Guide to The Brain®
Networking Installation and Operation

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Introduction

Both Modbus and BACnet are well established protocols that are commonly used and ideally suited for connecting multiple devices in a commercial/institutional or industrial environment for monitoring and controlling applications such as heating, ventilation, and air conditioning (HVAC), lighting, access, fire alarms etc. This is largely because of their resilience when it comes to electrical interference. The Brain's® interface is designed for serial communications protocols but can be configured to communicate with a BAS (Building Automation System) using Modbus or BACnet protocols.

The following is a guide for connecting the Brain (DRV25/DRV40/DRV80) to a BAS using Modbus RTU protocol or BACnet. Please review the appropriate Brain Installation and Maintenance guide available at http://www.armstronginternational.com/brain to familiarize yourself with the product specification and installation before attempting to connect the BAS.

The Brain® Electronics Overview (DRV 40/80)

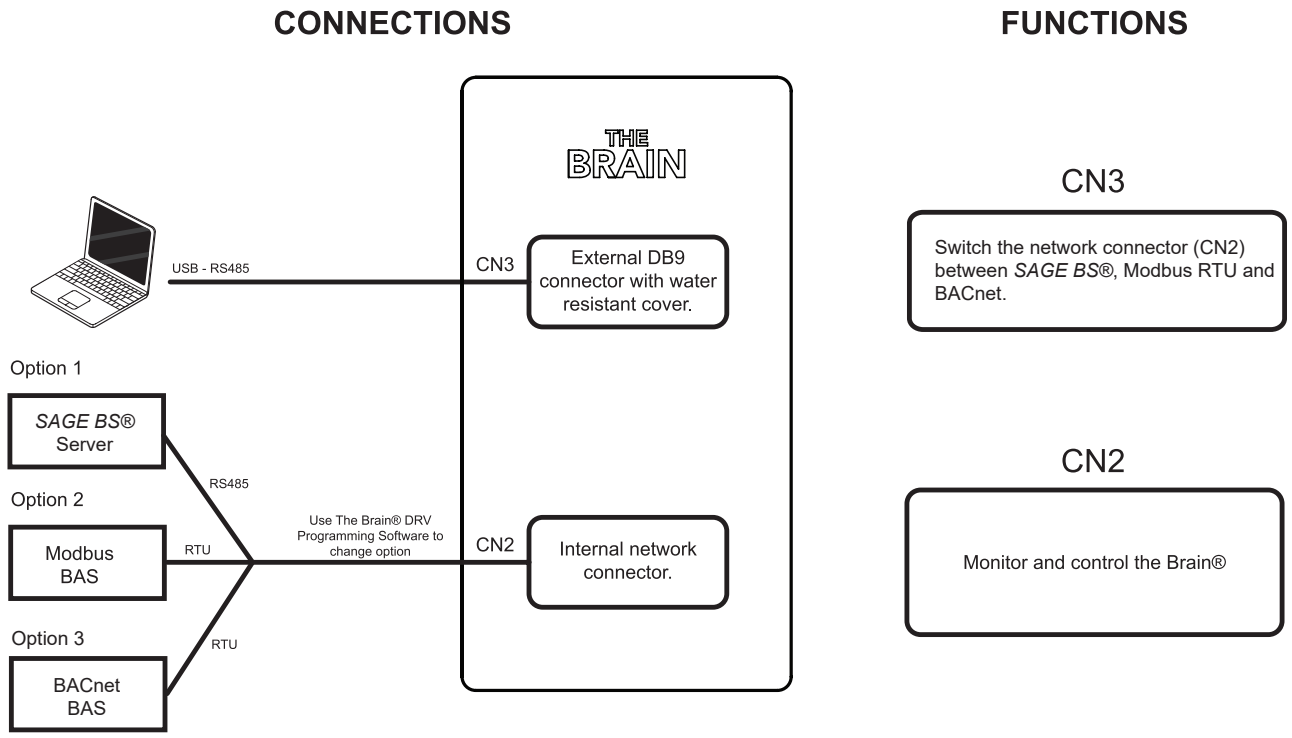

Figure 1: Functional diagram of The Brain Electronics Enclosure

CN3 is the DB9 or external debug port which can be accessed by removing the rubber plug on the side of the module.

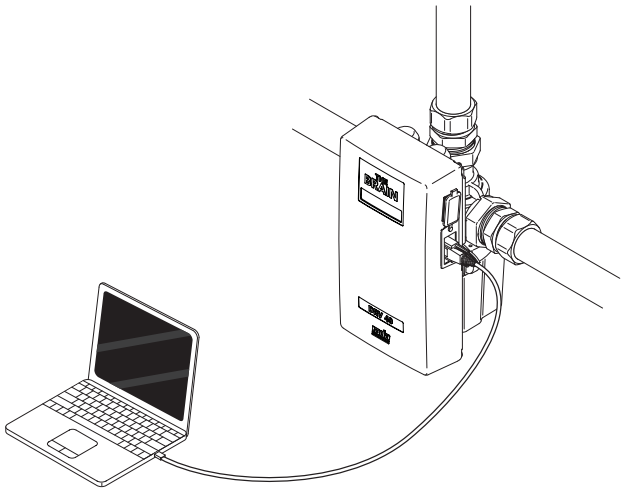

Figure 2

This connection can be used for setup, calibration, debug and diagnostics by connecting a laptop via the USB to RS485 cable and running the Brain® DRV Programming Software (available at www.armstronginternational.com/brain). This software is also used to switch the internal network connector (CN2) over from ***SAGE BS®*** to Modbus or BACnet and then set a unique network address for the valve. It can also be used to switch CN2 back to ***SAGE BS®*** if required.

CN2 is the internal network connection for the Brain®. CN2 also uses RS485, but with the option of running either the ***SAGE BS®*** protocol, BACnet or Modbus RTU protocol.

The Brain® Electronics Overview (DRV 25)

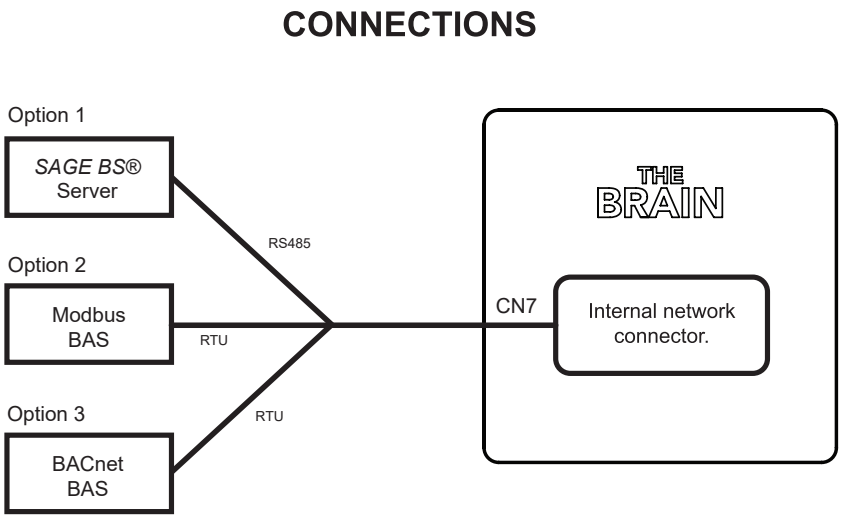

Figure 3: Functional diagram of The Brain® DRV25

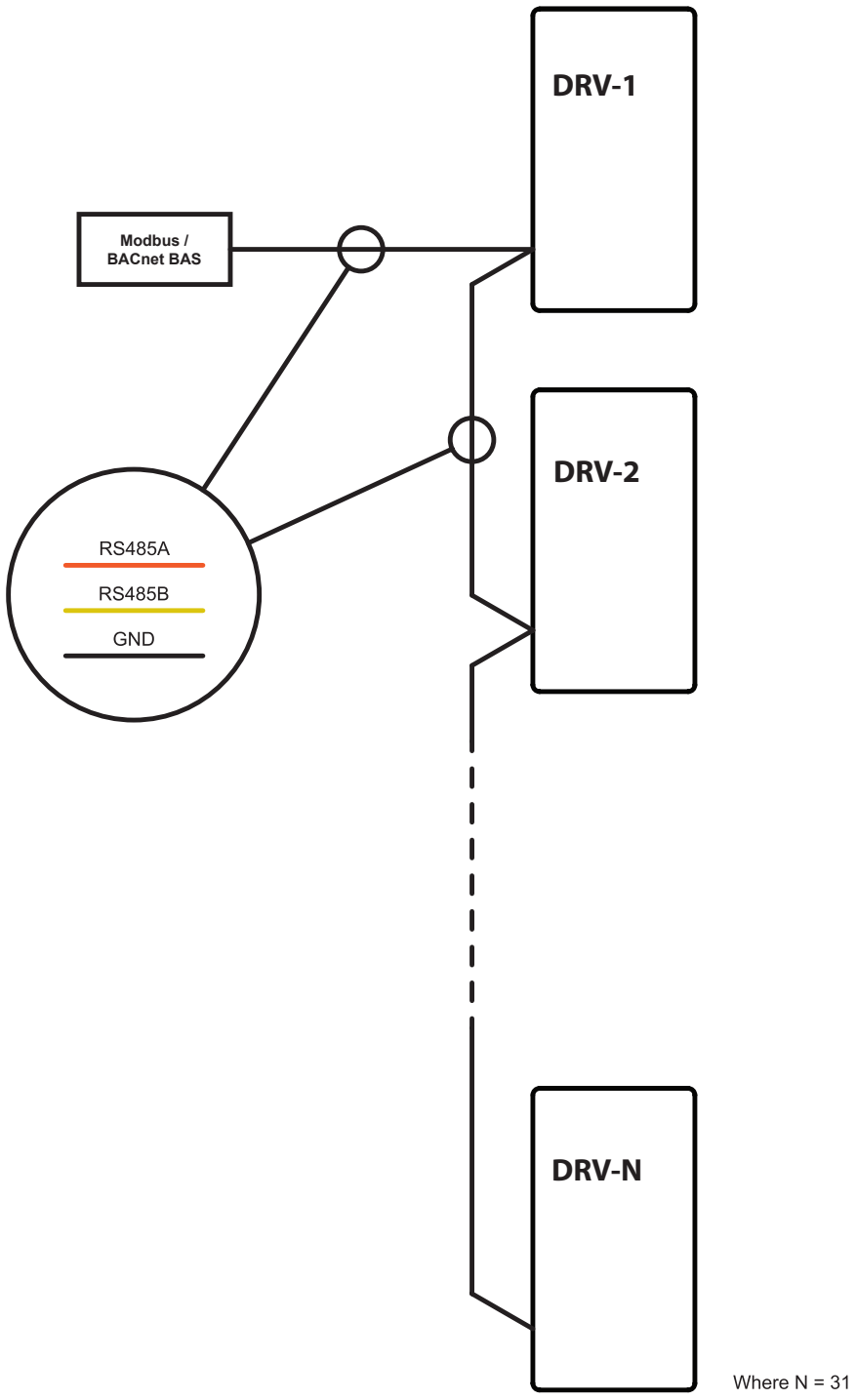

Figure 4: DRV 25/40/80 Modbus RTU

Figure 4 illustrates how a Brain® Modbus network should be arranged. For DRV40/80 the DRV Programming Software should be used first to set the valve to its unique address via CN3 connector. This should be done before the network is activated (or before each Brain® is connected to the network). The DRV25 unique address can be set via the SAGE® mobile application over a Bluetooth connection. Ensure the valve is in the OFF state before trying to set the address (DRV40/80 only).

The cable connecting to the BAS should be Cat5 twisted pair and should be in a 'daisy chain configuration'.

Wiring arrangement should be as shown above in figure 4. Do not connect in star formation (all Brains to one single point).

Connecting to the wired port (DRV40/80)

WARNING! There are high voltages on the control PCB. Ensure that the power supply to The Brain® has been isolated and that the unit has fully powered down before removing the cover to the network port.

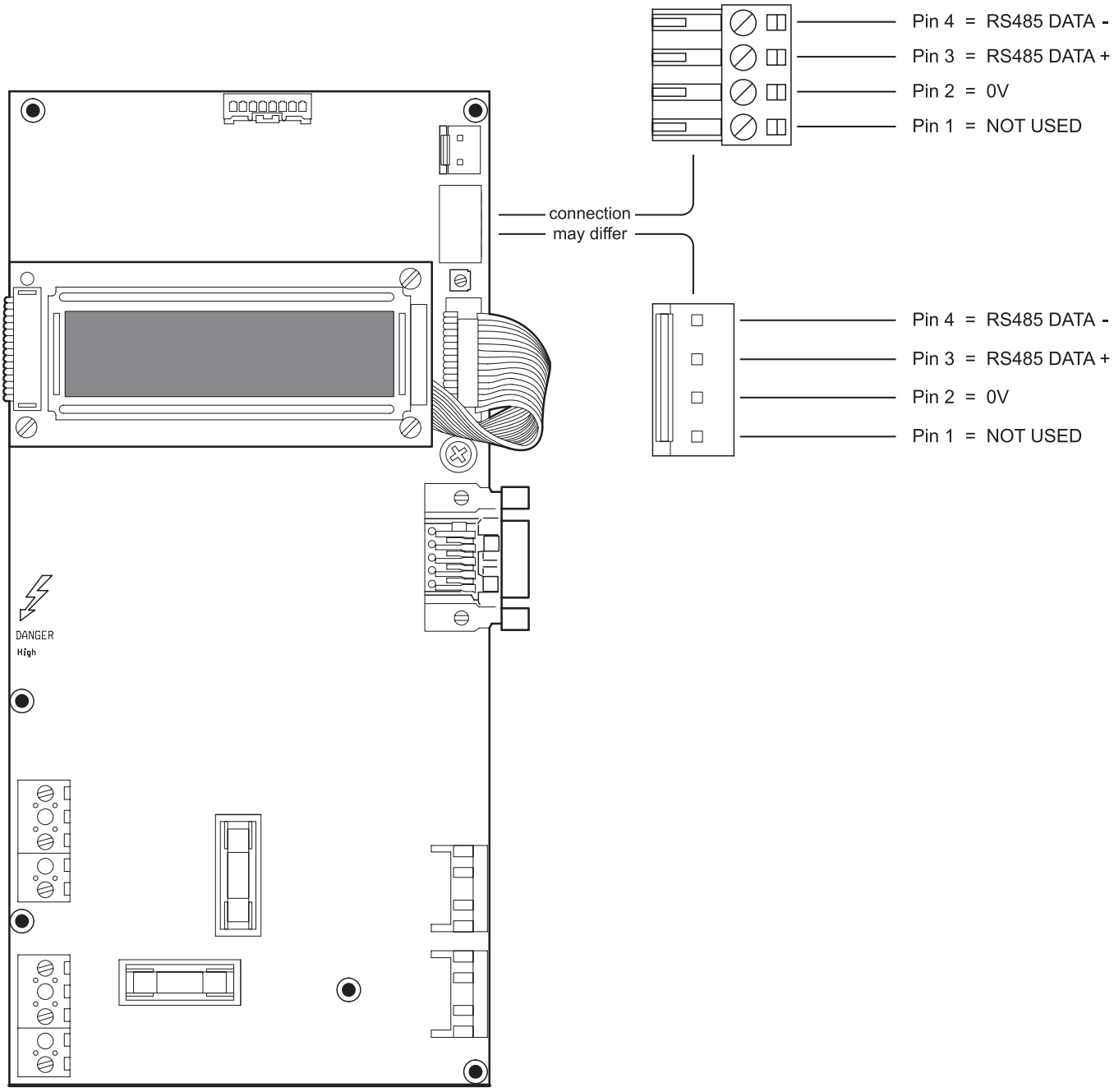

Figure 5: Modbus connector pinout

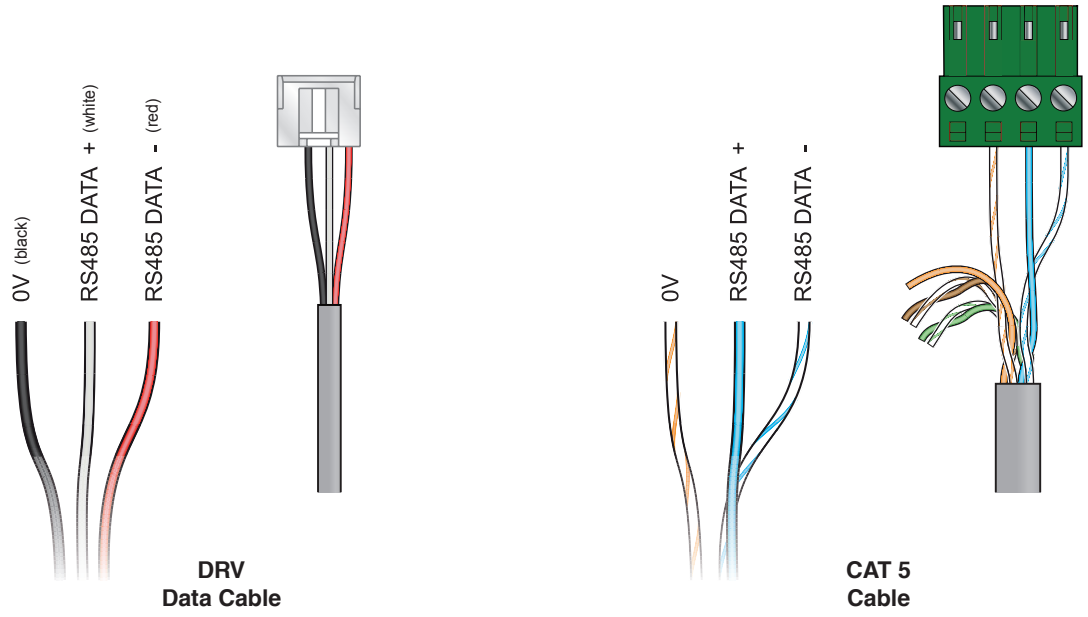

Figure 6: Recommended cable arrangement.

Figure 6 shows the connection for the DRV Data Cable or the Cat5 cable (depending upon the connector type of the DRV). The twisted pair Cat5 cable is used to minimize any signal interference.

Connecting to the wired port (DRV25)

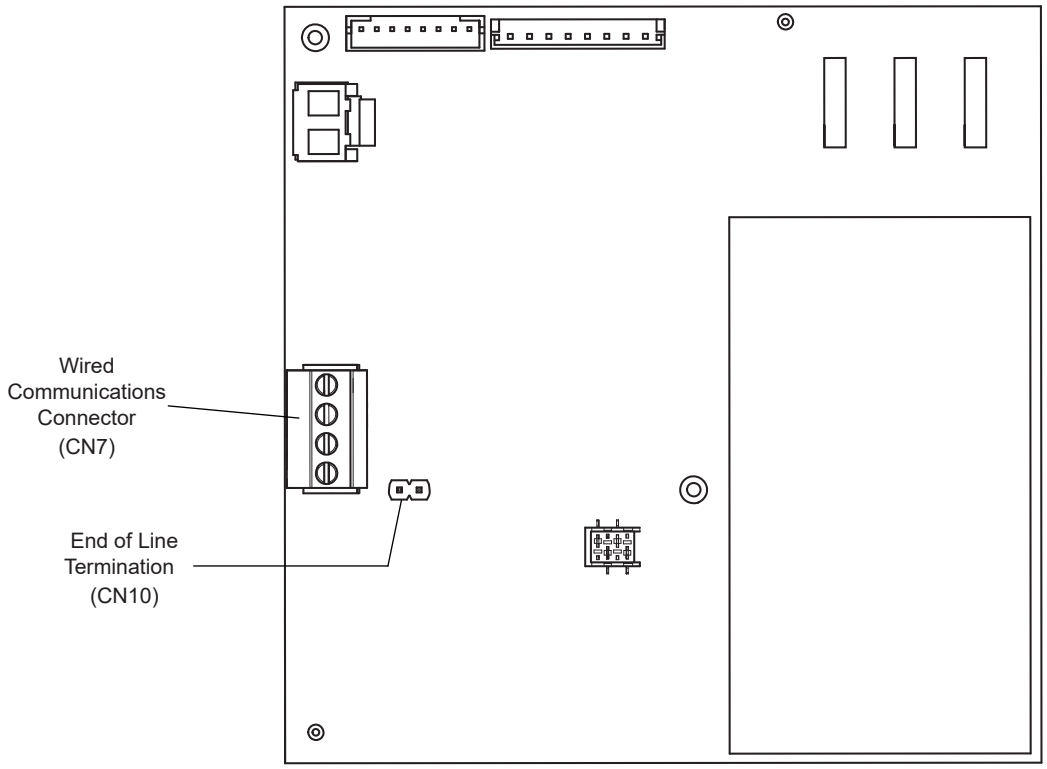

Figure 7

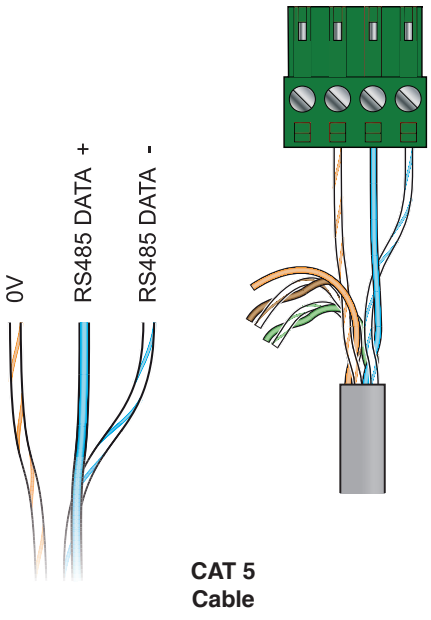

Figure 8: Recommended Cable Arrangement

An end of line termination jumper (CN10) is provided in instances where long cable distances or transmission line reflections are causing poor/unreliable connections. If necessary, fit a jumper across the pins to connect the provided termination resistor into the circuit.

The DRV 25/40/80 functional overview

The DRV product is a micro-processor-controlled recirculation valve specifically designed to be used in warm water systems. Hot and cold water is mixed to produce blended water at a setpoint stored in the configuration software of the valve.

In order to do this effectively it has 3 temperature sensors that constantly monitor the hot inlet, cold inlet and outlet (blended) temperatures. The DRV product is designed to maintain the water temperature automatically at the chosen setpoint however, for safety; provision is made to generate various alert and error conditions should the outlet temperature fall outside certain operating parameters:

High / Low Temperature Alerts (DRV 40/80 only)

Should the outlet temperature increase or decrease to outside the setpoint range,

An alert condition will be shown on the DRV 40/80's display. There is also the option to trigger a relay which can be linked to an auxiliary alarm. The valve will continue to operate normally during an alert condition.

Error Temperature (DRV 25/40/80)

Should the outlet temperature exceed this threshold, an error condition will be shown on the DRV40/80s display or in the case of the DRV25 the error will be displayed on the mobile application. An error condition will also trigger a relay which can be linked to an auxiliary alarm. For safety, the DRV product will drive to the full cold position and remain there until the power is cycled off/on.

Disinfection (Modbus only)

The DRV product has a disinfection feature which can be used to run full hot water to all outlets in order to clear bacteria from the plumbing system (and the outlet fittings as required). To use the disinfection feature, certain parameters must be defined and set within the DRV products software. For a remote monitoring system (BAS), this involves writing a specific set of registers in the correct sequence. This is described in the section 'The DRV Product Programming Sequence'.

Modbus Programming

The BAS software will need to be using Modbus RTU (Remote Terminal Unit) format in order to communicate with the Brain®.

START	ADDRESS	FUNCTION	DATA	CRC	END
3.5 Ch idle	8 bits	8 bits	N x 8 bits	16 bits	3.5 Ch idle
At least 3.5 character times of silence (MARK condition)	Station (RTU) Address	Function codes (E.g. Read coils / inputs)	Message data (length will depend on message type)	Error check	At least 3.5 character times of silence between frames

Figure 9: Modbus RTU format

Communications Standard

- Baud Rate 9600
- Parity None
- Data bits 8
- Stop Bits 1
- Mode RTU

Modbus Functions Supported

- Read Holding Registers (0x03)
- Write Single Register (0x06)
- Write Multiple registers (0x10)

Modbus Error Codes

- Illegal Address (Write Error 2) - Returned if the read or write register address is outside the address range.
- Legal Data (Write Error 3) - Returned if the data being written to the register is outside the bounds for that register or the valve is not configured to accept such data.
- Slave Failure (Write Error 4) - Returned if the connected DRV cannot be identified.

General Data Description

The valve data is divided as follows:

- Prime data section: Registers 1 through 11 - This is active data and represents the actual status of the valve.
- Commands: Registers 306 through 314 - Logic commands used to instruct the valve into different modes e.g. reboot, thermal disinfection.
- Configuration and Log Data: Registers 23 through 464 - This data is typically stored in non-volatile memory within the valve. Configuration data is used to control the DRV. Log data is also stored for various data and usage logging/error recording.

The DRV acts as the Modbus slave unit or RTU and keeps its registers synchronised with the internal database. Following a successful write command, the DRV internal database is updated with new settings/values. At least 5 seconds should be allowed between Modbus writes and subsequent reads to allow adequate time for the microprocessor to handle the command/ requests as well as physical mechanical movement of parts to complete in response to the request.

Table 1: Modbus Registers for the DRV

● Supported ● Not supported

Reg	Description	Read/Write	Units	DRV25	DRV40 DRV80
0	Unit Address	RO	Address 1 - 31	●	●
1	Setpoint Temperature	R/W	0.1 Deg C	●	●
4	Valve Status	R/W	Enumeration 2	●	●
6	Valve Outlet Temperature	RO	0.1 Deg C	●	●
8	Valve Error Code	RO	Enumeration 1	●	●
10	Hot Inlet Temperature	R/W	0.1 Deg C	●	●
11	Cold Inlet Temperature	R/W	0.1 Deg C	●	●
23	Disinfection Target Temperature/ Setpoint	R/W	0.1 Deg C	●	●
106	Valve Serial Number 1.2	RO	Serial Number	●	●
107	Valve Serial Number 2.2	RO	Serial Number	●	●
108	Date and Time of Manufacture	RO	Date / Time (Long)	●	●
109	Date and Time of Manufacture	RO	Date / Time (Long)	●	●
110	Valve Firmware Type Number	RO	Integer	●	●
111	Valve Firmware Version Number	RO	Integer	●	●
112	Valve Configuration ID	RO	Integer	●	●
113	Valve Configuration Version	RO	Integer	●	●
114	Adaptor (Bluetooth) Firmware Type	RO	Date/Time (Long)	●	●
115	Adaptor (Bluetooth) Firmware Type	RO	Integer	●	●
116	Date/Time of Commissioning 1.2	R/W	Date/Time (Long)	●	●
117	Date/Time of Commissioning 2.2	R/W	Date/Time (Long)	●	●
121	Number of Valve Operations 1.2	RO	Number (Long)	●	●
122	Number of Valve Operations 2.2	RO	Number (Long)	●	●
123	Total Valve On Time 1.2	RO	Minutes	●	●
124	Total Valve On Time 2.2	RO	Minutes	●	●
127	ID of Valve Service Engineer	RO	Integer	●	●
128	Hours Valve Has Been Unused 1.2	RO	Hours	●	●
129	Hours Valve Has Been Unused 2.2	RO	Hours	●	●
139	Valve Identity/Location 1.16	R/W	String	●	●
140	Valve Identity/Location 2.16	R/W	String	●	●
141	Valve Identity/Location 3.16	R/W	String	●	●
142	Valve Identity/Location 4.16	R/W	String	●	●
143	Valve Identity/Location 5.16	R/W	String	●	●
144	Valve Identity/Location 6.16	R/W	String	●	●
145	Valve Identity/Location 7.16	R/W	String	●	●
146	Valve Identity/Location 8.16	R/W	String	●	●
147	Valve Identity/Location 9.16	R/W	String	●	●
148	Valve Identity/Location 10.16	R/W	String	●	●
149	Valve Identity/Location 11.16	R/W	String	●	●
150	Valve Identity/Location 12.16	R/W	String	●	●
151	Valve Identity/Location 13.16	R/W	String	●	●
152	Valve Identity/Location 14.16	R/W	String	●	●
153	Valve Identity/Location 15.16	R/W	String	●	●

Table 1: Modbus Registers for the DRV Continued

Reg	Description	Read/Write	Units	DRV25	DRV40 DRV80
154	Valve Identity/Location 16.16	RW	String	●	●
155	Hours Since Last Disinfection	RO	Hours	●	●
156	Last Completed Disinfection Time & Date 1.2	RO	Date/Time (Long)	●	●
157	Last Completed Disinfection Time & Date 2.2	RO	Date/Time (Long)	●	●
159	Last completed Disinfection Result	RO	Logic	●	●
288	Real Time Clock Setting 1.2	R/W	Date/Time (Long)	●	●
289	Real Time Clock Setting 2.2	R/W	Date/Time (Long)	●	●
306	Arm Disinfection Command	WO	Command; Value Must = x6172	●	●
307	Trigger Disinfection Command	WO	Command; Value Must = x5452	●	●
308	Abort Disinfection Command	WO	Command; Any Value	●	●
309	Soft Valve Reset Command	WO	Command; Value Must = x1	●	●
314	Disinfection Cool down	WO	Command; Any Value	●	●
400	DRV Serial Line Address	R/W	Logic 0 = Standard 1= Alternate	●	●
401	Disinfection Enable	R/W	X00 = Disable, X40 = Enable	●	●
402	Disinfection Timeout	R/W	Minutes	●	●
403	High Alert	R/W	0.1 Deg c	●	●
404	Low Alert	R/W	0.1 Deg C	●	●
405	Error Temperature	R/W	0.1 Deg C	●	●
406	Relay Active	R/W	Logic 1=on 0=off	●	●
407	Offset Temperature	R/W	0.1 Deg C	●	●
408	Valve Temperature Units (F/C)	R/W	Logic 1= C 0= F	●	●
409	DRV Maximum Setpoint	R/W	0.1 Deg C	●	●
410	DRV Minimum Setpoint	R/W	0.1 Deg C	●	●
411	DRV Default Setpoint	R/W	0.1 Deg C	●	●
412	DRV Spare/Remote Thermistor 1	RO	0.1 Deg C	●	●
413	DRV Default Setpoint Thermistor 2	RO	0.1 Deg C	●	●
433	Reset Usage Logs Command	WO	Any	●	●
434	Reset Error Logs	WO	Any	●	●
435	Error 1 Code	RO	Enumeration 1	●	●
436	Date/Time Of Error 1(1.2)	RO	Date/Time (Long)	●	●
437	Date/Time Of Error 1 (2.2)	RO	Date/Time (Long)	●	●
438	Error 2 Code	RO	Enumeration 1	●	●
439	Date/Time Error 2 (1.2)	RO	Date/Time (Long)	●	●
440	Date/Time Error 2 (2.2)	RO	Date/Time (Long)	●	●
441	Error 3 Code	RO	Enumeration 1	●	●
442	Date/Time Error 3 (1.2)	RO	Date/Time (Long)	●	●
443	Date/Time Error 3 (2.2)	RO	Date/Time (Long)	●	●
444	Error 4 Code	RO	Enumeration 1	●	●
445	Date/Time Error 4 (1.2)	RO	Date/Time (Long)	●	●
446	Date/Time Error 4 (2.2)	RO	Date/Time (Long)	●	●
447	Error 5 Code	RO	Enumeration 1	●	●

Reg	Description	Read/Write	Units	DRV25	DRV40 DRV80
448	Date/Time Error 5 (1.2)	RO	Date/Time (Long)	●	●
449	Date/Time Error 5 (2.2)	RO	Date/Time (Long)	●	●
450	Error 6 Code	RO	Enumeration 1	●	●
451	Date/Time Error 6 (1.2)	RO	Date/Time (Long)	●	●
452	Date/Time Error 6 (2.2)	RO	Date/Time (Long)	●	●
453	Error 7 Code	RO	Enumeration 1	●	●
454	Date/Time Error 7 (1.2)	RO	Date/Time (Long)	●	●
455	Date/Time Error 7 (2.2)	RO	Date/Time (Long)	●	●
456	Error 8 Code	RO	Enumeration 1	●	●
457	Date/Time Error 8 (1.2)	RO	Date/Time (Long)	●	●
458	Date/Time Error 8 (2.2)	RO	Date/Time (Long)	●	●
459	Error 9 Code	RO	Enumeration 1	●	●
460	Date/Time Error 9 (1.2)	RO	Date/Time (Long)	●	●
461	Date/Time Error 9 (2.2)	RO	Date/Time (Long)	●	●
462	Error 10 Code	RO	Enumeration 1	●	●
463	Date/Time Error 10 (1.2)	RO	Date/Time (Long)	●	●
464	Date/Time Error 10 (2.2)	RO	Date/Time (Long)	●	●

The DRV Programming Sequence

Set **Reg 4** to **OFF** before adjusting any of the following registers:

Reg 400-411

Set **Reg 4** back to **ON**

All other registers can be set without setting **Reg 4** to OFF.

IMPORTANT!
The disinfection feature has a specific sequence as all Alerts and Errors are disabled temporarily while hot water is flushed through the DRV. Please read the following section on setting up the disinfection sequence carefully.

The DRV 25/40/80's disinfection feature is a manual process and for safety reasons must be monitored constantly.

Enabling Disinfection Feature

In order to enable the Disinfection feature for use, the following registers must be set up when the DRV is configured:

Reg 23 Disinfection Temperature (Minimum: DRV maximum setpoint temperature. Maximum: 99.9 deg C). Specifies the outlet temperature which the disinfection cycle will aim to achieve.

Reg 401 Set to **enable** the disinfection feature to be used.

Reg 402 Disinfection Timeout in minutes (max 1800).
The Disinfection Timeout is the number of minutes the temperature alert and error displays are disabled to allow for disinfection and cool down of the blend circuit before switching back to automatically. (See **DRV product manual** for full details of disinfection and how to determine a reliable Disinfection Timeout period.)

Triggering Disinfection Sequence

Each time a disinfection cycle is to be run the following sequence must be used:

1. **Reg 306** To **Arm** the disinfection cycle (set to x6172)

2. **Reg 307** To **Trigger** the disinfection cycle (set to x5452 within 10 seconds else DRV will clear **Arm** status)

3. Any attempt to write to registers **306** or **307** in the wrong sequence will result in an error response from the DRV.

Stopping Disinfection

Reg 314 Cool Down (normally be used to end the sequence – this will switch the DRV to the full cold position to allow the temperature of the blend circuit to be reduced to a safe level) - Set to any value e.g. x1.

Reg 308 Abort (Must be able to activate at any stage of the sequence. Emergency stop, DRV immediately re-enables temperature alert and error displays. If the cycle is at full hot, the DRV switches to full cold and displays Error Temp. Cycle the power off / on to reset the DRV, make sure the blend circuit is at a safe temperature before allowing any outlets to be used). Set to any value e.g. x1.

BACnet Programming

Communications Standard

1. Baud rate: 9600bps, 19200bps, 38400bps, 76800bps (configurable via SAGE® mobile app or PC configuration tool (DRV40/80 only), Modbus 9600bps only)
2. Parity None
3. Data bits 8
4. Stop Bits 1

Property Name	Units	Type	Read/Write	Description	Configurable Range
OutTemp	°F	Analog Input	Read Only	The DRV outlet temperature reading	N/A
ValErCode	Enum 1	Analog Input	Read Only	The current DRV error code	Refer to table below
HotInTemp	°F	Analog Input	Read Only	The hot inlet temperature recorded by the DRV	N/A
CldInTemp	°F	Analog Input	Read Only	The cold inlet temperature recorded by the DRV	N/A
FwTypeNum	Integer	Analog Input	Read Only	The firmware type code installed on the DRV PCBA	N/A
FwVerNum	Integer	Analog Input	Read Only	The firmware version installed on the DRV PCBA	N/A
ValStatus	Enum 2	Analog Value	Read/Write	The DRVs current status. Only certain states can be written	Refer to table below
DfStPtTmp	°F	Analog Value	Read/Write	The default setpoint temperature of the DRV – this will be the temperature the DRV attempts to control to after a power cycle.	78.8 – 185 °F
UnitAddr	Integer	Analog Value	Read/Write	The BACnet unit address of the DRV	1 - 127

Table 2: DRV25 BACnet Properties

Enumeration Details

Enumeration 1 - Valve Error Codes

0 = NO ERROR
1 = OVER TEMPERATURE
2 = STUCK MOTOR
3 = MOTOR CALIBRATION
4 = VALVE FAILURE
5 = THERMISTOR FAILURE
6 = UNCONFIGURED
7 = A TO D ERROR
8 = RAM ERROR
9 = EE ERROR
10 = FLASH ERROR
11 = ALGORITHM ERROR
12 = CONTROLLER ERROR
13 = BATTERY ERROR
14 = SCHEDULER ERROR

Enumeration 2 - Valve Status

0 = OFF - R/W
1 = ON - R/W
2 = FULL COLD - R/W
6 = DISINFECTION - RO
7 = ERROR - RO

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