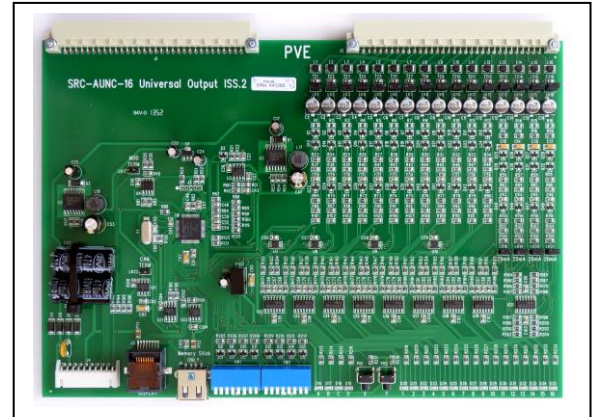


## Hurtwood Output Card User Guide

### Product Overview

The Hurtwood 16 channel output is designed to fit directly into existing Satchwell BAS 2000, 2800 and Sigma rack type control enclosures (known as UNC 96 controllers) and hence allow the existing analogue and digital outputs to be driven by a modern, web based master controller over a Modbus RS 485 network. It incorporates capacitors to allow it to drive the existing Satchwell latching relay output modules.



### Product Specification

The card provides 16 outputs, which can be configured as voltage outputs in the range 0 – 10V, or “latching relay” digital outputs. Four of the outputs can be configured for current-control, over the range 0 – 20mA. The outputs are numbered 1 to 16, with outputs 13 - 16 having the current-control capability.

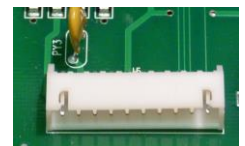
The card is communicated to by Modbus over a two-wire RS-485 network. The data format is 8bit RTU, with a choice of address, baud-rates and message formats configured by DIP switches (See Section 1.3). A software set-up tool is also available for commissioning the cards via a supervisor port in the absence of the master controller and Modbus network.

When setting up an output card initially, please note the Watchdog Feature (section 2.3), which may cause unexpected behaviour if you’re not aware of it.

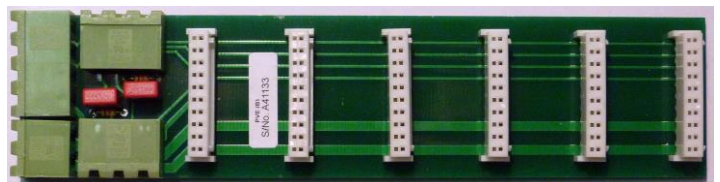
## 1. Hardware Configuration

### 1.1. Connections

The power and communications connections are made through connector J4, which in turn connects to the ConBus board. The ConBus board can then link up to six Satrofit cards with 24VDC, 0V, A = Data + and B = Data –.



NOTE: Some Modbus devices, e.g. Vacon variable speed drives, employ the convention of A = Data –. Connecting the data connections round the wrong way won’t damage the card, it just won’t work.



### 1.2. Output Type Selection

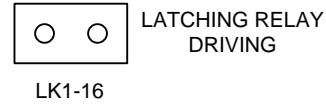
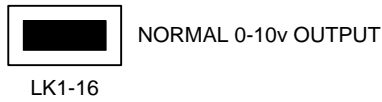
The choice of voltage, current or relay output is made via the two banks of jumpers on the board.

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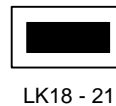
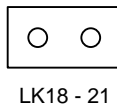
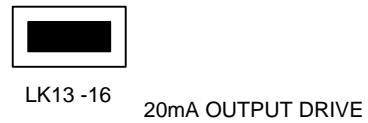
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The card has two banks of jumpers. The long bank closest to the output connector has a jumper per channel. Connecting a jumper sets the corresponding output to voltage-control operation. Removing the jumper sets the output to latching-relay-control.



The second bank of four jumpers sets the final four outputs to current-control (with the jumper fitted). When an output is configured for current-control the voltage jumper should also remain fitted.

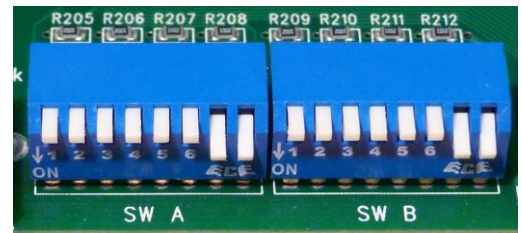


NOTE: Ensure that the current output jumper IS NOT fitted when working in the latching relay mode.

### 1.3. Modbus Address and Communication Set-Up

Note – Power cycle the card to use new settings

DIP Switch bank A, labelled “SW A” sets the Modbus address / ID of the card on the Modbus network. This can be set to any number between 0 – 255 (although zero should not be used as that is the Modbus broadcast address). The switches specify the number in binary. For example with all switches “up” (away from the board) except for the right-most two, the address will be 3.



DIP Switch bank B, labelled “SW B” specifies the communications parameters for data transmission on the bus. The right-most three switches (labelled 6, 7, 8) specify the baud-rate, the next two switches (labelled 5, 4) specify the parity setting and the next single switch (labelled 3) sets the number of stop bits, as follows:

Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8	Baud rate (bps)
			OFF	OFF	OFF	1,200
			OFF	OFF	ON	2,400
			OFF	ON	OFF	4,800
			OFF	ON	ON	9,600
			ON	OFF	OFF	19,200
			ON	OFF	ON	38,400
			ON	ON	OFF	57,600
			ON	ON	ON	115,200

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The Modbus message is 8 bits. The Parity configuration is set below:

Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8	Parity Bit
	OFF	OFF				None
	OFF	ON				Odd
	ON	OFF				Even
	ON	ON				None

Stop bits:

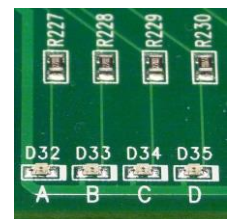
Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8	Num Stop Bits
OFF						1
ON						2

The MOD TERM jumper, when fitted, puts a 440 Ohm resistance across the Modbus A and B wires. This may be required if the board is an end-node on a long bus and is recommended to be fitted for all end of the line boards.

## 1.4. LEDs

There are four indicator LEDs labelled A, B, C and D. The first 3 are used as follows:

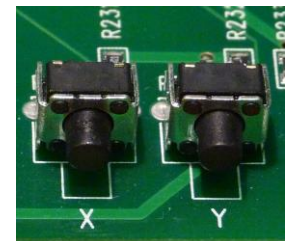
- A - flashes showing everything is running normally.
- B - is on while a Modbus "frame" is being received.
- C - is on while a Modbus "frame" is being transmitted.



## 1.5. Push Buttons

Pressing button Y for two seconds will reset the processor on the card. After this the processor will enter the boot-loader. When button Y is released the boot-loader will launch the main firmware. If the firmware needs to be upgraded this can be achieved by inserting a USB memory stick containing it, while still holding the Y button. This process is described in a separate document.

Pressing button X on its own will do nothing. Pressing button X and then pressing button Y while still holding button X, for four seconds, will reset the stored configuration to factory default settings. This configuration consists of all Modbus registers that are used to setup the behaviour of the card. These are described later in Appendix A.



## 1.6. USB port

The USB port is primarily for upgrading the firmware. However, inserting a memory stick while the card is powered will cause a text file to be written to the memory stick, describing the configuration and current-state of the software. In particular it will contain the software version and the Modbus parameters, so can be useful for setting-up a system and fault-finding.

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## 2. Functionality and Control

Note that the configuration of all features of the card is stored in non-volatile memory, so is maintained across power outages, etc.

### 2.1. Output Level Control

**Analogue Control:** The driven level of each output is internally controlled by 12-bit digital-to-analogue converter circuitry. The desired level of each output is set by writing to the first 16 Modbus Holding Registers (see the table in Appendix A). The range of values goes from the lower "bottom of range" to the upper "top of range" value, which are changeable via Modbus. The range defaults to 0-4095. Therefore, when an output is configured for voltage-control, writing the value 4095 to its register will cause the output level to be 10V. Writing zero will set the output to 0V. All values between these are linearly scaled between 0V and 10V.

**Digital Control:** The output levels can also be controlled via the digital output Modbus command – a coil. In this case setting the output to off, will cause the output to go to 0V. Setting it on will cause it to go to 10V. For current-control, the outputs will be 0mA and 20mA respectively.

If the output is configured for controlling latching relays then intermediate values should not be written to the control register. Only zero and the top-of-range values should be used (or just use the digital output Modbus command – a coil).

**Digital Multiplex Control:** To reduce Modbus comms, blocks of 8 digital outputs can be written to by a single 0-256 analogue number. They will be driven between the 0 and 1 state provided the output hasn't also been written to recently by a holding register.

The 16 LEDs on the front of the board give an indication of the level of each output. These LEDs are not controllable via Modbus – their brightness is controlled by the card proportional to the level the corresponding output is being driven.

### 2.2. Scaling Profiles

The card provides a set of scaling profiles, through which outputs can be written, to allow "real world" values across Modbus. The scaling-profiles are used by accessing the outputs through different ranges of Modbus addresses. There is a specific range for each scaling-profile. These ranges start at address 10000, and are detailed in the Register Listing in Appendix A.

When using the scaling profiles it is important to write/interpret the Modbus values correctly. This means that with the master controller, it is important to use the correct scaling and data type. See Appendix A for a full description.

### 2.3. Watchdog Features

The card has several watchdog features which will set all outputs to a "safe" value if comms with the Master is lost.

#### CommDog

If no comms to the card is seen for 5 seconds, configurable via Modbus or via the Satrotool, then output 11 is immediately set to its safe value, which defaults to zero. This output can be used to disconnect the Modbus external to the local unit, which allows some recovery in the case of an external short of the Modbus network outside of the control cabinet, for example, a short on a field mounted Variable Speed Drive comms.

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If, after setting output 11 to its safe value, no communication is received from the Master for another 5 seconds, then all outputs are set to their safe value (which defaults to zero).

The entire CommsDog feature can be disabled by setting the initial delay to a value of zero and the default is zero. This can be useful when configuring the card initially. See the Modbus table later for details of the registers that control this feature.

## **SoftDog**

If the card healthy bit goes to zero. This could be caused by the voltage to the card falling below a certain level, it is then safe to assume that the inputs are no longer working correctly. A time period can be set via the tool and a Modbus register and is in minutes between 1min and 240mins after which the output is set to a safe value. This allows the user to make an assessment of what is the safe period of time before the plant is put to the safe values. It may be several hours. As soon as the card enters the unhealthy state, it won't reply to any Coil or Holding Register commands from the master controller, the controller knows that there is a problem and hence to raise an alarm. This monitoring is known as "Softdog".

## **VoltDog**

If the voltage to the card falls below a certain level, the card concludes that the power to it has failed and therefore puts latching relay outputs to safe values. The voltage level has been selected so that the card can set the Satchwell latching relays to on, being latching, they will stay on. This is an important feature and can be used to enable safety critical systems, for example outside lighting, in the event of a power failure. If the safe value is on, and the output is off, then a momentary dip will turn on the relay until the Coil is updated over Modbus and the relay will be turned off again. If the relay is already on when the dip occurs, it will stay on. This monitoring is known as "Voltdog".

## **2.4. Satrofit Tool Port**

The RJ45 connection allows all the outputs to be overridden and driven using the Satrofit tool. (See the Satrofit tool datasheet) The Satrofit tool allows the card and all its connected field devices to be commissioned without the presence of the Modbus comms. The tool is a free software program that can run on any Windows based PC with a USB port. A 1.8 or 5m interface cable to connect between PC and card is available separately and connects to the Satrofit and Staefit cards. In addition, for commissioning and service, the tool also provides for each output:

- 1) A text field for entering the output name (max 40 char) and the units.
- 2) A text field for entering the date of the last valve or output exercising in dd/mm/yy format.
- 3) A text field for entering say, the actuator type (max 16 char) so the installer can put in the part number of the actuator, useful for difficult to get to actuators.

## Appendix A: Using Modbus Registers

Modbus registers are the method by which data is read from, and written to the Satrofit card. Each manufacturer of master controllers will have variations on how this data is read and written, however, some basic rules will apply.

### Register Format:

Registers can be addressed as either Hex, Decimal or Modbus

Satrofit has both 1 based and zero based registers within it. Zero based registers are called Decimal registers and 1 based registers are called Modbus registers. Decimal registers are in the 0-15 data format so to read from input 7, you need to use 6 in the register. Modbus registers start at 1 so to read, say input 7, you would use 7.

For example, North BT and OSS use zero based (Decimal) registers or offsets.

**Register type:** There are four data register types:

**Input Status** (Modbus 02 command) – a digital input. These can be read from the set of Modbus addresses beginning at 10001

**Coil** (Modbus 05 command) – Literally a relay coil – a digital output. These can be set by the Modbus addresses beginning at 20001

**Input Register** (Modbus 04 command) – An analogue input. These can be read from the set of Modbus addresses beginning at 30001

**Output or Holding register** (Modbus 06 command) – An analogue output or a parameter in the cards, for example, the top of range for the outputs. These can be read from or written to the card using the set of Modbus addresses beginning at 40001

The numeral next to each in brackets is the Modbus function code as defined in the Modbus protocol.

Manufacturers will either use a code to define what type of register it is or will have a strategy block that can communicate with each type. Holding registers and coils can also indicate statuses.

### Scaling

The scaling (divide or multiply) is needed since the basic Modbus spec requires all values to be transmitted as integers.

The cards, because of their 12 bit A-D conversion can work to 3 significant figures, hence a percentage can have 1 decimal point and a voltage or current can have 2 decimal points, e.g. 1.23V or 15.56mA

For example a percentage of 67.5% has to be transmitted as the integer 675. This number then needs to be interpreted as "Percentage times 10", so needs to be scaled by 10 to get the actual percentage. A signal of Volts or Milliamps requires scaling by 100, e.g. a voltage of 1.23V is transmitted as the integer 123.

Each manufacturer will provide codes or formulae numbers (as in North BT) or ask for a scaling factor in modules to achieve the scaling required above.

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## Data Type

All the registers are treated as signed binary integers because they may be negative, e.g. temperatures or voltages. Hence you will use signed binary values for analogue outputs and lowest bits of registers for digital outputs.

Again, some manufacturers will provide codes such as A, B and C in the North BT strings or the strategy modules will have a drop down list of permitted data types.

## Output Registers

Below are the registers for sending commands to the cards and for reading basic data from the cards.

DECIMAL ADDRESS	MODBUS ADDRESS	Type	VALUE DESCRIPTION	ADDRESS BLOCK EXPLANATION
0	40001/20001	Holding Registers or Coils (discrete outputs)	output 1 value	Can be written as an analogue or digital output type.
...			...	
15	40016/20016		output 16 value	
16	40017	Holding Registers	Digital Outputs 1-8	An analogue value between 0-255 that represents the binary status of the outputs
17	40018		Digital Outputs 9-16	
100	40101	Holding Registers	output 1 scaling	The value here is the "top of range" value. Default: 4095
...			...	
115	40116		output 16 scaling	
500	40501	Holding Registers	output 1 safe value	Watchdog Safe Values. If no valid messages are received from the Master for 10 seconds then the outputs are set to these values. See detailed description of the "Watchdog" feature for full description.
...			...	
515	40516		output 16 safe value	
590	40591	Holding Registers	Seconds till Bus Off	Delay until the external Modbus is removed via output 11. Set this to zero to disable the Watchdog feature.
591	40592		Seconds till Safe Values	Delay after bus-off to setting all outputs to safe values.

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DECIMAL ADDRESS	MODBUS ADDRESS	Type	VALUE DESCRIPTION	ADDRESS BLOCK EXPLANATION
600	40601	Holding Registers	output 1 scaling lower	The value here is the "bottom of range" value. Default: 0
...			...	
615	40616		output 16 scaling lower	
900	30901	Input Registers	Serial Number	Some information about the board
901	30902		Software Major Version	
902	30903		Software Minor Version	
903	30904		Hardware Revision	
904	30905		supply voltage (mV)	
905	30906		15V level (mV)	
906	30907		Returns 0	
907	30908		-5V level (mV)	
908	30909	Discrete Input	Healthy Bit	1 if card is healthy, 0 or no reply otherwise
909	30910	Input Registers	Modbus node ID	As configured by the dip-switches
910	30911		Card type	2=Satrofit Output
911	30912		Calibration status	0=uncalibrated; 1=calibrated
912	30913	Coil	Reset flag	Set to 1 on reset. Write zero to clear.

**Scaling Profiles:** Below are the scaling profiles for writing "human" values, such as volts and milliamps, directly to the card without having to set-up scaling profiles in the master controller. These are all decimal i.e. zero based Output or Holding registers (Type 06).

Profile name	Decimal address range	Scale By
Voltage 0 - 10V <-> 0 - 100%	10000 to 10015	10
Voltage 0 - 10V <-> lower - upper	10100 to 10115	1
Voltage 2 - 10V <-> 0 - 100%	10200 to 10215	10
Voltage 2 - 10V <-> lower - upper	10300 to 10315	1
Voltage 0 - 5V <-> 0 - 100%	10400 to 10415	10
Voltage 0 - 5V <-> lower - upper	10500 to 10515	1
Current 0 - 20mA <-> 0 - 100%	10600 to 10615	10
Current 0 - 20mA <-> lower - upper	10700 to 10715	1
Current 4 - 20mA <-> 0 - 100%	10800 to 10815	10
Current 4 - 20mA <-> lower - upper	10900 to 10915	1
Voltage in Volts	11000 to 11015	100
Current in milli-Amps	11100 to 11115	100



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<b>Profile name</b>	<b>Decimal address range</b>	<b>Modbus address range</b>	<b>Scale By</b>
Voltage 0 - 10V <-> 0 - 100%	3000 to 3015	43001 to 43016	10
Voltage 0 - 10V <-> lower - upper	3100 to 3115	43101 to 43116	1
Voltage 2 - 10V <-> 0 - 100%	3200 to 3215	43201 to 43216	10
Voltage 2 - 10V <-> lower - upper	3300 to 3315	43301 to 43316	1
Voltage 0 - 5V <-> 0 - 100%	3400 to 3415	43401 to 43416	10
Voltage 0 - 5V <-> lower - upper	3500 to 3515	43501 to 43516	1
Current 0 - 20mA <-> 0 - 100%	3600 to 3615	43601 to 43616	10
Current 0 - 20mA <-> lower - upper	3700 to 3715	43701 to 43716	1
Current 4 - 20mA <-> 0 - 100%	3800 to 3815	43801 to 43816	10
Current 4 - 20mA <-> lower - upper	3900 to 3915	43901 to 43916	1
Voltage in Volts	4000 to 4015	44001 to 44016	100
Current in milli-Amps	4100 to 4115	44101 to 44116	100

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## Appendix B – Specific Instructions for the North BT Commander

The instructions below are for the North Commander whereby the Modbus register is read and written to via a text string. It also contains information on the read rates and the triggering of outputs.

Object Reads and Writes are used to exchange Modbus information. The Object read rate is set-up by connecting a pulsar to the trigger with H as the number of seconds between reads.

Object writes: By setting the write trigger

**Interface Number: S** (S & Number) The interface number in the controller. Modbus needs to be selected as an interface and the details of the serial port number, baud rate and data format set-up in the Modbus module.

**Card Number: A** (A & Number) The card address

**Object Reference: f** (Letter & Number) This sets the type of command, whether it is a read or write command and whether it is analogue (a register) or a digital input (a status) or a digital output (a coil). Letters A-D from the table below are the only formats that we need to use. The number is the register listing that tells the Modbus device what input or output or internal register it wants to read/write. The **internal registers** are principally used for the scaling profiles which are the real power behind Satrofit. These allow the master controller to send "real world" values to the cards.

<i>Type</i>	<i>Meaning</i>	<i>Modbus Read Code</i>	<i>Modbus Write Code</i>	<i>Type</i>	<i>Meaning</i>	<i>Modbus Read Code</i>	<i>Modbus Write Code</i>
A	Input Status	02	n/a	K	Output Multi-Registers - 12	03	16
B	Input Register	04	n/a	L	Output Multi-Registers - 16	03	16
C	Output (Coil) Status	01	05	M	Input Multi-Registers - 1	04	n/a
D	Output Register	03	06	N	Input Multi-Registers - 2	04	n/a
E	Output Multi-Registers - 1	03	16	O	Input Multi-Registers - 3	04	n/a
F	Output Multi-Registers - 2	03	16	P	Input Multi-Registers - 4	04	n/a
G	Output Multi-Registers - 3	03	16	Q	Input Multi-Registers - 6	04	n/a
H	Output Multi-Registers - 4	03	16	R	Input Multi-Registers - 8	04	n/a
I	Output Multi-Registers - 6	03	16	S	Input Multi-Registers - 12	04	n/a
J	Output Multi-Registers - 8	03	16	T	Input Multi-Registers - 16	04	n/a

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**Value Type e:** (letter): The data type of the value we are passing. The most common one we use is C, the signed binary value.

<b>Type</b>	<b>Meaning</b>
A	Value of lowest bit of register
B	Unsigned binary value in register
C	Signed binary value in register
D	BCD value in lower nibble of register bytes
E	BCD value in both nibbles of register bytes
F	ASCII value in lower byte of register
G	ASCII value in both bytes of register
H	Unsigned binary value in lower byte of register
I	Unsigned binary value in upper byte of register
J	IEEE float stored in 2 registers

**Maths z:** (Number): This allows a multiplication to be made to the value written. The table of the available mathematical functions is below:

<b>Formula</b>	<b>Multiply</b>	<b>Add</b>	<b>Formula</b>	<b>Multiply</b>	<b>Add</b>
21	10	0	31	2	0
22	100	0	32	5	0
23	1000	0	33	0.2	0
24	10000	0	34	0.5	0
25	100000	0	35	0.05	0
26	0.1	0	36	0.005	0
27	0.01	0	37	1	0
28	0.001	0	38	1	0
29	0.0001	0	39	1	0
30	0.00001	0	40	1	0

**Example 1:** A sample message to set an analogue output on output 8 would be in the format: S2.A1.D10007.C26

S2 = interface number 2 on the master controller

A1 = Satrofit card address 1

D7 = an output register and register number 10007 is an output value between 0 and 100 which will set the output 8 voltage between 0V and 10V.

C26 = the reading is a signed binary value. B, the value for an un-signed binary value could be used because the output would never be negative. The maths function 26 is used to divide the 0-100% output as it will be transmitted as 0-1000.

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**Example 2:** To write to a digital output on output 8 we would be in the format: S2.A1.C7.A

S2 = interface number 2 on the master controller

A1 = Satrofit card address 1

C7 = an output coil (i.e. like a digital relay coil) at output 8.

A = the reading is a digital value.

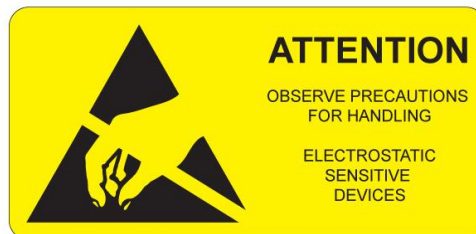
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## Appendix C: Revision History

Revision	Firmware version	Date	Description
0.1		18 <sup>th</sup> Mar 2013	Document created.
0.2		18 <sup>th</sup> Jul 2013	Scaling profiles, bottom-of-range and healthy-bit added. For firmware version 1.1.
0.3		7 <sup>th</sup> Oct 2014	Added link information and logo's
0.4		10 <sup>th</sup> Oct 2014	Updated card photo and examples.
0.5	2.09	2 <sup>nd</sup> Dec 2014	Updated formatting and new firmware to provide additional fields of data for servicing.
0.6	2.12	17 <sup>th</sup> May 2016	Updated formatting and registers tables.



Patent applied for.

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Dominion House, 2 Market Hill, Calne, Wiltshire, SN11 0BT Tel: 01249 248117

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