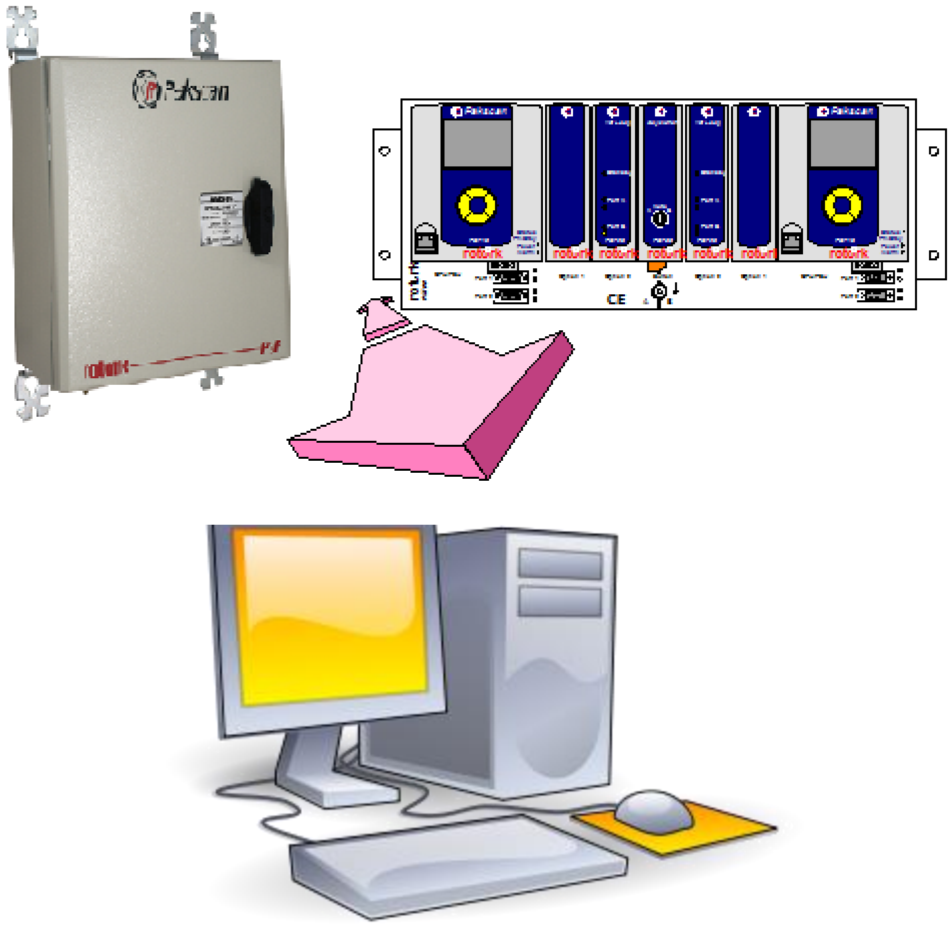

Modbus RTU Serial and TCP/IP Communication Specification for Pakscan P3 and P3F Master Station

Publication PUB059-003-00 Issue 01/15

Contents

Glossary of Terms:

Block	A master station data base entry covering 8 related parameters
Parameter	A master station data base entry of 16 bits
Bit	A master station data base discrete entry.
Modbus Address	The 8 bit address to which a Modbus Slave responds when interrogated.
Register Address	A data base start location within a Modbus address used to access at least one parameter (16 bits).
Discrete Address	A data base start location within a Modbus address used to access at least one bit.
Field Unit	A device connected to a master station that reports records into the master station data base.
Master Station	A Modbus slave containing a data base about itself and the connected field units.
Slave	A Modbus device containing data.
Host	A Modbus master controlling all data transactions on the Data Highway.
Data Highway	The mechanism along which the data flows; e.g. the RS 232, RS485 or Ethernet connection between Host and master station(s).
Gateway	The host device (PLC or DCS or other equipment) interface to the data highway
Pakscan 3	Generic term for a P3 or P3F master station controlled system
P3 master station	Refers to the rack or panel mounted version of the master station, single dual or Hot standby
P3F master station	Refers to the field mountable version of the master station

Abbreviations:

Comms	Communications
CRC	Cyclic Redundancy Check
DIP	Dual In-Line Package (chip)
FCU	Field Unit
FU	Field Unit
HW	Hardware
MS	Master Station
No	Number
RAM	Random Access Memory
ROM	Read Only Memory
RTU	Remote Terminal Unit
SW	Software

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This manual relates to Pakscan 3 Systems fitted with Current Loop modules

1 INTRODUCTION

This document provides information on the Modbus data base organisation and locations of information inside Pakscan 3 Current Loop Option master stations. In addition, it provides an overview for the connection of host systems to the Pakscan master stations.

- **Supporting Documents**:

<u>Modbus-IDA documentation:</u>

Protocol Documentation	
Modbus Application Protocol Specification	V1.1b December 2006
Implementation for Legacy Serial Systems	
Modbus Protocol Reference Guide	PI-MBUS-300 Rev J 1996
Implementation for New Serial Systems	
Modbus over Serial Line Specification & Implementation Guide	V1.02 December 2006
Implementation for Modbus TCP/IP systems	
Modbus Messaging on TCP/IP Implementation Guide	V1.0b October 2006

<u>Rotork Documentation</u>

Pakscan P3 Master Station System Manual	Publication PUB059-002
Pakscan P3FMaster Station Technical Manual	Publication PUB059-005

- **Supported Hardware:**

P3 and P3F Master Station (version 2.01.18) and PS720 module (version 1.1.7) or higher

All Pakscan master stations are **RTU slaves** on serial Modbus highways; they cannot act as masters. On TCP/IP systems they are **Servers** and cannot act as Clients.

1.1 General

All Pakscan master stations are supplied preconfigured with a standard, non-variable, data base relating to the field units connected. The data is always as listed in this document and does not vary between projects. Because various host systems have complexities and requirements that are slightly different there are two basic data base maps, each with two variations on analogue register value scaling.

The data base organisation that is accessed is chosen by the user. It is selected from the list of four by entering the choice into the system using the keypad and LCD screen on the master station. At any time the choice can be amended and no additional re-programming of the unit is required.

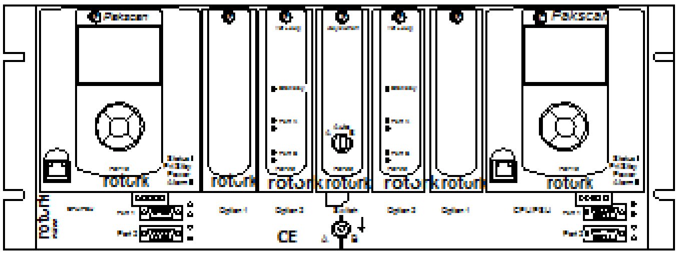


Fig 1: Pakscan P3 and Pakscan P3F master station

1.2 Serial communication to Pakscan master stations

All Pakscan master stations have two or more serial communication ports available for connection to host systems. These may be either RS232 or RS485 depending on the options specified when the unit was manufactured. It is possible to retrospectively change these ports after delivery by altering the DIP switches on the backplane of either unit.

In all cases, the communication is half-duplex and in the case of RS485 it is 2-wire.

1.2.1 Serial communication to a Pakscan P3F master station

The Pakscan P3F has two serial communication ports. These may be individually set for either RS232 or RS485. To change a port from RS232 to RS485, or vice versa, simply involves setting DIP switches on the main board to the appropriate positions. On the RS485 ports, DIP switches for pull-apart and termination resistors can be selected for line termination. Full information on setting the ports is contained in the Pakscan P3F Technical Manual.

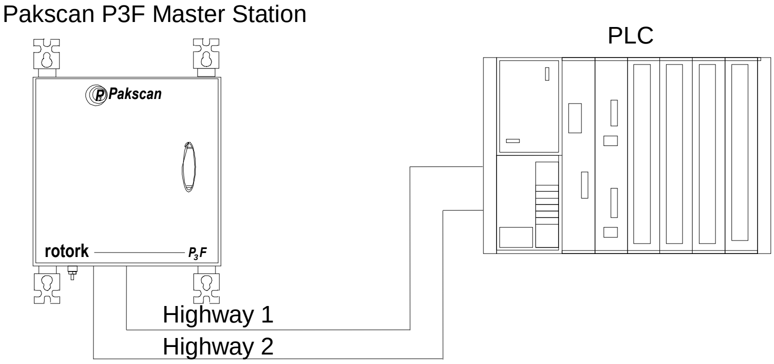


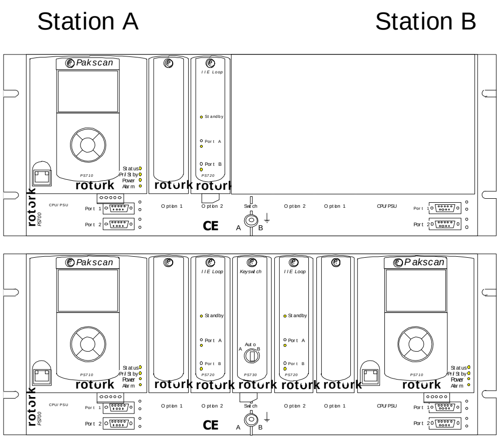
Fig 2: Pakscan P3F master station serial communications

Single or redundant communications can be used on either multi-drop or dedicated highways. The data base information remains the same whichever type of connection is used.

When redundant communications are employed such as shown in Fig. 2; the two data lines access Port 1 and Port 2. The data behind these ports is designed to allow communication to two separate host systems or a single host on redundant highways. The two ports are effectively handled by two independent data bases each fed with information from the connected actuators. Care must be taken in the handling of alarms that will be latched in the master station data bases. Either link the two ports by setting the ‘Alarms - Linked’ option for the Current Loop module Host Settings or ensure that all alarms are accepted on both highways.

1.2.2 Serial communication to a P3 master station

The P3 master station has two serial communication ports on each module. These may be individually set for either RS232 or RS485. To change a port from RS232 to RS485 or vice versa simply involves altering DIP switch settings on the rear chassis behind the main PS710 modules. When RS485 ports are selected, line termination settings for both pull-apart and termination resistors can also be DIP switch selected. With dual redundant P3 master stations in hot standby configuration there will be two communication ports on each side, giving four in total. Full information on setting the ports is contained in the P3 Technical Manual.



Station A		Station B	
Port 1	Port 2	Port 1	Port 2
RS232 or RS485	RS232 or RS485	N/A	N/A
RS232 or RS485	RS232 or RS485	RS232 or RS485	RS232 or RS485

Fig 3: Pakscan P3 master station serial communications

The communications may be organised in many ways. A single P3 master may be linked to the host system in the same way as the P3F described previously. When a hot standby master station is used, the variations are more complex.

When redundant communications are used, the two data lines should access both the A and B master stations. In a complex multi-drop redundancy, care is needed in alarm handling. Access is to Port 1 and Port 2 on both units A and B. The data behind these ports is designed to allow communication to two separate host systems, or a single host on redundant highways. The two ports are effectively handled by two independent data bases each fed with information from the connected actuators. When they are both connected to the same host system it is recommended that the two ports are linked for alarms by setting the ‘Alarms - Linked’ option for the Current Loop module Host Settings. This ensures that all alarms are accepted on both ports if alarms are accepted on one only.

1.2.3 Host communication connections for hot standby P3 master stations

The P3 hot standby system has two master stations operating one field network or Pakscan 2-wire current loop. One master station PS710 module will be the main or primary unit controlling the network and the other will be the standby unit monitoring the performance of the main unit. Either unit can be in either mode although they cannot both be in the same mode, i.e. either master station A or master station B can be the main or primary unit whilst the other is in standby mode.

Each module has two communication ports as described above. The configuration option for hot standby mode includes a choice for host communications, i.e. ‘Active’ or ‘Passive’ when the module is in Standby mode. This is a selection for the communications option of the PS710 module itself, rather than the hot standby pair (the setting is located in the M/S Settings menu page). The choice determines how the module responds to host communications when it is in standby mode, and each module has a separate choice for both of its host ports. If the module is set to ‘Passive’, it will not respond to messages from the host when it is the standby unit, however, it will reply when it is the main unit. When the unit is the main module, it will always respond to all instructions.

When the module is set to ‘Active’, it will respond to messages from the host irrespective of whether it is in main or standby mode. When ‘Active’ is selected, care must be taken to ensure that valve commands are addressed to the module that is in main mode as the module in standby mode is prevented from controlling the field network or Pakscan current loop.

It is also important to note how control passes from one module to the other. The command to change master will reverse the mode of the two units and the instruction can be instigated either from the keypad or via the serial communications link. Note that it is the only command actioned by a standby unit which is set to ‘Passive’. (The keyswitch can also be used to make either station A or station B the main module). A standby unit will change automatically to the main unit when it detects that its partner has failed or that it no longer has control.

Station in Primary/Main Mode	**Station in Standby Mode Comms port set Active**	**Station in Standby Mode Comms port set Passive**
Controls the field network and 2-wire current loop	Does **not** control the field network and 2-wire current loop	Does **not** control the field network and 2-wire current loop
Responds to all host messages and actions all commands	Responds to all host messages, does **not** action any commands	Does **not** respond to any host messages, only actions a change-over command
May be remotely commanded to change to standby mode	May be remotely commanded to change to main mode	May be remotely commanded to change to main mode

❑ Single host - RS485 (2-wire) communications

RS485 communications allow the user to multi-drop several devices on one data highway. One host port can be connected to up to 32 master station RS485 ports, (more if repeaters are used). The '2-wire' description refers to the communication highway using the same single pair of wires for both transmitting and receiving data. The P3 master station only supports 2-wire RS485 communications. The highway extension can be simplified by selecting the Cross Connect option on the chassis DIP switches.

With this configuration, as all master station modules are connected on the same highway, both station A and station B of each hot standby pair will receive data from the PLC. If both station A and station B were to reply together the resultant data at the PLC would be unintelligible and therefore rejected. To avoid this situation and have only either station A or station B replying **both** modules should be set to 'Passive' on the serial port being used (Port 1 or Port 2).

If the module in main mode fails, the standby unit will take control automatically. However, if the communication highway between PLC and the module in main mode fails, there will be no automatic switch over. The PLC will be unable to command the change-over of main to standby and vice versa, i.e. control any of the master stations beyond the failure point will not be possible.

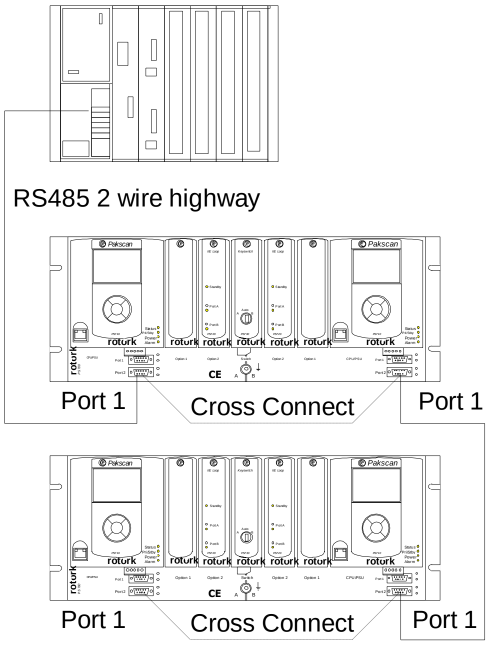


Fig 4: 2-wire RS485 single highway

❑ Twin host - RS485 (2-wire) communications

There are incidences when there are two host systems connected to one or more hot standby master stations, e.g. PLC and In-Vision. This method offers redundancy of the host controller and the master station units. In this case, two RS485 highways are needed, using both the stations' communication ports from each module. The Cross Connection DIP switches are used for highway extension.

With this configuration **both** the ports (port 1 and port 2) on each station should be set to 'Passive' in order to avoid the situation where two, (station A and station B), units reply at once. However, if a PLC fails or the communication highway fails between one PLC and the master stations, that communication will be lost. The second host (In-Vision) would continue without loss of master station control. As each host requires full access to the alarms present, the port alarms should be set to 'separate' in this configuration.

Note that there is no prioritisation of control via the host communications ports, i.e. commands from both PLC and In-Vision have equal weighting.

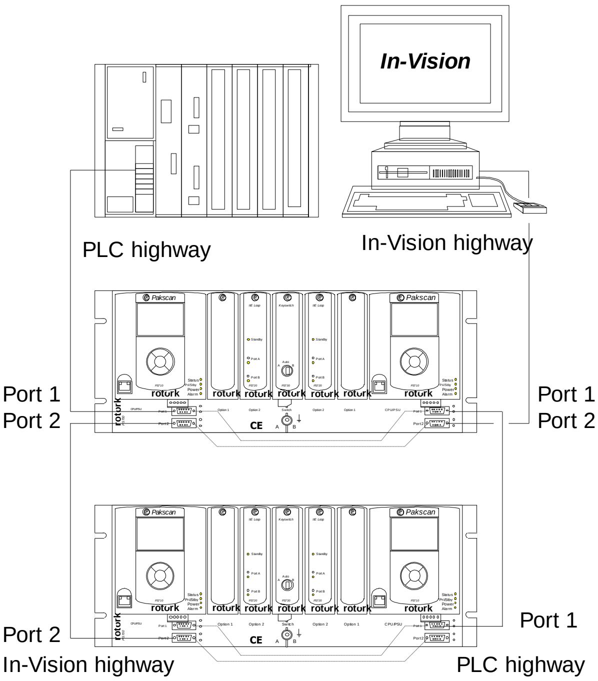


Fig 5: Twin Host, single RS485 comms

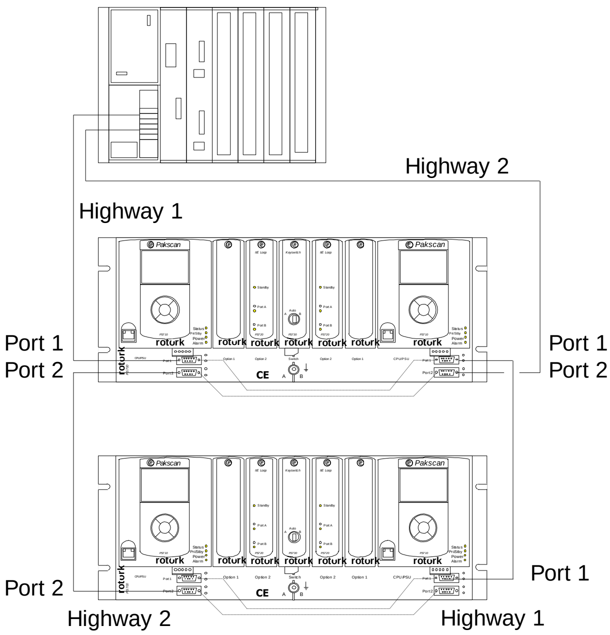


Fig 6: Single Host, dual redundant RS485 comms

❑ Single host - dual redundant RS485 (2-wire) communications

This configuration is similar to the dual system described above although in this case there is only one host, which has two interfaces. This method offers true redundancy of the master stations, host interface, and serial communications cabling. As before each module requires the 'Passive' option to be selected. The alarm handling also requires the port alarms to be set to 'Linked' so that the host system does not collect repeats of the alarms when changing the comms line in use.

❑ Single host - dual RS232 communications

RS232 communications are a point to point means of communication; i.e. one port on the host system will be connected to one port on the master station. Dual data highways from the host are required when using RS232 communications to a hot standby master station. The two RS232 ports on the host connect to one on master station A and one on master station B. This connection method can only be used where there is a single field network or 2-wire current loop and master station to be supervised. RS232 does not permit multi-drop communications to a number of master stations.

With this configuration, the PLC determines which of its output ports and highways it is using and therefore which unit it is talking to, i.e. there are separate paths for station A and station B communication links to the PLC. Consequently both modules should be set to 'Active', so that the PLC always receives an answer irrespective of which highway it uses. Note that only the unit in main mode will action any commands issued by the PLC, so the PLC needs to determine which of units A and B is the main and which is the standby.

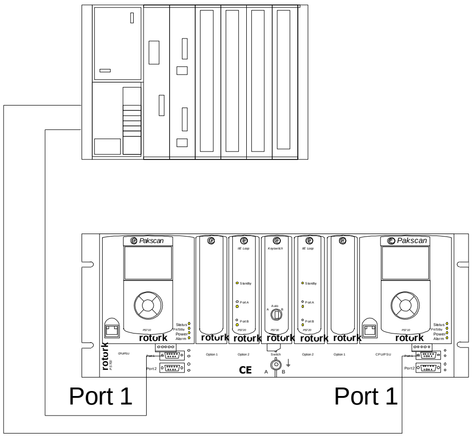


Fig 7: Single Host, dual redundant RS232 comms

If the main mode unit fails, the standby unit will take control automatically. However, if the communication highway between PLC and the main mode unit fails, there will be no automatic switch over. The PLC should read the master station data to determine which side is in control and then issue a suitable command the change over the main to standby if required.

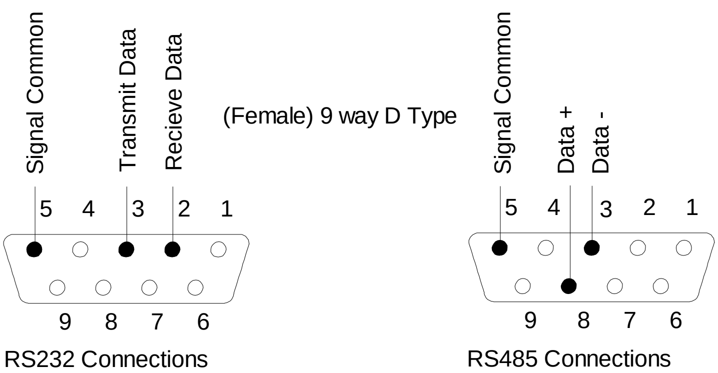
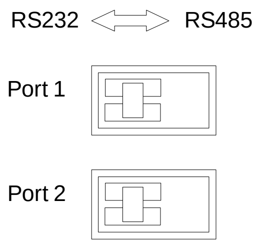


Fig 8: Pakscan 3 master station serial communications connections

General guidance	
1.	Both station A and B must be set to the same options with regard to all settings including the standby active/standby passive option.
2.	When using an RS485 highway, care must be taken to ensure that it is correctly terminated at both ends (and only at the ends).
3.	If the host system wishes to change over control of the loop such that master station A changes from main to standby or vice versa, it must do so by sending the change over command to either the main unit or the standby unit.

1.2.4 P3 master station – Port Function

The P3 master station chassis has DIP switches underneath the PS710 CPU module for setting the type of serial port that is presented at the port connectors.



The two DIP switches allow each port to be selected between RS232 and RS485. For RS485 slide the appropriate Port switch to the right, for RS232 they should be on the left.

Each of the two ports may be set independently.

Fig 9: Port Function Switches shown in RS232 position

1.2.5 P3 master station – RS485 termination

The master station chassis includes the DIP switches to select line termination and pull-apart resistors on the comms lines. All RS485 highways should be terminated correctly and when two wire data transmission is being used the possible errors in data that can occur during line turn around can be overcome with pull-apart resistors. Care must be taken to fit these resistor networks on the ends of the lines only; consequently the best location is at the PLC/DCS end of the multi-drop data highway. Prior to dispatch from Rotork these switches are normally set ‘Off’ to disable the resistors.

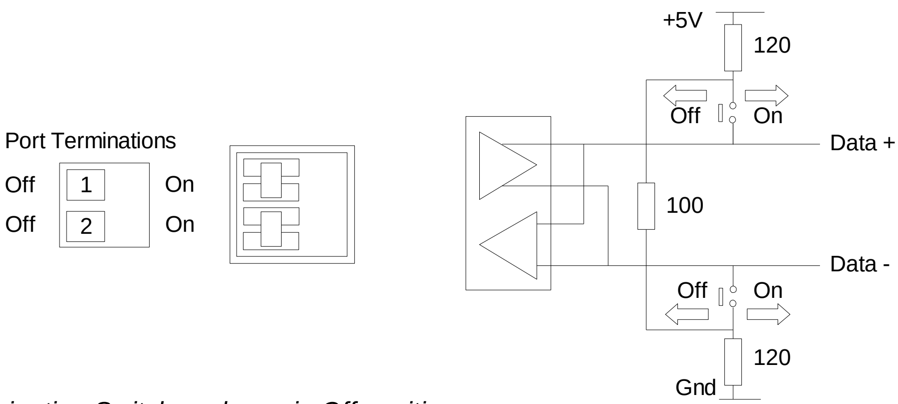


Fig 10: Port Termination Switches shown in Off position

The two DIP switches are used to connect end of line termination resistors and biasing resistors to the RS485 network. All RS485 network highways should be terminated at **both ends of the highway**. Each port can be terminated independently.

1.2.6 P3 master station – RS485 Cross Connection (Hot Standby Systems)

The cross connection DIP switches allow the serial ports on the two sides of the hot standby master station to be connected together as a multi-drop pair. The port should only be cross connected when either Port 1 and/or Port 2 are set to RS485. If a port is cross connected then its associated “A Only” and “B Only” feedback switches must also be set to the Cross Connected position (moved to the right). The feedback switches are used to inform the master station and modify the default set up options for a cross coupled port to “standby passive”.

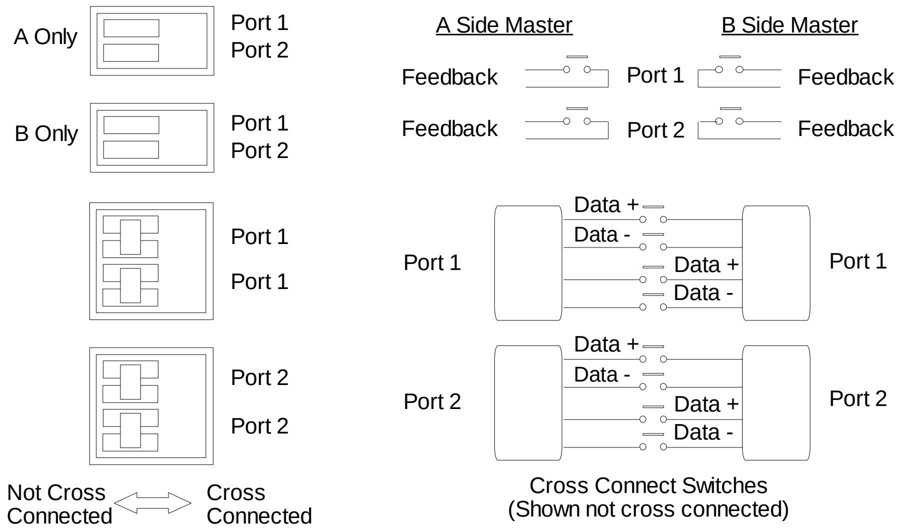


Fig 11: Port Cross Connection and Feedback Switches shown in Not Cross Connected position

1.2.7 RS485 termination – Pakscan P3F master station

The Pakscan P3F master station has pull apart and termination resistors that can be selected for each port by setting the DIP switches in the correct positions. All highways should contain at least one pair of pull-apart resistors and at the ends of each highway a termination resistor should be present. Termination is not required unless the P3F is at the end of a highway.

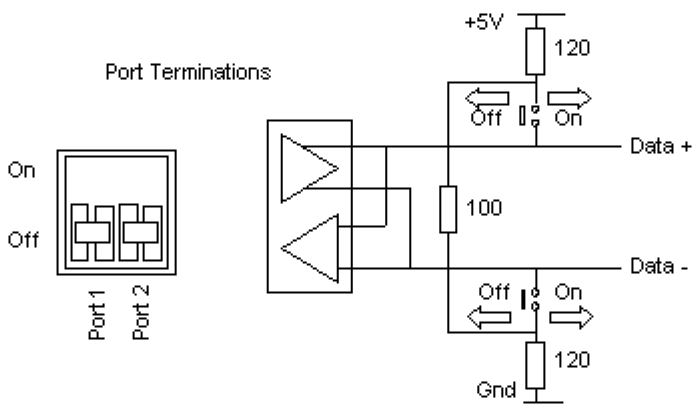


Fig 12: Pakscan P3F master station terminating resistors for RS485 2-wire highway

1.3 Ethernet Communications to Pakscan master stations

The Pakscan P3 and P3F master stations include dual Ethernet ports for communication by Modbus TCP/IP or to the internet.

1.3.1 Ethernet Connection

Two Ethernet ports are available for connection to host DCS or PLC systems. A third Ethernet port is also available for connection to a laptop computer for configuration purposes. The master station is ready to use with Ethernet and Modbus TCP protocol for the DCS to access data and control the actuators on the field network. The IP address is already set and can be changed during setting up the master station

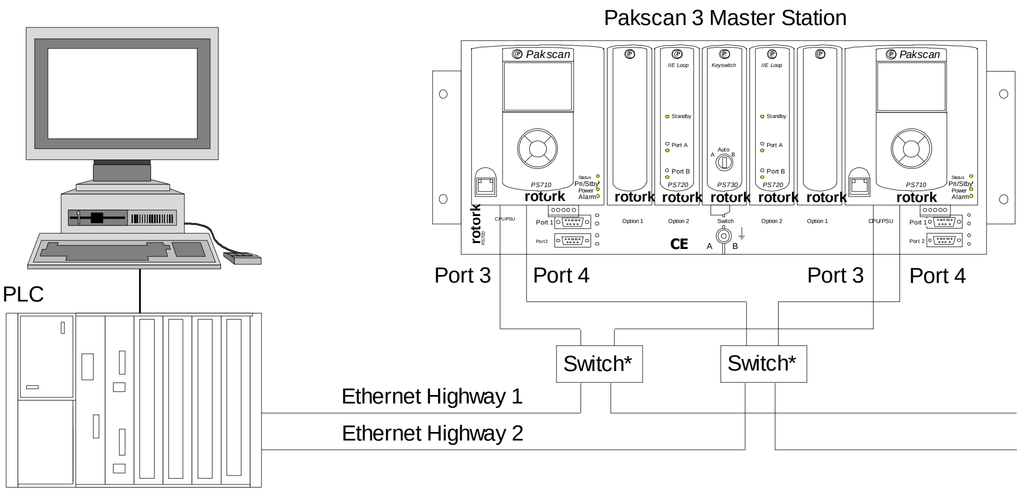


Fig 13: Ethernet, dual highway, from hot standby P3 master station to PLC

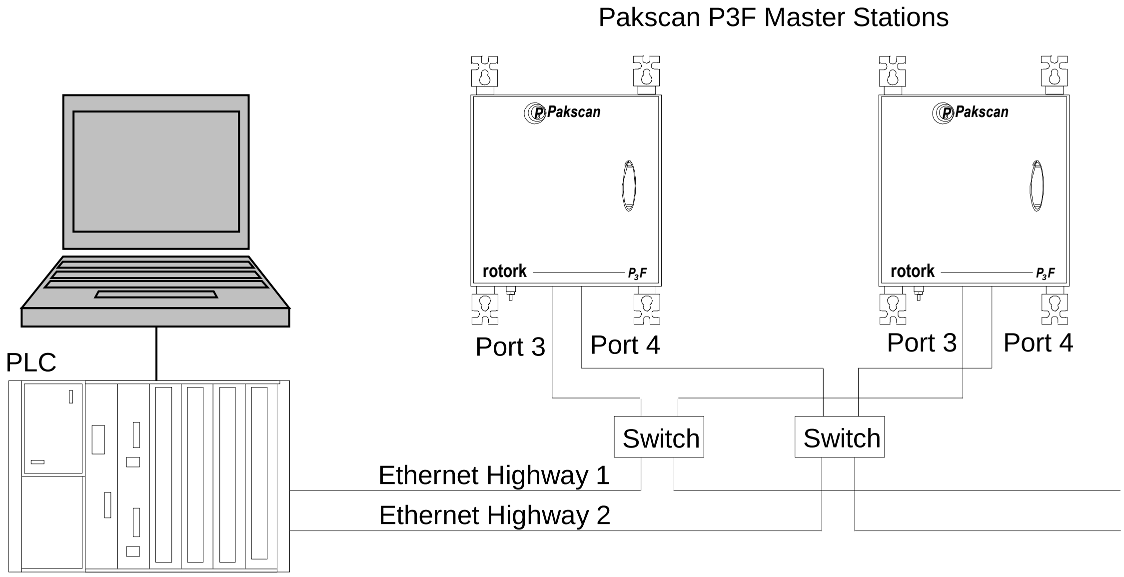


Fig 14: Ethernet Highway from PLC to Pakscan P3F master station

* If Port 3 and Port 4 are being utilised at least one switch must be a managed switch and support either Spanning Tree Protocol (STP) or Rapid Spanning Tree Protocol (RSTP).

❑ Setting-Up the Ethernet Comms

Ethernet connections require 10/100BaseT Ethernet Switches to connect the system together. Patch cords connect the ports on the master to the Switches. Independent highways are possible by using separate switches on each highway.

The Pakscan master station defaults to the same IP address on both the ports.
P3 Only: The same address can be used on the A and B master stations. It is possible to change the IP address on either master station, but the two ports always have the same address. When the A and B stations both use the same IP address it is important to set the **Standby Action** to **Passive**.

The two Ethernet inputs are logically combined within the P3 master station. This means that Alarms read over either highway are effectively read over both and there is only one alarm data base. It is not recommended to use the two highways to access different host systems.

The recommended highway setup should follow these guidelines

- Use two main data highway busses, both of which connects to all the master stations
- The master is left with a Static DHCP port setting
- **P3 Only:** Each hot standby pair has the same IP address on its port 3 and port 4
- **P3 Only:** The Standby action is set to passive (default is active)
- Keep the number of host connections below 10 (The master station can serve up to 10 simultaneous host connections).

With this arrangement either PLC port can always communicate with the master station in control of the loop. Heartbeat data requests on the second highway will always be acknowledged with a response.

DHCP	Static			
Default IP address	10	200	1	1
Subnet mask	255	255	255	0
Standby Action (P3 only)	Set to Passive			

2 DATA INTERPRETATION

This section describes the data organisation and meaning of the various data bits found in the protocol data for the Pakscan 3 Current Loop option.

2.1 Master station data

The Pakscan 3 Current Loop option perform various self-checking routines and control the 2-wire current loop. The status of the master station itself is available for interrogation by a host DCS over the serial interface. The relevant registers and the location of the data within them, together with the methods for reading and writing to these registers is detailed later in this document. The data is always related either to a field unit on the 2-wire current loop or to the master station module or the Current Loop module.

This section provides the interpretation of the information reported by each data bit or register in the master station area of the data base and the available registers to which system instructions may be written. Note that the Pakscan P3F does not have hot standby capability and the data bits relating to this feature are not applicable.

Information about the meaning of the information reported in the field unit area of the data base is contained in the individual field unit instruction manuals. A brief overview of these data bit interpretations follows later in this manual.

2.1.1 Data base segregation

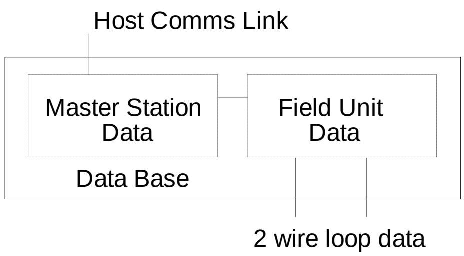


Fig 15: Data base segregation

Whichever data base Interface is chosen it will contain at least two sections. One of these is termed the Master Station Data Base, whilst the other is the Field Unit Data Base. The Field Unit Data Base contains the information from the attached devices on the current loop network, whilst the Master Station Data Base contains the system data.

- ❑ **Logical and physical master stations**

The P3F master station has only one physical and one logical master station.

The physical P3 master station (Current Loop access) may contain up to four logical master stations as described in the Generic and EPLCG Interface section. The logical master stations each have a different Modbus slave address and contain data about different groups of field units on the current loop. All of these logical master stations contain the same master station data. A command or write instruction to one is equivalent to writing to them all and all transactions should take place using the slave address of the base unit only. There is no need to read or write to more than one of them to achieve a read or write for all of them.

In the case of the Yokogawa and APM-SI interfaces, there is both one logical and one physical master station covering all the connected field units on the current loop.

2.1.2 Master station data description

The available data depends on the interface chosen; this section describes all the data bits. When a bit is present or asserted it will be a logical 1.

Auto-Loopback Occurred	This bit is an alarm bit that is present if a fault is detected on the current loop network and an automatic reconfiguration of the loop occurred.
Common Actuator alarm	This data is an alarm bit that is present if any field unit on the loop has its MREL data bit present. MREL is only available from Rotork actuator field units and is the state of the 'monitor relay'. It indicates that the actuator is not available for control. (The actuator field unit 'MREL' bit is described in the actuator field unit manual.)
Common Field Unit alarm	This data is an alarm bit that is present if any field unit on the current loop network has any of its alarm bits present, including those field units connected to other logical master stations within this physical station. Thus, this alarm is present whilst any one field unit is actually in alarm or if there is a field unit off line and is therefore unable to communicate. (The field unit alarm bits are described in the field unit manual.)
ESD Mode	This bit is present if a contact input wired to the ESD terminals of the master station is open circuit and the remote contact input ESD facility is enabled in the master station setup.
Loopback in Progress	This could be named 'reconfiguration in progress' and is present whilst the master station is in the process of reconfiguring the current loop network. It provides an indication that the master station is 'busy' and the field unit data may not be true during the reconfiguration time.
Loopback in Use	This signal is present whenever the master station has found a loop fault and is operating with Loopback asserted on the field cable. Note that under this condition loop doubling is not available.
Power On Reset	This bit is an alarm bit that is present if the system power has been lost and restored.
RAM test fail	This bit is an alarm bit that is present if the master station RAM test produces an error. The memory is tested periodically.
ROM test fail	This bit is an alarm bit that is present if the power up test of the EPROM in the station fails.
Serial Control Enabled	This bit is present if the master station can be controlled serially. (This signal is always present.)
Watchdog fail	This bit is an alarm bit that is present if the processor watchdog trips.

2.1.3 Alarm handling

Some of the data bits are described as ‘alarm bits’. These represent information that can be considered as an alarm. In each case the alarm bit is latched and it will not clear until the data has been read by the host, a serial data alarm accept has been issued to the master station and the source of the alarm has returned to normal.

2.1.4 Data relevant to hot standby systems

This data only has a true meaning for a P3 master station with a hot standby fitted. The left hand ‘A’ station is always the designated Main unit.

0 = A side, 1 = B side	This bit indicates ‘A station / B station communicating’. It is used to determine if the communication is to the left hand or right hand station (A or B) of a standby pair. The left hand ‘A’ unit is the designated ‘Main’ station. The data bit will be a 0 if the communication is to the ‘A’ station on the left-hand side. It is a 1 if the communication is to the B station on the right hand side.
Master Station ‘A’ OK (main unit)	This bit is present if the Main, A side, left hand, unit is functioning correctly.
Master Station ‘B’ OK (standby unit)	This bit is present if the Standby, B side, right hand unit is functioning correctly.
1 = Primary, (In Use), 0 = Standby, (Out of Use)	This bit is used to indicate if the station that is currently communicating on the serial link is in control of the current loop network or not. A ‘1’ indicates communication to a station that is in Main mode, whilst a ‘0’ indicates it is in Standby mode.

2.1.5 Additional data available using Generic / EPLCG Interface

FCU Failure Count	This is a series of registers containing data showing the absolute number of communication failures (including retries) for every connected field unit on the current loop. The maximum count for a field unit is 256 failures after which its counter rolls over to zero and starts again.
FCU Map	This is a series of registers containing the field unit addresses in the order in which they are connected on the 2-wire current loop
FCU on Loop to Scan Up To	This register contains a number equal to the master station setting for the highest FCU address to look for.
FCU's Connected	This register contains data to show the number of FCU's communicating on each of the current loop network ports. In normal circumstances all the FCU's will be connected to Port A. However, if there is a cable fault, then some will be connected to Port A and some to Port B. The numbers indicate the position of the cable fault.
Field Unit Address Fault	This register holds data about the position and address number that is found to be at fault during configuration.
Loop Baud Rate	This register contains a number that may be decoded to give the loop baud rate setting.
Loop Configuration Process	This register changes its value as the master station proceeds through the stages used in configuring the loop.
Loop Fault Information	This register holds data indicating loop faults that may be present and preventing complete loop configuration. Additionally it includes the last system reconfiguration code and the loop fault type.
PS720 Current Loop Card Software Version Number	This register contains a number collected from the loop card EPROM to indicate the software version that is in use.
Loop Test Result (%)	This register holds a hex number for the result of the last loop test in percent.
Loop Test Speed	The number in this register relates to the last Loop Test performed and the speed at which it was done.
Command Filter Timeout	This register contains the timeout setting for the command filter.
Master Station Type Number	This register contains a number that identifies the type and capacity of the master station.

2.1.6 Command description

It is possible to issue instructions to the system over the serial interface. These commands are directed either at a particular field unit or at the system as a whole. The commands relating to the system are as follows.

Alarm Accept	Energise this coil to issue an alarm accept to any alarm in the data base (field unit or master station) which has been read in a previous transaction. There is only one 'accept' coil for alarms, though each serial port, the Ethernet ports and the LCD on each station, have their own accept system and virtual data bases. Any alarms will only clear from the data base if they are read over the serial link or Ethernet link prior to being accepted and the alarm condition returns to normal. Note that if the alarms are 'linked' then the Alarm Accept accepts all the alarms on the linked the data bases
Change Main / Standby	Energise this coil in either the Main unit or Standby unit to cause the system to transfer control between units. A 'Main' unit may be switched to standby, or a 'Standby' unit may be switched to main. Note that this command is operative even when sent to a unit in Standby Mode that is set to 'Standby Passive'. It is the only message obeyed by a unit in this condition. 'Standby Passive' is the normal setting for a master station on a multi-drop system.
ESD Command to Loop	Energise this coil to cause a global emergency shut down instruction to be issued over the 2-wire current loop to all the field units. (The command will only be issued to the loop if the ESD facility is enabled in the master station setup.)
Reconfigure Loop	Energise this coil to cause the reconfiguration of the current loop. This command can be used to reset the system after the repair of a cable fault.

2.2 Field unit data

Field unit data is made available from the master station. The master station collects the data asynchronously from the connected field units in the actuators on the 2-wire current loop. The field units vary depending on the actuator in which they are fitted and the data available to report.

- IQ3, ROMpak, CVA and CMA contain the common protocol field unit
- IQ1, IQ2 and IQT actuators contain the IQ mk1 field units
- IQ analogue field units can only be fitted to IQT actuators in addition to the IQ mk1 field unit, IQ3 variant offers an option to include 2 analogue inputs to the same IQ field unit address by including extra analogue option cards.
- A, AQ and Q range actuators have Integral type field units
- General Purpose field units are mounted away from the devices they control and can be set to Actuator or General Purpose mode
- EH and SI actuators contain a derivative of the IQT field unit

In the interface sections that follow a series of abbreviations are used for the data bits. The information on the exact reason for each data bit to be present is explained in the individual instruction manuals for each field unit type. The list below provides a brief explanation of each of the major data bits listed. Note that not all the bits are available from all the actuators and the list is a definition table only.

All data is present (1) when the state is true.

IQ Range refers to IQ1, IQ2, IQ3 and IQT.

2.2.1 Digital status bits

ALARM	There is an alarm present on this field unit
AUX 1 to AUX 4	Refers to the digital inputs available from an IQ Range actuator
BATT	The IQ Range actuator battery is low
DIN1 to DIN8	Digital inputs 1 to 8 on a general purpose field unit
EXT	The external contact on an AQ or Q actuator is closed. This is not available if the actuator has to report actual percentage position data
LBON	Loopback on asserted on this field unit
MOVE	Actuator centre column moving
MRO and MRC	Motor running in the open (MRO) / close (MRC) direction
MRUN	The actuator motor is running
NALARM	There is a new, unread, alarm on this field unit
OAS and CAS	The actuator open limit switch (OAS) and close limit switch (CAS) made
Remote	Actuator local/remote selector in the remote position
STOP (reported data)	Actuator stationary in mid position
TRO and TRC	Actuator travelling towards the open (TRO) position or closed (TRC) position
Travelling	Actuator in motion
BAKPWR	CVA Under battery back-up power
BAKBATT	CVA Back-up battery low indication

2.2.2 Alarm data bits

AUXOR	On an IQ Range actuator this indicates that one of the auxiliary inputs is active
CNA	Actuator remote control not available because the local/local stop/remote selector is not in the remote position
COMMS	Communication failure between master station and field unit
EOT	Actuator continues to run the motor beyond the end of travel limit switch
LOCAL	IQ Range Actuator local/local stop/remote selector in the local position
LSTOP	Local/local stop/remote selector in the Local Stop position
MEMF	Memory chip fault
MMOVE	Manual movement of the valve detected
MOP and MCL	Actuator has reached the open (MOP) or close (MCL) position due to manual movement of the handwheel. MOP is manually opened, MCL is manually closed
MOPG and MCLG	Actuator has left the close position (MOPG) or the open position (MCLG) due to manual movement of the handwheel. MOPG is manual opening of the valve and MCLG is manual closing of the valve
MREL	Actuator monitor relay tripped. The monitor relay is a combination signal for the thermostat, local stop or local signals being present in electric actuators. In hydraulic or pneumatic actuators the signal is a combination of loss of pressure or local or off selected on the local/remote selector
POWR	Field unit power on reset alarm
SFAIL	Actuator fails to start or stop when expected to do so
THERM	Actuator thermostat tripped
FAULT	EH or SI actuator general fault indication
VJAM	Valve jammed at end of travel causing a torque trip
VOBS	Obstructed valve causing actuator to torque trip in mid travel
VTT	On an IQ Range, EH and SI this indicates valve travel time exceeded

2.2.3 Field unit commands

The actuators on the loop can be commanded to open, close, or stop by writing to the appropriate location in the data base. In all cases, there is no requirement to cancel a command to remove it. A new command will always remove any existing commands.

IQ Range, CVA, EH, SI and CMA actuators are capable of adopting an analogue position (0-100%). Note that A, AQ, Q and ROMpak actuators may require additional parts before they can provide this capability. Writing an analogue position to the appropriate register cancels any existing command. Writing an open/stop/close command will cancel any analogue setting previously made.

General purpose field units can have their relay outputs operated (energised or de-energised) and additionally they have an analogue output signal. Similar to actuator commands, with the GPFCU relays there is no requirement to cancel a command to remove it unless the relay outputs have been set to ‘Maintained’ action within the field unit.

OPEN	Causes the actuator to move to the open position
STOP	Causes the actuator to stop
CLOSE	Causes the actuator to move to the close position
ESD	Causes the actuator to adopt the internally set Emergency Shut Down position (which may be open. close or stay put)

Position Control	Writing a value to the valve desired position causes the actuator to adopt the desired position. This method of intermediate positioning must be used for modulating duty. The use of a 'move and stop' type of control will not be successful as the current loop network timing is not deterministic
RLY1 to RLY4	Writing to these locations causes the relay to energise or de-energise depending on the data written. In general only a GPFCU will consider the commands as operating relays. All other field units have logic outputs to the actuator internal controls

- ❑ **Command Filtering**

The Pakscan 3 master stations includes a command filter to reduce the replication of commands to a field unit over the current loop interface. If a command sent over the serial or Ethernet links is repeated within the time set in the filter, the second command will be discarded and only the first command will be actioned. The effect is to remove unwanted field network commands from the system and free up the maximum available time space for other valid commands or data retrieval from the field.

2.2.4 Field unit analogue inputs

There are several analogue inputs available from field units. Not all signals will be reported by all actuators and the tables for each protocol indicate what is available from each type of actuator. In particular A, AQ, Q and ROMpak range actuators cannot report valve position unless they are fitted with a potentiometer.

Valve position feedback	Reports the actual valve position as a percentage of full travel
Pulse input	This register from a GPFCU contains a counter value that increments on receipt of inputs to DIN1
12-bit analogue input 1 and 2	On GPFCU's, the IQT (or IQ1, IQ2) Analogue field unit and IQ3s with analogue input cards fitted there are two registers that report the value of the analogue input connected. These are termed '12-bit' since the input signal is resolved to 12 bits (1 in 4096). The actual register value will vary in accordance with the input signal over a range that depends on the protocol selected
Historic torque profile	On IQ Range and CVA, these registers have torque values measured at various positions across the stroke of the valve, for the EH and SI these report pressure
Instantaneous torque	On IQ Range and CVA, this indicates the last torque value, for the EH and SI this reports pressure

3 MODBUS SPECIFICATION

3.1 Electrical specification

Serial data Line Electrical Specification	RS485 or RS232
Ethernet	10baseT

3.2 Outer protocol

Modbus Transmission Mode	RTU (8-bit binary data)
Ethernet	Modbus TCP/IP Server

3.3 Serial Data

Baud Rate	
P3 and P3F master stations	2400, 4800, 9600, 19200, 38400, 57600, or 115200
Number of bits per character:	
start bits	1
data bits (LSB first)	8
parity (configurable)	Odd, Even, None, Always 0
stop Bits	1
Error checking	CRC

Modbus message turn round time

Minimum period between request and response	2400	16.00	mSec
(3.5 character period $t_{3.5}$ according to the	4800	8.00	mSec
Modbus Serial Line Implementation Guide V1.02,	9600	4.00	mSec
fixed at 1.750 mSec above 19200)	19200	2.00	mSec
	38400	1.75	mSec
	57600	1.75	mSec
	115200	1.75	mSec
Maximum period between request and response		100 00	mSec

The Modbus protocol supports two forms of data access Discrete (or Bit) and Register addressing. The Function Code determines which form of addressing is to be used.

3.4 Overview of the design

Modbus commands may be transmitted to the Pakscan 3 master stations via Ethernet, RS232 or RS485 physical interfaces. Up to 32 master station modules may be linked on a single RS485 highway to one host port. Each Pakscan 3 master station Current Loop Interface permits up to 240 field units to be connected to it. The Pakscan P3F master station supports up to 32 field units

The master station responds as a MODBUS SLAVE or SERVER to messages from the host. The serial ports can each use different data bases, whilst the two Ethernet ports must both use the same data base and protocol. Within the master station the Modbus address that the master station will respond to is set using the front keypad or web pages and the protocol used on the particular port is also set in the same way.

The master station maintains a sectioned data base covering all its connected field units, and the host reads this data without the need to access field units directly. The master station main module performs the functions of Data Concentrator and interface whilst the Current Loop module is the 2-wire loop master.

Within the field units, data is organised into processing blocks. Each block performs a specific function such as analogue scale and bias, characterised by a number of parameters. Modbus data locations within the master station Current Loop module data base relating to itself or a field unit are calculated by using the Block number, Parameter number, and field unit Address (see 4.3.3 Register and Discrete Address Formulae).

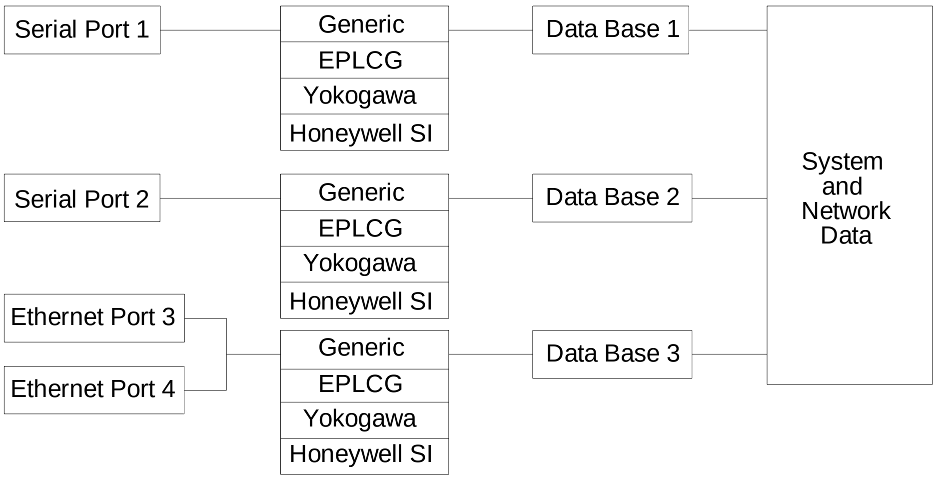


Fig 16: Data base Connections

4 GENERIC AND HONEYWELL EPLCG PROTOCOL INTERFACE SPECIFICATION

This section describes the two protocols that allow access to the maximum amount of data within the master station. The tables give locations for the data which may be read from either registers or discrete locations, or in some cases, both. The Generic protocol has access to all the blocks and parameters within the data base and is the most flexible choice. The Honeywell EPLCG protocol also allows access to all the blocks and parameters and has been specially tailored to meet the requirements of the Honeywell EPLCG gateway. Honeywell has approved this version as suitable for connection to their gateway.

On the Pakscan 3 Current Loop Option Module select 'GENERIC MODBUS' for the Generic configuration of the data base or ‘HONEYWELL EPLCG’ for the EPLCG version of the data base: the difference between these two choices is in the analogue data scaling only. Generic uses 16-bit 2’s complement and EPLCG uses a 12-bit value in the register.

Care must be taken to ensure that the correct protocol is routed to the port being used for the application concerned. Rotork’s own In-Vision system, for example, uses the Generic Modbus data base. The Modbus address is used to gain access to the correct section of the data base for the field unit whose data is to be collected. For a P3F master station there is only one address to cover all its field units, but with Pakscan 3 and the Current Loop module the Pakscan 2 base address does not cover the whole range of field unit addresses. The lowest, or Base, Modbus address allows access to the first 60 field units, the next address the next 60 field units and so on

4.1 Modbus unit address (Generic and Honeywell EPLCG protocols)

The first byte of all Modbus message frames is the Modbus Address byte. Modbus supports 248 addresses, of which value 0 is always allocated for Broadcast messages. This leaves 247 addresses for use by connected devices on the Modbus data link. Each master station is configured with a Modbus Base Address, which may be anywhere in the range 1 to 247.

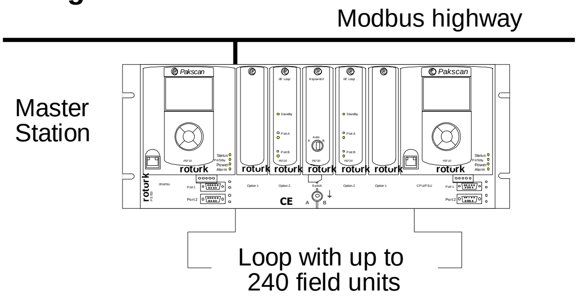
Modbus Address	Function Code	Register or Discrete Address	Number of Registers or Bits	Data Field	CRC Check
8 bits	8 bits	16 bits	16 bits	N bits	16 bits

Fig 17: Modbus transaction format

The P3F master station responds to the selected Modbus address. Each P3 master station Pakscan 2 Current Loop module will then respond to between 1 and 4 Modbus addresses depending on how many field units it has been configured to support. Physically a P3 master station is only one unit on the Modbus highway, but logically as far as the protocol is concerned it can appear to be up to 4 units. Each logical unit supports up to 60 field units.

As far as Modbus is concerned, each unit behaves as an independent slave. Fig. 18 illustrates this and Fig. 19 correlates the real field unit address with which logical master station unit it appears to be attached. Users may find that when assigning Modbus addresses for use on the network, configuring the setting of the Base address of the master station using increments of 4 will ensure future expansion space.

Physical arrangement



Logical arrangement

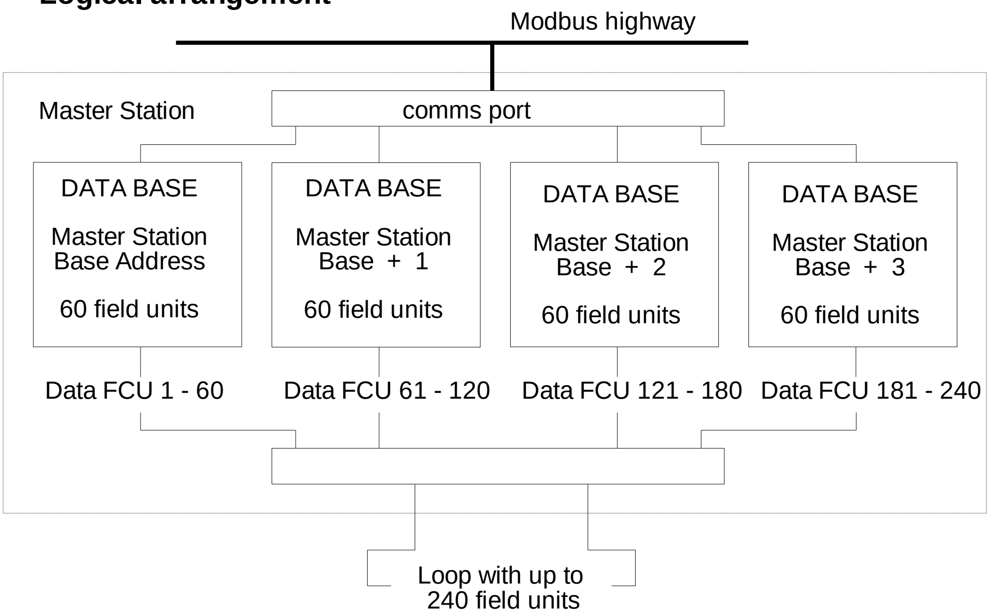


Fig 18: Pakscan P3 master station model – Generic and Honeywell EPLCG protocol

Field Unit Address	Number of Modbus Addresses Master Station Responds To	Modbus Address
1 to 60	1	Base
61 to 120	2	Base + 1
121 to 180	3	Base + 2
181 to 240	4	Base + 3

Fig 19: Modbus address organisation

Examples:
Physical Field Unit address 10 is accessed as FCU No. 10 within Modbus Base address.
Physical Field Unit address 61 is accessed as FCU No. 1 within Modbus Base address +1.
Physical Field Unit address 165 is accessed as FCU No. 45 within Modbus Base address +2.

4.2 Modbus function code support (Generic and Honeywell EPLCG protocols)

Details of Request and Reply formats are contained in the Modbus Reference Guide. The following section deals with how Pakscan 3 master stations interpret the commands. Fig 20 lists the supported Modbus commands.

Function Code	Modbus Name	Master Station Meaning	Addressing
01	Read coil status	Read master station status	Discrete
02	Read input status	Read FCU status	Discrete
03	Read holding registers	Read master station status	Register
04	Read input registers	Read FCU status	Register
05	Force single coil	Discrete output	Discrete
06	Preset single register	Register output	Register
08	Loopback diagnostic test		
15	Force multiple coils	Multiple discrete outputs	Discrete
16	Preset multiple registers	Multiple register outputs	Register
17	Report slave ID		

Error code	Meaning
01	Illegal function code or incorrect message length
02	Illegal data address (Register address invalid)
03	Illegal data value (value in data field out of range)
06	Slave Device Busy

Fig 20: Modbus function codes and error codes

To read data the function code to use will depend on whether the data is to be read as single bits or as 16 bit registers and also whether it is to be field unit or master station data. For example, code 01 reads master station data as discrete bits, whereas code 03 reads the same data as registers. Discrete and Register access read the SAME data.

For Discrete access, the Discrete address field is interpreted as a Bit offset into the data base. For Register access, the Register address field is interpreted as a Register location address in the data base.

- ❑ **Function Code 01 - Read Master Station Status (Bits)**

Function code 01 is used to read discrete (bit) data from the data base to obtain information about the master station itself.

Note: This function code is not generally supported for use in reading data from the data base for field unit information. The exception is where the gateway is set up to read the data from the actuator command open or close coils, for example prior to writing data, this is permitted by the master station. However, the coils do not physically exist and the data read back by the host is the current status of the Open and Close limit switch in the actuator (OAS for an Open command and CAS for a Close command). These signals may not reflect the state of the command coil. For example the actuator may have been opened by a system command to the open coil and then closed manually. The coil for open would be expected to be ‘on’, but the actuator will report the close coil as being ‘on’ since CAS will be present, and the open coil as being ‘off’. In addition for actuator control all the write signals become pulsed outputs at the field unit and the actuator responds to these pulse commands itself.

- ❑ **Function Code 02 - Read FCU Status (Bits)**

Within the master station, there are four sections of field unit data base, one for each group of 60 field units. Access to each section is via a different Modbus slave address.

Function code 02 is used to read discrete (bit) data from the field unit data base to obtain information about a field unit or group of field units. This function code is not supported for use in reading information about the master station itself.

- ❑ **Function Code 03 - Read Master Station Status and Read FCU Status (Registers)**

Function code 03 is used to read register (16 bit) data from the data base to obtain information about the master station itself. [This function code may also be used to read field unit data as Holding Registers in the same way as function code 04.]

- ❑ **Function Code 04 - Read FCU Status and Read Master Station Status (Registers**

Within the master station, there are four sections of field unit data base, one for each group of 60 field units. Access to each section is via a different Modbus slave address.

Function code 04 is used to read register (16 bit) data from the field unit data base to obtain information about a field unit or group of field units. [This function code may also be used to read master station data as Input Registers in the same way as function code 03.]

- ❑ **Function Codes 05 and 06 - Write Single Coil or Register Outputs**

Function codes 05 and 06 are used when data has to be written to the master station either for action by a field unit (such as a command to open a valve) or by the master station itself (such as accept an alarm).

Although function code 05 is legal for message transactions its effect is to write data in exactly the same locations as function code 06 (all ‘outputs’ from the master station occupy a 16 bit location). The calculation to determine the location for a data write using code 05 produces the same resultant location as a calculation for a register write using code 06. There is no support for writing to discrete data locations in the data base, all locations are registers.

If a Write request is to that part of the data base containing master station data, then the data is written directly to that register.

If the Write request is to that part of the data base relating to a field unit, then the information contained in the message is translated into a command that a field unit understands and sent to the field unit over the current loop network. The rate at which instructions are sent to the master station should not exceed the rate at which they can be sent on to the field units.

The sequence of events is:

(1) - Write command received by the Master Station
(2) - Response sent back to Host
(3) - Write message sent to Field Unit

A good response to the Host indicates that the request was received correctly, the message length is acceptable, and that the addressed field unit is on-line. It does not indicate that the write to the field unit was successful. Confirmation of a successful write comes some time later when new data is reported as a change in the main data base.

If commands are written at too high a rate then the current loop network is prevented from collecting data from the field units and the system will appear to slow down. The Command Filter provides some protection against too high a frequency of writing commands. It causes the system to ignore duplicated commands to the same field unit if the duplicate is within the time setting for the filter.

- ❑ **Function Code 08 - Loopback Diagnostic Test**

The purpose of the Loopback Test is to test the communication system between the host and the master station. Only Diagnostic sub-code 00 (Return Query Data) is supported.

- ❑ **Function Code 15 and 16 - Write Multiple Outputs**

Function codes 15 and 16 may be used when data has to be written to more than one register in the master station either for action by a field unit (such as a command to open a valve) or by the master station itself (such as accept an alarm).

Although function code 15 is legal for message transactions its effect is to write data in exactly the same locations as function code 16 (all ‘outputs’ from the master station occupy a 16 bit location). The calculation to determine the location for a data write using code 15 produces the same resultant location as a calculation for a register write using code 16. As with single instructions there is no support for writing data to discrete data locations, all locations are registers.

The master station is able to accept a single transaction multiple write message containing information to be written to a maximum of 123 registers. These instructions are then passed to a queue for onward transmission over the current loop network. The rate at which the data is written into the master station must not exceed the rate at which it can be sent on to the field units. The command filter will remove duplicated commands in the same way as for function code 01 writes.

In the case of actuator control there is never a need to write to turn a register or coil ‘off’ as the output is always treated as a pulse. If commands to turn off registers are sent these will be obeyed by the system with no actual result, the output already having turned off. The effect of sending these unnecessary commands will be to congest the communication on the current loop network.

- **Function Code 17 - Report Slave ID**

The response format is:

Byte count field	- 6
Slave ID field	- 40
Runlight field	- 255
Device dependent data (4 bytes)	- HW version (16 bits)
	- SW version (16 bits)

- **Error Codes 01, 02, 03 and 06**

Error code 01 will be presented back to the host if the function code in the data message is not one of those supported by the master station, or if the message length is incorrect.

Error code 02 will be presented back to the host if the Data Address is illegal; or if the write command is a multiple write (code 15 or 16) where the number of coils or registers exceeds the amount acceptable.

Error code 03 will be presented back to the host if the value contained in the data query field is illegal.

Error code 06 will also be sent back to the host if the master station has insufficient buffer space to handle the write request to coils or registers in a single transaction. Buffer space will become free as the writes are issued to the loop and field units.

4.3 Data base access (Generic and Honeywell EPLCG protocols)

The total data base for the Pakscan system is distributed across all the connected master stations. Each master station contains data base records relating to itself and the field units on the current loop connected to it.

4.3.1 Data Organisation

The data base comprises a series of records organised into Blocks and Parameters. Each parameter contains 16 bits of data. There are 32 Blocks each of 8 Parameters associated with data about the master station itself and 32 Blocks each of 8 Parameters for each field unit on the current loop.

The data to be found in each record is listed in section 4.5 for master stations and in section 4.6 for the field units.

4.3.2 Data Read Requests

If the request is for several registers, the address defines the start point for a group of Blocks and Parameters. The contiguous records in these registers are either associated with the master station itself, or with a GROUP of field units. This is particularly useful to collect, for example, the Alarm information from all field units connected to one master station in a single Modbus transaction. The alternative is to collect it with multiple transactions, one for each field unit address in use.

4.3.3 Register and Discrete Address Formulae

The following formulae allow discrete and register addressing to be calculated. Section 3.5 and 3.6 should be referred to, to determine the meaning of particular bits and parameters.

To use these formulae, first decide which 'bits' and 'registers' of information need to be collected, and which need to be written to. This will provide Field Unit, Block, Parameter, and Bit numbers that can be used in the equations. Note that the Modbus address for the particular master station also has to be known. (The FCU addresses will all be in the range 1-60 even if there are more than 60 field units connected. The master station address increments for each successive group of 60 field units.) Next, decide if register or discrete reads and writes are to be used and then determine the function code applicable. Finally, calculate the relevant start point in the data base using the information below.

Modbus Slave Address = Master Station base address (for physical FU 1-60)

= Master Station base address + offset (for physical FU above 60)

- **Function code 01: Read Master Station Status by Bits**

  Start Discrete = (128 x B) + (16 x P) + D see Note 1

- **Function code 02: Read FCU Data by Bits – Only applies to Blocks 0 to 7**

  Start Discrete = (7680 x P) + (960 x B) + (16 x [N-1]) + D see Note 1

- **Function code 03: Read Master Station Status by Register**

  Start Register = (8 x B) + P

- **Function code 04: Read FCU Data by Register**

  Start Register = 256 + (480 x B) + (60 x P) + (N-1)

- **Function code 05 or 15: Write Master Station Data by Single or Multiple Bits**

  Start Coil = (8 x B) + P see Note 2

- **Function code 05 or 15: Write FCU Data by Single or Multiple Bits**

  Start Coil = 256 + (480 x B) + (60 x P) + (N-1) see Note 2

- **Function code 06 or 16: Write Master Station Data by Single or Multiple Register**

Start Register = (8 x B) + P see Note 2

- **Function code 06 or 16: Write FCU Data by Single or Multiple Register**

Start Register = 256 + (480 x B) + (60 x P) + (N-1) see Note 2

In the formulae above, the following symbols are used:

N = FCU address (range 1 to 60)
B = Block number
P = Parameter number
D = Data bit number within parameter (register).

- **Note 1 - Limited address range**

This formula (reading discrete FCU data) has been carefully designed to allow for those Modbus hosts that have a limited address range. Parameter 0 has the most useful data and is located near the top end of the address field.

- **Note 2 - Writing Data**

The master station recognises write requests to both coils and registers. In the calculation of the location of the coil or register to be written to, the start location is the same for both types of 'write'. The master station considers coils and registers to be the same; they are always a whole parameter. There is no support for writing to an individual bit within a parameter.

Where multiple writes are used the maximum number that may be written in a single transaction 123 registers, if the host attempts to write more than this or the internal buffer is full error code 02 is returned by the master station and no action taken.

The rate at which data is written should not exceed the rate at which it can be transferred to the current loop network.

- **Note 3 - Address offsets**

This table and the examples are for a typical Modbus implementation only. Check your system documentation carefully.

The discrete and register addresses calculated in the formulae are those which should appear in the messages as they are transmitted on the Modbus link to the master station. Some Modbus hosts offset addresses as far as the user is concerned. In such cases, the address programmed by the user into the host would be different from those calculated. Check Host system documentation carefully.

Typical offsets are:

Function Code	Offset to be added to formulae result
1	1
2	10001
3	40001
4	30001
5	1
6	40001

Examples:

1) Calculate a field unit bit address to read as 1920. Use function code 02, so add 10,001 to get the number to programme into the Host system. The result is 11921.

2) Calculate a master station bit address to write to as 5. Use function code 05, so add 1. The result, which is the number to be programmed into the host system, is 6.

- **Note 4 - FCU number in formulae**

In the formulae the FCU addresses are the offsets within each section of the virtual data base. Remember that a P3 master station appears as 4 independent slaves (4 logical units) from a Modbus point of view (P3F is 1 independent slave). Table 1 indicates how to decide FCU addresses for the calculations.

- **Note 5 - Discrete addressing range**

A discrete address needs to be 16 times the register address to access the same parameter. Because of the limited size of the discrete address field in the Modbus message, discrete addresses can only reach parameters associated with low number registers.

4.4 Notes on the use of the Generic and EPLCG Modbus protocol

Normally a Modbus host will be set up to cyclically read data representing key variables of the master station and field units. It can do this using Read Register function codes (03 and 04), and Read Discrete Status function codes (01 and 02).

Parameters may contain either digital (bit) information or analogue (register) information. For digital records the Modbus discrete addressing commands are appropriate, whilst for analogue information the Modbus register address commands should normally be used.

Register and Discrete addresses in this specification are the addresses that should be used within messages on the Modbus data link. Modbus host software ***may*** need to be configured with addresses that are 1 more than those which must appear on the link. This is due to the Host regarding addresses as starting from 1, not 0.

Reading a group of registers in one transaction is more efficient than reading one register at a time.

Support for Modbus diagnostic code (function code 08) is provided, but it is not obligatory to use it.
.
The master station includes Alarm Accept logic with respect to field unit alarms. Alarms from field units are automatically accepted by the master station (so the field unit can clear its alarm latches) and latched within the master station. These alarms must be read by the Host and then accepted (with an Alarm Accept write, to master station Block 0 Parameter 5), before they can clear.

4.4.1 Suggested Scan Cycle

The Host should be configured to scan data from the master station in the following order:

Read Alarm Status
Read Digital Status
Perform Alarm Accept
    (Only strictly necessary if any new alarms have occurred)
Read Analogue Status
    (If any analogue data is to be read)

Commands to field units may be fitted in as required.

In some applications it may be desirable to scan some items e.g. analogues, less frequently than others. This is perfectly acceptable.

4.4.2 Writing to Coils

When writing to a coil the data field to turn off the coil has to be 0x0000. As the most common device connected is an actuator whose action is controlled by a pulse output there is often no need to turn off a coil that has previously been turned on. The output command from the DCS should, where possible, use a pulse type output. When writing to a coil the data field to turn on the coil may be 0xFF00 or any other non zero value.

4.4.3 Readback of Holding Registers

The master station supports the reading of the data in the Holding Registers. This data may not accurately reflect the state of the actuator as it could have been moved manually since the data was written. The data is a 2's complement 16 bit value (0x0000 – 0x7FFF in the case of the Generic protocol or 0x0000 – 0x0FFF in the case of the Honeywell EPLCG). It is calculated from the actual value used in the data transaction over the current loop network to the field unit. When 'read back' this value may differ by 1 digit due to rounding errors in the calculation. The value sent to the field unit when the register was written will be true. To establish the actual valve position the Input Register relating to the field unit Measured Value should be read.

4.4.4 Alarm Handling

The serial communication ports on the master station are each served by their own independent data base and alarm handling. The handling of alarms on one serial port does not reflect on the alarms of any of the other serial ports unless the master station is set to Link the alarms. On a Pakscan 3 system the two Ethernet ports share another independent data base with its own alarm handling which is common to both Ethernet ports.

In the data base there is a group of 16 bits of data defined as the 'Alarm Block' for each field unit, (for example, 'COMMS' is an alarm bit). Similarly, there are System Alarms as listed in section 3.6, (for example 'RAM test fail'). These data bits will all be latched by the master station if they should actually occur. The master station will therefore capture a transient alarm and keep it in its data base ready for the host to read it.

Any latched alarm from these data areas will only be reset on three subsequent conditions. Firstly the alarm bit must be read by the host, secondly the alarm bit must be accepted by the host (this is done by issuing an 'Alarm Accept'), and finally the source of the alarm itself must return to normal.

An example of the sequence would be:

Consider an Actuator Thermostat.

1. Thermostat gets hot and trips.
2. Host reads data bit for the thermostat for this actuator
3. Host issues Alarm Accept; this is registered by the system as applicable to the Thermostat Trip alarm.
4. The data bit remains set until the actuator cools down.
5. Once cooled below the trip point the data bit returns to normal.

If the host does not read the Thermostat bit for this field unit then the bit will remain set for all time (in this data base), even though the actuator cools down. Also if the host does not read this bit any Alarm Accept will not allow the alarm to reset itself. Any alarm bit must be read before it is able to be accepted.

If the alarms are read infrequently then the above procedure guarantees that the host will register any and every alarm from the alarm block.

In addition to the alarm data for each field unit there is a 'Status Block'. These status locations also contain information about the presence (or absence) of alarms in the Alarm Block.

- **'Alarm' bit**

For each field unit the 'Alarm' bit will be present if any of the source signals used to set bits in the Alarm block are present. Notice that the Alarm bit is an OR function of any alarm before the latch for that alarm. The 'Alarm' bit is latched and will not clear until it has been read, accepted and the source of the alarm has returned to normal. In the example of the thermostat, the 'Alarm' bit will be set when the thermostat is initially tripped.

- **'New Alarm' Bit**

For each field unit 'New Alarm' will be present every time a new alarm is detected as occurring in the field unit. However, every time an Alarm Accept is issued this data bit will be reset even if the alarm itself is still present.

The purpose of this bit is to indicate to the Host that there is a new alarm to be read from the alarm block.

- **System Common Alarms**

In the master station Block 0 Parameter 0, bit 2 will be set if any field unit has its own 'Alarm' bit set. Thus the 'Common Field Unit Alarm' is set whilst any one field unit has an input actually in alarm, or if there is a field unit off line that is therefore unable to communicate.

Block 0 Parameter 0, bit 3 contains a similar common data bit derived from the actuator 'Monitor Relay' source signals.

4.4.5 Use of Alarm Bits

The host may be configured to read as many, or all, of the alarm block data bits as required. (Those that are not being used will possibly fill up as alarms over the course of operating the Pakscan system; this will not have any detrimental effect on the system.)

For the alarms that are used they will individually appear in the data locations being read, and by means of the Alarm Accept process will transfer to the host. They will also reset themselves as they return to normal providing they are read and accepted.

The 'Alarm' bit will inform the host that any alarm is present, even those not normally being identified by the host as relevant. This bit may be used by the host as a flag that an alarm is currently present on a field unit. The host must take care of latching these bits in its own alarm handling system. This bit is analogous to a contact input that is self-resetting. As it is taken from before the internal latch, it is a true statement of the current alarm situation on the field unit.

The 'New Alarm' bit may be used to indicate to the host that an alarm reading process is required, or that an ‘Alarm Accept’ write is required. The New Alarm will by its very nature disappear once the Accept is issued irrespective of the actual plant status as it has to be available for each new alarm.

4.5 Master station data base (Generic and Honeywell EPLCG protocols)

The discrete and register numbers listed in the tables all start from '0', for example register 40000 would be referenced as 0000 in the serial transaction message and not as 0001.

4.5.1 Master Station Read Only Data

This set of registers exists in each of the four 'logical' master stations that exist within a single physical master station. The Modbus address used in transactions must be the master station Base address. Reading data from any one of the addresses is the same as any other as all four contain the same data. All the location numbers listed in this appendix are decimal numbers and zero based.

BLOCK 0 – Read Only Data (accessed with Modbus function code 01, 03 or 04)			Register Location
Parameter 0 – System Status and Alarm			0
			Discrete Location
	Bit 0	Loopback in Progress	0
	Bit 1	Loopback in Use	1
	Bit 2	Common Field Unit Alarm	2
	Bit 3	Common Actuator Alarm	3
*✞	Bit 4	0 = A side, 1 = B Side	4
	Bit 5	ESD Mode	5
	Bit 6	Reserved	6
*✞	Bit 7	1 = Primary, (In Use), 0 = Standby, (Out of Use)	7
	Bit 8	Failure On Start-up	8
	Bit 9	Reserved	9
	Bit 10	Power On Reset	10
	Bit 11	Watchdog Fail	11
	Bit 12	Auto-Loopback Occurred	12
✞	Bit 13	Field Unit in Comms Fail	13
*✞	Bit 14	P3 Master Station ‘A’ OK (main unit, left side)	14
*✞	Bit 15	P3 Master Station ‘B’ OK (standby unit, right side)	15
			Register Location
Parameter 1 - FCU on loop to Scan Up To			1
		Data = XXXX, Highest FCU Address	
Parameter 2 - Loop Baud Rate Code			2
		1 = 110 Baud	
		2 = 300 Baud	
		3 = 600 Baud	
		4 = 1200 Baud	
		5 = 2400 Baud	
		6 = 4800 Baud	
Parameter 3 - Loop Scan Count			3
		Data = Counter Value	

Note: Data bits marked * are not relevant to single P3 master stations
✞ are not relevant to P3F master stations

BLOCK 0 – Read Only Data (accessed with Modbus function code 01, 03 or 04)		Register Location
Parameter 4 - Loop Fault Information		4
Bits 15-12	Loop Address Faults	
Bit 15	0 = Port A, 1 = Port B	
Bit 14	Duplicate Address found	
Bit 13	Address Too High found	
Bit 12	Zero Address found	
Bit 11-8	Loop fault type	
	5 = Loop open circuit	
	6 = Loop short circuit	
Bits 7-0	Reason why loop last configured	
	1 = Reset occurred	
	2 = FCU found at address zero	
	3 = FCU found at too high address	
	4 = Two FCU's at same address found	
	5 = Loop fault on outward wire (loop complete)	
	6 = Loop fault found on A side (LB's in use)	
	7 = Loop fault found on B side (LB's in use)	
	8 = Test of 'return' wire failed	
	9 = Loop configure command received	
Parameter 5 - Field Unit Address Fault data		5
Bits 15-8	Loop position of address fault	
Bits 7-0	Offending address	
Parameter 6 - Loop Configuration Progress		6
	1 = Wait for loopbacks 1	
	2 = Find FCU's on Port A	
	3 = Test loop	
	4 = Find FCU's on Port B	
	5 = Wait for loopbacks 2	
	6 = Loopbacks off on Port A	
	7 = Loopbacks off on Port B	
	8 = Program Baud Rate on Port A	
	9 = Program Baud Rate on Port B	
Parameter 7 – Number of FCU’s found in Loop Configuration		7
Bits 8-15	Number of FCU’s on Port B	
Bits 0-7	Number of FCU’s on Port A	

BLOCK 1 to 15 – Read Only Data (accessed with function code 01, 03 or 04)		Register Location
Parameter 0-7 FCU Map		0008
240 8-bit fields with the address of each field unit connected in the order in which they are connected, e.g.		to 0127
Block 1 Parameter 0		
Bits 8 to 15	Address of first FCU	
Bits 0 to 7	Address of second FCU	

BLOCK 16 to 30 – Read Only Data (accessed with function code 01, 03 or 04)	Register Location
Parameter 0-7 FCU Failure Counts 240 8-bit fields with the failure count for one FCU. Incremented on each comms failure. e.g. Block 16 Parameter 0 Bits 8 to 15 Failure count for FCU 1 Bits 0 to 7 Failure count for FCU 2	0128 to 0247

BLOCK 31 - Read Only Data (accessed with Modbus function code 01, 03 or 04)	Register Location
Parameter 0 – Command Filter timeout (seconds), default value depends on loop speed Loop speed: 110 baud Filter Time: 60 seconds 300 30 600 15 1200 10 2400 5	248
Parameter 1 - Master Station Type 1 = Pakscan IIE 2 = Pakscan IIS 3 = Pakscan 3	249
Parameter 2 - Master Station Type Identifies the number of channels and if unit is Hot Standby Bits 8-15 1 = single unit, 2 = hot standby Bits 0-7 0 = 32 channel 1 = 60 channel 2 = 120 channel 3 = 180 channel 4 = 240 channel	250
Parameter 3 - Loop Interface card Software Version Number (see note below)	251
Parameter 4 - FCU's in Loopback at FCU (x) and FCU (y) [zero = none present] Bits 0-7 = FCU (x) Bits 8 - 15 = FCU (y)	252
Parameter 5 - Loop Test Speed Bits 0-7 1 = 110 baud 2 = 300 baud 3 = 600 baud 4 = 1200 baud 5 = 2400 baud	253
Parameter 6 - Loop Test Result in Percent 0000-0x0064)	254
Parameter 7 - FCU Data Upload Progress 0 = FCU data upload not started 255 = FCU data upload complete Other values indicate FCU currently being read	255

Note on software version numbers:

Software version numbers should be interpreted as 4 digits stored within the register. Bits 15 to 8 contain the major release number and bits 7 to 0 contain the minor release number e.g. 0x0156 will be version 01.5.6

4.5.2 Master Station Write Only Data

Only a few addresses accept 'writes' from a Modbus host. All except those listed below return an error code. The ‘written’ data may be any value (except zero) to achieve the desired action. The master station considers all writes to be to registers, even when a ‘coil’ function code command is used.

BLOCK 0 - Write Only Data (accessed with Modbus function code 05, 15, 06 or 16)	Register Location
Parameter 3 - Reconfigure Loop Data = any non-zero value to reconfigure	3
Parameter 4 - Change Main to Standby and vice versa * Data = any non-zero value to change	4
Parameter 5 - Alarm Accept Data = any non-zero value to Accept	5
Parameter 6 - Send ESD Command on Loop Data = any non-zero value to send ESD	6

BLOCK 31 - Write Only Data (accessed with Modbus function code 05, 15, 06 or 16)	Register Location
Parameter 7 – Start FCU Data Upload Data = any non-zero value to start upload	255

Attempting to read back from these locations will result in reading the ‘read only’ data and will not give a value for these locations.

Writing a command to Parameter 4, marked *, is only applicable to a P3 master station.

4.6 Field unit data base (Generic and Honeywell EPLCG protocols)

Data within the Pakscan system is organised in Blocks and Parameters relating to specific functions or activities within the FCU on the current loop (e.g. Digital inputs, Alarms, Position control). Each FCU supports up to 32 blocks with each block containing eight 16-bit parameters though not all these blocks contain relevant data. The master station maintains the data base for all the field units on the current loop without the need for any action from the host. This section details the use of these blocks and parameters in the transfer of data between the Master Station and Host computer.

Within the field unit data base certain areas are restricted to Read Only (RO), others to Write Only (WO), and some that may be both Read and Write (R/W).

When reading data it is permissible to use either Function code 02 for single discrete bits (or multiple bits), or Function code 04 for register (or multiple registers) for any data within the data base. It is usual to use register reads where the data is an analogue value. A group of 16 bits in 1 parameter may be read as a register.

When writing data all locations are treated as registers. Function codes 05, 15, 06, or 16 may be used and the location to which data is written is always the register location. For relay outputs the data to turn off a relay is always 0000h and any non-zero value will turn the relay on. For example values of 0001h, FF00h, or 00FFh will all energise the relay.

The registers are transmitted Most Significant Data Byte first.

- **Digital Inputs**

Each field unit has direct digital inputs from the connected actuator and the status is reported in the Digital Input Block (Block 2 Parameter 0). The block also contains indication of any alarms present in the Alarm block.

- **Alarm Block**

The Alarm Block holds data about alarms either directly connected to the field unit, or logically derived from the status of all the inputs. These Alarms data bits are individually latched by the master station and will not return to normal until both the source alarm condition is corrected and the alarm is both 'read' and 'accepted' by the host.

- **Analogue and Counter Input Data**

The field unit will report analogue or counter values to the master station only when the measurement changes by an amount that exceeds the 'Deviation' setting by 1 digit, or the 'Update Timeout' period has expired. These parameters are adjusted locally within the field unit itself, and included in the system to ensure that analogue reporting only occurs when necessary. The host computer has access to the last reported analogue value in the master station.

- **Outputs**

The master station transfers both digital and analogue outputs from the host computer directly to the connected field unit. There are no registers holding output data present within the master station itself.

❑ Field Unit Types Available

IQ Range Actuator	IQ1, IQ2, IQ3 Actuator or IQT actuator
INTEGRAL	Actuator control integral to the actuator
GPFCU (GP)	General Purpose version of GPFCU
GPFCU (Act)	Actuator Control version of GPFCU
IQ Analogue	Analogue input card for IQT's only
EH	EH actuator
SI	SI actuator
CVA	CVL or CVQ actuator
CMA	CMA actuator
ROMpak	ROMpak actuator

❑ Key to Symbols Used

RO	Read Only
R/W	Read / Write
WO	Write Only
Y	Item supported for this type of Field Unit
R	Reserved for internal or future use
BLANK	A Blank entry indicates that the item is not supported for that Field Unit type. Reads of that item generally return zero.
Register Location	The decimal number of the register for FCU address 1, 2 and 60, for the parameter indicated.
Discrete Location	The decimal number of the discrete bit for FCU address 1, 2 and 60, for the parameter and bit indicated.

4.6.1 Field Unit Data Base Locations

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Block 0 - FCU Type Block (accessed with Modbus function code 02, 03 or 04)										Register Location			
Parameter 0 - 7	RO	Y	Y	Y	Y	Y	Y	Y	Y	256	257	-	735
Block 1 - FCU Block (accessed with Modbus function code 02, 03 or 04)										Register Location			
Parameter 0 - 7	-	R	R	R	R	R	R	R	R	736	737	-	1215

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60

Block 2 – Digital Input Block
(accessed with Modbus function code 02, 03 or 04)

										Register Location			
Parameter 0	RO	Y	Y	Y	Y	Y	Y	Y	Y	1216	1217	-	1275
										Discrete Location			
Bit 0	RO	AUX 1	R (*AUX1**)	DIN 1	R	R	AUX 1	R	R	1920	1936	-	2864
Bit 1	RO	AUX 2	R (*AUX2**)	DIN 2	R	BAKPWR	AUX 2	R	R	1921	1937	-	2865
Bit 2	RO	OAS	OAS	DIN 3	OAS	OAS	OAS	OAS	R	1922	1938	-	2866
Bit 3	RO	CAS	CAS	DIN 4	CAS	CAS	CAS	CAS	R	1923	1939	-	2867
Bit 4	RO	STOP	STOP	DIN 5	STOP	STOP	STOP	R	R	1924	1940	-	2868
Bit 5	RO	MOVE	MRUN	DIN 6	MRUN	MOVE	Travelling	MOVE	R	1925	1941	-	2869
Bit 6	RO	MRO	MRO	DIN 7	MRO	TRO	TRO	R	R	1926	1942	-	2870
Bit 7	RO	MRC	MRC	DIN 8	MRC	TRC	TRC	R	R	1927	1943	-	2871
Bit 8	RO	AUX 3	EXT (*AUX3**)	R	EXT	R	AUX 3	R	R	1928	1944	-	2872
Bit 9	RO	AUX 4	R (*AUX4**)	R	R	R	AUX 4	R	R	1929	1945	-	2873
Bit 10	RO	LBON	LBON	LBON	LBON	LBON	LBON	LBON	LBON	1930	1946	-	2874
Bit 11	RO	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	1931	1947	-	2875
Bit 12	RO	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	1932	1948	-	2876
Bit 13	RO	BATT	R	R	R	BAKBATT	R	R	R	1933	1949	-	2877
Bit 14	RO	Remote **	R	R	R	R	R	R	R	1934	1950	-	2878
Bit 15	RO	R	R	R	R	R	R	R	R	1935	1951	-	2879
										Register Location			
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	1276	1277	-	1695

Key to Digital Input Labels:
AUX 1-4 - Aux Input 1-4
OAS - Open limit switch
CAS - Close limit switch
STOP - Actuator stopped in mid travel
MOVE - IQ/IQT valve moving
MRUN - Motor running
MRO - Motor running open direction
MRC - Motor running close direction
Travelling - Actuator moving
BAKPWR - Under battery back-up power
Notes: (*AUXn**) ROMpak only, ** IQ3 only

TRO - Travelling open direction
TRC - Travelling close direction
DIN 1 to 8 - Digital inputs 1 to 8
EXT - External contact input
LBON - Loopback on
NALM - New alarm flag
ALARM - Any alarm present on this FCU
BATT - Battery Low Indication
Remote - remote selected
BAKBATT - Back-up battery low indication

Note: When using the GPFCU (GP) for pump control the following arrangement is used:
DIN1 - Represents Monitor2
DIN2 - Represents Monitor3
DIN3 - Represents Motor Running
DIN4 - Not assigned
DIN5 - Represents Motor Stopped
DIN6 - Represents Monitor1
DIN7 & 8 - Not assigned
all other allocations are unchanged

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60

Block 3 – Alarm Block
(accessed with Modbus function code 02, 03 or 04)

										Register Location			
Parameter 0	RO	Y	Y	Y	Y	Y	Y	Y	Y	1696	1697	-	1755
										Discrete Location			
Bit 0	RO	MEMF	MEMF	MEMF	MEMF	MEMF	MEMF	R	MEMF	2880	2896	-	3824
Bit 1	RO	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	2881	2897	-	3825
Bit 2	RO	LOCAL	CNA	R	CNA	LOCAL	LOCAL	LOCAL	R	2882	2898	-	3826
Bit 3	RO	POWR	POWR	POWR	POWR	POWR	POWR	POWR	POWR	2883	2899	-	3827
Bit 4	RO	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	2884	2900	-	3828
Bit 5	RO	MREL	MREL	R	MREL	MREL	MREL	MREL	R	2885	2901	-	3829
Bit 6	RO	THERM	THERM	R	THERM	THERM	FAULT	R	R	2886	2902	-	3830
Bit 7	RO	LSTOP	LSTOP	R	LSTOP	LSTOP	LSTOP	LSTOP	R	2887	2903	-	3831
Bit 8	RO	SFAIL	SFAIL	R	SFAIL	SFAIL	SFAIL	SFAIL	R	2888	2904	-	3832
Bit 9	RO	VOBS	VOBS	R	VOBS	VOBS	VOBS	VOBS	R	2889	2905	-	3833
Bit 10	RO	VJAM	VJAM	R	VJAM	VJAM	VJAM	R	R	2890	2906	-	3834
Bit 11	RO	AUXOR	MOP	R	MOP	R	AUXOR	R	R	2891	2907	-	3835
Bit 12	RO	VTT	MCL	R	MCL	RL	VTT	R	R	2892	2908	-	3836
Bit 13	RO	R	MOPG	R	MOPG	R	R	R	R	2893	2909	-	3837
Bit 14	RO	MMOVE	MCLG	R	MCLG	MMOVE	MMOVE	R	R	2894	2910	-	3838
Bit 15	RO	EOT	EOT	R	EOT	EOT	EOT	R	R	2895	2911	-	3839
										Register Location			
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	1756	1757	-	2175

Key to Alarm Labels:

MEMF	-	RAM/ROM failure	LSTOP	-	Local stop operated	MCLG	-	Manual closing
COMMS	-	Comms fail	SFAIL	-	Start/stop fail	EOT	-	Motor running end of travel
LOCAL	-	Actuator not in remote control	VOBS	-	Valve obstructed	FAULT		Fault relay, any fault present
CNA	-	Control not available	VJAM	-	Valve jammed			
POWR	-	Power on reset	MMOVE	-	Manual valve movement			
WDOG	-	Watchdog fail	MOP	-	Manual open			
MREL	-	Monitor relay	MCL	-	Manual close			
THERM	-	Thermostat trip	MOPG	-	Manual opening			

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Block 4 - Analogue Input Block - Valve Position Feedback (accessed with Modbus function code 03 or 04)										Register Location			
Para' 0 (MV)	RO	Y	Y	R	Y	Y	Y	Y	R	2176	2177	-	2235
MV Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 100% position Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 100% position													
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	2236	2237	-	2655
Block 5 – Position Control Block – Valve Desired Position (accessed with Modbus function code 03 or 04, writes with 06 or 16)										Register Location			
Parameter 0	-	R	R	R	R	R	R	R	R	2656	2657	-	2715
Para' 1 (DV)	R/W	Y	Y	R	Y	Y	Y	Y	R	2716	2717	-	2775
DV Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 100% Desired pos'n Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 100% Desired pos'n													
Parameter 2 – 7	-	R	R	R	R	R	R	R	R	2776	2777	-	3135
Block 6 – Digital Output Block (accessed with Modbus function code 02, 03 or 04, writes with 05, 15, 06 or 16)										Register Location			
Parameter 0	RO	R	R	Y	R	R	R	R	R	3136	3137	-	3195
										Discrete Location			
Bit 0	RO	-	-	RLY4	-	-	-	-	-	5760	5776	-	6720
Bit 1	RO	-	-	RLY1	-	-	-	-	-	5761	5777	-	6721
Bit 2	RO	-	-	RLY3	-	-	-	-	-	5762	5778	-	6722
Bit 3	RO	-	-	RLY2	-	-	-	-	-	5763	5779	-	6723
Bit 4	RO	-	-	0	-	-	-	-	-	5764	5780	-	6724
Bit 5	RO	-	-	0	-	-	-	-	-	5765	5781	-	6725
Bit 6	RO	-	-	0	-	-	-	-	-	5766	5782	-	6726
Bit 7	RO	-	-	ACT (1)	-	-	-	-	-	5767	5783	-	6727
Bit 8 to 15	-	-	-	R	-	-	-	-	-	5768-75	5784-91	-	6728-35
(1) Key: ACT = Relay action, 0 = Fleeting, 1 = Maintained													

Block 6 – Digital Output Block (Continued)
(accessed with Modbus function code 02, 03 or 04, writes with 05, 15, 06 or 16)

	Read Write	FCU Type								Data Location (Register Location)			
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Parameter 1 - Open	WO	Y	Y	Y	Y	Y	Y	Y	N	3196	3197	-	3255
'OPEN' (Relay 2) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 2 - Stop	WO	Y	Y	Y	Y	Y	Y	Y	N	3256	3257	-	3315
'STOP' (Relay 3) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 3 - Close	WO	Y	Y	Y	Y	Y	Y	Y	N	3316	3317	-	3375
'CLOSE' (Relay 1) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 4 - ESD	WO	Y	Y	Y	Y	Y	Y	Y	N	3376	3377	-	3435
'ESD' (Relay 4) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 5 – Partial Stroke Test	WO	Y (Note 1)	N	N	N	N	N	N	N	3436	3437	-	3495
PST : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 5 - 7	-	R	R	R	R	R	R	R	N	3496	3437	-	3615

Note 1: Only IQ3, software version V209 or later

Block 7 – Pulse Input Block
(accessed with Modbus function code 03 or 04)

	Read Write	IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Parameter 0	RO	-	-	-	Y	-	-	-	-	3516	3517	-	3675
Range: 0x0000 to 0x270F = Counter value													
Parameter 1 – 7	-	R	R	R	R	R	R	R	R	3676	3677	-	4095

Block 8 – IQ Range Digital Output operation
(accessed with Modbus function code writes with 05, 15, 06 or 16)

	Read Write	FCU Type								Data Location / Register Location			
		IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Parameter 0	-	R	R	R	R	R	R	R	R	4096	4097	-	4155
Parameter 1 -	WO	Y	R	R	R	R	R	R	R	4156	4157	-	4215
Digital output 1 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 2 -	WO	Y	R	R	R	R	R	R	R	4216	4217	-	4275
Digital output 2 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 3 -	WO	Y	R	R	R	R	R	R	R	4276	4277	-	4335
Digital output 3 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 4 -	WO	Y	R	R	R	R	R	R	R	4336	4337	-	4395
Digital output 4 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay													
Parameter 5-7	-	R	R	R	R	R	R	R	R	4396	4397	-	4575

Note: This feature is only available on the IQ3 when fitted with an extra relay or DIO board, or an IQ1 / IQ2 / IQT when fitted with an extra relay board.

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Block 9 – 12 bit Analogue Input 1 Block (accessed with Modbus function code 03 or 04)										Register Location			
Parameter 0	RO	Y(note1)-	-	Y	-	-	-	-	Y	4576	4577	-	4635
An Input 1 Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 100% Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 100%													
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	4636	4637	-	5055
Block 10 – 12 bit Analogue Input 2 Block (accessed with Modbus function code 03 or 04)										Register Location			
Parameter 0	RO	Y(note1)-	-	Y	-	-	-	-	Y	5056	5057	-	5115
An Input 2 Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 100% Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 100%													
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	5116	5117	-	5535
Block 11 – 12 bit Analogue Output Block (accessed with Modbus function code 03, 04, 06 or 16)										Register Location			
Parameter 0	R/W	-	-	Y	-	-	-	-	-	5536	5537	-	5595
An Output Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 100% Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 100%													
Parameter 1 - 7	-	R	R	R	R	R	R	R	R	5596	5597	-	6015

Note 1: Only IQ3, software version V209 or later and additional analogue input cards, one card is required per analogue input.

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60

Block 12 – Historical Torque Profile – Opening Direction
(accessed with Modbus function code 03 or 04)

										Register Location			
8 torque (For EH / SI pressure.) values related to valve position across the valve stroke. Position 0 and 100% are not used as these may be set to full torque for a torque seating valve. Torque readings are available for 6%, 19%, 31%, 44%, 56%, 69%, 81%, and 94% positions. Parameters 1-7 contain this data for the OPENING direction of travel - note they only update if a complete stroke of the valve is made and contain the last profile.													
All are ranged as : Using **Generic Protocol**, 0x0000 = 0% rated torque, 0x7FFF = 120% rated torque Using **EPLCG Protocol**, 0x0000 = 0% rated torque, 0x0FFF = 120% rated torque													
Para' 0 - 6%	RO	Y	-	-	-	Y	Y	-	-	6016	6017	-	6075
Para' 1 - 19%	RO	Y	-	-	-	Y	Y	-	-	6076	6077	-	6135
Para' 2 - 31%	RO	Y	-	-	-	Y	Y	-	-	6136	6137	-	6195
Para' 3 - 44%	RO	Y	-	-	-	Y	Y	-	-	6196	6197	-	6255
Para' 4 - 56%	RO	Y	-	-	-	Y	Y	-	-	6256	6257	-	6315
Para' 5 - 69%	RO	Y	-	-	-	Y	Y	-	-	6316	6317	-	6375
Para' 6 - 81%	RO	Y	-	-	-	Y	Y	-	-	6376	6377	-	6435
Para' 7 - 94%	RO	Y	-	-	-	Y	Y	-	-	6436	6437	-	6495

Block 13 – Historical Torque Profile – Closing Direction
(accessed with Modbus function code 03 or 04)

										Register Location			
8 torque (For EH / SI pressure.) values related to valve position across the valve stroke. Position 0 and 100% are not used as these may be set to full torque for a torque seating valve. Torque readings are available for 6%, 19%, 31%, 44%, 56%, 69%, 81%, and 94% positions. Parameters 1-7 contain this data for the CLOSING direction of travel - note they only update if a complete stroke of the valve is made and contain the last profile.													
All are ranged as : Using **Generic Protocol**, 0x0000 = 0% rated torque, 0x7FFF = 120% rated torque Using **EPLCG Protocol**, 0x0000 = 0% rated torque, 0x0FFF = 120% rated torque													
Para' 0 - 6%	RO	Y	-	-	-	Y	Y	-	-	6496	6497	-	6555
Para' 1 - 19%	RO	Y	-	-	-	Y	Y	-	-	6556	6557	-	6615
Para' 2 - 31%	RO	Y	-	-	-	Y	Y	-	-	6616	6617	-	6675
Para' 3 - 44%	RO	Y	-	-	-	Y	Y	-	-	6676	6677	-	6735
Para' 4 - 56%	RO	Y	-	-	-	Y	Y	-	-	6736	6737	-	6795
Para' 5 - 69%	RO	Y	-	-	-	Y	Y	-	-	6796	6797	-	6855
Para' 6 - 81%	RO	Y	-	-	-	Y	Y	-	-	6856	6857	-	6915
Para' 7 - 94%	RO	Y	-	-	-	Y	Y	-	-	6916	6917	-	6975

	Read Write	FCU Type								Data Location			
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue	FCU 1	FCU 2	to	FCU 60
Block 14 – Instantaneous Torque (accessed with Modbus function code 03 or 04)										Register Location			
Parameter 0	RO	Y	-	-	-	Y	Y	-	-	6976	6977	-	7035
Inst. Torque Range: Using **Generic Protocol**, 0x0000 = 0%, 0x7FFF = 120% Using **EPLCG Protocol**, 0x0000 = 0%, 0x0FFF = 120% For EH / SI this value represents pressure.													
Parameter 1 - 3	-	R	R	R	R	R	R	R	R	7036	7034	-	7215
Parameter 4	RO	Y	-	-	-	Y	Y	-	-	7216	7217	-	7275
Torque Profile Counters Data Bits 8-15 = Opening Torque Profile count Data Bits 0-7 = Closing Torque Profile count													
Parameter 5 - 7	-	R	R	R	R	R	R	R	R	7276	7277	-	7455
Block 15 to 31 – Reserved										Register Location			
Block 15 Para 0 - Block 31 Para 7	-	R	R	R	R	R	R	R	R	7456	7457	-	15615

4.7 Modbus messages examples (Generic and Honeywell EPLCG protocols)

Examples are included here to clarify the use of the Modbus protocol. These examples assume that the master station base address is 01. **All data in the message tables is in hexadecimal notation.**

The register and discrete locations calculated by the earlier formulae all have a start point of 0 (zero), hence the Modbus message location is the same as that calculated by the formulae.

4.7.1 Read Master Station Status

Master Station Block 0 Parameter 0, register location is 0000 decimal, and may be read with function code 03, discrete locations are 0000-0015 decimal and may be read with function code 01.

Using Function Code 01:

Modbus Address	Function Code	Discrete Address	Number of Discretes	CRC Check
01	01	00 00	00 10	CRC

Using Function Code 03:

Modbus Address	Function Code	Register Address	Number of Registers	CRC Check
01	03	00 00	00 01	CRC

4.7.2 Write Master Station Alarm Accept

Master Station Block 0 Parameter 5, location 0005 decimal. Note that this is identified as a ‘write’ instruction by the function code used, which may be 05, 15, 06, or 16. The data written may be any value, excluding zero, to accept the alarm. There is no need to ‘cancel’ the accept with a zero write.

Using Function Code 05:

Modbus Address	Function Code	Coil Address	Data	CRC Check
01	05	00 05	FF 00	CRC

Using Function Code 16: (multiple is ‘1’)

Modbus Address	Function Code	Register Address	Quantity	Byte Count	Data	CRC Check
01	10	00 05	00 01	02	FF 00	CRC

4.7.3 Read Field Unit 12 Digital Status

Field unit digital status is in Block 2, Parameter 0. For FCU 12, the register location is 1227 decimal (= 0x04CB), or discrete locations 2096 to 2111 decimal (= 0x0830 to 0x083F). The data may be read with Function Code 02 or 04.

Using Function Code 02:

Modbus Address	Function Code	Discrete Address	Number of Discretes	CRC Check
01	02	08 30	00 10	CRC

Using Function Code 04:

Modbus Address	Function Code	Register Address	Number of Registers	CRC Check
01	04	04 CB	00 01	CRC

4.7.4 Read Field Unit 62 Digital Status

Field Unit 62 is found in Modbus Address Base + 1 = 02 as it is above number 60. The data is located in Block 2, Parameter 0. For FCU 62 the register location is as for FCU 02, 1217 decimal (= 0x04C1), and discrete locations 1936 to 1951 decimal (= 0x0790 to 0x079F).

Using Function Code 02:

Modbus Address	Function Code	Discrete Address	Number of Discretes	CRC Check
02	02	07 90	00 10	CRC

Using Function Code 04:

Modbus Address	Function Code	Register Address	Number of Registers	CRC Check
02	04	04 C1	00 01	CRC

4.7.5 Read Digital Status from 60 Field Units, Addresses 121 to 180

Modbus Address = Base + 2 = 03. Data is in Block 2 Parameter 0. FCU 1 data starts in register 1216 decimal (= 0x04C0).

Using Function Code 04:

Modbus Address	Function Code	Register Address	Number of Registers	CRC Check
03	04	04 C0	00 3C	CRC

4.7.6 Energise Command to OPEN relay of Field Unit 4

The OPEN relay for FCU 4 is located in Block 6 Parameter 1, register location 3199 decimal (= 0x0C7F). Either Function code 05 or 06 can be used, but the location to be written to is always the **register** number.

Using Function Code 05:

Modbus Address	Function Code	Address	Data	CRC Check
01	05	0C 7F	FF 00	CRC

Using Function Code 06:

Modbus Address	Function Code	Address	Data	CRC Check
01	06	0C 7F	FF 00	CRC

4.7.7 Write Desired Valve Position for FCU 26 to be 50%

The DV data is written to Block 5 Parameter 1, register 2741 decimal (= 0x0AB5) for FCU 26.
With **Generic Protocol**, 50% is 0x3FFF and with **EPLCG Protocol**, 50% is 0x07FF.

Using Function Code 06 and **Generic Protocol**

Modbus Address	Function Code	Address	Data	CRC Check
01	06	0A B5	3F FF	CRC

Using Function Code 06 and **EPLCG Protocol**

Modbus Address	Function Code	Address	Data	CRC Check
01	06	0A B5	07 FF	CRC

5 YOKOGAWA AND HONEYWELL SI PROTOCOL INTERFACE SPECIFICATION

This section describes the two protocols that pack the field unit data in the tightest way. This allows the host system to minimise the data traffic to and from the master station. The tables give register and discrete locations in the master station from which the data may be read.

The Yokogawa protocol is recommended when interfacing between a Pakscan master station and a Yokogawa Centum CS and ACM11 interface card, Centum XL, EFCD gateway and RS4 cards, or similar system where the data packing is suitable. The protocol has been tested by Yokogawa in Japan, Holland, and Singapore and found to successfully connect the Pakscan and Yokogawa systems together. The protocol allows a standard Yokogawa SI22 faceplate to be used for the screen displays associated with motor operated valves.

The Honeywell SI protocol is recommended for connection between the Pakscan master station and the Honeywell SI gateway. Honeywell has tested and approved the SI version for connecting the Pakscan system to a Honeywell TDC 3000 with an Advanced Process Manager and Serial Interface Gateway, or similar system where the data packing is suitable.

On the Pakscan 3 Current Loop Option Module select 'YOKOGAWA' for the Yokogawa configuration of the data base or ‘HONEYWELL SI’ for the SI version of the data base: the difference between these two choices is in the analogue data scaling only. Yokogawa uses 16-bit 2’s complement and Honeywell SI uses an integer value in the register, all locations for the data are identical. Care must be taken to ensure that the correct protocol is selected for the application concerned.

The master station responds as a Modbus Slave to messages from the host. Each master station responds to a single Modbus address. The serial ports can each use different data bases, whilst the two Ethernet ports must both use the same data base and protocol

The master station maintains a data base covering all its connected field units, and the host reads this data without the need to access field units directly. The master station performs the functions of Data Concentrator, Protocol Converter, and 2-wire current loop master. Within the field units data is organised in blocks. The data base locations listed in this section are the spaces from which and to which this data is moved.

5.1 Modbus unit address (Yokogawa and Honeywell SI protocols)

The first byte of all Modbus message frames is the Modbus Address byte. Modbus supports 248 addresses, of which value 0 is always allocated for Broadcast messages. This leaves 247 addresses for use by connected devices on the Modbus data link.

Modbus Address	Function Code	Register or Discrete Address	Number of Registers or Bits	Data Field	CRC Check
8 bits	8 bits	16 bits	16 bits	N bits	16 bits

Fig 21: Modbus transaction format

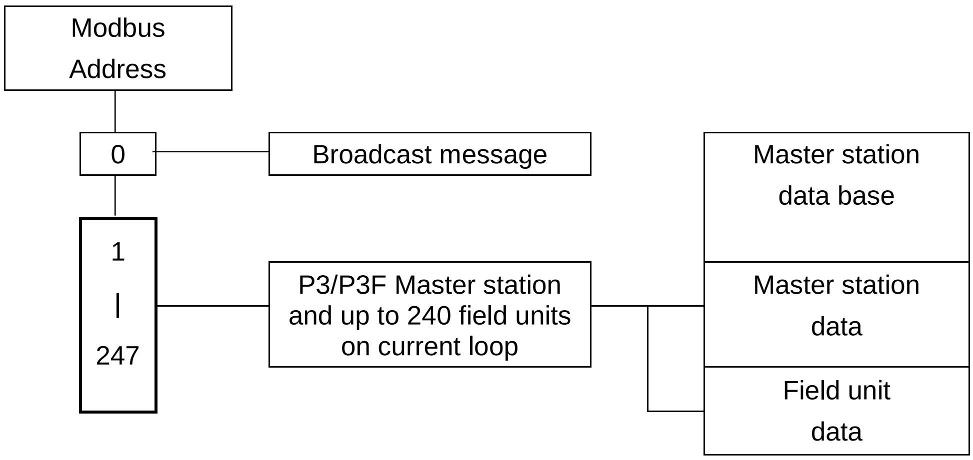


Fig 22: Modbus unit address structure – Yokogawa and Honeywell SI protocol

Each Pakscan 3 Current Loop Option Card occupies a single Modbus address in which all the data relating to itself and the connected field units is located. Modbus 'Read' requests return field unit data from the data base in the appropriate master station; Modbus 'Write' requests are translated into write commands which are sent to the field unit concerned.

Modbus Address	Responding Master Station	Interpretation
0	All	Modbus Broadcast
1	1	Data base access
2	2	Data base access
|	|	|
247	247	Data base access

Fig 23: Modbus addressing for master stations

5.2 Modbus function code support (Yokogawa and Honeywell SI protocols)

Details of Request and Reply formats are contained in the Modbus Reference Guide. The following section deals with how Pakscan 3 master stations interpret the commands. Fig 24 lists the supported Modbus commands.

Function Code	Modbus Name	Addressing
01	Read coil status	Discrete
02	Read input status	Discrete
03	Read holding registers	Register
04	Read input registers	Register
05	Force single coil	Discrete
06	Preset single register	Register
08	Loopback diagnostic test	
15	Force multiple coils	Discrete
16	Preset multiple registers	Register

Error code	Meaning
01	Illegal function code or incorrect message length
02	Illegal data address (Register address invalid)
03	Illegal data value
06	Slave Device Busy

Fig 24: Modbus function codes and error codes

Within the master station there is one data base associated with each serial comms port and one shared between the two Ethernet ports. All data read commands access these data bases.

- ❑ **Function Code 01 - Read Coil Status Requests**

Where the gateway is set up to read the data from the open or close coils, for example prior to writing data, this is permitted by the master station. However the coils do not physically exist and the data read back by the host is the current status of the Open and Close limit switch in the actuator (OAS for an Open command and CAS for a Close command). These signals may not reflect the state of the command coil. For example the actuator may have been opened by a system command to the open coil and then closed manually. The coil for open would be expected to be ‘on’, but the actuator will report the close coil as being ‘on’ since CAS will be present, and the open coil as being ‘off’. In addition for actuator control all the write signals become pulsed outputs at the field unit and the actuator responds to these pulse commands itself.

- **Function Code 02 - Read Input Status Requests**

Any Input Status data within the master station may be read with a Code 02 Read request. The returned data will be valid for the discrete locations chosen.

- **Function Code 03 - Read Holding Register Requests**

Holding registers are used for the location of Output registers. In the case of Pakscan systems these output registers are used either to position a valve or for setting an analogue output. Where the gateway is set up to read the data in a Holding register, for example prior to writing data, the master station permits this. However, the data read back by the host may not be true.

In the case of reading the state of an output (holding) register the master station may not directly reflect the current position of the attached field unit or actuator since the actuator may have been moved manually or by a digital command since the analogue position was last sent. The data read may not be valid, though it will be the last state written.

- **Function Code 04 - Read Input Register Requests**

Any register data within the master station may be read with a Code 04 Read request. The returned data will be valid for the discrete locations chosen.

- **Function Code 05 and 06 - Force Single Coil, Preset Single Register**

If a Write request is to a discrete coil or register associated with the master station, then data is written directly to that coil or register.

If the Write request is to a discrete coil or register associated with a Field Unit, then the information contained in the message is translated into a command that a field unit understands. The command is then sent to the field unit over the current loop network. The rate at which instructions are sent must not exceed the rate at which they can be sent on to the field units.

The sequence of events is:

(1) - Write command received by the master station.
(2) - Response sent back to Host
(3) - Write message sent to Field Unit

A good response to the Host indicates that the request was received correctly, the message length is acceptable, and that the addressed Field Unit is on-line. It does not indicate that the Write to the Field Unit was successful. A successful write is confirmed some time later when new data is reported as a change in the main data base.

If commands are written at too high a rate then the current loop network is prevented from collecting data from the field units and the system will appear to slow down. The Command Filter provides some protection against too high a frequency of writing commands. It causes the system to ignore duplicated commands to the same field unit if the duplicate is within the time setting for the filter.

- **Code 08 - Loopback Diagnostic Test**

The purpose of the Loopback Test is to test the communication system between the master station and the gateway. The master station supports this test when used with diagnostic code 00, Return Query Data. No other diagnostic test codes are supported.

- **Code 15 and 16 - Force Multiple Coils, Preset Multiple Registers**

If a Write request is to discrete coils or registers associated with the master station, then data is written directly to those coils or registers.

If the Write request is to discrete coils or registers associated with Field Units, then the information contained in the message is translated into a commands that field units understand. The command is then sent to the field unit over the current loop network. The master station is able to accept a single transaction multiple write message containing information to be written to a maximum of 123 registers. These instructions are then passed to a queue for onward transmission over the current loop network. The rate at which instructions are sent must not exceed the rate at which they can be sent on to the field units.

If commands are written at too high a rate then the current loop network is prevented from collecting data from the field units and the system will appear to slow down. The Command Filter provides some protection against too high a frequency of writing commands. It causes the system to ignore duplicated commands to the same field unit if the duplicate is within the time setting for the filter.

In the case of actuator control there is never a need to write to a coil to turn it off as the output is always treated as a pulse. The DCS control should be arranged for the outputs to be pulse type. If this is not done the communication on the current loop network will carry unnecessary control commands to ‘turn off’ coils that are already off.

- **Error Codes 01, 02 and 06**

Error code 01 will be presented back to the host if the function code in the data message is not one of those supported by the master station or the message length is not as expected.

Error code 02 will be presented back to the host if the Data Address is illegal; or if the write command is a multiple write (code 15 or 16) where the number of coils or registers exceeds the amount acceptable.

Error code 03 will be presented back to the host if the value contained in the data query field is illegal.

Error code 06 will also be sent back to the host if the master station has insufficient buffer space to handle the write request to coils or registers in a single transaction. Buffer space will become free as the writes are issued to the loop and field units.

5.3 Data base access (Yokogawa and Honeywell SI protocols)

The data base is accessed by use of the Modbus address structure using Register Numbers or Discrete Numbers in accordance with the Modbus standard. The data base contains information collected from field units and is the data actually in the master station. Data transfers to and from the field units are under the control of the Pakscan 3 master station option card.

5.3.1 Data Organisation

The data base comprises a series of records organised in accordance with the Modbus documentation. Messages with function codes 01 to 06, 15 and 16 indicate specifically which locations in the data base are to be accessed.

Function Codes 01, 05, and 15	refer to coils 0XXXX
Function Code 02	refers to discrete inputs 1XXXX
Function Code 04	refers to read only registers 3XXXX
Function Codes 03, 06, and 16	refer to registers 4XXXX

Coils are used for digital outputs. The status of maintained digital outputs should be read from discrete status inputs and not from the coil itself. Data read back from a coil may not be valid.

Registers are used for all multiple bit signals (analogues and counters). Some are protected and may only be read. Data read back from a Holding register with code 03 will contain the last data written to that coil. It may not reflect the actual status of the register in the field unit.

The data in each record is listed in the following sections for both master stations for field units.

5.3.2 Data Interchange Requests

Data may be interchanged between the host and the master station data base using Modbus Register or Discrete Numbers.

5.4 Notes on the use of the Yokogawa and Honeywell SI Modbus protocol

Normally the Modbus host will be set up to cyclically read data representing key variables of the master station and field units. It can do this using Read Input Register function code 04, and Read Discrete Status function code 02. In addition the gateway may be set to use function code 01 to read Output Coils prior to a write (05) or code 03 to read Holding Registers prior to a write (06).

Register and Discrete address numbers referred to in the standard Modbus documentation all start from number 1, though the actual data request on the data link takes its start as 0. The Modbus host software ***may*** need to be configured with addresses that are 1 less than those listed in the tables following. This is due to the Host regarding addresses as starting from 0, not 1. The actual method used by the gateway is specified in its documentation.

The discrete and register numbers listed in the tables all start from '1', register 40001 would be referenced as 0000 in the serial transaction.

The data base is arranged to provide maximum efficiency in the use of the gateway space available and reading a group of registers in one transaction is more efficient than reading one register at a time. The Honeywell SI, because of the link to the APM Arrays may be easily set to collect multiple data in a transaction. The Yokogawa gateway should be organised to use efficient data transfer at all times. Note that the discrete bits may be moved in a minimum of 16 bits to the card working space.

The master station includes Alarm Accept logic with respect to field unit alarms. Alarms from field units are automatically accepted by the master station (so the field unit can clear its alarm latches) and latched within the master station. These alarms must be read by the Host and then accepted (with an Alarm Accept write to coil 32) before they can clear.

5.4.1 Suggested Scan Cycle

The Host should be configured to scan data from the master station in the following order:

Read Alarm Status
Read Digital Status
Perform Alarm Accept
(only strictly necessary if any New Alarms have occurred)
Read Analogue Status
(if any analogue data is to be read)

Commands to Field Units may be fitted in as required.

In some applications it may be desirable to scan some items e.g. analogues, less frequently than others. This is perfectly acceptable.

Within the master station area of the data base there are common alarm bits for loop fault, field unit fault and actuator fault. These may be used as a quick way of checking for new alarms.

5.4.2 Writing to Coils

When writing to a coil the data field to turn off the coil has to be 0x0000. As the most common device connected is an actuator whose action is controlled by a pulse output there is often no need to turn off a coil that has previously been turned on. The output command from the DCS should, where possible, use a pulse type output. When writing to a coil the data field to turn on the coil may be 0xFF00 or any other non zero value.

5.4.3 Readback of Holding Registers

The master station supports the reading of the data in the Holding Registers. This data may not accurately reflect the state of the actuator as it could have been moved manually since the data was written. The data is a 2’s complement 16 bit value (0x0000 – 0x7FFF) in the case of the Yokogawa protocol or a signed integer value (0-0x0064) in the case of the Honeywell SI. It is calculated from the actual value used in the data transaction over the current loop network to the field unit. When ‘read back’ this value may differ by 1 digit due to rounding errors in the calculation. The value sent to the field unit when the register was written will be true. To establish the actual valve position the Input Register relating to the field unit Measured Value should be read.

5.4.4 Alarm Handling

The two serial communication ports on the master station are each served by their own independent data base and alarm handling. The two Ethernet ports share a third independent data base. The handling of alarms on one port does not reflect on the alarms of any of the other port.

In the data base there is a group of 16 bits (bits 13 to 28) of data defined as the 'Alarm Block' for each field unit (for example 'COMMS' is an alarm bit).

Similarly there are System Alarms as listed in the master station data section, for example 'RAM test fail'.

These data bits will all be latched by the master station if they should actually occur. The master station will therefore capture a transient alarm and keep it in its data base ready for the host to read it.

Any latched alarm from these data areas will only be reset on three subsequent conditions. Firstly the alarm bit must read by the host, secondly the alarm bit must be accepted by the host (this is done by issuing an 'Alarm Accept'), and finally the source of the alarm itself must return to normal.

An example of the sequence would be:

Consider an Actuator Thermostat.

1. Thermostat gets hot and trips.
2. Host reads data bit (bit 19) for the thermostat for this actuator
3. Host issues Alarm Accept; this is registered by the system as applicable to the Thermostat Trip alarm.
4. The data bit remains set until the actuator cools down.
5. Once cooled below the trip point the data bit returns to normal.

If the host does not read the thermostat bit for this field unit then the bit will remain set for all time, even after the actuator cools down. In addition, if the host does not read this bit any Alarm Accept will not allow the alarm to reset itself. Any alarm bit must be read before it is able to be accepted.

Even if the alarms are read infrequently, the above procedure guarantees that any alarm from the alarm block will be registered by the host.

In addition to the alarm data for each field unit there is a 'Status Block'. These status locations also contain information about the presence (or absence) of alarms in the Alarm Block.

- **‘Alarm’ Bit (bit 12)**

For each field unit the 'Alarm' bit will be present if any of the source signals used to set bits in the Alarm block are present. Notice that the Alarm bit is an OR function of any alarm before the latch for that alarm. The 'Alarm' bit is latched and will not clear until it has been read, accepted and the source of the alarm has returned to normal. In the example of the thermostat, the 'Alarm' bit will be set when the thermostat is initially tripped.

- **'New Alarm' Bit (bit 11)**

For each field unit, 'New Alarm' will be present every time a new alarm is detected as occurring in the field unit. However, every time an Alarm Accept is issued this data bit will be reset even if the alarm itself is still present.

The purpose of this bit is to indicate to the Host that there is a new alarm to be read from the alarm block.

- **System Common Alarms**

In the master station bit 10250 will be set if any field unit has its own 'Alarm' bit set. Thus the 'Common Field Unit Alarm' is set whilst any one field unit has an input actually in alarm.

Bit 10251 contains a similar common data bit derived from the actuator 'Monitor Relay' source signals.

5.4.5 Use of Alarm Bits

The host may be configured to read as many, or all, of the alarm block data bits as required. Those that are not being used will probably 'fill up' as alarms over the course of operating the system.
For the alarms that are used they will individually appear in the data locations being read, and by means of the Alarm Accept process will transfer to the host. They will also reset themselves as they return to normal provided they are read and accepted.

The 'Alarm' bit will inform the host that any alarm is present, even those not normally being identified by the host as relevant. This bit may be used by the host as a flag that an alarm is currently present on a field unit.

The 'New Alarm' bit may be used to indicate to the host that an alarm reading process is required, or that an alarm accept is required. The New Alarm will by its very nature disappear once the Accept is issued irrespective of the actual plant status as it has to be available for each 'new' alarm.

5.5 Master station data base (Yokogawa and Honeywell SI protocols)

5.5.1 Master Station Records

The discrete and register numbers listed in the tables all start from '1', for example discrete input 10001 would be referenced as 0000 in the serial transaction and not 0001.

- **Digital Inputs – Read Only Data (accessed with Modbus function code 02)**

Individual Bits - Discrete Locations (1 bit per)

Location	Description
System Alarms	
10001 to 10240	Reserved
10241	RAM test fail
10242	ROM test fail
10243	Power On Reset
10244	Watchdog fail
10245	Auto loopback
10246	Reserved
10247	Reserved

Location	Description
System status and flags	
10248	Loopback in progress
10249	Loopback in use
10250	Common Field Unit alarm
10251	Common Actuator alarm
10252	Master station A (Main) ok
10253	Master station B (Standby) ok
10254	Communicating to: 0 = Master station A (Left), 1 = Master station B (Right)
10255	1 = Primary (In Use), 0 = Standby (Out of Use)

- **Digital Outputs – Write function (accessed with Modbus function code 05 and 15)**

Individual Bits - Discrete Locations (1 bit per)

When writing to a location the data field should comply with the Modbus instructions, although writing any value (including zero) to these locations will cause the action to occur.

Function	Action	Location	Description
Global ESD Trigger	write to trigger ESD	0001	ESD
Change Master	write to change over	0015	Change Master
System reconfiguration	write to trigger	0016	Reset Loop
System/Comms Alarm Accept	write to accept	0032	Alarm Accept

5.6 Field unit data base (Yokogawa and Honeywell SI protocols)

The field unit data base is organised to present the same information from each sequential field unit address in adjacent record entries. This general rule is broken only by the signals indicating valve open (OAS) and valve closed (CAS), and the commands to 'Open' and 'Close' the valves. These records are located adjacent to one another in pairs for each field unit.

As the field units may be of differing types, a Bit No., Relay No. or register description identifier is attached, together with its meaning for each record group. The different Bit No., Relay No. and register meanings are also listed for the different field unit types at the end of this section.

5.6.1 Digital Inputs (Field Units)

The discrete and register numbers listed in the tables all start from '1', discrete input 10001 would be referenced as 0000 in the serial transaction and not 0001.

- **Read Only Data (accessed with Modbus function code 02)**

Status - Adjacent Bits per Field Unit - Discrete locations (1 bit per)

Location	Description		Location	Description	
10257	Bit 3 FCU 1	(CAS)	10258	Bit 2 FCU 1	(OAS)
10259	Bit 3 FCU 2	(CAS)	10260	Bit 2 FCU 2	(OAS)
10261	Bit 3 FCU 3	(CAS)	10262	Bit 2 FCU 3	(OAS)
10263	Bit 3 FCU 4	(CAS)	10264	Bit 2 FCU 4	(OAS)
10265	Bit 3 FCU 5	(CAS)	10266	Bit 2 FCU 5	(OAS)
10267	Bit 3 FCU 6	(CAS)	10268	Bit 2 FCU 6	(OAS)
10269	Bit 3 FCU 7	(CAS)	10270	Bit 2 FCU 7	(OAS)
10271	Bit 3 FCU 8	(CAS)	10272	Bit 2 FCU 8	(OAS)
|			|		
|	FCU 'N' Bit 3 = 10256 + 2N - 1		|	FCU 'N' Bit 2 = 10256 + 2N	
|			|		
10723	Bit 3 FCU 234	(CAS)	10724	Bit 2 FCU 234	(OAS)
10725	Bit 3 FCU 235	(CAS)	10726	Bit 2 FCU 235	(OAS)
10727	Bit 3 FCU 236	(CAS)	10728	Bit 2 FCU 236	(OAS)
10729	Bit 3 FCU 237	(CAS)	10730	Bit 2 FCU 237	(OAS)
10731	Bit 3 FCU 238	(CAS)	10732	Bit 2 FCU 238	(OAS)
10733	Bit 3 FCU 239	(CAS)	10734	Bit 2 FCU 239	(OAS)
10735	Bit 3 FCU 240	(CAS)	10736	Bit 2 FCU 240	(OAS)

Note that the information in these locations is also mapped to alternate locations starting 11217 (OAS) and 11457 (CAS)

N = field unit address number in the range 1 to 240

❑ Read Only Data (accessed with Modbus function code 02)

Status bits - Individual Bits per Field Unit - Discrete Locations (1 bit per)

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 0 - AUX 1</td></tr>
<tr><td>10737</td><td>Bit 0 FCU 1</td></tr>
<tr><td>10738</td><td>Bit 0 FCU 2</td></tr>
<tr><td>10739</td><td>Bit 0 FCU 3</td></tr>
<tr><td>10740</td><td>Bit 0 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 0 = 10736 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>10974</td><td>Bit 0 FCU 238</td></tr>
<tr><td>10975</td><td>Bit 0 FCU 239</td></tr>
<tr><td>10976</td><td>Bit 0 FCU 240</td></tr>
</table>

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 1 - AUX 2</td></tr>
<tr><td>10977</td><td>Bit 1 FCU 1</td></tr>
<tr><td>10978</td><td>Bit 1 FCU 2</td></tr>
<tr><td>10979</td><td>Bit 1 FCU 3</td></tr>
<tr><td>10980</td><td>Bit 1 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 1 = 10976 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>11214</td><td>Bit 1 FCU 238</td></tr>
<tr><td>11215</td><td>Bit 1 FCU 239</td></tr>
<tr><td>11216</td><td>Bit 1 FCU 240</td></tr>
</table>

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 2 - OAS</td></tr>
<tr><td>11217</td><td>Bit 2 FCU 1</td></tr>
<tr><td>11218</td><td>Bit 2 FCU 2</td></tr>
<tr><td>11219</td><td>Bit 2 FCU 3</td></tr>
<tr><td>11220</td><td>Bit 2 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 2 = 11216 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>11454</td><td>Bit 2 FCU 238</td></tr>
<tr><td>11455</td><td>Bit 2 FCU 239</td></tr>
<tr><td>11456</td><td>Bit 2 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 3 - CAS</td></tr>
<tr><td>11457</td><td>Bit 3 FCU 1</td></tr>
<tr><td>11458</td><td>Bit 3 FCU 2</td></tr>
<tr><td>11459</td><td>Bit 3 FCU 3</td></tr>
<tr><td>11460</td><td>Bit 3 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 3 = 11456 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>11694</td><td>Bit 3 FCU 238</td></tr>
<tr><td>11695</td><td>Bit 3 FCU 239</td></tr>
<tr><td>11696</td><td>Bit 3 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 4 - STOP</td></tr>
<tr><td>11697</td><td>Bit 4 FCU 1</td></tr>
<tr><td>11698</td><td>Bit 4 FCU 2</td></tr>
<tr><td>11699</td><td>Bit 4 FCU 3</td></tr>
<tr><td>11700</td><td>Bit 4 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 4 = 11696 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>11934</td><td>Bit 4 FCU 238</td></tr>
<tr><td>11935</td><td>Bit 4 FCU 239</td></tr>
<tr><td>11936</td><td>Bit 4 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 5 - MOVE</td></tr>
<tr><td>11937</td><td>Bit 5 FCU 1</td></tr>
<tr><td>11938</td><td>Bit 5 FCU 2</td></tr>
<tr><td>11939</td><td>Bit 5 FCU 3</td></tr>
<tr><td>11940</td><td>Bit 5 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 5 = 11936 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>12174</td><td>Bit 5 FCU 238</td></tr>
<tr><td>12175</td><td>Bit 5 FCU 239</td></tr>
<tr><td>12176</td><td>Bit 5 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 6 - MRO</td></tr>
<tr><td>12177</td><td>Bit 6 FCU 1</td></tr>
<tr><td>12178</td><td>Bit 6 FCU 2</td></tr>
<tr><td>12179</td><td>Bit 6 FCU 3</td></tr>
<tr><td>12180</td><td>Bit 6 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 6 = 12176 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>12414</td><td>Bit 6 FCU 238</td></tr>
<tr><td>12415</td><td>Bit 6 FCU 239</td></tr>
<tr><td>12416</td><td>Bit 6 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 7 - MRC</td></tr>
<tr><td>12417</td><td>Bit 7 FCU 1</td></tr>
<tr><td>12418</td><td>Bit 7 FCU 2</td></tr>
<tr><td>12419</td><td>Bit 7 FCU 3</td></tr>
<tr><td>12420</td><td>Bit 7 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 7 = 12416 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>12654</td><td>Bit 7 FCU 238</td></tr>
<tr><td>12655</td><td>Bit 7 FCU 239</td></tr>
<tr><td>12656</td><td>Bit 7 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 8 - AUX3</td></tr>
<tr><td>12657</td><td>Bit 8 FCU 1</td></tr>
<tr><td>12658</td><td>Bit 8 FCU 2</td></tr>
<tr><td>12659</td><td>Bit 8 FCU 3</td></tr>
<tr><td>12660</td><td>Bit 8 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 8 = 12656 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>12894</td><td>Bit 8 FCU 238</td></tr>
<tr><td>12895</td><td>Bit 8 FCU 239</td></tr>
<tr><td>12896</td><td>Bit 8 FCU 240</td></tr>
</table>

❑ Read Only Data (accessed with Modbus function code 02)

Status bits - Individual Bits per Field Unit - Discrete Locations (1 bit per)

Location	Description
	Bit 9 - AUX4
12897	Bit 9 FCU 1
12898	Bit 9 FCU 2
12899	Bit 9 FCU 3
12900	Bit 9 FCU 4
|	
| FCU 'N' Bit 9 = 12896 + N	
|	
13134	Bit 9 FCU 238
13135	Bit 9 FCU 239
13136	Bit 9 FCU 240

Location	Description
	Bit 10 - LBON
13137	Bit 10 FCU 1
13138	Bit 10 FCU 2
13139	Bit 10 FCU 3
13140	Bit 10 FCU 4
|	
| FCU 'N' Bit 10 = 13136 + N	
|	
13374	Bit 10 FCU 238
13375	Bit 10 FCU 239
13376	Bit 10 FCU 240

Location	Description
	Bit 11 - NALM
13377	Bit 11 FCU 1
13378	Bit 11 FCU 2
13379	Bit 11 FCU 3
13380	Bit 11 FCU 4
|	
| FCU 'N' Bit 11 = 13376 + N	
|	
13614	Bit 11 FCU 238
13615	Bit 11 FCU 239
13616	Bit 11 FCU 240

	Bit 12 - ALARM
13617	Bit 12 FCU 1
13618	Bit 12 FCU 2
13619	Bit 12 FCU 3
13620	Bit 12 FCU 4
|	
| FCU 'N' Bit 12 = 13616 + N	
|	
13854	Bit 12 FCU 238
13855	Bit 12 FCU 239
13856	Bit 12 FCU 240

N = field unit address number in the range 1 to 240

❑ **Read Only Data (accessed with Modbus function code 02)**

Alarm bits - Individual Bits per Field Unit - Discrete Locations (1 bit per)

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 13 - MEMF</td></tr>
<tr><td>13857</td><td>Bit 13 FCU 1</td></tr>
<tr><td>13858</td><td>Bit 13 FCU 2</td></tr>
<tr><td>13859</td><td>Bit 13 FCU 3</td></tr>
<tr><td>13860</td><td>Bit 13 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 13 = 13856 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>14094</td><td>Bit 13 FCU 238</td></tr>
<tr><td>14095</td><td>Bit 13 FCU 239</td></tr>
<tr><td>14096</td><td>Bit 13 FCU 240</td></tr>
</table>

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 14 - COMMS</td></tr>
<tr><td>14097</td><td>Bit 14 FCU 1</td></tr>
<tr><td>14098</td><td>Bit 14 FCU 2</td></tr>
<tr><td>14099</td><td>Bit 14 FCU 3</td></tr>
<tr><td>14100</td><td>Bit 14 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 14 = 14096 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>14334</td><td>Bit 14 FCU 238</td></tr>
<tr><td>14335</td><td>Bit 14 FCU 239</td></tr>
<tr><td>14336</td><td>Bit 14 FCU 240</td></tr>
</table>

<table>
<tr><th>Location</th><th>Description</th></tr>
<tr><td></td><td>Bit 15 - LOCAL</td></tr>
<tr><td>14337</td><td>Bit 15 FCU 1</td></tr>
<tr><td>14338</td><td>Bit 15 FCU 2</td></tr>
<tr><td>14339</td><td>Bit 15 FCU 3</td></tr>
<tr><td>14340</td><td>Bit 15 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 15 = 14336 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>14574</td><td>Bit 15 FCU 238</td></tr>
<tr><td>14575</td><td>Bit 15 FCU 239</td></tr>
<tr><td>14576</td><td>Bit 15 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 16 - POWR</td></tr>
<tr><td>14577</td><td>Bit 16 FCU 1</td></tr>
<tr><td>14578</td><td>Bit 16 FCU 2</td></tr>
<tr><td>14579</td><td>Bit 16 FCU 3</td></tr>
<tr><td>14580</td><td>Bit 16 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 16 = 14576 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>14814</td><td>Bit 16 FCU 238</td></tr>
<tr><td>14815</td><td>Bit 16 FCU 239</td></tr>
<tr><td>14816</td><td>Bit 16 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 17 - WDOG</td></tr>
<tr><td>14817</td><td>Bit 17 FCU 1</td></tr>
<tr><td>14818</td><td>Bit 17 FCU 2</td></tr>
<tr><td>14819</td><td>Bit 17 FCU 3</td></tr>
<tr><td>14820</td><td>Bit 17 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 17 = 14816 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>15054</td><td>Bit 17 FCU 238</td></tr>
<tr><td>15055</td><td>Bit 17 FCU 239</td></tr>
<tr><td>15056</td><td>Bit 17 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 18 - MREL</td></tr>
<tr><td>15057</td><td>Bit 18 FCU 1</td></tr>
<tr><td>15058</td><td>Bit 18 FCU 2</td></tr>
<tr><td>15059</td><td>Bit 18 FCU 3</td></tr>
<tr><td>15060</td><td>Bit 18 FCU 4</td></tr>
<tr><td colspan="2">| FCU 'N' Bit 18 = 15056 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>15294</td><td>Bit 18 FCU 238</td></tr>
<tr><td>15295</td><td>Bit 18 FCU 239</td></tr>
<tr><td>15296</td><td>Bit 18 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 19 - THERM</td></tr>
<tr><td>15297</td><td>Bit 19 FCU 1</td></tr>
<tr><td>15298</td><td>Bit 19 FCU 2</td></tr>
<tr><td>15299</td><td>Bit 19 FCU 3</td></tr>
<tr><td>15300</td><td>Bit 19 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 19 = 15296 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>15534</td><td>Bit 19 FCU 238</td></tr>
<tr><td>15535</td><td>Bit 19 FCU 239</td></tr>
<tr><td>15536</td><td>Bit 19 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 20 - LSTOP</td></tr>
<tr><td>15537</td><td>Bit 20 FCU 1</td></tr>
<tr><td>15538</td><td>Bit 20 FCU 2</td></tr>
<tr><td>15539</td><td>Bit 20 FCU 3</td></tr>
<tr><td>15540</td><td>Bit 20 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 20 = 15536 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>15774</td><td>Bit 20 FCU 238</td></tr>
<tr><td>15775</td><td>Bit 20 FCU 239</td></tr>
<tr><td>15776</td><td>Bit 20 FCU 240</td></tr>
</table>

<table>
<tr><td></td><td>Bit 21 - SFAIL</td></tr>
<tr><td>15777</td><td>Bit 21 FCU 1</td></tr>
<tr><td>15778</td><td>Bit 21 FCU 2</td></tr>
<tr><td>15779</td><td>Bit 21 FCU 3</td></tr>
<tr><td>15780</td><td>Bit 21 FCU 4</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td colspan="2">| FCU 'N' Bit 21 = 15776 + N</td></tr>
<tr><td>|</td><td></td></tr>
<tr><td>16014</td><td>Bit 21 FCU 238</td></tr>
<tr><td>16015</td><td>Bit 21 FCU 239</td></tr>
<tr><td>16016</td><td>Bit 21 FCU 240</td></tr>
</table>

❑ Read Only Data (accessed with Modbus function code 02)

Alarm bits - Individual Bits per Field Unit - Discrete Locations (1 bit per)

Location	Description
	Bit 22 - VOBS
16017	Bit 22 FCU 1
16018	Bit 22 FCU 2
16019	Bit 22 FCU 3
16020	Bit 22 FCU 4
|	
|	FCU 'N' Bit 22 = 16016 + N
|	
16254	Bit 22 FCU 238
16255	Bit 22 FCU 239
16256	Bit 22 FCU 240

Location	Description
	Bit 23 - VJAM
16257	Bit 23 FCU 1
16258	Bit 23 FCU 2
16259	Bit 23 FCU 3
16260	Bit 23 FCU 4
|	
|	FCU 'N' Bit 23 = 16256 + N
|	
16494	Bit 23 FCU 238
16495	Bit 23 FCU 239
16496	Bit 23 FCU 240

Location	Description
	Bit 24 - AUXOR
16497	Bit 24 FCU 1
16498	Bit 24 FCU 2
16499	Bit 24 FCU 3
16500	Bit 24 FCU 4
|	
|	FCU 'N' Bit 24 = 16496 + N
|	
16734	Bit 24 FCU 238
16735	Bit 24 FCU 239
16736	Bit 24 FCU 240

	Bit 25 - VTT
16737	Bit 25 FCU 1
16738	Bit 25 FCU 2
16739	Bit 25 FCU 3
16740	Bit 25 FCU 4
|	
|	FCU 'N' Bit 25 = 16736 + N
|	
16974	Bit 25 FCU 238
16975	Bit 25 FCU 239
16976	Bit 25 FCU 240

	Bit 26 - R
16977	Bit 26 FCU 1
16978	Bit 26 FCU 2
16979	Bit 26 FCU 3
16980	Bit 26 FCU 4
|	
|	FCU 'N' Bit 26 = 16976 + N
|	
17214	Bit 26 FCU 238
17215	Bit 26 FCU 239
17216	Bit 26 FCU 240

	Bit 27 - MMOVE
17217	Bit 27 FCU 1
17218	Bit 27 FCU 2
17219	Bit 27 FCU 3
17220	Bit 27 FCU 4
|	
|	FCU 'N' Bit 27 = 17216 + N
|	
17454	Bit 27 FCU 238
17455	Bit 27 FCU 239
17456	Bit 27 FCU 240

	Bit 28 - EOT
17457	Bit 28 FCU 1
17458	Bit 28 FCU 2
17459	Bit 28 FCU 3
17460	Bit 28 FCU 4
|	
|	FCU 'N' Bit 28 = 17456 + N
|	
17694	Bit 28 FCU 238
17695	Bit 28 FCU 239
17696	Bit 28 FCU 240

N = field unit address number in the range 1 to 240

❑ Read Only Data (accessed with Modbus function code 02)

Digital Inputs (Field Units) – Relay Coil Status (Applies to General Purpose Field Units only)

The following data locations contain the status of the output relays in the General Purpose field units. These may be considered as 'status signals'. The state of the coil may be examined by using Function Code 02 on a discrete by discrete basis. For writing data to relay coils see later.

Location	Description
	Relay 4 Coil
17697	Rly 4 FCU 1
17698	Rly 4 FCU 2
17699	Rly 4 FCU 3
17670	Rly 4 FCU 4
|	
| FCU 'N' Rly 4 = 17696 + N	
|	
17934	Rly 4 FCU 238
17935	Rly 4 FCU 239
17936	Rly 4 FCU 240

Location	Description
	Relay 1 Coil
17937	Rly 1 FCU 1
17938	Rly 1 FCU 2
17939	Rly 1 FCU 3
17940	Rly 1 FCU 4
|	
| FCU 'N' Rly 1 = 17936 + N	
|	
18174	Rly 1 FCU 238
18175	Rly 1 FCU 239
18176	Rly 1 FCU 240

Location	Description
	Relay 3 Coil
18177	Rly 3 FCU 1
18178	Rly 3 FCU 2
18179	Rly 3 FCU 3
18180	Rly 3 FCU 4
|	
| FCU 'N' Rly 3 = 18176 + N	
|	
18414	Rly 3 FCU 238
18415	Rly 3 FCU 239
18416	Rly 3 FCU 240

	Relay 2 Coil
18417	Rly 2 FCU 1
18418	Rly 2 FCU 2
18419	Rly 2 FCU 3
18420	Rly 2 FCU 4
|	
| FCU 'N' Rly 2 = 18416 + N	
|	
18654	Rly 2 FCU 238
18655	Rly 2 FCU 239
18656	Rly 2 FCU 240

N = field unit address number in the range 1 to 240

5.6.2 Digital Outputs (Field Units)

❑ **Write Data (accessed with Modbus function code 05 and 15)**

When writing outputs to the field units, to assert the command (energise the coil) write 0xFF00 (or any data other than 0x0000). To remove the command (de-energise the coil) write 0x0000. Actuator control commands never require to be turned off, so there is no need to write a de-energise command.

Commands - Adjacent coils per Field Unit - Coil locations (1 bit per)

Location	Description		Location	Description	
00033	Rly 1 FCU 1	(Close Cmd)	00034	Rly 2 FCU 1	(Open Cmd)
00035	Rly 1 FCU 2	(Close Cmd)	00036	Rly 2 FCU 2	(Open Cmd)
00037	Rly 1 FCU 3	(Close Cmd)	00038	Rly 2 FCU 3	(Open Cmd)
00039	Rly 1 FCU 4	(Close Cmd)	00040	Rly 2 FCU 4	(Open Cmd)
00041	Rly 1 FCU 5	(Close Cmd)	00042	Rly 2 FCU 5	(Open Cmd)
00043	Rly 1 FCU 6	(Close Cmd)	00044	Rly 2 FCU 6	(Open Cmd)
00045	Rly 1 FCU 7	(Close Cmd)	00046	Rly 2 FCU 7	(Open Cmd)
00047	Rly 1 FCU 8	(Close Cmd)	00048	Rly 2 FCU 8	(Open Cmd)
00049	Rly 1 FCU 9	(Close Cmd)	00050	Rly 2 FCU 9	(Open Cmd)
00051	Rly 1 FCU 10	(Close Cmd)	00052	Rly 2 FCU 10	(Open Cmd)
00053	Rly 1 FCU 11	(Close Cmd)	00054	Rly 2 FCU 11	(Open Cmd)
00055	Rly 1 FCU 12	(Close Cmd)	00056	Rly 2 FCU 12	(Open Cmd)
00057	Rly 1 FCU 13	(Close Cmd)	00058	Rly 2 FCU 13	(Open Cmd)
00059	Rly 1 FCU 14	(Close Cmd)	00060	Rly 2 FCU 14	(Open Cmd)
00061	Rly 1 FCU 15	(Close Cmd)	00062	Rly 2 FCU 15	(Open Cmd)
00063	Rly 1 FCU 16	(Close Cmd)	00064	Rly 2 FCU 16	(Open Cmd)
|			|		
|	FCU 'N' Rly 1 00032 + 2N - 1		|	FCU 'N' Rly 2 = 00032 + 2N	
|			|		
00501	Rly 1 FCU 235	(Close Cmd)	00502	Rly 2 FCU 235	(Open Cmd)
00503	Rly 1 FCU 236	(Close Cmd)	00504	Rly 2 FCU 236	(Open Cmd)
00505	Rly 1 FCU 237	(Close Cmd)	00506	Rly 2 FCU 237	(Open Cmd)
00507	Rly 1 FCU 238	(Close Cmd)	00508	Rly 2 FCU 238	(Open Cmd)
00509	Rly 1 FCU 239	(Close Cmd)	00510	Rly 2 FCU 239	(Open Cmd)
00511	Rly 1 FCU 240	(Close Cmd)	00512	Rly 2 FCU 240	(Open Cmd)

Note that the access to these coils is also mapped to alternate locations starting 00513 (Open Command) through to 01472 (ESD Command, field unit 240)

N = field unit address number in the range 1 to 240

❑ Write Data (accessed with Modbus function code 05 and 15)

Commands - Individual Coils per Field Unit - Coil Locations (1 bit per)

Location	Description
	Relay 2 - OPEN COMMAND
00513	Rly 2 FCU 1
00514	Rly 2 FCU 2
00515	Rly 2 FCU 3
00516	Rly 2 FCU 4
|	
| FCU 'N' Rly 2 = 00512 + N	
|	
00750	Rly 2 FCU 238
00751	Rly 2 FCU 239
00752	Rly 2 FCU 240

Location	Description
	Relay 3 - STOP COMMAND
00753	Rly 3 FCU 1
00754	Rly 3 FCU 2
00755	Rly 3 FCU 3
00756	Rly 3 FCU 4
|	
| FCU 'N' Rly 3 = 00752 + N	
|	
00990	Rly 3 FCU 238
00991	Rly 3 FCU 239
00992	Rly 3 FCU 240

Location	Description
	Relay 1 - CLOSE COMMAND
00993	Rly 1 FCU 1
00994	Rly 1 FCU 2
00995	Rly 1 FCU 3
00996	Rly 1 FCU 4
|	
| FCU 'N' Rly 1 = 00992 + N	
|	
01230	Rly 1 FCU 238
01231	Rly 1 FCU 239
01232	Rly 1 FCU 240

	Relay 4 - ESD COMMAND
01233	Rly 4 FCU 1
01234	Rly 4 FCU 2
01235	Rly 4 FCU 3
01236	Rly 4 FCU 4
|	
| FCU 'N' Rly 4 = 01232 + N	
|	
01470	Rly 4 FCU 238
01471	Rly 4 FCU 239
01472	Rly 4 FCU 240

N = field unit address number in the range 1 to 240

5.6.3 Analogue Inputs (Field Units)

❑ **Read Only Data (accessed with Modbus function code 04)**

Each suitably equipped Field Unit is able to collect Analogue data from various inputs. In the Yokogawa protocol the registers each contain a 2's complement value for the measurement. In the Honeywell SI protocol the registers each contain an integer value for the measurement.

Location	Description
Applicable to Actuator Field Units only	
	Valve Position
Range:	**Yokogawa**, 0x0000 = 0% 0x7FFF = 100% **Honeywell SI**, 0x0000 = 0% 0x0064 = 100%
30001	FCU 1 Position
30002	FCU 2 Position
30003	FCU 3 Position
30004	FCU 4 Position
|	
|	FCU 'N' Position = 30000 + N
|	
30238	FCU 238 Position
30239	FCU 239 Position
30240	FCU 240 Position

Location	Description
Applicable to General Purpose Field Units and IQ Analogue Field Units only	
	Analogue Input 1
Range:	**Yokogawa**, 0x0000 = 0% 0x7FFF = 100% **Honeywell SI**, 0x0000 = 0% 0x0064 = 100%
30241	FCU 1 An 1 I/P
30242	FCU 2 An 1 I/P
30243	FCU 3 An 1 I/P
30244	FCU 4 An 1 I/P
|	
|	FCU 'N' An 1 I/P = 30240 + N
|	
30478	FCU 238 An 1 I/P
30479	FCU 239 An 1 I/P
30480	FCU 240 An 1 I/P

Location	Description
Applicable to General Purpose Field Units and IQ Analogue Field Units only	
	Analogue Input 2
Range:	**Yokogawa**, 0x0000 = 0% 0x7FFF = 100% **Honeywell SI**, 0x0000 = 0% 0x0064 = 100%
30481	FCU 1 An 2 I/P
30482	FCU 2 An 2 I/P
30483	FCU 3 An 2 I/P
30484	
|	
|	FCU 'N' An 2 I/P = 30480 + N
|	
30718	FCU 238 An 2 I/P
30719	FCU 239 An 2 I/P
30720	FCU 240 An 2 I/P

Location	Description
Applicable to General Purpose Field Units only	
	Pulse Input
Range:	**Yokogawa** and **Honeywell SI**, 0x0000 to 0x270F counter value
30721	FCU 1 Pulse I/P
30722	FCU 2 Pulse I/P
30723	FCU 3 Pulse I/P
30724	FCU 4 Pulse I/P
|	
|	FCU 'N' Pulse I/P = 30720 + N
|	
30958	FCU 238 Pulse I/P
30959	FCU 239 Pulse I/P
30960	FCU 240 Pulse I/P

N = field unit address number in the range 1 to 240

❑ Read Only Data (accessed with Modbus function code 04)

IQ Range, CVA and EH / SI Actuator Field Units are able to collect both Current and Historical Torque (pressure for EH / SI) data from the actuator. The following 16 bit register locations each contain a value relating to the actuator torque.

Location	Description
Current Torque	
Range: **Yokogawa**, 0x0000 = 0% 0x7FFF = 120% **Honeywell SI**, 0x0000 = 0% 0x0078 = 120%	
30961	FCU 1 Current Torque
30962	FCU 2 Current Torque
30963	FCU 3 Current Torque
30964	FCU 4 Current Torque
|	
| FCU 'N' Position = 30960 + N	
|	
31198	FCU 238 Current Torque
31199	FCU 239 Current Torque
31200	FCU 240 Current Torque

Historical Torque Profile

Range: **Yokogawa**, 0x0000 = 0% 0x7FFF = 120%
Honeywell SI, 0x0000 = 0% 0x0078 = 120%

The Torque value is related to the readings taken across the valve stroke, Position 0 and 100% are not used as these may be set to full torque for a torque seating valve. Torque readings are available for 6%, 19%, 31%, 44%, 56%, 69%, 81%, and 94% positions. The data is stacked in pairs where an open torque is followed by a close torque for each position, for each field unit.

The data is historical and only updated on completion of a full stroke of the valve from open to close, or from close to open. Further the data is not reported from the actuator to the master station unless the Torque Data Filter Factor is set to 0 (refer to the Field Unit manual for more information).

Location	Description	Location	Description
31201	6% Open Torque FCU 1	31202	6% Close Torque FCU 1
31203	6% Open Torque FCU 2	31204	6% Close Torque FCU 2
31205	6% Open Torque FCU 3	31206	6% Close Torque FCU 3
|		|	
| FCU 'N' 6% Open Torque = 31200 + 2N -1		| FCU 'N' 6% Close Torque = 31200 + 2N	
|		|	
31679	6% Open Torque FCU 240	31680	6% Close Torque FCU 240

Location	Description
31681	19% Open Torque FCU 1
| FCU 'N' 19% Open Torque = 31680 + 2N -1	
32159	19% Open Torque FCU 240
32161	31% Open Torque FCU 1
| FCU 'N' 31% Open Torque = 32160 + 2N -1	
32639	31% Open Torque FCU 240
32641	44% Open Torque FCU 1
| FCU 'N' 44% Open Torque = 32640 + 2N -1	
33119	44% Open Torque FCU 240
33121	56% Open Torque FCU 1
| FCU 'N' 56% Open Torque = 33120 + 2N -1	
33599	56% Open Torque FCU 240
33601	69% Open Torque FCU 1
| FCU 'N' 69% Open Torque = 33600 + 2N -1	
34079	69% Open Torque FCU 240
34081	81% Open Torque FCU 1
| FCU 'N' 81% Open Torque = 34080 + 2N -1	
34559	81% Open Torque FCU 240
34561	94% Open Torque FCU 1
| FCU 'N' 94% Open Torque = 34560 + 2N -1	
35039	94% Open Torque FCU 240

N = field unit address number in the range 1 to 240

Location	Description
31682	19% Close Torque FCU 1
| FCU 'N' 19% Close Torque = 31680 + 2N)	
32160	19% Close Torque FCU 240
32162	31% Close Torque FCU 1
| FCU 'N' 31% Close Torque = 32160 + 2N	
32640	31% Close Torque FCU 240
32642	44% Close Torque FCU 1
| FCU 'N' 44% Close Torque = 32640 + 2N	
33120	44% Close Torque FCU 240
33122	56% Close Torque FCU 1
| FCU 'N' 56% Close Torque = 33120 + 2N	
33600	56% Close Torque FCU 240
33602	69% Close Torque FCU 1
| FCU 'N' 69% Close Torque = 33600 + 2N	
34080	69% Close Torque FCU 240
34082	81% Close Torque FCU 1
| FCU 'N' 81% Close Torque = 34080 + 2N	
34560	81% Close Torque FCU 240
34562	94% Close Torque FCU 1
| FCU 'N' 94% Close Torque = 34560 + 2N	
35040	94% Close Torque FCU 240

5.6.4 Analogue Outputs (Field Units)

❑ **Write Data (accessed with Modbus function codes 03, 06, 16)**

Particular Actuator Field Units are able to accept a Desired Position signal. The following 16 bit register locations may be written to with a 2's complement value (Yokogawa protocol), or signed integer value (Honeywell SI protocol) relating to the desired valve position.

Location	Description
Applicable to Actuator Field Units only	
Valve Position Control	
Range:	**Yokogawa**, 0x0000 = 0% 0x7FFF = 100% **Honeywell SI**, 0x0000 = 0% 0x0064 = 100%
40001	FCU 1 Position control
40002	FCU 2 Position control
40003	FCU 3 Position control
40004	FCU 4 Position control
|	
|	FCU 'N' Position = 40000 + N
|	
40238	FCU 238 Position control
40239	FCU 239 Position control
40240	FCU 240 Position control

General Purpose Field Units are able to accept an 'Analogue Output' signal for connection to a controller or positioner. The following 16 bit register locations may be written to with a 2's complement value (Yokogawa protocol), or signed integer value (Honeywell SI protocol) relating to the setting of this output.

Location	Description
Applicable to General Purpose Field Units only	
Analogue Output	
Range:	**Yokogawa**, 0x0000 = 0% 0x7FFF = 100% **Honeywell SI**, 0x0000 = 0% 0x0064 = 100%
40241	FCU 1 Analogue output
40242	FCU 2 Analogue output
40243	FCU 3 Analogue output
40244	FCU 4 Analogue output
|	
|	FCU 'N' Position = 40240 + N
|	
40478	FCU 238 Analogue output
40479	FCU 239 Analogue output
40480	FCU 240 Analogue output

5.7 Field unit inputs and outputs available

5.7.1 Digital Inputs

	FCU Type							
Data Bit or Register	IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Bit 0	AUX 1	R	DIN 1	R	R	AUX 1	R	R
Bit 1	AUX 2	R	DIN 2	R	BAKPWR	AUX 2	R	R
Bit 2	OAS	OAS	DIN 3	OAS	OAS	OAS	OAS	R
Bit 3	CAS	CAS	DIN 4	CAS	CAS	CAS	CAS	R
Bit 4	STOP	STOP	DIN 5	STOP	STOP	STOP	R	R
Bit 5	MOVE	MRUN	DIN 6	MRUN	MOVE	Travelling	MOVE	R
Bit 6	MRO	MRO	DIN 7	MRO	TRO	MRO	R	R
Bit 7	MRC	MRC	DIN 8	MRC	TRC	MRC	R	R
Bit 8	AUX 3	EXT	R	EXT	R	AUX 3	R	R
Bit 9	AUX 4	R	R	R	R	AUX 4	R	R
Bit 10	LBON	LBON	LBON	LBON	LBON	LBON	LBON	LBON
Bit 11	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM
Bit 12	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM
Bit 13	MEMF	MEMF	MEMF	MEMF	MEMF	MEMF	R	MEMF
Bit 14	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS
Bit 15	LOCAL	CNA	R	CNA	LOCAL	LOCAL	LOCAL	R
Bit 16	POWR	POWR	POWR	POWR	POWR	POWR	POWR	POWR
Bit 17	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG
Bit 18	MREL	MREL	R	MREL	MREL	MREL	MREL	R
Bit 19	THERM	THERM	R	THERM	THERM	FAULT	R	R
Bit 20	LSTOP	LSTOP	R	LSTOP	LSTOP	LSTOP	LSTOP	R
Bit 21	SFAIL	SFAIL	R	SFAIL	SFAIL	SFAIL	SFAIL	R
Bit 22	VOBS	VOBS	R	VOBS	VOBS	VOBS	VOBS	R
Bit 23	VJAM	VJAM	R	VJAM	VJAM	VJAM	R	R
Bit 24	AUXOR	MOP	R	MOP	R	AUXOR	R	R
Bit 25	VTT	MCL	R	MCL	R	VTT	R	R
Bit 26	R	MOPG	R	MOPG	R	R	R	R
Bit 27	MMOVE	MCLG	R	MCLG	MMOVE	MMOVE	R	R

	FCU Type							
Data Bit or Register	IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Bit 28	EOT	EOT	R	EOT	EOT	EOT	R	R
Relay 4	R	0	RL4	0	0	R	R	R
Relay 1	R	0	RL1	0	0	R	R	R
Relay 3	R	0	RL3	0	0	R	R	R
Relay 2	R	0	RL2	0	0	R	R	R

AUX1 - Aux. Input 1
AUX2 - Aux Input 2
OAS - Open limit switch
CAS - Close limit switch
STOP - Actuator stopped in mid travel
MOVE - IQ/IQT valve moving
MRUN - Motor running
MRO - Motor running open direction
MRC - Motor running close direction
AUX3 - Aux Input 3
AUX4 - Aux Input 4
DIN 1 to 8 - Digital inputs 1 to 8
EXT IP - External digital input
LBON - Loopback on
NALM - New alarm present on this FCU
ALARM - Any alarm present on this FCU
R - Reserved
Travelling - Actuator in motion
TRO - Travelling open direction
TRC - Travelling closed direction

MEMF - RAM/ROM failure
COMMS - Comms fail
LOCAL - Actuator not in remote control
CNA - Control not available
POWR - Power on reset
WDOG - Watchdog fail
MREL - Monitor relay
THERM - Thermostat trip
FAULT - Actuator fault
LSTOP - Local stop operated
SFAIL - Start/stop fail
VOBS - Valve obstructed
VJAM - Valve jammed
AUXOR - Aux I/P Override
VTT - Valve Travel Time
MOP - Manual open
MCL - Manual close
MMOVE - Manual valve movement
MOPG - Manual opening
MCLG - Manual closing
EOT - Motor running end of travel
BAKPWR - Under battery back-up power

5.7.2 Digital Outputs

	FCU Type							
Data Bit or Register	IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Open (Relay 2)	Y	Y	Y	Y	Y	Y	Y	N
Stop (Relay 3)	Y	Y	Y	Y	Y	Y	Y	N
Close (Relay 1)	Y	Y	Y	Y	Y	Y	Y	N
ESD (Relay 4)	Y	Y	Y	Y	Y	Y	Y	N

5.7.3 Analogue Inputs

	FCU Type							
Data Bit or Register	IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Valve Position	Y	Y	N	Y	Y	Y	Y	N
Current Torque	Y	N	N	N	Y	Y (pressure)	N	N
Historical Torque	Y	N	N	N	Y	Y	N	N
Analogue Input 1	N	N	Y	N	N	N	N	Y
Analogue Input 2	N	N	Y	N	N	N	N	Y
Pulse Input	N	N	Y	N	N	N	N	N

5.7.4 Analogue Outputs

	FCU Type							
Data Bit or Register	IQ Range Actuator	A, AQ, Q, ROMpak	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Position Control	Y	Y	N	Y	Y	Y	Y	N
Analogue Output	N	N	Y	N	N	N	N	N

5.8 Modbus message examples (Yokogawa and Honeywell SI protocols)

A few examples are included here to clarify the use of the Modbus protocol. These examples assume that the master station address is set to 01. **All data is in hexadecimal notation**.

Remember that the address used in the Modbus message assumes start points of zero for coils, registers etc. However the locations indicated in the tables above put the first register or coil etc. as number 1. Therefore 1 must be deducted from the locations indicated when determining the Modbus message location.

5.8.1 Read Field Unit Bit 5 from FCU 1 to 100

To determine which Actuator motors are running. Bit 5 is located in discrete areas 11937 to 12036 for actuators 1 to 100.

Modbus Address	Function Code	Discrete Address	Number of Discretes	CRC Check
01	02	07 90	00 64	CRC

5.8.2 Read Field Unit Bit 2 and 3 from FCU 1 to 120

To use a single transaction by collecting the data from the 'two bit' area. Bits 2 and 3 are located in discrete areas 10257 to 10496 for actuators 1 to 120.

Modbus Address	Function Code	Discrete Address	Number of Discretes	CRC Check
01	02	01 00	00 F0	CRC

5.8.3 Read Valve Position from FCU 26

Register is located at 30026

Modbus Address	Function Code	Register Address	Number of Registers	CRC Check
01	04	00 19	00 01	CRC

5.8.4 Energise Command to Open relay of Field Unit 104

The coil is located at 00616
To write a single coil the data field must be FF00

Modbus Address	Function Code	Coil Address	Data	CRC Check
01	05	02 68	FF 00	CRC

OR:

Using the 'two command area' the coil is located at 00240
To write a single coil the data field must be FF00

Modbus Address	Function Code	Coil Address	Data	CRC Check
01	05	00 F0	FF 00	CRC

5.8.5 Write Desired Valve Position for FCU 26 to be 50%

Register is located at 40026.
With **Yokogawa protocol**, 50% is 3FFF and with **Honeywell SI protocol**, 50% is 0032

Using **Yokogawa protocol**

Modbus Address	Function Code	Register Addess	Data	CRC Check
01	06	00 19	3F FF	CRC

Using **Honeywell SI protocol**

Modbus Address	Function Code	Register Addess	Data	CRC Check
01	06	00 19	00 32	CRC

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6 FIELD UNIT BLOCK AND PARAMETER ALLOCATIONS

The Pakscan current loop system comprises a number of Field Control Units connected to a Master Station via a 2-wire loop. The Master Station manages the loop, collects data from, and issues instructions to, the Field Units. Data within the Pakscan system is organised in Blocks and Parameters relating to specific functions or activities within the Field Control Units (e.g. Digital inputs, Alarms, Position control). Each FCU supports up to 32 blocks with each block containing eight 16-bit parameters.

This section details the use of these blocks and parameters in the transfer of data between the Field Unit and Master Station. A subset of this data is then used in host computer communications when using Modbus. The field unit blocks and parameters can be examined on a Pakscan 3 master station on specific field unit screens (HMI or web).

The various types of Field Unit have different block and parameter allocations. The following sections give details of all the allocations applicable to each actuator and field unit type.

6.1 Block and parameter construction

The FCU acts as a slave to the master station, responding only when interrogated, just as the master station acts as a slave to the host computer system. The data base in the field unit comprises a series of records organised into Blocks and Parameters. Each Parameter contains 16 data bits. There are 32 Blocks, each of 8 Parameters, allocated for every field unit on the system, though not all these Blocks contain relevant data.

6.1.1 Digital inputs

Each field unit has direct digital inputs from the connected actuator or other device. The status of these digital signals is reported in the Digital Input Block (Block 2 Parameter 0). The block also contains indication of any alarms present in the Alarm block.

6.1.2 Alarm block

The Alarm Block holds data about alarms either directly connected to the field unit, or logically derived from the status of all the inputs. Transient alarm data bits are individually latched by the master station and automatically cleared from the field unit on successful transfer. Alarm conditions will not return to normal until both the source of the alarm is corrected and the alarm is both 'read' and 'accepted' by the master station.

6.1.3 Analogue and counter input data

The field unit will report analogue or counter values to the master station only when the measurement changes by an amount that exceeds the 'Deviation' setting by 1 digit, or the 'Update Timeout' period has expired. These parameters are adjustable, and included in the system to ensure that analogue reporting only occurs when necessary. The host computer has access to the last reported analogue value in the master station.

6.1.4 Outputs

The master station transfers both digital and analogue outputs from the host computer directly to the connected field unit. There are no registers holding output data present within the master station itself.

6.2 Block and parameter usage

The following lists show all the relevant Blocks and Parameters that may exist in FCU's. They also show the meaning of parameters for each Field Unit type and which parameters are supported by the particular Field Unit types. All parameters are 16 bit quantities although most have a limited range of values. The Parameters are transmitted Most Significant Data Byte first.

Field Unit Types Available:

CP	-	Used for IQ3, CVA, CMA, ROMpak actuators
IQmk1	-	Used for IQ1, IQ2 and IQT actuators
INTEGRAL	-	A, AQ and Q Actuator control integral to the actuator
GPFCU (GP)	-	General Purpose version of GPFCU
GPFCU (Act)	-	Actuator Control version of GPFCU
IQ Analogue	-	Additional analogue input card for IQT actuators already fitted with FCU
EH / SI	-	Electro-hydraulic actuator version of IQT field unit

Key to Symbols Used:

RO	-	Read Only
R/W	-	Read / Write
WO	-	Write Only
Y	-	Item supported for this type of Field Unit
R	-	Reserved for internal or future use
BLANK	-	A Blank entry indicates that the item is not supported for that Field Unit type. Reads of that item generally return zero.
M	-	Data indicated is as read with a Paktester, if it is read via a master station screen using Block and Parameter reads the data will be invalid.

❑ **Notes:**

a) Great care must be exercised in the writing of data to a field unit. In general this can only be achieved if the field unit is in ‘loopback’.

b) The range display will differ when viewed with a master station block and parameter read compared to a Paktester read. In general, the master station re-ranges the range to show 32767 as the 100% value as a decimal whilst the Paktester will show 100% as 0xFFFF in hexadecimal. Writes from the master station should use the master station range.

c) The ranges indicated in the tables are those seen with a Paktester directly connected to the field unit.

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Block 0 - FCU Type Block									
Parameter 0 – FCU Type	RO	Y	Y	Y	Y	Y			Y
Data:		IQ1/IQ2 = 0006 IQ3 = 0011 IQT = 0008	0002 ROMpak = 000E	0004	0003	CVL = 000C CVQ= 000D	EH = 0009 SI = 000A	CMA = 0014	0007
Parameter 1 – SW version	RO	Y	Y	Y	Y	Y	Y	Y	Y
Parameter 2	R/W	Y	Y	R	Y	Y	Y	Y	R
Data: Tag string / Stall timer									
Parameter 3 to 7		R	R	R	R	R	R	R	R
Block 1 - FCU Block									
Parameter 0		R	R	R	R	R	R	R	R
Parameter 1 – Baud rate	M	Y	Y	Y	Y	Y	Y	Y	Y
Data: 0000 = 110, 0001 = 300, 0002 = 600, 0003 = 1200, 0004 = 2400									
Parameter 2 - Address	M	Y	Y	Y	Y	Y	Y	Y	Y
Range: 0001 to 00F0									
Parameter 3 – Address in L/B	M	Y	Y	Y	Y	Y	Y	Y	Y
Range: 0001 to 00F0									
Parameter 4 to 7		R	R	R	R	R	R	R	R

Block 2 – Digital Input Block

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Parameter 0 – Digital I/P	RO	Y	Y	Y	Y	Y	Y	Y	Y
Bit 0	RO	AUX 1	R (*AUX1*)	DIN 1	R	R	AUX 1	R	R
Bit 1	RO	AUX 2	R (*AUX2*)	DIN 2	R	BAKPWR	AUX 2	R	R
Bit 2	RO	OAS	OAS	DIN 3	OAS	OAS	OAS	OAS	R
Bit 3	RO	CAS	CAS	DIN 4	CAS	CAS	CAS	CAS	R
Bit 4	RO	STOP	STOP	DIN 5	STOP	STOP	STOP	R	R
Bit 5	RO	MOVE	MRUN	DIN 6	MRUN	MOVE	Travelling	MOVE	R
Bit 6	RO	MRO	MRO	DIN 7	MRO	TRO	MRO	R	R
Bit 7	RO	MRC	MRC	DIN 8	MRC	TRC	MRC	R	R
Bit 8	RO	AUX 3	EXT(*AUX3*)	R	EXT	R	AUX 3	R	R
Bit 9	RO	AUX 4	R (*AUX4*)	R	R	R	AUX 4	R	R
Bit 10	RO	LBON	LBON	LBON	LBON	LBON	LBON	LBON	LBON
Bit 11	RO	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM	NALRM
Bit 12	RO	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM	ALRM
Bit 13	RO	BATT	R	R	R	BAKBATT	R	R	R
Bit 14	RO	Remote (IQ3)	R	R	R	R	R	R	R
Bit 15	RO	R	R	R	R	R	R	R	R
Parameter 1 – Invert mask	R/W	R	R	Y	R	R	R	R	R
Parameter 2 – Aux I/P config	R/W	Y	R	R	R	R	Y	R	R
Parameter 3 to 7		R	R	R	R	R	R	R	R

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue

Block 3 – Alarm Block

Parameter 0 – Alarms	RO	Y	Y	Y	Y	Y	Y	Y	Y
Bit 0	RO	MEMF	MEMF	MEMF	MEMF	MEMF	MEMF	R	MEMF
Bit 1	RO	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS	COMMS
Bit 2	RO	LOCAL	CNA	R	CNA	LOCAL	LOCAL	LOCAL	LOCAL
Bit 3	RO	POWR	POWR	POWR	POWR	POWR	POWR	POWR	POWR
Bit 4	RO	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG	WDOG
Bit 5	RO	MREL	MREL	R	MREL	MREL	MREL	MREL	R
Bit 6	RO	THERM	THERM	R	THERM	THERM	FAULT	R	R
Bit 7	RO	LSTOP	LSTOP	R	LSTOP	LSTOP	LSTOP	LSTOP	R
Bit 8	RO	SFAIL	SFAIL	R	SFAIL	SFAIL	SFAIL	SFAIL	R
Bit 9	RO	VOBS	VOBS	R	VOBS	VOBS	VOBS	VOBS	R
Bit 10	RO	VJAM	VJAM	R	VJAM	VJAM	VJAM	R	R
Bit 11	RO	AUXOR	MOP	R	MOP	R	AUXOR	R	R
Bit 12	RO	VTT	MCL	R	MCL	R	VTT	R	R
Bit 13	RO	R	MOPG	R	MOPG	R	R	R	R
Bit 14	RO	MMOVE	MCLG	R	MCLG	MMOVE	MMOVE	R	R
Bit 15	RO	EOT	EOT	R	EOT	R	EOT	R	R
Parameter 1 – Alarm Accept		R	R	R	R	R	R	R	R
Para' 2 – Valve Travel Time	R/W	Y	R	R	R	R	Y	R	R
Parameter 3 to 7		R	R	R	R	R	R	R	R

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Block 4 - 8 Bit Analogue Input Block - Valve Position Feedback									
Parameter 0 – Position MV	RO	Y	Y	R	Y	Y	Y	Y	R
Range: 0x0000 = 0% position, 0x00FF = 100% position IQ3, CVA, CMA Range in high precision mode: 0x0000 = 0% position, 0xFFFF = 100% position (transmission byte order in little endian)									
Para'1 – Deviation Threshold	R/W	Y	Y	R	Y	Y	Y	Y	R
Range: 0x0000 = 0%, 0x00FF = 100%, (0 = disable)									
Para' 2 – Update Timeout	R/W	Y	Y	R	Y	Y	Y	Y	R
Range: 0x0000 = 0 sec, 0x00FF = 255 sec, (0 = disable)									
Para' 3 – 0% calibration	R/W	Y	R	R	R	Y	Y	Y	R
Para' 4 – 100% calibration	R/W	Y	R	R	R	Y	Y	Y	R
Para' 5 – Raw Input	RO	Y	Y	R	Y	Y	Y	Y	R
Parameter 6 - 7		R	R	R	R	R	R	R	R
Block 5 – Position Control Block (Valve Desired Position)									
Parameter 0		R	R	R	R	R	R	R	R
Parameter 1 – Desired value	R/W	Y	Y	R	Y	Y	Y	Y	R
Range: 0x0000 = 0% Desired position, 0x00FF = 100% Desired position IQ3, CVA, CMA Range in high precision mode: 0x0000 = 0% position, 0xFFFF = 100% position (transmission byte order in little endian)									
Para' 2 – Motion Inhibit Timer	R/W	Y	Y	R	Y	R	Y	R	R
Range: 0x0000 = 0 sec, 0x00FF = 128 sec									
Para' 3 – Deadband Setting	R/W	Y	Y	R	Y	Y	Y	Y	R
Range: 0x0000 = 0%, 0x00FF = 12%									
Para' 4 – Hysteresis	R/W	Y	R	R	R	R	Y	R	R
Parameter 5 to 7		R	R	R	R	R	R	R	R

Block 6 – Digital Output Block

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Parameter 0 – Digital Output	RO	R	R	Y	R	R	R	R	R
Bit 0	RO	0	0	RLY 4	0	0	0	0	0
Bit 1	RO	0	0	RLY 1	0	0	0	0	0
Bit 2	RO	0	0	RLY 3	0	0	0	0	0
Bit 3	RO	0	0	RLY 2	0	0	0	0	0
Bit 4	RO	0	0	0	0	0	0	0	0
Bit 5	RO	0	0	0	0	0	0	0	0
Bit 6	RO	0	0	0	0	0	0	0	0
Bit 7	RO	0	0	ACT	0	0	0	0	0
Bit 8 – 15	RO	0	0	0	0	0	0	0	0
	Key: ACT = relay action, 0 = Fleeting, 1 = Maintained								
Parameter 1 - Open	WO	Y	Y	Y	Y	Y	Y	Y	R
'OPEN' (Relay 2) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 2 – Stop	WO	Y	Y	Y	Y	Y	Y	Y	R
'STOP' (Relay 3) : 0x0000 = De-energise 0Xff00 or any non-zero value = Energise relay									
Parameter 3 - Close	WO	Y	Y	Y	Y	Y	Y	Y	R
'CLOSE' (Relay 1) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 4 - ESD	WO	Y	Y	Y	Y	Y	Y	Y	R
'ESD' (Relay 4) : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 5 – Partial Stroke Test	WO	Y (IQ3)	N	N	N	N	N	N	R
'PST' : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 5 - 7		R	R	R	R	R	R	R	R

Block 7 – Pulse Input Block

Parameter 0 – Counter Value	RO	R	R	Y	R	R	R	R	R
Range: 0x0000 to 0x270F = 0 to 9999 decimal									
Parameter 1 to 7		R	R	R	R	R	R	R	R

Block 8 – IQ Range Digital Output operation

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue
Parameter 0	-	R	R	R	R	R	R	R	R
Parameter 1 -	WO	Y	R	R	R	R	R	R	R
Digital output 1 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 2 -	WO	Y	R	R	R	R	R	R	R
Digital output 2 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 3 -	WO	Y	R	R	R	R	R	R	R
Digital output 3 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 4 -	WO	Y	R	R	R	R	R	R	R
Digital output 4 : 0x0000 = De-energise 0xFF00 or any non-zero value = Energise relay									
Parameter 5-7	-	R	R	R	R	R	R	R	R

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue

Block 9 – 12 bit Analogue Input 1 Block

Para' 0 – Analogue Input 1	R/O	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0%, 0x0FFF = 100%									
Para' 1 – Deviation Threshold	R/W	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0%, 0x00FF = 100%, (0 = disable)									
Para' 2 – Update Timeout	R/W	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0 sec, 0x00FF = 255 sec (0 = disable)									
Para' 3 – AI 1 Min (0% input)	R/W	R	R	Y	R	R	R	R	Y
Para' 4 – AI 1 Max (100% i/p)	R/W	R	R	Y	R	R	R	R	Y
Para; 5 – Raw An I/P 1	RO	R	R	Y	R	R	R	R	Y
Parameter 6 and 7		R	R	R	R	R	R	R	R

Block 10 – 12 bit Analogue Input 2 Block

Para' 0 – Analogue Input 2	R/O	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0%, 0x0FFF = 100%									
Para' 1 – Deviation Threshold	R/W	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0%, 0x00FF = 100%, (0 = disable)									
Para' 2 – Update Timeout	R/W	Y(IQ3)	R	Y	R	R	R	R	Y
Range: 0x0000 = 0 sec, 0x00FF = 255 sec (0 = disable)									
Para' 3 – AI 2 Min (0% input)	R/W	R	R	Y	R	R	R	R	Y
Para' 4 – AI 2 Max (100% i/p)	R/W	R	R	Y	R	R	R	R	Y
Para; 5 – Raw An I/P 2	RO	R	R	Y	R	R	R	R	Y
Parameter 6 and 7		R	R	R	R	R	R	R	R

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue

Block 11 – 12 bit Analogue Output Block

Para' 0 – Analogue Output	R/W	R	R	Y	R	R	R	R	R
Range: 0x0000 = 0%, 0x0FFF = 100%									
Para' 1 – 0% Calibration	R/W	R	R	Y	R	R	R	R	R
Range: 0x0000 to 0x0FFF = Value at 0%									
Para' 1 – 100% Calibration	R/W	R	R	Y	R	R	R	R	R
Range: 0x0000 to 0x0FFF = Value at 100%									
Parameter 3 to 7		R	R	R	R	R	R	R	R

Block 12 – Historical Torque Profile – Opening Direction

The IQ Range Actuator is able to report 8 torque values related to valve position across the valve stroke. Position 0 and 100% are not used as these may be set to full torque for a torque seating valve. Torque readings are available for 6%, 19%, 31%, 44%, 56%, 69%, 81%, and 94% positions. The following parameters contain this data for the OPENING direction of travel - note that they only update if a complete stroke of the valve is made and contain the last profile only.

Range: 0000 = 0% rated torque, 00FF = 120% rated torque

Para' 0 - 6%	RO	Y	R	R	R	Y	Y	R	R
Para' 1 - 19%	RO	Y	R	R	R	Y	Y	R	R
Para' 2 - 31%	RO	Y	R	R	R	Y	Y	R	R
Para' 3 - 44%	RO	Y	R	R	R	Y	Y	R	R
Para' 4 - 56%	RO	Y	R	R	R	Y	Y	R	R
Para' 5 - 69%	RO	Y	R	R	R	Y	Y	R	R
Para' 6 - 81%	RO	Y	R	R	R	Y	Y	R	R
Para' 7 - 94%	RO	Y	R	R	R	Y	Y	R	R

	Read Write	FCU Type							
		IQ Range Actuator	A, AQ, Q, ROMPAK	GPFCU (GP)	GPFCU (ACT)	CVA	EH / SI Pro	CMA	IQ Analogue

Block 13 – Historical Torque Profile – Closing Direction

The IQ Range Actuator is able to report 8 torque values related to valve position across the valve stroke. Position 0 and 100% are not used as these may be set to full torque for a torque seating valve. Torque readings are available for 6%, 19%, 31%, 44%, 56%, 69%, 81%, and 94% positions. The following parameters contain this data for the CLOSING direction of travel - note that they only update if a complete stroke of the valve is made and contain the last profile only.

Range: 0000 = 0% rated torque, 00FF = 120% rated torque

Para' 0 - 6%	RO	Y	R	R	R	Y	Y	R	R
Para' 1 - 19%	RO	Y	R	R	R	Y	Y	R	R
Para' 2 - 31%	RO	Y	R	R	R	Y	Y	R	R
Para' 3 - 44%	RO	Y	R	R	R	Y	Y	R	R
Para' 4 - 56%	RO	Y	R	R	R	Y	Y	R	R
Para' 5 - 69%	RO	Y	R	R	R	Y	Y	R	R
Para' 6 - 81%	RO	Y	R	R	R	Y	Y	R	R
Para' 7 - 94%	RO	Y	R	R	R	Y	Y	R	R

Block 14 – Historical Torque Profile – Closing Direction

Para' 0 – Current Torque	R/O	Y	R	R	R	Y	Y	R	R
Range: 0x0000 = 0%, 0x00FF = 120%									
Para' 1 – Deviation Threshold	R/W	Y	R	R	R	Y	Y	R	R
Range: 0x0000 = 0%, 0x00FF = 100%,									
Para' 2 – Update Timeout	R/W	Y	R	R	R	Y	Y	R	R
Range: 0x0001 = 1 minute, 0x00FF = 255 minutes (0 = disable)									
Para' 3 – Filter	R/W	Y	R	R	R	Y	Y	R	R
Data: 0x0000 = Off, 0x00FF = On, Automatic torque reporting is only available with the filter Off									
Para' 4 – Profile Counters		M	R	R	R	M	M	R	R
Bits 8-15 = Open counter, Bits 7-0 = Close counter (available from the master station only)									
Parameter 5 to 7		R	R	R	R	R	R	R	R

Block 15 to 31 – Reserved

Block 15 - 31 Parameter 1 - 7		R	R	R	R	R	R	R	R

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