Area: Digital Protocols
Title: Data Link Signal Mapping
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Introduction

Any project that finds its self purchasing packaged based equipment will encounter the need to provide some form of data exchange between the proprietary package controller and main plant control system. This paper presents a tried and tested format for handling the large number of signals that must be reviewed and selected for use in the main control system. As an example of the magnitude of this data, a typical centrifugal compressor data map could easily provide more than 1000 registers of data to the host control system. Don't forget that for discrete data a single register can represent 16 individual signals.

Any modern hydrocarbon project will require the administration of many data links. These links may utilise different protocols but all tend to be address based technologies. This paper uses Modbus as a basis for describing the database format used to store the individual package data maps. The data handling concepts can be easily adapted to other protocols such as OPC.

What Is Modbus?

The Modbus protocol was first introduced in the late 1970's by Modicon. Devices communicate in a master/slave configuration with a single master station communicating with either single or multiple slaves. The protocol is message based and data is transferred when it has been requested by the master station. Typically, the plant control system will be configured as the master station with the packaged equipment controllers configured as slave stations.

The most basic physical interface uses copper cable and the RS-232 connection method. This interface supports point-to-point connection only, has a maximum connection length of around 15 meters at a maximum communication rate of 20 kbps. RS-485 on the other hand supports communication with multiple slaves, operates at speeds in excess of 100kbps and can connect devices up to 1200 metres apart.

Unlike RS-232, RS-485 is a floating signal – the transmitter and receiver do not share a ground connection. This gives RS-485 excellent noise rejection capabilities not possible with a shared ground RS-232 connection.

Network connections are typically made using twisted pair copper cable. As RS-485 is a half duplex connection (i.e. only one device can 'talk' at any one time) two wires are sufficient to make the connection although some host systems look for a four wire connection. It is also usual to specify cable with an overall shield to further protect the signals from electrical noise.

Interface Detail

The package supplier and system engineering companies must agree the protocol and speed of the links along with cable types and any other interface requirements such as signal isolation. The engineering company will normally express any requirements for link redundancy and how this is to be provided. Full redundancy provides duplicated communications interface units at both the master and slave locations along with duplicated, sometimes diversely routed, connection cables and interface hardware. It is also possible to provide partial redundancy by specifying dual interface cards at either the master or slave units as agreed between the supplier and purchaser.

To allow the control system supplier to develop the data link design it is necessary to provide them with detailed information about the interface physical requirements. Figure 1 details a typical data link summary.

Project X – Gas Compressor K-YYY	
Vendor	Supplier Y
Contact	Mr A….B… a.b@y.com
Protocol	RS-485
Infrastructure	2-wire copper, overall screen, 200 metres
Speed	19200 bps
Redundancy	Required
Special Requirements	Isolate communication lines on area gas detection.

Figure 1 – Communication Link Physical Layer Summary

Data Exchange

Figure 2 provides a typical database structure typically used by the design engineer to store information from multiple suppliers.

Table	Field Name	Field Type	Field Size
My_Data_Link	Index	Long	4
My_Data_Link	Deleted	Boolean	1
My_Data_Link	Project	Text	3
My_Data_Link	Package	Text	20
My_Data_Link	Tag	Text	20
My_Data_Link	Used	Boolean	1
My_Data_Link	Vendor_Tag	Text	50
My_Data_Link	Descriptor	Text	80
My_Data_Link	Service	Text	{DCS Specific}
My_Data_Link	Data_Type	Text	40
My_Data_Link	Range_Min	Text	10
My_Data_Link	Rage_Max	Text	10
My_Data_Link	Range_Unit	Text	10
My_Data_Link	Station	Long	4
My_Data_Link	Address	Long	4
My_Data_Link	Bit	Text	2
My_Data_Link	Direction	Text	10
My_Data_Link	Notes	Text	100

Figure 2– Database Field Structure

Individual data-maps are created by each package supplier. Each map identifies all registers configured within the communication structure and provides details of the signals, data type, range information and any other specific information such as bit offset. It is common for the signals to be identified by supplier specific tags and descriptions which may not be appropriate for the main plant control system. This therefore requires a cross reference to be established between the supplier and control system tags. The data contained within the data-map must be evaluated and main control system tags allocated to those signals which will be used to provide dynamic data to the main plant control system – not all data will be used.

'Vendor_Tag' and 'Descriptor' fields are used as the primary link to the supplier database whereas 'Tag' and 'Service' are used by the main plant control system database.

'Range_Min' and 'Range_Max' are defined as text fields to allow the field to define the '0' and '1' states of discrete points such as 'Range_Min' ('0') = Healthy and 'Range_Max' ('1') = Alarm.

'Data_Type' provides details of how the register is to be decoded by the master station such that the correct data is presented to the plant control system.

'Direction' is used to indicate the direction of information flow between master and slave stations. Typically VEN->DCS implies data is read from the slave, DCS->VEN indicates a command is issued from the DCS whilst bi-directional data such as slave clock synchronisation registers are represented by VEN<->DCS.

Figure 3 shows parts of a typical data-link database based on the above table structure.

Tag	Enabled	Descriptor	Service	DataType	RangeMin	RangeMax	EU	Stn	Addr	Bit	Dir
Read/Writes											
X-KI-xxx-Y	☑	Set/Get Year	Year	16-bit signed integer	0	2099	year	1	0		VEN<->DCS
X-KI-xxx-M	☑	Set/Get Month	Month	16-bit signed integer	1	12	month	1	1		VEN<->DCS
X-KI-xxx-D	☑	Set/Get Day	Day	16-bit signed integer	1	31	day	1	2		VEN<->DCS
X-KI-xxx-H	☑	Set/Get Hour	Hour	16-bit signed integer	0	23	hour	1	3		VEN<->DCS
X-KI-xxx-M	☑	Set/Get Minute	Minute	16-bit signed integer	0	59	min	1	4		VEN<->DCS
X-KI-xxx-S	☑	Set /Get Second	Second	16-bit signed integer	0	59	sec	1	5		VEN<->DCS
X-Not Con	☑	Modbus Sys Base Addr		16-bit signed integer				1	6		VEN<->DCS
Analogue Reads											
X- AI-xxx	☑	Density	LP Flare Gas Density	16-bit signed integer	0	10	Kg/m3	1	10021		VEN->DCS
X-AI-xxx-2	☑	Z factor, standard cond	LP Flare Gas Z	16-bit signed integer			Month	1	10022		VEN->DCS
X-Not Con	☑	Z factor, operating cond		16-bit signed integer				1	10023		VEN->DCS
X-FQI-xxx	☑	Accumulated Volume	LP Flare Volume	16-bit signed integer	0	65535	m3	1	10024		VEN->DCS
Discrete Reads											
X-UB-xxx-1	☑	CMOS Alarm	Flare Gas Meter Memory	Packed				1	20020	0	VEN->DCS
X-UB-xxx-2	☑	Measurement Alarm	Flare Gas Meter Sensor	Packed				1	20020	1	VEN->DCS
X-UB-xxx-3	☑	Density Alarm	Flare Gas Meter Density	Packed				1	20020	2	VEN->DCS
X-UB-xxx-4	☑	Pressure Alarm	Flare Gas Meter Pressure	Packed				1	20020	3	VEN->DCS
X-UB-xxx-5	☑	Temperature Alarm	Flare Gas Meter Temp.	Packed				1	20020	4	

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Figure 3 – Datamap summary report

As can be seen from the data shown in Figure 3, not all signals are to be used by the main control system. Due to the way in which the Modbus protocol transmits its registers it is generally more efficient to transmit a block of addresses to the master unit. The master is then configured to pass on only those signals required by the host system. The 'Enabled' field (when checked) indicates those signals that will be passed from slave to master and on to the host system. An unchecked 'Enabled' field means that the master does not link those address to the master system database – the tag is also set to indicate that the registers are not used by the host control system.

By controlling the individual data-maps in a common database application it is easy to see how the engineer can keep control of the signal tagging and ensure that all signals are accounted for. The database structure could easily be extended to provide details of how each individual signal is used by the plant control system or where the signals are presented to the operator.

Change Control is another important consideration. Project evolution means that an initial review of the data-map may exclude particular signals which later become required. Change control can easily be implemented inside database applications so that changes are easily visualised. An example of change control is shown in Figure 2.

Other Common Issues

Every project will have the debate of whether or not to import the data-link tags into the main instrument database. There isn't a right answer to this question and every project seems to adopt a different approach.

Considerations against incorporating the potentially thousands of additional points into the main database centre on the fact that these points will only load the database without any significant benefit. However, not including serial data means that ensuring duplicate tags do not manifest themselves becomes a potential problem.

One useful suggestion is to always include a tag for each physical communication link connection. This will ensure that the physical cabling is engineered and isn't forgotten.

The issue of electrical isolation of the data link during detection of a hazardous atmosphere is another subject which does not appear to have any common solutions. Requirements of this nature should be addressed during the early stages of the data-link physical cabling design.

Summary

The huge amount of data produced by data links to packaged equipment must not be underestimated. Failure to control this data will ultimately lead to poor design and late delivery of key project equipment.