





# **Xcell INTEGRATORS TECHNICAL MANUAL**

## **INTEGRATED PROTECTION AND CONTROL SYSTEMS**

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# **SECTION 1 - System Overview**

## ***1.1 Introduction***

P&B Engineering have manufactured Motor Protection devices for 60 years and are the UK's leading supplier of such equipment.

At the Electrotech 92 exhibition P&B Engineering introduced the MPC2000 the first Intelligent Motor Protection Control System that was openly available to all Switchgear/MCC OEM's.

In 1996 at the same exhibition the SUPERVISION range was unveiled as the successor and is specifically designed for competitive use with LV and HV Motors of any size and Voltage, resulting in it being the most comprehensive Motor Protection device ever manufactured by P&B Engineering. In addition we can provide a comprehensive XCell Gateway System, providing many proven industry standard Protocols. This makes the P&B system not only openly available to users or manufacturers at the same price, but also the most flexible available allowing total integration with other manufacturers equipment such as DCS, PLC or SCADA systems e.g. Foxboro, Honeywell, Fisher etc.

Since it's launch the 2000 and Supervision ranges have been installed in a variety of applications in many different industries throughout the world.

At the Electrotech 94 exhibition P&B Engineering demonstrated a complete Integrated Electrical Switchgear Protection, Monitoring and Control System, which won the Technical Excellence Commendation at the fair. This achievement was assisted by a display of the developed range of sophisticated Intelligent Protection Relays for Motor, Feeder and Generator protection all of which are able to provide remote monitoring and configuration of setting parameters using the field proven P&B Network Gold protocol.

In addition to this the protocol has been Integrated into the XCell Advanced Cellular RTU system which brings complete flexibility and Integration to the system enabling totally distributed, fully redundant systems to be applied at a minimal cost.

### **1.2 Integrated Protection & Control**

The use of serial communications to provide an Integrated Motor Protection, Control & Monitoring system such as the Motorvision/XCell system is now well proven and specified as standard for many new industrial installations, including offshore Oil and Gas platforms, refineries, etc. Many companies who supply similar systems use fibre-optic communications as standard, which has severe cost implications and is not always necessary. For this reason, P&B generally uses shielded twisted pair copper cable for communications, with the fibre-optic option available if required.

In developing the P&B system we have taken into consideration all of these past areas of doubt and have produced a system which can be installed either as; (1) a stand alone system providing full monitoring & configuration of a complete protection system via an engineering PC running custom designed Windows based software to provide a highly user friendly graphical man machine interface. or,(2) as a total integrated system for the complete protection, control and monitoring of both distribution and LV motor switch/control gear. Plus Process & Energy Control & Monitoring by Distributed Control Systems with Electrical System Control, Maintenance and Monitoring via our Windows based Engineering software.

By designing the products to include communications features as standard and by developing the use of the modular XCell system for data acquisition and protocol conversion, we are now able to offer the considerable benefits of Integrated Systems at very affordable costs. This means that the full benefits offered by this technology are provided at a total project installation cost which is often considerably less than if conventional Switchgear & MCC's were used.

### **1.3 Communications**

The communications between devices is achieved using Isolated RS485 Twisted Pair data highways connected in daisy chain or multi-drop configuration. Up to 32 devices can be connected to a highway. This media offers highly reliable communications over long distances of up to 1.5 km without the need for expensive line drivers, signal converters etc.

P&B Engineering has developed a specific protocol for use with the Supervision relays which permits the full use of the vast amount of data available from each device. The ASCII based protocol has message lengths limited to 9 bytes and with the use of a 16 bit CCITT approved CRC gives complete data integrity.

Motor Protection Controllers can provide comprehensive data from each device (32 digital states and 25 analogue values for the Motorvision). The use of this data can be divided into 2 distinct categories, Process Critical & Electrical Engineering Data.

The first category 'Process Critical' is data required by the PLC or DCS which essentially is limited to the small portion of the data available which is relevant to its Process Control function. This small amount of data however is required to be updated frequently i.e. every <2 seconds. This category of data could for example cover Motor Availability - e.g. is it Running, is there a current Alarm or Fault, what control mode applies, as well as information on the Motor load or thermal capacity.

The second category of data is best described as Engineering Data. This would include the Process Critical data but would also comprise a great deal of detailed data available from the Protection device, such as the type of Alarm or Fault, the associated fault currents or voltages. For Motor Protection Controllers we also provide the status of each hard wired input connected to the device. Historical data is also provided such as the number of motor starts and the latest start characteristics, motor hours run etc. This data because of it's very nature does not need to be updated as often as Process Control data, except when an Alarm or Fault condition occurs and is invaluable to an

## **SECTION 1 - SYSTEM OVERVIEW**

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Electrical Engineer in establishing & rectifying faults quickly, predicting maintenance requirements and controlling energy costs etc.

The P&B Standard protocol achieves this requirement by breaking transactions into Fastscan & Full Read operations. In normal conditions the Fastscan or Process Critical data for each of the 32 drives is read by the XCell every 1-2 seconds. A set interval determines how often the Full Read is carried out by the XCell and would be typically updated for a particular drive once for every 5 fastscans. The exception to this being when the Fastscan detects an Alarm or Fault condition for a drive in which case a full read is carried out immediately so that all Alarm or Fault data is immediately available to the host system.

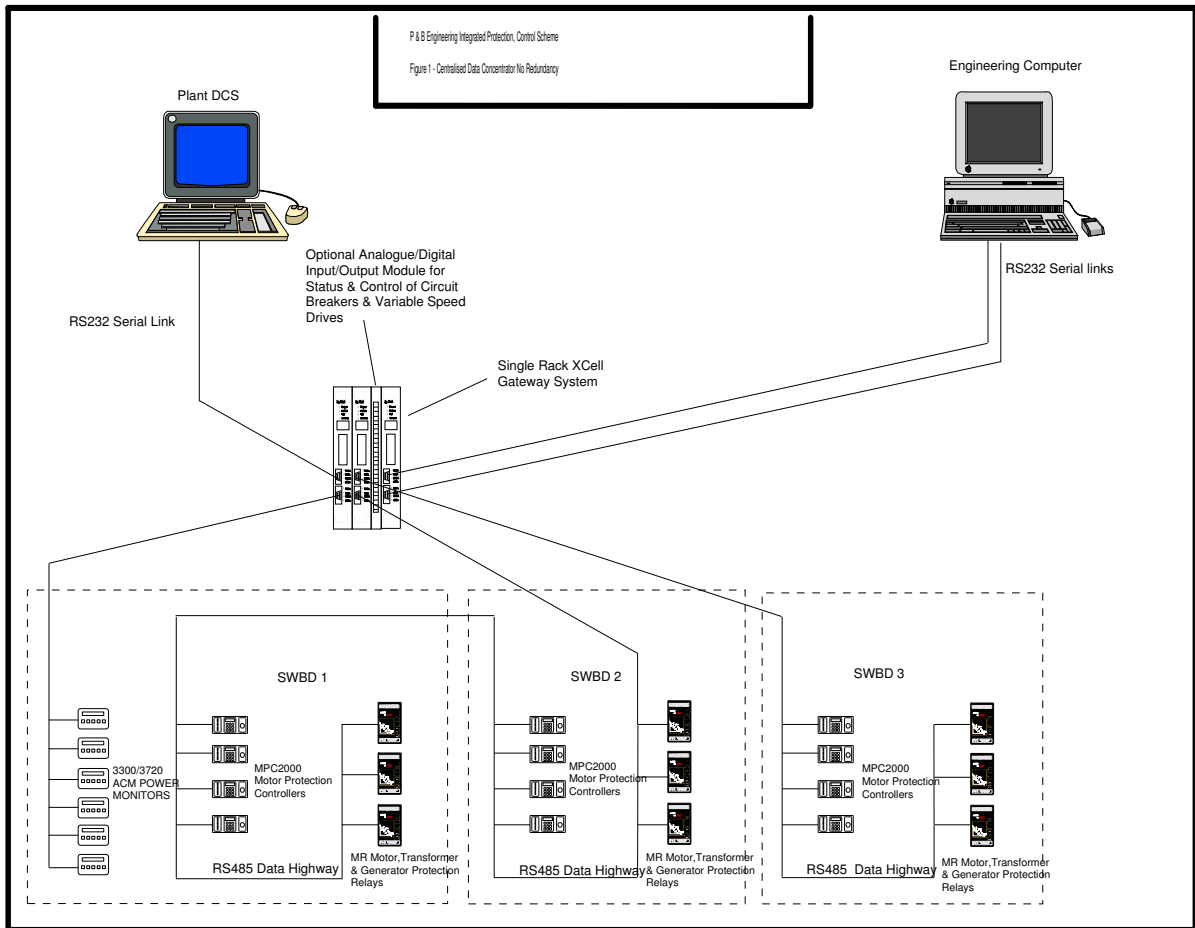
In addition to the Fastscan and Full Read operations is the command functions for Starting, Stopping or Resetting Motorvision units. In order to provide fast response to host system commands the read function are split into several operations to keep the message lengths as short as possible. This means that when an interrupt command is received by the XCell from the host system it can be acted on almost immediately typically within 70 msec.

## **1.4 Integrating the System**

To make full use of the benefits of Network Gold the XCell Intelligent RTU system is used to Integrate and concentrate the system data in a form suitable for use by virtually every PLC or DCS system. For example the XCell has an implementation of a Modbus RTU Slave protocol which has been proven considerably in the field, Modbus itself enables the Xcell system to be integrated into the majority of PLC & DCS systems such as Valmet, Honeywell, Allen Bradley, ABB, etc. Figure 1 shows how a small system is configured using a centralised XCell Processor modules to integrate up to 96 P&B devices to a DCS/PLC system and to P&B's Electrical Maintenance Engineering Software system for a minimal total cost.

However in the case of Foxboro Or Texas Instruments DCS systems another solution can be provided. The XCell unit to a Foxboro I/A processor will appear in all aspects as a Foxboro device. This means that total integration is achieved. The benefit of this approach can go considerably further than just cost - the Foxboro network communicates at a speed of 280 Kbaud which means that the output of data is made extremely quickly. Also full fault redundancy with redundant Foxboro CP's is possible.

## SECTION 1 - SYSTEM OVERVIEW



As the diagrams show the XCell is modular, up to 6 data highways can be connected to one XCell system enabling the unit to communicate with up to 192 devices. This single system however does not have to be in 1 rack, the XCell has a redundant high-speed network that allows units to be linked together to form a distributed system over a distance up to 70 m. As the data from all devices is globally available the data from any device can be accessed from any XCell unit in the system fitted with the necessary output serial port. In addition units can simultaneously access data and issue commands such that a number of outputs can be included and if required all using different protocols.

## **1.5 Control**

Full status monitoring and control of motors is included in the Motorvision as in virtually every application the majority of motors are automatically controlled by the plant DCS. Integration of control features can offer considerable cost benefits to the project in addition to the many technical benefits. In the case of circuit breakers for Generator/Transformer duties the need for automatic control by DCS is rarely present. For this reason logic control is not included in the MR series in order to keep the unit costs down. There are however cases when control of circuit breakers by DCS or Engineering Software using the Integrated system does offer benefits. Where this applies Digital Input & Output Modules can be installed in the XCell system to provide full status monitoring and control. This also applies where non intelligent devices require interfacing such as with some Variable Speed Drives where 4-20 mA Analogue Input & Output modules can be installed in the XCell system to provide control and monitoring of speed over the serial link either by DCS or Engineering Software. To make the system cost effective a full range of mix & match or high density I/O modules are available in order to provide a minimum fit/ minimum cost system.

## **SECTION 1 - SYSTEM OVERVIEW**

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### **1.6 Data Concentration - Minimum Fit - Minimum Cost**

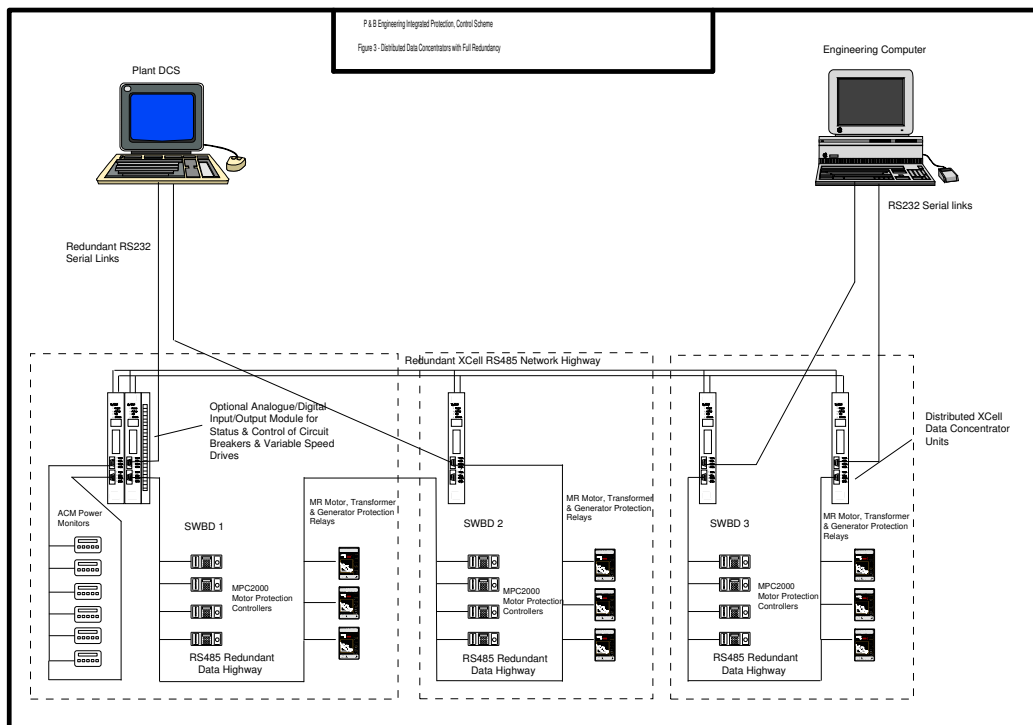
The XCell Intelligent RTU has been selected by P&B as the Data Concentrator and means of Integrating all of our Intelligent Products. The P&B protocol has been designed to take full advantage of the XCell's capability. In the same manner the XCell has been designed with considerable input from DCS manufacturer's such as Foxboro and Texas Instruments. By developing together a fully Integrated system with each product designed to work in unison with the other to make the best use of the technology being used. This means that fewer compromises are made when compared with other Intelligent system which are Interfaced as opposed to Integrated with DCS systems.

Because the XCell is a modular system the cost of installation is extremely competitive, only the required amount of Serial Ports and I/O boards need be installed. In many systems only one unit which caters for the maximum system capability is available. Therefore systems with only 64 Intelligent devices required are fitted with a unit which is capable of communicating with 192 devices with considerable cost redundancy. If in this case a dual redundant system is required the cost redundancy has to be doubled.

The XCell unit is supplied in a modular format with the minimum installation being a singular XCell Processor Board which has 2 Serial Ports built in. This unit is capable of communicating with up to 32 P&B Intelligent devices via one RS485 Serial Port via P&B Standard Protocol and to a DCS via a selectable RS232/RS422/RS485 Serial Port with a Slave Modbus RTU Protocol.

## 1.7 Redundant Systems

The XCell system having an Intelligent network between the units has one of the most advanced dual redundant facilities available. As mentioned before all the data acquired from any Intelligent device or I/O modules connected to the system is available simultaneously at any XCell unit in a global database. This means that any number of Serial Outputs to the higher level system can be included. In the event of part of the system failing, full data and control is available with bumpless transfer. At the Intelligent device level one end of the RS485 Data Highway is connected to a XCell with a Primary Port and the other end to an XCell with Secondary Port. The intelligent XCell network ports communicate with each other to ensure that the data is available to the global database either from the primary or the secondary device. As far as the higher level system is concerned the data is addressed exactly the same irrespective of whether the primary or secondary port is communicating with the Intelligent devices.



In the event that the primary cannot communicate with some or all Intelligent devices the secondary automatically tries to gather data or issue commands to the affected units. This removes the need for dual ports and networks from the slave devices. The

## **SECTION 1 - SYSTEM OVERVIEW**

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primary and secondary Xcell work in sync and not as a hot or duty standby, in this way even if a physical cable break occurred in the RS485 data highway communication with all slave units is still possible.

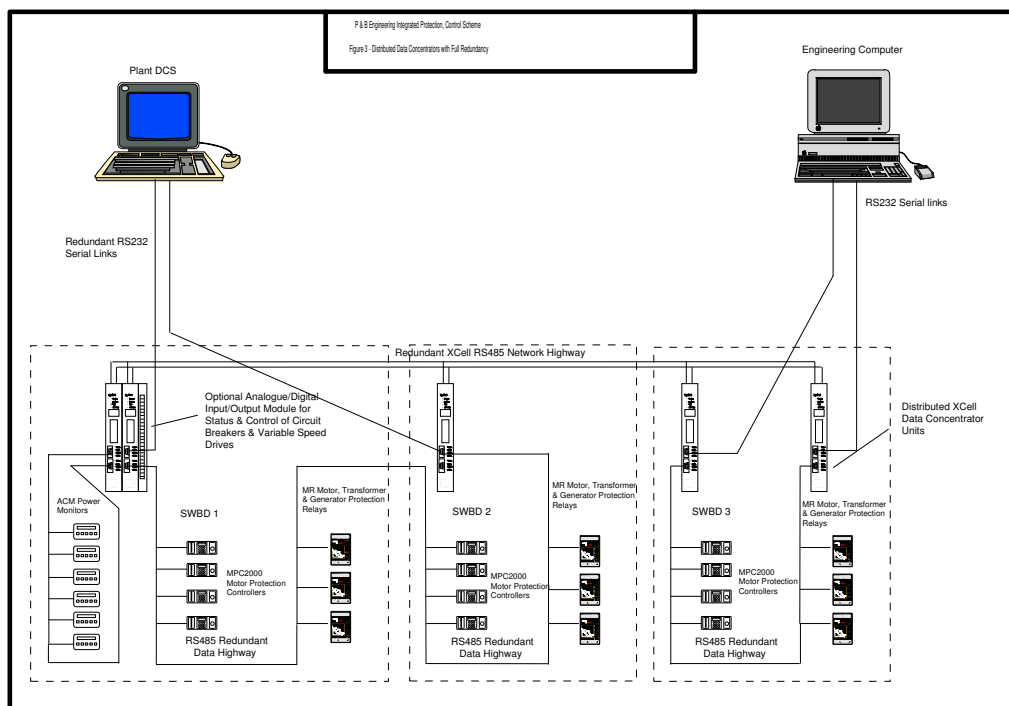
In the event that the Master fails completely the Slave will detect this and take over communications fully until the Master is made available.

As can be seen from figure 2 even a non-distributed XCell system can be given an high level of integrity probably at this moment better than can be achieved by any other manufacturer of Intelligent systems.

Figure 3 shows a fully distributed XCell system with full redundancy. This system can be installed at a very competitive cost particularly when compared to other systems available. This system has probably the highest level of practical security and redundancy currently available for this type of application. As can be seen from the diagrams the system configuration is extremely flexible and a configuration can be competitively achieved to suit virtually any installation.

## 1.8 Distributed Systems

This cost saving benefit is considerable particularly when distributed MCC's are being used over a large geographical area such as an Oil Refinery. Traditionally major installations distribute their MCC's but with most Intelligent systems it is not practical or economical to distribute the Data Acquisition units. This is a major area of system insecurity as the whole process is dependant on one centralised Data Concentrator unit. The XCell system has a high speed network using RS485 which can be used to distribute the XCell Processors over a distance up to 70m. As this facility is built in and as the XCell is of a modular nature, only the minimum required for each section need be purchased and a distributed system with high integrity and security, even without redundancy, is achievable as each MCC can each be given full independence without having to pay unreasonable costs. The other benefit is that where a system needs to be expanded, it can be done easily by simply plugging in a new module. No software changes are needed, thus reducing the initial cost and minimising the need for specific software support.



Figures 1 & 2 show P&B systems which compare with that offered by most manufacturers. The drawback of such systems is that there is little integrity at each level and a failure at the XCell unit although unlikely could cause a complete failure of the system.

## **SECTION 1 - SYSTEM OVERVIEW**

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Figure 3 shows a fully distributed XCell system being used for exactly the same purpose. In this case with redundancy there is a high level of security as a failure of any one MCC will not affect the others. This installation only costs approximately 20 percent more than the first.

A major benefit of distributing the system is that each MCC can be fully tested including the communicating system at the manufacturers works prior to reaching the site. With most systems a great deal of time has to be spent at site to before a complete working system is achieved. The distributed system also means that MCC's can be installed and commissioned and put into full service one at a time with virtually no system interruption when the next MCC is brought on line.

The following products within P&B range can be connected into the XCELL system:-

### Motor/ Feeder Protection

MPR3E5, MPR/MPC2000

### Transformer/Generator Protection

MRI            Series Overcurrent and Earth Fault Relays

MR            Most MR type relays

### Protection & Control

MPC2000D            Motor Protection Controller

Motorvision2            Motor Protection Controller  
+ variants

Feedervision2            Feeder Protection Controller  
+ variants

Advanced Feedervision2    Automatic Changeover System

Microvision & Microvision Plus:

Micromotor            Motor Protection Controller

MicroFeeder            Feeder Protection Controller

## **SECTION 2 - The XCell System**

The XCell system is supplied in standard 19 inch schroff euroracks, two types are available, standard and EMC compliant, the racks are usually supplied full width front mounting but when required and space allowing can be reduced in width to a half of the normal size.

To locate the XCell components a backplane system is employed and will be specific to the rack contents.

A full rack can accommodate 84 hp (horizontal pitch units) each hp being 5.09mm wide and can accommodate any combination of modules not exceeding the 84 hp.

The list below is a samples of the modules only and specialist modules for high speed counting modules are available and details can be submitted on request.

The comprehensive range of modules allows the user to design an XCell system not only to communicate with P&B intelligent protection relays and controllers but with the use of discrete i/o allows interfacing of non- intelligent devices.

- **Primary PSU - Power Supply Unit:**  
provides conversion of a 110 or 240 VAC auxiliary supply to a regulated 24 VDC output required for XCell modules. The module includes isolator switch and fused for both supply input and output. The power supply module can provide 50 watts and takes up 14 hp of a rack.
- **Secondary PSU (optional):** as above usually fed from a separate source from the primary, typically DC or UPS supply.
- **XCell Communications Processor:**  
Processing module for serial communications, is supplied with 1 - RS485 serial port to communicate with up to 32 P&B devices using P&B Standard protocol and 1 - RS232/RS485/RS422 serial port with a slave Modbus RTU protocol to allow communication with host systems such as DCS/PLC or SCADA systems. Includes dual XCell Fieldnet interface.

# SECTION 3 - Installation of XCell and Communications

## 3.1 Introduction

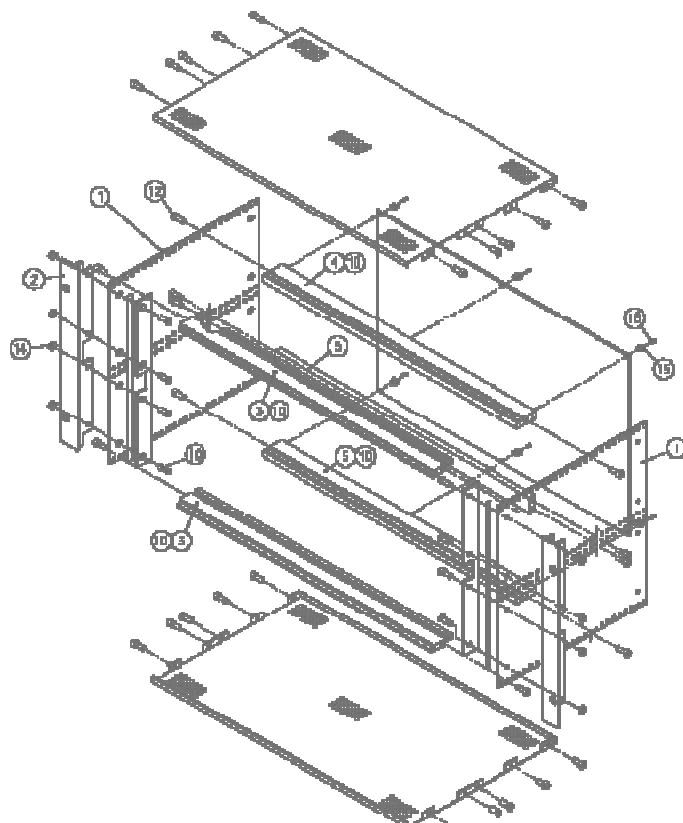
When designing an installation of Xcell communications it is important to ensure that the recommendations detailed below are followed correctly, correct planning and testing will significantly reduce on site commissioning time.

## 3.2 XCell Installation Guidance Notes

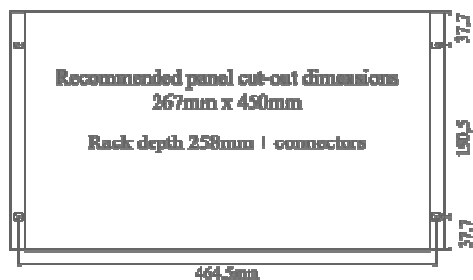
RS485 Data Highways as used for the XCell Network and P&B Standard Data Highway can communicate over distances of up to 1.5km.

RS232 Serial Highways as used For the Modbus RTU protocol links to host systems can only be up to 15m. For distances of greater than 15m line drivers to amplify the signal over longer distances must be fitted at either end of the link.

The XCell is supplied in full or reduced 19 inch Euroracks and is suitable for mounting on a swing frame within the MCC enclosure, it is helpful to install a window in the compartment door to allow viewing of the XCell Indicators and Unit Status panels without access to the equipment.



ITEM	QTY	DESCRIPTION	UNIT	REMARKS
1	1	XCELL UNIT	1	
2	1	TOP COVER	1	
3	4	TOP COVER SCREWS	4	
4	4	TOP COVER SCREWS	4	
5	4	TOP COVER SCREWS	4	
6	4	TOP COVER SCREWS	4	
7	4	TOP COVER SCREWS	4	
8	4	TOP COVER SCREWS	4	
9	4	TOP COVER SCREWS	4	
10	4	TOP COVER SCREWS	4	
11	4	TOP COVER SCREWS	4	
12	4	TOP COVER SCREWS	4	
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## **SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS**

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It is essential that the rack is connected to an instrument earth, a connection can be made to one of the bolts securing the side plates in place.

The following pages fully details and explains the XCell rack configuration, The following points should be noted:

- The 'Watchdog Fail' contacts from each XCell Processor Backplane & Power Supply Unit can be wired to outgoing terminals to give the customer the option of using these contacts. The contacts can be connected in common mode to reduce costs.
- Ensure that the 120ohm terminating resistors are fitted to both the main and secondary network terminals on the first and last processor in the rack, or in the case of distributed XCell's on the 1st XCell CPU of the first rack and the last XCell CPU of the last rack such that the resistors are located at the two extreme ends.
- Only use crimped connectors, P&B do not recommend the use of 'Bootlace Ferrules' as in past history we have found them to be unreliable for use with serial communications.
- When installing a redundant system it is essential to use separate screened twisted pair cables for both the main and secondary XCell networks and when distributed XCell's are connected over the field we suggest that where possible the field cables be installed in separate trunking and routing to give maximum system integrity.
- Cable screens should be connected at one point only to an instrument earth.

The XCell modules all operate on a DC voltage in the range of 18-66 volts. This voltage can be supplied either by using an XCell PSU which requires a 110/240V AC/DC input or by using an external 24V DC supply.

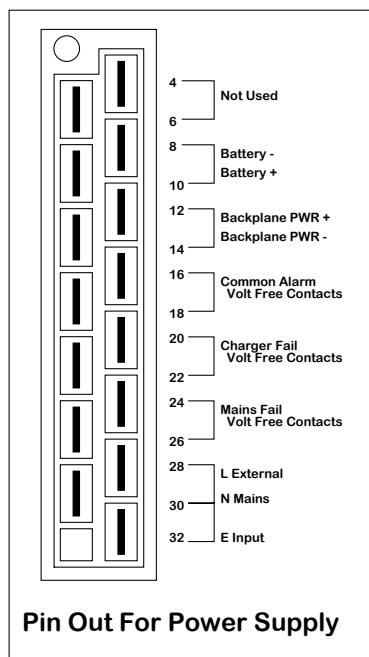
### **3.2.1 Connecting the XCell PSU**

The XCell PSU converts AC or DC mains to a DC voltage in the range required by the XCell units.

The XCell power supply unit differs from the other modules in that it is not plugged into the backplane. The unit comes fitted with H-Type connectors at the back for wiring into.

## SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS

The connections to the XCell PSU are as follows:



**Note:** The backplane power outputs from the supply, terminals 12 and 14, are NOT connected directly to the backplane. They must be linked to the backplane using suitable cabling.

**Note:** The volt-free contacts are normally open contacts which close on failure.

The wiring schedule is as follows:

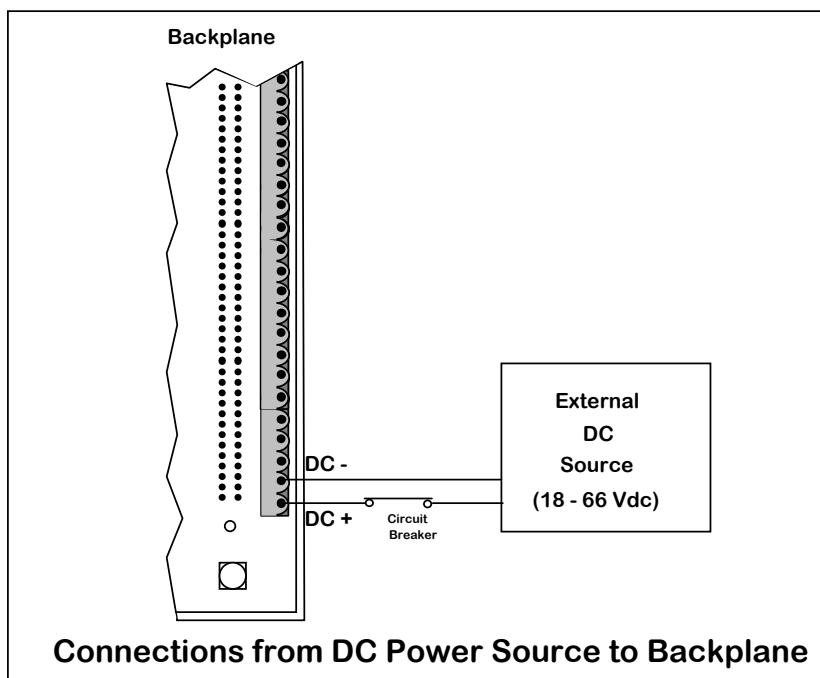
Backplane JP1	PSU H- Connector	Description
	28	Live
	30	Neutral
	32	Earth
	8	Battery +
	10	Battery -
DC1+	12	Backplane PWR +
DC1-	14	Backplane PWR -

## SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS

### 3.2.2 Connecting External DC Power

When powering the XCell from an external DC power source the supply voltage must be between 18-66 volts. Voltages above this will result in damage to the equipment. Voltages below 18 volts will not be sufficient to power the units.

A typical setup would be the following:



The wiring schedule in this case will be thus:

External DC Source	Description	Backplane JP1	Description
VDC-	Negative Terminal	DC1-	Primary power bus
VDC+	Positive Terminal	DC1+	Primary power bus

It can be clearly seen that an external power supply is wired in the same way as an XCell PSU.

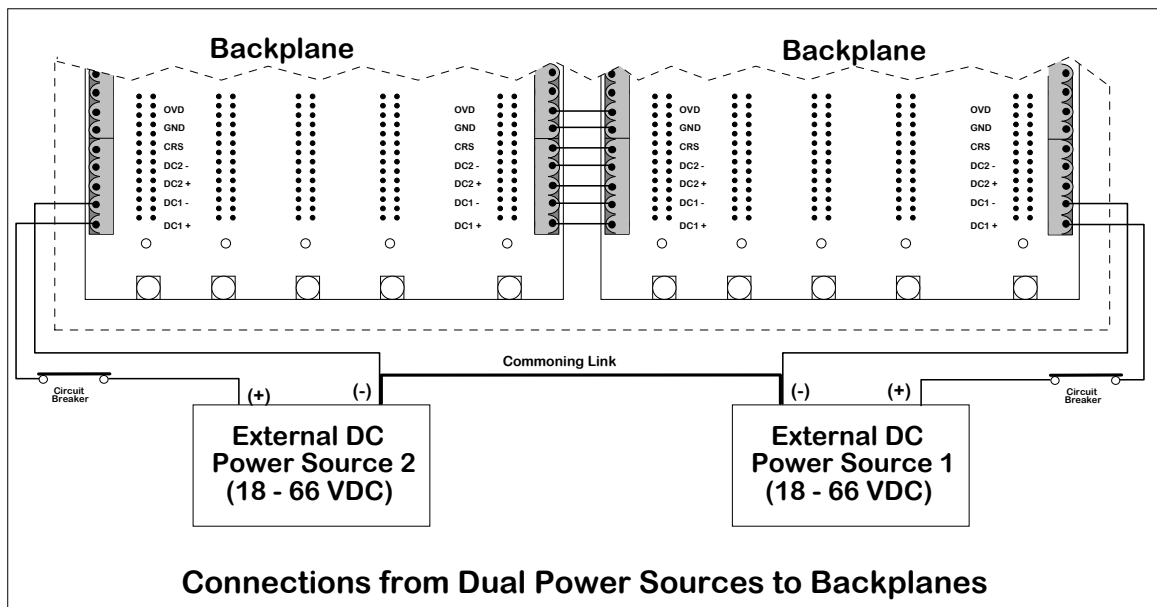
## SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS

### 3.2.3 Connecting Dual Supplies

XCell provides the means of allowing connection of a secondary power supply for high security applications. While the location of the power sources can be anywhere on the system, it is recommended that the power sources be located in close physical proximity to one another (same enclosure). This will ensure that a single cell failure will not result in failure of power to the system.

Use of a dual supply introduces the potential problem of current flow to the lowest ground potential. To prevent this problem a commingling link should be connected between the grounds of both supplies.

A typical setup is as follows:



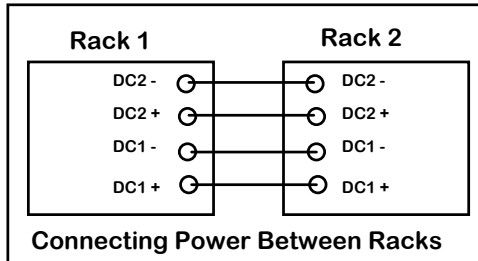
Wiring schedule:

DC Source 1	DC Source 2	Description	B'plane JP1	B'plane JP3	Description
DC+		Positive	DC1+		Pri Powerbus
DC-		Negative	DC1-		Pri Powerbus
	DC+	Positive		DC2+	Sec Powerbus
	DC-	Negative		DC2-	Sec Powerbus

Again, the XCell PSU is wired in exactly the same manner as an external supply.

### 3.2.4 Connecting Power Between Racks

Backplanes and racks can be powered from other backplanes if required. The connections are shown below:



Wiring Schedule:

JP1	JP3	Description
DC2-	DC2-	Secondary Power Bus -
DC2+	DC2+	Secondary Power Bus +
DC1-	DC1-	Primary Power Bus -
DC1+	DC1+	Primary Power Bus +

### 3.3 Communication Lines to Backplanes

Communication to and from racks and backplanes can be achieved in a variety of different ways depending on the application.

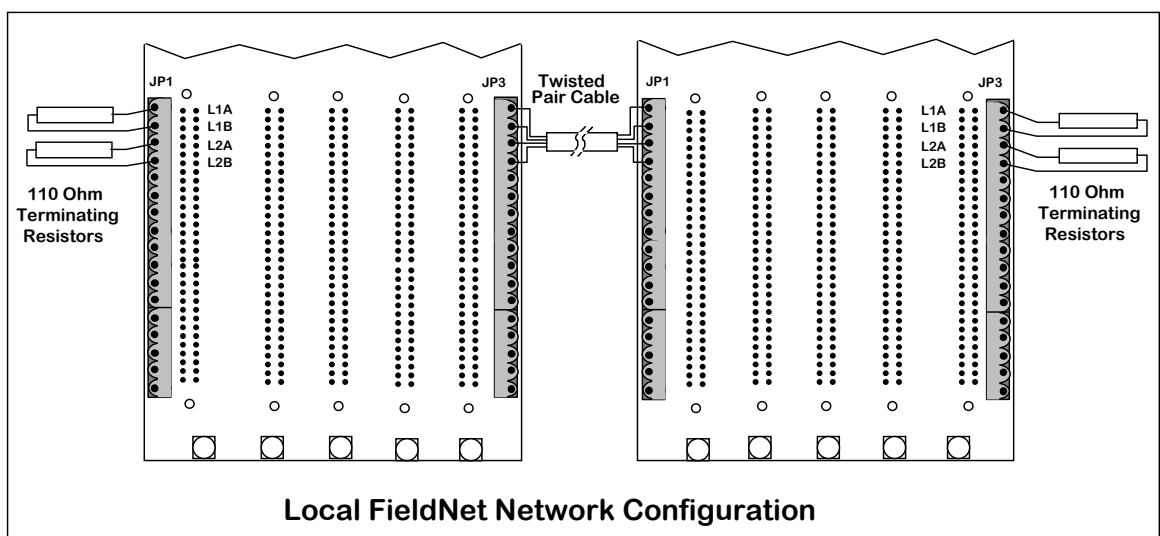
#### 3.3.1 Local Fieldnet

The local Fieldnet network is used so that the XCell units can communicate with each other so that they each have up-to-date information about the devices connected to them. This is especially important when a fault occurs, for instance a cable break. When this happens, the secondary unit needs to be able to attempt to re-establish communications as quickly as possible so that control is not lost.

### SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS

The Local Fieldnet network operates across short distances (up to 70m) and has a maximum cell capacity of 6. A potential difference of not more than 2 volts may exist between ground points of the network in order for it to operate correctly. This can be achieved by ensuring that all of the XCells are linked to the same ground reference (the XCell chassis can be linked together to do this, taking care to avoid earth loops) and ensuring that the shield for the Fieldnet communications line is linked to all XCells and earthed at one end only.

Each local Fieldnet network must be terminated at each end of the copper highway.



#### Note:

- The primary local Fieldnet highway is labelled L1A and L1B on the backplane.
- The secondary local Fieldnet highway is labelled L2A and L2B on the backplane.
- Network connections between racks must be made using a shielded twisted pair cable to minimise noise interference.
- Each network used must be terminated with a 110 Ohm resistor at each end.

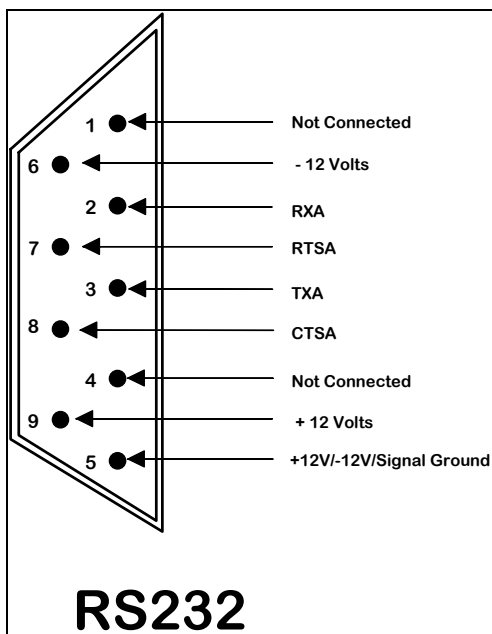
### **3.4 XCell Communications Ports**

The XCell processor module is fitted with two 9-way D-Type communications ports on the front panel. In general, one of these ports communicates with up to 32 slave devices (e.g. MV2's) and the other communicates with some kind of upstream host computer, for example an engineering computer, DCS, SCADA, etc.. The different types of port available are discussed below.

#### **3.4.1 RS-232 Port**

The RS-232 port on the XCell is generally used for connecting to a host computer. It is worth noting, however, that the RS-232 hardware restricts the operation of the port to point-to-point communications only, i.e. the units cannot be multi-dropped unless special converters are employed.

The pin-outs of the RS-232 port on the front of the XCell unit are as follows:

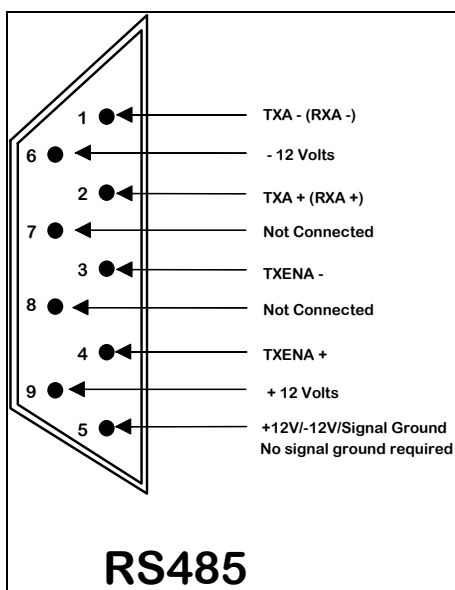
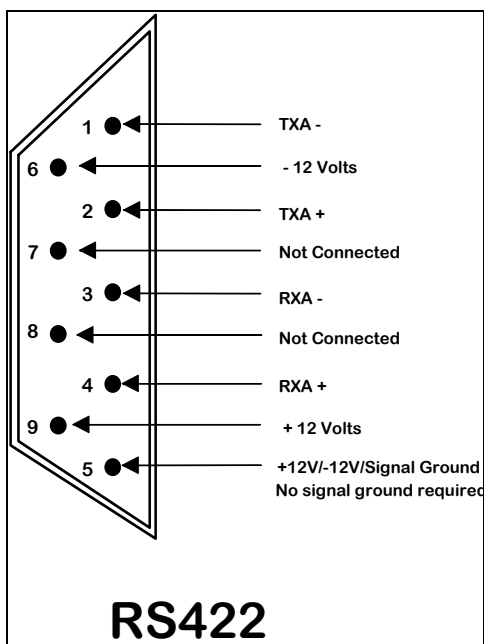


## SECTION 3 - INSTALLATION OF XCELL AND COMMUNICATIONS

### 3.4.2 RS-422 / RS-485 Port

The RS-422 and RS-485 ports are very similar as far as hardware is concerned. RS-485 is used to communicate with the relays for two reasons: firstly it is possible to multi-drop the relays on one communication line and secondly RS-485 uses 'differential' transmission in order to avoid noise errors. Some host computer systems use RS-422/485.

RS-485 is also capable of 'asynchronous transmission', i.e. a node can receive and transmit simultaneously, although the XCell system does not support this mode.



## **SECTION 4 - Relay Communications Installation Guide Notes**

For full details of how to install P&B Intelligent Protection Controllers and Protection Relays refer to the specific documentation supplied with the products, this section covers installation of the RS485 Data Highways.

The RS485 Data Highway may be up to 1.5km in distance, the Data Highway requires the use of Screened Twisted Pair cables.

There are 2 methods of connecting the RS485 Data Highway for slave units, the simplest is to connect the units together in a 'Daisy Chain' method. With this method the 3 cables, positive, negative and screen are looped from relay to relay.

The second method is to 'Multi-drop' the devices from the data highway, in this method the highway runs across the units with a individual tee off points to each relay. This gives higher integrity in that the main line does not have to enter individual compartments and in the event of a fault or fire in a starter compartment damage to the tee off to the starters does not effect the operation of other units.

The disadvantages of using a 'Multi-drop' system is that more termination points are used and every termination is possible point of failure and usually requires considerably more commissioning. In general P&B recommend the use of the daisy chain connection.

- Ensure that terminating resistors are fitted to both the first and last devices on the Data Highway. In the case of redundant systems in the D type connector at each XCell port.
- Only use crimped connectors, P&B do not recommend the use of 'Bootlace Ferrules' as in past history we have found them to be unreliable for use with serial communications.
- Cable screens should be connected at one point only to an instrument earth.

To ease commissioning connect the devices in a logical order, i.e. top to bottom, then left to right.

## SECTION 4 – RELAY COMMUNICATIONS INSTALLATION GUIDE NOTES

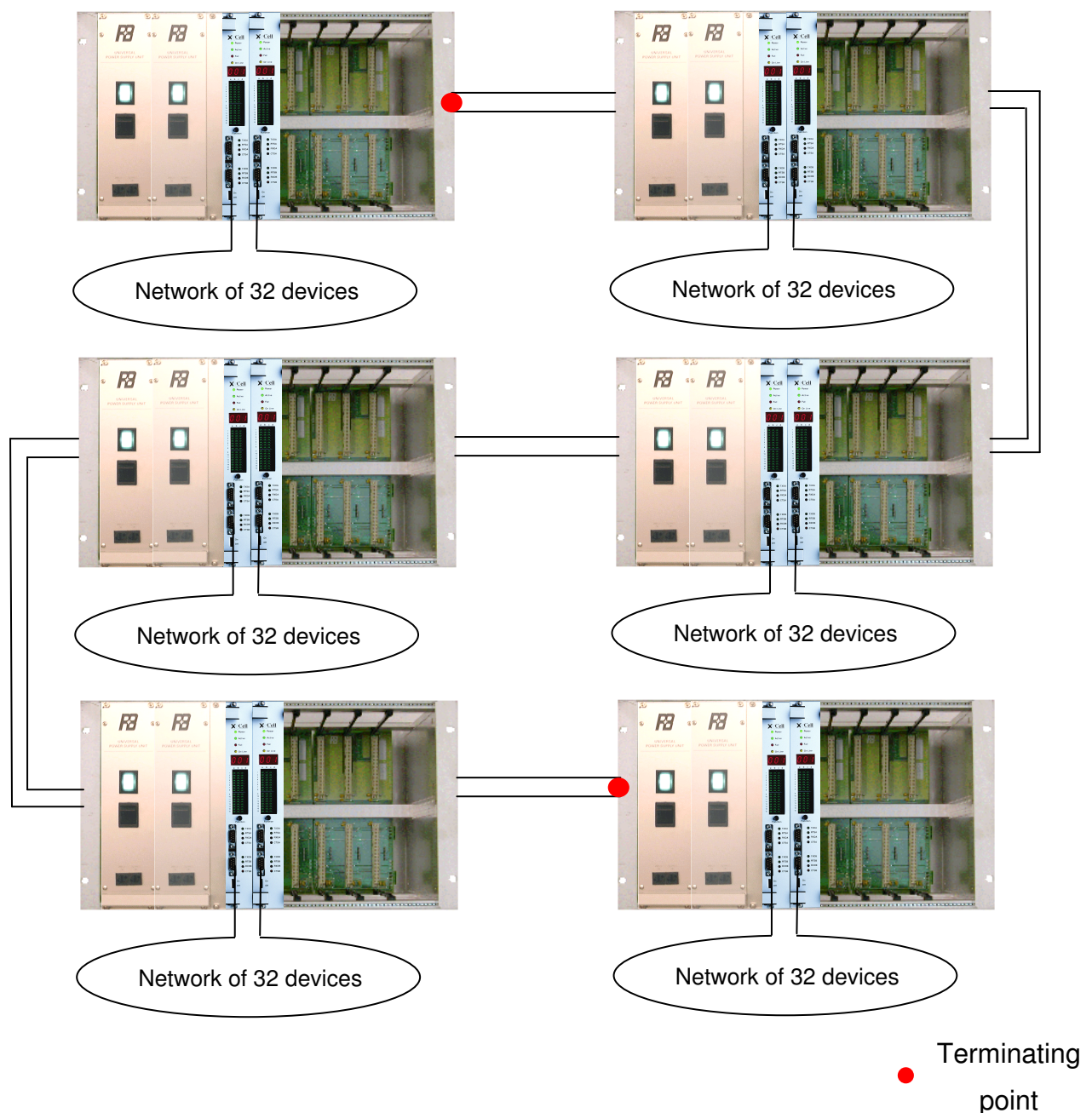
Xcell Rack Interconnection.

As noted it is possible with the Fieldnet of the backplanes to physically separate the racks which allows the racks to be mounted in individual switchboards without increasing the modbus ports required by any upstream host, DCS for example.

A total of six nodes can be networked together from a single modbus connection. Nodes can be a dual pair or a single processor. In this example all nodes are dual pairs.

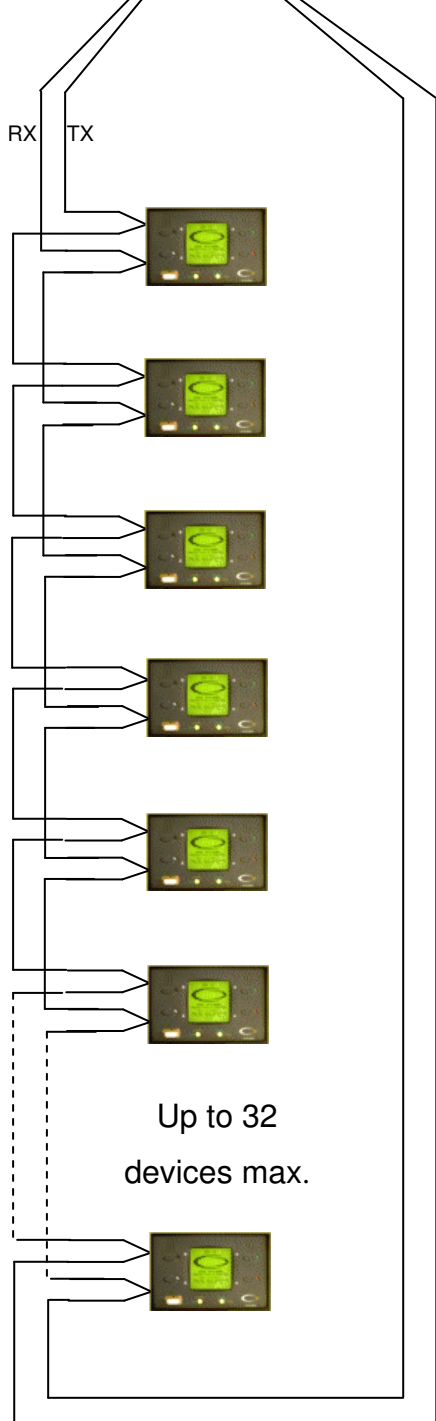
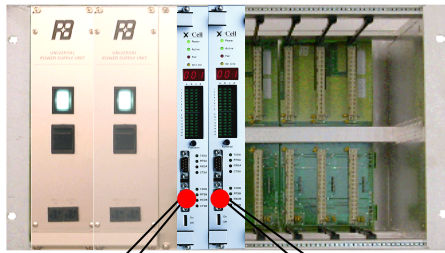
Any of the 12 top ports can be used for upstream host communications.

Distance between the first and last rack not to exceed 70m.



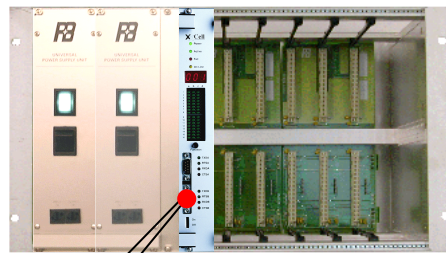
# SECTION 4 - RELAY COMMUNICATIONS INSTALLATION GUIDE NOTES

## Dual Redundant Method

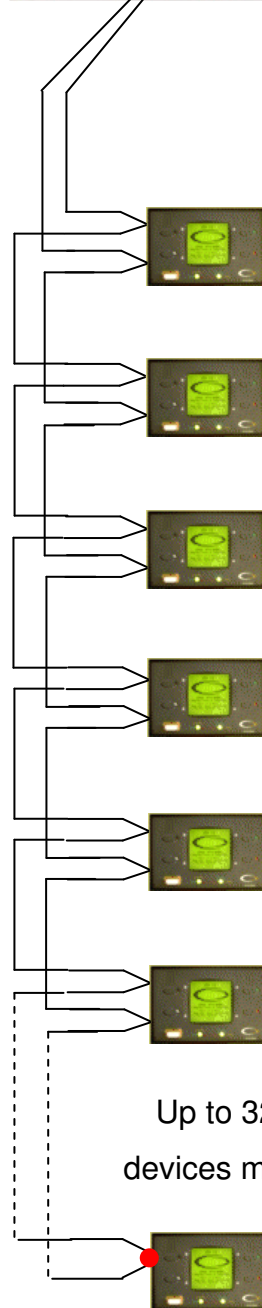


Up to 32  
devices max.

## Single Processor Method



Terminating  
point

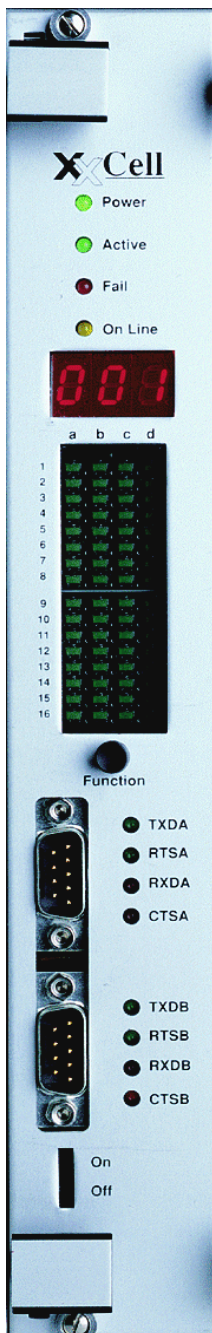


Up to 32  
devices max.

# SECTION 5. - Using the XCell Processor Unit

## 5.1 Introduction

The XCell processor unit consists of three 7-segment LED's, an LED matrix and a function button. This section describes how to use the function button to change the functionality of the processor module to suit the application.



One of the main advantages of the Xcell is its plug and play ability. There is no require configuration and the LED matrix will illuminate for each connected downstream device. This alone makes the Xcell system much easier to commission than other systems as any lamps not lit can quickly be identified and investigated.

There is no requirement for special or bespoke software of any kind, the only configuration is the addressing of the 'node' number.

### **5.2 The Function Menu**

The function menu is driven by the function button. The function button is used to:

- Move through a menu or sub-menu.
- Select an option.
- Increment a value.
- Exit an option.
- Accept a setting.
- Remove a system message.

The message display shows the menu options and settings which can be changed using the function menu.

The function button should be pressed in and held before releasing for:

A count of two (2)

- To remove a system message from the message display.
- When moving through the function / sub-menu.
- When incrementing a value within a function menu option.

A count of five (5)

- When selecting an option from the function menu / sub-menu.
- When accepting a setting configured while in an option / sub-option.
- To exit an option.

#### **Menus:-**

- Function Menu
  - Message Accept
  - Unit Number
  - AUN
  - SHC

- Slot 1
- Slot 2
- Slot 3
- Slot 4
- Slot 5
- Slot 6
- Slot 7
- Slot 8
  
- LED (Configure I/O Status Indication Matrix)
  - GPA (Group A - first 64 I/O channels)
  - GPB (Group B - second 64 I/O channels)
  - TOG (Toggle between GPA and GPB every 5 secs.)
  
- FSD (Field Service Data)
  - OLU (Online Units - limited to units in range 1-64)
  - PRI (Units visible via Primary Fieldnet)
  - SEC (Units visible via Secondary Fieldnet)
  - DBG (Field Service General Debug Display)

### ***5.3 Removing a Message from the Message Display***

System messages may be displayed in the message display on the cell processor front panel. The system is made up of a three-digit alpha code and a three-digit numeric code. These two codes combine to form a message code (system message). The message code alternates every two seconds, between the alpha and numeric codes in the message display. The three-digit alpha code identifies the part of the system where the message originated and the three-digit numeric code identifies the exact message. Only the most recent message is displayed at any given time.

To remove a message from the front panel:

- Press the function button and hold for a count of two (2) before releasing it.
- Repeat for any other messages on the display.

## **5.4 Changing the Unit Number**

This option is only available from the function menu for 10 seconds after boot up. After this time the option is automatically removed from the menu.

- Select the Alter Unit Number (AUN) option from the function menu.
- Increment the unit number in the message display until the desired value is displayed.
  - Each of the three digits in the message display must be changed separately
  - The value displayed in one digit of the display must be accepted before the next can be changed.
  - Accepting the value on the third digit will exit the option and reboot the processor.

### **5.4.1 Unit Number Considerations**

There are a few considerations to be made when assigning unit numbers:

- A unit number can only be configured in the range 1-254.
- For stand-alone XCells, the unit number must be even.
- For dual redundant XCells, each XCell in the pair is given the number on either side of the required node number. For instance if the required node number is 6, the dual XCells will be numbered 5 and 7. Any XCell with an ODD node number is assumed to be part of a dual pair. Dual redundant XCells also skip numbers, i.e. the pairs can be set to 1 and 3, or 5 and 7, or 9 and 11, etc. which means that the address that the XCells reply to is 2, 6, 10, etc, i.e. any even number **not** divisible by 4

The unit number used for particular XCell units is important as the virtual number will be used as the PLC address at the host interface.

### **5.5 Configuring the I/O Status Indicator Matrix**

This option allows the operator to select the use of the I/O status indicator matrix on the processor module front panel. The 64 LED's which make up this matrix may be configured to represent:

#### **GPA (Group A)**

If GPA is selected the I/O status indicator matrix will mimic the first 64 I/O channels on the cell or if used as a communications module will indicate the on-line status of the 32 devices which can be connected.

#### **GPB (Group B)**

If GPB is selected the I/O status indicator matrix will mimic the second 64 I/O channels on the cell.

#### **TOG (Toggle)**

If TOG is selected the I/O status indicator matrix will alternate between GPA and GPB every five seconds, thus displaying all 128 I/O channels.

- Select the LED option from the function menu.
- Move through the LED sub-menu to the option required.
- Accept the option and exit the function menu.

When the I/O status indicator matrix is configured:

**GPA** - The message display will show either the unit number or one of the function menu options. No decimal point will be displayed on the message display.

**GPB** - The message display, along with showing the unit number or one of the function menu options, will also display a dot between the first and second characters on the display.

**TOG** - As the I/O status indicator matrix toggles between GPA and GPB so too will the dot on the message display.

### **5.6 Viewing the I/O Hardware in Each Slot in a Cell**

The SHC option in the function menu allows the operator to view the type of I/O in each of the eight possible hardware slot positions. Each cell processor can support a maximum of four plug-in I/O boards. As each board can have a maximum of two Mix and Match I/O modules a plug-in board type takes up two slots. This gives a maximum of 8 possible I/O slots in a cell.

When the SHC option is selected the message display will toggle between showing the slot number and the type of I/O module present in that slot. The abbreviation for each I/O module and what it represents is given below:

<b>DI</b>	-	Digital Input module
<b>HDI</b>	-	High Density Digital Input module
<b>IDI</b>	-	Interrupting Digital Input module
<b>DO</b>	-	Digital Output module
<b>HDO</b>	-	High Density Digital Output module
<b>HC</b>	-	Counter module
<b>AI</b>	-	Analogue Input module
<b>HAI</b>	-	High Density Analogue Input module
<b>AIR</b>	-	Analogue Input Relay module
<b>AO</b>	-	Analogue Output module
<b>AOI</b>	-	Isolated Analogue Output module
<b>G74</b>	-	G74 module
<b>UNC</b>	-	Unknown module or no module present in slot

- Select the Show Hardware Configuration (SHC) option from the Function menu.
- Move through the slot positions checking the hardware configuration.

Exit the option.

**Note:** Both the Fibre-Optic and Ethernet modules will be displayed as **UNC** in the message display when viewed under the SHC option.

## **5.7 Displaying Field Service Data**

These options are intended for use by field service engineers. The options provided from the Field Service Data (FSD) control the information shown on the I/O status indicator matrix. The Field Service Data options available are:

### **OLU (On Line Units)**

If OLU is selected the I/O status indicator matrix will show any units that can be seen by this unit on the network with a unit number in the range 1-255. The I/O status indication LED's operate in wrap around mode in the LED options. The top left-hand LED (LED 1a in the matrix) is activated by units 1, 65, 129 or 193.

### **PRI (Primary FieldNet)**

As for OLU option, but shows units visible via the Primary FieldNet network.

### **SEC (Secondary FieldNet)**

As for OLU option, but shows units visible via the Secondary FieldNet network.

### **DBG (Debug)**

Displays specific internal status indicators.

- Select the FSD option from the function menu
- Move through the sub menu to the option required.
- Accept the option and exit the function menu.

Once a Field Service Data option has been selected:

**OLU** - The message display will show either the unit number or one of the function menu options. Two decimal points will be displayed on the message display, one

## **SECTION 5 - USING THE XCELL PROCESSOR UNIT**

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between the first and second digits and one between the second and third digits of the display.

**PRI** - The message display will show the unit number. The LED's will show all units visible on the Primary FieldNet channel. One decimal point, after the third character, will be displayed. The decimal point after the first character will be lit if the XCell Secondary FieldNet channel is active and unlit if the XCell Primary FieldNet channel is active.

**SEC** - The message display will show the unit number. The LEDs will show all units visible on the Secondary FieldNet channel. Two decimal points will be displayed - one between the first and second characters and one after the third character. The decimal point in the middle will be lit if XCell Secondary FieldNet channel is active and unlit if XCell Primary FieldNet channel is active.

**DBG** - The message display will show either the unit number or one of the function menu options. One decimal point will be displayed between the second and third characters on the display.

**5.8 Powering Up the System**

When a cell is powered up it automatically performs a self test. Following a successful power up the following LED's on the processor board should be thus:

- Power LED - Permanently ON
- Active LED - Flashing ON/OFF
- Online LED - OFF when not on network  
ON if on network

### ***5.9 Setting the Unit Number***

For 10 seconds following a cell powering up the Function menu contains an additional option, the AUN (Adjust Unit Number) option. This option allows the user to set the unit number for the cell.

Ten seconds after a cell has powered up the AUN option is automatically removed from the Function menu and can no longer be selected. Once a unit number has been set the cell automatically resets.

If a wrong unit number is set on a unit following power up, the unit should be powered down and up again and the unit number re-entered using the AUN option.

Note: Be careful not to configure two units on the same network with the same unit number. If two units on the same network are configured with the same unit number then the second unit will not come on line - the On-Line LED on the front panel will not illuminate.

See section 5.4 for more information.

## **SECTION 6 XCell/P&B Standard Driver Functional Specification**

### **GENERAL DESCRIPTION**

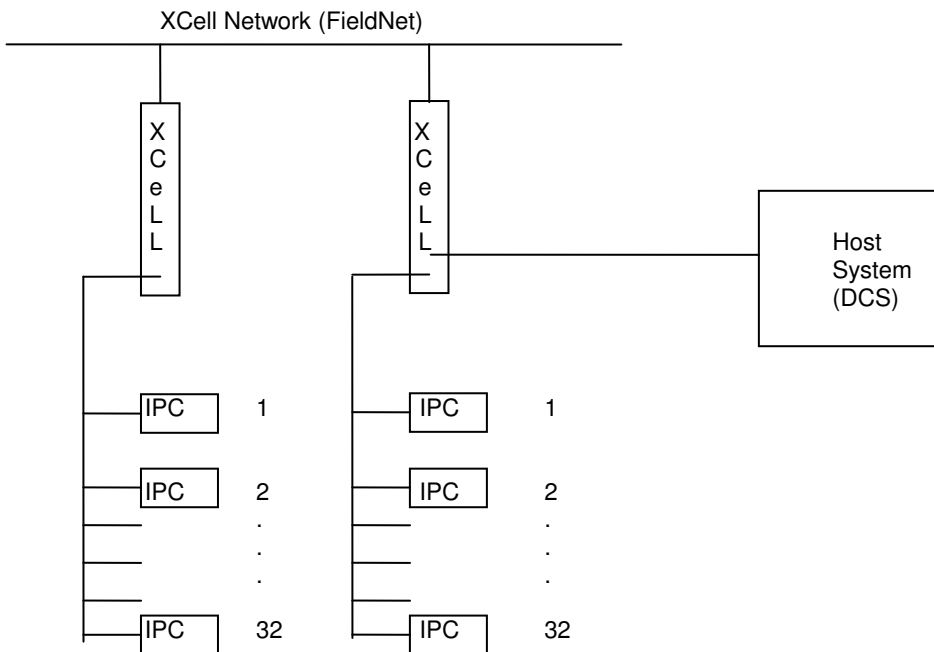
#### ***6.1 Product Perspective***

The P&B Standard Protocol is used to retrieve data and issue commands from motor protection controllers and intelligent protection relays. These are devices which sample currents and voltages and monitor discrete inputs to determine operating conditions and control switchgear. They incorporate a serial communications port by which data may be retrieved for display or for control purposes. There is also a considerable amount of configuration data which can be both read and altered via the serial port. The purpose of implementing the P&B Standard protocol in the XCell system is to enable multiple data highways to be connected to an XCell system and the data to be read and commands to be issued by a single or multiple connection to a host system.

## **6.2 Overview**

The devices operate on an RS485 network where the XCell will be the Master polling each of the devices (Slaves). There can be a maximum of 32 devices connected to each XCell Processor module. To allow overhead P&B recommend not exceeding 25 devices on each network.

The link can be configured with dual XCell Masters, where one XCell is Primary Master and the other is a Secondary unit, unless either some or all of the devices are not responding to the Primary Master or unless the Primary Master fails. In these cases the secondary partner is used to poll all or some of the devices.



**NOTE:** IPC can be MV2 or any intelligent P&B Device.

### **6.3 Device Data Structure and Commands**

There are three blocks of data that can be retrieved from the P&B Devices,

1. Fast Scan Data (Critical Data) - 16 bytes max.
2. Read Only Data (less critical or accumulated data) - 256 bytes
3. Read/Write Data (configuration data) - 256 bytes

These are read using separate protocol commands.

The large blocks of data (256 bytes) are retrieved in multiple reads of smaller blocks rather than one large read. This means that any command outputs will not have to wait as long to be transmitted if they are received in the middle of a block read.

Refer to Appendix 1 for the data types contained in each of these sections.

The Read/Write data can, as implied, be read and written. One command is used for both digital and analogue parameter writes.

In addition there are four separate drive commands that can be issued to the P&B devices,

1. Start\_A (used to start with contactor A)
2. Start\_B (used to start with contactor B)
3. Stop (used to open both contactors i.e. stop motor)
4. Reset (used to reset the device after an Alarm or Trip condition)

Contactor A usually used. B used for 2 speed drives, reversing, star delta, etc.

These four commands along with the parameter write commands are initiated elsewhere in the XCell system, generally by a Control/Monitoring System connected to another part of the system. They arrive at the XCell communicating with the relevant device and are put into a queue for immediate transmission to the appropriate device as soon as the current transaction has been completed. Commands **always** have priority over other transactions.

## **6.4 Polling Sequence**

As already outlined there are three blocks of data that are retrieved from the devices, Fast Scan data, Read Only data and Read/Write data.

### **6.4.1 Fast Scan Polling**

The Fast Scan data is the most critical data particularly used by the Control/Monitoring System for controlling motors. It is on this data that the Control System makes decisions. Therefore the polling sequence reflects this by requesting the Fast Scan data on a continuous basis.

The response to the Fast Scan poll can be either 8, 12 or 16 bytes depending on the device type. The data length byte in the response will indicate the number of bytes returned. Despite this, a block of 16 bytes is always stored to ensure a standard structure for data storage and a standard format for the 16 bytes.

### **6.4.2 Read Only and Read/Write Polling**

Both the Read Only data and the Read/Write data are less critical and are retrieved as a background function where only one device is polled at a much slower interval. This interval is set to one device every 5 complete fastscans, a second set of 5 fastscans take place then the next relay in sequence is polled for slowscan data and so on.

In addition, however, should any change in the fastscan logic status bits, returned in the Fastscan response then this also initiates an immediate full read of the device

As already mentioned Read Only and Read/Write data blocks are retrieved using multiple read commands for blocks of not more than 64 bytes each. This means that any command outputs will not have to wait as long to be transmitted if they are received in the middle of a block read.

## **SECTION 6 - XCELL/P&B STANDARD DRIVER FUNCTIONAL SPECIFICATION**

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Once the time has come to poll for Read data then sufficient polls are transmitted to retrieve all the data for that one device without any further Fast Scan polls being sent.

These reads are always read from even byte boundaries and for an even number of bytes.

In order to make sure that all data is valid when a change in condition occurs the XCell monitors the state of the logic status bits returned in the Fastscan response, if either of these change state ie pick-up or reset the XCell interrupts the polling routine and immediately carries out a full read of the affected device/devices.

### **6.4.3 Command Outputs**

As already mentioned there are five possible commands that can be sent to any particular P&B device Start\_A, Start\_B, Stop, Reset and Stop/Lockout (e.g. serial port inhibit). These are the most critical functions that are utilised. They control the actual contactors connected to the P&B devices.

Therefore these commands have the highest priority and while they do not cancel any current poll commands they are inserted immediately after the current command is complete. Once there are no more command outputs to be sent to any device the normal polling will resume from where it had been interrupted.

### **6.4.4 Parameter Writes**

Parameter writes are processed in the same manner as command outputs despite the fact that they are not critical to the operation but because it simplifies the operation of the protocol.

Because any bit in any parameter may be altered and because the minimum write is a byte write, it is necessary to read the parameter from the device, alter the required bit and write the byte back to the device. This is only necessary for write data that is not writing complete parameter bytes

### **6.4.5 Password Writes**

Certain write locations in P&B MR. Series of Protection Relays are password protected to ensure integrity. These are handled as normal Parameter Writes which will cause them to return a data length of 00 bytes in the response (i.e. command not actioned). When this is detected then a Password Write should be initiated to the same location. The Control/Monitoring system should first send a password value to an analogue address in the database. This is retained in the database memory for 2 minutes, after which the value is erased.

The password is really a pass number and is a 2 byte integer broadcast from the Master interface to all XCell units as an analogue output drive command. A pre-defined register number of is assigned as the analogue output password register. The P&B device must recognise the register in any broadcast analogue output drive messages and store the value as the new password.

### **6.4.6 Command Summary**

Command	Master	Slave Response
Fast Scan Read	\$01	\$81
Poll Read Only data	\$02	\$82
Poll Read/Write data	\$03	\$83
Parameter Write	\$04	\$84
Stop/Lockout	\$04	\$84
Stop	\$05	\$85
Start_A	\$06	\$86
Start_B	\$07	\$87
Reset	\$08	\$88
Password Write	\$09	\$89

Start, Stop, Reset and Write commands suspend the polling mechanism until the commands have been transmitted to the device.

Read-modify-write is necessary for non byte writes. Writes to password protected values will respond with length 00 and this will initiate a password write to the location.

### **6.4.7 Stop/Lockout Command**

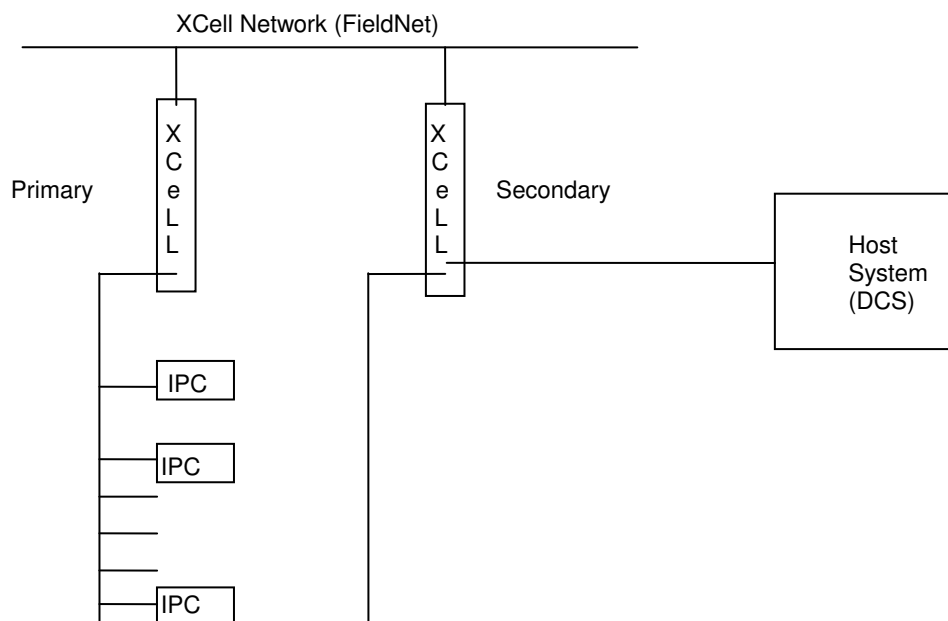
This command detailed above is a special feature included in the protocol for MV2 units. When the host system sends this command to all or a particular unit the MV2 will immediately stop the drive and will not accept a command to start the motor from any source until the Stop/Lockout reset command is sent by the host system. This can be used as a DCS lockout mechanism.

### **6.4.8 Broadcast Commands**

Included in the XCell implementation is the facility to send any of the above commands to all 32 P&B units connected to an XCell port by the host sending a single command to a digital output address. When this command is received the XCell will halt the Fastscan polling sequence and will repeat the command individually to all 32 units connected after which the XCell will revert to its Fastscan polling sequence.

### **6.4.9 Dual Master Operation**

For ultimate system security and reliability the XCell unit can be configured as Primary and Secondary Masters to the units. With this arrangement XCell units are connected at both ends of the data highway with one unit configured as a Primary Master to the units and the other configured as a Secondary Master to the units.



## **SECTION 6 - XCELL/P&B STANDARD DRIVER FUNCTIONAL SPECIFICATION**

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In normal operation the Primary XCell unit polls the units, the Secondary XCell monitors the communications between the Primary XCell and the Secondary XCell and copies the data set from the Primary. Provided that the Primary is communicating with all of the units the Secondary XCell is dormant.

In the event that the Primary XCell stops polling the units the Secondary XCell will commence polling and establish communications with as many units as possible. If the Primary unit has failed totally and the data highway is intact the Secondary XCell will communicate with all the units connected to the line.

If however the Primary XCell is still active but the Secondary cannot see communications between the Primary XCell and the units this would indicate a break in the data highway in which case the Secondary XCell will establish communications with the units connected to its side of the break and the Primary XCell will continue to communicate with the units connected to its side of the break.

Tests have proved in practice this system will work for clean breaks in one or both of the RS485 twisted pairs, however if the pair is shorted or earthed, communications with all units cannot be guaranteed as this is dependant on the characteristics of the data highway.

Data acquired from units is sent to the same node and address by both Primary and Secondary XCell units and is therefore available to the host system at the same location irrespective of whether the Primary or/and Secondary XCell are polling units.

This method of intelligent dual redundancy is employed to eliminate the need for dual networks to the same slave devices. Dual networking is normally used for systems where the standby master takes over polling entirely on loss of the primary master.

## **6.5 Physical Interface**

This is an RS485 interface with a maximum of 32 devices on a single communications link.

An XCell processor module can support one communications link to the devices

The link operates at 9600 baud, 1 start bit, 1 stop bit, 8 data bits and even parity.

## **6.6 Frame Format**

The following is the frame format for the protocol used for communicating from the XCell to the P&B devices,

### **XCell Poll**

Sync Char	\$5A
Slave Addr	Slave Addr 1-32
Data Length	CRC Check
Command	(Command MSB clear)
(Data if required)	
CRC low	
CRC high	

### **Device Response**

Sync Char	\$5A
Slave Addr	Slave Addr 1-32
Data Length	CRC Check
Command	Command MSB set
(Data if required)	
CRC low	
CRC high	

If the Sync Character occurs in the data stream the it must be delimited by inserting the delimiting character \$FD immediately following the \$5A. This ensures that the Sync Character can always be uniquely identified.

## **6.7 Mapping**

When data is retrieved from the devices it is converted to an XCell database format so that the standard XCell communications mechanism can be utilised to transfer the data throughout the XCell system.

This is achieved by mapping the data to Digital Input Groups, Digital Output Groups, Analogue Input Groups and Analogue Output Groups. All of the data for the 32 devices connected to an XCell Processor port is mapped to the Processor unit number. The unit number is configured for the XCell Processor by the user.

The XCell/MPC Modbus Mapping document details how the data is mapped into these groups. To allow maximum efficiency of communications between the XCell and a control system Fastscan data is continuously mapped such that the Digital input data for 32 units can be read by the host with a single command and similarly Analogue Input data can be read in blocks of 32 .

## **6.8 Configuration**

A number of configuration parameters can be adjusted for each XCell serial port connected to P&B devices. These parameters are outlined as follows,

1. Base XCell number
2. Mode [Single/Primary/Secondary]
3. Number of Devices
4. Slow read time.

### **6.8.1 Base XCell Number & Mode**

The Base XCell number and the Mode are configured at the XCell using the function button within 30 seconds of powering up the XCell Processor. Whether the XCell is to act as a Single Master or Primary Master or Secondary Master on a Dual Redundant system is determined by the unit number assigned.

For example for single masters only even numbers are used, such as 2, 4, 6 etc.

For Dual Redundant systems only odd numbers are used for the Primary and Secondary Masters for example setting an XCell Processor to unit number 1 sets the unit as a Primary to a virtual (software) XCell unit number 2. Setting an XCell Processor to unit number 3 sets the unit as a Secondary Master to the virtual XCell unit number 2.

For further Dual Redundant highways numbers 5 & 7, 9 & 11, 13 & 15 etc. are used to provide Primary and Secondary Masters to virtual XCell unit numbers 6, 10 & 14.

See Section 5.4 for more details.

### **6.8.2 Number of Devices**

It is not necessary to tell an XCell unit how many devices are connected, on initialisation the XCell will attempt to communicate with 32 devices, after an initial 3 attempts to establish communications with each device the XCell goes into a normal scanning routine. After each Fastscan of all on-line devices the XCell will try to communicate with missing devices. This way if a further device is added it will be detected within a maximum period of 2 minutes, allowing devices to be added on-line with no down time and no reconfiguring at the Xcell level.

### **6.8.3 Slow Read Time**

This is the time interval between retrieving full data from devices. As outlined the Protocol is constantly retrieving Fast Scan Data and at regular intervals retrieves full data from one device. The default setting for this is once every 5 fastscans.

## **SECTION 7 - Host Systems**

### ***7.1 Introduction***

One of the reasons for having a 'layered' system such as the XCell – MV2 system is so that host systems, such as DCS or SCADA systems may be utilised. These are high-end interfaces designed to present relevant information to the user in an efficient and friendly manner. Examples of the systems are ABB DCS, Foxboro IA and P&B's own Engineering / SCADA software, to name a few. In the majority of cases the host system will be connected to the upper port of the XCell unit and will communicate using the Modbus protocol, which is an industry standard protocol used on many applications due to its simplicity and efficiency.

### **7.2 The Modbus RTU Interface.**

#### **7.2.1 Introduction**

The XCell unit is capable of utilising the industry standard Modbus RTU protocol, which has been widely accepted and utilised by the vast majority of DCS vendors world-wide. Modbus is an ASCII-based protocol which is well structured and efficient in use - it incorporates methods of dealing with transmission errors, facilities for direct addressing of individual nodes and broadcasted messages. The upper port on the XCell processor unit uses the Modbus protocol with an RS232 interface which is sufficient for point-to-point communications. In many cases, however, it is required to 'multi-drop' the XCell units on one communication line. The technology of RS232 does not allow this, so converters are used to convert RS232 to RS485 in two-wire half-duplex mode. This allows up to 32 units to be connected on the same communications line accessible by different node addresses. The XCell itself may also be supplied with the upper port configured to directly interface with RS-422 / RS-485, which means that the converters would not be required.

The host computer issues instructions to the XCell units by sending command messages over the serial communications link. The XCell unit responds to the host by sending response messages back.

Communications is based on serial asynchronous character transfer, using 8 data bits, even parity and one stop bit, and the bit rate can be set to any value up to 19200 baud in the usual increments. This is in keeping with the Modbus RTU mode of transmission where character transfer is in binary format.

The protocol has a 16-bit CRC (Cyclic Redundancy Check) on all message transactions. The host computer initiates the transaction by sending a command addressed to one of the XCell units on the network which, assuming the request is valid, will return an acknowledgement to the host along with any requested data.

Note that in all cases of Host - XCell communications, the Host is the Master and the XCell is the Slave, i.e. the Host must always initiate the transfer and the XCell will only 'speak when spoken to'.

**7.2.2 Modbus Protocol Information**

All commands consist of four main parts as described below:

<b>Address</b>	<b>Function</b>	<b>Data</b>	<b>CRC</b>
8 Bits	8 Bits	N x 8 Bits	16 Bits

**Address** - This field consists of 8 bits representing the XCell unit for which the command is destined. Note that the notation is in hexadecimal format, so address 1 would be '01' and address 10 would be '0A', etc. Each hexadecimal character constitutes four bits.

**Function** - This is an 8-bit field which defines the command type for the present message packet. The available functions are as follows:

<b>CODE</b>	<b>FUNCTION DESCRIPTION</b>
01	Read Digital Outputs
02	Read Digital Inputs
03	Read Analogue Outputs
04	Read Analogue Inputs
05	Force Single Coil Output
06	Force Single Analogue Output
15	Force Multiple Coil Outputs
16	Force Multiple Analogue Outputs

Typical function uses are as follows:

**Code 01:**

Used to read the status of digital outputs, e.g. Start output bit, etc. It is worth noting that the XCell will return dummy values so as not to stop this function from working if necessary, but it is not generally used in this application.

**Code 02:**

Used to read digital items such as fault, alarm, running, etc. from the XCell.

**Code 03:**

Used to read setpoints of a relay from the XCell where available.

**Code 04:**

Used to read analogue values such as Full Load Current, Thermal Capacity, Hours Run, etc. of a particular relay or motor from the XCell unit.

**Code 05:**

Used to force a single coil (bit) so as to perform a command, e.g. Start motor.

**Code 06:**

Used to write analogue values to the XCell unit such as setpoint data.

**Code 15:**

Used to force multiple coils (bits) to perform commands, for example stopping more than one motor at a time.

**Code 16:**

Used to force multiple analogue registers, usually for the control of Variable Speed Drives.

**NOTE:** Function Code 15 usually used by DCS systems to perform operations on drives, e.g. Start, Stop, etc.. Although the use of this code is generally more efficient than writing single bits with function code 5, it is very important that commands sent are done on an exception basis, i.e. commands are only sent if they are required to be actioned. Some systems issue commands with code 15 on a regular basis regardless of change - this puts a very heavy load on the XCell unit and subsequently degrades communication performance. The majority of systems use code 15 for convenience; most can be easily adapted to either use code 5 instead or send code 15 on exception. The same applies for codes 16 and 6.

**Data** - The Data field contains information needed by the XCell unit to perform a specific operation or it contains data collected by the XCell unit in response to a query. The data information will vary in contents and length depending on the message function type.

**CRC** - Stands for 'Cyclic Redundancy Check'. The field is 16 bits long and allows both the host and the XCell unit to check a message for transmission errors. Sometimes due to electrical noise or other interference, a message may be changed slightly while it is on its way from one unit to another. The error checking assures that the host or the XCell does not react to corrupted messages.

### 7.2.3 XCell Data Mapping

The XCell unit 'maps' all of the relay data into its own memory and provides the means for a host system to request information from specific Modbus addresses. The XCell map is basically a list of items from the relays along with which address must be polled for to obtain the information from the XCell. A sample map is shown in Appendix A.

### 7.2.4 Additional information

Additional information on the Modbus protocol can be obtained from the 'AEG Modicon Modbus protocol reference guide', ISDN PI-MBUS-300 Rev.D by Modicon Inc. Industrial Automation Systems at 1 High Street, North Andover, MA01845, USA.

### **7.3. XCELL Modbus Protocol as Implemented for P&B Engineering.**

#### **7.3.1. Introduction:**

The following is a summary of the Modbus protocol as implemented in the Xcell for host communications with intelligent P&B protection and control devices. It is a subset of the overall protocol and implements the Modbus RTU mode of transmission only. It provides for both reading and driving of analogue and digital values at any XCell unit connected to the XCell network.

#### **7.3.2. General:**

The host computer (master) issues instructions to the XCell units (slaves) by sending command messages over the serial communications link. The XCell unit responds to the host by sending response messages back.

Communications is based on serial asynchronous character transfer, using 8 data bits, no parity and one stop bit. This is in keeping with the Modbus RTU mode of transmission where character transfer is in binary format.

The protocol is a two pass protocol with a 16-bit CRC on all message transactions. The host computer initiates the transaction by sending a command addressed to one of the XCell units on the network. The XCELL Gateway unit verifies that the addressed unit is present and that the command is valid. It then passes on the command for execution to the appropriate unit and returns an acknowledgement to the host along with any requested data.

If the XCELL Gateway unit detects any errors in the host commands it will respond with an error code to the host. In addition to this the XCELL Gateway unit can report errors by means of the 'Error' LED display on the front of the unit. Thus a visual indication is also provided for any protocol/communication errors detected by the XCELL Gateway unit. For further information on error reporting refer to the Microsol User Manual. The error code numbers reported by the XCELL Gateway unit, on both the Modbus protocol to the host, are outlined in the following sections.

Commands:

All commands consist of four main parts as described below:

Address	Function	Data	CRC
8 -bits	8-bits	N x 8-bits	16-bits

**Address:** This field consists of 8-bits representing the XCELL unit for which the command is destined. Each XCELL unit on the network is assigned a unique unit number and it is this number that is used in the address field. Broadcast messages are not supported.

Address 255 (FF hex) is an invalid address and should not be used.

**Function:** This field is an 8-bit field which defines the command type for the present message packet. Each command is represented by a unique function character. The supported functions are summarised in a later section along with detailed descriptions.

## **SECTION 7 - HOST SYSTEMS**

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**Data:** The data field contains information needed by the XCELL unit to perform a specific function or it contains data collected by the XCELL unit in response to a query. The data information will vary in contents and in length depending on the message function type. It will contain start channel number and number of channels for a query messages, start channel and value for setting outputs, etc. The data field contents will be described in the following sections for each of the function types.

**CRC:** This is a 16-bit field which allows both the host and the XCELL unit to check a message for transmission errors. Sometimes due to electrical noise or other interference, a message may be changed slightly while it is on its way from one unit to another. The error checking assures that the host or the XCELL does not react to corrupted messages. The protocol uses CRC-16 check which will be described later.

---

*Supported Modbus Functions*

A summary of the function types supported by the XCELL Gateway unit is given below along with an outline of their format. A detailed description of each function follows this summary.

Code	Function description	Format
01	Read digital outputs	Addr : Func : Start chan : No. Chans : CRC
02	Read digital inputs	Addr : Func : Start chan : No. Chans : CRC
03	Read analogue outputs	Addr : Func : Start chan : No. Chans : CRC
04	Read analogue inputs	Addr : Func : Start chan : No. Chans : CRC
05	Drive single digital output	Addr : Func : Chan : State : CRC
06	Drive single analogue output	Addr : Func : Chan : State : CRC
08	Loopback Diagnostic	Addr : Func : Diag code : Data : CRC
15	Drive multiple digital outputs	Addr : Func : S. Chan : # Chans : Count : States... : CRC
16	Drive multiple analog outputs	Addr : Func : S. Chan : # Chans : Count : States... : CRC

## SECTION 7 - HOST SYSTEMS

---

### READ DIGITAL OUTPUTS

---

Function 01

Function 01

---

Purpose:

Read the value, (on/off), of each digital output channel given the start channel and the number of channels required.

Format:

Hex →	Addr	Func	Start chan		No of chans		CRC	
			hi.	lo.	hi.	lo	hi.	lo
	06	01	00	03	00	09	0D	BB

Notes:

The Number Of Channels defines the number of consecutive channels to be read by this command.

Example:

The above sample command requests the status of digital outputs to be read from XCELL unit number 06. The read is to start at channel 3 for 9 consecutive channels, i.e. read channels 3 through to 11 inclusive.

Response:

Hex →	Addr	Func	Byte count	Data chans	Data chans	CRC	
				03 - 10	11 - 11	hi.	lo
	06	01	02	0F	01	C8	0C

Notes:

The response contains the Address and Function as in the original command. The byte count is the number of bytes of digital output values in the response. The data is packed with one bit for each output (1 = ON, 0 = Off). The low order bit of the first character contains the status of the start channel, and the remainder follow. Where the number of channels requested is not an even multiple of eight, the last character will be filled in with zeros at the high order end.

The response in the example is returned from unit 06 and has two bytes of digital output data.

The status of channels 3 - 10 is shown as FF hex = 1111 1111 binary. Reading right to left shows that channels 3,4,5,6 are all ON, and channels 7,8,9,10 are all OFF. Any other status bytes are decoded similarly. Due to the number of requested bytes the last data byte which is shown as 01 hex = 0000 0001 binary, contains the status of only 1 channel (channel 11) instead of 8. The 7 left-most bits are provided as zeros to fill the 8-bit format. Reading this byte from right to left, 0000 0001 shows that channel 11 is ON.

Summary:	Channels = ON
	3,4,5,6
	7,8,9,10 = OFF
	11 = ON

It should be noted that when driving digital outputs to control MPC2000+, MPC2000D or Supervision series controllers, the state of these outputs when read using this command will always be Ø. Status is read using function 02 read digital inputs.

## SECTION 7 - HOST SYSTEMS

---

### READ DIGITAL INPUTS

Function 02

Function 02

---

Purpose:

Read the value, (on/off), of each digital input channel given the start channel and the number of channels required.

Format:

Hex →	Addr	Func	Start chan		No of chans		CRC	
			hi.	lo.	hi.	lo.	hi.	lo.
	08	02	00	02	00	16	58	9D

The Number Of Channels defines the number of consecutive channels to be read by this command.

Example:

The above sample command requests the status of digital inputs to be read from XCELL unit number 08. The read is to start at channel 2 FOR 22 (16 hex) consecutive channels, i.e. read channels 2 through to 23 inclusive.

Response:

Hex →	Addr	Func	Byte count	Data chans	Data chans	Data chans	CRC	
				02 - 09	10 - 17	18 - 23	hi.	lo.
	08	02	02	F8	03	3E	79	FA

Notes:

The response contains the Address and Function as in the original command. The byte count is the number of bytes of digital input values in the response. The data is packed with one bit for each output (1 = ON, 0 = Off). The low order bit of the first character contains the status of the start channel, and the remainder follow. Where the number of channels requested is not an even multiple of eight, the last character will be filled in with zeros at the high order end.

The response in the example is returned from unit 08 and has three bytes of digital input data.

The status of channels 2 - 9 is shown as F8 hex = 1111 1000 binary. Reading right to left shows that channels 2,3,4 are all OFF, and channels 5,6,7,8,9 are all ON. Any other status bytes are decoded similarly. Due to the number of requested bytes the last data byte which is shown as 3E hex = 0011 1110 binary, contains the status of only 6 channels instead of 8. The 2 left-most bits are provided as zeros to fill the 8-bit format. Reading this byte from left to right, 0011 1110 shows that channel 18 is OFF and channels 19,20,21,22,23 are all ON.

Summary:	Data byte	Channel	State
	F8 = 1111 1000	2,3,4	= OFF
		5,6,7,8,9	= ON
	03 = 0000 0011	10,11	= ON
		12,13,14,15,16,	= OFF
		17	
	3E = 0011 1110	18	= OFF
		19,20,21,22,23	= ON

## SECTION 7 - HOST SYSTEMS

---

### READ ANALOGUE OUTPUTS

---

Function 03

Function 03

---

Purpose:

Read the value of each analogue output channel given the start channel and the number of channels required.

Format:

Hex →	Addr	Funct	Start chan		No of chans		CRC	
			hi.	lo.	hi.	lo	hi.	lo
	20	03	00	00	00	03	03	7A

Notes:

The Start Channel is the initial channel to be read. This should be in the range

0 - 15 for 16 channel units, and

0 - 31 for 32 channel units

Channel 0 corresponds to the first connector position on the XCELL unit.

The Number Of Channels defines the number of consecutive channels to be read by this command.

Example:

The above sample command requests the status of digital inputs to be read from XCELL unit number 32 (20 hex). The read is to start at channel 0 for 3 consecutive channels, i.e. read channels 0,1,2 inclusive.

Response:

Hex →	Addr	Func	Byte count	Data chan 0		Data chan 1		Data chan 2		CRC	
				hi	lo	hi	lo	hi	lo	hi.	lo
	20	03	06	40	00	FF	FF	CO	00	EB	C0

Notes:

The response contains the Address and Function as in the original command. The byte count is the number of bytes of analogue values in the response, i.e. the number of channels x 2.

The data values in the response are 16-bit values in keeping with Modbus 184, 384 and 584.

## SECTION 7 - HOST SYSTEMS

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### READ ANALOGUE INPUTS

---

Function 04

Function 04

---

Purpose:

Read the value of each analogue input channel given the start channel and the number of channels required.

Format:

Hex →	Addr	Func	Start chan		No of chans		CRC	
			hi.	lo.	hi.	lo	hi.	lo
	11	04	00	08	00	03	33	59

Notes:

The Start Channel is the first channel to be read. This should be in the range

0 - 15 for 16 channel units, and

0 - 31 for 32 channel units

Channel 0 corresponds to the first connector position on the XCELL unit.

The Number Of Channels defines the number of consecutive channels to be read by this command.

Example:

The above sample command requests analogue inputs to be read from XCELL unit number 17 (11 hex). The read is to start at channel 8 for 3 channels, i.e. read channels 8,9 and 10.

Response:

Hex →	Addr	Func	Byte count	Data chan 8	Data chan 9	Data chans 10	CRC	
				hi - lo	hi - lo	hi - lo	hi.	lo
	11	04	06	FF FF	80 00	00 00	84	88

Notes:

The response contains the Address and Function as in the original command. The byte count is the number of bytes of analogue values in the response, i.e. the number of channels x 2.

The data values in the response are 16-bit values in keeping with Modbus 184, 384 and 584.

## SECTION 7 - HOST SYSTEMS

---

### DRIVE SINGLE DIGITAL OUTPUT

Function 05

Function 05

---

Purpose:

This function enables a single digital output to be driven ON or OFF, given the output channel number and the output state.

Format:

Addr	Funct	Output chan		Output state		CRC	
		hi.	lo.	hi.	lo.	hi.	lo.
Hex → 05	05	00	0A	FF	00	AD	BC

Notes:

The Output Channel is the digital output channel to be driven. This should be in the range

0 - 15 for 16 channel units, and

0 - 31 for 32 channel units

Channel 0 corresponds to the first connector position on the XCELL unit.

The Output State defines the new state of the digital output channel to be driven by this command. Value FF00 = ON

0000 = OFF

All other values are illegal and will not effect the output state.

Example:

The above sample command is to drive a digital output channel in the XCELL unit number 5. The channel to be driven is channel 10 (0A hex) and it is to be switched ON (FF00 hex).

Response:

Hex →	Addr	Funct	Output chan		Output state		CRC	
			hi.	lo.	hi.	lo.	hi.	lo.
	05	05	00	0A	FF	00	AD	BC

Notes:

The normal response to the command request is to re-transmit the message as received.

It should be noted that when using this command to control MPC2000+, MPC2000D or Supervision series controllers, a positive response from the XCELL indicates only that the command has been sent to the device and has been received. This does not indicate whether the command has been actioned. Verification that the command has been actioned is given by reading the device status using function 02.

## SECTION 7 - HOST SYSTEMS

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### DRIVE SINGLE ANALOGUE OUTPUT

---

Function 06

Function 06

---

Purpose:

This function enables a single analogue output channel to be driven to a new value.

Format:

Addr	Funct	Output chan		Output value		CRC	
		hi.	lo.	hi.	lo.	hi.	lo.
Hex → F0	06	00	1E	80	00	9D	2D

Notes:

The Output Channel is the analogue output channel to be driven. This should be in the range

0 - 15 for 16 channel units, and

0 - 31 for 32 channel units

Channel 0 corresponds to the first connector position on the XCELL unit.

The Output Value defines the new value to which the analogue output channel is to be driven by this command. The value is a 16-bit value in keeping with Modbus 184, 384 and 584.

Example:

The above sample command is to drive an analogue output channel in the XCELL unit number 240 (F0 hex). The channel to be driven is channel 30 (1E hex) and it is to be driven to a value 8000 hex - 50% of scale.

Response:

Hex →	Addr	Funct	Output chan		Output value		CRC	
			hi.	lo.	hi.	lo.	hi.	lo.
	F0	06	00	1E	80	00	9D	2D

Notes:

The normal response to the command request is to re-transmit the message as received.

To use this command to transmit setting parameters to MR series protection relays a password must first be driven to a particular address. Refer to mapping documents for details of this.

---

LOOPBACK TEST

Function 08

Function 08

---

Purpose:

This function enables the communications link to be tested without affecting the channels on the XCELL units. It merely requests the same message to be returned by the XCELL Gateway so that the communications link can be checked.

Format:

	Addr	Funct	Diagnostic code		Data		CRC	
			hi.	lo.	hi.	lo.	hi.	lo.
Hex →	04	08	00	00	80	22	01	87

Notes:

The diagnostic code must always be zero as this is the only diagnostic supported by this version of XCELL protocol. The data value can be any value desired for the test.

Response:

The normal response to the command request is to re-transmit the message as received.

---

**DRIVE MULTIPLE DIGITAL OUTPUTS**

---

Function 15

Function 15

---

Purpose:

This function enables consecutive digital output channels to be driven ON or OFF, given the first output channel number, the number of consecutive outputs to be driven and the output state for each of the output channels.

Format:

	Addr	Funct	Start chan		No. Chans	Byte count	Data chan		CRC	
			hi.	lo			7 - 14	15 - 18	hi	lo
Hex →	1C	0F	00	07	00 0C	02	81	03	51	06

Notes:

The Number of Channels defines the number of consecutive channels to be driven by this command.

The Byte Count is the number of bytes of digital output values in the command. The data is packed with one bit for each output (1 = ON, 0 = Off). The low order bit of the first character contains the output state for the start channel, and the remainder follow. Where the number of channels to be driven is not an even multiple of eight, the last character will be filled in with zeros at the high order end.

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Example:

The above sample command is to drive digital output channels in the XCELL unit number 28 (1C hex). The first channel to be driven is channel 7 and 12 consecutive channels are to be driven. There are 2 bytes defining the new output states for the channels. The output states for channels 7 - 14 are given as 81 hex = 1000 0001 binary. Reading right to left shows that channels 7,14 are both to be switched ON, and channels 9,10,11,12,13 are all to be switched OFF. Any other output control bytes are decoded similarly. Due to the number of outputs to be driven the last data byte which is shown as 03 hex = 0000 0011 binary, contains the output state for only 4 channels instead of 8. The 4 left-most bits are provided as zeros to fill the 8-bit format. Reading this byte from left to right, 0000 0011 shows that channels 15,16 are to be driven ON and channels 17,18 are to be driven OFF.

Summary:	Data byte	Channel	New state
	81 = 1000 0001	7,14	= ON
		8,9,10,11,12,13	= OFF
	03 = 0000 0011	15,16	= ON
		17,18	= OFF

Response:

Hex →	Addr	Funct	Start Chan		No. Chans		CRC	
			hi.	lo.			hi.	lo.
	1C	0F	00	07	00	0C	E7	82

Notes:

The normal response to this command request is to re-transmit the address, function code, start channel number and number of channels driven.

It is important to note that it is acceptable to use this command to send a string containing all commands to a group of controllers connected to a particular XCELL unit. However the string must be sent on an exception basis i.e. only when a command is needed as continual writing of the string will overload the XCELL network and cause the system to fail. It is also recommended that the string be split into 2 groups so as not to create loading problems.

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### DRIVE MULTIPLE ANALOGUE OUTPUTS

Function 16

Function 16

---

Purpose:

This function enables consecutive analogue output channels to be driven to new values, given the first output channel number, the number of consecutive outputs to be driven and the output value for each of the output channels.

Format:

Addr	Funct	Start chan		No. Chans	Byte count	Data chan 7		Data chan 8		CRC		
		hi.	lo					hi	lo	hi	lo	
Hex → 0A	10	00	07	00	02	04	80	00	20	00	A7	6D

Notes:

Broadcast mode is supported with this function code. Use address 00 (broadcast mode) to force all attached XCELL units to drive the specified output.

The Start Channel is the initial channel to be driven.

The Byte Count is the number of bytes of analogue output values in the command. The data values are each 16-bit values in keeping with Modbus 184, 384, 584. The most significant byte of the data value is transmitted first, followed by the least significant byte.

Example:

The above sample command is to drive analogue output channels in the XCELL unit number 10 (0A hex). The first channel to be driven is channel 7 and 2 consecutive channels are to be driven. There are 4 bytes defining the two new output values for the channels. The output value for channel 7 is given as 8000 hex = 50% of scale and the output value for channel 8 is given as 2000 hex = 12.5% of scale.

Response:

Hex →	Addr	Funct	Start Chan	No. Chans	CRC	
			hi. lo.		hi.	lo
	0A	10	00 07	00 02	F1	72

Notes:

The normal response to this command is to re-transmit the address, function code, start channel number and number of channels driven.

**Protocol Errors**

The XCELL Gateway unit analyses all of the incoming messages from the host. If the data received does not match the configuration of the destination XCELL unit then an error needs to be reported. Errors may need to be reported by the Gateway unit for various reasons.

The XCELL Gateway unit reports errors in two separate ways. First it may return an error packet to host as specified in the Modbus protocol. Secondly it may flash error codes on the display and light the Error LED on the front of the XCELL Gateway unit.

**Protocol Error codes:**

The Modbus protocol allows error codes to be returned to the host if any errors are detected by the Gateway unit. The format of the error response is shown below.

Address	Function	Error Code	CRC	
	MSB = 1		hi	lo
05	84	02	83	00

If a function code is returned to the host with the most significant bit set then this indicates to the host that an error was detected at the XCELL Gateway. The following character is the error code and indicates the reason for the error. The first character is the address of the unit for which the original message was destined when the error was detected. The following is a list of the error codes and their possible causes.

**01 Illegal Function**

The function code received by the XCELL Interface unit was either invalid or not supported by this XCELL protocol version.

**02 Invalid Channel No.**

The specified channel no. either exceeds the limit of the XCELL I/O count or the hardware at the specified channel location does not match the required type. For example, a request may have been received to read analogue input from channel 1 but channel 1 may actually be a digital channel or possibly have no I/O hardware for that channel.

**03 Illegal Data Value**

The contents of the value field is invalid. For example, to drive a digital output On or Off only two possible values are allowed in the value field 0000 for OFF and FF00 for On, anything else will result in this error code being returned.

**The following is a list of error codes associated with protocol errors.**

**15 Invalid channel/value**

The specified channel no. either exceeds the limit of the XCELL I/O count or the hardware at the specified channel location does not match the required type. For example, a request may have been received to read analogue input from channel 1 but channel 1 may actually be a digital channel or possibly have no I/O hardware for that channel. It could also be generated as a result of an invalid data value for driving digital outputs On/Off i.e. only 0000 or FF00 permitted.

**16 Invalid Function**

The function code received by the XCELL Interface unit was either invalid or not supported by this XCELL protocol version.

### **17 XCELL Hardware Error**

A problem exists with either the serial interface card or the memory allocation in the XCELL Gateway unit. Switch the Xcell off using the slide on/off switch and reboot. The Xcell should begin a booting sequence which will cause the display to increment to from 000 to 340 then a 'waterfall' effect will display on the LED matrix. The Xcell should then display its node number and begin polling relays. If this does not happen contact your nearest distributor for further advice.

---

**Error Check Sequence: CRC-16**

The CRC-16 error check sequence is implemented as described in the following paragraphs.

The message (data bits only, disregarding start/stop bits) is considered as one continuous binary number whose most significant bit (MSB) is transmitted first. The message is pre-multiplied by  $X^{16}$  (shifted left 16 bits), then divided by  $X^{16} + X^{15} + X^2 + 1$  expressed as a binary number (11000000000000101). The integer quotient digits are ignored and the 16-bit remainder (initialised to all ones at the start to avoid the case of all zeros being an accepted message) is appended to the message (MSB first) as the two CRC check bytes. The resulting message when divided by the same polynomial ( $X^{16} + X^{15} + X^2 + 1$ ) at the receiver will give a zero remainder if no errors have occurred. The receiving unit recalculates the CRC and compares it to the transmitted CRC. All arithmetic is performed in modulo 2 (no carries).

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The following is a step by step procedure to calculate the CRC-16.

1. Load a 16-bit register with all 1's.
2. Exclusive OR the first 8-bit byte with the high order byte of the 16-bit register, putting the result in the 16-bit register.
3. Shift the 16-bit register one bit to the right, bringing in a zero bit.
4. a) If the bit shifted out to the right (flag) is one, exclusive OR the generating polynomial 1010 0000 0000 0001 with the 16-bit register  
b) If the bit shifted out to the right is a zero; return to step 3
5. Repeat steps 3 and 4 until 8 shifts have been performed
6. Exclusive OR the next 8-bit byte with the 16-bit register.
7. Repeat steps 3 through 6 until all bytes of the message have been exclusive OR'd with the 16-bit register and shifted 8 times.

The contents of the 16-bit register are the 2 byte CRC error check and is appended to the message, most significant byte first.

An example the CRC-16 calculation for the following 2 byte abbreviated message is given below

The message : 02 07 now calculate the CRC-16

	LSB	16-bit Register				MSB	Flag
Pre-load with 1's	1111	1111	1111	1111		#	
02 data byte			0000	0010			
EOR							
	1111	1111	1111	1101			
Shift 1	0111	1111	1111	1110		1	
Polynomial	1010	0000	0000	0001			
EOR							
	1101	1111	1111	1111			
Shift 2	0110	1111	1111	1111		1	
Polynomial	1010	0000	0000	0001			
EOR							
	1100	1111	1111	1110			
Shift 3	0110	0111	1111	1111		0	
Shift 4	0011	0011	1111	1111		1	
Polynomial	1010	0000	0000	0001			
EOR							
	1001	0011	1111	1110			
Shift 5	0100	1001	1111	1111		0	
Shift 6	0010	0100	1111	1111		1	
Polynomial	1010	0000	0000	0001			
EOR							
	1000	0100	1111	1110			
Shift 7	0100	0010	0111	1111		0	
Shift 8	0010	0001	0011	1111		1	
Polynomial	1010	0000	0000	0001			
EOR							
	1000	0001	0011	1110			

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07 data byte			0000	0111	
EOR					
	1000	0001	0011	1001	
Shift 1	0100	0000	1001	1100	1
Polynomial	1010	0000	0000	0001	
EOR					
	1110	0000	1001	1101	
Shift 2	0111	0000	0100	1110	1
Polynomial	1010	0000	0000	0001	
EOR					
	1101	0000	0100	1111	
Shift 3	0110	1000	0010	0111	1
Polynomial	1010	0000	0000	0001	
EOR					
	1100	1000	0010	0110	
Shift 4	0110	0100	0001	0011	0
Shift 5	0011	0010	0000	1001	1
Polynomial	1010	0000	0000	0001	
EOR					
	1001	0010	0000	1000	
Shift 6	0100	1001	0000	0100	0
Shift 7	0010	0100	1000	0010	0
Shift 8	0001	0010	0100	0001	0

CRC-16 =	\$12	\$41
----------	------	------

The CRC-16 is appended to the end of the message, most significant byte first. The complete message would then be as follows,

02 07 41 12

## **SECTION 8 - XCell Modbus Data Mapping**

Data for each intelligent device is mapped under the XCell module or redundant pair unit number, to assist in maximising the efficiency of the communications between an XCell system and DCS/PLC/SCADA system, data regarded as Fastscan is mapped in continuous list of device 1-32, in this way the essential data for all devices on a data highway can be scanned as large block, thus reducing the scanning time.

As non-fastscan data is for maintenance purposes, it make sense to only collect this on a drive at a time basis and as such this data is mapped in a block for each device.

The attached sheets show the typical data available from the various protection controllers and relays when the serial link number for the device is set to 1, a spreadsheet is available from P&B which can give the relevant addresses for each device singly by entering the serial link number for each device connected. Alternatively P&B can supply the maps provided details of each type of relay and intended serial link numbers on each data highways are provided

Any combination of different P&B devices can be connected and each device appears the same the XCell except that the addresses have different meanings.

This allows the XCell to have distinct advantage that there is no project specific configuration required, greatly reducing the project engineering and testing costs as the mapping is already use and proven.

This also gives long benefits in that no modification of software is required when adding further devices.

Communication maps for specific devices are readily available; please contact us for the relevant documents.

## **SECTION 9 - Direct Communications**

### **9.1 Introduction**

P&B relays are capable of communicating with an XCell unit or directly with a host system, which is capable of communicating using the P&B relay protocol. It is worth noting that our relays are also capable of communicating in Modbus RTU mode directly.

### **9.2 The P&B Protocol**

#### **9.2.1 Overview**

##### **9.2.1.1 Characteristics**

Electrical Features -	RS485 with galvanised protection
Transmission lines -	Up to 1000m long
Structure -	Screened two wire twisted pair
Transmission method	Half duplex, 9600 baud, 8 databits, 1 start bit, 1 stop bit, even parity.
Access Principle -	Master / Slave (single Master)
No of users -	33 (32 slaves, 1 master)
Data Length -	up to 64 bytes
Data Protection -	16 Bit CRC, parity bit.

##### **9.2.1.2 Line Termination**

The RS485 bus is terminated by a 120 ohm resistor across the two communications lines (TX+ and TX-). Line termination is to be installed in the master unit and also at the end of the main line. Drop lines from the main line should not exceed 5m.

##### **9.2.1.3. Transmission**

The transmission of data is at 9600 bit/sec or 9600 baud. The characteristic consists of a start bit, 8 data bits, a parity bit followed by the stop bit. The start bit is a logic 0, the stop bit is a logic 1.

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### 9.2.1.4 Data Communications

Data exchange is always monitored by the Master which gives commands to the slaves, these commands are listed in the following sections.

### 9.2.1.5 Data Protection

Data transmission of 8 bit characters with 1 parity bit. The parity bit is the modulo-2 total of the eight bits of a character including zero for the parity bit. (see Section 7)

### 9.2.1.6 Algorithm for 16 bit CRC

```

Step 1      G = A001 (h)
            A = FFFF (h)
            N = No. of Data Bits
            i = 0
            |
            \|/ <-----
Step 2      j = 0
            AL = AL XOR Data[i]
            |
            \|/ <-----
Step 3      j = j + 1
            Shift Right (A)
            |
            \|/
Step 4      Carry = 1? ---- Yes -----> A = A XOR G
            No |
            \|/ <-----
Step 5      j = 8? --- Yes -----
            No |
            \|/
Step 6      i = i + 1
            |
            \|/
Step 7      I = N? -- Yes -----
            No |
            \|/
End         CRC = A
    
```

Key:

- A = Working register;
- AL = Low order byte of A;
- G = 16 bit characteristic polynomial;
- N = No. of bytes to be processed;
- i&j = Loop counters;
- CRC = Result.

**9.2.1.7. Timeout**

The minimum dead time on the line before the start of a telegram is 5mS (TD). This then must be kept from the master after receipt of the last slave reply and by the slave after the receipt of the last master command.

The maximum time between sending two bytes is 3mS (TC). If a slave is not able to send a byte within this time, the slave will cancel the telegram allowing the master to have bus access. In such cases, the master command is not answered.

The maximum time for a slave to answer a master is 40mS (TR). If a slave is not able to answer a command within this time, then no answer is given at all and the master is allowed bus access.

**9.2.1.8. Synchronisation character**

The hex value \$5A is used to synchronise all traffic on the link. When the value \$5A appears within the message as data, it must be delimited by \$FD. The delimiter (\$FD) will always follow \$5A on both message data and if the CRC contains \$5A. The delimiter is not included in the CRC or the declared message length.

**9.2.1.9. Communications Timing**

Fastscan data for each device cannot be polled more than once per second.

**9.2.1.10 Errors**

If the CRC or parity are wrong then there will be no reply from the slave. If the MPC command is wrong, then the slave will reply with \$D6.

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### **9.2.2 Command Structure**

#### **9.2.2.1 Overview**

The following commands are available for use with the relays :-

##### **\$01 Fast Scan Command**

Using a Fast Scan command to a slave will cause the slave to return a given number of data bytes. The pre-defined structures of these replies is given later in this document. Only one fast scan per second can be given to each node.

##### **\$02 Read command**

After receiving this command, the slave will reply with the requested data.

##### **\$03 Read Setpoint Command**

After receiving this command, the slave will reply with the requested data.

##### **\$04 Write Command**

After receiving this command, the slave will write the new data into the object and return an acknowledgement.

##### **\$05 Stop Command**

After receiving this command, the slave will issue a stop command to the specified device. If the node number is read as 33, 34, 35 or 36, followed by the stop command, this has the effect of stopping a group of motors.

##### **\$06 Start A command**

After receiving this command, the slave will initiate the Start A sequence.

##### **\$07 Start B command**

After receiving this command, the slave will initiate the Start B sequence.

##### **\$08 Reset Command**

After receiving this command, the slave will issue a Reset command to the device.

\$09 Protected write command

A protected write command can only access one object at a time. The command will include the password for the device. The slave will only perform a protected write command if the password matches, it will then write the new data to the object and return an acknowledgement.

**9.2.2.2 Command and Response**

With the exception of broadcast stops the response to a command is 80 (hex) greater than the issued command:-

	Master Command	Slave Reply
Fast Scan	\$01	\$81
Read	\$02	\$82
Read Setpoint	\$03	\$83
Write	\$04	\$84
Stop	\$05	\$85
Start A	\$06	\$86
Start B	\$07	\$87
Reset	\$08	\$88
Protected Write	\$09	\$89

**9.2.2.3 Fast Scan Response for IPC's**

Byte 1 DB	Byte 2 AB	Byte 3 Byte 4 AW1	Byte 4 Byte 6 AW2	Byte 7 Byte 8 AW3
--------------	--------------	----------------------	----------------------	----------------------

DB = Digital Byte, AB = Analogue Byte

AW = Analogue Word

The driver will need to map the digital and analogue data into the structure. In the case of the MPC unit, the digital will fill bits 0-7 of the word, and bit 8F will be zero. The analogue byte will become the first analogue word, with the others following.

The result of this will allow the use of direct access addressing to call FA1, for example, to read the first analogue word (or byte) for the node. The direct access address FD1:1 will access bit zero at the first digital word for the node and FD2:16 will access the last bit of the second digital word.

**9.2.2.4 Example commands**

9.2.2.4.1 Command \$01 - Fast Scan example

		Master	Slave
	Sync	\$5A	
CRC	Slave address	\$01	
CHECK	Data length	\$00	
	Fast Scan Command	\$01	
	CRC Low	\$E1	
	CRC High	\$CO	

		Sync	\$5A	
CRC		Slave Address	\$01	
		Data Length	\$08	
		Fast Scan Command	\$81	
		Logic Status		
		Alarm Register		
		I1 Low		
		I2 Low	5A	
		<b>\$FD Always follows \$5A in data</b>	Delimiter	\$FD
			I2 High	
			I3 Low	
		I3 High		
		CRC Low		
		CRC High		

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*9.2.2.4.2 Command \$02 - Read Example*

Read 6 bytes of data from node 1 Starting at address 20

	Master	Slave
	Sync	\$5A
	Slave address	\$01
	Data length	\$02
CRC	Read Command	\$02
	ID of Data`	\$20
	Bytes to Read	\$06
	CRC Low	\$20
	CRC High	\$7A

	Sync	\$5A
	Slave Address	\$01
	Data Length	\$07
	Read Command	\$82
	ID of Data	\$20
CRC	Phase 1V Low	
	Phase 1V High	
	Phase 2V Low	
	Phase 2V High	
	Phase 3V Low	
	Phase 3V High	
	CRC Low	\$20
	CRC High	\$5A
	Delimiter	\$FD

*9.2.2.4.3 Command \$03 - Setpoint Read Example*

Structure for this command is the same as command \$02 - see section 2.2.4.2. above

**9.2.2.4.4 Command \$04 - Write Example**

Write an 0009 to \$40 in node 1

	Master	Slave
	Sync	\$5A
	Slave address	\$01
	Data length	\$03
	Write command	\$04
CRC	ID of Data`	\$SL10
	Tx value low	\$09
	Tx value high	\$00
	CRC Low	\$7E
	CRC High	\$BE

	Sync	\$5A
	Slave Address	\$01
	Data Length	\$02
CRC	Write Command	\$84
	ID of Data	\$40
	Bytes to write	\$02
	CRC Low	\$E8
	CRC High	\$50

If the object is not write-able, “Bytes to Write” of the slave returns \$00.

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*9.2.2.4.5 Command \$05 - stop example*

	Master	Slave
	Sync	\$5A
CRC	Slave address	\$01
	Data length	\$00
	Stop Command	\$05
	CRC Low	\$E0
	CRC High	\$03

	Master	Slave
	Sync	\$5A
CRC	Slave Address	\$01
	Data Length	\$00
	Stop Command	\$85
	CRC Low	\$E1
	CRC High	\$A3

*9.2.2.4.6 Command \$06 - Start A example - see section 9.2.2.4.5*

*9.2.2.4.7 Command \$07 - Start B example - see section 9.2.2.4.5*

*9.2.2.4.8 Command \$08 - Reset example - see section 9.2.2.4.5*

*9.2.2.4.9 Command \$05 - Stop Broadcast example*

stop motors in group 33

	Master	Slave
	Sync	\$5A
CRC	Slave address	\$21
	Data length	\$00
	Stop Command	\$05
	CRC Low	\$E1
	CRC High	\$C9

No response

*9.2.2.4.10 Command \$09 - Protected Write example*

Using password \$4321

	Master	Slave
	Sync	\$5A
CRC	Slave address	\$01
	Data length	\$03
	Write Command	\$09
	ID of Data	\$40
	Password low	\$21
	Password high	\$43
	Tx value low	
	Tx value high	
	CRC Low	
	CRC High	

	Master	Slave
	Sync	\$5A
CRC	Slave Address	\$01
	Data Length	\$02
	Write Command	\$89
	ID of Data	\$40
	Protected write starts	
	Written value Low	
	Written value High	
	CRC Low	
	CRC High	

Under a protected write, the slave will respond in a number of ways :-

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Protected write status	Result	Comment	Contents of written value field
\$00	OK	Tx'ed value written to slave	
\$10	error	Invalid object ID	\$00
\$11	error	Invalid no of objects	\$00
\$20	error	Invalid password	Value from slave
\$28	error	Tx value exceeds defined limit	Value from slave
\$29	error	TX value smaller than defined	Value from slave
\$2A	error	limit	Value from slave
\$40	warning	Tx value has illegal bit combination Tx value adjusted by slave	Adjusted value from slave