MTL8000

Process I/O for Process Control

8505 - Modbus BIM

Instruction Manual

Contents

INM8505-7 MARCH 2001

Introduction

The MTL8000 Series - 8505-BI-MB - Bus Interface Module (BIM) provides the interface between a Modbus master and up to 32 MTL8000 Series I/O modules.

This manual applies only to BIM software releases of Version 2.00 or later.

The BIM mounts on a purpose-built carrier, which provides connections to the I/O modules and also to the local area network (LAN) which runs the Modbus protocol. It is configured, through a local or remote (LAN B) connection, using an IBM-compatible PC running the 8455 Configurator software.

About this manual

This manual provides information about the MTL8000 I/O sub-system and how it communicates with a Modbus Host and is organised as follows:

Modbus BIM operation

A description of MTL8000 operating modes, which includes both normal and failure conditions.

Recommended set-up for Host Communications

Information on how best to set up host communications with the system.

Modbus Data Mapping

Where a Modbus master can gain access to the MTL8000 I/O data.

This section may be subject to revision - see Revisions Section in Appendix C.

Appendix A Modbus Functions and Exception Responses

Details of the Modbus functions and responses supported by the BIM. This section is subject to revision as facilities are added to the BIM. See Revisions Section.

Appendix B Field Removal & Replacement of Modules

Advice on removal and replacement of BIM, Power Supply and I/O modules, especially in hazardous areas.

Appendix C Software Revision Status

A history of changes to the software.

Assumptions

The reader is assumed to be a control engineer or technician, who needs to set up the master to communicate with the BIMs connected to it, and maintain the system during operation.

It is also assumed that the system has been specified according to the System Specification Guide and installed and wired according to instructions in the Installation Guide.

Note that set-up details are provided in the Configurator Instruction Manual.

Related literature

The following literature, produced by MTL, will be of assistance to the reader of this manual:

	Process I/O™ catalogue
AN8002	Modbus Communications Manual - a background to Modbus
INM8455	BIM Configurator Software – Instruction Manual
INM8512	HART Interface Module – Instruction Manual

Trademark Acknowledgement

Modbus BIM Operation

MTL8000 Overview

General

An MTL8000 node comprises a Bus Interface Module (BIM) and up to 32 I/O modules, together with associated power supplies, on one or more module carriers. The BIM communicates with the I/O modules via a proprietary serial bus (“Railbus”) which is distributed via the carrier backplane circuit board.

Modbus BIM communications and configuration

Figure 1 shows a typical configuration for an MTL8000 system where it links to the host DCS, or PC. Communication can take place over a single link, or a redundant link can be added. The physical LAN configuration, RS485 or RS422, is configurable on the carrier using DIL switches.

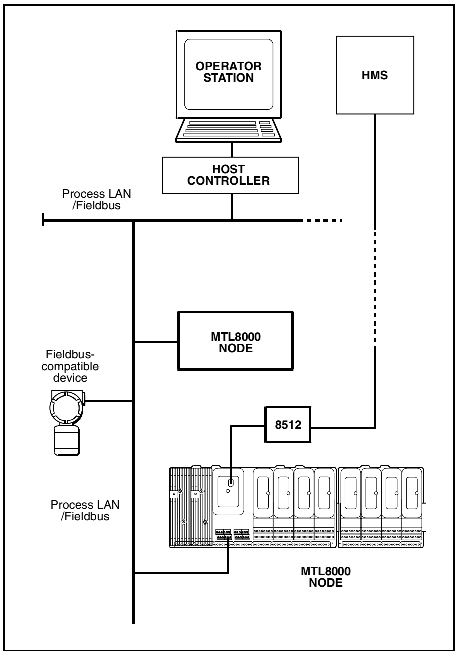


Figure 1 - Typical MTL8000 system

In order for the BIM to operate correctly within a node it must be configured. This consists of downloading a configuration file to the BIM which describes to it the modules in the node. Once configured, the BIM can store this configuration in its non-volatile memory (NVM) for recall on power up.

The 8455 Configurator software runs on a Windows™-compatible PC, which is connected to the BIM via an RS232 link to the D-connector on the top of the BIM. Configuration can also be carried out remotely, using the same software, via LAN B.

The address for the node is stored in the BIM's memory as part of the configuration.

The host establishes communications with the node based upon a Modbus query-response cycle, allowing it to both read and write data.

After configuration, an 8512 Hart maintenance module can be connected to each BIM. This enables a HART Maintenance System (e.g. AMS, Cornerstone, etc.) to communicate with any HART field devices connected to the node.

Note: Modules/Devices - In configuration software terms the I/O modules are often referred to as devices. The user should be aware that these two terms are interchangeable and either is acceptable.

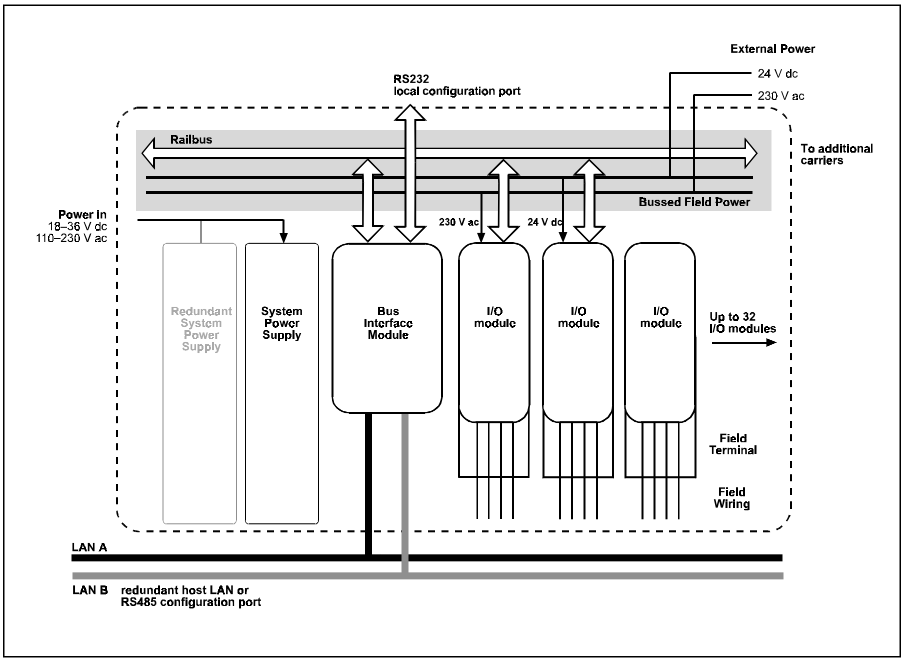


Figure 2 Schematic of node architecture

The schematic for a single node is shown in Figure 2 above. The I/O modules transfer information to and from the communication module (BIM) via the Railbus. The Railbus is a fast (500 kbits/s), internal, serial data bus, with parallel addressing, which can accommodate up to 32 modules at a single node. The BIM polls the I/O modules for data via the Railbus and also regularly monitors the "health" of them.

Node operation

A typical request for data from the field might happen as follows:

The host controller transmits a signal on the LAN, requesting (say) the temperature from a particular thermocouple input at a particular node. There are several MTL8000 nodes on the LAN, but the Bus Interface Module (BIM) at the chosen node recognises its own node address, and acknowledges the request.

At each node, the input modules constantly monitor, linearise and digitise their respective field signals, and make them available to scanning on the node's internal bus (Railbus).

The BIM is continually scanning the I/O modules via the Railbus, and has built up a map of the values of the input variables, ready for the host controller to read. These are converted into the LAN protocol and placed on the LAN by the BIM, together with acknowledgement signals. The host controller then interprets the signal and reconstructs the temperature reading.

HART data

All variable and status data, from HART I/O devices connected to the modules, are passed through the Railbus to the BIM and are made available to the host via the node's LAN port. Maintenance of the individual HART I/O devices can be achieved using the 8512-IF-HA HART interface module. This connects to the RS232 configuration port on the BIM and relays the data to a PC running maintenance software.

The 8512-IF-HA enables HART® devices connected to MTL's 8000 series modules, to communicate with instrument management software - like Fisher-Rosemount's AMS and Applied System Technologies' Cornerstone™ software - running on a PC workstation. The instrument management software can obtain access to the HART parameters of field devices because of the HART passthrough capabilities of the MTL8000 BIM. With AMS or Cornerstone software, the system provides access to all of the smart features of HART® devices; calibration and maintenance history for individually addressable devices; and an instrument database. The hardware and software requirements can be referred to in the appropriate AMS or Cornerstone software product catalogue/ user manuals.

Instrument management software, typically, allows the user to monitor, configure, calibrate and maintain any HART devices connected to an MTL8000 network. The PC workstation connects to the remote 8512 units via an RS485, 2-wire, multidrop network which is capable of supporting up to 31 individual 8512 devices.

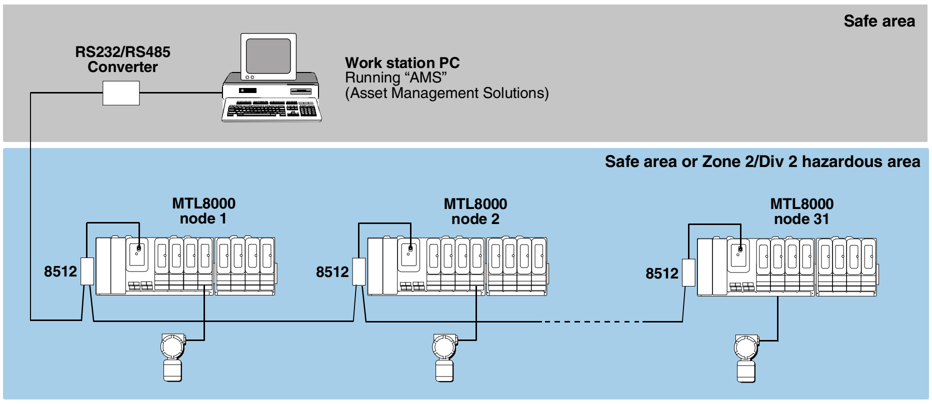


Figure 3 – Locations of 8512-IF-HA units in MTL8000 architecture

A single MTL8000 node can support up to 32 I/O modules. So, if a node was fully populated with 8-channel HART AI or AO modules, up to 256 HART devices could be connected to a single node.

With one 8512 unit per node and 31 available addresses on an RS485 serial link up to 7936 HART devices can be connected to the instrument management software running on a PC.

i.e. *8 channels per I/O module x 32 I/O modules x 31 communication modules = 7,936*

The workstation software gives a user access to all of the smart features of HART devices. Records can be generated and updated automatically, in accordance with ISO9000 quality standards. This results in considerable time savings in the collection and management of maintenance information and, in addition, users are able to benefit from the standardisation of operator test and calibration procedures as well as increased accuracy.

The network parameters (poll address, baud rate, etc.) for the 8512 can be programmed remotely using configuration software that runs on the same PC as the instrument management software.

The 8512 may be installed in safe areas or Zone 2 or Div 2 hazardous areas.

For further details on the 8512-IF-HA contact your local MTL representative.

Data update mechanisms

Data updates between the physical I/O and the Host controller take place via three independent and asynchronous mechanisms:

- Each module functions autonomously, updating its I/O at a rate according to its specification.
- The BIM scans the modules for data via the Railbus communications link at a user definable rate.
- Data is exchanged between the Host controller and the BIM according to the LAN communications mechanism.

If a module does not receive regular communication from the BIM it will adopt a failsafe mode. Such a failure is detected by a lack of communication over a preset interval ("Failsafe Timeout"). Similarly, the BIM monitors the host LAN communication activity. If there is no activity within a pre-set interval ("Comms Lost Timeout") it deduces a failure and adopts failsafe mode. These mechanisms ensure maximum integrity of the system.

I/O module data recovery

Field data and status information is obtained from the I/O modules by the BIM's constant interrogation of them. This is not a conventional scanning process that goes to each module in turn but is one that adopts a more intelligent approach. The BIM refreshes its database as fast as it can but it will weight its interrogation of the modules according to their individual types, or according to user defined maximum times that can be defined during configuration of the BIM.

If the BIM cannot achieve the required maximum times, a flag is set to indicate such circumstances.

Some modules have secondary data to recover, like HART variables and DI pulse counts. This is usually less urgent and can be recovered at less frequent intervals. The BIM can also be given a maximum refresh time for this data in its configuration instructions.

Operating States

I/O Module operating states

I/O Modules can adopt any one of the following three states:

Normal

This is when there is a healthy transfer of data to and from the BIM. Individual channels may be configured to be either normally active or normally inactive in the configuration file. For example, the inactive state would be appropriate for channels which are either unused or temporarily out of service.

Power-up

On power-up or reset the I/O module initially adopts a de-energised state until it establishes communication with the BIM. It then receives configuration data from the BIM and, if applicable, outputs are set to the pre-defined initialisation state.

Initialisation/power-up “cold-start” states may be individually defined for each output channel in the configuration file.

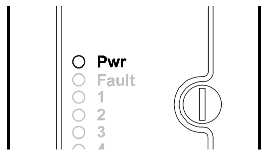
Failsafe

Under various fault conditions, in particular the loss of Railbus communications with the BIM, the module will adopt a pre-defined failsafe state when the Module Failsafe Timeout period is exceeded. This will occur also if the BIM adopts a failsafe state, as a consequence of BIM failsafe is the halting of Railbus communications. This happens when the BIM has no configuration information, or if LAN communications fail. The failsafe state of the I/O module is configurable independently of the initialisation/power-up state, and channels may be set to either retain last value or be forced to a specific value. Failsafe modes and timeout periods can be set in the configuration file. Failsafe mode (and indication) can be inhibited by setting the Module Failsafe Timeout period to ‘0’.

I/O Module status indication

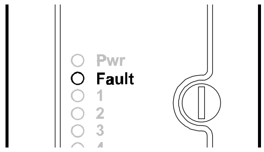
The status of the I/O modules may be deduced from observing the LEDs on their front panels as follows; note that colours and legends follow NAMUR NE44 except for labelling ”fault” instead of ”error”.

Power LED - Green



Off	On	Flashing
Power Fail	Power OK	N/A

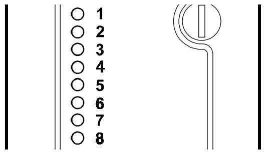
Fault LED - Red



Off	On	Flashing
Normal	• Failsafe, • A/D error on AI • BFP failure	Initialisation error

BFP = Bussed Field Power

Channel LEDs - Yellow



I/O type	Function	Off	On	Flashing
AI	I/P status	Channel inactive	OK	HiHi or LoLo alarm (but not Hi or Lo alarm) or loss of HART signal
Temp	I/P status	Channel inactive	OK	Hi or Lo alarm or open circuit field wiring
AO	O/P status	Channel inactive	OK	O/C field wiring & active or loss of HART signal
DI	I/P status	Low or inactive	High	N/A on 2/2 modules. Line Fault on 2/1 modules.
DO	O/P status	Low or inactive	High	N/A on 2/2 modules. Line Fault on 2/1 modules.

BIM operating states

The BIM can adopt one of several states as follows:

Normal

This is when there is a healthy transfer of data over the LAN and to and from the I/O modules

Power-up

On power up the BIM performs a self-test and initialises. The BIM then detects whether or not it has a valid configuration stored in Non-Volatile-Memory (NVM), and proceeds accordingly:

If a previous configuration exists

Initially, the I/O modules assume de-energised states then the BIM configures the I/O modules according to the stored configuration with outputs set to initialisation/power-up values. Subsequently, the modules respond to any commands received over the LAN via the BIM.

If there is no previous configuration

The BIM assumes a default state based on no modules being present.

Failsafe

The BIM adopts a failsafe state if it detects a loss of LAN communications. This will then automatically trigger the failsafe mode in all the I/O modules. The BIM can be forced into failsafe mode, or reset, using the Configurator, or with an instruction from the host.

The Host may monitor overall BIM status over the LAN. Guidelines for the host to recover from a possible failsafe state are provided in a later section of this manual (page 16)

Failsafe override

If a Configurator cable is connected to the Config port on the BIM, a wire link in the connector prevents the BIM from going into failsafe while it is in this "commissioning" mode.

However, if the link is a *permanent* one, as it would be when connecting an 8512 module, it is undesirable to have the failsafe disabled. To overcome the effect of the cable link, the user can change the setting of the LAN Mode register – see BIM Parameters in the Data Mapping section.

In addition, BIM failsafe on the loss of LAN communications may be inhibited by setting the Comms Lost Timeout to "Disable" using the Configurator.

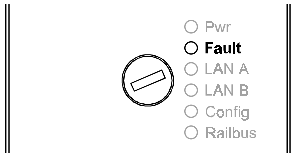
Modbus BIM status indication

BIM status may be deduced from observing the LEDs on the front panel as follows; note that colours and legends follow NAMUR NE44 except for labelling ”fault” instead of ”error”.

Power LED – Green

Off	**On**	**Flashing**
Power Fail	Power OK	N/A

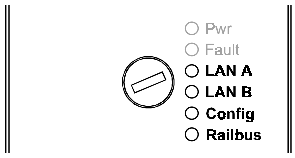
Fault LED – Red



Off	**On**	**Flashing**
Normal	Failsafe or Fault	N/A

The Red Fault LED ON while all Yellow LEDs are OFF indicates that the watchdog has tripped causing the CPU to be held in reset. It will remain in this condition until power to the BIM is switched off and then re-instated.

Other LEDs - Yellow



(See table on next page for LED states.)

Function	**Off**	**On**	**Flashing**
LAN A LAN B	LAN disabled or Host port locked	Communication in progress	Port has timed-out waiting for traffic
Config	Configurator not connected	Configurator connected to local port	Configuration in progress over LAN
Railbus	No Railbus comms. in last 2 secs.	Good Railbus comms. in last 2 secs.	Bad Railbus comms or timeout in last 2 secs*.

* The BIM is sending commands to modules but either the reply is garbled, or there is no response, i.e. a proper response has not been received for the last 2 seconds.

Failure Conditions & Diagnostics

Two of the key features of the MTL8000 are its comprehensive diagnostic capability and its failsafe mechanisms. The Host controller is able to detect failure of a component in the I/O sub-system and identify whether the problem is at BIM, module or channel level.

The following tables summarise various fault conditions and LED indication, along with information on diagnostics and what might be inferred about the problem.

Status and diagnostic information may also be obtained over the LAN communications link and this is described in more depth in the data mapping tables provided in a later section.

I/O channel fault

BIM LED status:	Fault LED (Red) - OFF (Normal)
Module LED status:	Flashing (the fault depends upon the type of module)
Effect:	I/O module data discrepancy with respect to plant I/O
LAN diagnostic data:	Channel Health register will have a bit set for the faulty channel. Channel status may show further details of the anomaly.
Rectification:	Check for and rectify external device or wiring fault

Module fault

BIM LED status:	Fault LED (Red) - OFF (Normal); possibly all lights OFF
Module LED status:	Fault LED (Red) - ON
Effect:	Outputs adopt failsafe values; inputs forced to fail states
LAN diagnostic data:	Module Health register will have a bit set for the faulty module. (Diagnostic Status byte or) Current Module/Comm status – least significant byte - is not ‘06’
Rectification:	Replace module; follow hot-swap procedure

Railbus fault

BIM LED status:	Railbus LED (Yellow) – OFF
Module LED status:	Fault LED (Red) - ON
Effect:	Outputs adopt failsafe values; inputs forced to fail states
LAN diagnostic data:	(Railbus Status is non-zero)
Rectification:	Check Carrier and extender cables; otherwise suspect BIM

BIM failsafe

BIM LED status:	LAN A or LAN B LED (Yellow) - Flashing; Fault LED (Red) - ON
Module LED status:	Fault LED (Red) – ON
Effect:	Outputs adopt failsafe values; inputs forced to fail states
LAN diagnostic data:	Overall BIM status register. Failsafe Mode (bit 0) = 1
Rectification:	Host must reset the failsafe bit (see page 19)

BIM fault

BIM LED status:	Fault LED (Red) - ON; Yellow LEDs - OFF indicates Watchdog tripped
Module LED status:	Fault LED (Red) - ON (Failsafe)
Effect:	Outputs adopt failsafe values.
LAN diagnostic data:	LAN comms fail
Rectification:	Replace BIM (configured); system will adopt initialisation/power-up state on restart.

LAN Comms fault

BIM LED status:	LAN A or LAN B LED (Yellow) - Flashing; Fault LED (Red) - ON
Module LED status:	Fault LED (Red) - ON
Effect:	Outputs adopt failsafe values
LAN diagnostic data:	LAN comms fail
Rectification:	Check Host and LAN cabling/converters

Power Supply fault

(2/1 supply only, assuming redundant PSU in use and BIM has power)

BIM LED status:	All LEDs in Normal operating mode
Module LED status:	All LEDs in Normal operating mode
Effect:	Power LED on faulty PSU is extinguished. No effect on system.
LAN diagnostic data:	Bit 13 of Overall BIM Status word is set
Rectification:	Check PSU(s) for extinguished Power LED. Remove PSU and replace. See also Appendix B.

Configuration fault

BIM LED status:	Config LED (Yellow) - OFF; Fault LED (Red) - OFF
Module LED status:	Fault LED (Red) - Flashing (unconfigured)
Effect:	I/O does not update; possible download error
LAN diagnostic data:	Current Module/Comm status – least significant byte - is not '06' (see also Module Status on page 22)
Rectification:	Clear BIM, check and reload configuration; system will adopt default/power-up state on restart

Heartbeat

The BIM can be instructed by the Host to detect the continuous toggling of a data bit by the Host. If the BIM has been told to monitor this 'heartbeat' via the LAN, but detects a 'frozen' state, the BIM will adopt a failsafe mode, just as it would in the case of LAN failure (see 'BIM failsafe' above). The 'heartbeat' mechanism is optional and may be activated/de-activated by command from the host.

LAN communication links

The 8505-BI-MB has **two internal ports** and these are switched, independently, between **three external ones**.

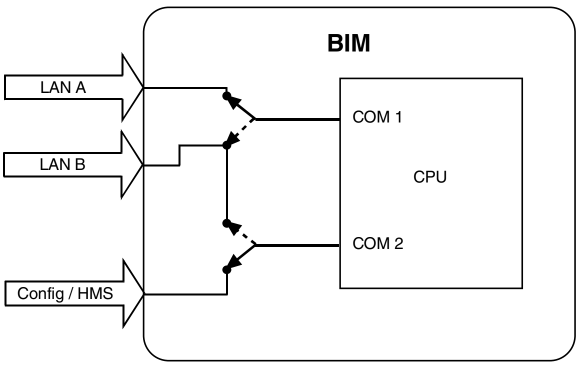


Figure 4 - External and internal ports on the BIM

Although the two COM ports behave identically to the software, they have different physical attributes that must be understood to use them effectively.

COM 1 is a full, direct memory access (DMA) port that interrupts the CPU only when a complete message is received. This enables the CPU to work on other tasks with the minimum of interruption.

COM 2 however, is a normal serial port that interrupts the main CPU on a per character basis. This requires a much larger CPU overhead, which leaves less time for other functions because the CPU regards the serial port as a high priority.

The two LAN connections are located on the carrier, together with switching options for RS485 or RS422. The Configurator / HMS port is a physical connector on the BIM itself.

The operating mode for these ports is determined by the configuration data within the BIM, which is implemented at power up. Subsequently, the mode can be changed, either dynamically by issuing a command from the host, or by reconfiguration of the BIM, locally or remotely.

Note: It is important to recognize that **only two ports are available at any one time**.

A number of different modes and configurations are available which include redundant operation and remote configuration. Figure 5 shows the inter-host communication that would be expected in a redundant host, but not in a simple duplicate host. The same diagram would apply to a single host that had two separate LAN ports.

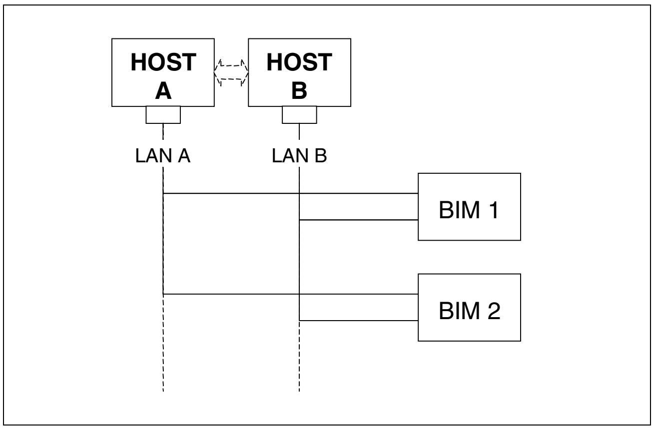


Figure 5 - Inter-host communications link

LAN modes

Three modes of operation are identifiable for the LANs: **Primary** (host read/host write), **Secondary** (host read only) and **Configuration** (remote configuration of the BIM)/**HART maintenance**. (See also LAN Mode Switching on page 20.) In practice, the two BIM ports have the following functions:

LAN A

Supports read/write access by the Primary Host; but is not used for remote configuration

LAN B

Supports read-only or read/write access by the Secondary Host. The detailed behaviour depends upon the mode selected. It also supports remote configuration.

A range of configuration options is possible by writing the appropriate value to the LAN mode register, Holding Register 9984. A full description of how the register value is constructed from the individual bit settings is provided in the Modbus mapping section.

Some of the modes provide LAN redundancy while others do not. The six main options are listed here and then each is described individually.

Mode	Description
Single LAN	In this mode, all communication is on LAN A. LAN B is disabled. The Config / HMS port **is available**.
Dual LAN	This permits two hosts to have simultaneous read/write privileges. This is appropriate for manual control via duplicate MMI/SCADA workstations. The Config / HMS port is **not available**.

Mode	Description
Active Standby	A redundant mode intended for use with a simple pair of duplicate hosts. The Config / HMS port is **not available**.
Passive Standby	A redundant mode intended for a host pair where Host B is capable of detecting the failure of Host A, or LAN A, and taking action to assume active control. The Config / HMS port is **not available**.
Shared LAN mode	A redundant mode where LAN A and LAN B ports share the COM 1 port. The Config / HMS port **is available**.
Remote Configuration	In this mode all communication is on LAN A. LAN B is used for remote configuration.The Config / HMS port is **not available**.

Single LAN

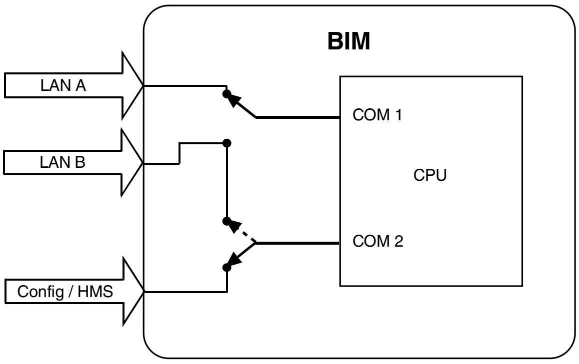


Figure 6 - Single LAN operation

This mode uses LAN A for all host communications. It has exclusive use of COM 1 and can be used at speeds up to 115.2 kbaud. See the **LAN mode register** information for details of setting this mode.

COM 2 is available for HMS duties or configuration but speeds of no greater than 19.2 kbaud are recommended. Configuration would be possible locally using the configuration port or remotely using LAN B.

If HMS is being used then the HMS bit in the LAN mode switching register must be set. This allows the 8512 module to read from the BIM and also permits the BIM to adopt a failsafe mode if necessary.

Dual LAN

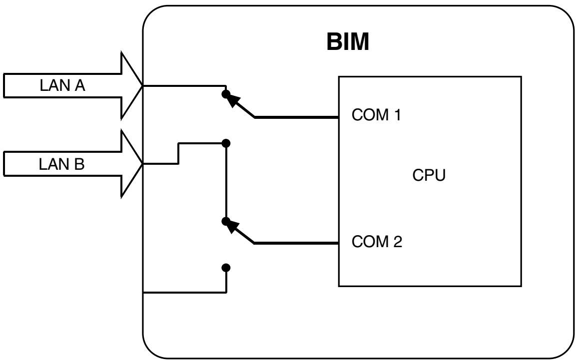


Figure 7 - Dual LAN operation

Here LAN A is linked to the primary host and LAN B to the secondary host. Both LANs are given primary mode status in the **LAN mode** register. See the **LAN mode register** information section for details of setting this mode.

The LANs should be set to the same baud rate to give both hosts the same performance. Because of the high overhead on the system, with both LANs running at full capacity, a maximum baud rate of 19.2 kbaud is recommended. If the LAN traffic is very intermittent, i.e. large gaps between messages, then it might be possible to use a higher baud rate.

Configuration or HMS operation is not available in this mode.

Active Standby

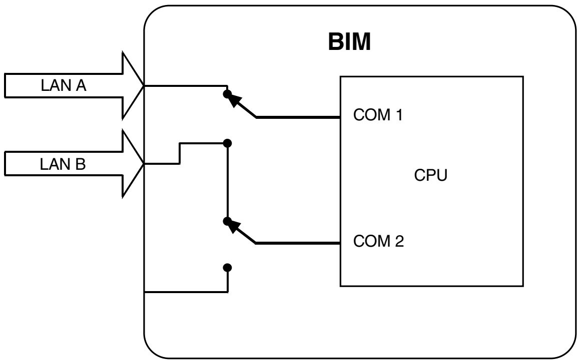


Figure 8 - Active standby operation

Active standby mode is intended for a pair of duplicate hosts. It is similar in appearance to Dual LAN mode but, unlike LAN A, which stays in primary mode, LAN B is now set to secondary mode. This means that LAN B is permitted reads but not write commands and any attempts will be answered with an "illegal function" response (exception code 01).

In the event of a failure of LAN A – defined as no communications for a user configured time out period – the BIM will promote LAN B to primary mode which enables write commands. See the **LAN mode register** information for details of setting this mode.

In this mode the baud rate limitations are the same as Dual LAN mode because of the relatively high level of COM 2 activity. Like Dual LAN mode, configuration or HMS operation is not available in this mode.

Passive Standby

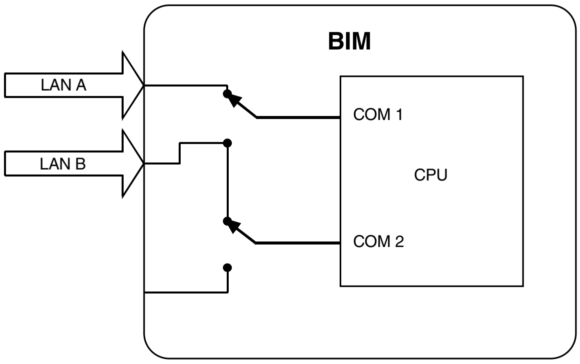


Figure 9 - Passive standby operation

Passive standby mode is used most often with a redundant host pair. LAN A is the primary communication link while LAN B, in secondary mode, has no activity except for the occasional health check or read task. This also means that LAN B is not permitted any write commands and any attempts will be answered with an "illegal function" response (exception code 01).

In the event of LAN A failure the BIM takes no action. It waits for host B to detect the failure, which will then send a **broadcast** command over the LANs to the BIM to force LAN B into primary mode. See the **LAN mode register** information for details of setting this mode.

In this mode both LANs can be run at speeds up to 38.4 kbaud as there is little or no activity on LAN B. The Config/HMS port should not be used, as health checks on LAN B would fail.

Shared LAN mode

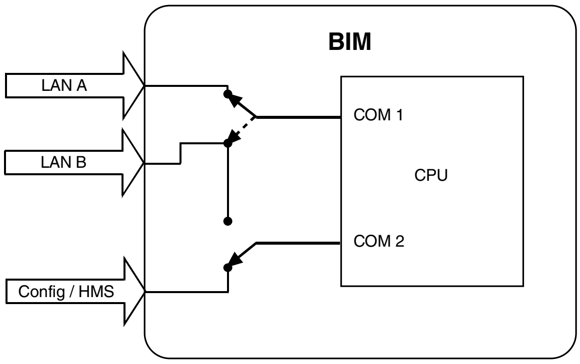


Figure 10 - Shared LAN operation

This mode can be described as active standby while allowing HMS communications.

HMS operation is enabled via COM 2 while COM 1 is switched automatically between LAN A and LAN B if the BIM detects a failure. This will reverse the mode of each LAN, i.e. the previously primary LAN becomes the secondary and the secondary becomes the primary. In the event of a switch, the BIM then disables the auto-changeover bit to prevent unwanted toggling between the two LANs.

The host will detect a LAN failure, as there will no longer be any responses on it, and start communicating over the other LAN. However, the host should be programmed to read the LAN mode register at regular intervals over both LANs. By doing so, it can detect a change in primary/secondary status of either LAN or the fact that the auto-changeover bit has been reset. See the LAN mode register information for “read” tests to detect a failure.

The failure of a LAN should prompt repair procedures by maintenance staff; after which the BIM can be instructed to continue with the current LAN as the primary, or switch back to the original primary. In either case the auto-changeover bit must be set once again in readiness for a possible future LAN failure. These commands to change the mode must be **broadcast** over the primary LAN.

COM 2 remains unaffected by any of these changeovers and the HMS bit remains set at all times. See the LAN mode information for details of setting this mode.

The primary LAN can be set to speeds up to 115.2 kbaud as the HMS traffic should not have any significant impact on the CPU.

Continuous LAN testing

As only one LAN is connected to COM 1 at any one time, LAN integrity can be confirmed by alternating their use. In other words, COM 1 is connected to LAN A for a short period, it is then swapped to LAN B for a similar period and then returned to LAN A.

A sequence of regular broadcast commands could be sent to switch communications between the two LANs. These would take the form of a Preset Single Register command:

00 06 26 FF 00 **aa** CRC CRC

where the **aa** value would alternate as follows

aa	**Description**
5E	Communicate over LAN A
6D	Communicate over LAN B
5E	Communicate over LAN A
6D	Etc.

Remote Configuration

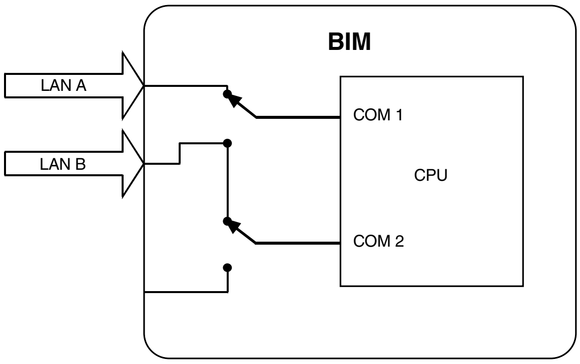


Figure 11 - Remote Configuration operation

This mode uses LAN A as the primary host link while LAN B is used to configure the BIM from a remote location. See the LAN mode information for details on setting this mode.

Traffic on LAN B will be limited and intermittent, so LAN A can be run at speeds up to 38.4 kbaud. Use of the local Config/HMS port **is not available** in this mode.

Recommended set-up for Host Communications

The Modbus host should be configured for efficient communications and this section identifies some of the considerations that will help the user in optimising data flow both for the process I/O data and also the associated Status and Diagnostic data. The data available to the user is shown in the later section "Modbus Parameters by System Type". Fault indication is explained in the earlier section titled "Failure Conditions and Diagnostics".

Module grouping

Sound installation practice would suggest grouping modules on the carrier according to their type. This simplifies wiring and maintenance and helps to ensure efficient communications.

Scanning for process I/O data

Rather than scanning I/O data one module at a time, requests can be sent that span a range of similar channels/modules with one command. These are called *multi-parameter* requests and reduce the network overhead and speed the acquisition process. It is recommended that polling starts at a module boundary.

Host status

The BIM can detect failure of the Host Controller, even if LAN communications are apparently working – a condition that can arise if the host has a dedicated communications processor. This is done by instructing the host to toggle a ('heartbeat') bit in the BIM, between the values 0 and 1; if the host stops toggling this bit, the BIM detects the 'freezing' of this bit and adopts a failsafe mode, as in the case of LAN failure.

This 'heartbeat' mechanism is optional and may be activated by command from the host.

BIM status

The "Overall BIM Status" word (page 19) should be monitored to ensure that the BIM is functioning correctly. In particular, the BIM should be monitored for a "failsafe" state that could arise following, for example, a temporary loss of LAN comms. If the BIM goes into failsafe it can be returned to normal by writing a '0' to the BIM failsafe switch coil.

Module status

The Module Health Register (page 31) will indicate any module that has problems. Once the module has been identified, the "Module/Comm Status" flags (page 22) can then be read to indicate the type of problem. A "healthy" running module returns the value "00 06" (hex.).

Figure 12 and Figure 13 below indicate how module health (status) is monitored for input and output modules. The host control strategy should take account of possible module failure and take action accordingly to ensure a safe recovery.

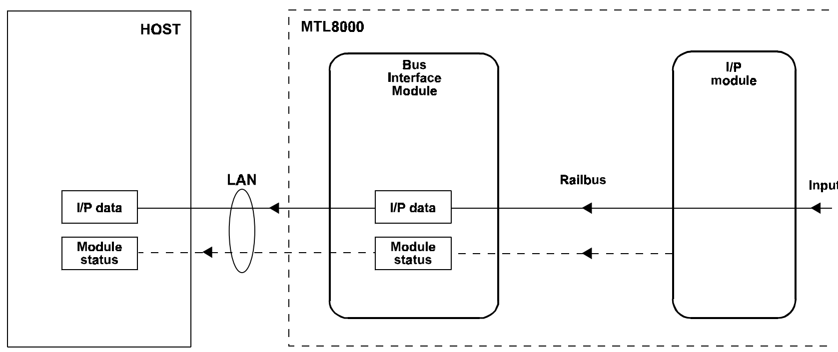


Figure 12 Monitoring "health" of input modules

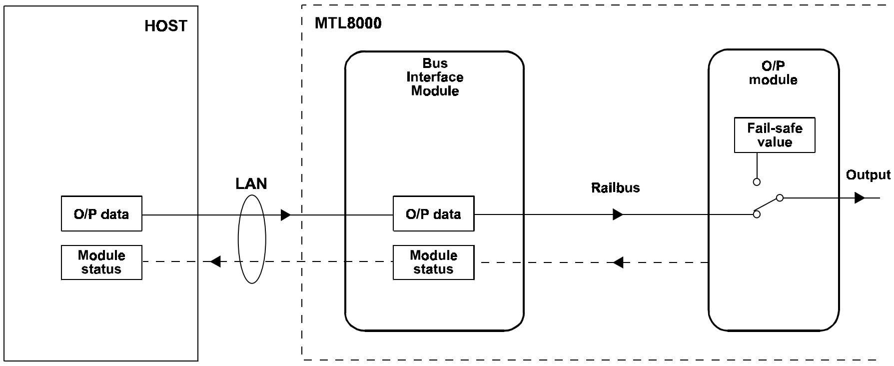


Figure 13 - Monitoring 'health' of output modules

Normal operation

Module health shows 0000 on both registers (46337–46338).

Current module status = ‘Normal’ [= “00 06” (hex)].

Output

Host writes O/P data to BIM which transfers it to the module

Input

Host reads I/P data from BIM as transferred from the module

Faulty module operation

Module health has a bit set for any faulty module in registers (46337–46338).

Current module status = ‘Abnormal’ [≠ “00 06” (hex)]

Output

O/P module adopts pre-configured failsafe state
Output Echo value is forced to the same (deduced) value

Host should then write a safe output value to BIM (normally, the failsafe value as above) to ensure that the subsequent resumption of normal operation is “bumpless”.

Input

I/P value is no longer updated
Pre-configured ‘fail’ state value is now the reported value
Host should take appropriate action to ensure safe operation

The Host should continue to monitor the module status for a return to the normal value (00 06), or deduce recovery on release of the input from the ‘fail’ state.

The process of return to normal operation will depend upon what caused the fault:

Transient module fault - module recovers automatically

Failed module - replacement module will initialise automatically

BIM in failsafe - BIM reset by Configurator or cycling the power on then off

On recovery, the BIM will write the current data to the module (output) or read the newest data from the module (input).

Channel status

The 32 Channel Health registers (6305 – 6336) provide a register for each module. Each register, starting at the least significant bit, has a bit to indicate the channel health. Any bit that is set (‘1’), indicates a faulty channel. If any module status is “Failed”, then all channel status bits for that module will be set.

The “general purpose” 2/2 modules provide limited channel status and diagnostic information, while the 2/1 modules, for IS field wiring, provide detection for open or short circuited field circuits, ground faults, etc. Further details are available in the I/O module data sheets and the channel status parameters in the next section.

The **Analog Channel Status** data provides 8 bits per channel which may be interrogated for details on individual channel operation. The **Discrete Channel Status** data provides 1bit per channel.

Modbus Data Mapping

Modbus uses sets of single-bit flags (coil status flags and input status flags) and 16-bit registers (input registers and holding registers) in which to store information. These flags and registers have numbered locations and are allocated a specific types of data.

This section lists the flag and register locations and identify the types of data located in each. After each list, or table, the groups of flags and registers are discussed individually to explain more about the data they contain.

The following is a key to the data **types** shown.

Type	Description	Modbus Location	Read functions	Write functions
CS	Coil Status	00001	01	15, 05
IS	Input Status	10001	02	-
IR	Input Register	30001	04	-
HR	Holding Register	40001	03	16, 06

Some of the data is provided in more than one place. For example, the 8- and 16- channel DI Field Input Data are available from Input Status Flag 6145 onwards and also starting at Input Register 4097.

Fixed Mapping and Packed Mapping

The above section describes the conventional or **fixed** method of mapping data. Although this is precise, it is not the fastest method of recovering of data because the individual memory locations are spread out and require many individual reads to obtain the data.

A faster method, called **packed** mapping, takes the same fixed data and arranges it in contiguous memory locations so that the host read request only needs to specify one, or maybe two, sections of memory to obtain the data. Version 2.00 of the Modbus BIM provides this method in addition to the fixed mapping method but the packed method does require a host with the ability to handle and decode the data.

Further details are given in the Packed Data Mapping Parameters section.

Modbus Parameters by System Type

This section groups the system fixed parameters by type: BIM parameters, I/O module parameters, DI channel parameters, DO channel parameters, AI channel parameters and AO channel parameters.

BIM Parameters

Parameter	Type	Format	Modbus Base Location
Heartbeat pulse	CS	1 bit	09841
	HR	Bit 2	48193
Heartbeat switch	CS	1 bit	09842
	HR	Bit 3	48193
BIM failsafe switch	CS	1 bit	09984
	HR	Bit 0	48193
Overall BIM Status	IR	16 bit	30673
	HR	16 bit	46339
BIM control word	HR	16 bit	48193
LAN Mode	HR	16 bit	49984

Heartbeat Pulse

This flag holds the value of the last Host pulse for comparison with the next (For more details see page 10).

Heartbeat switch (enable/disable)

This is used to enable/disable the Heartbeat feature.

0 = Disabled 1 = Enabled

BIM failsafe switch

Writing **On** to this flag will put the BIM into 'failsafe' mode; writing **Off** to it will recover normal operation.

Off = 0x0000 On = 0xFF00

Overall BIM status

Also known as the **BIM Status Overview**, this 16-bit register is structured as follows:

Bit #	Name	Description
15	Configurator port connected	Set when cable connector inserted.
14	Diagnostic change	Set when Module or Channel Health bits are changed. Cleared when the host reads the registers.
13	Power Supply error detected	A power supply has failed.
12	Error Log overflow	The event log has wrapped around. Cleared when read by 8455.
11	Scanning overload	The scanner cannot maintain its schedule. Bit is latched for 2 seconds.
10	Not scanning Railbus	Reflects Railbus LED status.
9	Host LAN locked out	Port lock-out active on LAN A.
8	Configurator locked out	Port lock-out active on LAN B.
7	No LAN B communications	
6	No LAN A communications	
5	Modbus mapping changed	A configuration change that affects the packed data has occurred. Cleared when host reads the Configuration register.
4	Config not saved to NVM	A new config has been loaded but not yet saved to NVM.
3	Node Services Module not present	NSM not in place.
2	BIM not configured	No configuration found in the NVM.
1	BIM restarted	Set on BIM restart. Cleared when host has read the BIM Overview word.
0	BIM in Failsafe mode	

If a bit is set (1), then the named condition exists or the named event has occurred. See the instruction manual - **INM8455** Configurator Software - for further explanation on these bits.

BIM control word

The BIM Control word allows the host to enable the heartbeat facility and to toggle its value; to request the BIM to exit or enter Failsafe mode and to restart the BIM.

The only flags currently used in the 16 bit BIM Control word are:

Bit #	Name
3	Enable/disable heartbeat
2	Desired heartbeat toggle
1	Reset the BIM
0	Desired BIM failsafe mode

The commands initiated by this control word are performed only on detecting a *change* between the value in the word being written and the values written, via the same LAN, previously. For example, to command the BIM to exit Failsafe mode the host must first write a '1' to bit 1 ("Desired BIM failsafe mode") followed by writing a '0' to the same bit. If the BIM enters Failsafe as a result of a heartbeat timeout, or some other reason, then this mechanism ensures that the BIM will not be taken out of Failsafe mode inadvertently.

The same applies to the heartbeat toggle and enable. This prevents LAN A, say, from sending a heartbeat toggle permanently set to 0 while LAN B is sending a toggle value that is permanently set to 1, as this could give the impression that the heartbeat is valid. To toggle the heartbeat, each LAN must *alternate* its toggle value.

Setting the reset BIM flag to 1 causes the BIM to restart itself.

Note: The register holding the BIM Control word immediately precedes the Packed Output data. This enables the host to write to the BIM Control word in the same Modbus request that is used to write to the output modules.

LAN mode

Writes to this register are used to set the LAN modes – see LAN configuration options in the BIM operation section of this manual for a description of the modes. Use "Preset Single Register" to write values.

Note: If the mode is being changed by a Modbus command from the host, then the command must be broadcast (i.e. sent to address 0).

The register can also be read to obtain status information, a facility that is used particularly with Shared LAN mode. Use "Read Holding Register" to perform reads.

Only the lower eight bits are used and their significance is as follows:

Bit #	Name	Description
7	Config port disable	When set, COM 2 is dedicated to LAN B, even though an 8512 module may be connected to the Config port.
6	HMS mode	When set it allows the 8512 module to read from the BIM and also permits the BIM to adopt a failsafe mode when the Config port is in use.
5 4	LAN A mode	See next table for settings
3	Auto-change	When set, and on detection of a communications failure, the BIM will reverse the primary/secondary status of the two LANs and reset its own status, i.e to '0'.
2	Share LAN	When set, the COM 1 port will toggle between LANs.
1 0	LAN B mode	See next table for settings

The bit settings that determine the LAN A and LAN B modes are as follows:

Values Bin.	Hex.	LAN A (bits 4 & 5)	LAN B (bits 0 & 1)	Meaning
00	0	–	Unused	LAN not in use
01	1	Primary	Primary	Reads & writes permitted
10	2	Secondary	Secondary	Read commands only
11	3	–	Config	Used with 8455 Configurator

To assist the user, the main modes are described below in terms of their bit settings and also as hexadecimal words.

Mode	LAN mode switching bits 7	6	5	4	3	2	1	0	Hex
Single LAN*	0	0	0	1	0	0	0	0	10
Dual LAN	0	0	0	1	0	0	0	1	11
Active standby	0	0	0	1	1	0	1	0	1A
Passive standby	0	0	0	1	0	0	1	0	12
Shared LAN - A primary	0	1	0	1	1	1	1	0	5E
Shared LAN - B primary	0	1	1	0	1	1	0	1	6D
Remote configuration	0	0	0	1	0	0	1	1	13

* Set bit 6 if HMS will be used. Hex value then becomes 50.

Testing for the failure of the primary LAN

When using the Shared LAN mode, a LAN failure can be detected by reading the LAN mode register. The following values will reveal to the host that a failure has occurred, the LANs have swapped primary status and that a repair is necessary on the failed LAN.

LAN mode register value (hex.)	Meaning
65	LAN A has failed and LAN B is now the primary
56	LAN B has failed and LAN A is now the primary

I/O Module Parameters

Module Parameters	Type	Format per module	Modbus Base Location	Locations per module	Prim/Sec Scan
Module/Comms Status	IR	16 bit	30641	1 bit	P
Module Control Register	HR	16 bit	49729	1 bit	P
Device Status Register	IS	8 bit	10001	8 bits	P
Module Health Register	HR	32 bit	46337-38	1 bit	

Module/Comms Status

Each of the 32 slots has a 16-bit register (2 bytes) to provide status information on the module occupying it. This is interpreted as a pair of numerical values contained in the 16-bit register.

The status for a healthy module running normally should be '00 06'; any other value represents a fault condition.

Most Significant Byte - Current Comm. Status - factory use only

Specific hex. values can be interpreted as shown in the following table.

Value	Name	Description
0x00	OK	Communications are working correctly.
0x01	TIMEOUT	Timeout
0x81	BAD CRC	Bad CRC on message from module
0x86	LENGTH	Invalid length
0xF8	BNACK	Unable to perform this operation
0xF9	INACK	Data was sent incorrectly
0xFA	BANACK	Bad argument byte
0xFB	IFNACK	Function byte inappropriate
0xFC	IONACK	Operation byte inappropriate
0xFD	UFNACK	Unknown function code
0xFE	UONACK	Unknown operation byte
0xFF	CNACK	Bad CRC on message from BIM

Least Significant Byte - Module Status

Specific hex. values can be interpreted as follows:

Value	Name	Description
0x00	EMPTY	The slot is empty, it has no configuration and a module is not detected.
0x01	UNTRAINED	Set during the **first** pass of the training procedure after the module has been just powered up.
0x02	TRAINED	Set during the **second** pass of the training procedure after the module has been just powered up.
0x03	NO CONFIGURATION	Set after training procedure if a valid configuration is not present.
0x04	VENDOR ID MISMATCH	Vendor ID of module differs from value provided during configuration.
0x05	DEVICE ID MISMATCH	Device ID of module differs from value provided during configuration.
0x06	RUNNING	Everything OK. The module is initialised and working.
0x07	FAILED	Module cannot be communicated with.

Note: If the LSB contains (07) i.e. FAILED, then the MSB will contain a diagnostic value, otherwise the MSB will be 0x00.

Module Control Register

The Module Control word allows the host to initiate control actions on a module. The action on the module is initiated only if the value of the bit is *changed*, by the host, to a ‘1’.

Reset
To reset a module, bit 0 for the module must be changed to a ‘1’.

Failsafe
To change the failsafe state the Enter or Exit bit must be changed to a ‘1’. If both have the same value then both are ignored.

Pulse Input Counter
Either counter can be reset by setting the appropriate bit to a ‘1’. If both the Start and Stop bits are set to a ‘1’ then both the bits are ignored. These PI flag bits are ignored if the module is not a PI module.

Bit #	Name
15	Unused
14	PI only – Stop Counter 2
13	PI only – Start Counter 2
12	PI only – Reset Counter 2
11	Unused
10	PI only – Stop Counter 1
9	PI only – Start Counter 1
8	PI only – Reset Counter 1
7	Unused
6	Unused
5	Unused
4	Unused
3	Unused
2	Exit Failsafe
1	Enter Failsafe
0	Reset module

Device Status Register

A Device Status Register is provided for each module. It has a number of uses but one of the most useful is that bit 0 indicates whether a module is currently in Failsafe.

Bit #	Name	Description
7	FAILSAFE	1 = Device in Failsafe mode. 0 = Normal
6	RBMODE	Railbus communication mode. 1 = Custom. 0 = Short
5	DSE	1 = Device Specific Event occurred
4	DGE	1 = Device Generic Event occurred
3	JPU	1 = Just Powered Up
2	POC	1 = A Pending Operation is Complete
1	Unused	–
0	Unused	–

Module Health Registers

0 = "healthy" 1 = "unhealthy"

Two 16-bit registers are used to represent the 32 modules. The lower register represents modules 1 to 16 and the higher one 17 to 32. The least significant bit in each register represents the lowest numbered module.

See Packed Data Mapping Parameters (page 29) for further details.

Discrete Input Channel Parameters

Discrete Input Channel Parameters		Type	Format per channel	Modbus Base Location	Locations per module	Prim/Sec Scan
DI LFD	(8 ch)	IS	1 bit	10257	8	P
	(16 ch)	IS	1 bit	15633	8	P
DI Field	(8 ch)	IS	1 bit	10513	8	P
Input Data	(16 ch)	IS	1 bit	16145	16	P
	(8 or 16 ch)	IR	1 bit	34097	1	P
DI Transition Counter	(8ch)	HR	16 bits	40257	8	S
	(16ch)	HR	16 bits	40513	16	S
Channel Health Register		HR	16 bits	46305	1	P

A single node can accommodate up to 32 I/O modules and so there are 32 potential module locations (slots). Data is organised in order by slot then by channel, i.e. Slot 1/Channel 1 then Slot 1/Channel 2, etc.

Note: When 8 channel information is held in 16 channel locations the "upper" 8 bits are not used and contain zeros.

DI Line Fault Detect

A line fault in a channel will cause the relevant bit to be set. Separate regions are provided for 8 and 16 channel DI modules.

DI Field Input Data

0 = Off 1 = On

Each bit contains the current input status of one channel of an 8-channel DI Module.

Note: 8-channel data is available from more than one location. The 8/16-channel locations are recommended for use when 8- and 16-channel modules are being used at one node.

DI Transition Counter

This counts the low-to-high input transitions. A 16-bit counter is available for each channel of a DI Module. When the counter exceeds 65535 it rolls over to start again at zero.

Note: 8-channel and 16-channel modules use different locations.

Channel Health Register

0 = "healthy" 1 = "un-healthy"
Starting at bit 0 the channels are represented in order. However, the modules are numbered in reverse order. That is, the base address is that for module 32. See page 31 for further details.

Discrete Output Channel Parameters

Discrete Output Channel Parameters	Type	Format per channel	Modbus Base Location	Locations per module	Prim/Sec Scan
Discrete Channel (4 or 8 ch)	IS	1 bit	10257	8	P
Channel Health Register	HR	16 bits	46305	1	P
Status (4 ch)	IS	1 bit	15377	4	P
DO Field (8 ch)	CS	1 bit	00001	8	P
Output Data (4 ch)	CS	1 bit	00257	4	P
(4 or 8 ch)	HR	16 bit	44097	1	P
DO On Time (4 ch)	HR	16 bit	41025	4	P
(8 ch)	HR	16 bit	41153	8	P
DO LFD (4 ch)	IS	1 bit	15377	4	P
DO Field (8 ch)	IS	1 bit	10769	8	P
Output Echo (4 ch)	IS	1 bit	15505	4	P

A single node can accommodate up to 32 I/O modules and so there are 32 potential module locations (slots). Data is organised in order by slot then by channel, i.e. Slot 1/Channel 1 then Slot 1/Channel 2, etc.

Discrete Channel Status

0 = No Line Fault 1 = Line Fault Detected

Each bit can be used to indicate a line fault for one channel of a DO Module. Unused bits are set to 0.

Channel Health Register

0 = "healthy" 1 = "un-healthy"
Starting at bit 0 the channels are represented in order. However, the modules are numbered in reverse order. That is, the base address is that for module 32. See page 31 for further details.

DO Field Output Data

0 = Not driving 1 = Driving

Each bit holds the current output status of one channel of a DO Module. The master will write to these locations to switch a channel of a DO.

DO On Time

This controls the ON time for single-shot pulse outputs. This facility is not available with Version 1 of the Mk 1 BIMs. Values are in milliseconds, with a minimum value of 2 ms, increasing in increments of 2 ms.

DO Line Fault Detect

A line fault in a channel will cause the relevant bit to be set. Applies to 4-channel DO modules only.

DO Field Output Echo

0 = Off 1 = On

Each bit represents **one channel** of a DO Module and holds a copy of the data last output to the channel.

Analog Input Channel Parameters

Analog Input Channel Parameters	Type	Format per channel	Modbus Base Location	Locations per module	Prim/Sec Scan
8-channel Status	IS	8 bit	11025	8	P
4-channel Status	IS	8 bit	14353	4	P
Channel Health Register	HR	16 bits	46305	1	P
8-ch Field Input Data	IR	16 bit	30001	8	P
4-ch Field Input Data	IR	16 bit	30513	4	P
HART Status	IR	16 bit	37681	8	S
HART Primary	IR	32 bit	37937	16	S
HART Secondary	IR	32 bit	38449	16	S
HART Tertiary	IR	32 bit	38961	16	S
HART Fourth	IR	32 bit	39473	16	S

A single node can accommodate up to 32 I/O modules and so there are 32 potential module locations (slots). Data is organised in order by slot then by channel, i.e. Slot 1/Channel 1 then Slot 1/Channel 2, etc.

8-channel Status (including 8-ch TI & VI modules)

Space is allocated for 32 module slots each with 8 channels, where each channel has 8-bits to describe its current status.

Note: This memory space is shared with the analog output channels (see AO Channel Status on page 26) and the pulse input channels (see page 28). The contents will depend upon the module type.

Status bits - 8-channel analog current or voltage input

Bit #	Name	Description
7	HartStatusChange*	Toggles when Tx device status changes
6	A/D Error	1 = A/D conversion failure, 0 = Fault cleared
Bit #	**Name**	**Description**
5	HartNoComm *	1 = lost HART comms, 0 = Fault cleared
4	HartComm5Err *	1 = > 5% HART comms. Errors, 0 = Cleared
3	HHAlrm	1 = Hi Hi Alarm set, 0 = Alarm cleared
2	Halrm	1 = Hi Alarm set, 0 = Alarm cleared
1	Lalrm	1 = Lo Alarm set, 0 = Alarm cleared
0	LLAlrm	1 = Lo Lo Alarm set, 0 = Alarm cleared

* Supported by the 4–20mA HART Analog Input Module only

Status bits - 8-channel temperature input

Bit #	Name	Description
7	–	N/A
6	–	N/A
5	CJC error	1 = Error set, 0 = Error cleared (8-ch modules only)
4	A/D Error	1 = Error set, 0 = Error cleared
3	–	
2	Sensor O/C	1 = Sensor O/C, 0 = Sensor normal
1	Halrm	1 = Hi Alarm set, 0 = Alarm cleared
0	Lalrm	1 = Lo Alarm set, 0 = Alarm cleared

4-channel Status

Note: Currently, this only applies to 2/2 TI modules 8105 & 8106.

Bit #	Name	Description
7	Resolution	N/A
6	Resolution	N/A
5	CJC error	1 = Error set, 0 = Error cleared (8-ch modules only)
4	A/D Error	1 = Error set, 0 = Error cleared
3	–	
2	Sensor O/C	1 = Sensor O/C, 0 = Sensor normal
1	Halrm	1 = Hi Alarm set, 0 = Alarm cleared
0	Lalrm	1 = Lo Alarm set, 0 = Alarm cleared

Channel Health Register

0 = “healthy” 1 = “un-healthy”
Starting at bit 0 the channels are represented in order. However, the modules are numbered in reverse order. That is, the base address is that for module 32. See page 31 for further details.

8-channel Field Input Data

Each 16-bit location holds the current input data for **one channel** of an 8-channel AI, VI or TI module.

Note: Data is also available at these locations for 4-channel temperature input modules. In this case, data corresponding to channels 5-8 (which are not present) will be returned as zeros.

4-channel Field Input Data

Each 16-bit location contains the current input data for **one channel** of a 4-channel TI module.

HART Status

Each register contains 16-bit status information for one channel.

HART Primary, Secondary, Tertiary and Fourth

The **8101** and **8201** analog input modules can be configured to poll intelligent transmitters for up to 4 HART variables on a cyclic basis using Universal Command 3. A status value is also provided (see HART Status above and HART data format description on page 35).

Analog Output Channel Parameters

Analog Output Channel Parameters	Type	Format per channel	Modbus Base Location	Locations per module	Prim/Sec Scan
AO Channel Status	IS	8 bit	11025	8	P
Channel Health Register	HR	16 bits	46305	1	P
AO Field Output Data	HR	16 bit	40001	8	P
AO Output Echo	IR	16 bit	30257	8	P
HART Dev. Var. Slot 0	IR	32 bit	36533	8	S
HART Dev. Var. Slot 1	IR	32 bit	36145	8	S
HART Dev. Var. Slot 2	IR	32 bit	36657	8	S
HART Dev. Var. Slot 3	IR	32 bit	37169	8	S

A single node can accommodate up to 32 I/O modules and so there are 32 potential module locations (slots). Data is organised in order by slot then by channel, i.e. Slot 1/Channel 1 then Slot 1/Channel 2, etc.

AO Channel Status

Space is allocated for 32 module slots each with 8 channels, where each channel has 8-bits to describe its current status.

Note: This memory space is shared with the analog input channels (see 8-channel Status on page 25) and the contents will depend upon the module type.

Bit #	Name	Description
7	HartStatusChange*	Toggles when Tx device status changes
6	Diagnosis in progress*	1 = A/D conversion failure, 0 = Fault cleared
5	HartNoComm *	1 = lost HART comms, 0 = Fault cleared
4	HartComm5Err *	1 = > 5% HART comms. Errors, 0 = Cleared
3		
2		
1		
0	Output O/C	1 = Output O/C, 0 = Output normal

* Supported by the 4–20mA HART Analog Output module only

Channel Health Register

0 = “healthy” 1 = “un-healthy”
Starting at bit 0 the channels are represented in order. However, the modules are numbered in reverse order. That is, the base address is that for module 32. See page 31 for further details.

AO Field Output Data

Each 16-bit location can contain the data for **one channel** of an AO Module. The master can write output values to these locations for each channel.

AO Output Echo

Each 16-bit location represents one channel of an AO Module and holds a copy of the data last output to the channel.

HART Device Variables Slot 0

This parameter is currently used only on the 8102-HO-IP module (8-ch, AO + HART). HART transmitter variables for slots 0 - 3 are supported (see Slots 1, 2 & 3 below).

A slot requires a 32-bit location to accommodate one channel of this module.

HART Device Variables Slot 1, Slot 2 & Slot 3

See Slot 0 above.

Pulse Input Channel Parameters

Pulse Input Channel Parameters	Type	Format per channel	Modbus Base Location	Locations per module	Prim/Sec Scan
Analog Channel Status	IS	8 bit	11025	64	P
Channel Health Register	HR	16 bits	46305	1	P
PI Channel Status	IS	8 bit	13585	16	P
PI Preset Counter	HR	2 x 16 bit	49825	4	P
Pulse Input Values	IR	4 x 16 bit	30674	8	P

Analog Channel Status

The contents of the channel status vary according to the module type. For the pulse input module, the bits are allocated as follows:

Bit #	Name	Description
7	–	Unused
6	Missing pulse alarm	Missing pulse has been detected
5	Acceleration alarm	Acceleration alarm limit exceeded
4	DI LFD	The digital input has a line fault – open or short circuit
3	Short circuit	Field wiring is short circuit
2	Open circuit	Field wiring is open circuit
1	High alarm	High alarm tripped
0	Low alarm	Low alarm tripped

Channel Health Register

0 = "healthy"   1 = "un-healthy"
Starting at bit 0 the channels are represented in order. However, the modules are numbered in reverse order. That is, the base address is that for module 32. See page 31 for further details.

PI Channel Status

Only four bits are required to indicate the PI channel status. These should not be confused with the alarm status bits in the analog channel status.

Bit #	Name	Description
7	–	Unused
6	–	Unused
5	–	Unused
4	–	Unused
3	Digital input state	Current state of digital input (high '1' or low '0')
2	Preset count reached	Preset count has been reached
1	Quadrature reverse	Reverse motion detected by quadrature sensors
0	Quadrature forward	Forward motion detected by quadrature sensors

PI Preset Counter Values

Two registers are allocated per channel. Each register pair can be written to with the Preset Counter Value. Both registers of the Counter Value must be read together. Attempts to read one will result in an Exception 2 – Illegal Address being returned.

Pulse Input Values

A Pulse Input module has 2 channels, each of which has four successive input registers allocated for the following values:

Frequency	1 register
Counter	2 register
Acceleration	1 register

Both registers of the Counter value must be read together. Attempts to read one will result in an Exception 2 – “Illegal Address” being returned.

Packed Data Mapping Parameters

Version 2.00, and later, of the Modbus BIM can support “packed” data as can the 8455 Configurator software. For hosts that can interpret this type of data, it is an alternative to fixed data mapping and speeds up data exchange by placing it in contiguous memory locations, so that it can be accessed with only one read command for input and echo data and one write command for output data.

The data is packed into two regions of the Holding Registers. The input data and the output echo values are stored in registers 6340 to 8192. The output data is stored from 8194 to 9728.

More information is provided below as the individual register areas are explained.

Packed mapping registers

The following registers hold the packed mapping data

Parameter	Type	Modbus Base Location
Cross-reference - Input	HR	46145
Cross-reference - Echo	HR	46177
Cross-reference - Output	HR	46209
Secondary Scan rates	HR	46241
Configuration types	HR	46273
Channel health	HR	46305
Module health	HR	46337
Packed input data followed by packed output echo data	HR	46340
Packed output data	HR	48194

This table shows the start addresses of the holding registers used for packed data.

Cross-reference parameters

There are three holding register regions that contain cross-reference data for the packed mapping: Input (6145), Echo (6177) and Output (6209). Each of these contain one register per module, i.e. 32 registers. The purpose of these registers is to enable a host system to decode the data in the Packed Input, Echo and Output regions. The contents of each register provide the base address of the register that holds the input, echo or output data for that module. See **Packed input & echo data** (page 31) and **Packed output data** for more details. This address is 1-based. If the module type is not appropriate to the data then the register will contain a zero.

Example: If the configuration consisted of these modules:

1 AI module
2 AO module
3 DI module
4 DO module

The following table illustrates how this data would be expressed in the cross-reference registers.

Register	Contents	Explanation
Input data		
6145	6340	Module 1 is an i/p module with 8 registers
6146	0	Module 2 is not an input module
6147	6348	Module 3 is an i/p module with 1 register
6148	0	Module 4 is not an input module
6149	0	Module 5 is not an input module
. . .	0	The entries up to module 32 are also not input modules
Echo data		
6177	0	Module 1 is not an output module
6178	6349	2 is an o/p module with 8 registers and follows 3's i/p data
6179	0	Module 3 is not an output module
6180	6357	4 is an o/p module with 1 register
6181	0	5 is not an output module
. . .	0	The entries up to module 32 are also not output modules
Output data		
6209	0	Module 1 is not an output module
6210	8194	2 is an output module with 8 registers
6211	0	Module 3 is not an output module
6212	8202	4 is an output module with 1 register
6213	0	5 is not an output module
. . .	0	The entries up to module 32 are also not output modules

Secondary scan rates

These registers contains the rates at which the BIM scans the modules for its secondary data (HART variables and DI Counters). It is provided to help the host understand the configuration of the modules in the BIM. There are 32 registers, one per modules starting with module 1, and each contains the secondary data scan rate.

Configuration types

Each module type has a configuration type number, see list below, that uniquely defines the module type and each of these 32 registers, one for each of the 32 module slots available, contains a configuration number. If no module is present the slot configuration register contain a zero.

Configuration type	No of channels	Module type
0	-	No module
3	8	Discrete Output 2/2
4	4	Discrete Output 2/1 or 1/1
5	8	Discrete Input 2/2
6	8	Discrete Input 2/1
7	16	Discrete Input 2/1 & 1/1
8	2	Pulse Input 2/1
10	8	Analog Input with HART
11	4	Temperature Input 2/2
12	8	Analog Input 2/2
13	8	Temperature Input 2/1 & 1/1
20	8	Analog Output
50	8	Analog Output with HART
60	4 + 4	Analog Input /Output 2/2

Channel Health

0 = Healthy channel 1 = Unhealthy channel

This region has 32 registers, one per module. Each register should be considered as a bit-map, with the bits representing channels and the least-significant-bit representing channel 1. A 16-channel module uses all the bits while 2, 4 and 8-channel modules leave some of the higher bits unused.

Unlike similar regions the modules are encoded in reverse sequence, which means that the lowest numbered register represents module 32 and the highest numbered register represents module 1. This sequence is designed to enable a host to make use of the most efficient retrieval mechanism.

These registers do not indicate *why* the channel is unhealthy; that information can be obtained from the channel status flags for the module.

Module Health

0 = Healthy module 1 = Unhealthy module

This region has 2 registers, with each bit representing one module. The lower-numbered register is used to represent module 1 to 16 and the higher-numbered register represents modules 17 to 32. The least significant bit in each register represents the lowest-numbered module.

As with the Channel Health registers, there is no diagnostic information given here; for that the user should consult the Module/Comms Status register.

Packed input and echo data

Starting at register 6340, each module that has input data is allocated register space.

The number of registers allocated depends upon the amount of space required to hold the data. In general:

- a discrete module uses one register **per module**, while
- an analog module uses one register **per channel**.

Space is used for each successive module from slot 1 up to slot 32. A module with no values to pass is omitted from the packed data. In other words, an *output* module would not be allocated any register space in the packed *input* data registers. Similarly, an input module would not occupy any registers in the packed output registers.

The space requirements per module are given in the following table.

Module type	# of registers	Allocation
Analog input	8	1 register per channel
Analog output	0	–
TI 4-channel	4	1 register per channel
TI 8-channel	8	1 register per channel
DI 8-channel	1	1 bit per channel. Channel 1 is LSB*
DI 4-channel	1	1 bit per channel. Channel 1 is LSB*
Pulse input	10	5 registers per channel. Channel state, Frequency, Counter (2 registers) and Acceleration.
DO 4-channel	0	–
DO 8-channel	0	–
AI / AO combo	4	1 register per input channel

*LSB = Least significant bit

The echo data follows on from the input data with no gap in the allocation of registers. This enables the host to read the input data and the echo data with one command. Modules with no echo data to pass do not occupy any register space.

Echo data is the value currently being written by an output module. It uses registers in a similar manner to the input data, as shown in the following table.

Module type	# of registers	Field
Analog input	0	–
Analog output	8	1 register per channel
TI 4-channel	0	–
TI 8-channel	0	–
DI 8-channel	0	–
DI 4-channel	0	–
Pulse input	0	–
DO 4-channel	1	1 bit per channel. Channel 1 is LSB*
DO 8-channel	1	1 bit per channel. Channel 1 is LSB*
AI / AO combo	4	A value for each output channel starting at 5

*LSB = Least significant bit

Packed output

The output data is stored in registers starting at 8194. The BIM sends the values written to these registers to the output modules. The requirements per module are the same as for the packed echo data and can be seen in the above table.

If a module is not in the “Running” state or if it is in failsafe mode then output values are not passed to it. If a module has no output values to pass then it is not included in the packed output data registers.

Host interpretation of packed data

In order for the host to use the data in the packed mapping registers it must have some means of identifying the values that it reads. This can be achieved by a number of methods.

1. Starting with a list of the modules in the configuration, and using the tables that follow, the address of each parameter can be identified.
2. The 8455 Configurator is capable of producing a .csv file which can be fed into the host-system Configurator. This file contains the types and base addresses for each module.
3. The BIM provides a set of cross-reference registers at fixed addresses. These are dynamically calculated and they hold the base address for each module in each packed region.

Gathering additional information with packed data

The holding registers for the packed input data follow on from the Channel Health, Module Health and Overall BIM Status registers. Consequently, this data can be gathered with the same read command.

Similarly, the BIM Control Word immediately precedes the packed output data and can be written to with the same command that is used to write the output data.

Modbus Data Representation

Discrete Status Values

Modbus Status and Coil locations generally hold single bit data. However some status information is encoded numerically in one or two bytes

Analog Values

Modbus Register Data generally represents analog values as 16 bit integers which may be either signed or unsigned, depending on parameter type. Specific data types are explained as follows:

Analog Input & Output Data

Most analog data (4-20mA or 1-5V) is represented by a positive integer (0 to 65535) that corresponds to the full range of a 16-bit A/D or D/A converter. The conversion equations are:

Current (mA) = 25 x Raw Modbus Data / 65535

Voltage (V) = 6.25 x Raw Modbus Data / 65535

Thus the relationship between percent of span, 4-20mA and Raw Modbus data is shown in the following table:

mA	Raw Modbus data	Percentage of Span %
0	0	–25.00
4	10486	0.00
20	52428	100.00
25	65535	131.25

Alternatively, to calculate a percentage level from a current value, use the equation:

Percentage value (%) = 6.25 x Current (mA) – 25

Similarly, the relationship between percent of span, 1-5V and Raw Modbus data is:

V	Raw Modbus Data	Percentage of Span %
0	0	–25.00
1	10486	0.00
5	52428	100.00
6.25*	65535	131.25

* This value is not actually achievable. It is quoted only as a "logical" value. The maximum value is approx. 5.6V.

Alternatively, to calculate a percentage level from a voltage value, use the equation:

Percentage value (%) = 25 x Voltage (V) – 25

Temperature Input Data (including mV & ohms)

Data for low level inputs is represented differently for 2/2 modules (8105/6) and 2/1 (8205/6) modules. The 2/2 modules use a 16-bit, signed (2's complement) integer which has a range of –32768 to +32767, whereas 2/1 modules use a 16-bit unsigned integer with the range 0 to 65535. In view of these differences, two separate methods of internal scaling are used to translate the raw data to a meaningful value.

2/2 module scaling

Positive and negative values are represented by positive and negative integers respectively. For any given sensor, the scaling factor is always based upon the upper (i.e. positive) range and this is applied to both positive and negative values. The physical units and the raw data are related in the following way:

Value in units (i.e. °C) = Raw Data x Scaling factor

Scaling factor = Upper range ÷ 32767

The ranges for the supported input types are provided in the tables that follow. Select the table that corresponds to the module type in use. See also the example that follows.

8106-TI-RT - RTD module - signed 16-bit

Input type	Lower range °C	Upper range °C	Scaling factor /°C
Pt100	–200	850	0.025941
JPt100	–200	510	0.015564
Ni120	–60	320	0.009765

Pt100 to BS1904/DIN43760/IEC75
Ni120; jPt100 to JIS C1604: 1989

8105-TI-TC - Thermocouple module - signed 16-bit

Input type	Lower range °C	Upper range °C	Scaling factor /°C
B	0	1820	0.055543
E	–270	1000	0.030518
J	–210	1200	0.036622
K	–270	1372	0.041871
N	–270	1300	0.039674
R	–50	1767	0.053926
S	–50	1767	0.053926
T	–270	400	0.012207
W3	0	2320	0.070802
W5	0	2320	0.070802

Example:

A “J-type” thermocouple has an upper range of 1200 °C, so the scaling factor is 1200 ÷ 32767

Therefore +2731 would represent 2731 x 0.036622 = +100°C

Similarly, –2731 would represent –100°C.

2/1 module scaling

For 2/1 modules the total span of the sensor (upper range - lower range) is handled by a 16-bit **unsigned** integer. The physical units and the raw data are related in the following way:

Value in units = Raw Data x Scaling factor - Lower Range

Scaling factor = (Upper range - Lower range) ÷ 65535

The ranges for the supported input types are provided in the tables that follow. Select the table that corresponds to the module type in use. See also the example that follows.

8206-TI-IS - RTD and Ω module - unsigned 16-bit

Input type	Lower range Ω	Upper range Ω	Scaling factor / Ω
Ohms	0	110	0.001679
Ohms	0	280	0.004273
Ohms	0	470	0.007172
Ohms	0	2000	0.030518

Input type	Lower range °C	Upper range °C	Scaling factor /°C
Pt100	–200	850	0.016022
Pt500	–200	850	0.016022
JPt100	–200	650	0.012970
Ni120	–60	250	0.004730

Pt100 & Pt500 to BS EN50751: 1996 Ni120 to DIN 43 760: 1985

JPt100 to JIS C1604: 1981

8205-TI-IS - Thermocouple & mV module - unsigned 16-bit

Input type	Lower range mV	Upper range mV	Scaling factor /mV
mV	0	120	0.001831

Input type	Lower range °C	Upper range °C	Scaling factor /°C
B	0	1820	0.027771
E	–270	1000	0.019379
J	–210	1200	0.021515
K	–270	1372	0.025055
N	–270	1300	0.023957
R	–50	1767	0.027726
S	–50	1767	0.027726
T	–270	400	0.010224
W3	0	2320	0.035401
W5	0	2320	0.035401
Russian K	–200	1300	0.022889
Russian L	–200	800	0.015259

Example:

A 'J-type' thermocouple has a range of –210°C to 1200°C therefore the scaling factor is

$$(1200 - (-)210) \div 65535 = 1410 \div 65535 = 0.021515$$

Therefore, 14409 would represent 14409 x 0.021515 + (–210) = +100°C

And 5112 would represent 5112 x 0.021515 + (–210) = –100°C

HART data

Some modules, e.g. **8101** and **8201**, can be configured to poll intelligent transmitters for up to 4 HART variables on a cyclic basis using Universal Command #3. The 8102 module (AO +HART) can also access an additional 4 HART *device* variables by using Common Practice Command #33. The HART data is presented as a 32-bit (IEEE754) floating point for each variable. The format presents the sign and exponent byte first and the least significant byte of the mantissa last. A status value is also provided that is common to all variables on a given module channel.

Although only one HART device can be connected per channel, 4 or 8 (8102) variables are available to it. To poll the data for a channel, the secondary scan rate must be non zero. The secondary scan rate is normally set to a lower rate than the primary scan rate used for the main analogue value.

The maximum number of HART variables that can be specified is currently limited by the capacity of the secondary scan list which may have up to 48 entries (i.e. channels) per BIM.

Parameters by Modbus Flag and Register Types

A single node can accommodate up to 32 I/O modules and so there are 32 potential module locations (slots).

Coil Status Flags (Discrete Outputs) – Address Space 0xxxx (Read/Write)

Name		Modbus Locations	Addresses per slot
DO Field Output Data	(8 ch)	0001 – 0256	8
DO Field Output Data	(4 ch)	0257 – 0384	4
Special BIM commands			
Heartbeat pulse		9841	N/A
Heartbeat switch (enable/disable)		9842	N/A
BIM failsafe switch		9984	N/A

Input Status Flags (Discrete Inputs) – Address Space 1xxxx (Read only)

Name		Modbus Locations	Addresses per slot
Device Status Register		0001 - 0256	8
DI LFD	(8 ch)	0257 – 0512	8
DI Field Input Data	(8 ch)	0513 – 0768	8
DO Field Output Echo	(8 ch)	0769 – 1024	8
8-channel Analog Status	(AI/TI/VI/PI/AO)	1025 – 3072	64
PI Channel Status	(2 ch)	3585 – 4096	16
4-channel Analog Status	(TI)	4353 – 5376	32
DO LFD	(4 ch)	5377 – 5504	4
DO Field Output Echo	(4 ch)	5505 – 5632	4
DI LFD	(16 ch)	5633 – 6144	16
DI Field Input Data	(16 ch)	6145 – 6656	16

Input Registers – Address Space 3xxxx (Read only)

Name		Modbus Locations	Addresses per slot
8-channel Analog Field Input Data (AI/VI/TI)		0001 – 0256	8
AO Output Echo		0257 – 0512	8
4-channel Analog Field Input Data (TI)		0513 – 0640	4
Module/Comms Status		0641 – 0672	1
Overall BIM Status		0673	N/A
PI Value - frequency, counter and acceleration		0674 – 0929	2 x 4
DI Field Input Data	(8/16 ch)	4097 – 4128	1
HART device variable slot 0	(2 reg. per)	5633 – 6144	8 x 2
HART device variable slot 1	(2 reg. per)	6145 – 6656	8 x 2
HART device variable slot 2	(2 reg. per)	6657 – 7168	8 x 2
HART device variable slot 3	(2 reg. per)	7169 – 7680	8 x 2
HART Status	(1 reg. per)	7681 – 7936	8
HART Primary	(2 reg. per)	7937 – 8448	8 x 2
HART Secondary	(2 reg. per)	8449 – 8960	8 x 2
HART Tertiary	(2 reg. per)	8961 – 9472	8 x 2
HART Fourth	(2 reg. per)	9473 – 9984	8 x 2

Holding Registers – Address Space 4xxxx (Read/Write)

Name		Modbus Locations	Addresses per slot
AO Field Output Data		0001 – 0256	8
DI Transition Counter	(8 ch)	0257 – 0512	8
DI Transition Counter	(16 ch)	0513 – 1024	16
DO on-time	(4 ch)	1025 – 1152	4
DO on-time	(8 ch)	1153 – 1408	8
DO Field Output Data	(4/8 ch)	4097 – 4128	1
Input cross reference		6145 – 6176	1
Echo cross reference		6177 – 6208	1
Output cross reference		6209 – 6240	1
Secondary scan rates		6241 – 6272	1
Configuration types		6273 – 6304	1
Channel health		6305 – 6336	1
Module health		6337 – 6338	N/A
Overall BIM status		6339	N/A
Packed I/P data followed by packed echo data		6340 –8192	N/A
BIM control word		8193	N/A
Packed output data		8194 – 9728	N/A
Module control registers		9729 – 9760	1
DI clear latch		9761 – 9792	1
DI clear count		9793 – 9824	1
PI Preset Counter	(2 ch)	9825 – 9952	2 x 2
Special BIM Commands			
LAN Mode		9984	N/A

Appendix A Functions and Exception Responses

This appendix lists the Data Functions, and Exception Responses supported by the MTL8505 Modbus BIM. For more detail on these commands and their responses see MTL publication **AN8002** – Modbus Communications Manual.

Data Functions

Function Code	Function Name	Notes
01	READ COIL STATUS	
02	READ INPUT STATUS	
03	READ HOLDING REGISTERS	
04	READ INPUT REGISTERS	
05	FORCE SINGLE COIL	
06	PRESET SINGLE REGISTER	
08	DIAGNOSTICS	
11*	FETCH COMM. EVENT COUNTER	
12*	FETCH COMM. EVENT LOG	
15	FORCE MULTIPLE COILS	
16	PRESET MULTIPLE REGISTERS	
17	REPORT SLAVE ID	Returns ID = 00 and Run status = FF (‘Normal’) = 00 (‘Failsafe’)
23	READ THEN WRITE HOLDING REGISTERS	

* Not currently implemented

Diagnostics sub-functions

The DIAGNOSTICS function (08) can use the following sub-functions to request information:

Sub-Function Code	Sub-Function Name	Notes
00	RETURN QUERY DATA	
02	RETURN DIAGNOSTIC REGISTER	Returns ‘Overall BIM Status’ register

Exception Responses

If a command (data function) cannot be implemented, the Modbus slave may return one of the following responses.

Exception Code	Exception Name
01	ILLEGAL FUNCTION
02	ILLEGAL DATA ADDRESS
03	ILLEGAL DATA VALUE
04*	SLAVE DEVICE FAILURE
05*	ACKNOWLEDGE
06*	SLAVE DEVICE BUSY
07*	NEGATIVE ACKNOWLEDGEMENT

* Not currently implemented

Appendix B Field Removal & Replacement of Modules

A key benefit of the MTL8000 is its ability to allow faulty components to be replaced without powering down or stopping the system. The BIM and I/O modules can be replaced in the field under power-on conditions (“*hot-swapping”*), even in Division 2 and Zone 2 hazardous areas This allows the MTL8000 to continue to function normally when modules are being changed, giving improved system availability.

I/O Module replacement

A defective I/O module may be replaced without switching off the internal system (Railbus) power supply. However, there are certain precautions to be considered, especially when the equipment is located in Class I, Division 2 and Zone 2 hazardous areas:

Discrete Output modules

All DO modules must have an isolation switch for *Bussed Field Power* when used. When changing such modules the *Bussed Field Power* should first be switched off. Failure to do this may result in arcing at the field terminal block, especially with AC outputs driving inductive loads. This can result in damage to the I/O module or connectors, and may present an ignition risk in hazardous locations.

For DO module types having *unpowered* outputs, the source of field power must, similarly, be isolated before removing or replacing the module.

Discrete Input modules

The field circuits of DI modules that use 115/230V wetting voltage must also be isolated before hot-swapping. This applies both to the *Bussed Field Power* circuit on *module-powered* versions and to the source of field power on *sinking* versions.

Note: In Division 2 or Zone 2 applications, the *Bussed Field Power* for 24 V dc module-powered DI versions must also be de-energised before hot-swapping. Where an isolating switch is located within a hazardous area, it must be suitably protected by means of a recognised explosion-protection method.

After insertion, a replacement module will initially adopt an inactive state, which the BIM should detect within approximately 10 seconds. The BIM then loads the module configuration automatically, after which normal operation should resume.

If the BIM finds the module type to be different from that in its configuration file, it will signal a device mismatch (‘05’ in the Current Module/Comms Status – second byte) and the module will remain inactive with its Power (green) LED illuminated.

BIM replacement

The BIM may be replaced without switching off the main ‘Railbus’ power supply. A valid configuration may be loaded and stored to NVM in advance; in which case, it should “cold-start” normally with default/power-up values. Alternatively, the configuration may be loaded in-situ—taking appropriate precautions in hazardous areas—and the system cold-started as above.

Note: In Class I, Division 2 hazardous areas, the Local Area Network (‘fieldbus’) circuit must be de-energised before removing or replacing the BIM.

Power supply replacement

Where MTL8000 power supplies are operating in redundant, power sharing mode, a failed supply module may be replaced while power for the node is still provided by the other supply module or modules. However, the supply *input* to the failed supply must first be isolated before removal of the module from the carrier.

Note: In Class I, Division 2 or Zone 2 applications, where the isolating switch is located within a hazardous area, it must be suitably protected by means of a recognised explosion-protection method

Appendix C Software Revision Status

Software Revision Status

Software version	Date	Mod no	Description of change
1.02	Nov 97	New Issue 447-178/1	• Atlanta release
1.04	04/02/98	447-178/2	• Support for additional LAN baud rates: 1200, 2400, 4800, 38400 • Modbus block reads work across multiple modules, provided start address corresponds to module boundary • Temperature inputs mapped to specific address locations • Module state is updated when module removed • Supports full carrier of 32 modules
1.07	17/03/98	447-178/3	• Software improved to stop modules on Railbus timing out spontaneously. • "Current Module" Status byte modified to indicate failed or removed module (state: 00 06 = normal, 00 07 = failed). • Carrier detection improved to indicate module fault when carrier removed.
1.11	17/09/98	447-178/4	• Modbus commands 5, 6, 8, & 17 • I/O Module data mapping improvements: • TI channel status mapped to a discrete input location • Current Module/Comm status mapped to an input register location • TI data now also available in same location as AI • New word for Overall BIM status plus failsafe recovery (reset by host) • Serial Port timeouts extended, and may be disabled
1.20	13 Jan 99	447-178/5	• 2/1 I/O module support: 8201(8AI),8204(8AO),8215(4DO),8220(8/16DI) • HART variable (UC3) support • Dual LAN operation • Remote Configuration via LAN B • DI Counter • Host heartbeat • Failsafe status location changed • Overall BIM status word – change of location
1.21	17 Mar 99	447-178/6	• Dual LAN initialisation
1.30	30 May 99	447-178/7	• Input Fail States and Output Readback (Echo) • Power Supply Fail detection • Modbus Address Map 'hole' fixes
1.31	28 Nov 99	447-178/8	• Pre-release support for 8103 & 8119 AI, 8121/2 DI • Minor bug fixes
1.33	16 Feb 00	447-178/9	• Pre-release support for 8205/6 (8 ch TI); note user linearisation not supported • Support function code 15 for BIM failsafe control
1.40	21 Aug 00	447-178/10	• Support for AO+HART with 8 variables
1.41	28 Nov 00	447-178/11	• 8512 - HART maintenance module support
2.13	14 Mar 01	447-178/12	• First release of Version 2 BIM which offers: - speed improvement, - packed mapping and - use of 8455 Configurator software

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