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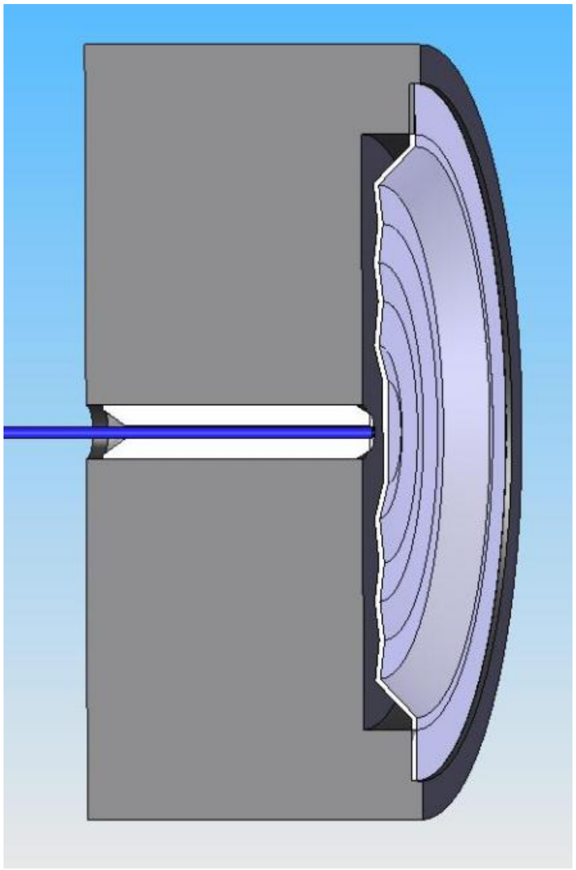
DavidsonSensors™

Guide to Configuring a Fiber Optic Sensing System



Davidson Fiber Optic Sensing System

- DavidsonSensors™ Measure Temperature, Pressure, Vacuum, Flow, Level, and Vibration
- DavidsonSensors™ Transmit Intrinsically Safe Signals to Passive Fiber Optic Transducers
- DavidsonSensors™ are Immune to Lightning Damage and Grounding Problems
- DavidsonSensors™ are Immune to Electromagnetic and Radio Frequency Interference (EMI/RFI)
- DavidsonSensors™ Operate at 1000°F
- DavidsonSensors™ are Easy to Install and Require Very Low Maintenance

Guide to Configuring a Fiber Optic Sensing System

1. Introduction

Fiber optic sensing technology offers a number of advantages for measurement in harsh industrial environments. Fiber optic transducers are tolerant to high temperatures, intrinsically safe, and immune to electromagnetic interference. Since many fiber optic transducers can be multiplexed with a single signal conditioner, significant cost savings can be achieved. To realize the full potential of this technology, the sensing system must be configured to balance cost, accuracy, update rate, frequency response, transmission distance, etc. This guide is intended to help the new user understand enough about fiber optics to configure a cost-effective and successful fiber optic sensing system.

2. Safety

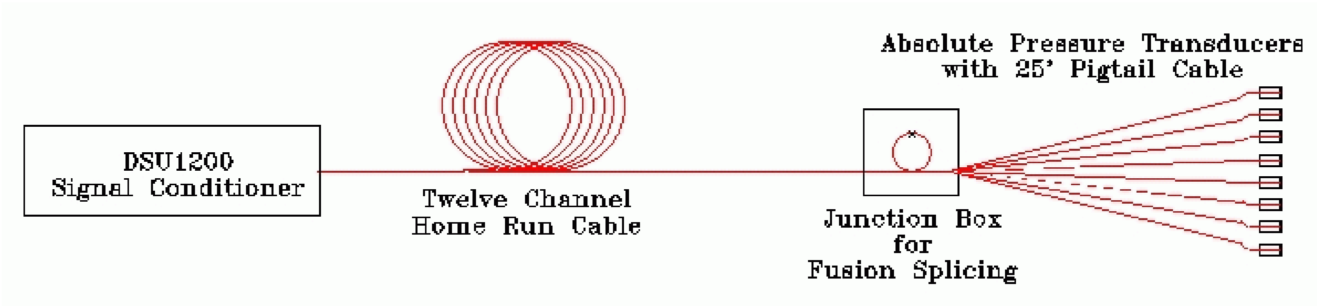
Davidson has designed its systems for industrial applications. The systems are eye-safe and intrinsically-safe. DavidsonSensors™ use broadband white light from tungsten lamps and narrow-band LEDs as the light sources. The amount of light energy transmitted into an optical fiber is not sufficient to cause damage to the eye and is not sufficient for ignition. The maximum energy transmitted in a fiber is below the standards set by ANSI/ISA-TR12.21.01-2004, Use of Fiber Optic Systems in Class I Hazardous (Classified) Locations.

- **Regardless of the energy level being transmitted in an optical fiber, never look directly into an optical fiber that is transmitting light.**
- **Not all fiber optic systems use safe levels of white light and serious damage could occur from looking into fibers connected to systems that use invisible light, (i.e. light at wavelengths longer than 700 nm).**
- **The human eye is not a good indicator of light intensity and has quite different sensitivity than the detectors used to measure the light level. A light meter is the proper instrument for measuring light intensity.**
- **A broken glass fiber or cable should never be placed near the eye because of the physical danger and potential consequences of getting a glass fiber in the eye.**

3. Components of a Fiber Optic Sensing System

There are three basic components in a fiber optic sensing system – Transducers, Cables, and Signal Conditioners. Fiber optic transducers are passive devices that require a fiber optic signal conditioner to convert the light signal into an electronic signal in the appropriate engineering units. Cables are used to transmit the light from the signal conditioner to the transducer. Signal conditioners are devices that transmit light to the transducer and convert the reflected light signal into an electronic signal that is transmitted to a control system.

It is important to understand that fiber optic transducers must be designed to interface with specific fiber optic signal conditioners. At the present time, transducers and signal conditioners from one manufacturer are not interchangeable with those manufactured by others. Fortunately, fiber optic cable is manufactured to standards that enable interchangeability between all fiber optic cable suppliers.



Schematic of Fiber Optic Sensing System

4. Getting Started

To get started with the task of configuring a fiber optic sensing system, some basic questions need to be answered.

4.1 Transducers:

4.1.1 What do you need to measure, i.e. temperature, pressure, level, flow, density, acceleration?

Temperature sensors can be inserted into pressure transducers to make two measurements with a single point of penetration.

4.1.2 What accuracy is required?

Since all transducers have some thermal sensitivity, the highest accuracy is obtained when temperature correction is applied. This is especially true when the temperature range is uncertain or for transducers subjected to very high temperatures. Review your application and the product specifications carefully to determine if temperature correction is warranted for your application. Is the process stable or cyclic?

4.1.3 How many sensors of each type need to be included in the design of your sensing system?

The standard multiplexing package is an eight-channel signal conditioner but other options are available. Multiplexing eight channels is a good compromise between cost and update rate. For measurements where redundancy is critical, a dedicated signal conditioner may be a better trade-off.

4.1.4 What is the ideal physical interface and location for the transducers?

Fiber optic transducers can handle higher temperatures and more corrosive environments than electronic transducers. Many of Davidson fiber optic transducers can tolerate temperatures to 1000°F and can be located safely in explosion hazardous areas. This allows you to locate the transducers directly in very harsh operating environments and eliminates the need for purging systems, capillary tubes, and impulse lines, and all of the associated weatherization issues. Huge cost savings can be accrued through the elimination of such systems. Further, Davidson can design transducers with a variety of external packaging. The sensors are identical , only the transducer body is different. Note the following possibilities:

- As small as 0.100 inch in diameter
- Flexible probes for installation in difficult access locations
- Male or female NPT fittings or flange connections

4.1.5 What is the process media?

Davidson transducers can operate in a variety of process media. Unless otherwise specified, Davidson transducers use Inconel-718 for the wetted parts. If your process media is not tolerant to Inconel-718, call Davidson and ask for an application engineer to discuss other available materials.

4.1.6 What other environmental factors need to be considered?

Will the transducer be subjected to high thermal gradients, mechanical strain, vibration, or severe cold?

4.2 Signal Conditioners:

4.2.1 Does the application require an absolute or a dynamic measurement?

Davidson offers two families of signal conditioners, one for absolute high-resolution measurements and another for dynamic measurements requiring high frequency response.

4.2.2 What is the required update rate/frequency response?

Absolute systems offer greater accuracy with lower frequency response (update rate). Absolute systems can resolve better than 0.01% of full scale and provide an updated output signal several times per second. Dynamic systems offer reduced accuracy but much higher frequency response than absolute systems. Dynamic systems can resolve better than 0.5% of full scale and provide frequency response exceeding 5kHz.

4.2.3 What is the ideal output signal?

Davidson offers several standard options including:

- 4-20mA
- RS-485 Modbus

4.2.4 What power is available?

Davidson systems work with either 110VAC or 24VDC.

4.2.5 Where will the signal conditioners be located?

Davidson signal conditioners are best located in a control room environment and configured as 19" rackmount or in NEMA enclosures. For those applications which require form-fit-function replacements of existing transducers and transmitters, Davidson offers a line of explosion-proof signal conditioners. Although not intrinsically safe, NEMA enclosures can tolerate temperature and humidity extremes.

5. Definitions for Optical Circuit

Once you have defined the number, location, and type of transducers and signal conditioners, you need to complete the optical circuit with a cable system consisting of cables, connectors, and junction boxes. It is good work practice to create a schematic of the fiber optic circuit when designing a fiber optic sensing system. We'll start with a few definitions to help with the planning process:

5.1 Transducer Cables – The optical cables that are a part of the transducers are called transducer cables. These cables can be terminated with mechanical connectors or left as pigtails to be cut to length and terminated in the field. These cables can be made temperature tolerant and can be sheathed in stainless steel armor sleeving.

ILLUSTRATION OF TRANSDUCER CABLE

5.2 Jumper Cables – The optical cables that connect a transducer to a junction box or signal conditioner are called jumper cables. These cables are configured with or without mechanical connectors and cut to length and terminated in the field.

ILLUSTRATION OF JUMPER CABLE

5.3 Home Run Cables – The optical cables that run from junction boxes in the field to the signal conditioners are generally grouped in a multistrand cable which is called a home run cable.

The home run cable can be configured with or without mechanical connectors and cut to length and terminated in the field.

ILLUSTRATION OF home run CABLE

5.4 Junction Boxes – Junction boxes are typically NEMA enclosures that have special provisions for making fiber optic connections. Boxes may range in size for single or multiple terminations.

ILLUSTRATION OF JUNCTION BOX

5.5 Level 1 Systems – In simple installations, it may not be necessary to have junction boxes, home run cables, jumper cables. The cable and connectors provided with the transducers may be connected directly to the signal conditioner. This arrangement is most appropriate in laboratory type installations where frequent connect and disconnects are required.

ILLUSTRATION OF LEVEL 1 SYSTEM

5.6 Level 2 Systems – For slightly more complex systems, separate fiber optic jumper cables may be required. These cables typically have a connector on each end of the cable and serve to connect the transducer to the signal conditioner. Jumper cables may minimize the complexity of the installation. The transducers, jumper cables, and signal conditioners may be installed separately. After the optical circuits are terminated, the system can be commissioned.

ILLUSTRATION OF LEVEL 2 SYSTEM

5.7 Level 3 Systems – For systems with many transducers, home run cables may be required. Home run cables containing many fibers are used for long runs. A home run cable may have connectors on one end to connect to the signal conditioner. The other end may be cut to length in the field and terminated in a junction box with fusion splices or mechanical connectors. Home run cables may minimize the complexity of the installation. The cables, junction boxes, transducers, and signal conditioners may be installed separately. After the optical circuits are terminated, the system can be commissioned.

ILLUSTRATION OF LEVEL 3 SYSTEM

5.8 Level 4 Systems – For complex industrial sensing systems, it may be necessary to configure a fiber optic cable system that includes jumper cables as well as home run cables and a variety of junction boxes.

ILLUSTRATION OF LEVEL 4 SYSTEM

6. Details of the Cable System

6.1 Selection of Fiber Optic Cable – Although fiber optic cable from different vendors is interchangeable, the specifications for the optical fiber must match those used in the transducers and signal conditioners. If the optical fiber specifications do not match, severe degradation in the system performance will occur. The fiber optic cable used for telecommunications systems may not be appropriate for fiber optic sensing systems. For more detail on this subject, see **Davidson Fiber Optic Cable and Transmission Standard**.

6.2 Cable Temperature Rating – Davidson recommends standard cable be used when the cable is exposed to temperatures ranging from –40°F to 125°F. Temperature tolerant cable is suitable for use at temperatures up to 550°F. Other special cables can be manufactured for exposure to temperatures up to 1000°F.

6.3 Mechanical Protection of the Cable – Davidson recommends the use of stainless steel armor for cables that may be subject to mechanical damage. Two types of armor are available: stainless steel overbraid for minimal protection and stainless steel corrugated sleeving for maximum protection.

6.4 Fiber Optic Cable Runs – When the length of the cable run is uncertain, it is best to order enough fiber to assure a good field termination. For optimal system performance in process control applications, the total transmission distance (length of the cable run) from the signal conditioner to transducer should be limited to 1000 feet although the system can work at ranges greater than 1000 feet with some degradation of signal quality. For more detail on this subject, see **Davidson Fiber Optic Cable and Transmission Standard**.

6.5 Multiplexing of Transducers – Davidson discrete fiber optic sensing systems are different from telecommunication systems and require a dedicated optical fiber for each sensor. Fortunately, large numbers of optical fibers can be packaged in a single small diameter home run cable to provide effective multiplexing of many transducers with a single signal conditioner.

6.6 Location of Terminations – For optimal system performance, it is best to minimize the number of terminations in the fiber optic circuit and to plan the location of junction boxes in areas convenient for installation technicians to make the necessary terminations. The optical fibers need to be properly terminated at every junction to complete the optical circuit. Typical junctions include the terminations between the following:

- Fiber optic cable and transducer
- Fiber optic cable and signal conditioner
- Mating optical fibers at each junction box

6.7 Fiber Optic Terminations – Ideally, all terminations are made as permanent fusion splices although temporary mechanical connections may be acceptable. Mechanical connections should be limited to use in those situations where periodic connect and disconnect is required.

Mechanical connections are not a good substitute for permanent fusion splices in hazardous field conditions. Davidson uses the most rugged and dependable connectors available but even these connectors are not as good as a permanent fusion splice connection.

The standards of acceptable quality of the connectors and terminations for fiber optic sensing systems exceed the standards for digital signal quality required in telecommunication systems. When making a mechanical connection, it is important that the termination be made and inspected in compliance with Davidson termination standards. Severe degradation will result from poor terminations. For more detail on this subject, see **Davidson Fiber Optic Termination Standards**.

7. Generating the Bill of Materials

When the design of the fiber optic system is complete and the schematic of the system has been detailed a detailed bill of materials should be generated to assure quick and efficient installation.

The bill of materials should provide a listing of the location and type of each transducer, cable, junction box, and signal conditioner with complete ordering data for each item. The bill of materials should also provide a listing of the location and type of termination at each junction, i.e. fusion splice or mechanical connection and type of connector if it is a mechanical connection. See Davidson product specification sheets for ordering data.

8. Sample Bill of Materials

Here is a sample bill of materials for a sixteen (16) channel fiber optic sensing system consisting of four absolute pressure transducers in two different pressure ranges, four gage pressure transducers in four pressure ranges. Each of the pressure transducers has a temperature correction sensor. The signal conditioner is a sixteen (16) channel rackmount high resolution type. The cabling system is a Level 4 System and uses fusion splices at all locations except the home run cable to signal conditioner.

Component	Item	Qnty	Ordering Data (See Davidson Product Specification Sheets)	Location	Cable Length
Transducers					
Absolute 2000	001	2	AP1200-J-7-Y-50-B-1-P-M-6-375-4-X-B-X-0	ECM120	50’
Absolute 1000	002	2	AP1200-I-5-Y-20-B-1-P-M-6-375-4-X-B-X-0	ECM100	20’
Gage 3000	003	1	GP1200-K-5-Y-20-B-1-P-M-6-375-4-X-B-X-0	ECM060	25’
Gage 1000	004	1	GP1200-I-5-Y-20-B-1-P-M-6-375-4-X-B-X-0	NHM118	30’
Gage 500	005	1	GP1200-H-5-Y-20-B-1-P-M-6-375-4-X-B-X-0	NHM106	50’
Gage 100	006	1	GP1200-F-5-Y-20-B-1-P-M-6-375-4-X-B-X-0	ECM112	100’
Signal Conditioner					
19” High Res	007	1	DSU1250-B-R-0-0	Control Rm	N/A
Junction Boxes					
16 Channel	008	1	JB1200-A-8-A-0	NHM	N/A
2 Channel	009	8	JB1200-A-2-A-0	ECM/NHM	N/A
Home Run Cable					
18 Fiber	010	1	HR1200-18-200-N-1-P-P-0		200’
Jumper Cables					
Short	011	2	JC1200-2-50-N-1-P-P-0		50’
Intermediate	012	4	JC1200-2-100-N-1-P-P-0		100’
Long	013	2	JC1200-2-200-N-1-P-P-0		200’
Fusion Splices	014	32	FS1200		N/A
Connectors	015	32	ST1200		N/A

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