Intelligent Leak Detector System

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Table of Contents

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1. Introduction

The Deeter Intelligent Leak Detector System comprises a leak controller in a DIN-rail enclosure and a set of leak sensors in small, floor-mounting ABS enclosures. Sensors are connected to the controller in a daisy-chain arrangement using 4-core cable.

The controller can identify sensors based on their position in the chain and can thereby provide information about the location of a leak.

The maximum number of sensors in a system is dependent on cable lengths. Up to 40 sensors can be used in a system with 30m of cabling between each. For shorter cables the absolute maximum number of sensors is 80. The maximum length of cable between sensors is approximately 200m.

The controller has a display and three push-button switches to enable the user to access option menus and select from a variety of programmable features. During normal operation the display shows system status or the identity of any leaks.

The controller has the following process outputs:

- Two SPDT relays for direct control of pumps, valves or alarms
- An open-collector transistor for connection to a programmable logic controller (PLC), building management system (BMS) or for indirectly driving further valves or pumps via an external relay.
- An RS485 serial communications port for remote setup and monitoring.

Three communication protocols are supported: Modbus RTU *(optional)*, Modbus ASCII *(optional)* and a simplified ASCII protocol *(standard).*

The controller is capable of detecting system faults such as a broken cable or shorted wires. Outputs can be assigned to respond to faults or to leaks.

Outputs assigned to leaks can be further assigned to respond to any leak, a leak within a group of sensors, or to a leak at an individual sensor.

The controller has a variety of power supply options, with separate inputs for mains-voltage supplies and low-voltage supplies. There are two versions of controller, one for 210-250Vac supplies (UK version) and another for 105-130Vac supplies (US version). Both versions can be powered from 8-24Vac or 10-32Vdc through the low-voltage supply terminals.

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2. Controller

The Leak Controller is housed in a UL94-V0 flame retardant case that fits to a standard 35mm 'top-hat' section DIN rail.

2.1 Controller Electrical Connections

All electrical connections are via two rows of screw terminals – see Figure 1.

The bottom row, with screw terminals on a 5mm pitch, is used for extra-low-voltage (ELV) connections – less than 50V.

The bottom left group of four terminals connect to the sensor chain, with two wires for power and two for communications. The sensor supply is 5V and is current-limited to 150mA. If this load is exceeded, the supply will switch off and a fault will be indicated by the controller. The 5V output will recover unharmed once the overload is removed.

The next group of three terminals are associated with the transistor output. A regulated 5V supply is provided for powering external devices. This supply is limited to 50mA and will recover automatically from an overload.

The transistor output is an NPN open-collector and requires a pull-up in the off state, with maximum pull-up voltage of 40V. In the on state the transistor will sink up to 50mA to the 0V rail and is protected from overload or short-circuit. A transient voltage suppressor must be fitted externally if the transistor is used for switching an inductive load.

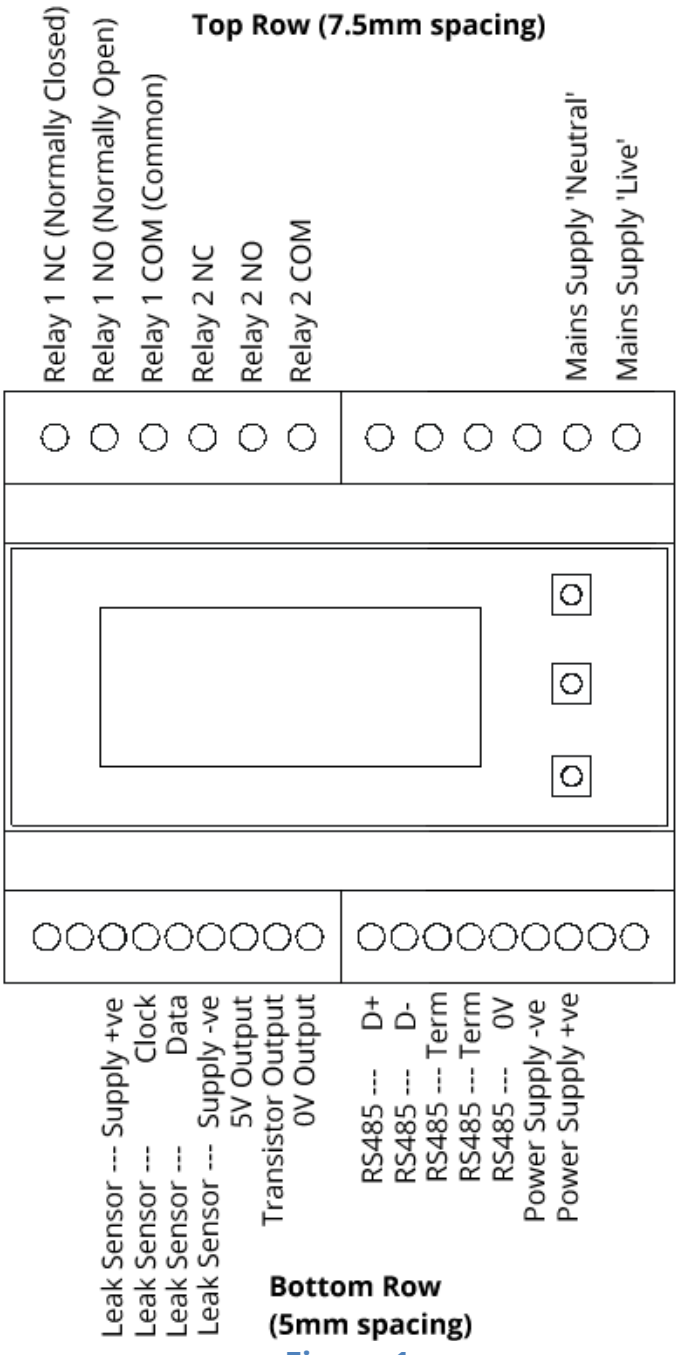

Figure 1

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The RS485 serial communications port is half-duplex, using the balanced-pair lines D+ and D-. A line-termination resistor can be enabled by linking the two connectors labelled TERM together. This will reduce data-line reflections and may be required for improved communications reliability. The 0V terminal should be connected to the 0V terminal of the other communicating device in order to limit common-mode voltages at the receiver and improve communications reliability.

See section 7 for details of the communications protocols, commands and responses.

Terminals along the top row are on a 7.5mm pitch. The relay connections have a current rating of 6A at 250VAC and may be used for switching either mains voltages or lower voltages. When switching inductive loads at any voltage, an external transient suppressor must be fitted to protect the relay contacts.

There are two pairs of power supply terminals, a mains-voltage pair on the top row and an extra-low-voltage pair on the bottom row. Connect to one pair only**.**

Two versions of the Controller are available, one for 230VAC supplies, the other for 120VAC supplies. An anti-surge fuse limits the mains supply current – 32mA for 23VAC, 100mA for 120VAC.

The ELV supply terminals will accept AC voltages from 8V to 24V, or DC voltages between 10V and 32V. The supply is protected by a 500mA anti-surge fuse accessible by removing the right-hand screw terminal cover. Normal maximum supply current is approximately 200mA.

Where mains voltages are used, either as power source or switched by the relays, the DIN rail enclosure of the controller must be fitted within another enclosure to prevent accidental exposure to mains voltages.

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3. Sensors

Leak sensors are housed in ABS enclosures rated to IP65 and have a pair of stainless steel sensing probes protruding through the underside. The probes will detect 'normal' water to a depth of about 1mm. They will detect other conducting fluids or purer water, but may require greater depth of contact with the liquid. To achieve even greater contact for poorly conducting liquids, or to enable the probes to reach further, they can be extended using M3 threaded spacers.

If required, sensors can be fixed in position using two holes located under the lid. Fixing screws are hidden by the lid and do not compromise the enclosure IP rating.

A blanking plug is provided with each controller to seal the spare cable gland in the final sensor of the chain.

3.1 Sensor Electrical Connections

Sensors are linked in a daisy-chain configuration using 4-core cable. The two sets of 4-way screw terminals are offset from the centre of the enclosure to help with identification. With the connectors offset to the right (as shown in Figure 2) the top connector goes to the controller or the next sensor closer to the controller, and the bottom connector goes to the next sensor further down the chain.

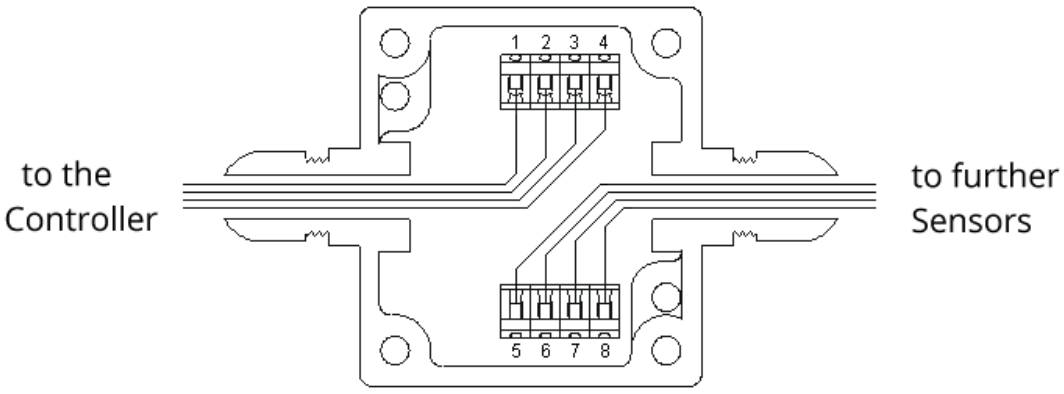

Figure 2

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Table 1 shows sensor electrical connections. The screw terminals for the first column are shown in Figure 1 and screw terminals for the sensor are indicated in Figure 2.

Table 1

Function	To-the-controller Terminal	To-further-sensors Terminal
Supply +ve	1	5
Clock	2	6
Data	3	7
Supply –ve	4	8

The maximum cable length between sensors is approximately 200m. For cable runs greater than 200m, extra sensors can be added to act as signal repeaters.

Please note that although wiring fault conditions will be detected automatically, in the unlikely event of a sensor failure there may be no indication of a fault. All sensors should therefore be tested periodically to confirm that they operate by placing the probes in the liquid they are required to detect.

4. Operator Controls

The top panel of the controller has three push-buttons and a 2-line by 16-character display to enable the operator to perform setup tasks and observe system status.

The three buttons have the following symbols to indicate their function:

Table 2

SYMBOL	FUNCTION
∧	UP
∨	DOWN
↵	ENTER

The display has a backlight which comes on for 20 seconds after power-up and for 20 seconds after any button press. It will remain on while a leak is detected, while any outputs are latched or during any fault condition.

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5. Operating States

5.1 Power-up

The display shows the firmware version for 5 seconds at power-up, then progresses to either quiescent, leak or fault states.

```
LEAK CONTROLLER
V1.01
```

5.2 Quiescent State

When there are no leaks or faults the display will show the number of sensors. All outputs will be in their inactive state – open or closed depending on their normally-off and normally-on settings (see section 6.2.1)

```
SYSTEM DRY
15 SENSORS
```

5.3 Single Leak

When a single leak is detected, the display shows the sensor number for the leak. Sensor numbers start from 1, closest to the controller.

Outputs assigned to leaks will change to their active state, subject to the range options.

```
LEAK AT SENSOR
12
```

5.4 Multiple Leaks

When there are several leaks, the display shows the number of leaks on the top line.

```
3 LEAKS                    ^
1 @ SENSOR 10              v
```

Press UP to scroll through a list of wet sensors. DOWN will scroll back down through the list. The number on the bottom left of the display indicates the position in the list (1 to 3 in the example above); the number on the right is the sensor number and hence location of the leak.

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5.5 Latched Outputs

Outputs can be assigned to follow or latch. An output set to follow will become active with a leak and return to inactive when the leak has cleared. Outputs set to latch will activate with a leak and remain active when the leak has cleared.

If any outputs are latched, a display similar to the following will be seen:

```
LATCHED:  R1  R2  T
    15 SENSORS
```

The top row indicates which outputs are latched. In this example all three outputs, relay 1 (R1), relay 2 (R2) and the transistor (T) are active.

Latches can be reset by pressing the ENTER button or via a communications command. When latches are cleared the controller returns to the quiescent state.

5.6 Fault Conditions

The number of sensors in the system is entered in a setup menu. If a cable is accidently cut or wires are shorted together, the number of sensors seen by the controller will not match and the controller will display the following fault screen:

```
      FAULT:  15
SENSOR COUNT  10
```

The top line shows the number of sensors expected and the bottom line the number detected.

Outputs assigned to faults will go to their active state and outputs assigned to leaks will go to their inactive state.

To find the fault, look for a shorted wire, loose screw-terminal connection or cut cable. In the example shown, five sensors are missing and the fault is therefore likely to be between sensors 10 and 11.

This fault will clear automatically once the sensor count matches the setup number.

If the 5V supply to the sensor chain is overloaded, the following display will appear:

```
      FAULT:
SENSOR WIRING
```

Outputs assigned to faults will go to their active state and outputs assigned to leaks will go to their inactive state.

This fault will clear automatically once the 5V output current returns to normal.

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6. Option Menus

Option menus are accessed from any operating state by pressing and holding the ENTER button for 3 seconds.

Menus are organised into levels, with all top-level menus indicated by the enter symbol ↵

SET NUMBER OF SENSORS ↵
RELAY 1 ASSIGNMENT ↵
RELAY 2 ASSIGNMENT ↵
TRANSISTOR ASSIGNMENT ↵
OUTPUT TEST MODE ↵
COMMUNICATION SETTINGS ↵
EXIT ↵

Pressing UP or DOWN will cycle through the top-level menus and ENTER will select a sub-menu. ENTER pressed from the EXIT menu will return to normal operation.

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6.1 Set Number of Sensors

N	U	M	B	E	R		O	F							^
S	E	N	S	O	R	S	:				1	5			v

Press UP to increment the number of sensors, DOWN to decrement and ENTER to save the new number and return to the top level menu.

6.2 Relay and Transistor Assignments

All three outputs have the same set of assignment options. The following descriptions and examples are for Relay 1, but equivalent sub-menus are available for Relay 2 and the Transistor output. To help navigate multiple sub-menus, a sub-menu level indication is shown in the top left of the display.

6.2.1 Normally-Off/Normally-On Assignment

'Normal' refers to the inactive state when there are no leaks or faults detected.

1					R	E	L	A	Y		1				
			N	O	R	M	A	L	L	Y		O	F	F	

1					R	E	L	A	Y		1				
			N	O	R	M	A	L	L	Y		O	N		

Press UP or DOWN to toggle between options and ENTER to advance to the next sub-menu.

Although both relays have normally-open (NO) and normally-closed (NC) terminals, this first sub-menu provides options for fail-safe operation when taking into consideration the fact that relays will be off when power is removed from the controller. The full range of relay states is shown in Table 3.

Table 3

Power	Output Setting	Active State	Output State	NO Contacts	NC Contacts
Off	-	-	Off	Open	Closed
On	Normally off	Off	Off	Open	Closed
On	Normally off	On	On	Closed	Open
On	Normally on	Off	On	Closed	Open
On	Normally on	On	Off	Open	Closed

Throughout this document the terms 'active state' and 'inactive state' refer to an output's response to a leak or fault condition. The output state is not defined without knowledge of the normally-on/normally-off assignment.

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6.2.2 Leak/Fault Assignment

The second sub-menu assigns an output to either a leak or fault condition.

Press UP or DOWN to toggle between options. If FAULT is selected, there are no further sub-menus and ENTER returns to the top-level menu. Otherwise, ENTER advances to the next sub-menu.

6.2.3 Follow/Latch Assignment

The third sub-menu enables the output to follow or latch. Latching outputs remain active after a leak has cleared and require a button-press or serial communications command to be reset.

Press UP or DOWN to toggle between options and ENTER to advance to the next sub-menu.

6.2.4 Any/Range Assignment

ANY means the relay becomes active if any sensor detects a leak. RANGE allows a selection of sensors with consecutive numbers to be assigned to an output.

Press UP or DOWN to toggle between options. If ANY is selected there are no further sub-menus and ENTER returns to the top-level menu. Otherwise, ENTER advances to the next sub-menu.

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6.2.5 Range Setting

5					R	E	L	A	Y		1					^
		R	A	N	G	E	:		1	4	-	1	5			v

A cursor will initially underline the left number. This is the lower end of the range and can be incremented or decremented using UP and DOWN buttons.

Pressing ENTER moves the cursor to the right-hand number which can then be adjusted using UP and DOWN to set the upper end of the range. Pressing ENTER again returns to the top-level menu. A single sensor can be selected by making the upper and lower sensor numbers equal.

6.3 Output Test Mode

A test mode is provided to help with installation or to diagnose any output problems.

R	l	y	1			R	l	y	2			T	r			
O	N					O	F	F				O	F	F		

UP and DOWN buttons toggle the output indicated by the underscore cursor. ENTER selects the next output, and after the transistor output, exits back to the option menus.

6.4 Communication Settings

6.4.1 Baud Rate

Four baud rate settings are available: 2400, 9600, 19200 and 38400.

			B	A	U	D		R	A	T	E					^
					1	9	2	0	0							v

UP and DOWN buttons cycle through the available baud rates. ENTER changes the baud rate setting and either returns to the option menu (*standard version*) or advances to the Comms Protocol menu *(optional).*

Other serial port settings are fixed to 8 data bits, no parity bit and 1 stop bit.

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6.4.2 Communications Protocol

(This menu is not available in the standard version)

Three serial RS485 communications protocols are available: Modbus RTU, Modbus ASCII and a proprietary protocol labelled DeeterLeak ASCII.

	C	O	M	M	S		P	R	O	T	O	C	O	L		
D	E	E	T	E	R	L	E	A	K		A	S	C	I	I	

	C	O	M	M	S		P	R	O	T	O	C	O	L		
		M	O	D	B	U	S		A	S	C	I	I			

	C	O	M	M	S		P	R	O	T	O	C	O	L		
			M	O	D	B	U	S		R	T	U				

UP and DOWN buttons cycle between options. If DEETERLEAK ASCII is selected, ENTER returns to the option menu. If a MODBUS option is selected, ENTER proceeds to the Modbus Address menu.

6.4.3 Modbus Address

M	O	D	B	U	S		A	D	D	R	E	S	S			^
0	0	5														v

UP and DOWN buttons are used to select an address within the decimal range 001 to 247. ENTER saves the Modbus address to non-volatile memory and returns to the option menu.

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7. RS485 Serial Communications

The RS485 serial communications port is half-duplex, using the balanced-pair lines D+ and D-. A line-termination resistor can be enabled by linking the two connectors labelled TERM together. This will reduce data-line reflections and may be required for improved communications reliability. The 0V terminal should be connected to the 0V supply of the other communicating device in order to limit common-mode voltages at the receivers.

Serial port settings are: 8 data bits, no parity bit, 1 stop bit.
Baud rate options are: 2400, 9600, 19200 and 38400

Three communication protocols are currently supported: DeeterLeak ASCII, Modbus RTU and Modbus ASCII.

7.1 DeeterLeak ASCII

DeeterLeak ASCII is a simple proprietary protocol that uses ASCII characters in the displayable range 20h to 7Eh. This makes commands easy to generate and responses easy to view and interpret on a PC using readily-available terminal-emulation software.

There are only four recognised commands that allow for monitoring of activity and clearing of latches, but do not allow for remote setup.

Commands are all single, upper-case characters. Other characters in the range A to Z will be ignored. Characters outside this range will elicit the response:

B<CR>

All responses are terminated with the carriage-return character, 0Dh.

Table 4

Command Character	Command Name	Action	Example Response	Comments
R	Reset Latches	Resets all latched outputs	R<CR>	
N	Report Version Number	None	LC V1.02<CR>	Example for firmware version 1.02
T	Status (Test) Report	None	T1A,00,1B,02,01,05<CR>	See description below
L	Status (Leak) Report	None	L1A001B02040800000000 00000000<CS><CR>	See description below

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7.1.1 Status Reports

Status Reports start with the command character echoed back, followed by a series of 8-bit hexadecimal numbers sent as pairs of ASCII characters in the range 0-9 and A-F.

The two versions of status report return the same information but differ in several respects:

- Leak locations are encoded differently
- Test Reports have commas separating each hexadecimal number
- Leak Reports are a fixed length (33 bytes including the <CR> at the end)
- Leak Reports include a checksum before the carriage-return.

Table 5 lists the first four hexadecimal numbers in the order sent and their meaning.

Table 5

Number order	Example	Meaning
1	1A	Report number in hexadecimal. This will increment for every report, from 00h to FFh and back to 00h
2	00	Status code – see below for details
3	1B	The number of sensors currently seen by the controller. The status code will indicate an error if this does not match the number of sensors set by menu
4	02	The number of leaks detected. If this is zero, Test Reports terminate here with a carriage-return

If there are leaks, Test Reports will be followed with the identity number of each leak (up to a maximum of the first 12 leaks). In the example of Table 4, there are leaks at sensors 01 and 05.
Leak Reports return ten 8-bit bytes in ASCII format (20 characters). Each of the 80 bits represent a sensor and a bit is set if there is a leak detected or cleared if there is no leak or the sensor is not fitted. The most-significant bit represents the first sensor in the chain, hence in the example above, 0408... signifies sensor numbers 6 and 17.

Status codes are:

- 00 = system okay
- 0x = system okay, active outputs (latched outputs)
- 1x = leak(s) detected, active outputs
- 21 = error. Number of sensors does not match the programmed number
- 22 = error. Over-current fault. The test report is terminated here.

Active outputs are represented in binary form:

- Bit 0 = relay1 active
- Bit 1 = relay2 active
- Bit 2 = transistor active

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The checksum appended to Leak Reports is an 8-bit longitudinal redundancy check, formed from the hexadecimal numbers following the 'L'. To generate the checksum:

1. Convert pairs of ASCII characters to 8-bit numbers, e.g. 1 and A become 1Ah
2. Add together all 8-bit numbers in the message, discarding any carries, e.g. 1Ah+00h+1Bh+02h+04h+08h+00h+00h+...= 43h
3. Calculate the 8-bit two's-complement of this sum, e.g. 100h-43h = BDh
4. Convert the resulting 8-bit checksum to two ASCII digits for transmitting most-significant-digit first, e.g. B and D

The 8-bit sum of hexadecimal numbers in the message plus checksum will be zero, e.g. 43h+BDh=00h (truncated to 8-bits).

7.2 Modbus RTU

Modbus RTU is a de facto standard, having achieved wide acceptance for connecting industrial devices without rigid standardisation or formal acceptance by standards authorities.

The Leak Controller conforms to the Modbus RTU command and response framing standard as a slave device. Detailed descriptions of this standard are readily available on the world-wide web and Appendix A provides a brief description and some example commands.

7.2.1 Supported Function Codes

The supported functions will allow the monitoring of activity, clearance of latches and the remote setup of controller option settings.

Table 6 lists the function codes supported.

Table 6

Function Code	Function Name	Description
3	Read Holding Registers	Reads a set of 16-bit read/write registers
4	Read Input Registers	Reads a set of 16-bit read-only registers
6	Write Single Holding Register	Writes to a single 16-bit read/write register
16	Write Multiple Holding Registers	Writes to a set of 16-bit read/write registers

Commands containing other Modbus function codes will elicit an exception code response.

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7.2.2 Register Assignments

There are 8 read/write registers, accessed by function codes 3, 6 and 16, defined in Table 7. Attempts to write values outside permitted ranges will elicit an exception code response.

Table 7

Register	Address	Description	Comments
40001	0000	Number of sensors	Valid range 1-80
40002	0001	Output 1 settings	Relay 1. See bit assignment details below
40003	0002	Output 2 settings	Relay 2
40004	0003	Output 3 settings	Transistor
40005	0004	Output 1 range	See description below
40006	0005	Output 2 range	
40007	0006	Output 3 range	
40008	0007	Latched outputs	See bit assignments below. Bits can be cleared but not set.

There are 16 read-only registers, accessed by function code 4, defined as follows:

Table 8

Register	Address	Description	Comments
30001	0000	Firmware version	e.g. V1.02 will be sent as 0102
30002	0001	Status code	See below for details
30003	0002	Number of sensors detected	
30004	0003	Number of leaks detected	
30005	0004	Location number of 1st leak	0 = no leak
30006	0005	Location number of 2nd leak	
…	…	…	Location of leaks 3 to 11
30016	000F	Location number of 12th leak	

For an installation with more than 12 sensors, the locations of only the first 12 leaks can be returned.

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7.2.3 Bit Assignments

The output settings in registers 40002, 40003 and 40004 have the following bit-assignments:

Table 9

Bit	Description	Bit = 0	Bit = 1	Comments
0	Normally-off/Normally-on	Off	On	
1	Leak/Fault	Leak	Fault	
2	Follow/Latch	Follow	Latch	
3	Any/Range	Any	Range	
4-15	Not used			Writes to here must be 0. Read as 0

Registers 40005, 40006 and 40007 contain the range settings for the three outputs. The higher range number is in the most-significant 8 bits of the register and the lower range number is in the least-significant 8 bits. When writing to these registers, for the data to be accepted and not cause an exception response, the higher range number must be greater than or equal to the lower range number, both numbers must be greater than zero, and both numbers must be less than or equal to the number of sensors already defined in register 40001.

The latched output settings in register 40008 are shown in Table 10. Bits in register 4008 can be read and individually cleared by writing a 0, but cannot be set by writing a 1.

Table 10

Bit	Description	Bit = 0	Bit = 1	Comments
0	Output 1	Unlatched	Latched	
1	Output 2	Unlatched	Latched	
2	Output 3	Unlatched	Latched	
3-15	Not used			Writes to here must be 0. Read as 0

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The status code in register 30002 has the following bit-assignment:

Table 11

Bit	Description	Bit = 0	Bit = 1	Comments
0	Controller State	Inactive	Active	The controller is inactive in any setup menu
1	Output 1 state	Inactive	Active	Relay 1. The active state may set the output on or off depending on the normally-off/on selection.
2	Output 2 state	Inactive	Active	Relay 2
3	Output 3 state	Inactive	Active	Transistor
4	Leaks detected	None	1 or more	The number of leaks is reported in register 30004
5	Output 1 latch	Off	On	On if the output is active and there are no leaks or faults detected
6	Output 2 latch	Off	On	
7	Output 3 latch	Off	On	
8	Sensor fault	No	Yes	The number of sensors detected does not match the number selected by menu
9	Over-current fault	No	Yes	Sensor current exceeds limits
10-15	Not used			Read as 0

7.2.4 Broadcast and Exception Responses

If the Modbus broadcast address is received (address zero), the Leak Controller will act on the command without sending a response. This address is only meaningful for the write function codes 6 and 16.

If the Leak Controller detects another slave's address, it will ignore the command and not respond. If the received command is corrupted and a redundancy check error is detected, the Leak Controller will also ignore this command and not respond.

If the slave address is correct and there are no errors in the transmission, but the Leak Controller cannot action the command for another reason, it will reply with an exception response.

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Exception responses include the slave address, the function code with the most-significant bit set and an exception code. The Leak Controller supports the following set of exception codes:

Table 12

Exception Code	Name	Description
01	Illegal Function	The function code is not supported by the Leak Controller
02	Illegal Data Address	Either the start address was beyond limits or the start address plus number of registers took the address beyond limits. (16 read-only registers and 8 read/write registers have been assigned)
03	Illegal Data Value	A value in the data field is not recognised by the Leak Controller. For example, attempts to write a number greater than 80 to register 40001 will cause this response

7.3 Modbus ASCII

The Leak Controller conforms to the Modbus ASCII command and response framing standard, details of which are readily available on the world-wide web. Appendix A provides a brief description and some example commands.

Supported function codes, register assignments, bit assignments and exception responses are the same as those described above for Modbus RTU. These functions will allow for the monitoring of activity, clearance of latches and the remote setup of controller option settings.

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8. Specifications

Controller dimensions:	90mm high x 106mm wide x 58mm deep 35mm 'top-hat' section DIN rail mounting
Sensor dimensions:	100mm (including cable glands) x 64mm x 40mm high
Sensor probes:	Pair, 5mm long stainless steel M3 threaded, spaced at 20mm centres
Mains power supply options:	210Vac – 250Vac at 20mA (UK version) 105Vac – 130Vac at 50mA (US version)
Low-voltage supply options: (UK and US versions)	10 – 32Vdc at 250mA 8 – 24Vac at 250mA
Mains supply fuse:	32mA anti-surge, 5x20mm cartridge (UK version) 100mA anti-surge, 5x20mm cartridge (US version)
Low-voltage supply fuse:	500mA anti-surge, Omni-Blok® cartridge
Relay contacts:	6A at 250Vac
Transistor output:	NPN open-collector Maximum pull-up voltage, 40Vdc. Current limited to 50mA
5V output current limit:	50mA
Sensor supply current limit:	150mA
Maximum cable length between sensors:	200m (cable capacitance < 100pF/m)
Maximum number of sensors:	80, depending on cable lengths and resistance
Estimated maximums for 100 ohm/km cable:	70 sensors with 10m cables 40 sensors with 30m cables 16 sensors with 200m cables

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Appendix A – Modbus Examples

Slave address range: 1-247 (01h – F7h)
Functions supported: 03, 04, 06 and 16 (03h, 04h, 06h, 10h)

Modbus RTU
Modbus RTU messages start and end with a pause of 3.5 times the character transmit time. Times between characters must not exceed 1.5 character times.

A 16-bit cyclic redundancy check of all previous message bytes is added before the end pause. The checksum is sent least-significant byte first.

Function 03
Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	CRC	End
	8-bit	8-bit	16-bit	16-bit	16-bit	

Response:

Start	Slave Address	Function	Data Byte Count	N* Register Data	CRC	End
	8-bit	8-bit	8-bit	N* 16-bit	16-bit	

Example:
Read all read/write (holding) registers, slave address 05.

Command Start_05_03_0000_0008_8845_End
Response
Start_05_03_10_0014_0000_0001_0004_1401_1401_1401_0000_814D_End

Interpretation:

20 sensors (0014h),
Output 1 set to normally-off, leak, follow, any (0000)
Output 2 set to normally-on, leak, follow, any (0001)
Output 3 set to normally-off, leak, latch, any (0004)
Output 1 range 1-20 (1401h)
Output 2 range 1-20
Output 3 range 1-20
No latched outputs (0000)

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Function 04

Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	CRC	End
	8-bit	8-bit	16-bit	16-bit	16-bit	

Response:

Start	Slave Address	Function	Data Byte Count	N* Register Data	CRC	End
	8-bit	8-bit	8-bit	N* 16-bit	16-bit	

Example:

Read status code, number of sensors detected and number of leaks, slave address 05.

Command Start_05_04_0001_0003_8FB1_End

Response Start_05_04_06_001F_0014_0001_5546_End

Interpretation:

Active state, leak detected and all outputs active (001Fh)

20 sensors detected (0014h)

1 leak detected (0001)

Function 06

Command:

Start	Slave Address	Function	Register Address	Data	CRC	End
	8-bit	8-bit	16-bit	16-bit	16-bit	

Response:

Start	Slave Address	Function	Register Address	Data	CRC	End
	8-bit	8-bit	8-bit	N* 16-bit	16-bit	

Example:

Set number of sensors to 20 (0014h), slave address 05.

Command Start_05_06_0000_0014_4188_End

Response Start_05_06_0000_0014_4188_End

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Function 16

Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	Data Byte Count	N* Data	CRC	End
	8-bit	8-bit	16-bit	16-bit	8-bit	N*16-bit	16-bit	

Response:

Start	Slave Address	Function	Start Address	No. of Registers	CRC	End
	8-bit	8-bit	8-bit	16-bit	16-bit	

Example:
Set Output 1 to normally-on and assigned to fault (0003)
Set Output 2 to normally-off, leak and latch (0004)
Set Output 3 to normally-off, leak and follow (0000)
Slave address 05

Command Start_05_10_0001_0003_06_0003_0004_0000_00BC_End
Response Start_05_10_0001_0003_4CD0_End

Modbus ASCII

Messages start with the colon character (3Ah) and end with <CR> (carriage-return – 0Dh) and <LF> (line-feed – 0Ah).

All data bytes are sent as pairs of ASCII characters in the ranges 0-9 (30h – 39h) and A-F (41h – 46h)

An 8-bit longitudinal redundancy check of all previous number bytes (excludes the colon start) is added before the end <CR><LF>. This is sent as two ASCII characters.

There are no timing constraints between characters in a command; a start character will terminate any previous incomplete command sequences.

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Function 03

Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	LRC	End
:	8-bit	8-bit	16-bit	16-bit	8-bit	CR LF

Response:

Start	Slave Address	Function	Data Byte Count	N* Register Data	LRC	End
:	8-bit	8-bit	8-bit	N* 16-bit	8-bit	CR LF

Example:

Read all read/write (holding) registers, slave address 05.

Command : 05 03 0000 0008 F0 <CR><LF>

Response : 05 03 10 0014 0000 0001 0004 1401 1401 1401 0000 90 <CR><LF>

Interpretation:

20 sensors (0014h),
Output 1 set to normally-off, leak, follow, any (0000)
Output 2 set to normally-on, leak, follow, any (0001)
Output 3 set to normally-off, leak, latch, any (0004)
Output 1 range 1-20 (1401h)
Output 2 range 1-20
Output 3 range 1-20
No latched outputs (0000)

Function 04

Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	LRC	End
:	8-bit	8-bit	16-bit	16-bit	8-bit	CR LF

Response:

Start	Slave Address	Function	Data Byte Count	N* Register Data	LRC	End
:	8-bit	8-bit	8-bit	N* 16-bit	8-bit	CR LF

Example:

Read status code, number of sensors detected and number of leaks, slave address 05.

Command : 05 04 0001 0003 F3 <CR><LF>

Response : 05 04 06 001F 0014 0001 BD <CR><LF>

Interpretation:

Active state, leak detected and all outputs active (001Fh)
20 sensors detected (0014h)
1 leak detected (0001)

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Function 06

Command:

Start	Slave Address	Function	Register Address	Data	LRC	End
:	8-bit	8-bit	16-bit	16-bit	8-bit	CR LF

Response:

Start	Slave Address	Function	Register Address	Data	LRC	End
:	8-bit	8-bit	8-bit	N* 16-bit	8-bit	CR LF

Example:

Set number of sensors to 20 (0014h), slave address 05.

Command : 05 06 0000 0014 E1 <CR><LF>

Response : 05 06 0000 0014 E1 <CR><LF>

Function 16

Command:

Start	Slave Address	Function	Start Address	No. of Registers (N)	Data Byte Count	N* Data	LRC	End
:	8-bit	8-bit	16-bit	16-bit	8-bit	N*16-bit	8-bit	CR LF

Response:

Start	Slave Address	Function	Start Address	No. of Registers	LRC	End
:	8-bit	8-bit	8-bit	16-bit	8-bit	CR LF

Example:

Set Output 1 to normally-on and assigned to fault (0003)

Set Output 2 to normally-off, leak and latch (0004)

Set Output 3 to normally-off, leak and follow (0000)

Slave address 05

Command : 05 10 0001 0003 06 0003 0004 0000 DA <CR><LF>

Response : 05 10 0001 0003 E7 <CR><LF>

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