White Paper

Feedback

Open vs. Closed Encoder Communication Protocols:

How to Choose the Right Protocol For Your Application

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I. Introduction

Imagine that you are specifying an encoder to provide motion control feedback. You have already decided whether the encoder needs to be incremental or absolute, and you now have to decide on the communication protocol. The application has too many devices to use parallel communication, and too few to require a bus such as DeviceNet or Profibus. The best choice appears to be a serial communication link. Unfortunately, the numerous choices in serial communication links can make the choice a confusing task. On what basis should you choose one protocol over another? This application example highlights the key questions typical for most applications. This paper is intended to answer and demystify some of these questions and help you choose the right serial communications protocol for your encoder application.

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II. Open vs. Closed Communications Protocols:

What does it mean to me and my application?

You might have noticed that some communication protocols are available from a limited number of manufacturers. Chances are that these protocols are *closed-type communications protocols*. Closed communication protocols are proprietary, meaning that they require a user license and license fee for users to design their own interface with a closed protocol slave. Detailed specifications on a proprietary protocol are restricted; they are available to license holders and not the general public. Closed-protocol devices are essentially 'black-box' devices because not much is known about the specifics of their operation. The most common closed serial communication protocols for encoders include EnDat® and HIPERFACE®, which were developed by individual encoder manufacturers.

Open communication protocols, on the other hand, are non-proprietary and non-restrictive. The developers of communication protocols freely share specifications regarding data format and electrical design. Designers of products that use serial communications, such as sensors and encoders, can create their own interfaces without paying a licensing fee. This means that – when you are shopping for a replacement serial communication device – you'll find many more encoders available on the market. The most popular open communications protocol is *Synchronous Serial Interface* (SSI). SSI is a well accepted and time-tested protocol. More recently, the *Bi-directional Synchronous Serial Interface* (BiSS) open serial protocol has come into the market. Using SSI as a basis, it represents an alternative to bi-directional communication protocols such as EnDat® and HIPERFACE®.

III. Why use a closed communications protocol?

There is one good reason to use a closed proprietary protocol; simplicity. For instance, the communication protocols slave configuration software is usually pre-designed, saving time and development costs. Another reason may be that a user prefers a particular vendor's product and agrees to pay the licensing fee in exchange for the ability to completely rely on that manufacturer for all levels of required support for the encoder or sensor. Of course the

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drawback to this approach is that the user limits his/her options in the future, when a replacement device is needed.

IV. Why use an open communications protocol?

The key benefits to using an open communication protocol include:

- **Availability** – Encoder buyers have more selection options and alternative manufacturers to choose from.
- **Cost** –Manufacturers of products using closed communication protocols can charge any fee that the market will bear for a replacement encoder, since there is virtually no competition from other manufacturers. On the other hand, competition among suppliers of open-communication-based products promotes price and product alternatives.
- **Information** - Closed protocol developers limit the amount of information that is published and available to buyers. However, if the need exists, an educated user can check the compliance of an open protocol from a specific manufacturer. Information regarding that protocol is freely posted on the internet.

V. How do the various communication protocols operate?

In order to select the right protocol, buyers must fully understand the operating capabilities and functional limitations of each of the available feedback control protocols.

SSI

SSI is the foundation on which all of the aforementioned protocols are based. SSI communication requires two twisted pair wires plus two wires for power. Encoders may also be supplied with additional incremental outputs for speed feedback. For serial communications, one pair of wires is for a differential clock signal and the other pair is for data feedback from the sensor. Clock frequencies can be as high as 1.5MHz. However, as clock frequency increases, the maximum cable run decreases, which is a limitation common to all protocols.

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Cable Length	Data Rate
50 m	400 KHz
100 m	300 KHz
200 m	200 KHz
400 m	100 KHz

Table #1, Cable Length vs. Data Rate

The data frame length depends on the device and its resolution. In an SSI interface, there is one slave per master, referred to as a point-to-point connection. The clock remains high until the master needs information from the sensor. It then sends a stream of clock pulses equivalent to the number of bits of information from the sensor. Samples of each bit are usually taken on the falling edge of the clock pulse. This insures that the propagation and process delays are accounted for. Sensor manufacturers are free to insert alarm bits if required, but the requirement must be provided before the product is shipped, and a single alarm bit may have several meanings. See Figure 1 for an example of what an SSI trace may look like.

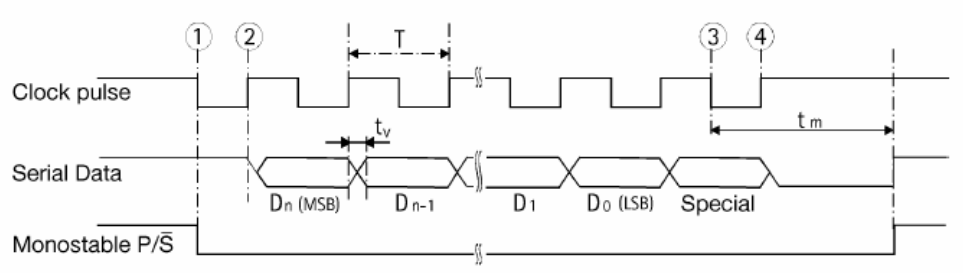

Figure #1, SSI Communication Format

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VI. EnDat®

EnDat is a proprietary protocol created by Heidenhain of Germany. EnDat is similar to SSI in that it is a point-to-point connection. EnDat is also a synchronous protocol like SSI, meaning that the data, with a speed of 4 MHz, is received as clock pulses are sent simultaneously. However, much more data can be read from an encoder and stored due to the provided internal memory. This can include diagnostics, identification, alarms, and warnings. It can also contain information about the motor in which it was mounted to such as model and serial numbers. Varying clock pulse stream lengths are also required from the varying data that may be received or sent to the device. Also, using a function called a Datum Shift, an encoder can easily be reset to a new zero or reference point. The Datum Shift is a value that is added to the physical position of an encoder. SSI provides a direct reading of the physical position, so it requires the end user to rotate the shaft to the zero position.

The hardware level minimally requires six wires for communications. Depending on the version of EnDat, there may be an additional wire that carries an analog incremental output for faster speed sampling. This is useful for speed-controlling drives that can be more demanding than the rate at which serial feedback is normally provided.

For more information on the EnDat protocol refer to the Heidenhain website at www.heidenhain.com.

VII. HIPERFACE®

HIPERFACE is a proprietary serial protocol created by Max Stegmann GmbH. HIPERFACE can be point-to-point like SSI and EnDat, but it can also use bus connections in which several encoders can be wired together and addressed by a single master. HIPERFACE is the only one of the four major serial protocols that is asynchronous. It uses bidirectional RS-485 communications to send and receive data. The data comes at a relatively slower rate of 38.4Kbps, but contains much more information than provided in SSI communications.

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Like EnDat, it has internal memory that can hold motor information such as voltage, current, and other parameters. Using a licensed master, you can also define an absolute zero position. Because HIPERFACE is proprietary, the user doesn't know how the communications work and how parameters are addressed. Setting and storing parameters are essentially "plug and chug" with the manufacturer provided software. Generally, the data sent and received from the master is at a fixed length and is not controllable by the end user or OEM.

At the hardware level, eight wires are required. The proprietary SinCos® output requires four wires for each differential pair, with two wires required for data communication and two for power.

For more information on HIPERFACE, refer to the Stegmann website at www.sick-stegmann.de.

VIII. BiSS

BiSS is the latest protocol designed and developed by IC-Haus, Germany. It was created to be an open non-proprietary protocol alternative to EnDat® and HIPERFACE® but designed with the capabilities of the proprietary protocols in mind. Combined features such as alarms, warnings, and the ability to store motor information to the encoder exist in the BiSS protocol.

BiSS has two modes; sensor mode and register mode. In sensor mode, the sensor or encoder communicates in a manner similar to SSI. The master begins to send a stream of clock pulses. Eventually the data line level will drop low and data sampling will begin. The data can be received and clocked at a blazing 10MHz. Due to the speed of transmission, many drives may not require additional analog incremental outputs to control motor speed. In ACURO encoders available from Danaher Industrial Controls Group, the propagation and calculation delay is so brief that communication is backwards compatible with the SSI protocol. Figure 2 shows the communication format and a data frame map.

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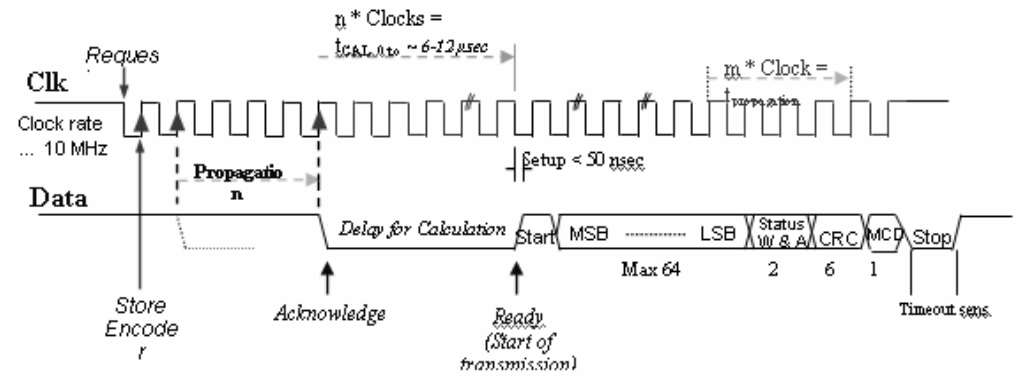

Figure #2, BiSS Sensor Mode

In register mode, the protocol modulates the clock pulse width to address specific slaves and parameters. This mode is unlike any other protocol. If in the sensor mode a warning or alarm bit is set high by the sensor or encoder, the end-user may access the register mode and find specifics on the alarm or warning. This might be an over-temperature warning or, in the case of an encoder, a disk pollution alarm. Danaher Industrial Controls Group is currently developing the ability to provide single step alarms in case improper position is being provided in sequence. Other information such as acceleration, temperature, and identification can be retrieved from an encoder with BiSS. Also, as mentioned before, register mode allows for sending and storing data to the encoder. Figure 3 and 4 illustrate the communication format and data map of a BiSS device in register mode.

Figure #2, BiSS Register Read Mode

Figure #3 BiSS Register Write Mode

On a hardware level, the same cable used in SSI and EnDat can be used with BiSS applications. For more information on IC-Haus and the BiSS protocol , refer to the BiSS Website at www.biss-interface.com.

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IX. Summary of the Four Dedicated Serial protocols

Table 2 shows some of the key differentiators for each protocol.

Dedicated Serial Interfaces				
	HIPERFACE®	SSI + Sine/ Cos	EnDat®	BiSS
Open Protocol	No	No (License available)	No	Yes
Connection	RS-485: Bus or Point-to-Point Analog: Point-to-Point	Point-to-Point	Point-to-Point	Bus or Point-to-Point
Analog Signals Required	Yes	Yes	No	No
Transmission Mode (Digital)	Bidirectional, asynchronous	Unidirectional, synchronous	Bidirectional, synchronous	Bidirectional, synchronous
Digital Data Transmission Rate	38.4 kBaud	1.5 MHz	4 MHz	10 MHz
Cable Length Compensation	No	No	Yes	Yes
Protocol Length Adjustable	No	No	Yes	Yes
No. of Wires	8	6–8	6 to 12	6
Hardware Compatible	← →			
Alarm/Warning Bit	No	Definable	Yes	Definable

Table #2, Serial Interface comparison

X. Conclusion

Choosing the right communication protocol for an encoder application can be difficult. This primer gives OEM project engineers and end-users enough knowledge of the basic operating principles to make an educated buying decision. Encoders that offer open communications protocols offer the most flexibility, and new non-proprietary protocols such as BiSS will accelerate the trend away from using closed communication protocols.

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