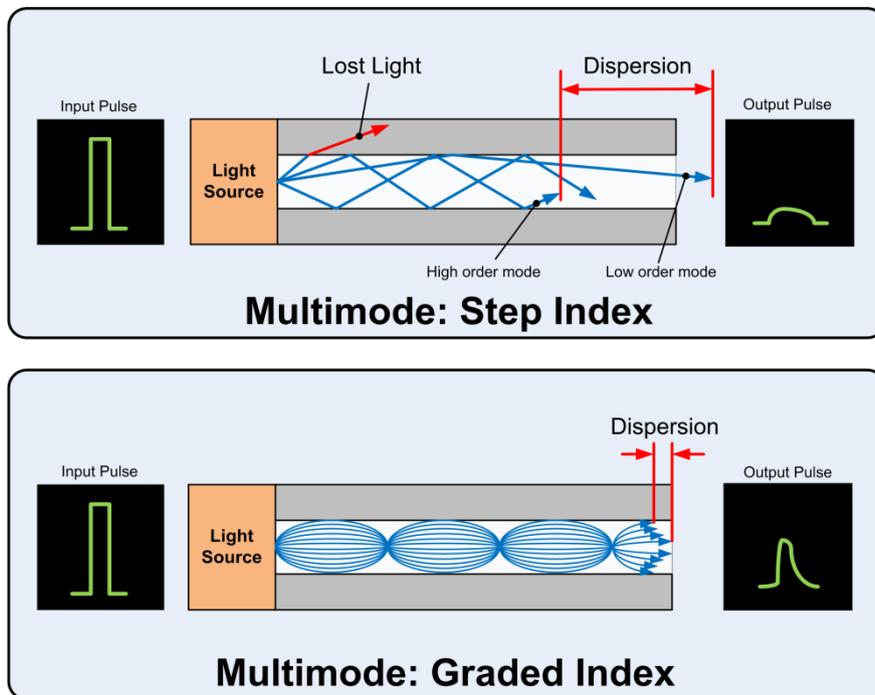
Singlemode Fiber Cable

Singlemode cable is typically step index using one material for the core and one for the cladding but shrinks the core down so small that only a single ray of light can pass through the cable. The core diameter is typically 8 or 9 microns, (you cannot even see it without a microscope). This increases the bandwidth to almost infinity, but is practically limited to around 100GHz. As it's a single path of light there are no detrimental effects from intermodal dispersion and the distances supported are much larger than Multimode cable.
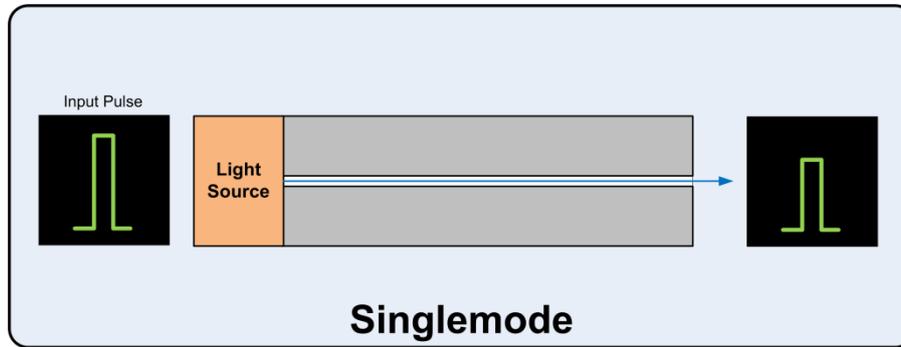
Singlemode

However, a characteristic called "chromatic dispersion" does have an impact on Singlemode links and this is due to the narrow band (or spectrum) of wavelengths the laser emitter occupies.

Different wavelengths travel at different speeds through fiber cable. For cost reasons the lasers used for fiber communications do not emit a single "ultra precise" wavelength of light; moreover they have a narrow band (or spectrum) of light with a peak wavelength and roll off into surrounding wavelengths. After travelling though the Singlemode core this small mixture of wavelengths hits the optical receiver at slightly different time intervals, which causes the Chromatic dispersion; this effect obviously multiples with distance. This will have a detrimental effect on signal recovery over very long distances. This is improved greatly if the laser has a very narrow band (or spectrum), and some lasers are better than others in terms of spectral performance.

*For single point to point applications there are predominantly two fixed wavelengths used for fiber; 1310nm and 1550nm. These have a wider spectral response and are lower in cost. These are available with different power levels which equates to the maximum distance possible (10km, 40km or 80km). The same two wavelengths are available as "CWDM" versions (along with 16 other wavelengths) which have a very narrow spectral response and are more expensive. CWDM (**C**oarse **W**avelength **D**ivision **M**ultiplexing) is a process of combining up to 18 signals into a single fiber strand. Each channel is only separated by 20nm, therefore a narrow spectral response is required. This is covered in the second fiber paper from LYNX Technik titled "The CWDM Fiber Primer."*

In general the effects of chromatic dispersion has a much smaller impact than the effects of intermodal dispersion. For short haul applications with Singlemode fiber (less than 10-20km) then chromatic dispersion is not something you should be overly concerned with.

With the obvious benefits of Singlemode you may ask why bother to use Multimode cable? The primary reasons are cost and ease of use. For computer backbone applications low cost transmitters and receivers can be used (LED emitters). It's also easier to make connections and splice and generally considered more "installation friendly". However, there are some unpredictable variables which will impact distance because of the effects of intermodal dispersion at the higher (3Gbit) data rates we will be using for video.

Tip: Given the choice then keep it simple; always use Singlemode cable. Multimode can be very limiting in terms of distance even within a building at 3Gbit bandwidths. Singlemode will cover many km (miles) and easily accommodates 3Gbit bandwidths. This prevents getting overly concerned with calculations, optical budgets and link losses and provides overhead for nice system extras like signal splitters and patch panels.

Connectors

There are quite a few fiber connectors to choose from, but your choices are determined by the equipment you need to connect to. For broadcast applications these tend to be limited to LC, SC or ST type connectors. LC and SC connectors snap into place and provide a secure mechanical connection. ST connectors resemble a BNC bayonet type connector. All are available for Singlemode and Multimode cable. LYNX Technik uses LC connectors on all its fiber products.
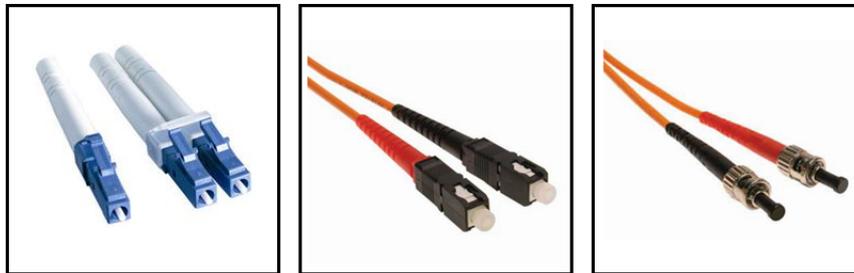
LC Connectors   **SC Connectors**   **ST Connectors**

Adapters are available to convert between different connectors; these are normally like patch cords and have the two connectors required with a short fiber tail joining the two. What's important is to ensure the fiber cable used in the adapter is the correct type exactly matching the cable you are connecting to. Even if the adapter cable is really short, connecting an adapter made with Multimode fiber to a Singlemode cable will result in significant signal losses.

Generally, it's a bad idea to try to mix and match fiber cables. Connecting Singlemode to Multimode will result in a 20dB loss across the connection, which is 99% of the power. Even connections between Multimode cables with slightly different core sizes (50 micron cable to a 62.5 micron cable) will result in 3dB of signal loss, which is over half the power. So know your fiber. Understand what you have installed and carefully read the specs when buying adapters and such like. Never attempt to splice different types of fiber cable together.

There are two different ways a fiber connector will physically make the fiber connection. APC (Angled Physical Contact) or PC (Physical Contact). One of these methods is always indicated in the connector part number, and most connectors can be purchased either way. Most broadcast applications will use PC. APC is a more expensive low loss connection typically used for super long distance external links outside of the facility. The manufacturer's specs should indicate the fiber connection method (PC or APC)

Fiber Cable Care and Installation

Fiber cable is delicate, the core is made from glass which is brittle and care needs to be taken when handling fiber cable. Special attention needs to be made on the bend radius. Most fiber has a minimum bend radius of approximately 4cm (1.5 inches). Be very careful tie-wrapping fiber bundles (in fact avoid it if possible). These are normally issues your installer should be aware of but it's prudent to check they are familiar with the precautions and requirements for installing fiber. In some cases when the facility was constructed the designers has the forethought to install multiple core fiber bundles between key locations in the facility to allow for future expansion. In this case you will only need to worry about the connections from the fiber bundle to the equipment.

As fiber uses light there is no electrical resistance or contact corrosion to worry about. Light is not susceptible to magnetic interference so the cables require no electrical screening therefore fiber cable is very thin and flexible and the connectors small and made of plastic. All fiber connectors will have a dust cover, even small amounts of dirt and dust will interfere with the light transmission and cause losses. When a manufacturer delivers equipment the fiber connections will be plugged to prevent dust and dirt contamination. Likewise a fiber cable will have a dust cap fitted to the connector for the same reason. Always replace dust covers when connections are not mated. Should cleaning be required don't blow on the end of the cable and wipe it with your finger, or jam a Q-tip into the connector. Inexpensive cleaning kits are available which include specialized cleaning sticks to clean the connection ends.

In most cases if you keep the dust caps in place when the connections are not being used then cleaning will not be an issue.

Is fiber dangerous?

As we use lasers as a light source the optical transmitters are "Class 1 Laser Devices", which technically means it's dangerous to use optical instruments for inspection with the laser switched on. Use common sense and don't look directly down the end of an active fiber cable to try and see if it's working, there is nothing to see anyway as the laser wavelengths are not in the visible spectrum.

However, the use of a "non laser" visible light source is very useful for basic fault finding, shine light down one end and you will see light emerge from the other end. This is useful for quickly identifying fiber cores in a multi-core bundle, and also testing for broken links.

Calculating Maximum Fiber Distance

If using Singlemode cable within a facility and 10km fiber transmitters then is safe to assume there will no issues exceeding the maximum reach of the fiber links. If you have a longer link and would like to calculate the max distance then you will need to gather some basic information to make a simple calculation, namely:

- *Cable loss data for the type of fiber cable used*
- *Optical transmitter power and optical receiver sensitivity*
- *Loss data for the connectors and any splices in the cable*

Note*. Signal loss or gain within a system is expressed in dB (decibel). dB is not a measure of signal strength but a measure of power loss or gain. It is important not to confuse dB with dBm (decibel milliwatt) as this is a measure of signal power in relation to 1mW. Thus a power of 0dBm is 1 mW, 3dBm is 2 mW, 6dBm is 4 mW, and so on.*

For our example let's assume we have determined the following:

- *Singlemode cable 9/125 @ 1310nm : link loss per km =* ***0.4dB***
- *2 x LC/PC connectors: Loss =* ***0.25dB each***
- *4 x Cable Splices: Loss =* ***0.1dB Each***
- *Optical Transmitter power =* ***-5dbm***
- *Optical Receiver Sensitivity =* ***-19dBm***

The first thing we need to calculate is our "Optical Loss Budget" which is obtained by subtracting the receiver's minimum sensitivity from the transmitter's power.

Optical loss budget = (-5dBm) – (-19dBm) = ***14dB***

Now we add up the losses for the connectors and splices and add in a margin of error. (Typically 3dB)

Connector losses = 2 x 0.25dB	*=* ***0.5dB***
Splice losses = 4 x 0.1dB	*=* ***0.4dB***
Margin of error	*=* ***3.0dB***
Total link losses	*=* ***3.9dB***

Next we subtract the total link losses from the optical loss budget

14dB – 3.9dB   *=* ***10.1dB***

Using the cable loss/km data for the cable we are using (=0.4dB/km in this example) we now calculate the max distance by dividing the remainder of our optical loss budget by the cable loss per km.

10.1dB / 0.4dB (per km) =   *=* ***25.25km***

Multimode Maximum Distance Calculation

We can perform the same exercise for Multimode cable, our only difference is the cable type which we will assume is Multimode Graded Index 50/125 @ 1310nm: Link loss per km = 1.5dB

The loss budget calculation remains the same but the remaining budget is now applied to the Multimode cable:

> *10.1dB/1.5db (per km)*   *= **6.7km** **but…***

But Wait…..

This looks great on paper, but before we run off to buy kilometers of Multimode cable to drape around our facility this figure is very misleading. We are using 3Gbit signals (a relatively high bandwidth for Multimode fiber) and intermodal dispersion errors will significantly impact the performance and therefore the calculated achievable distance.

This is a complex issue; there is no published correlation between video signal bandwidth, dispersion and link loss. Broadcast has inherited fiber cable technology from the Telco and computer industry and we are attempting to achieve bandwidths up to 3Gbit with this technology. The perception (and sometimes assumption) is a fiber cable can transport unlimited bandwidth, which in essence is true for a Singlemode fiber link (theoretically it is infinity) but 100Gbit is considered the "practical" limit for Singlemode fiber cable. The same is far from true for Multimode cable because of dispersion, even in Multimode graded Index fiber cable. At higher frequencies dispersion errors are multiplied with distance and the operational distances greatly reduced, how much, it's hard to say because there are different types of Multimode cable, all with different characteristics.

Multimode cable bandwidth is generally expressed in computer terms and related to standard network backbones; therefore most Multimode fiber is optimized for use in these applications. (100Mbit, 1Gbit and 10Gbit). You may have existing Multimode fiber cable assets in place within your facility which you would like to use for 3Gbit video but before you start making connections, here are a few tips:

1. *Find out the cable type and look up the specs!*
2. *A lot of Multimode fiber cable used for computer networks is optimized for 850nm, which is a problem as broadcast applications almost always use emitters at 1310nm or 1550nm wavelengths and would require Multimode fiber optimized for 1310nm/1550nm - so check the specs!*
3. *If the cable has been there a while, it's fair to assume it not some of the newer Multimode fiber which has a reported 300m reach at 10Gbit – if it is - then great.*
4. *If the cable is older, and happens to be a type optimized for 1310nm, then you can assume a reach of between 26m and 82m is possible for a 10Gbit network, therefore 3Gbit (theoretically) will be longer. (not factoring connector and splice losses)*

5. No Multimode cable will support CWDM multiplexing applications. So if you were thinking of using CWDM over Multimode, think again…

To conclude, the use of certain types of Multimode Fiber cable is certainly possible for 3Gbit bandwidths, but use caution, there are a lot of potential problems. You need to research and test. No published empirical data exists for the use of Multimode cable with 3Gbit bandwidths and the effects of dispersion at this frequency are not known and only estimated through trial and error. LYNX products are specified for use with Singlemode cable and while using them on Multimode cable is possible, it is not recommended because of the unknowns and resulting unpredictable performance.

When in doubt just test it.

With no published empirical data to rely on then one option is to test it. We have customers who have made their own tests using Multimode fiber, who have achieved 1Km at 1.5Gbit and 300m at 3Gbit so the results are encouraging. How do you test it? The easiest way to test a cable is by using SDI video, this exactly replicates the application. Inject a video test signal into an optical transmitter, send over a length of fiber into the optical receiver and analyze the SDI output. The easiest signal to use is the pathological test pattern (we are all familiar with this) which will show any errors in the SDI signal. You will need to have a fiber link in place to test, or a reel with enough Multimode fiber to experiment with.

Minimum Fiber Distances

Yes, there are minimum distances. This is something we never experience with copper connections, but if a fiber link is particularly short then there is a possibility the optical receiver will become overloaded. All optical receivers have an operational input range. The -19dBm figure we used in our example to determine the maximum distance is the optical receiver's minimum sensitivity. The receiver also has a maximum input level, which if exceeded will result in overload.

Generally a fiber transmitter's output power is on the high side compared to an optical receiver's maximum input level because there is an assumption there will be some attenuation (or losses) in the fiber link connecting the two. With very short links cable attenuation becomes negligible and the signal reaching the optical receiver can exceed the maximum input level resulting in overload. While this overload will not cause any physical damage to the optical receiver, it will render the link inoperable while overloaded.

Fortunately this is solved very easily with the use of an optical attenuator which reduces the power to within the receiver's operational range. To determine attenuator size it's simply a case of comparing the transmitters output power to the to the receivers maximum input level. Below are some examples:

*Transmitter Power = **-5dBm**, Receiver operational range **-3dBm to -19dBm***

For this example no attenuator is required because the transmitter's power is already below the maximum input level, so the receiver will never become overloaded*

*Transmitter Power= **-1dBm**, Receiver operational range **-3dBm to -19dBm***

Here you can see the transmitter power is 2dB higher than the receivers maximum input level, therefore an attenuator between 2 and 17dB would be required. (3dB would be optimum)

****Note.** Even if the transmitters power is within the receivers max input level the use of very short links (<10m) should be avoided. Internal reflections within the fiber cable can be problematic.*

Some Practical Solutions

LYNX manufactures a number of standalone fiber interfaces. We have also directly incorporated fiber I/O into some of our latest 3Gbit signal processing products. For the sake of the following examples we will assume we have existing equipment with copper I/O which we wish to augment with fiber connectivity.

LYNX modular fiber products are part of our **yellobrik**® *product line and we have a number of solutions to facilitate adding fiber connectivity to an existing copper installation.*

One Direction Single link (Unidirectional)

The most simplistic application is to use a fiber transmitter close to the source and a receiver at the destination. For this we can use the **OTX 1810 3Gbit SDI to Fiber Transmitter** *and the* **ORX 1800 3Gbit Fiber to SDI Receiver**. *These devices are both reclocking and will support 270Mbit/1.5Gbit /3Gbit SDI streams with automatic clock rate detection.*
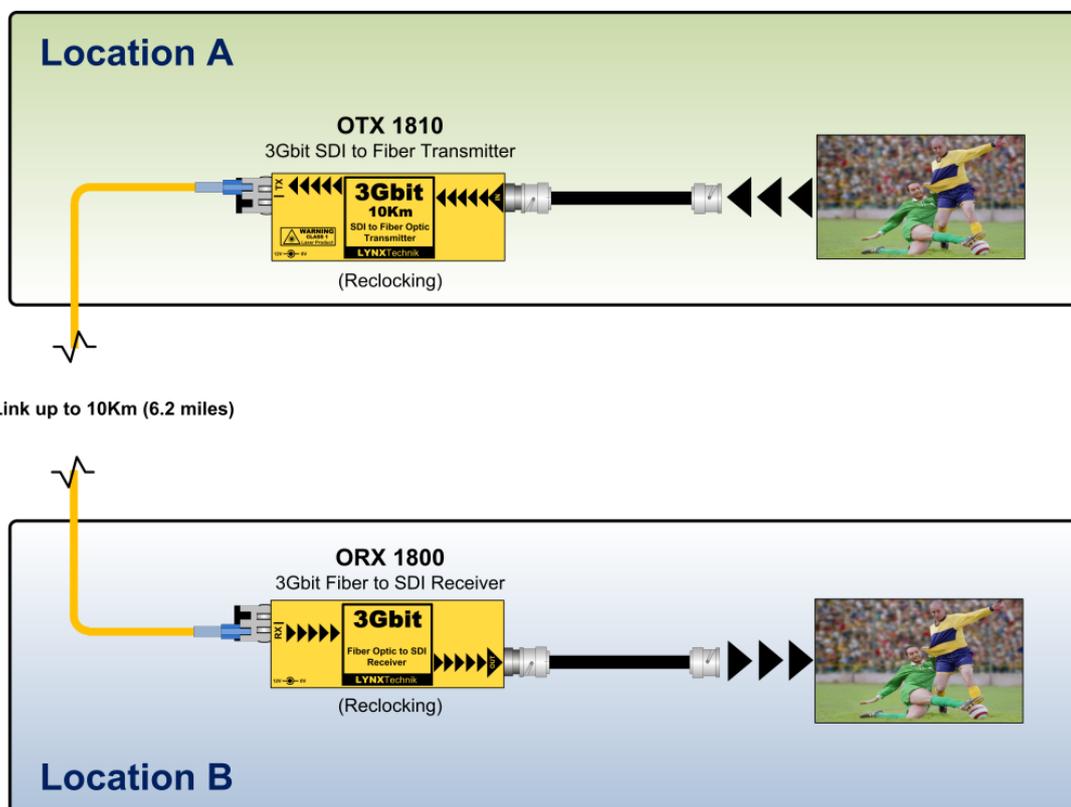
Send and Receive Between Multiple Locations

*Often we need signals distributed to and from a central location. For this a Transceiver is a good solution. The **OTR 1810 Fiber Transceiver** combines a Transmitter and Receiver into a single unit. This version uses two fiber links one for the send and one for receive, and is used primarily to save on system cost and space. A sample application is shown below.*
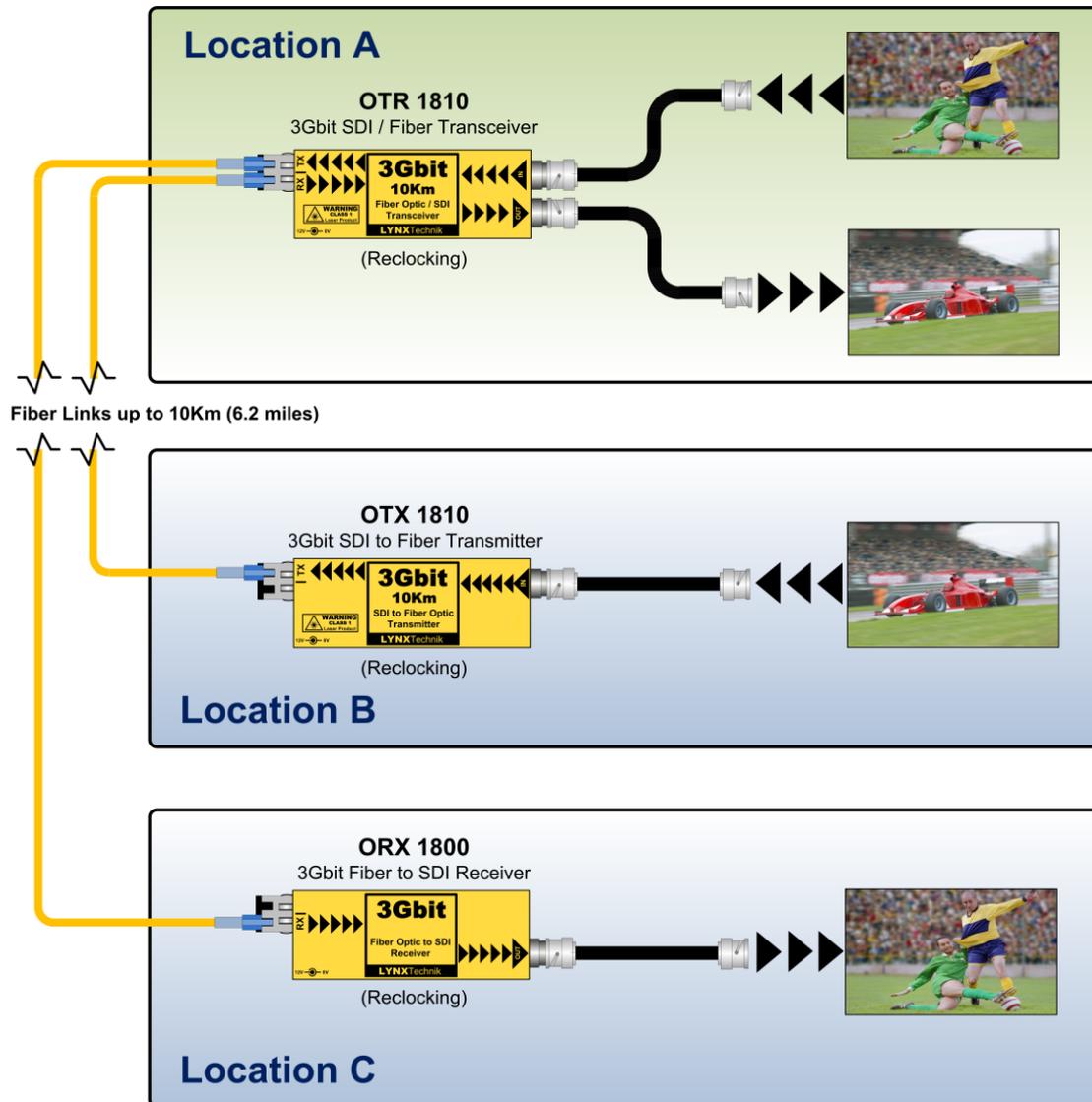
Bidirectional Fiber Links

*If video signals are being sent back and forth between two fixed locations then a bidirectional transceiver can be used which sends and receives video simultaneously over a single fiber link. The obvious benefit is the use of one fiber link whereas two would normally be needed. LYNX Technik provides a bidirectional transceiver for this purpose the **OBD 1810 - 3Gbit Bidirectional Transceiver**. This uses WDM (Wavelength Division Multiplexing) with signals at two wavelengths in the single fiber link; 1310nm and 1550nm. The send and receive paths are independent meaning different format video can be sent and received, for example you could send 270Mbit SDTV video and receive 3Gbit HDTV video. These are sold in pairs, and the application is shown below.*
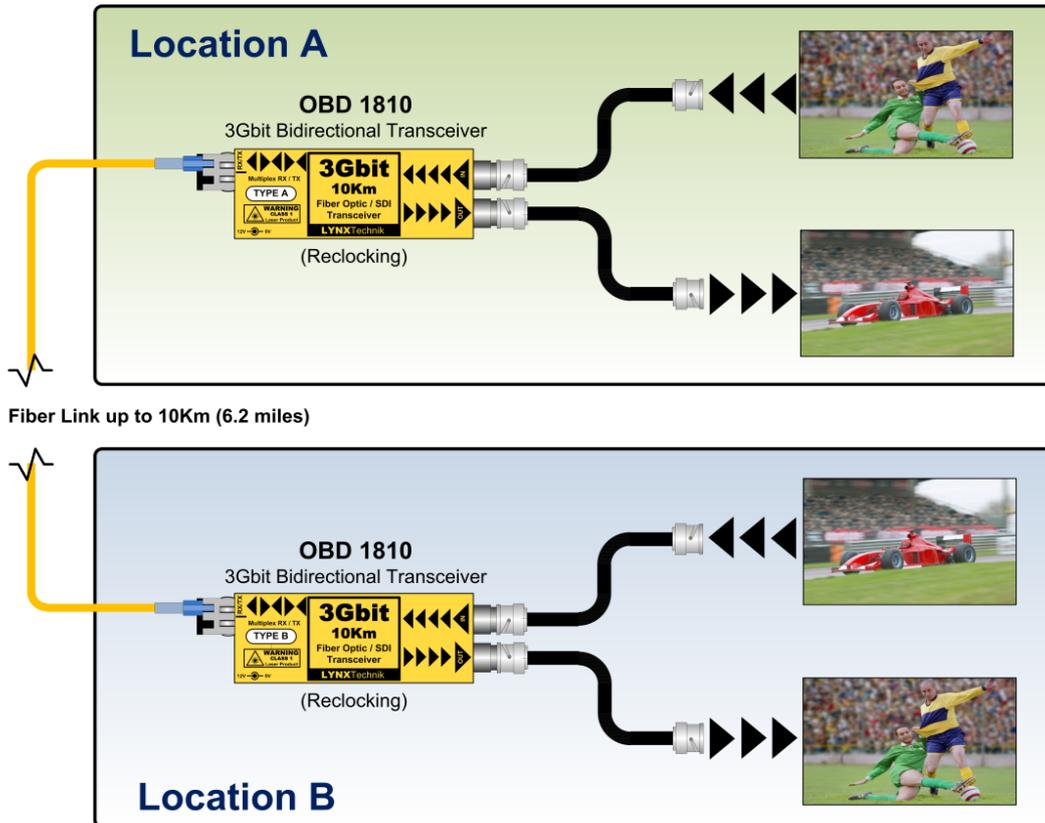

Longer Distances

The solutions above will accommodate 10km distances with Singlemode fiber connections. The wavelength for these modules is 1310nm, (1310nm and 1550nm for the WDM solution). This is a common wavelength used in the video industry and LYNX Technik fiber optic transmitters and receivers are compatible with any other manufactures fiber interfaces using 1310nm wavelength.

*We also offer a 40km SDI fiber transmitter (**OTX 1840**) and transceiver (**OTR 1840**) for applications which may require longer distances, and these can be used with the **ORX 1800 Fiber Receiver module**. The 40Km solutions have 18 wavelength selections (1270nm – 1610nm) and are typically*

used for CWDM applications (a process of multiplexing up to 18 signals in a single fiber link) but can also be used for single point to point applications. The yellobrik is designed to accommodate a SFP fiber stick sub module, which can be easily removed and exchanged for an alternative. We provide a choice of 18 different wavelength SFP sub modules which is important for a facility using CWDM.

Removable Fiber "Stick" Sub Modules
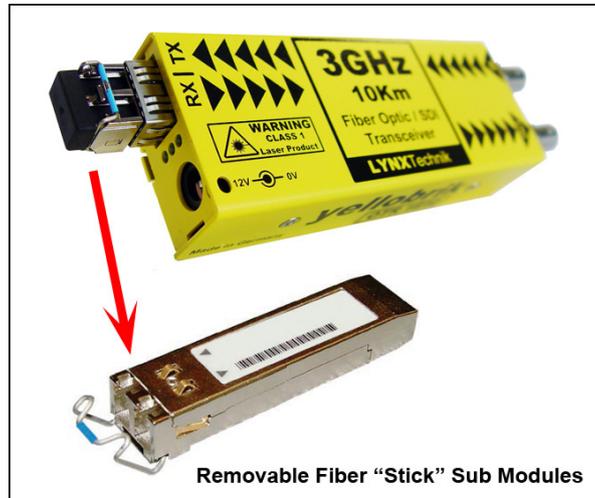
Mechanical issues

The yellobrik modules are individual self contained solutions that are ideal for applications where limited fiber connectivity needs to be added to a specific location. For installations that require multiple fiber connections the use of individual throw down modules becomes impractical. LYNX has a 1RU rack chassis which can accommodate up to 14 of the yellobrik fiber modules. The chassis provides central power with redundant backup and also GPO alarm outputs. This facilitates a more permanent and mechanically secure solution allowing the centralization of all fiber I/O in a system installation. As the chassis has two external 12VDC inputs (primary and redundant) then the use in mobile units with existing 12VDC power sources is also simplified.

The bulky SDI coaxial connections are made on the rear of the rack, and the fiber connections are on the front. A space provided on one side to route the fiber loops into the back of the 19" rack for cable distribution. Fiber activity LEDs are visible from the front (for each module).

LYNX yellobrik 1RU chassis with fiber modules fitted

Direct Fiber I/O Products

*LYNX also has a 2RU rack frame modular terminal equipment product line (**Series 5000**) which has a wide array of modules. This also includes multi-format solutions for 3Gbit. We have designed fiber I/O directly into the modules negating the need for external conversion. This also uses the fiber sick sub modules, which are an integral part of the individual modules backplane. The cards can be unplugged, removed and exchanged without the need to physically disconnect the fiber cables. Solutions include multi channel fiber transmitters and receivers, frame synchronizers, up/down/cross converters, audio embedders / de-embedders and distribution amplifiers. The picture below shows a LYNX 3Gbit SDI distribution amplifier card with the fiber and copper I/O back panel.*
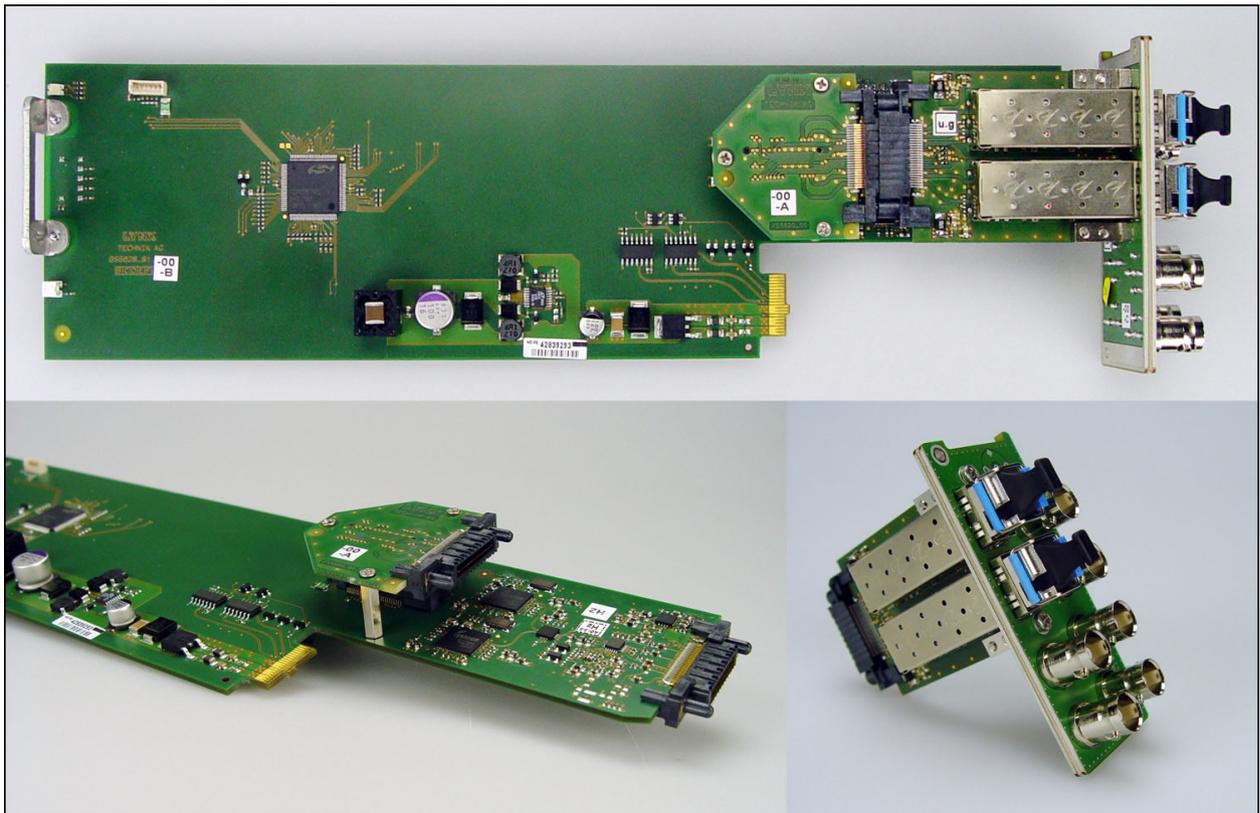
Those of you familiar with fiber interface cards will note the absence of the familiar "service loop" of fiber cable coiled around on top of the card. Using SFP sub modules removes the need for a service loop and improves serviceability. The SFP sub modules can be easily exchanged or upgraded for CWDM multiplexing applications.

Conclusion

Fiber is a wonderful thing, and will become more and more an integral part of broadcast facility design. It has many advantages over copper, not only in terms of distance. It's much thinner and lighter than coax and is available in multi core configurations significantly reducing bulk, it does not suffer from electromagnetic interference, there are no ground loops to worry about, no crosstalk, no connector corrosion problems, and no cable delays to calculate and compensate system timing for. It can also support multiple uncompressed 3G SDI streams on a single fiber core using CWDM (something we only dream of in the copper world) - It's hard to think how we survived so long without it!

While tempting to use Multimode fiber cable for an easier installation, it's better to avoid any potential problems and use Singlemode wherever possible. The performance is predicable and documented. This removes the headaches, guess work and assumptions needed for Multimode cable. 10Km transmitters used with Singlemode cable within a facility gives you a huge optical loss budget, making fiber very much a "plug and play" solution almost removing the need to even pick up a calculator. With so much loss budget in the bank, you can easily add fiber splitters, fiber patch panels and such like to enhance the system design, and not worry about adding multiple splices. You are also ready for multiplexed CWDM fiber applications which uses 18 wavelengths from 1270nm to 1610nm used for multiplexing multiple uncompressed signals over single fiber links.

We hope this "primer" has been useful. This is only very basic information and is only intended as an introduction to fiber technology. This also included some simple cost effective solutions so you can "get your feet wet" and start implementing some basic fiber connectivity within your facility without breaking the bank.

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Please visit **www.lynx-technik.com** *for more information on LYNX Technik products*