High Speed Data Networking

for the Automotive Market

Tyco Electronics

Tyco Electronics Ltd. is a leading global provider of engineered electronic components, network solutions and wireless systems, with customers in more than 150 countries. We design, manufacture and market products for customers in industries from automotive, appliances and aerospace and defense to telecommunications, computers and consumer electronics. With over 8,000 engineers and worldwide manufacturing, sales and customer service capabilities, Tyco Electronics' commitment is our customers' advantage.

GLOBAL AUTOMOTIVE DIVISION
HIGH SPEED DATA NETWORKING

With the introduction of the D2B Optical Networking System in 1997, the way was set for the automotive world to start reaping the benefits for optical data transmission. The D2B system enjoyed a successful launch which resulted in the system been introduced across the full product portfolio of the main car OEM who developed the D2B system technology. The benefits of the D2B system were also introduced by one other car OEM who started to introduce the system in 1998.
The advantages of Optical Networking were attracting the attention of many other car OEM's and in 1998 with the foundation of the MOST® Co-operation the first steps were taken to build on the work of the D2B technology and spread the benefits of the Optical Networking technology throughout the automotive world.
The MOST Co-operation focused on developing an optical network specification defining all key interface points which would enable the automotive supplier market to develop components when based on the MOST Specification to be compatible and interoperable.

MOST® is a trademark

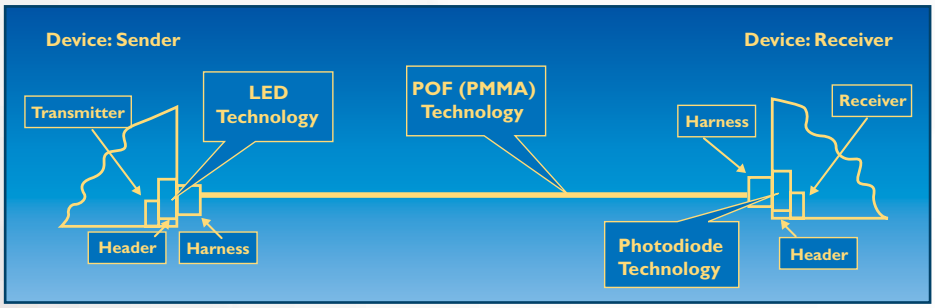
TECHNOLOGY

BASICS

The principle of the high speed data transmission based on optical fibers is the transport of the signals as digital light pulses. In optical networks you have always Fiber Optic Transceivers (FOT) to switch the electrical signals in to optical signals and back again.

That means for a point to point link we have one side as transmitter of the optical signals and one side as receiver of the signals.

The “Physical Layer” of a network defines the conditions of the data transport.



Basis of optical data transmission point to point

To guaranty the integrity of the signals, especially in an automotive application, it is necessary to use optimised optical fibers and connectors in these fields. Due to the harsh automotive environment with many moving parts, high density of electronic equipment and compact packaging requirements, we have special requirements for these systems like:

- Temperature stability over lifetime within -40 °C to +85 °C (105 °C)
- Mechanical vibration and shock
- High relative humidity
- Applied forces
- Chemical resistance
- Dust contamination

To fulfil the special requirements of the automotive application it is necessary to define and develop special components and technologies.
Based on the existing experience of the communication industry in combination with the special conditions in the vehicles, the core of the optical networks for automotive application was created.

AUTOMOTIVATED IN EVERY DETAIL

Our global automotive research centers are setting the technological landscape by developing new technologies, products and production processes. The increasingly fast growing number of functions in present and future cars require varieties of powerful and versatile connection systems. We compare existing standards with alternative possibilities in which costs, functionality, dependability and serial production are the basics of our procedures.

To anticipate the potential application areas for Optical Networks in the automotive industry we should first review the benefits achieved to date and the technology which has been developed.

The benefits of Optical Networking:

1) Wide bandwidth
2) Electromagnetic immunity
3) Light weight
4) Small packaging requirements

Current optical networking has been achieved based on the current design building blocks:

1) LED: Light Emitting Diode
2) Polymer Optical Fibers (POF): Multi-Mode Step Index Plastic Optical Fibers
3) Laser welded Optical contacts (Ferrules), a Tyco Electronics creation which combines the optimal between pull out force of the contact with optical loss of the light power

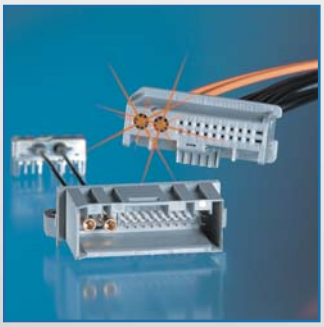
Tyco Electronics components for MOST Networks

CRITICAL ROLE FOR TYCO ELECTRONICS

Throughout this development Tyco Electronics played a critical role in the specification development with the MOST Co-operation and also in the project / product development with all OEM's and relevant Tier 1's. This has resulted in Tyco Electronics achieving a 90% market share of all MOST Physical Layer components. Parallel to the MOST development, Tyco Electronics was involved in the Physical Layer development for an Optical Safety Bus system, Byteflight. This system has carried over many key physical layer components of the MOST system allowing the increased volume requirements reduce the overall cost of the system.

When these features are coupled with the Tyco Electronics connector systems then the following system features are available:

1) Data transmission up to 50 MBit/s
2) Bandwidth 200 MHz * 10 m
3) Temperature range from -40 °C to +85 °C (95 °C)
4) Optical Loss of 0.25 dB/m (with 650 nm)
5) Bending radius of 25 mm



Fiber Optic Connectors based on the MOST Interface

Because MOST is a ring bus structure of single optical fibers which are better to handle in a harness. At the end of each lead a ferrule is attached which can easily be put into a header. The fixation of the optical fiber to the ferrule must fulfil a pullout force of >60 N. Tyco Electronics investigated various different methods to fix the ferrules.

Tyco Electronics researched the brass crimp, the ultrasonic welding and the laser welding technology.

In mass production the laser welding technology is used because of the best process performance. The brass crimp will serve as a fixing method in the field and for service.

Brass crimp

Laser welding

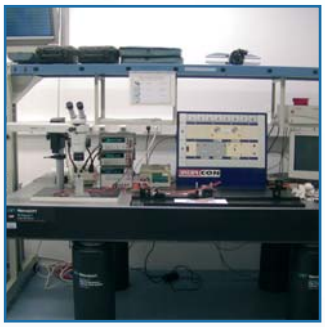
COMPETENCIES

EVALUATION/INVESTIGATION

Laser cleave device for Polymer Clad Silica fiber (PCS) Fiber

The standard POF technique used in a lot of today's vehicles for multimedia systems and also for safety system applications is the result of a long development process. At the beginning of the development of automotive optical systems, problems like high attenuation, constant quality of the fiber, the finishing process of the fiber and the issue of how to fix the fiber and the ferrule had to be resolved. For that reason the optical Tyco Electronics Laboratory in Bensheim was established. The competencies concentrated on the special processing of fibers. The finishing processes like mechanical cutting and laser cleaving, as well as the crimp and laser welding technologies were developed in the optical laboratory. These technologies were then carried over in to the production process.

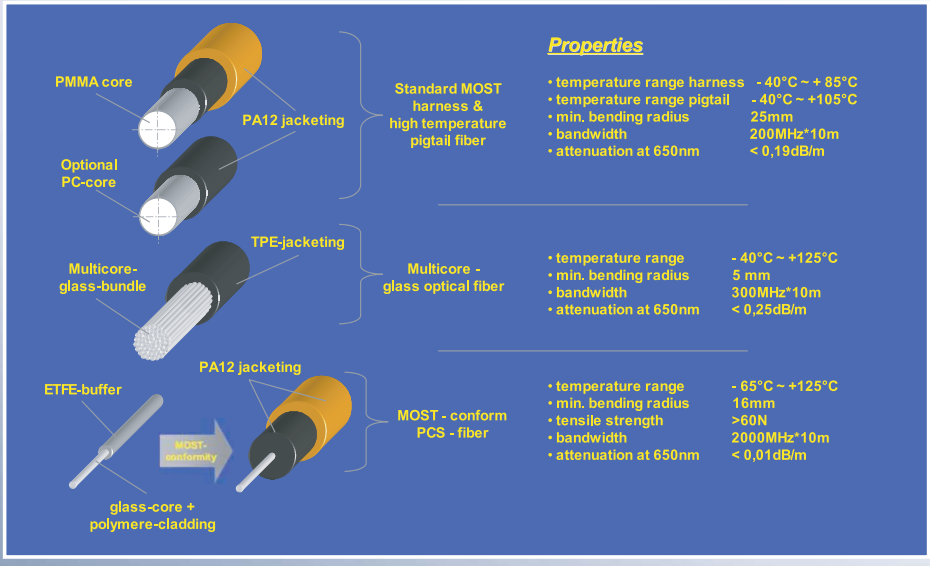
With the planned introduction of PCS (Polymer Clad Silica) Fibers, a lot of investigations had to be done regarding the automotive compatibility of the fiber in the current processing environment. The measurement of the attenuation is one of the basic technologies for establishing the optical system in cars.
Therefore the insertion loss method was defined and implemented. Target was that every measurement location should measure the same values based on a common method.



Optical bench for optical power and attenuation measurement

Today we are able to measure the optical attenuation of different types of optical fibers by varying the optical output power of different transmitters and also the sensitivity of optical receivers. In the last few years, optical sources like Vertical Cavity Surface Emitting Laser (VCSEL) or Resonant Cavity Light Emitting Diode (RCLED) have become interesting for the automotive market. Techniques like PCS Fibers, Glass-Fibers and Multicore Glass-Fibers are currently planned to be implemented.

Tyco Electronics has invested in the training of personnel and high tech equipment (i.e. laser cleave device for PCS fiber) to enhance the competency for supporting customers in these applications. Higher data rates and growing demands on data integrity also drive the need of measurement equipment with increased sensitivity and electrical bandwidth of about 1 GHz for getting more reliable data on the physical layer. The development of new products from concept to implementation in our production is dependent greatly on excellent customer contact to fulfil all application requirements.



Existing and potential optical fiber technologies for automotive applications

DESIGN OF COMPONENTS

The mechanical design of optical connectors and optical-electronic components for automotive applications is a very sophisticated challenge. Not only automotive requirements have to be considered, also the optical functionality calls for a very precise design.

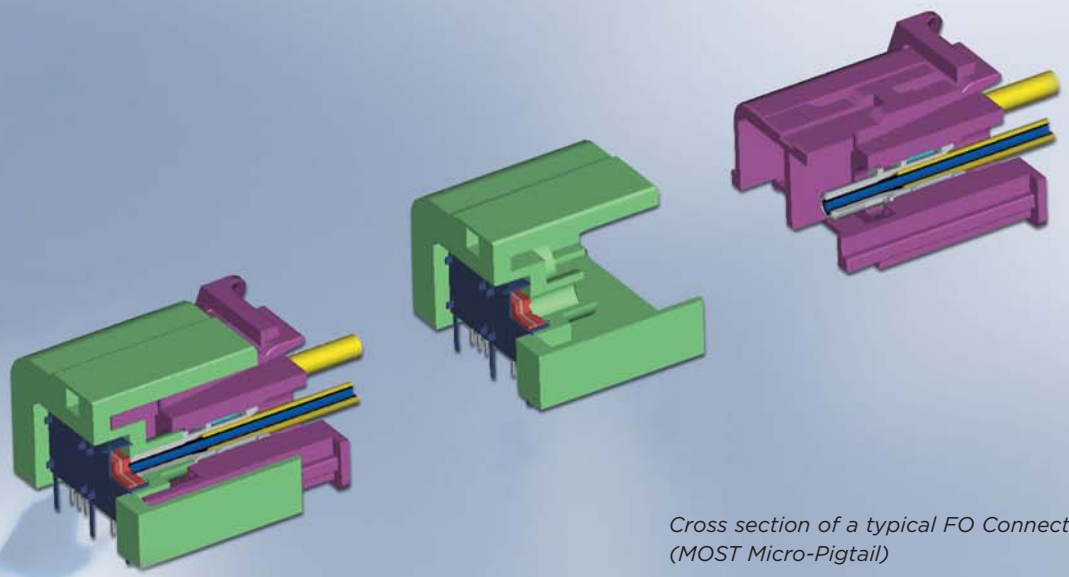
To ensure a safe optical coupling, the tasks for an optical connector are different from those of an electrical connector.

For the optical connector, not only all needs of an electrical connector have to be considered but also additional functions which are specific for a perfect optical coupling.

Since there are many influences on the optical power budget in an automotive point-to-point connection, i.e. thermal influences on the semiconductor devices, attenuation in the fiber etc., there is not much margin left for the optical connection.

An automotive capable optical connector has to fulfil at least the demands of any other optical connector known from telecommunications or consumer electronic while being

- automotive qualified
- easier to assemble (fully-automatic assembly preferred)
- assembled in less time (automotive cycle times)
- assembled with easier processes



Cross section of a typical FO Connector (MOST Micro-Pigtail)

The growing demand of higher data rates and higher temperature requirements in today's automotive industry leads us - besides the higher EMI requirements - to new technologies like smaller glass fibers instead of the large core Polymer Optical Fibers (POF).

Having only 1/5 of the diameter of a POF and therefore only 1/25 of the optical surface. A Polymer Clad Silica fiber (PCS) is more complex in handling and processing as well as the requirements / tolerances in the connector increase greatly.

For the optical coupling of a 200 µm fiber, known tolerances from existing plastic parts are not suitable. To obtain the needed precision, Tyco Electronics analysed tool making in other industries such as high quality watch making, to achieve the required tolerances.

So the design of optical connectors for automotive applications is a challenging task for our new century and a sophisticated technology business with high future potential.

QUALIFICATION AND TESTS

From a first idea to a definite product a lot of steps have to be taken. At the beginning of the development the idea must be specified in detail. From this moment we work closely together with our customer to investigate the optimum man power and resources for saving time and cost.

In a second step the prototyping phase begins. Therefore we build up the first samples of a product and test them in our laboratory to find out mechanical, electrical or optical weak points.

For example in the optical header development, the extraction force of the optical fiber, the data integrity and the EMI behaviour and also the optical output power and the sensitivity of the receiver has to be evaluated.

When this is completed the first pre-series device can be tested in a Tyco Electronics test laboratory under environmental conditions. These tests are normally well defined OEM specified test procedures which are fundamental for the overall qualification process. In these test procedures the devices will be exposed to high and low temperatures, moisture, oil, dust and mechanical shock. After that we can guarantee the best possible quality of our products which we will ship to the customer.

APPLICATIONS

APPLICATIONS, MARKETING & SYNERGIES

As mentioned in the introduction D2B with a data rate of 5.6 MBit/s was the first optical bus system built in cars. The system was developed only for audio data transport but with a big number of channels. After the last few years the system has shown its robustness over the years. In the same time the idea to develop a safety system was born. But based on optical data transmission. The system was called Byteflight. Because of safety reasons the bus system was realised in a star structure. Only one wire for the data transmission per node is used in the optical system so only half the duplex data transmission is possible. That is why the data rate is about maximum 10 MBit/s.
The desire for higher data rates leads into the development of the MOST system. The MOST system based also on a ring bus structure like D2B but supports higher data rates.
With the momentary data rate of 24.8 MBit/s the system can be used for audio applications and additional for video applications. MOST is not a real time system because of data compression.

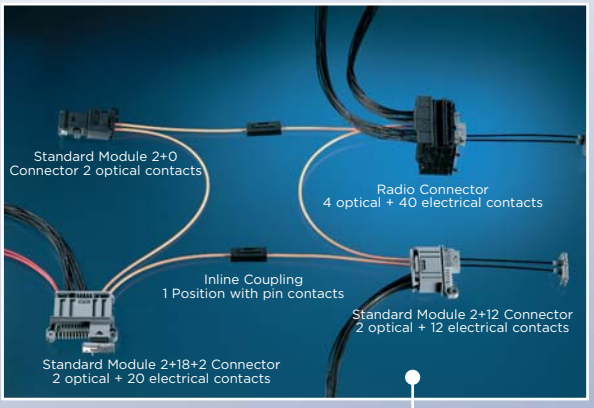
At this time MOST, D2B and Byteflight are all based on Tyco Electronics components and are well established in the automotive industry.
D2B will be replaced by MOST. Byteflight maybe replaced by the FlexRay system. In future when data rates of a few hundred MBit/s will be required (real time video link) new technologies have to be established. One technology seems to fulfil the demands, data transmission via PCS Fiber and optical transmitter in VCSEL technology.

Additionally optical signals used as sensing technology as opposed to transmission of data signals is also being actively examined. With the new European Regulations relating to Pedestrian Protection Systems, Tyco Electronics is actively involved with safety system suppliers working on such systems. The sensitivity of the light system can be manipulated to detect the contact on the front bumper of the car. A critical benefit of this technology is utilising the current components used on the Physical Layer Data Transmission systems.

RELATED TECHNOLOGIES

MECHATRONICS

TERMINALS & CONNECTORS



MOST ring with different types of pigtails and connectors from Tyco Electronics

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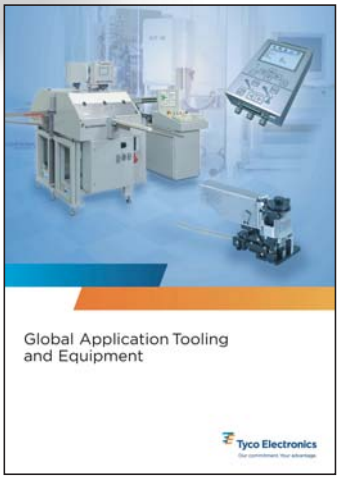

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