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## **Application Note AN-03**

### **Pressure Tolerant Solutions**

**Electronics Design Group**



**Document No.:** 700-0429-03  
**Revision:** 2  
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**Date of Issue:** November 17, 2009

#### ***Restrictions on Disclosure***

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## 1.0 Introduction

Focal's subsea multiplexer cards are typically installed in pressure housings that maintain the electronics at a one atmosphere pressure. Although this is a common and well proven configuration, it does usually require a relatively expensive enclosure including the pressure housing, seals, endcaps, and an array of subsea connectors or penetrators for connection to external devices. In ROV systems, in particular, the external devices can be cameras, sonars, sensors, and various control systems, all of which need to be connected to the multiplexer for combining the signals onto a high speed optical link to the surface.

Typically the multiplexer is installed in a pressure housing that is already required for other electronics. In some system configurations, though, the cost of an enclosure can be avoided by installing the multiplexer in an existing oil-filled compartment, such as a junction box, where the multiplexer will be exposed to the same ambient pressure as the vehicle, roughly 1.5 psi per meter depth. Focal has developed a full range of pressure tolerant multiplexer cards and components for these applications with typical depth ratings of 4000 m (6000 psi).

## 2.0 Tradeoffs

Although significant equipment cost can be saved by eliminating pressure housings and associated components, the total cost of operating with pressure tolerant components needs to be carefully considered:

1. **Maintenance:** Installing and servicing cards in oil filled boxes can be difficult and messy compared to air filled housings. Accessing the cards to reconfigure modes of operation via switch settings, for example, inherently requires some drainage of pressure compensating fluids.
2. **Life:** Pressure tolerant components see significantly more stress at 6000 psi than regular components at 15 psi, so component lifetimes are expected to be less in the long term. Focal conducts life tests on pressure tolerant components to establish reasonable baselines for component life. The standard one year warranty applies to all pressure tolerant cards.
3. **Availability:** Since cards and critical components, such as optical transceivers, need to be tested and qualified for operation at depth, the range of options for pressure tolerant products is somewhat less than for standard products. Focal can qualify new configurations per customer requests, but obviously this requires additional time versus using off-the-shelf products.

Pressure tolerant solutions tend to be suitable for cost-sensitive configurations of small to mid-size vehicles where installation of a multiplexer would otherwise force the addition of another pressure housing. In many workclass ROVs, existing pressure housings provide sufficient room for multiplexers, although decentralized or multi-node topologies can also save cost by eliminating several enclosures.

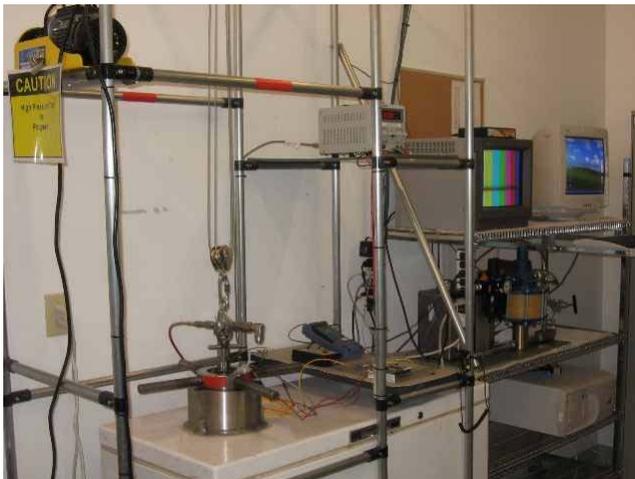
### 3.0 Pressure Tolerant Process

Focal has been developing pressure tolerant electronics assemblies since 2004. Generally, pressure tolerant cards are modified remote (subsea) versions of standard cards that are paired with standard non-pressure-tolerant versions of the cards at the console (surface) end of the system. The pressure tolerant cards are otherwise functionally identical to standard cards with respect to specifications on electrical input/output signals, possible switch configurations, diagnostics, etc. Optical components, such as transceivers and couplers, do exhibit a small reduction in performance at pressure, typically 1-3 dB, but this is incorporated in the specifications and overall system design. Optical power budgets with most pressure tolerant cards are greater than 20 dB.

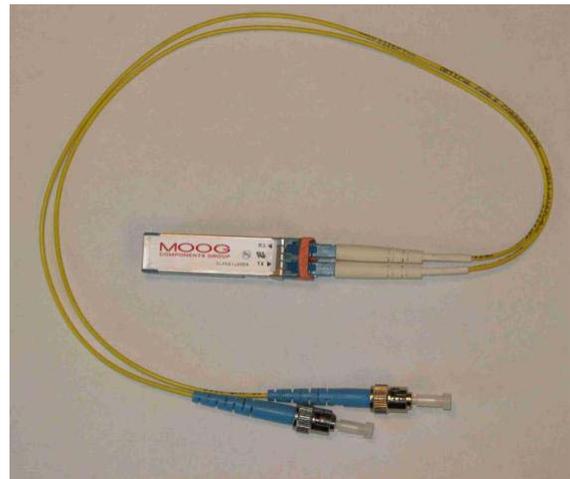
Over the years, Focal has established multiple test protocols for pressure tolerant components:

1. Design testing validates new products, processes, or configurations and includes extensive temperature cycling, pressure cycling, life testing (cycling and soaking), and review and testing of material compatibility with common oils, e.g. Tellus 32, used in pressure compensation systems.
2. Part screening ensures subassemblies, such as optical transceivers and couplers, are fully compliant with pressure tolerant specifications before they are installed in complete stack assemblies. Part screening includes temperature cycling, rapid pressure cycling, and pressure soaks.
3. Factory Acceptance Testing (FAT) retests all of the subassemblies at pressure as a final verification of performance. FAT also includes pressure cycling and pressure soaks.

Focal's facilities include two complete pressure testing stations, each certified for 10,000 psi maximum test pressure. The pressure housings are installed in a controlled cooler to allow simultaneous testing at maximum pressure and low temperature to better simulate real ocean conditions at depth. All test results are recorded by serial number for reference to production jobs and later used in statistical analysis and process control. Careful monitoring of materials and assembly procedures is crucial to maintaining high yields in the screening process.



**Pressure Testing Station**



**Pressure Tolerant Fiber Optic Transceiver**

Fiber optic transceivers are critical components for pressure tolerant applications, and Focal has successfully conducted extensive life testing on several solutions. Typical life testing includes 100 rapid cycles to 6500 psi and one full month soak at 6500 psi. Life testing is performed on products that have already been through production screening, thereby validating the screening process. Additional tests, such as extended temperature cycling, have been conducted as required for evaluation of new processes or new potting materials.

#### 4.0 Pressure Tolerant Components

Focal currently provides pressure tolerant versions of most standard cards and components in the Model 907 series of products. This includes multiplexer cards, expansion cards, media converters, power supply modules, and various optical modules. (See also the Model 907 Users Guide, 907-0601-00.) Most cards are available with a rating of 6000 psi, equivalent to roughly 4000 m depth of seawater. Cards using 1x9 transceivers or bidirectional SFP transceivers are limited to 3000 psi ratings. Please contact Focal for the latest availability of pressure tolerant products. A sample of standard Model 907 cards is given in the table below, although this is not a comprehensive list and does not include options for other Model series, such as the 914. Typically pressure tolerant versions of cards are ordered by appending "-P" to the end of the sales ID code. Pressure tolerant cards all have unique part numbers versus their standard counterparts.

**Standard Pressure Tolerant Cards**

Sales ID*	Description	Pressure Rating (psi)	Wavelengths Supported (nm)
907-R-XXX-P	Remote Multiplexer (3 video)	3000	1310, 1550
907V-R-XXX-P	Remote Video Multiplexer (6 video) with Bidi SFP	3000	1310, 1550
907V-R-XXX-P	Remote Video Multiplexer (6 video)	6000	1471 - 1611
907+R-XXX-P	Remote Plus Multiplexer (4 video)	6000	1471 - 1611
907-GBE-XXX-P	Gigabit Ethernet Media Converter (no switch)	6000	1471 - 1611
907-GBES-XXX-P	4-Port Gigabit Ethernet Media Converter	6000	1471 - 1611
907-GBE2-XXX-P	Dual Gigabit Ethernet Media Converter	6000	1471 - 1611
907-ECL-XXX-P	ECL (Sonar) Media Converter	6000	1471 - 1611
907-HDV-XXX-P	HD-SDI Media Converter	6000	1471 - 1611
907-EIBS-P	3-Port 10/100M Ethernet Expansion Card	6000	n/a
907-232-P	8-Channel RS-232 Expansion Card	6000	n/a
907-485-P	8-Channel RS-485/422 Expansion Card	6000	n/a
907-AUDIO-P	4-Channel Audio Expansion Card	6000	n/a
907-CIB-P	4-Channel Control Interface Card	6000	n/a
907-SER-P	8-Channel RS-232/485 Serial Expansion Card	6000	n/a
907-DC-24V-P	DC-DC Power Supply Module (18-30 VDC In)	6000	n/a
907-WDM-SM-P	Singlemode Wavelength Division Multiplexer	6000	1310, 1550
907-SPLIT-SM-P	Singlemode 1x2 Splitter Card	6000	1260 - 1620
907-CWDM-4R1-P	4-Channel CWDM (1471 - 1531 nm)	6000	1471 - 1531
907-CWDM-8R-P	8-Channel CWDM (1471 - 1611 nm)	6000	1471 - 1611

\*-XXX- represents the optical configuration, e.g. SMD47 for singlemode, dual bushing, 1471 nm.