

Connectors and Cables 101

FULLY UNDERSTANDING THE APPLICATION WILL HELP ENSURE THAT THE CABLING AND CONNECTORS UTILIZED PROVIDE THE EXPECTED PERFORMANCE AND DURABILITY. By Ron Folkeringa



For a GigE Vision camera, this locking system can be as simple as the latch lock on an RJ45 Ethernet connector, or it may be thumbscrews, or the threaded body mount of a circular M12 connector. *Source: Nortech Systems*

- Is there a risk of the camera and cable being subjected to external influences such as vibration, temperature, moisture, oils, weld slag, sunlight?
- Will the camera and/or cable need to be accessed after installation?
- Is there a risk of EMI or noise interference from other equipment in the area that could negatively impact the image quality?

With these concerns in mind, we can begin to determine the correct cable and connector solution for your application. Let's start with the connector.

Over the past year, much has been written about the development of new technologies for the machine vision industry. Camera Link HS, CoaxPress, Camera Link 2.0, USB 3.0 and GigE Vision 2.0—to name a few. It

can be a daunting task to understand the pluses and minuses of each technology and determine the right solution for your specific application. This article will provide a general overview of machine vision cabling and connectors, regardless of the technology used.

Before discussing connectors and cables, the vision application

should be considered. Fully understanding the application will help ensure that the cabling and connectors utilized provide the expected performance and durability. These are just some of the important factors to consider:

- Is this a static or dynamic application? In other words, will the camera be stationary or moving?

CONNECTORS: STARTING—AND FINISHING—STRONG

If your application is a basic setup with no motion or little risk of external forces, a non-locking plug may be sufficient. Examples of friction-fit plugs would be those found on a Firewire or USB cable for a computer keyboard or other peripheral. These friction-fit plugs provide an extremely quick connection and are readily available from many sources.

If there is a risk of the cable being pulled from its receptacle, then additional consideration must be given to a connector locking method. Fortunately, the vast majority of camera manufacturers has recognized this risk and has integrated a

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- ▶ One of the most important factors in considering connectors and cables is whether the camera will be stationary or moving.
- ▶ Determine if there is a risk of the camera and cable being subjected to external influences such as vibration, temperature and moisture.
- ▶ Decide if the camera and/or cable will need to be accessed after installation.
- ▶ Consider whether there is a risk of EMI or noise interference from other equipment in the area that could negatively impact the image quality.



A simple continuity test can be performed by touching one probe to the threaded metal body of the M12 connector and the other probe to the metal shield on the RJ45 connector. The presence of electrical continuity indicates a properly designed and terminated assembly.
Source: Nortech Systems



Kinking of a cable must be avoided at all times and properly designed strain reliefs will help to prevent this from occurring.
Source: Nortech Systems

cable/connector locking feature into their cameras.

For a GigE Vision camera, this locking system can be as simple as the latch lock on an RJ45 Ethernet connector, or it may be thumbscrews, or the threaded body mount of a circular M12 connector.

Although the plastic latch of a RJ45 connector does help prevent a plug from being accidentally pulled out, it provides little protection against a corrupted image caused by the connector being torqued from side to side. Today, most cameras feature the ability to secure the connector with a pair of thumbscrews integrated into the cable's connector overmold. This provides a very secure and robust connection, able to withstand both tensile and torque stresses.

Recently, some GigE camera manufacturers started utilizing circular M12 connectors in place of the standard RJ45 connector. The M12 connector provides an excellent durable interconnect while also offering the possibility of an IP rating when needed. IP "Ingress Protection" rating is defined by

International Standard IEC 60529 as the level of protection against solids and liquids to which the cable and camera may be exposed. An IP67 rating, for example, would provide protection from solids such as dust, and also from water ingress to a depth of up to one meter for up to 30 minutes.

One type of protection that doesn't get much consideration is electromagnetic interference (EMI) protection. EMI can have several sources and can degrade the image quality being captured. Utilizing a cable that has shielding (braid and/or foil) which has been properly terminated can help to protect against the harmful effects of EMI.

Although the M12 cable assembly mentioned above can provide a durable interconnect, not all M12s provide optimized EMI protection through a terminated chassis ground. To determine if an M12 cable assembly has a terminated chassis ground, a simple continuity test can be performed. Touch one probe to the threaded metal body of the M12 connector

and the other probe to the metal shield on the RJ45 connector. The presence of electrical continuity indicates a properly designed and terminated assembly.

The use of thumbscrews is generally the most common method for providing a positive interlock of cable to camera. However, care must be taken when plugging and securing a cable assembly to a camera that utilizes thumbscrews. It's important to ensure the thumbscrew does not become cross-threaded. Experience has also shown that not all camera manufacturers provide a mating jackscrew interface in a proper axial relationship to the thumbscrew and not all thumbscrews are built to as tight a length tolerance as should be utilized. While some camera manufacturers may provide a threaded hole in the camera back plate, others will provide a jack nut into which the thumbscrew is fastened. Some jack nuts may be mounted in such a way that the thumbscrew bottom outs in the jack nut prior to the plug being fully seated in the receptacle.

When this occurs it provides a false indication that the plug is fully seated. To determine if the plug is properly seated, pulling slightly on the overmolded plug after tightening the thumbscrew should result in no end play of the plug to the receptacle. The presence of end play indicates the thumbscrew has bottomed out prematurely and needs to be corrected to ensure a proper connection.

CABLES: THE MIDDLE MATTERS

As with connectors, understanding the application will help to ensure your cable choice is appropriate. If the cable will not be exposed to motion or other environmental

factors, a standard-grade cable may be sufficient. However, the introduction of motion, extreme temperatures, EMI or contaminants may quickly cause an inexpensive commodity-grade cable to become your machine vision application's weakest link. Unfortunately, providing a comprehensive list of cable attributes is not possible within this article's scope. Instead, we will focus on cable flex life and flexibility.

As with the connector, understanding the type of motion your cable will be exposed to is one of the key pieces of information needed to ensure a successful machine vision implementation.

Not only is it important to know if the cable will be exposed to motion but equally critical is the type of motion. Two of the more common types of motion are torsional or rolling flex. Many motion applications involve a rolling flex such as in a moving gantry where the cable is exposed primarily to one axis of travel. For these CatTrac applications it is important to know the minimum bend radius. As a rule of thumb, the recommended minimum bend radius of a cable is its diameter multiplied by a factor of 15 times for dynamic applications and 10 times for static applications.

For example, if a cable has a diameter of 8 mm, the minimum



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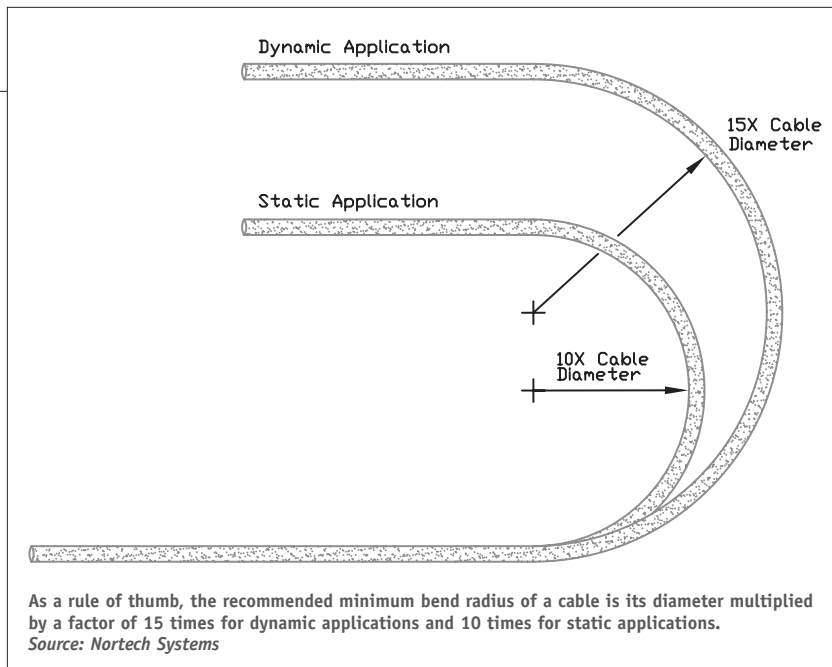
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bend radius for a rolling flex application would be 120 mm. For a static application the minimum bend radius would be 80 mm. Violating the minimum bend radius of a cable will cause the cable to fail prematurely due to the mechanical stresses placed on the various components within the cable.

No rule of thumb exists for torsional flex due to the many variables that can exist. It is also not uncommon for a cable manufacturer to be hesitant to provide the expected number of flex cycles for your specific application; the dynamics of each application can be quite different. To best understand how a cable will perform in a torsional application it is best to test the cable in the actual setup or to enlist the test services of the cable manufacturer. Providing your cable supplier some important information, such as the degrees of rotation over the affected length of the cable assembly, will be helpful in determining a proper torsional cable solution.

A word of caution: when investigating potential high-flex cable solutions. Terms such as high-flex, continuous flex, long flex life and others are commonly used but can mean different things to various manufacturers and users. It is vitally important to ask your supplier what flexing motion the cable has been designed for; also, they should provide any test data that is available. Be sure to ask for clarification in regard to what they consider a failure. Although it may be impressive to hear that a cable can endure 10 million cycles, their definition of a failure may be at the point continuity is lost, while the cable may have actually become unusable for its intended purpose in as few as 1 million cycles. For example, although continuity may be present through 10 million cycles, a CAT 6a Ethernet cable may see its signal integrity diminish to that of CAT 5 performance at 1 million cycles due to the degradation of the components within the cable.

Another area to consider in regard to the flexing of a cable

is the area immediately behind the camera where the cable is plugged in. Cameras are being stuffed into smaller and smaller locations which result in the cable being shoehorned into whatever space is left over. These cramped conditions not only put strain on the cable but also the camera and its connector. Utilizing a right angle connector cable assembly to take the strain off the cable and connector will reduce the risk of damaged hardware or diminished signal quality. Along with the higher bandwidth cameras comes an increasing importance of the electrical properties of the cable. Kinking of a cable must be avoided at all times and properly designed strain reliefs will help to prevent this from occurring.

PUTTING IT ALL TOGETHER

This brief overview of some mechanical issues involving cabling and connectors should provide new machine vision users with a basic understanding. Additional factors such as chemicals, weld slag and proper installation of the assembly into the CatTrac should also be considered. Working with your machine vision cable supplier to address these issues will help ensure your machine vision application is a success.

A special thanks to Motion Analysis and Pyramid Imaging for allowing us to use their cameras for this article.

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