SPOT

USER GUIDE

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SPOT MODBUS CONTROLS

LAND
AMETEK®
PROCESS & ANALYTICAL INSTRUMENTS

QUALITY CUSTOMER SOLUTIONS

IMPORTANT INFORMATION - PLEASE READ

PROCESS & ANALYTICAL INSTRUMENTS

Health and Safety Information

Read all of the instructions in this booklet - including all the WARNINGS and CAUTIONS - *before* using this product. If there is any instruction which you do not understand, DO NOT USE THE PRODUCT.

Safety Signs

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in death or personal injury.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to the user or users, or result in damage to the product or to property.

NOTE
Indicates a potentially hazardous situation which, if not avoided, could result in damage or loss of data.

Signs and Symbols used on equipment and Documentation

Caution, risk of electric shock.

Caution, attention to possibility of risk of damage to the product, process or surroundings. Refer to instruction manual.

Caution, hot surface.

Protective Conductor Terminal.

Observe precautions for handling electrostatic discharge sensitive devices.

Equipment Operation
Use of this instrument in a manner not specified by AMETEK Land may be hazardous. Read **and understand** the user documentation supplied **before** installing and operating the equipment.

The safety of any system incorporating this equipment is the responsibility of the assembler.

Protective Clothing, Face and Eye Protection
It is possible that this equipment is to be installed on, or near to, machinery or equipment operating at high temperatures and high pressures. Suitable protective clothing, along with face and eye protection must be worn. Refer to the health and safety guidelines for the machinery/equipment before installing this product. If in doubt, contact AMETEK Land.

Electrical Power Supply
Before working on the electrical connections, all of the electrical power lines to the equipment must be isolated. All the electrical cables and signal cables must be connected exactly as indicated in these operating instructions. If in doubt, contact AMETEK Land.

Storage
The instrument should be stored in its packaging, in a dry sheltered area.

The maximum storage temperature is 10 °C (18 °F) higher than the maximum operating temperature.

The minimum storage temperature is 10 °C (18 °F) lower than the minimum operating temperature.

Refer to the Technical Specification for details of the operating temperature limits.

Unpacking
Check all packages for external signs of damage. Check the contents against the packing note.

Lifting Instructions
Where items are too heavy to be lifted manually, use suitably rated lifting equipment. Refer to the Technical Specification for weights. All lifting should be carried out in accordance with local and national regulations.

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Return of Damaged Goods

IMPORTANT If any item has been damaged in transit, this should be reported to the carrier and to the supplier immediately. Damage caused in transit is the responsibility of the carrier not the supplier.

DO NOT RETURN a damaged instrument to the sender as the carrier will not then consider a claim. Save the packing with the damaged article for inspection by the carrier.

Return of Goods for Repair

If you need to return goods for repair please contact our Customer Service Department for details of the correct returns procedure.

Any item returned to AMETEK Land should be adequately packaged to prevent damage during transit.

You must include a written report of the problem together with your own name and contact information, address, telephone number, email address etc.

Design and Manufacturing Standards

The Quality Management System of Land Instruments International is approved to BS EN ISO 9001 for the design, manufacture and on-site servicing of combustion, environmental monitoring and non-contact temperature measuring instrumentation.

Registered ISO 9001 Management System approvals apply in the USA.

UK Calibration Laboratory: UKAS 0034.

USA Calibration Laboratory: ANAB Accredited ISO/IEC 17025.

National Accreditation Board for Testing and Calibration Laboratories approvals apply in India.

Operation of radio transmitters, telephones or other electrical/electronic devices in close proximity to the equipment while the enclosure doors of the instrument or its peripherals are open, may cause interference and possible failure where the radiated emissions exceed the EMC directive.

The protection provided by this product may be invalidated if alterations or additions are made to the structural, electrical, mechanical, pneumatic, software or firmware components of this system. Such changes may also invalidate the standard terms of warranty.

Contents

1

MODBUS TCP COMMUNICATION

1.1 Modbus TCP Communication with a SPOT Thermometer

The SPOT thermometer functions as a Modbus slave. To communicate with a SPOT thermometer, your device must be configured as a Modbus master.

Your device’s IP address must be compatible with, but not the same as, that of the SPOT thermometer. Setting up a compatible IP address is explained fully in Section 2.6 of the SPOT Thermometer User Guide.

The SPOT thermometer uses standard Modbus TCP protocol, with messages of the format:

Modbus TCP Frame Format		
Name	Length	Function
Transaction Identifier	2 bytes	For synchronisation between messages of server & client
Protocol Identifier	2 bytes	Zero for Modbus/TCP
Length Field	2 bytes	Number of remaining bytes in this frame
Unit Identifier	1 byte	Slave Address (255 if not used)
Function Code	1 byte	Function codes (see below)
Data Bytes	n bytes	Data as response or commands

The SPOT thermometer uses read and write instructions to holding registers for all communication. It does allow direct access to its inputs and outputs.

Thus the only Modbus Function Codes that are supported are 3 (read one or more registers), 6 (write to a single register) and 10 (write multiple).

The full list of holding registers is given below for reference. Section 2 gives pseudocode examples of how to implement common functions.

1.2 List of Modbus Registers

Modbus writes should only be performed when necessary. Every time new values are written to registers highlighted in orange, the settings are saved to flash. There is a finite limit of typically 100,000 writes to flash memory before PCB failure.
Items highlighted in yellow are activated in V8 firmware onwards.
Items highlighted in green are activated in V10 firmware onwards.
Items highlighted in blue are activated in V15 firmware onwards.

Modbus address (16 bit)	Name	Type	Bytes	Bits	Default	Permitted Range	Access	Notes
1 lo	Firmware version	uc	1				ro	
1 hi	Display version	uc	1				ro	Display version not applicable from July 2019
2	Current focal distance	us	2			300 - 10000 mm	ro	
3,4	Current IP address	ul	4			Any 8 digit hex	ro	
5 lo	Requests - set the relevant bit to request the function. The bit will be cleared auto-matically	uc	1	5. unlock	0	Used internally	rw	
				4. lock		0 = unlock, 1 = lock (also clear the unlock number, register 6 hi)		To lock the instrument, also clear the unlock number, register 6 hi
				3. reload display		0 = off, 1 = on		
				2. default values		0 = off, 1 = on		
				1. reboot		0 = off, 1 = on		
				0. jpeg		0 = off, 1 = on		
5 hi	Reserved	uc	1		0		rw	
6 lo	Language	uc	1	0	1	0 = unspecified (uses English UK)	rw	Other languages may be added
						1 = English UK		
						2 = English US		
						3 = German		
						4 = Italian		
						5 = French		
						6 = Spanish		
						7 = Brazilian Portu-guese		
						8 = Japanese		
						9 = Mandarin Chinese		
						10 = S Korean		
						11 = Russian		
						12 = Polish		
6 hi	Unlock PIN	uc	1		230	230 to unlock	rw	
7,8	Set IP Address	ul	4		0x0A010A32	Any digit hex	rw	Used on startup if Set IP selected (register 14 bit 15). Also used as a default if DHCP is set (IP address 10.1.10.50
9 lo	Mode	uc	1		0	0 = first detector	rw	Only modes which are enabled on a particular instrument can be selected. Mode 0 will be set if the user attempts to set a mode which is not available.
						1 = second detector		
						2 = duo		
						3 = ratio		
						4 = multi		
						5+ = application spe-cific		
9 hi	Units	uc	1		C	C or F	rw	
10	Emissivity 1	us	2		1000	50 - 1000 (for emissivi-ty 0.05 - 1)	rw	See Example 3
11	Emissivity 2	us	2		1000	50 - 1000 (for emissivi-ty 0.05 - 1)	rw	

Modbus address (16 bit)	Name	Type	Bytes	Bits	Default	Permitted Range	Access	Notes
12	Background temperature	us	2		0	0 - 5000 deg C or F	rw	
13	Set focal distance	us	2		1000		rw	Note the instrument does not respond while moving the focus mechanism.
14 lo	LED Flash Rate	uc	1		5	1 - 30 flashes per second	rw	
14 hi	Display booleans	uc	1	7 set IP	0x81	0 = DHCP, 1 = Set IP	rw	
				6 Use background correction		0=off, 1=on	rw	
				5 Automatic calculation of background temperature		0=off, 1=on	rw	
				4 Process window		0 = none, 1 = process window	rw	
				3 lock (internal use)			rw	
14 hi	Display booleans	uc	1	2 LED on		0 = off, 1 = on	rw	Use bit 2 of register 134 to switch the LED on and off as in example 5 below - this bit of register 14 is just an indicator of LED current state.
				1 Demo mode		0 = off, 1 = on	rw	In demo mode, the LED is switched on when any button is pressed on the keypad, and remains on for 15 minutes rather than 30s.
				0 Camera or data screen on display		0 = data, 1 = live camera	rw	
15 - 18	Name	c(8)	8		Default text	Alphanumerics	rw	A user-configurable name
19 lo	Calibration Current Value	uc	1		10	0 - 20mA	rw	Set bit 12 of register 19 to switch on the fixed calibration current of this value. It will switch off automatically after 15 minutes
19 hi	IOMode booleans	uc	1	7 Display under-range values	0	0 = off, 1 = on		
				6 CMD IN mode		0 = track & hold, 1 = peak picker reset	rw	
				5 Raw data		0 = off, 1 = on	rw	
				4 Calibration current output		0 = off, 1 = on	rw	The bit will be set to zero and the calibration current switched off automatically after 15 minutes.
			1	3 CMD OUT		0 = use for alarms (if set), 1 = use as watchdog	rw	The watchdog setting toggles the CMD Out line every second.
				2 CMD IN		0 = don’t use, 1 = use (according to CMD IN mode)	rw	
				1 NONC		0 = normally open, 1 = normally closed	rw	
				0 Analogue Mode		0 = 4 - 20mA, 1 = 0 - 20mA	rw	
20	Current output low temperature (0 or 4mA equivalent temperature)	s	2		0	0 - 5000 deg C or F	rw	
21	Current output high temperature limit (20mA equivalent temperature)	s	2		1600	0 - 5000 deg C or F	rw	
22	High target alarm threshold	s	2		1600	0 - 5000 deg C or F	rw	
23	Low target alarm threshold	s	2		0	0 - 5000 deg C or F	rw	
24 lo	High instrument alarm threshold	c	1		70	0 - 70 deg C or F		

Modbus address (16 bit)	Name	Type	Bytes	Bits	Default	Permitted Range	Access	Notes
24 hi	Low instrument alarm threshold	c	1		0	0 - 70 deg C or F	rw	
25 lo	AlarmMode booleans	uc	1	4 Low Signal %	0	0 for off, 1 for on	rw	All bits can be set independently. If multiple bits are set, an alarm will be raised if any threshold is exceeded. Note that low signal% alarm is only available in ratio modes.
25 lo	AlarmMode booleans	uc	1	3 High target			rw	
				2 Low target			rw	
				1 High ambient			rw	
				0 Low ambient			rw	
25 hi	TimeMode booleans	uc	1	7 Limiter mode	0	0 = Hold, 1 = Reset	rw	
				6 Use limiter	0	0 = Don't use, 1 = Use	rw	
				5 Peak Picker mode off	0	0 = Hold, 1 = Reset	rw	
				4 Pick Peaks or Valleys		0 = Peaks, 1 = Valleys	rw	
				3 Use Peak or Valley Picker		0 = don't use, 1 = use	rw	
				2 ModeMaster		0 = don't use, 1 = use	rw	
				1 Ratio Raw		0 = don't use, 1 = use	rw	Only used in low temperature ratio instruments with transient suppression.
				0 Averager		0 = don't use, 1 = use	rw	
26 lo	Averager number	uc	1		1	1 to 250	rw	
26 hi	Low signal% alarm threshold	uc	1		0	0 to 100%	rw	
27	Peak/Valley Picker Threshold	us	2		500	0 - 5000 deg C or F	rw	
28	Peak/Valley Picker Off Delay	us	2		0	0 - 10000 ms	rw	
29	Peak/Valley Picker On Delay	us	2		0	0 - 10000 ms	rw	
30	Peak Picker Decay Rate	us	2		0	0 - 1000 deg/s, C or F	rw	
31	Output Time	us	2		100	1 - 10000 ms	rw	
32-33	Reserved	uc	1				ro	
34, 35 lo	Detector 1 name	c[]	3				ro	
35 hi, 36	Detector 2 name	c[]	3				ro	
37	Detector 1 minimum temperature	s	2			Deg C or F	ro	
38	Detector 1 maximum temperature	s	2			Deg C or F	ro	
39	Detector 2 minimum temperature	s	2			Deg C or F	ro	
40	Detector 2 maximum temperature	s	2			Deg C or F	ro	
41-43	MAC address	uc[]	6			Any 8 digit hex	ro	
44	Calibration Date	us	2			YYMM	ro	
45-52	Serial Number	c[16]	16			Alphanumerics	ro	
53-133	Reserved							
134	Modbus CMDIn	us	2	2. LED	0	4 = LED on (6 = LED on while resetting peak picker, 5 = LED on while sampling)		The LED will start flashing when this bit is set, and will switch off automatically after 30s, or 15 minutes if demo mode is set. The LED can be switched at the same time as sampling or peak picker reset. See example 5 below.
				1. Reset peak picker		2 = reset peak picker		IOXInMode must be set to peak picker for this to work

Modbus address (16 bit)	Name	Type	Bytes	Bits	Default	Permitted Range	Access	Notes
				0. Sample and hold	0	1 = sample	rw	Note IOXInMode must be set to sample and hold for this to work
135	Modbus CMDOut	us	2			0 or 1 depending on state of output line	ro	
136-212	Reserved							
213 lo	Watchdog	uc	1	Toggles between 0 and 1 every s		0 or 1	ro	Provides a 'keepalive' signal
213 hi	reserved	uc	1				ro	
214	Limiter low limit	us	2				rw	
215	Limiter high limit	us	2				rw	
216 lo	IOX Input mode	uc	1			0 = CMD In not used	rw	
						1=CMD In used for sample and hold (mirrors 0x04 InMode)		
						2 = CMD In used to reset pp (mirrors 0x44 PP)		
						3 = CMD In used to switch LED		LED switches on and off with rising / falling edge according to logic direction. Timeout still applies.
						4 = mA In used for E1 (and E2)		For instruments with additional IO capabilities.
						5 = mA In used for NG		For instruments with additional IO capabilities.
						6 = mA In used for BGT		For instruments with additional IO capabilities.
216 hi	IOX Output mode	uc	1			0=CMD Out used for alarms (mirrors 0x00 IOMode)	rw	
						1=CMD Out used for watchdog (mirrors 0x08 IOMode)		
						2 = mA Out used for signal		For instruments with additional IO capabilities.
						3 = mA Out used for E1		For instruments with additional IO capabilities.
						4 = mA Out used for E2		For instruments with additional IO capabilities.
						5 = mA Out used for T1		For instruments with additional IO capabilities.
						6 = mA Out used for T2		For instruments with additional IO capabilities.
						7 = mA Out used for Tinst		For instruments with additional IO capabilities.
217	IOX mA In low	us	2				rw	For instruments with additional IO capabilities.
218	IOX mA In high	us	2				rw	For instruments with additional IO capabilities.
219	IOX mA Out low	us	2				rw	For instruments with additional IO capabilities.
220	IOX mA Out high	us	2				rw	For instruments with additional IO capabilities.
221-244	JPEG buffer		48				ro	See Example 4
245	ErrorCode		2	2 Display firmware error			ro	
				1 Focusing error			ro	
				0 Flash save error			ro	
246 lo	Status		1	7 Write in progress			ro	
				6 Low signal% alarm active			ro	

Modbus address (16 bit)	Name	Type	Bytes	Bits	Default	Permitted Range	Access	Notes
				5 Settings have been changed on display - PC software should reload				
				4 Settings have been changed via Modbus - display should reload			ro	
246 lo	Status		1	3 High target alarm active			ro	
				2 Low target alarm active			ro	
				1 High ambient alarm active			ro	
				0 Low ambient alarm active			ro	
246 hi	jpeg control		1	1 New jpeg data is available		1 when written, 0 when read	ro	See Examples
				0 jpeg request active		1 for active	ro	
247	Latest temperature measurement - as shown in the display		2			degCorF x 10 or 0xFFFF to denote an over- or under-range value	ro	See Examples
248	Latest instrument internal temperature measurement - as shown on the display		2			degCorF x 10	ro	See Examples
249	Signal % (if used in a dual wavelength mode)		2			1 to 1000%, or 0xFFFF to denote "don't display"	ro	
250	Emissivity output for detector 1 (application thermometers only)		2			Emissivity * 1000	ro	
251	Emissivity output for detector 2 (if present) (application thermometers only)		2			Emissivity * 1000	ro	
252	Most recent temperature measurement from detector 1		2			degCorF x 10	ro	
253	Most recent temperature measurement from detector 2 (if present)		2			degCorF x 10	ro	
254	Pointer to output data buffer		2			0-99	ro	Indicates the word-length offset from the start of the output data buffer of the last data entry. See note below.
255-354	Output data buffer		200	100 short ints		degCorF x 10 or 0xFFFF to denote an over- or under-range value	ro	The data buffers are rolling 100-word blocks. The latest entry is in register (255+ [value of register 254]). This will be the same value as in register 247,
569	App 1 Offset	s	2		0	-1000 to 1000	rw	Offset to the App1 algorithm gradient, used to tune the algorithm to site conditions
581	App 2 Offset	s	2		0	-1000 to 1000	rw	Offset to the App2 algorithm gradient, used to tune the algorithm to site conditions
593	App 3 Offset	s	2		0	-1000 to 1000	rw	Offset to the App3 algorithm gradient, used to tune the algorithm to site conditions
1024	Thermocouple value	us	2		0	0 - 50000	rw	Thermocouple value in 10x degrees C or F. Write a value here to autoset emissivity or automatically tune the algorithm in App mode. If the entered value is within the allowed tuning range, the instrument will automatically adjust its emissivity / offset and write 0 to this register. If the entered value is out of range, the instrument will not change its settings and write 0xFFFF to this register.

2 EXAMPLES

The examples below give code snippets written in pseudocode. It is assumed that the user has a Modbus tcp stack with functions:

```
ModbusRead (start register, n registers)
ModbusWrite (register, value)
ModbusWriteMany (start register, n registers, array)
```

ModbusRead returns an array of length n registers, containing the values of the Modbus registers on the SPOT thermometer from start register onwards.

ModbusWrite writes one value to a Modbus register on the SPOT thermometer; ModbusWriteMany writes n values from an array.

Further functions must also be written in user code:

```
AddToLog (unsigned short integer)
AddToJPG (unsigned char)
ReportError (string)
```

These functions add a word length data point to the log, add a byte of data to the jpeg file that is being compiled, or alert the user to an error.

2.1 Get Latest Temperature

The most recent temperature measurement can simply be obtained by reading register 247, and the internal instrument temperature from register 248. These can be read with one Modbus read command (read 2 registers starting at 247).

```
Array = ModbusRead (247, 1)
Temperature = Array[0]
```

2.2 Log Temperatures at High Speed

SPOT thermometers can provide temperature measurement at up to 1 kHz if instrument output time is set to 1 ms.

The output data buffer permits every 1 ms measurement to be recorded and transmitted in a single large batch of data.

Every output time, when register 247 is updated with the latest temperature measurement, that measurement is also copied to a circular output data buffer in registers 255-354.

Register 254 is incremented at the same time so that it always contains the position of the latest measurement within that buffer.

A Modbus ‘read multiple registers’ command can then be used to read 101 registers starting at register 254. The new data will be indicated by the difference in the pointer position since the previous read.

The ‘read multiple registers’ command should be repeated at regular intervals of 50 to 70 times the instrument’s output time.

More frequent communication is unnecessary, and it reduces the time available for the instrument to measure temperature, which in turn reduces the averaging statistics and increases noise.

Longer read intervals risk loss of data, particularly on a Windows platform where timer scheduling is not absolute.

```
//Logging code called on a timer, interval of 50*output time is
recommended
Array = ModbusRead (254,101)   // Read the buffer pointer and the whole
buffer
Pointer = Array[0]       // The last data point in the circular buffer is
at this position
ReadCount = Pointer - OldPointer + 1
// ReadCount is the number of values since the last buffer read, plus one
so we check the last buffer pointer value hasn't changed
if (ReadCount < 0) ReadCount = ReadCount + 100; HasWrapped = true
// In case writing has started again at position 0 since the last read
if (HasWrapped) {
 For i = OldPointer+1 to 100: AddToLog Array[i]       // Data is in
array position 1 to 101 not 0 to 100, so add 1 to OldPointer
 For i = 1 to ReadCount - (100-OldPointer): AddToLog Array[i]
 // and start at position 1
} else {
 For i = OldPointer+1 to Pointer: AddToLog Array[i]
}
if (Array[OldPointer + 1] != OldPointerValue) ReportError ("Buffer read
error. Ouput data has been missed")
// If the value at the old pointer position has changed, the buffer is not
being read often enough.
```

2.3 Set Emissivity

The emissivity used within the instrument for temperature calculation is held in register 10, or in registers 10 and 11 for a dual detector instrument.

To change the emissivity of the instrument, or of channel 1, to 0.9 use:

```
ModbusWrite (10, 900)
```

To change the emissivity of both channels on a dual detector instrument to 0.9 use:

```
Array = (900,900)
ModbusWriteMany (10, 2, Array)
```

2.4 Capture a JPEG from the Instrument

JPEGs are transmitted by the instrument copying data to a buffer within the Modbus registers, then the PC software reading it.

If bit 1 of the requests byte is set, the instrument will set bit 0 of the jpeg control byte to indicate that jpeg capture is active then capture an image. It will then repeatedly:

- Wait till bit 1 of the jpeg control byte is clear
- Copy next 48 bytes of image into buffer
- Set bit 1 of the jpeg control byte

Meanwhile the pc software must read the data, so the buffer can be used again.

The instrument watches for a read of the jpeg buffer and clears bit 1 of the jpeg control byte automatically, so that the process above can be repeated. When all data has been transmitted, the instrument will clear both bits of the jpeg control flag.

The jpeg file starts with FF D8, includes a config frame, the length of the main frame and 11 unnecessary bytes, then the main frame ending FF D9. To compile a jpeg from the Modbus words transmitted, save words 4 – 346 then 361 onwards (counter starts at 0); high byte first.

```
ModbusWrite (5, 1)          // Request a JPEG
WordCounter = 0             // Initialise a counter for the JPEG acquisition
Array = ModbusRead (246, 1)            // Read the JPEG status bit
StatusValue = Array [0]                // and monitor it
while (StatusValue > 0xFF) {   // While jpeg transmission active, loop
 Array = ModbusRead (221, 26) // Read the whole jpeg buffer and
status byte
 StatusValue = Array [25]
 if (statusval > 0x1f) {       // If there is new data
 for i = 0 to 24 {             // for each word in the latest buffer
       if  ((wordcounter >= 4) && ((wordcounter < 347) ||
       (wordcounter > 360)))   {    // The words required for a jpeg
       AddToJPEG ((Array[i] & 0xFF00) >> 8)     // upper byte
       AddToJPEG (Array[i] & 0x00FF)      // lower byte
       }
       WordCounter ++    //wordcounter starts at 0 at the beginning
 of the transmission of the first buffer
       }
 }
}
```

2.5 Switch the LED on and off (firmware v10 onwards)

To switch the LED on remotely, you need to set bit 2 of register 134. If you are not using sample and hold or the peak picker, use command:

```
ModbusWrite (134, 4)
```

If you are also using another function of register 134, check the current value of the register first:

```
Array = ModbusRead (134, 1)
currentvalue = Array [0]
LEDonvalue = currentvalue OR 0x04
ModbusWrite (134, LEDonvalue)
```

The LED will switch off automatically after 30s or 15 minutes if demo mode is set to switch the LED on remotely, write 0x04 to register 134.

To switch it off sooner, clear bit2 of register 134:

```
Array = ModbusRead (134, 1)
currentvalue = Array [0]
LEDoffvalue = currentvalue OR 0x04
ModbusWrite (134, LEDoffvalue)
```

2.6 Enter a Thermocouple calibration value

A thermocouple value can be used to calibrate the emissivity or tune an algorithm, by writing the correct temperature to register 1024.

If the instrument is in a **Mono** or **Ratio** mode, the value will be used to autoset the emissivity for each detector channel. If the instrument is in an **App** mode, the thermocouple value is used to tune the algorithm.

Thermocouple calibration must be performed while the instrument has a live temperature reading of the product for comparison and calculation.

To enter the reference temperature measurement (900C in this example), write the temperature in 10x degrees C or F to register 1024:

```
ModbusWrite (1024, 9000) //enter thermocouple value in 10x deg C or F
```

Mono or Ratio Mode

In Mono or Ratio modes, the instrument will calculate the emissivity values that, used with the current radiance measurements, would give temperature output of 900C for each channel.

If the entered value is within range and the calculation results in sensible emissivity values between 0.05 and 1, Modbus register 1024 is set to 0. If the entered value is out of range and the calculation does not result in real emissivity values, register 1024 is set to 0xFFFF.

If you want to check the success of the calculation, read register 1024:

```
Array = ModbusRead (1024, 1) //Optionally check calculation success
Success = Array[0] //0 for OK, 0xFFFF for error
```

If the calculation was successful, the emissivity values in registers 10 and 11 are set to the calculated emissivity values.

If you want to read the new emissivity values, read registers 10 and 11:

```
Array = ModbusRead (10, 2) //Optionally check emissivity values
Emissivity1 = Array[0]
Emissivity2 = Array[1]
```

This may not be necessary, as the new values will be used and corrected temperatures output immediately after successful emissivity calculation.

App Mode

In App mode, the thermocouple wil be used to adjust the offset to the current App, so that the instrument now reads temperature of 900C in the current app.

If the entered value is within range and the calculation results in a permitted value of algorithm offset between -2000 and 2000, Modbus register 1024 is set to 0. If the entered value is out of range and the calculation does not result in real emissivity values, register 1024 is set to 0xFFFF.

If you want to check the success of the calculation, read register 1024:

```
Array = ModbusRead (1024, 1) //Optionally check calculation success
Success = Array[0] //0 for OK, 0xFFFF for error
```

If the calculation was successful, the offset value for the current algorithm is set to the calculated offset value. For App1, this is register 569, for App2 it would be register 582 - as defined in the table of modbus registers above.

If you want to read the new offset value, read the offset value for the current App. If the instrument is currently in App1 (eg. AL E for an AL EQS thermometer):

```
Array = ModbusRead (569, 1) //Optionally check algorithm offset
Offset = Array[0]
```

This may not be necessary, as the new offset value will be used and corrected temperature output immediately after successful app tuning.

It is also possible to make a direct adjustment to the offset, by writing to the offset register. For example, to remove the offset that was just set with a thermocouple, write 0 to register 569.

```
ModbusWrite (569, 0)  //enter new offset value (0 to remove offset and use
                       default algorithm)
```

Direct adjustment of the offset value can be useful when target temperature changes too rapidly to permit entry of thermocouple values in real time.

The offset is an adjustment to non-greyness not temperature, so a small positive adjustment to the offset will lead to a reduction in temperature reading and vice versa.

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