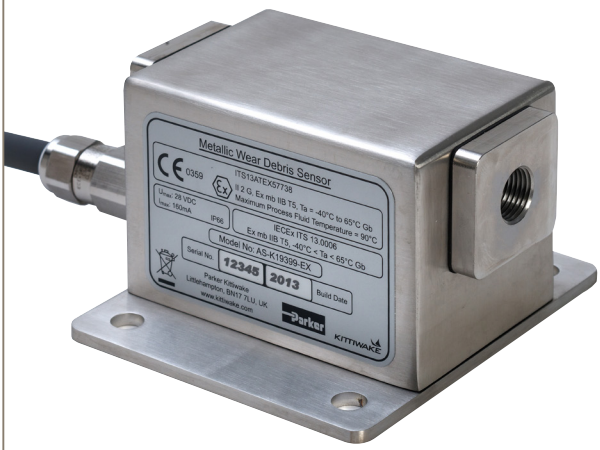
aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding



Metallic Wear Debris Sensor

Software Protocol Manual

Parker Kittiwake

ENGINEERING YOUR SUCCESS.

MWDS - Metallic Wear Debris Sensor

Communication Protocol Manual: EMA-K19555-KW issue 10

Contents

1 Manufacturer Information

Please see contact details on cover of this manual.

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Do not discard this manual. This instruction manual comprises a functional part of the Metallic Wear Debris Sensor product. The instruction manual must be kept safe for future reference.

 The Installation and Operation instruction manual is a separate manual supplied with the product – MA-K19578.

Key to Symbols

 = Caution

 = Note – Helpful Hints and Tips

2 Introduction

The Metallic Wear Debris Sensor [MWDS] is a robust online multi parameter sensor which can be used to monitor the amount of metallic ferrous and non-ferrous wear debris in an oil or other fluid medium.

The MWDS differentiates between discrete metallic particles of ferrous and non-ferrous origin. It simultaneously quantifies the metallurgical composition and the size of particles in a fluid as the fluid flows through the MWDS.

2.1 Scope of this manual

This manual covers the communication protocols and is supplementary to the Metallic Wear Debris Sensor 'Installation and Operation Manual MA-K19578.

The MWDS supports 3 network protocols:

- CANopen
- Modbus TCP/IP (Ethernet)
- Modbus RTU (RS485)

 Only one of these protocols can be used at a time. The default communications protocol is Modbus TCP/IP and this supports DHCP address allocation.

In addition, there is a text-based serial Engineering Mode that allows the MWDS to be configured by connecting it to a terminal via RS485. This uses the same wire pair as Modbus RTU & CANopen and the MWDS should be disconnected from these networks to use Engineering Mode. This mode can only be entered at start-up and provides a fail-safe configuration method - if the MWDS has been incorrectly configured so that it is not possible to communicate with it via one of the network protocols, Engineering Mode allows the situation to be recovered.

 The user should ensure that they are able to access Engineering Mode via a terminal program (e.g. Term, provided on the USB stick supplied with the MWDS).

 Test Mode: It is possible to configure the MWDS to generate pre-determined data patterns for a test session to verify connectivity. Note it is possible to save the configuration (as well as make changes) from within Normal Operation. However, changes to communications parameters will only take effect if they are saved and the MWDS rebooted. It is recommended to test communications prior to installation to ensure that the MWDS and the user system are both configured correctly.

2.2 Abbreviations

Fe	Ferrous
NFe	Non-Ferrous
MPH	Mass per hour
PPM	Particles per Minute
MWDS	Metallic Wear Debris Sensor
U16	Unsigned 16-bit integer
U32	Unsigned 32-bit integer with the Least Significant 16 bits stored first

3 Key changes from previous versions

3.1 General:

- MWDS now has DNV GL approval

3.2 Electrical:

- MWDS no longer provides 4-20 mA outputs

3.3 Communications:

- An additional register for reporting abnormal detection events that cannot be classified as individual particles and counted (typically when multiple particles pass through the sensor together); these events were previously ignored (section 4.4)
- The CANopen map has been completely revised with many new registers and features (section 7). Details are given in this Protocol Manual and as a machine-readable Electronic Data Sheet (EDS file) supplied with the MWDS.
- A new Command Register set has been added to the Modbus and CANopen interfaces and some old command registers have been deleted.
- Default Modbus & CANopen node is now 21, this can be reconfigured (section 5.2)
- Default CANopen baud rate is now 500 kbps, this can be reconfigured (section 5.2)

4 Technical Information

4.1 Interfaces

The MWDS supports the following:

- Status lights (LEDs)
- Engineering Mode over RS485 – a limited facility during sensor start-up
- Modbus RTU over RS485
- Modbus TCP/IP over Ethernet which supports DHCP address allocation.
- CANopen
- Opto-isolated alarm contacts


The MWDS is delivered configured for Modbus TCP/IP (Ethernet). If the MWDS is to be connected via CANopen or Modbus RTU over RS485, the communications method will need to be changed before the MWDS can be connected to the data polling system. The user should use Engineering Mode over RS485 or DebriSCAN over Ethernet to select the required mode.

4.2 User HMI/PLC Development “Test Mode”

Test mode is to help the testing and development of user interfaces, HMI/PLCs and DAQ. It can also help identify protocol errors.

During Test Mode, the MWDS readings are replaced by generated values. These start at the minimum possible value and ramp up to the maximum value over a 5 minute period and are then reset to zero. These cycles continue for 10 minutes. Test Mode then ceases. This allows the user HMI/PLC or other interface to be tested over the full range of possible values. Once started, Test Mode can be halted at any time. There is no LED indication that the MWDS is in Test Mode.

Test Mode can be enabled via the Toggle Test Mode Command (see section 8 Detailed Register Information and section 8.5 Command Registers).

4.3 Factory Default Configuration

The Factory Default Configuration is shown in the following table.

IP Address	DHCP or 169.254.1.32
Modbus Node Id	21
Modbus RS485 Baud Rate	19200
Modbus RS485 Configuration	8 data bits, 2 Stop bits* and Even Parity
CAN Node Id	21
CAN Baud Rate	500kbs
MPH Alarm Level	0 (Off)
PPM Alarm Level	0 (Off)
Communications Mode	Modbus TCP/IP (Modbus over Ethernet)
Status Word	Reset plus any other condition(s) detected
Termination Bit	Disabled (note: will not be restored if Factory Default Condition is requested).

* This is for backwards compatibility with DebriSCAN software - for standard Modbus the configuration should be changed to 1 stop bit.

4.4 Particle Classification & Sizing

The MWDS automatically classes particles into size categories or classes. These are termed ‘Bins’. These bins can be viewed and allow access to high resolution histogram analysis of detected particles. The following table describes these Bins.

Bin	Ferrous Ranges	Non-Ferrous Ranges
	Minimum value (µm)	Minimum value (µm)
A	40	135
B	70	200
C	100	300
D	150	400
E	200	500
F	300	600
G	400	700
H	600	800
I	800	900
J	>1000	>1000

Each Bin size range has the following 3 values available:

- Cumulative count
- Particles per minute
- Mass per Hour (µg) (to avoid floating point and have integer value).

Therefore, there are a total of 60 bins; 30 per metal type – of which 10 are cumulative count, 10 are particles per minute and 10 are mass per hour.

The MWDS can only distinguish and count separate particles, and correctly estimate particle material type and size, if no more than one particle passes through the sensor at a time. The particle speed must also be within the specified range. If additional particles enter the sensor before the last particle has left then the MWDS is able to detect that an event has occurred but it cannot determine how many particles were involved or how big they were.

Two or more particles passing through the sensor at exactly the same time will produce a normal signal and simply be detected as a single, larger particle but if they are spread out slightly in time the MWDS is able to detect this as an abnormal event. In this case it is not counted in any of the particle bins. Instead, the MWDS measures the duration of the event and reports it in a separate register in seconds per minute, rounded to the nearest second. If more than one such event occurs in a minute then the total duration is reported. Particles travelling slower or faster than the specified speed range can also trigger an abnormal event.

It should be noted that the counts of particles are not a good indicator in themselves and the lubrication system layout should be referred to. For instance, on an unfiltered system the same particles will be counted repeatedly. The count numbers increase and thus a change may not be immediately noticeable (e.g. after months of running with counts above 20,000 an increase in the number of particles of 200 may not be obvious).

For this reason, it is recommended that the particle per minute should be monitored to give an indication of change in rate of particle numbers and total mass per hour to give an indication of the size of any change.

It should be noted that the bin counts are U32 but can be operated as U16 (as they are in CAN). This will reduce the amount of data required to be transferred. The main reason for the large data size available is to handle unfiltered systems where the same particles are continually being counted.

4.5 Data Polling (data request period)

4.5.1 Minimum Polling Frequency

The MWDS operates as a Slave Device and will not instigate communications. Due to the limit of information that can be transmitted per message, multiple message requests are required to obtain a full set of information.

Communications should not interfere with the sensors functionality of particle detection other than the time taken to service interrupts. The message processing and any response to a request may be delayed whilst sensor functionality takes place. There should be a minimum of 2 milliseconds between the reception of the last byte of a received message and the transmission of the next message request by the Master.

 Polling for a full set of information should not be more often than once a second (longer at slower speeds) with requests spread evenly throughout the polling period.

4.5.2 Register Update Timings

The MWDS updates the following parameters at the timings below: -

Particle counts and count totals	As particles are detected
PPM counts and totals	10 Seconds
MPH values and totals	5 Minutes
Status	As changes are detected.

Unless another particle is detected in the meantime the PPM data will read zero after approximately 1 minute and MPH after 1 hour.

 When requesting data, it should be noted that the data can be updated during a polling sequence. When a block of Modbus Registers is requested, they are first copied to an intermediate buffer and it is ensured that the block is internally consistent. (This method cannot be employed with CAN as CAN operates on individual fields.) However, no check is made to ensure they are consistent with a following block in the series.

Example:
- A request is made for the Particle Counts for 10 Fe Bins
- The data is transmitted, during which time a Fe particle is detected
- A request is made for the total number of Fe Particles
- The data is transmitted and will include the new Fe Particle in the total count. This will not match the total of the values transmitted earlier.

As the count of particles per minute is updated every 10 seconds and the mass per hour values every 5 minutes, the chance of these being out of synchronisation is low but not impossible.

Example:
- A request is made for the Particle Counts for the 10 Fe Bins – no particles have been detected
- The data is transmitted, during which time a Fe particle is detected
- The Particles per minute counts are updated
- A request is made for the Particles per minute Counts for the 10 Fe Bins
- The data is transmitted and will include the number of particles per minute for 1 bin of 1 whilst the particle count for that bin previously got will be 0.

There are various combinations of circumstances that can result in data being out of synchronisation for short periods. Though the probability is low, eventually one of the situations will occur.

4.5.3 Effective Polling Strategies

There may be a wish to minimise the amount of traffic to any one slave device, and thus strategies to retrieve the minimum amount of data each time may be required.

4.5.3.1 Lean Data retrieval

Many data recording devices can manipulate and post process the data. Therefore, the additional calculated values – such as particles per minute, can be derived from the count totals. It is possible to retrieve only the totals and calculate ‘particles per minute’ and set alarm levels. Mass per hour is calculated by the sensor based on actual particle sizes rather than nominal values of the particle bins. It would be possible to approximate the mass per hour based on count and nominal bin values; whilst still providing useful trending, this calculated value would differ slightly from the more precise values calculated by the sensor.

It should be noted that the bin counts are U32 but can be operated as U16 (as they are in CAN). This will reduce the amount of data required to be transferred. The main reason for the large data size is to handle unfiltered systems where the same particles are continually being counted. In this case though the PPM and MPH are a better indication of the system health.

4.5.3.2 Data retrieval based on status word

The Status word can be examined to see if the “Particle Count change”, bit is set.

Once this status word has been read, it should be cleared. If, at the next polling interval, the status word has not been set, the sensor has not detected any particles and the full set of data does not require being read as it will not have changed.

Note that the PPH and MPH will continue to update until they read zero. Should the PPM or MPH be a logged parameter, the sensor should be polled until the both PPM and MPH reach zero. The polling of data would then revert to changes to Particle count change. The PPM data will read zero after approximately 1 minute and MPH after 1 hour - unless another particle is detected in the meantime.

4.5.3.3 Synchronisation and heartbeat

The PPM and MPH bits update at their respective refresh intervals, this can allow the user to achieve synchronisation with the sensor functionality if the user polls at longer intervals. The PPM interval can be used as a heartbeat signal.

If the user polls for data infrequently (e.g. hourly or daily), polling the Status Word and clearing activity bits becomes a useful 'Idle' activity to confirm that the MWDS is functioning correctly.

Status is used to indicate several conditions that occur as and when. It is up to the user to determine how often this should be polled. Conditions requiring to be cleared by the operator can be ignored unless the operator wants to utilise the functionality.

4.5.3.4 Data retrieval based on count totals

Poll the totals at intervals and compare them with the previous values. If a total has changed, then the associated data (i.e. counts, PPM and/or MPH) can be polled. The totals can then be polled again to see whether they have changed.

However, it is not anticipated that users will require to poll the data at less than 10 second intervals and thus the recommended simple Modbus strategy is to poll as follows:

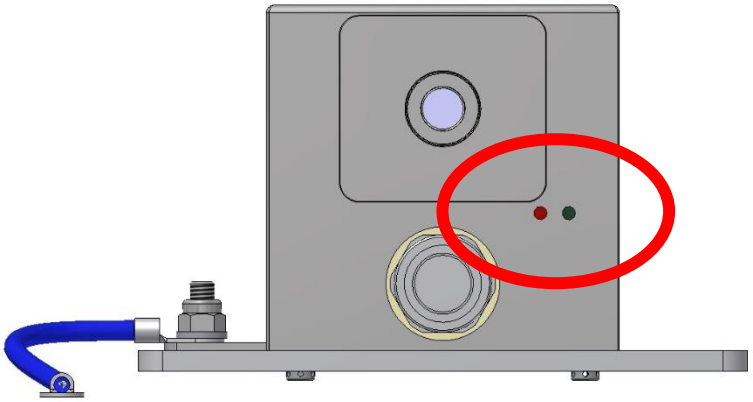
- Read the totals
- Read the bin counts, PPM and MPH values
- Reread the totals
- If the totals have changed, repeat from the second step until either the totals are consistent, or it is clear the numbers are changing rapidly.

4.6 Data Accumulation and Analysis

Consideration should be given to the amount of data being accumulated. For each of the 20 bins, the combined count, PPM and MPH counts will require 10 bytes so depending on what additional information is stored, storing all the data could require 1Kb for every 4 polls. At 5 second intervals, the file accumulated over 24 hours will be just over 3.1Mbytes. Whilst disc space will probably not be a consideration, speedily accessing the data might be.

Consideration should be given to extracting and storing periodic files (e.g. daily, weekly, monthly) giving different resolutions depending on the newness of the data. The aim would be to be able to quickly detect trends and then zero into to further detail as required.

4.7 Status Lamps (LEDs)



The Status Lamps are useful during commissioning, setup and equipment inspections.

- During Start up, both LEDs flash in unison, indicating Engineering mode is available.
- Following Start up, both LEDs will be on, with the Green LED flickering whenever data is transmitted or received. The Red LED will flash (indicating a power) up until the relevant Status bit is cleared.
- A continuously flickering Red LED indicates a failure or issue.
- Following Start up, either of the LEDs flashing indicates the occurrence of a condition (see table).

State of LED	Red LED 1 Hardware	Green LED 2 Communications
Off	No Power or software frozen.	No Power No reception
Steady On	Monitoring without Error	Reception without error
Flickering (<0.1 Hz)	Hardware issue (Not Monitoring – e.g. Balancing)	Data transmission; the MWDS will only transmit on receipt of a message
Flashing (0.5Hz)	Power Reset has occurred	Alarm Level Triggered

It should be noted that the operator should clear the Status Word Reset Bit to acknowledge the Reset condition. The Red LED should then remain on and cease flashing. From that point, if the Reset bit is set and the Red LED is flashing than a power cycle/sensor reset will have occurred.

4.8 Sensor Start-up

On powering up both the LEDs will flash in unison for approximately 10 seconds indicating that the Engineering Communication Interface is active.

 During this period, the operator may carry out recovery actions such as restoring the MWDS to its factory defaults using the Engineering Communication Interface – see 5.

The alarm output is active (open circuit) during this period to enable the circuits to be tested. Note: this means that in the event of a power cycle the alarm will be active and may therefore signal alarm conditions to any monitoring equipment.

4.9 Alarm

Alarms can be activated via all digital protocols including the DebriSCAN PC application. The Alarm is reported through the Green Status LED, the Status Word (bit set) and the alarm circuit on the standard sensor. Note, the Hazardous area sensor does not have this alarm circuit.

Parameter	Update Frequency	Alarm value
PPM	10 seconds	16 Bit (0 … 65535), 0 = Off
MPH	5 minutes	32 Bit (0 … 4.2E+9), 0 = Off

5 Engineering Communication Interface

The Engineering Communications Interface exists to allow the operator to carry out basic functionality and configuration of the device. It is expected that Modbus or CANopen is used for normal operation. It can be used to enable change the communication interface – for example, changing the communications to CANopen.

This mode can only be accessed during the first 10 seconds from power on, whilst the MWDS performs self-diagnostics and checking routines. During this period both the Green and Red LEDs flash on and off in unison. After 10 seconds, the sensor starts to use the communication protocol is has been set to use. The default communications protocol is Modbus TCP/IP.

The operator should only have to use this mode if they have set the MWDS to a communications configuration that the controlling software is unable to handle, for example, if the baud rate had been set to a point where noise interferes with communication and then being unable to set the baud rate to a different value). It can be useful when disconnecting a system employing one means of communication to set up another method for diagnosis.

If changes are made via Engineering Mode and not saved (i.e. the mode is left to timeout) then the changes will be valid only for the following session (until reboot).

5.1 Access to Engineering Communication Interface

5.1.1 Communication settings

Hardware Connection:	RS485
Baud rate:	57600
Parity:	Even
Data bits:	8
Stop bits:	2
Hardware Control	None

5.1.2 Entering Engineering Communication Interface

Connect MWDS to a PC via a terminal program such as ‘Term’ (supplied on the USB stick packaged with the MWDS) and power the MWDS. The mode operates with the PC being the Master and the MWDS as the Slave and the MWDS will not instigate communications.

It is necessary to distinguish between genuine attempts to connect to engineering mode and default connections within the customer set-up (i.e. if a set-up system is rebooted, then a remote system might start polling the sensor over RS485 whilst the Engineering Communication Interface is active).

The operator is required to type 123456789 (i.e. the digits 1 to 9). The typed digit will be echoed to the screen. In the event of an error, the correct digit is output following the one typed and the index reset (i.e. the operator must start again from 1). There should be a slight pause between each key of 2 milliseconds as having read a character, the 8-character input buffer is flushed.

On rebooting, to synchronise with the start of the period, the operator is advised to press 1 until a 1 is echoed and then proceed with the following digits. When successful the following message will be output:

"Engineering Mode Active"

On Pressing a non-menu character (e.g. 0), the following will be displayed for a default configuration:

1-6) Only valid if CAN or RS485 Modbus selected

A) Display Banner and Status

B) Display Diagnostics

C) Use RS485 ModBus Node 21 (19200, 8 Data, 2 Stop, Even Parity)

D) Use CAN Communications - Node=21, Baud= 2 [4=125, 3=250, 2=500, else 50Kbs]

E) Use Ethernet (DHCP or 169.254.1.32)

F) Zero Particle Counts

G) Go to Firmware Update via Ethernet

H) Set and Store Factory Defaults

X) Store Changes and Start Operation

No activity for 30 seconds => Start Operation with Temporary Changes

A non-menu character displays the menu

>

For a device configured for RS485, the first menu option reads:

```
1-6) RS485 Bit & Parity Settings

     1 = 8 Data, None, 1 Stop       4 = 8 Data, Even, 2 Stop

     2 = 8 Data, None, 2 Stop       5 = 8 Data, Odd, 1 Stop

     3 = 8 Data, Even, 1 Stop       6 = 8 Data, Odd, 2 Stop
```

For a device configured for CAN, the first menu option reads:

```
1-6) CAN Baud Setting [4=125, 3=250, 2=500, else 6=50Kbs]
```

 Options C, D and E display the current settings for the communications mode.

 Each received character resets the Engineering Mode timeout to 30 seconds. If Engineering Mode has been unlocked and then ends or times out, then the following message is displayed:

```
>Engineering Interface Terminated, Starting Program
```

On selecting a command, the command line is echoed, and the appropriate action taken.

5.2 RS485 and CAN Settings

Selecting a value from 1 to 6 with Ethernet set as the communications mode will result in the menu being displayed.

Selecting a value from 1 to 6 with RS485 or CAN set as the communications mode will result in the Banner and Status being displayed showing the new Communications settings. Note for CAN entered values 1 and 5 are reset to 6 (50k).

5.3 Options A to X

5.3.1 [A] Display Banner and Status

This prints a display identifying the firmware and some status information in the form:

*** Wear Debris Sensor FW-19339 <version>, <Date> <Time> ***

(Reboot = <number>, <number>, Reboot due to < Reason for Last Reboot>).

Using <Communications Mode Information>

Example:

```
*** Wear Debris Sensor FW-19339 v3.00, Mar  6 2019 14:55:42 ***

(Reboot = 1620, 16, Reboot due to Power ON Reset)

Using RS485 ModBus Node 21 (19200, 8 Data, 2 Stop, Even Parity)
```

5.3.2 [B] Display Diagnostics

This displays up to 25 lines of diagnostic data mainly for factory use. Each diagnostic contains the reboot number, an indicator number and the reason for rebooting (typically Power ON Reset). It is possible that more than 1 set of diagnostics will be stored for a single session. Entering bootloader mode, updating the firmware and restarting will generate two messages – one for exiting the previous session and another when starting normal operation.

Diagnostics are only stored once the MWDS has started normal operation (i.e. after initialisation and the Engineering Mode), so it is possible for the reboot number to ‘jump’ indicating that diagnostics had not had time to be stored.

5.3.3 [C] Use RS485 Modbus

This sets the communications mode for the following session to be RS485. The settings to be used are displayed. The menu will then display options to select the Parity and bit settings.

5.3.4 [D] Use CAN Communications

This sets the communications mode for this session to be CAN. The settings to be used are displayed. The menu will then display options to select the baud rate.

5.3.5 [E] Use Ethernet

This sets the communications mode for this session to be Ethernet. The settings to be used are displayed.

5.3.6 [F] Zero Particle Counts

This sets the particle counts to zero.

5.3.7 [G]) Goto Firmware Update via Ethernet

This sets the MWDS into the bootloader mode so that new firmware can be uploaded.

The user should not enter Firmware Update Mode unless following explicit instructions from the supplier. Should this mode be entered then the only method of exiting is to reboot the MWDS by power cycling it.

5.3.8 [H] Set and Store Factory Defaults

This overwrites all customer changes made, setting the MWDS to a known state. The Sensor number and Termination Bit state will be preserved.

5.3.9 [X] Store Changes and Start Operation

This makes the changes permanent and exits Engineering mode. If there is no activity for 30 seconds, the current changes are retained for this session only. Rebooting the sensor will result in the changes being lost. Note that within the session, the changes can be saved via a command and made permanent.

6 Modbus

6.1 Overview

The MWDS supports Modbus via two physical connection types; Modbus RTU using RS485 or Modbus TCP/IP.

Modbus Register maps are common to both Modbus RTU using RS-485 and Modbus TCP/IP. Parts of the map have been allocated functionality for future enhancement, contain diagnostics for maintenance purposes or are currently unused.


Do not write to reserved Holding Register locations.

Both Register types are mapped at offset 256 (Hex 0x100) and use plus one notation, so the first 16-bit address is at address 257. The Modbus frame limit is 256 bytes, which includes the header, CRC and data. The maximum amount of data per message is 124 Words.

6.1.1 Modbus TCP/IP over Ethernet

Hardware Connection:	10 Base-T Ethernet

Default settings:

Modbus Node ID:	21
IP Address:	DHCP or 169.254.1.32
Speed:	10Mbps

The TCP/IP implementation also supports Discovery messages. This provides the IP address, default host name, MAC address as well as the firmware build date and time. The default host name includes the firmware version number.

TCP/IP implementation also supports DHCP address allocation which will override the default or user set IP address. A DHCP change should occur seamlessly whilst a user requested change requires the MWDS to be rebooted. If communications are lost because of a change, the MWDS should be rebooted, and a Discovery message made to obtain the current IP address once any DHCP activity has ceased.

6.1.2 Modbus RTU using RS485

Default settings:

Modbus Node ID:	21
Modbus Baud rate:	19200
Parity:	Even
Data bits:	8
Stop bits:	2†
Termination Bit	Disabled

Due to half-duplex RS485, the Master-Slave protocol should be strictly adhered to. The MWDS operates as a Slave Device and will not instigate communications.

6.2 Modbus Holding Registers (40nnn) - Control

The MWDS is supplied with a default configuration, some aspects of which may be altered via the Holding Registers. All these values are unsigned integers. They may be read using a base address of 40000.

For Modbus addressing, U32 values are ordered so Address n holds the Least Significant Word and Address n+1 holds the Most Significant Word. In several cases, the Most Significant Word is redundant (e.g. CAN Node Id) and hence the address could be more efficiently handled as an U16 value.

There is a delay between a change being made and a write to EEPROM. This allows a series of changes to accumulate before being written. As the data is required to be saved to EEPROM, 30 seconds should be left between the last change made and powering off the MWDS.

In the event of rebooting and being unable to restore the settings, see Engineering Communication Interface – section 5.

†This is for backwards compatibility with DebriSCAN software - for standard Modbus the configuration should be changed to 1 stop bit.

Length	Address (+40000)	Description
U32	257	CAN Node ID
U32	259	CAN Baud
U32	261	Modbus Node ID
U32	263	Modbus Baud rate
U16	265	Sensor Number
U16	266	Alarm Level for Total particles per minute
U32	268	Alarm Level for Total Particles Mass per Hour
U16	272	Communications Mode
U32	273	Status Word
U16	275-278	IP Address octets
U16	279	Command: Zero All Particle Counts
U16	280-282	Reserved
U16	283	Command: Toggle Test Mode
U16	284	Termination Bit
U16	285	Modbus Parity
	286 - 326	Reserved
U16	327	Command Number
U32	328-335	Parameter 1-4
U16	336	Command Activator
	337 - 416	Reserved

6.3 Modbus Input Registers (30nnn) - Monitoring

They may be read using a base address of 30000.

The Modbus Identifier (U32 30257) and Top of Input Registers (U16 30691) are used to synchronise Modbus addressing schemes. Locating these values enable the addressing method used by the master to be aligned correctly with that used by the slave. The Identifier has a fixed value of 0x000001AD and the Top of Input Registers has a fixed value of 0xAAAA.


For Modbus addressing, U32 values are ordered so Address n holds the Least Significant Word and Address n+1 holds the Most Significant Word. In several cases, the Most Significant Word is redundant (e.g. CAN Node Id) and hence the address could be more efficiently handled as an U16 value.

Length	**Address (30000+)**	**Description**
U32	257	Identifier (0x01AD)
U32	259	Product Code
U32	261	Software Revision
U32	263	Sensor Serial Number
U32	265	Modbus Node ID
U32	267	Modbus Baud Rate
U32	269	CANOpen Node ID
U32	271	CAN Baud Rate
	272 - 294	Reserved
U32	295	Sensor Runtime
	297 - 338	Reserved
U32	339	Status Word
U32	341 - 360	Ferrous (Fe) Bin Counts for bins A-J
U32	361-380	Non-Ferrous (NFe) Bin Counts for bins A-J
	381 - 382	Reserved

U32	383	Alarm Level for Total Particles Mass per Hour
	386 - 390	Reserved
U16	391	Alarm Level for Total particles per minute
	392 - 392393	Reserved
U16	394	Sensor Number
U16	395	Communication Mode
	396-415	Reserved
U16	416-419	IP Address as 4 values
	420-448	Reserved
U16	449	Termination Bit
	450-510	Reserved
U32	511	Modbus Parity
U16	512	Unclassified events in seconds per minute
U16	513-522	Ferrous (Fe) Bin Particles Per Minute for bins A-J
U16	523-532	Non-Ferrous (NFe) Bin Particles Per Minute for bins A-J
	533-623	Reserved
U16	624	Sensor Particle Speed
	625-631	Reserved
U32	633-651	Ferrous (Fe) Bin Mass Per Hour in micrograms for bins A-J.
U32	653-672	Non-Ferrous (NFe) Bin Mass Per Hour in micrograms for bins A-J
U32	673	Total Fe particles per minute
U32	675	Total NFe particles per minute
U32	677	Total All particles per minute
U32	679	Total Fe particles
U32	681	Total NFe particles

U32	683	Total All particles
U32	685	Total Fe mass per hour(µg)
U32	687	Total NFe mass per hour (µg)
U32	689	Total All particle mass per hour (µg)
U16	691	Top of Input Registers = 0xAAAA

7 CAN

7.1 Overview

The MWDS implements a subset of the full CANopen standard. Any CANopen features that are not listed in this section are not supported.


The information given in this section is also provided in the form of a machine-readable Electronic Data Sheet (EDS file) on the USB stick packaged with the MWDS.

CAN Node ID:	21
CAN Baud rate:	500kb
Termination Bit	Disabled

The CAN bit rates supported are limited to 50,125,250 and 500 kbps. The node number is from 1 to 127. Changes to both the baud rate and Node ID can be made at run time to be stored in memory to take effect after the next power-cycle. Otherwise the nodes are pre-configured and cannot change during operation.

The standard Identity Object section at 0x1018 is a supported providing product information.

The Transmit PDO Mapping Parameter Section (0x1A00 to 0x1A0F) define 16 TPDOs. These allow the automatic transmission of 16 values on receipt of a SYNC message.

The MWDS supports a Manufacturer Specific data map containing Write Only and Read Only Sections. All values are stored as signed or unsigned 16 or 32-bit integers.

Read/Write registers are not supported as some HMIs use a read to confirm the write. If the value written is invalid, no write is carried out and the subsequent read value is not a match for that which was sent to be read. Some HMIs take this as a communications failure and continually resend the write message containing the invalid value.

Reserved registers are present for future expansion or diagnostic reasons.

The Manufacturer Specific Write-Only sections (each containing one or more values) are:

1) 0x2010 Command Registers
2) 0x2011 Alarm Levels
3) 0x2012 Communications Configuration
4) 0x2013 Status Register

The Manufacturer Specific Read-Only sections (each containing one or more values) are:

1) 0x2100 Sensor Run Time
2) 0x2110 Command Registers
3) 0x2111 Alarm Levels
4) 0x2112 Communications Configuration
5) 0x2113 Status Register
6) 0x2114 Totals
7) 0x2115 Fe Bin Counts
8) 0x2116 Fe Bin PPMs
9) 0x2117 Fe Bin MPHs
10) 0x2118 NFe Bin Counts
11) 0x2119 NFe Bin PPMs
12) 0x211A NFe Bin MPHs

 There is a delay between a change being made and a write to EEPOM. This allows a series of changes to accumulate before being written. As the data is required to be saved to EEPROM, 30 seconds should be left between the last change made and powering off the MWDS.

In the event of rebooting and being unable to restore the settings, see Engineering Communication Interface – section 5.

7.2 Communications Profile

7.2.1 Manufacturer Fields (0x1008,0x1009,0x100A)

These are text fields of 16,16 and 6 characters respectively.

7.2.2 Identity Objects (Index 0x1018)

The Identity Objects are all unsigned 32bit integers (u32). The Modbus equivalents for those with an address range are text fields.

Sub-index	Description	Value
0x01	Vendor ID	CIA registered Vendor ID 0x01AD
0x02	Product Code	The numeric part of the Code (e.g. 19339)
0x03	Firmware Number	Value multiplied by 100
0x04	Serial Number	

7.2.3 Transmit PDO Mapping Parameter Section

Each Transmit PDO contains up to 4 sub-indices each containing a pointer to a PDO. The value contains the Index and Sub-Index of the PDO as well as its length (16 or 32 bit).


In the tables below the referenced PDOs with an * are 32-bit, otherwise 16-bit. The total length of the PDO values pointed to by each TPDO Mapping parameter cannot exceed 8 bytes (64-bits).

7.2.3.1 0x1A00 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2115	01	Count for FE Bin A
2115	02	Count for FE Bin B
2115	03	Count for FE Bin C
2115	04	Count for FE Bin D

7.2.3.2 0x1A01 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2115	05	Count for FE Bin E
2115	06	Count for FE Bin F
2115	07	Count for FE Bin G
2115	08	Count for FE Bin H

7.2.3.3 0x1A02 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2115	09	Count for FE Bin I
2115	0A	Count for FE Bin J
2114	01	Total Count for FE Bin*

7.2.3.4 0x1A03 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2118	01	Count for NFE Bin A
2118	02	Count for NFE Bin B
2118	03	Count for NFE Bin C
2118	04	Count for NFE Bin D

7.2.3.5 0x1A04 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2118	05	Count for NFE Bin E
2118	06	Count for NFE Bin F
2118	07	Count for NFE Bin G
2118	08	Count for NFE Bin H

7.2.3.6 0x1A05 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2118	09	Count for NFE Bin I
2118	0A	Count for NFE Bin J
2114	04	Total Count for NFE Bin*

7.2.3.7 0x1A06 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2116	01	PPM for FE Bin A
2116	02	PPM for FE Bin B
2116	03	PPM for FE Bin C
2116	04	PPM for FE Bin D

7.2.3.8 0x1A07 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2116	05	PPM for FE Bin E
2116	06	PPM for FE Bin F
2116	07	PPM for FE Bin G
2116	08	PPM for FE Bin H

7.2.3.9 0x1A08 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2116	09	PPM for FE Bin I
2116	0A	PPM for FE Bin J
2114	02	Total PPM for FE Bin*

7.2.3.10 0x1A09 Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2119	01	PPM for NFE Bin A
2119	02	PPM for NFE Bin B
2119	03	PPM for NFE Bin C
2119	04	PPM for NFE Bin D

7.2.3.11 0x1A0A Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2119	05	PPM for NFE Bin E
2119	06	PPM for NFE Bin F
2119	07	PPM for NFE Bin G
2119	08	PPM for NFE Bin H

7.2.3.12 0x1A0B Transmit PDO Mapping Parameter

Index	Sub-Index	Description

2119	09	PPM for NFE Bin I
2119	0A	PPM for NFE Bin J
2114	05	Total PPM for NFE Bin*

7.2.3.13 0x1A0C Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2114	07	Total Bin Counts*
2114	08	Total Bin PPM*

7.2.3.14 0x1A0D Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2114	03	Total Fe Bins MPH*
2114	06	Total NFe Bins MPH*

7.2.3.15 0x1A0E Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2114	09	Total Bins MPH*
2113	01	Status Word*

7.2.3.16 0x1A0F Transmit PDO Mapping Parameter

Index	Sub-Index	Description
2114	0A	Unclassified events in seconds per minute
2114	0B	Particle Speed
2100	01	Run Time (Seconds)*

* PDOs which are 32-bit.

7.2.4 Manufacturer Specific Write Only Sections (0x20nn) - Control

7.2.4.1 0x2010 Command Registers

Sub-index	Bytes	Description
1	4	Command Parameter 1
2	4	Command Parameter 2 (Unused/Diagnostic)
3	4	Command Parameter 3 (Unused/Diagnostic)
4	4	Command Parameter 4 (Unused/Diagnostic)
5	2	Command Identity
6	2	Command Activate

7.2.4.2 0x2011 Alarm Levels

Sub-index	Bytes	Description
0x01	2	PPM Alarm Level
0x03	4	MPH Alarm Level

7.2.4.3 0X2012 Communications Configuration

Sub-index	Bytes	Description
0x01	2	Sensor Id
0x02	2	Can Baud Rate
0x03	2	Can Node Id
0x04	2	Modbus Baud Rate
0x05	2	Modbus Node Id
0x06	2	Rs485 Parity & Stop Bits
0x07	2	IP Address Octets 1
0x08	2	IP Address Octets 2
0x09	2	IP Address Octets 3
0x0A	2	IP Address Octets 4
0x0B	2	Communications Mode
0x0C	2	Termination Bit

7.2.4.4 0x2013 Status Register

Sub-index	Bytes	Description
0x01	4	Status Word

7.2.5 Manufacturer Specific Read Only Sections (0x21nn) - Monitoring

7.2.5.1 0x2100 Sensor Run Time

Sub-index	Bytes	Description
0x01	4	Run Time (Seconds)

7.2.5.2 0x2110 Command Registers

Sub-index	Bytes	Description
1	4	Command Parameter 1
2	4	Command Parameter 2 (Unused/Diagnostic)
3	4	Command Parameter 3 (Unused/Diagnostic)
4	4	Command Parameter 4 (Unused/Diagnostic)
5	2	Command Identity
6	2	Command Activate

7.2.5.3 0x2111 Alarm Levels

Sub-index	Bytes	Description
0x01	2	PPM Alarm Level
0x03	4	MPH Alarm Level

7.2.5.4 0x2112 Communications Configuration

Sub-index	Bytes	Description
0x01	2	Sensor Id
0x02	2	Can Baud Rate
0x03	2	Can Node Id
0x04	2	Modbus Baud Rate
0x05	2	Modbus Node Id
0x06	2	RS485 Parity & Stop Bits

0x07	2	IP Address Octets 1
0x08	2	IP Address Octets 2
0x09	2	IP Address Octets 3
0x0A	2	IP Address Octets 4
0x0B	2	Communications Mode
0x0C	2	Termination Bit

7.2.5.5 0x2113 Status Register

Sub-index	Bytes	Description
0x01	4	Status Word

7.2.5.6 0x2114 Fe and NFe Count, PPM and MPH Totals

Sub-index	Bytes	Description
0x01	4	Total of Fe Bins Counts
0x02	4	Total of Fe Bins PPM
0x03	4	Total of Fe Bins MPH
0x04	4	Total of NFe Bins Counts
0x05	4	Total of NFe Bins PPM
0x06	4	Total of NFe Bins MPH
0x07	4	Total of All Bins Counts
0x08	4	Total of All Bins PPM
0x09	4	Total of All Bins MPH
0x0A	2	Event Secs Per Min
0x0B	2	Sensor Particle Speed

7.2.5.7 0x2115 Fe Bin Counts

Sub-index	Bytes	Description
0x01	2	Count for Fe Bin A
0x02	2	Count for Fe Bin B
0x03	2	Count for Fe Bin C
0x04	2	Count for Fe Bin D
0x05	2	Count for Fe Bin E
0x06	2	Count for Fe Bin F
0x07	2	Count for Fe Bin G
0x08	2	Count for Fe Bin H
0x09	2	Count for Fe Bin I
0x0A	2	Count for Fe Bin J

7.2.5.8 0x2116 Fe Bin PPMs

Sub-index	Bytes	Description
0x01	2	PPM Fe Bin A
0x02	2	PPM Fe Bin B
0x03	2	PPM Fe Bin C
0x04	2	PPM Fe Bin D
0x05	2	PPM Fe Bin E
0x06	2	PPM Fe Bin F
0x07	2	PPM Fe Bin G
0x08	2	PPM Fe Bin H
0x09	2	PPM Fe Bin I
0x0A	2	PPM Fe Bin J

7.2.5.9 0x2117 Fe Bin MPHs

Sub-index	Bytes	Description
0x01	4	MPH Fe Bin A
0x02	4	MPH Fe Bin B
0x03	4	MPH Fe Bin C
0x04	4	MPH Fe Bin D
0x05	4	MPH Fe Bin E
0x06	4	MPH Fe Bin F
0x07	4	MPH Fe Bin G
0x08	4	MPH Fe Bin H
0x09	4	MPH Fe Bin I
0x0A	4	MPH Fe Bin J

7.2.5.10 0x2118 NFe Bin Counts

Sub-index	Bytes	Description
0x01	2	Count for NFe Bin A
0x02	2	Count for NFe Bin B
0x03	2	Count for NFe Bin C
0x04	2	Count for NFe Bin D
0x05	2	Count for NFe Bin E
0x06	2	Count for NFe Bin F
0x07	2	Count for NFe Bin G
0x08	2	Count for NFe Bin H
0x09	2	Count for NFe Bin I
0x0A	2	Count for NFe Bin J

7.2.5.11 0x2119 NFe Bin PPMs

Sub-index	Bytes	Description
0x01	2	PPM NFe Bin A
0x02	2	PPM NFe Bin B
0x03	2	PPM NFe Bin C
0x04	2	PPM NFe Bin D
0x05	2	PPM NFe Bin E
0x06	2	PPM NFe Bin F
0x07	2	PPM NFe Bin G
0x08	2	PPM NFe Bin H
0x09	2	PPM NFe Bin I
0x0A	2	PPM NFe Bin J

7.2.5.12 0x211A NFe Bin MPHs

Sub-index	Bytes	Description
0x01	4	MPH NFe Bin A
0x02	4	MPH NFe Bin B
0x03	4	MPH NFe Bin C
0x04	4	MPH NFe Bin D
0x05	4	MPH NFe Bin E
0x06	4	MPH NFe Bin F
0x07	4	MPH NFe Bin G
0x08	4	MPH NFe Bin H
0x09	4	MPH NFe Bin I
0x0A	4	MPH NFe Bin J

8 Detailed Register Information (CAN and Modbus)

8.1 MWDS Product Code (RO)

Modbus RO	**CAN RO**	**Description**
	0x1008-0	16-character string
30258	0x1018-2	The numeric part of the Code (e.g. 19339)

8.2 Firmware Code and Revision (RO)

Modbus RO	**CAN RO**	**Description**
	0x1009-0	Firmware Code as 16-character string
	0x100A-0	Revision as 6-character string
30260	0x1018-3	the Revision number *100 (e.g. 302 => v3.02)

8.3 Serial Number (RO)

Modbus RO	**CAN RO**	**Description**
30262‡	0x1018-4	Numeric Value

8.4 Sensor Runtime (RO)

Modbus RO	**CAN** RO 0x2100-	Description
30295	1	Seconds

This word holds the time since power-up/reset in seconds. This parameter is provided for indication purposes only since there may be drift that can amount to 90 seconds per week.

8.5 Command Registers

Modbus RW 40000+	**CAN WO** 0x2010- **CAN RO** 0x2110-	Bytes	Description
285	1	4	Command Parameter 1

‡ The Modbus Registers contain an ASCII representation of the Serial Number (8 characters).

287	2	4	Command Parameter 2 (Unused/Diagnostic)
289	3	4	Command Parameter 3 (Unused/Diagnostic)
291	4	4	Command Parameter 4 (Unused/Diagnostic)
284	5	2	Command Identity
293	6	2	Command Activate
279	N/A	2	Command: Zero All Particle Counts
280-282	N/A	3*2	Reserved
283	N/A	2	Command: Toggle Test Mode

The primary use of commands is to instigate functions (e.g. Reboot, Test Mode etc.) and these are handled via commands 11 to 16. Commands 1 to 10 allow the setting of various configuration values.

Command Parameters 2 to 4 are currently unused other than for diagnostic purposes and are referred to in the appropriate sections. The diagnostics provided should only be used for set-up purposes (troubleshooting) as later versions of firmware may not support the same diagnostics. The diagnostics relate to invalid message requests and are covered in the Last Error Code description.

The user can issue commands to the MWDS by setting:

1) The Command Identity to 0x5500 plus a command value (1-14).
2) Command Parameter 1. For some commands, this Parameter is used as an additional verification safeguard.
3) Setting the Command Activate to 0x5500 plus a command value (1-14)

The Command Identity and Parameter values can be set in any order, but setting the Command Activate to a non-zero value actions the command and should be done last. The Activate and (where required) Verification values should prevent any accidental invocations of the commands.

If the command is actioned successfully, the MWDS will clear all the registers. Note that the reboot command will result in a loss of communications for up to 20 seconds whilst the MWDS re-initialises.

No	Command
1	Zero All Registers *
2	Set Sensor Number
3	Set PPM Alarm Level
4	Set MPH Alarm Level

5	Reserved
6	Reserved
7	Set Modbus Node Id
8	Set Modbus Baud Rate, Data and Stop Bits, and Parity
9	Set CANOpen Node Id
10	Set Can Baud Rate
11	Set IP Address
12	Restore Factory Defaults*
13	Reboot *
14	Set Comms Method
15	Reserved
16	Clear Status Word*
17	Toggle Test Mode *
18	Enter Ethernet boot loader mode *

8.5.1 Set Modbus Baud Rate, Data and Stop Bits, and Parity

Parameter 1 is set to the Baud rate.

Parameter 2 is set to the UART Configuration:

0 = 8 Data, None, 1 Stop 3 = 8 Data, Even, 2 Stop

1= 8 Data, None, 2 Stop 4 = 8 Data, Odd, 1 Stop

2 = 8 Data, Even, 1 Stop 5 = 8 Data, Odd, 2 Stop

8.5.2 Set IP Address

Parameters 1 to 4 are set to the four address octets.

8.5.3 Other Set Commands

Parameter 1 contains the value to be set.

8.5.4 * Commands

No parameters need be set.

8.5.5 Zero All Particle Counts

All the particle values (i.e. counts, PPM and MPH bins and totals) will be zeroed. The non-volatile memory counts will also be cleared immediately. On completion the value is cleared. This can also be invoked by setting the appropriate Modbus register to non-zero.

8.5.6 Reset to Factory Defaults

Changes because of this command will only take effect following a reboot of the MWDS.

The configuration stored in non-volatile memory is restored to the Factory Defaults.


This will not zero the particle counts. When the MWDS is next rebooted, the runtime configuration will be reset with the factory defaults. Until then the current configuration will still be operating. On completion the value is cleared.

The Sensor Number and Termination Bit value will be preserved.

8.5.7 Reboot MWDS

The MWDS will be rebooted. Changes to the configuration which require a reboot will come into effect, once the MWDS has fully booted. The MWDS will be unable to communicate to the Modbus interface for approximately 30 seconds. The Particle Counts will be preserved but the Particles Per Minute and Mass Per Hour values will be zeroed. On completion the value is cleared.

8.5.8 Enter Ethernet boot loader mode


Do not enter Firmware Update Mode unless following explicit instructions from the manufacturer. If this mode be entered then the only method of exiting is to reboot the MWDS by power cycling it.

The MWDS will enter the Firmware Update Mode. No further communication will be possible via the Modbus interface. On completion the MWDS will require to be rebooted. The configuration (i.e. user settings) and previous particle counts should be preserved.

8.5.9 Toggle Test Mode

This causes the MWDS to enter/exit Test Mode. The particle counts are zeroed, and a test sequence is invoked for 10 minutes or until the command is set again. On exit the particle counts are zeroed to clear the test data. On completion the value is cleared. This can also be invoked by setting the appropriate Modbus register to non-zero.

The test sequence adds large values to the bins and totals for particle counts, particles per minute and mass per hours. This allows the operators configuration and data handling methods to be verified.


The Mass Per Hour totals will overflow and return to zero one or more times during the test.

During test mode a value is added to all the bins at 10 second intervals. The values are as follows (where Bin is in the range 1-10 equivalent to A to J):

Particle Counts – Bin * 20000

Particles Per Minute – Bin * 20

Mass Per Hour – Bin * 2000000

The totals represent the sum of 10 Fe and 10 NFe bins being treated as above.

The Alarm outputs will be set as appropriate for the current test values. Alarms should be set to appropriate values to test alarm function.

8.6 Alarm Levels

Modbus RW **Modbus RO**	**CAN RO** 0x2111- **CAN RW** 0x2011-	Bytes	Description
30390 40266	0x01	2	Alarm Level for Total particles per minute
30382 40268	0x03	4	Alarm Level for Total Particles Mass per Hour

8.6.1 Alarm Level for Total particles per minute

If the number of particles per minute exceeds this level, the PPM alarm is set. If the level is zero the alarm is switched off. The range is 0 – 1000.

8.6.2 Alarm Level for Total Particles Mass per Hour

If the total particle mass per hour exceeds this level, the MPH alarm is set. If the level is zero the alarm is switched off. The range is 0 – 10,000,000 (µg).

8.7 Communications Configuration

Modbus RW **Modbus RO**	**CAN RO** 0x2111- **CAN RW** 0x2011-	Bytes	Description
40265 30394	0x01	2	Sensor Id
40259 30270	0x02	2	Can Baud Rate
40257 30268	0x03	2	Can Node Id
40263 30266	0x04	2	Modbus Baud Rate
40261 30264	0x05	2	Modbus Node Id
40285 30511	0x06	2	RS485 Parity & Stop Bits
40275-40278 30416-419	0x07-0A	4*2	IP Address Octets 1-4
40273 30395	0x0B	2	Communications Mode
40284 30449	0x0C	2	Termination Bit

8.7.1 Sensor Number

This identifies the MWDS within the system for customer use. The range is 0 to 65535.

8.7.2 CAN Node ID

A change to this value will only take effect following a reboot of the MWDS.

This identifies the MWDS within a network so that several MWDSs each uniquely identified by their Node Id can coexist on a network. Note that the ID is held in the bottom 8 bits of the U16 value at address 258 and all other bits should be zero.

8.7.3 CAN Baud

A change to this value will only take effect following a reboot of the MWDS.

The CAN Baud rate is a value equating to Baud Rates in the range 50 to 500K (6=50, 5=50, 4=125, 3=250 and 2=500)). The default is 2 (i.e. 500k baud). Note: both 5 & 6 equate to 50k as 100k is not supported.

8.7.4 Modbus Node ID

A change to this value will only take effect following a reboot of the MWDS.

This identifies the MWDS within a network so that several MWDSs each uniquely identified by their Node Id can coexist on a single RS485 network. The range is 1 to 247. Note that the ID is held in the bottom 8 bits of the U16 value at address 262 and all other bits should be zero.

8.7.5 Modbus Parity and Stop Bits

A change to this value will only take effect following a reboot of the MWDS.

The values are calculated as the sum of two numbers:

1) Data and Parity
    a. 4 = 8-bit data, odd parity
    b. 2 = 8-bit data, even parity
    c. 0 = 8-bit data, no parity
2) Stop Bits
    a. 1 = 2 Stop bits
    b. 0 = 1 Stop bit

The default is 3 (8-bit data, even parity and 2 stop bits) - this is for backwards compatibility with DebriSCAN software. For use with standard Modbus systems this value should be changed to 2 (8 bits data, even parity, 1 stop bit). Any value above 5 will be ignored.

Read Only values reflect the current state whilst RW values represent the state that will take effect if the configuration was stored, and the MWDS rebooted.

8.7.6 Modbus Baud Rate

A change to this value will only take effect following a reboot of the MWDS. The following standard values are supported by DebriSCAN; 1200, 2400, 4800, 9600, 19200, 38400 and 57600.


Different baud rates may be requested and, depending on the interface, may also result in good communications. Slower baud rates may necessitate less frequent polling.

The time taken to transfer data should be considered when determining polling times. The total amount of data to be transferred could be 240 bytes which is then formed into packets. At 1200 baud this will take several seconds. It is up to the user to ensure that they are not requesting a subsequent set of data before the previous data transfer is complete.

8.7.7 Communications Mode

A change to this value will only take effect following a reboot of the MWDS.

This sets which mode is to be used the next time the MWDS is powered up. The valid modes are:

Value	Communication Mode
1	Modbus RTU over RS485
2	CANOpen
3	Modbus TCP/IP on Ethernet


Invalid values will be ignored. In the event the MWDS boots up with an invalid value, it will be reset to use Ethernet (3).

8.7.8 IP Address

A change to these values will only take effect following a reboot of the MWDS.


These values may be automatically changed if the MWDS is connected to a DHCP server. A discovery request may be used to obtain the current settings.

8.7.9 Termination Bit (Internal Terminating Resistor)

A change to this value will only take effect following a reboot of the MWDS.

Set the value to zero to enable the internal termination resistor. If an external termination resistor is fitted then the internal termination should be disabled by setting the bit to one.

8.8 Status Register

Modbus RW **Modbus RO**	**CAN RO** 0x2113- **CAN RW** 0x2013-	Bytes	Description
40273 30338	0x01	4	Status Word

This value is used to reset the Status Word temporarily as Status conditions will be retested during the appropriate time in the execution cycle and the bits set accordingly. In the intervening time, the Status Word will reflect the value that has been set and not the actual status of the system.

This allows the user to verify their system in respect of setting and clearing alarms and other status reporting. Note that unused bits will not normally be set or cleared by the MWDS.

On power up the reset bit of the Status Word is set causing the Red LED to flash. Clearing the bit in the Status Word clears the condition and causes the Red LED to stop flashing. Any future power cycles/reboots will then be brought to the attention of the operator through this bit.

0=LSB	Function	Notes
Bits 0 & 1	Reserved.	
Bit 2	Particles per Minute Alarm	Set/Clear if the PPM alarm is set or clear. This flag is updated every 10 seconds.
Bit 3	Mass per Hour Alarm	Set/Clear if the MPH alarm is set or clear. This flag is updated every 5 minutes.
Bit 4	MWDS Balancing	Set whilst the MWDS is balancing and clear otherwise. Whilst the MWDS is balancing, particles are not being detected. Under normal operation, balancing will take approximately 100 milliseconds and will occur not more than once a day. Balancing will occur more frequently if the temperature is changing rapidly.
Bit 5	MWDS has Reset	Set on power up. This bit should be cleared by the user on installation or when the power has been interrupted. This flag

		does not affect the logging capability of the sensor; it is for information purposes only.
Bit 6	MWDS is in Test Mode	Set when MWDS is outputting Test Data and clear otherwise. Test mode lasts 10 minutes and can be toggled on and off.
Bit 7	Reserved	
Bit 8	Particle Counts Changed	Set when the Particle Counts have changed. This bit should be cleared by the user if knowledge of when the Particle Counts have Changed is required. Note: this does not reflect changes to the PPM and MPH counts.
Bit 9	PPM Update	Set when the PPM values are recalculated. This bit should be cleared by the user if knowledge of when the PPM values have been updated is required.
Bit 10	MPH Updated	Set when the MPH values are recalculated. This bit should be cleared by the user if knowledge of when the PPM values have been updated is required.
Bit 11	Data To Write	Set when configuration data is waiting to be written to EEPROM. Cleared when the EEPROM has completed the write
Bits 12-31	Unused.	

8.9 Fe and NFe Count, PPM and MPH Totals

Modbus RO 30000+	**CAN RO** 0x2114-	Bytes	Description
678	0x01	4	Total of Fe Bins Counts
672	0x02	4	Total of Fe Bins PPM
684	0x03	4	Total of Fe Bins MPH
680	0x04	4	Total of NFe Bins Counts
674	0x05	4	Total of NFe Bins PPM
686	0x06	4	Total of NFe Bins MPH
682	0x07	4	Total of All Bins Counts

676	0x08	4	Total of All Bins PPM
688	0x09	4	Total of All Bins MPH
512	0x0A	2	Abnormal Event Duration
624	0x0B	2	Sensor Particle Speed

8.9.1 Totals

These hold U32-bit totals as listed. The totals are updated as follows:

1) Bin Counts – as particles are detected
2) PPM – every 10 seconds
3) MPH – every 5 minutes.

8.9.2 Abnormal Event Duration

If successive particles enter the MWDS before the previous particle has left, or if particles pass through the MWDS outside the specified speed range then this can be detected as an abnormal event. In this case, no particles are counted. The duration of each abnormal event is timed and the total duration for all abnormal events over the last minute is reported in seconds per minute. This field is updated every second.

8.9.3 Sensor Particle Speed

This 16-bit word gives an indication of the speed of the last particle in millimetres per seconds. It should not be used as a measurement of fluid speed or flow.

8.10 Counts, PPM and MPH for each Bin

	Modbus RO 30000+	
U32	341-360	Ferrous (Fe) Bin Counts for bins A-J.
U32	361-380	Non-Ferrous (NFe) Bin Counts for bins A-J.
U16	513-522	Ferrous (Fe) Bin Particles Per Minute for bins A-J.
U16	523-532	Non-Ferrous (NFe) Bin Particles Per Minute for bins A-J.
U32	633-651	Ferrous (Fe) Bin Mass Per Hour in micrograms for bins A-J.
U32	653-672	Non-Ferrous (NFe) Bin Mass Per Hour in micrograms for bins A-J

	CAN Index/SubIndices	
U16	0x2115/0x01-0x0A	Ferrous (Fe) Bin Counts for bins A-J.
U16	0x2116/0x01-0x0A	Non-Ferrous (NFe) Bin Counts for bins A-J.
U16	0x2117/0x01-0x0A	Ferrous (Fe) Bin Particles Per Minute for bins A-J.
U16	0x2118/0x01-0x0A	Non-Ferrous (NFe) Bin Particles Per Minute for bins A-J.
U32	0x2119/0x01-0x0A	Ferrous (Fe) Bin Mass Per Hour in micrograms for bins A-J.
U32	0x211A/0x01-0x0A	Non-Ferrous (NFe) Bin Mass Per Hour in micrograms for bins A-J

It should be noted that the counts of particles are not a good indicator in themselves and the lubrication system layout should be referred to. For instance, on an unfiltered system the same particles will be counted repeatedly. The count numbers increase and thus a change may not be immediately noticeable (e.g. after months of running with counts above 20,000 an increase in the number of particles of 200 may not be obvious).

For this reason, it is recommended that the particle per minute should be monitored to give an indication of change in rate of particle numbers and total mass per hour to give an indication of the size of any change.

 Bin counts obtained via CAN are 16-bit whilst those via Modbus are 32-bit.

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