Instruction Manual

TCM_COMO_S_EN_150408_E005

TRICOR®

Modbus (RTU)

TRICOR
Coriolis Technology

Version

Manual-Version

TCM_COMO_S_EN_150408_E005

SW-Version

This manual is valid for

Main SW: Mv3.40 and higher

Display SW: Dv3.40 and higher

Index

TCE Modbus RTU Communication

Modbus is an application layer messaging protocol for client/server communication between devices connected on different types of buses or networks. On TCE Modbus is implemented using the asynchronous serial transmission over the RS485 physical interface. The TCE is equipped with an RS485 Interface as a standard.

1. Electrical connection of RS485

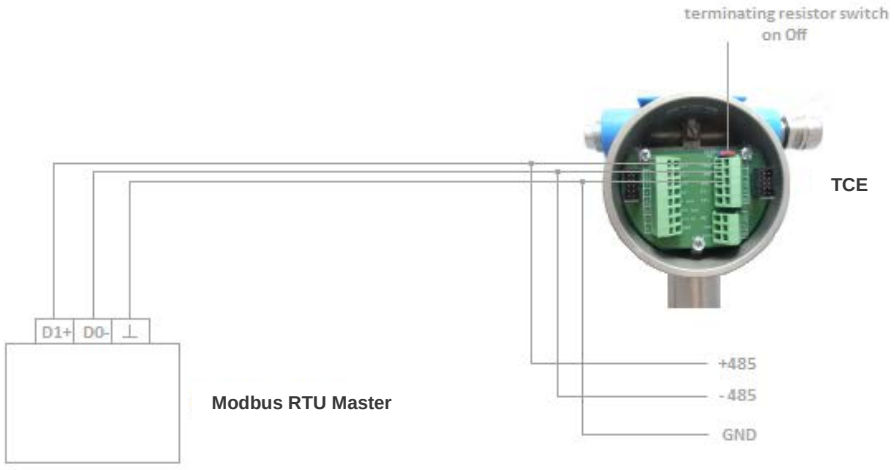
Prepare the TCE and the cable as described in chapter 3.3.2. or 3.3.3. in the TRICOR manual.

Connect the signal RS485A, RS485+ or D1+ (all three names are used in the literature) to terminal 22 and RS485-, RS485B or D0- to terminal 21. Terminal 20 is the ground reference pin for the interface and is connected to GND (terminal 8) with the non- Ex versions and connected to PE (terminal 52) with the Ex versions.

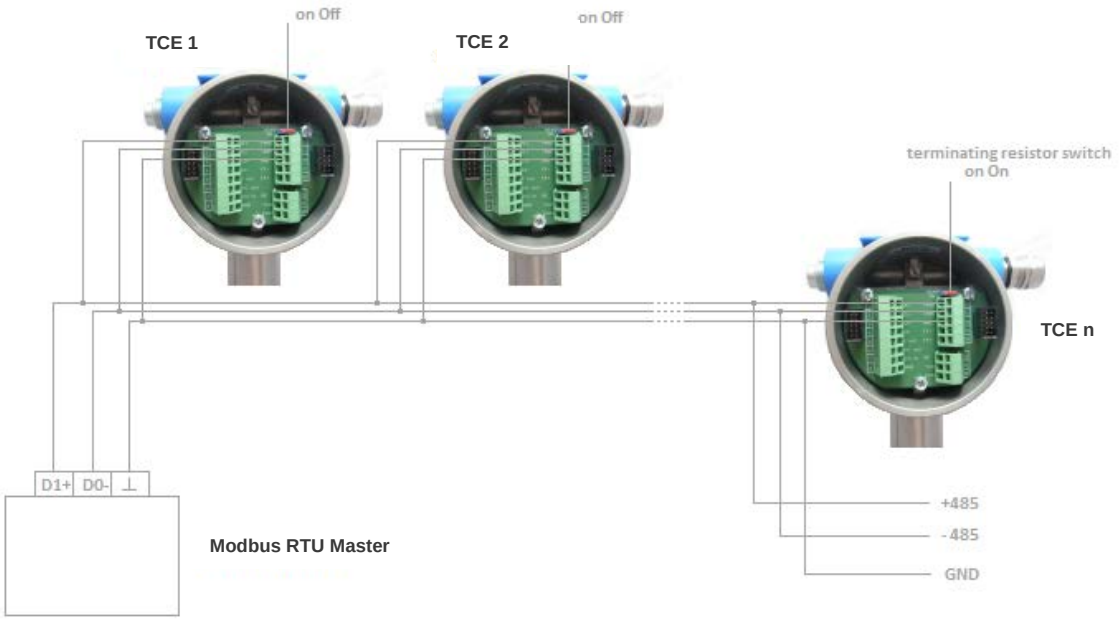
NOTE:

The operating range of the data terminals (21 and 22) is -7 V to +12 V referred to the reference pin (20). Voltages outside that range could damage the TCE.

1.1. Single-mode connection



1.2. Operating TCE in multi-drop network



2. Ex installation of RS485

The RS485 terminals are designed for an operating voltage of -7 V to +12 V and a rated voltage of 30 V AC.

For connecting the interface refer to chapter 5.1.1 in the TRICOR manual.

WARNING!

Applying more than 30 V DC to any of the RS485 terminals will damage the TCE and destroy the protection of the TCM!

WARNING!

If more than 30 V have been applied to any of the RS485 terminals, the unit must be returned to KEM/AWL for repair as the safety barrier might have been destroyed!

3. TCE Modbus RTU Interface Overview

3.1. RS485 settings

The TCE uses a Modbus data byte structure without parity bit. The characters are transmitted in the following structure:

- 1 Start Bit
- 8 Data Bit
- No Parity Bit
- 2 Stop Bits

3.2. Frame structure

The Modbus frame contains the following blocks:

Address	Func. Code	Data Field (command address + data)	CRC (error check)	
1 byte	1 byte	up to 80 bytes	1 byte	1 byte

2 characters must not be separated by more than 1.7 ms at 9600 baud or by more than 0.75 ms at 19200 or 56000 baud.

2 Frames must be separated by at least 4 ms at 9600 baud or at least 1.75 ms at 19200 or 56000 baud.

3.2.1. Address = Slave address

The slave addresses can be set between 1 and 247 (see chapter 4.5.8.6. in the TRICOR manual).

Address “0” is reserved for broadcast communication and addresses 248 to 255 are reserved for special purposes. Those addresses cannot be assigned to a unit.

3.2.2. Function Code

The following Modbus RTU function codes are available in the TCE electronics.

Code	Function	Data Access	Description
0x01	Read Coil	Bit access	Internal Bits or Physical Coils
0x02	Read Discrete Input		Physical Discrete Inputs
0x03	Read Holding Registers	16-bit access	Internal Registers or Physical Output Registers
0x04	Read Input Registers		Physical Input Registers
0x05	Write Single Coil	Bit access	Internal Bits or Physical Coils
0x06	Write Single Register	16-bit access	Internal Registers or Physical Output Registers
0x0F	Write Multiple Coils	Bit access	Internal Bits or Physical Coils
0x10	Write Multiple Registers	16-bit access	Internal Registers or Physical Output Registers

3.2.3. Data Field

The data field is function code specific. See tables below for descriptions:

3.2.3.1. 0x01 Read Coil/0x02 Read Input/0x03 Read Holding Registers /0x04 Read Input Registers

Request:

Address	Function	Start Address		Number of coils/registers		CRC	
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

Response:

Address	Function	Byte Count	Data	CRC	
1 byte	1 byte	1 byte	(up to 80 bytes)	1 byte	1 byte

0x05 Write single Coil/0x06 Write single Register

Request:

Address	Function	Start Address		Data		CRC	
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

Response:

Address	Function	Start Address		Data		CRC	
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

3.2.3.2. 0x10 Write multiple Register

Request:

Address	Function	Start Address		Number of registers (max. 40)		Byte Count (2 x number of registers)	Data	CRC	
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	(up to 80 bytes)	1 byte	1 byte

Response:

Address	Function	Start Address		Number of registers (max. 40)		CRC	
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

3.2.4. Error Checking Field

The content of the 2 bytes of the error-checking field are calculated according to the Modbus rules.

Byte ordering of Floating Point Data

The TCE uses by default a “Big-Endian” representation for floating point or 32-bit data (also known as “3-2-1-0” or “ABCD”). This means that when a numerical quantity larger than a single byte is transmitted, the most significant byte is sent first.

3.3. Exception responses

In case the TCE receives a complete frame, but with invalid addresses or data, an exception response is returned.

In the returned function code the MSB will be set to “1”. The returned function code can be calculated as:

Returned function code = received function code +0x80

The data field will contain one of the following error codes:

Code	Name	Description
01	Illegal Function	The requested function is not existing/not implemented
02	Illegal Data Address	The address (plus length) is not existing/not allowed
03	Illegal Data Value	The transferred data are out of range

3.4. TCE Modbus data model

Modbus defines the following data:

Primary Table	Object type	Communication type
Discrete inputs	Single bit	Read-Only
Coils	Single bit	Read-Write
Input registers	16 bit	Read-Only
Holding registers	16 bit	Read-Write

3.5. Event Logging

Since firmware version 3.40 TCE supports an event logging mechanism (described in the TRICOR instruction manual).

For accessing the event logging via Modbus the firmware has the following register/coil:

Name	Description	Register type	Start Address
Event Log Total Count	Total count of all logged events	Input Register	7749
Event Log Error Count	Count of all logged error events (ERR:ON and ERR:OFF)	Input Register	7750
Event Log Read Entry 0	First part of the log entry that is referenced by the log cursor (= byte 0-1 of the timestamp)	Input Register	7751
Event Log Read Entry 1	Second part of the log entry that is referenced by the log cursor (= byte 2-3 of the timestamp)	Input Register	7752
Event Log Read Entry 2	Third part of the log entry that is referenced by the log cursor (= byte 0-1 of the event code)	Input Register	7752
Event Log Cursor	Cursor that selects the current event log (for reading or clearing)	Holding Register	7567
Event Log Clear	Clears the current log entry, that is referenced by the event log cursor	Coil	41

3.5.1. Data format

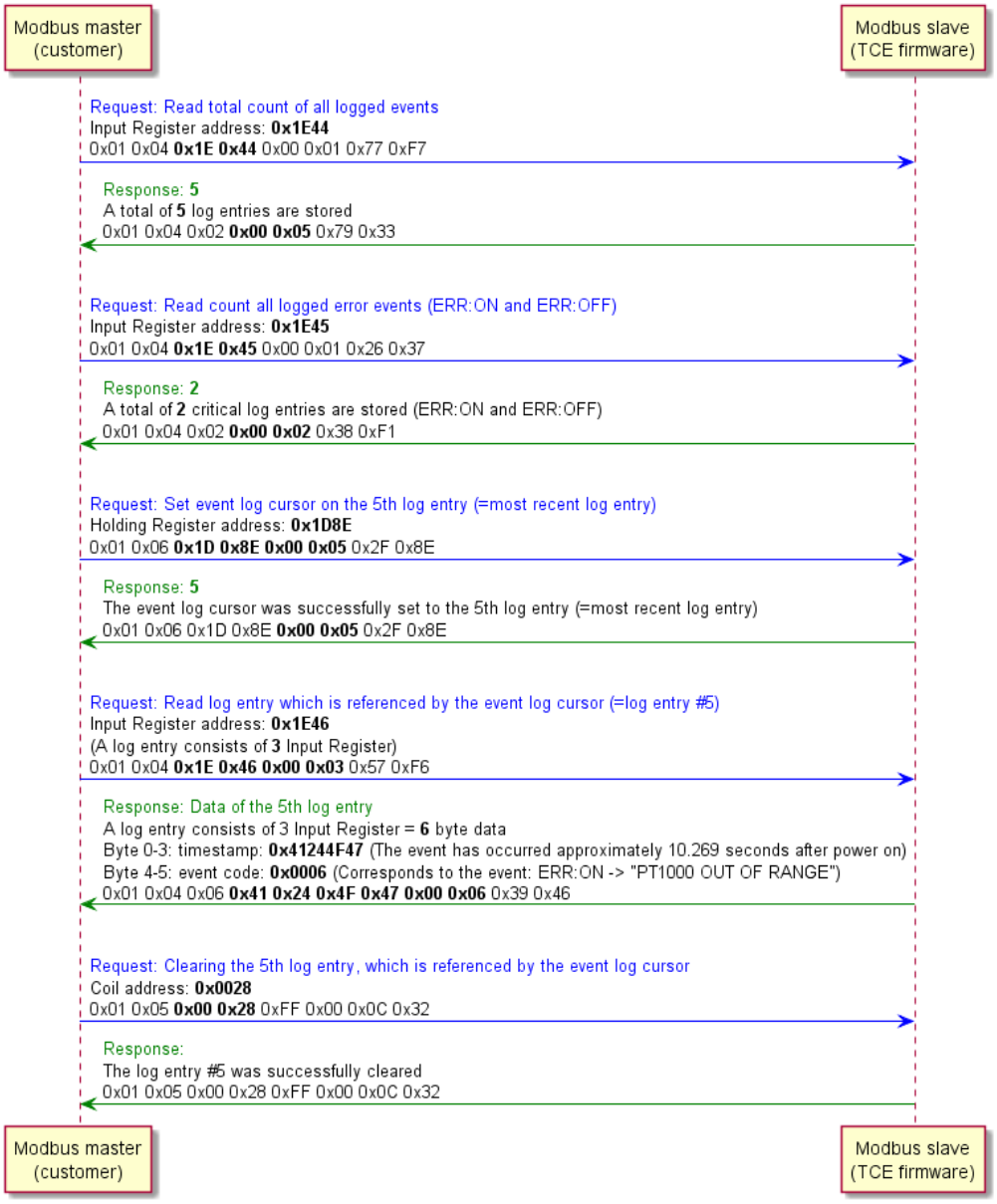
A log entry claims 6 byte data:

- The first 4 byte represents the timestamp in the 32-Bit data format float (Big Endian, IEEE 747).
- The last 2 byte represents the 16-Bit event code number (Big Endian, unsigned integer).

Input-Register #	7751		7752		7753	
Byte #	0	1	2	3	4	5
Content	Timestamp [s]				Event Code	
Type	float (32-Bit, Big Endian, IEEE 754)				unsigned int (16-Bit, Big Endian)	

3.5.2. Example

The following sequence diagram describes the complete procedure for reading and clearing a log entry:



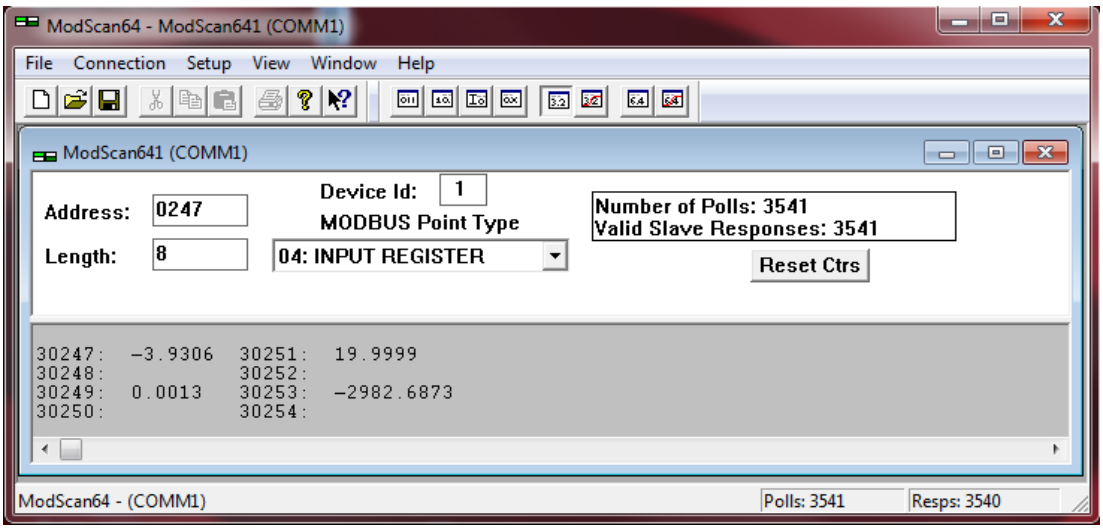
3.6. Examples of use

3.6.1. ModScan64

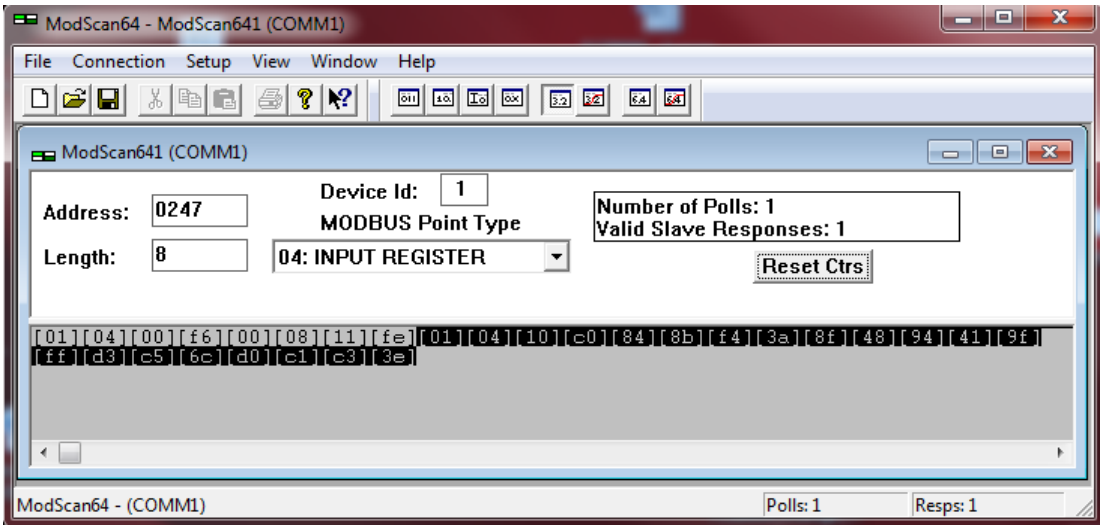
See screen shots below for the communication example with ModScan64 (reading out the process parameters: Mass Flow Rate [g/s], Density [g/cc], Temperature [°C], Volume Flow Rate [cc/s]).

The ModScan64 Modbus RTU master uses like many others the one-based addressing. You can use the TCE Coil/Register Addresses as listed in the last chapter “TCE Modbus register map”.

The start register address to be read is 247 for Mass Flow Rate see TCE Modbus register map. The last register would be 254 (the end address of Volume Flow Rate). The number of registers is therefore 8. See screen shot below for reading out the 4 floating point parameters (using the IEEE 754 standard) or 8 16-bit Modbus registers.



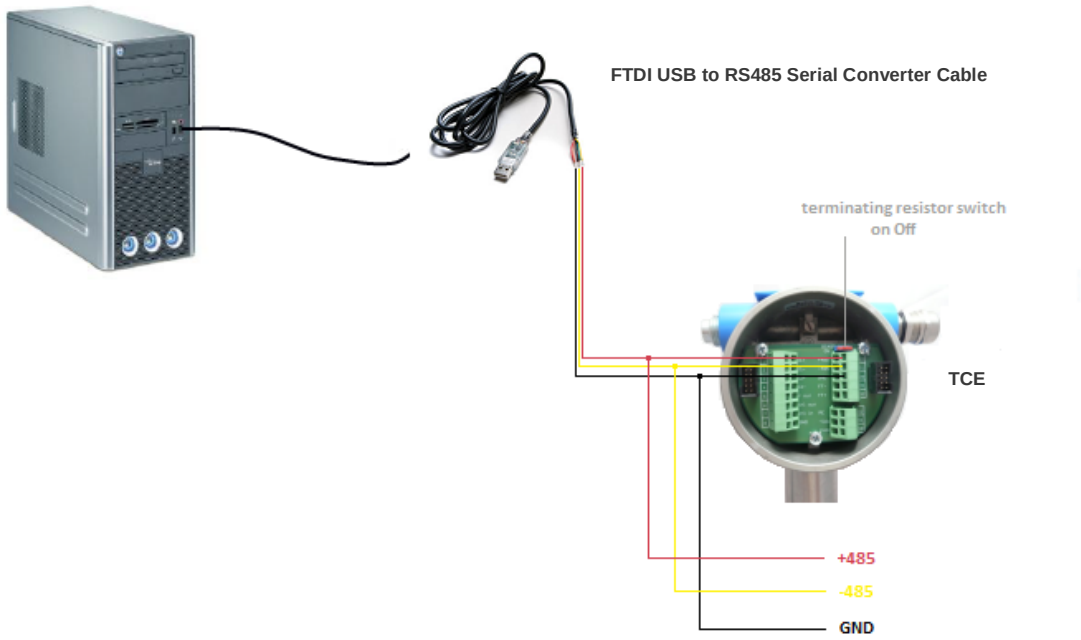
In the next screen shot you can see the traffic corresponding to the data shown above (therefore see the data field description in section: 0x01 Read Coil/0x02 Read Input/0x03 Read Holding Registers /0x04 Read Input Registers.



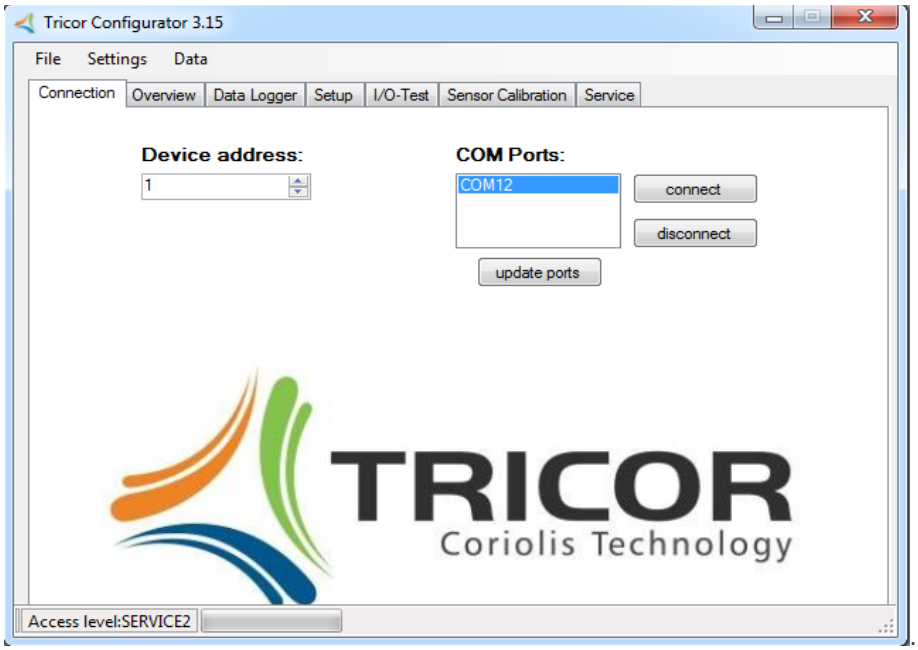
3.7. TRICOR Configurator

TRICOR Configurator is Windows based software for communication with TCE electronics. Please download the current revision from the KEM (http://www.kem-kueppers.com/downloads/software/?lang=en) or AW-Lake homepage.

For connecting the TCE electronics on your Laptop/PC please use the FTDI USB to RS485 Serial Converter Cable (s .wiring diagram below). The current revision of TRICOR Configurator is operable only in combination with the FTDI Converter! The FTDI USB driver is also available on our homepage.



Please install both TRICOR Configurator and the FTDI driver on your Windows Laptop/PC. Connect the TCE as shown in the diagram above and start TRICOR Configurator. The screen shot below shows the main window with the list of connected TCE devices. The TRICOR Configurator operation manual can be also downloaded from KEM/AW-Lake homepages



3.8. TCE Modbus register map

NOTE:

If your equipment or software uses zero-based addressing, you will need to subtract a value of 1 from the coil/register start address in the map below.

The EEPROM Write Enable Coil 11 has to bet set before writing the new values to the Holding Registers permanently.

The TCE implements 32-bit (2 Modbus registers) floating point data using the IEEE-754 standard.

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
DISCRETE INPUTS (read-only bit addresses, read function byte 0x02)				
CtrlIn Level	208	1	Bool	0 – Low 1 – High
CtrlIn2 Level	209	1	Bool	TCE 6000 only 0 – Low 1 – High
EEPROM Backup Matches Working Memory	210	1	Bool	Is the customer backup up to date? 0 – yes 1 – no
EEPROM Factory Backup Done	211	1	Bool	Was the factory backup done? 0 – yes 1 – no
DISCRETE COILS (read/write bit addresses, read function byte 0x01, write function byte 0x05 for single or 0x0f for multiple coils)				
Reset Batch Totals	003	1	Bool	Write: 1 – start reset
Reset Grand Totals	004	1	Bool	Write: 1 – start reset
Start Zero Offset Procedure	005	1	Bool	Write: 1 – start zero offset Duration by default: 10sec. The result is written to holding registers: 3303
EEPROM Write Enable Flag	011	1	Bool	Has to be set before writing holding registers to save the new values permanently. 0 – disable 1 – enable
EEPROM Customer Backup Enable Flag	012	1	Bool	Has to be set before performing customer data backup: 0 – disable 1 – enable

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
EEPROM Factory Backup Enable Flag	013	1	Bool	Has to be set before performing factory data backup: 0 – disable 1 – enable
EEPROM Start Customer Backup	014	1	Bool	Write: 1 – start backup/restore Read: 0 - backup/restore is done 1 – backup/restore is in progress
EEPROM Start Customer Restore	015	1	Bool	
EEPROM Start Factory Backup	016	1	Bool	
EEPROM Start Factory Restore	017	1	Bool	
Event Log Clear	041	1	Bool	Write: 1 – clears the current log which is referenced by the event log cursor (holding. reg.: 7567)
FreqOut Direction Mode	101	1	Bool	0 – FreqOut gives out frequencies only at positive flow rate 1 – FreqOut gives out frequencies at positive (CtrlOut in active state) and at negative (CtrlOut in inactive state) flow rate as well. CtrlOut mode has to be set to FLOW DIRECTION
Primary mA Output Setup Mode Enable	201	1	Bool	0 – setup mode is disabled 1 – setup mode is enabled
Secondary mA Output Setup Mode Enable	202	1	Bool	0 – setup mode is disabled 1 – setup mode is enabled
Pressure Compensation Enable	203	1	Bool	0 – disable 1 – enable
CtrlOut Level	207	1	Bool	If CtrlOut is in test mode: 0 – CtrlOut Low 1 – CtrlOut High
Density Correction Factors Calculation	301	1	Bool	1 – calculate density correction factors, based on calibration parameters (s. holding registers: 3069 - 3079) captured at air and at water
Air Density Calibration	421	1	Bool	1 – start density at air calibration (the results are written to holding registers: 3069 - 3073)
Water Density Calibration	422	1	Bool	1 – start density at water calibration (the results are written to holding registers: 3075 - 3079)

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Write 4mA to Primary mA Output	423	1	Bool	If the primary mA output is in setup mode writing 1 to this coil sets the output to 4 mA
Write 20mA to Primary mA Output	424	1	Bool	If the primary mA output is in setup mode writing 1 to this coil sets the output to 20 mA
Write 4mA to Secondary mA Output	425	1	Bool	If the secondary mA output is in setup mode writing 1 to this coil sets the output to 4 mA
Write 20mA to Secondary mA Output	426	1	Bool	If the secondary mA output is in setup mode writing 1 to this coil sets the output to 20 mA
Start Pt1000 Amplitude Calibration	427	1	Bool	Writing 1 to this coil starts Pt1000 amplitude calibration
Start Pt1000 Offset Calibration	428	1	Bool	Writing 1 to this coil starts Pt1000 offset calibration
Activate Pressure Compensation of the Zero Offset	429	1	Bool	0 – disabled 1 – enabled
Write Calibration Values To EEPROM	451	1	Bool	1 – write calibration values to EEPROM
Gauge Data Request	8001	1	Bool	0 – disable 1 – enable
INPUT REGISTERS (read-only register addresses, read function byte 0x04)				
Primary mA Output Current Value	203	2	FP	Milliamps
Secondary mA Output Current Value	213	2	FP	Milliamps
Frequency Output Value	229	2	FP	Hz
Mass Flow Rate Display	231	2	FP	Is derived from Mass Flow Rate 247 by applying the display flow filter 3025. In selected mass flow units.
Volume Flow Rate Display	233	2	FP	Is derived from Volume Flow Rate 253 by applying the display flow filter 3025. In selected volume flow units.
CC	247	2	FP	Selected mass flow units
Density	249	2	FP	Selected density units
Temperature	251	2	FP	Selected temperature units
Volume Flow Rate	253	2	FP	Selected volume flow units
Pressure Rate	257	2	FP	Selected pressure units
Mass Flow Batch Total	259	2	FP	Selected mass flow total units
Volume Flow Batch Total	261	2	FP	Selected volume flow total units

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Mass Flow Grand Total	263	2	FP	Selected mass flow total units
Volume Flow Grand Total	265	2	FP	Selected volume flow total units
Mass Flow Grand Total Forward	267	2	FP	Selected mass flow total units
Volume Flow Grand Total Forward	269	2	FP	Selected volume flow total units
Mass Flow Grand Total Reverse	271	2	FP	Selected mass flow total units
Volume Flow Grand Total Reverse	273	2	FP	Selected volume flow total units
Analog Input	277	2	FP	mA (optional)
Mass Flow Disturbance Total	279	2	FP	Selected mass flow total units
Volume Flow Disturbance Total	281	2	FP	Selected volume flow total units
Sensor Frequency	285	2	FP	Hz
Sensor A Voltage	287	2	FP	Millivolts
Sensor B Voltage	289	2	FP	Millivolts
Drive Current	291	2	FP	Milliamps
Temperature (internal value)	293	2	FP	Selected temperature units
PT1000 value	295	2	FP	Ohms
Time Shift with correction (s. Coil 429)	297	2	FP	Micro seconds
Time Shift	299	2	FP	Micro seconds
Operation Time	301	2	FP	Time in seconds since the last power on
PCZ Correction Values	1001	2	FP	Pressure Compensation of the Zero Offset correction value in micro seconds
Fault Word 1	7001	1	Int	s. 3.11.1 “Fault Word 1”
Fault Word 2	7002	1	Int	s. 3.11.2 “Fault Word 2”
Warning Word	7003	1	Int	s. 3.11.3 “Warning Word”
SW Version Byte 1	7567	1	Int	First char. in main board firmware rev. number
SW Version Byte 2	7568	1	Int	Second char.
SW Version Byte 3	7569	1	Int	Third char.
SW Version Byte 4	7570	1	Int	Fourth char.
PORSF Counter	7601	1	Int	Power-On Reset Counter
PINRSF Counter	7602	1	Int	HW Reset Counter
Event Log Total Count	7749	1	Int	Count of all logged events
Event Log Error Count	7750	1	Int	Count of logged errors

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Event Log Read Entry 0	7751	1	FP	First part of the log entry referenced by the event log cursor in the holding reg. 7567. For the log entry it represents the first two bytes of the timestamp.
Event Log Read Entry 1	7752	1	FP	Second part of the log entry referenced by the event log cursor in the holding reg. 7567. For the log entry it represents the last two bytes of the timestamp.
Event Log Read Entry 2	7753	1	Int	Third part of the log entry referenced by the event log cursor in the holding reg. 7567. For the log entry it represents the event code number.
Fluid Volume Flow Rate Ref	9063	2	FP	Selected volume flow rate units
Fluid Volume Accumulator Ref	9067	2	FP	Selected volume total units
Data Valid Period	9123	2	FP	Seconds
Max Fluid Volume Flow Rate	9125	2	FP	Selected volume flow rate units
Min Fluid Volume Flow Rate	9127	2	FP	Selected volume flow rate units
Max Fluid Density	9129	2	FP	Selected density units
Min Fluid Density	9131	2	FP	Selected density units
Max Drive Current	9133	2	FP	mA
Min Drive Current	9135	2	FP	mA
Gauged Fluid Volume Ref	9163	2	FP	Selected volume flow rate units
Raw Fluid Volume Flow Rate Ref	9261	2	FP	Selected volume flow rate units
HOLDING REGISTERS (read-write register addresses, read function byte 0x03, write function byte 0x06 for single or 0x10 for multiple registers)				
Mass Flow Rate High Limit(Q_{max})	3001	2	FP	Selected mass flow units
K-Factor	3003	2	FP	
Low Flow Cut Off in % f.s.	3005	2	FP	In % of $Q_{max.}$ (s. 3001)
Flow Filter Step Response in % f.s.	3007	2	FP	In % of $Q_{max.}$ (s. 3001)
Flow Filter Value	3013	2	FP	Seconds
Density Filter	3015	2	FP	Seconds
Flow Direction	3017	2	FP	1 = Forward -1 = Reverse
Low Density Cut Off	3019	2	FP	Selected density units
RR Filter Value	3021	2	FP	Samples

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Temperature Filter Value	3023	2	FP	Seconds
Display Flow Filter Value	3025	2	FP	Seconds
High Density Cut Off	3035	2	FP	Selected density units
Sensor Amplitude Set Value	3051	2	FP	Millivolts
Current Resistor Value	3053	2	FP	Ohms
Sensor Amplitude Control PID Kp	3055	2	FP	
Sensor Amplitude Control PID Ki	3057	2	FP	
Sensor Amplitude Control PID Kd	3059	2	FP	
Meter Variable	3061	2	FP	g/s per µs
Zero Offset Value	3063	2	FP	Timer ticks
PT1000 Correction Value	3065	2	FP	
Temperature Correction Value On Density Calculation ToD_b	3067	2	FP	
Frequency At Air	3069	2	FP	Hz
Temperature At Air	3071	2	FP	°C
Density At Air	3073	2	FP	g/cc
Frequency At H2O	3075	2	FP	Hz
Temperature At H2O	3077	2	FP	°C
Density At H2O	3079	2	FP	g/cc
Primary mA Output 4mA Calibration Value	3081	2	FP	Milliamps
Primary mA Output 20mA Calibration Value	3083	2	FP	Milliamps
Secondary mA Output 4mA Calibration Value	3085	2	FP	Milliamps
Secondary mA Output 20mA Calibration Value	3087	2	FP	milliamps
Temperature Calibration Value	3089	2	FP	°C
Analog Input Calibration Value	3091	2	FP	Milliamps
Primary mA Output 4mA Calibration DAC Value	3093	2	FP	0-4095
Primary mA Output 20mA Calibration DAC Value	3095	2	FP	0-4095
Secondary mA Output 4mA Calibration DAC Value	3097	2	FP	0-4095
Secondary mA Output 20mA Calibration DAC Value	3099	2	FP	0-4095
Pt1000 Amplitude Calibration Resistor	3101	2	FP	Ohms
Pt1000 Offset Calibration Resistor	3103	2	FP	Ohms
Pt1000 Offset Calibration Ro	3105	2	FP	Ohms
Pt1000 Amplitude Calibration K	3107	2	FP	Ohms
Temperature Correction Value On Density Calculation ToD_a	3109	2	FP	
Temperature Correction Value On Density Calculation ToD_c	3111	2	FP	
Primary mA Output Flow Rate At 4mA	3201	2	FP	Selected flow units
Primary mA Output Flow Rate At 20mA	3203	2	FP	Selected flow units
Primary mA Output Density At 4mA	3205	2	FP	Selected density units
Primary mA Output Density At 20mA	3207	2	FP	Selected density units

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Primary mA Output Temperature At 4mA	3209	2	FP	Selected temperature units
Primary mA Output Temperature At 20mA	3211	2	FP	Selected temperature units
Primary mA Output Batch Total At 4mA	3213	2	FP	Selected flow total units
Primary mA Output Batch Total At 20mA	3215	2	FP	Selected flow total units
Secondary mA Output Flow Rate At 4mA	3217	2	FP	Selected mass flow units
Secondary mA Output Flow Rate At 20mA	3219	2	FP	Selected mass flow units
Secondary mA Output Density At 4mA	3221	2	FP	Selected density units
Secondary mA Output Density At 20mA	3223	2	FP	Selected density units
Secondary mA Output Temperature At 4mA	3225	2	FP	Selected temperature units
Secondary mA Output Temperature At 20mA	3227	2	FP	Selected temperature units
Secondary mA Output Batch Total At 4mA	3229	2	FP	Selected temperature units
Secondary mA Output Batch Total At 20mA	3231	2	FP	Selected temperature units
mA Input Pressure Rate at 4 mA	3241	2	FP	Selected pressure units
mA Input Pressure Rate at 20 mA	3243	2	FP	Selected pressure units
Pressure Rate Manual Input	3245	2	FP	Selected pressure units
Frequency Out Flow At Full Scale Frequency	3251	2	FP	Selected flow units
Frequency Out Full Scale Frequency	3253	2	FP	Hz
Frequency Out Total Count Value	3255	2	FP	Selected flow total units
Ctrl Out Batch Value	3257	2	FP	Selected flow total units
Fault LED Turn On Time	3259	2	FP	Seconds
Fault LED Turn Off Time	3261	2	FP	Seconds
CtrlOut Flow Limit Value	3263	2	FP	In g/s
CtrlOut Limit Hysteresis	3265	2	FP	%
CtrlOut Flow At Full Scale Frequency	3267	2	FP	Selected flow units
CtrlOut Full Scale Frequency	3269	2	FP	Hz
CtrlOut Flow Limit Value	3271	2	FP	Selected flow units
CtrlOut Density Limit Value	3273	2	FP	Selected density units
Zero Offset Procedure Running Time	3301	2	FP	Sets running time in seconds and automatically starts the offset procedure. The return value: the remaining time in seconds.
Zero Offset Value	3303	2	FP	The result of the zero offset procedure in micro seconds
Frequency Out Fixed Value	3351	2	FP	Hz
Primary mA Output Fixed Value	3353	2	FP	Milliamps
Secondary mA Output Fixed Value	3355	2	FP	Milliamps

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Pressure Compensation Corr. Value 1	3401	2	FP	%
Pressure Compensation Corr. Value 2	3403	2	FP	%
Pressure Compensation Corr. Value 1	3405	2	FP	%
Pressure Compensation Corr. Value 2	3407	2	FP	%
Pressure Compensation Pressure Value 1	3421	2	FP	bar
Pressure Compensation Pressure Value 2	3423	2	FP	bar
Pressure Compensation Pressure Value 3	3425	2	FP	bar
Pressure Compensation Pressure Value 4	3427	2	FP	bar
Temperature Correction Value On Flow Calculation	3501	2	FP	
Pressure Correction of the Zero A	3503	2	FP	
Pressure Correction of the Zero B	3505	2	FP	
Pressure Correction of the Zero Offset	3507	2	FP	Selected pressure units
Drive Current Min Threshold	4001	2	FP	mA
Drive Current Max Threshold	4003	2	FP	mA
Mass Flow Rate Min Threshold	4005	2	FP	g/s
Mass Flow Rate Max Threshold	4007	2	FP	g/s
Temperature Min Threshold	4009	2	FP	°C
Temperature Max Threshold	4011	2	FP	°C
Density Min Threshold	4013	2	FP	g/cc
Density Max Threshold	4015	2	FP	g/cc
Pressure Min Threshold	4017	2	FP	bar
Pressure Max Threshold	4019	2	FP	bar
Meter Mode	7011	1	Int	0 = Mass Meter 1 = Volume Meter 2 = Ref. Volume 3 = Net Oil
UART0 Modbus Additional Time Delay	7021	1	Int	ms
UART0 Device Address	7023	1	Int	1-246 (default: 1)
UART0 Modbus Baud Rate	7024	1	Index	0 - 9600 1 - 19200 2 - 57600 3 - 115200
UART0 Modbus Byte Order	7025	1	Index	0 - ABCD (3-2-1-0) 1 - BADC (2-3-0-1) 2 - CDAB (1-0-3-2) 3 - DCBA (0-1-2-3) (default: 0)
Mass Flow Units	7101	1	Index	s. 3.11.4 “Mass Flow Units”
Density Units	7102	1	Index	s. 3.11.5 “Density Units”
Temperature Units	7103	1	Index	s. 3.11.6 “Temperature Units”
Volume Flow Units	7104	1	Index	s. 3.11.7 “Volume Flow Units”

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Mass Flow Total Units	7105	1	Index	s. 3.11.8 “Mass Flow Total Units”
Volume Flow Total Units	7106	1	Index	s. 3.11.9 “Volume Flow Total Units”
Pressure Units	7107	1	Index	s. 3.11.10 “Pressure Units”
Primary mA Out Mode	7151	1	Index	0 = Mass Flow 1 = Density 2 = Temperature 3 = Batch Total
Secondary mA Out Mode	7152	1	Index	0 = Mass Flow 1 = Density 2 = Temperature 3 = Batch Total
Frequency Out Mode	7153	1	Index	0 = Frequency 1 = Total Count
Ctrl Out Mode	7154	1	Index	0 = Fault 1 = Freq. Out Direction 2 = Batch 4 = Flow Limit
Ctrl In Mode	7155	1	Index	0 = Zero Offset 1 = Reset Batch Total 2 = Off 3 = Hold
Ctrl Out Active State	7156	1	Index	0 = Active High 1 = Active Low
Analog Input Mode	7157	1	Index	0 = Off 1 = Pressure Input
Pressure Measuring Mode	7158	1	Index	0 = Off 1 = Analog In 2 = Manual Input
Ctrl In 2 Mode (TCE 6000 only)	7159	1	Index	0 = Off 1 = Pressure Input
Ctrl In Active State	7160	1	Index	0 = Active High 1 = Active Low
Interface Mode	7161	1	Index	0 – RS485/Modbus RTU 1 – HART 2 – FF
Totalizer Count Mode	7162	1	Index	0 – Both 1 – Forward 2 – Reverse
Ctrl Out Level	7163	1	Index	0 – High 1 – Low
Device Access Code	7301	1	Int	Password protection for the “P”-button(“local log out”): 0 – 9999
Sensor Type Byte 1	7551	1	Int	char #1 in TCM sensor type (e.g.T in TCM03100)
Sensor Type Byte 2	7552	1	Int	char #2
Sensor Type Byte 3	7553	1	Int	char #3
Sensor Type Byte 4	7554	1	Int	char #4

Name	Coil/Register Start Addr.	Address Count	Value Type	Value Units/Description
Sensor Type Byte 5	7555	1	Int	char #5
Sensor Type Byte 6	7556	1	Int	char #6
Sensor Type Byte 7	7557	1	Int	char #7
Sensor Type Byte 8	7558	1	Int	char #8
Serial Number Byte 1	7559	1	Int	char #1 in serial number (e.g. 1 in 12345678)
Serial Number Byte 2	7560	1	Int	char #2 in S/N
Serial Number Byte 3	7561	1	Int	char #3 in S/N
Serial Number Byte 4	7562	1	Int	char #4 in S/N
Serial Number Byte 5	7563	1	Int	char #5 in S/N
Serial Number Byte 6	7564	1	Int	char #6 in S/N
Serial Number Byte 7	7565	1	Int	char #7 in S/N
Serial Number Byte 8	7566	1	Int	char #8 in S/N
Event Log Cursor	7567	1	Int	Event log cursor read/write current event log position
Multiphase Comp. Mode	8002	1	Int	0 – COMP OFF 1 – COMP ON
Gas Density Ref	9005	2	FP	Selected density units
Multiphase Min Drive Current	9021	2	FP	mA
Multiphase Max Drive Current	9023	2	FP	mA
Multiphase Min Valid Period	9025	2	FP	Seconds
Data Update Period	9041	2	FP	Seconds

3.9. Meter Parameter Description

The parameters listed in the previous section are defined in this section.

3.9.1. Meter Mode

This setup parameter partly determines the units in which fluid flow is measured in the meter. When “MASS METER” is selected measurements are in mass units, while for the volume and net oil modes measurements are in volume units.

When the “meter mode” parameter is set to “MASS METER” the meter’s total and flow rate displays are in units of mass and mass per unit time.

When the “meter mode” parameter is set to “VOLUME METER” the total and flow rate displays are in units of volume and volume per unit time at the ambient temperature and pressure.

When the “meter mode” parameter is set to “REF. VOLUME” the total and flow rate displays are in units of volume and volume per unit time, corrected to the reference temperature of 60 °F (16 °C) and atmospheric pressure.

When the “meter mode” parameter is set to “NET OIL,” the meter’s net oil computer is enabled and there are total and flow rate displays for oil and water at the ambient temperature and pressure as well as for the oil and water cuts.

Register Type: Holding Register
Variable Type: Integer
Low Address: 7011
High Address: none
Default: MASS MODE (0)

3.9.2. Gas Density Ref

This is the entered density of the gas produced by the well, measured at atmospheric pressure and a temperature of 60 °F. This setup is used when the “meter mode” parameter is set to “REF. VOLUME.”

Register Type: Holding Register
Variable Type: Floating Point
Start Address: 9005
Units: selected density units
Min: 0.000500 g/cm^3
Max: 0.005000 g/cm^3
Default: 0.001000 g/cm^3

3.9.3. Multiphase Comp. Mode

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” then when, because of the presence of entrained liquid in the gas stream, the drive current is greater than the value of the “Multiphase Max Drive Current” setup or is less than the value of the “Multiphase Min Drive Current” setup then the meter’s flow rate data is not considered valid.

Register Type: Holding Register
Variable Type: Integer
Start Address: 8002
Selection List: COMP. OFF (0), COMP. ON (1)
Default: COMP. OFF (0)

3.9.4. Multiphase Min Drive Current

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the drive current is less than the value of the “Multiphase Min Drive Current” setup then the meter’s flow rate data is not considered valid.

Register Type: Holding Register
Variable Type: Floating Point
Start Address: 9021
Units: mA
Min: 0.0 mA
Max: Multiphase Max Drive Current
Default: 2.0 mA

3.9.5. Multiphase Max Drive Current

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the drive current exceeds the value of the “Multiphase Max Drive Current” setup, then the meter’s flow rate data is not considered valid.

Register Type: Holding Register
Variable Type: Floating Point
Start Address: 9023
Units: mA
Min: Multiphase Min Drive Current
Max: NONE
Default: 15.0 mA

3.9.6. Multiphase Min Valid Period

When the “meter mode” parameter is set to “REF. VOLUME” and the multiphase compensation mode parameter is set to “COMP. ON” and the time interval during which the drive current is within the limits set by the multiphase min and max drive current setups is less than the “Multiphase Min Valid Period” parameter, then the flow rate data from the previous update time interval is used for purposes of incrementing the reference volume accumulator.

Register Type: Holding Register
Variable Type: Floating Point
Low Address: 9024
High Address: 9025
Units: sec
Min: 1.0 sec
Max: net oil update time
Default: 10.0 sec

3.9.7. Data Update Period

When the “meter mode” parameter is set to “REF. VOLUME” the “data update period” parameter sets the time interval during which flow data is accumulated and averaged before updating the reference volume accumulator and flow rate display values. When the “Multiphase Compensation Mode” parameter is set to “COMP. ON” this time interval is partitioned into a period where the meter’s flow data is considered valid and another where it is considered invalid. The mean flow rate during the valid period is used during the entire time interval for purposes of computing the accumulated net reference volume for the time interval.

Register Type: Holding Register
Variable Type: Floating Point
Start Address: 9041
Units: sec
Min: data min valid time
Max: 3,600.0 sec
Default: 60.0 sec

3.9.8. Gauge Data Request

When the “meter mode” parameter is set to “REF. VOLUME” and the “Gauge Data Request” setup is momentarily set to “ENABLE” (FF), the meter will save the net reference volume accumulator to the gauged total parameter and will reset the accumulator to zero. The meter will then disable (00) the “Gauge Data Request” parameter.

Register Type: Coil
Variable Type: Integer
Start Address: 8001
Selection List: DISABLE (00), ENABLE (FF)
Default: DISABLE (00)

3.9.9. Fluid Volume Flow Rate Ref

When the “meter mode” parameter is set to “REF. VOLUME” the “Fluid Volume Flow rate Ref” parameter displays the fluid volume flow rate, corrected to a temperature of 60 °F (16 °C) and atmospheric pressure. The update time is determined by the value of the “data update period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9063
Units: selected volume flow rate units

3.9.10. Fluid Volume Accumulator Ref

When the “meter mode” parameter is set to “REF. VOLUME” the “Fluid Volume Accumulator Ref” parameter displays the net fluid volume that has passed through the meter since the last gauge event, corrected to a temperature of 60 °F (16 °C) and atmospheric pressure. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9067
Units: selected volume flow rate units

3.9.11. Data Valid Period

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME”, and the multiphase compensation mode parameter is set to “COMP. ON”, the “Data Valid Period” parameter displays the time interval during which the drive current is within the limits set by the multiphase compensation flow min and max drive current setups. It is updated every data update period.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9123
Units: seconds

3.9.12. Max Fluid Volume Flow Rate

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Max Fluid Volume Flow Rate” parameter displays the maximum fluid volume flow rate measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9125
Units: selected volume flow rate units

3.9.13. Min Fluid Volume Flow Rate

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Min Fluid Volume Fow Rate” parameter displays the minimum fluid volume flow rate measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9127
Units: selected volume flow rate units

3.9.14. Max Fluid Density

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Max Fluid Density” parameter displays the maximum fluid density measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9129
Units: selected density units

3.9.15. Min Fluid Density

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Min Fluid Density” parameter displays the minimum fluid density measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9131
Units: selected density units

3.9.16. Max Drive Current

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Max Drive Current” parameter displays the maximum drive current measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9133
Units: mA

3.9.17. Min Drive Current

When the “meter mode” parameter is set to either “NET OIL” or “REF. VOLUME” the “Min Drive Current” parameter displays the minimum drive current measured during a single tube vibration period. The update time is determined by the value of the “Data Update Period” parameter.

Register Type: Input Register
Variable Type: Floating Point
Start Address: 9135
Units: mA

3.9.18. Gauged Fluid Volume Ref

When the “meter mode” parameter is set to “REF. VOLUME” the “Gauged Fluid Volume Ref” parameter displays the net fluid volume that passed through the meter, corrected to a temperature of 60 °F (16 °C) and atmospheric pressure, during the time between the last two gauge events. It is updated whenever the “gauge data request” parameter is enabled. Typically the “Gauge Data Request” parameter would be enabled once each day at exactly the same time in which case this parameter would display the net fluid volume for the previous day.

Register Type: Input Register
Variable Type: Floating Point
Low Address: 9163
Units: selected volume flow rate units

3.9.19. Raw Fluid Volume Flow Rate Ref

When the “meter mode” parameter is set to “REF. VOLUME” the “Raw Fluid Volume Flow Rate Ref” parameter displays the raw fluid volume flow rate, corrected to a temperature of 60 °F (16 °C) and atmospheric pressure, filtered with a time constant determined by the “flow filter” setup. It is updated every tube vibration time period.

Register Type: Input Register
Variable Type: Floating Point
Low Address: 9261
Units: selected volume flow rate units

3.10. Tables

3.10.1. “Fault Word 1” code descriptions

Code	Name	Description
0x0001	FAULT_POWER_UP	Power on sequence is in progress
0x0002	FAULT_SENSOR_A_PEAK	Amplitude sensor A is out of range (too high or too low)
0x0004	FAULT_SENSOR_B_PEEK	Amplitude sensor B is out of range (too high or too low)
0x0008	FAULT_MEASUREMENT_LENGTH	Measured time delay is too high
0x0010	FAULT_OFFSET_PROCEDURE	Offset adjustment procedure is in progress
0x0020	FAULT_EXCESSIVE_CURRENT_JUMPS	Driver current is not stable
0x0040	FAULT_PT_RESISTOR_RANGE	Temperature sensor is out of range (Typically indicated if the line is broken or has a short circuit)
0x0080	FAULT_LOW_TUBE_FREQUENCY	Oscillating frequency too low
0x0100	FAULT_HIGH_TUBE_FREQUENCY	Oscillating frequency too high
0x0200	FAULT_LOW_DRIVE_CURRENT	Driver current too low
0x0400	FAULT_HIGH_DRIVE_CURRENT	Driver current too high
0x8000	FAULT_EXTERNAL_OFFSET_PROCEDURE	External offset adjustment procedure is in progress

3.10.2. “Fault Word 2” code descriptions

Code	Name	Description
0x0001	FAULT_MASS_FLOW_HIGH	Mass flow is too high
0x0002	FAULT_MASS_FLOW_LOW	Mass flow is too low
0x0004	FAULT_TEMPERATURE_HIGH	Temperature is too high
0x0008	FAULT_TEMPERATURE_LOW	Temperature is too low
0x0010	FAULT_DENSITY_HIGH	Density is too high
0x0020	FAULT_DENSITY_LOW	Density is too low
0x0040	FAULT_PRESSURE_HIGH	Pressure is too high
0x0080	FAULT_PRESSURE_LOW	Pressure is too low

3.10.3. “Warning Word” code descriptions

Code	Name	Description
0x0001	WARNING_EEPROM_FACTORY_BACKUP	Factory backup wasn’t done
0x0002	WARNING_EEPROM_CUSTOMER_BACKUP	Customer backup isn’t up to date

3.10.4. “Mass Flow Rate Units”

Index	Name	Description
0	G/S	grams per second
1	KG/S	kilograms per second
2	LB/S	pounds per second
3	OZ/S	ounces per second
4	T/S	tons per second
5	ST/S	stones per second
6	G/MIN	grams per minute
7	KG/MIN	kilograms per minute
8	LB/MIN	pounds per minute
9	OZ/MIN	ounces per minute
10	T/MIN	tons per minute
11	ST/MIN	stones per minute
12	G/H	grams per hour
13	KG/H	kilograms per hour
14	LB/H	pounds per hour
15	OZ/H	ounces per hour
16	T/H	tons per hour
17	ST/H	stones per hour
18	G/D	grams per day
19	KG/D	kilograms per day
20	LB/D	pounds per day
21	OZ/D	ounces per day
22	T/D	tons per day
23	ST/D	stones per day
24	MT/S	metric tons per second
25	MT/MIN	metric tons per minute
26	MT/H	metric tons per hour
27	MT/D	metric tons per day

3.10.5. “Density Units”

Index	Name	Description
0	G/CC	grams per cubic centimeter
1	G/L	grams per liter
2	KG/L	kilograms per liter
3	LB/CF	pounds per cubic feet
4	LB/GAL	pounds per gallon
5	BRIX	sugar content in degrees Brix
6	KG/M3	kilograms per cubic meter
7	API	API Gravity

3.10.6. “Temperature Units”

Index	Name	Description
0	°C	degrees Celsius
1	°F	degrees Fahrenheit
2	Kelvin	Kelvin

3.10.7. “Volume Flow Rate Units”

Index	Name	Description
128	cm3/S	cubic centimeters per second
129	L/S	liters per second
130	GAL/S	gallons per second
131	BBL/S	barrels per second
132	LOZ/S	liquid ounces per second
133	IGAL/S	imperial gallons per second
134	IBBL/S	imperial barrels per second
135	m3/S	cubic meters per second
136	kM3/S	1.000 cubic meters per second
137	hL/S	hectoliters per second
138	kL/S	1.000 liters per second
139	ML/S	1.000.000 liters per second
140	CF/S	cubic feet per second
141	MCF/S	1.000.000 cubic feet per second
142	cm3/M	cubic centimeters per minute
143	L/MIN	liters per minute
144	GAL/M	gallons per minute
145	BBL/M	barrels per minute
146	LOZ/M	liquid ounces per minute
147	IGAL/M	imperial gallons per minute
148	IBBL/M	imperial barrels per minute
149	m3/MIN	cubic meters per minute
150	kM3/M	1.000 cubic meters per minute
151	hL/MIN	hectoliters per minute
152	kL/MIN	1.000 liters per minute
153	ML/MIN	1.000.000 liters per minute
154	CF/MIN	cubic feet per minute
155	MCF/M	1.000.000 cubic feet per minute
156	cm3/H	cubic centimeters per hour
157	L/H	liters per hour
158	GAL/H	gallons per hour
159	BBL/H	barrels per hour

Index	Name	Description
160	LOZ/H	liquid ounces per hour
161	IGAL/H	imperial gallons per hour
162	IBBL/H	imperial barrels per hour
163	m3/H	cubic meters per hour
164	kM3/H	1.000 cubic meters per hour
165	hL/H	hectoliters per hour
166	kL/H	1.000 liters per hour
167	ML/H	1.000.000 liters per hour
168	CF/H	cubic feet per hour
169	MCF/H	1.000.000 cubic feet per hour
170	cm3/D	cubic centimeters per day
171	L/D	liters per day
172	GAL/D	gallons per day
173	BBL/D	barrels per day
174	LOZ/D	liquid ounces per day
175	IGAL/D	imperial gallons per day
176	IBBL/D	imperial barrels per day
177	m3/D	cubic meters per day
178	kM3/D	1.000 cubic meters per day
179	hL/D	hectoliters per day
180	kL/D	1.000 liters per day
181	ML/D	1.000.000 liters per day
182	CF/D	cubic feet per day
183	MCF/D	1.000.000 cubic feet per day

3.10.8. “Mass Flow Total Units”

Index	Name	Description
0	GRAM	grams
1	KG	kilograms
2	POUNDS	pounds
3	OUNCES	ounces
4	TONS	tons
5	STONES	stones
6	MTONS	metric tons

3.10.9. “Volume Flow Total Units”

Index	Name	Description
128	cm3	cubic centimeters
129	LITER	liters
130	GAL	gallons
131	BBL	barrels
132	LOZ	liquid ounces
133	IGAL	imperial gallons
134	IBBL	imperial barrels
135	m3	cubic meters
136	kM3	1.000 cubic meters
137	hL	hectoliters
138	kL	1.000 liters
139	ML	1.000.000 liters
140	CF	cubic feet
141	MCF	1.000 cubic feet
142	MMCF	1.000.000 cubic feet

3.10.10. “Pressure Units”

Index	Name	Description
0	BAR	bar
1	KPA	Kilopascal
2	MPA	Megapascal
3	PSI	psi

4. Contact

TRICOR web page

www.tricorflow.com

Sales

North and South America:
AW-Lake Company
2440 W. Corporate Preserve Dr. #600
Oak Creek WI 53154
USA

Tel.: +1 414 574 4300
sales@aw-lake.com
www.aw-lake.com

China:
KEM Flow China
Rm. 430, JInYuan Building, No. 36 BeiyuanLu,
CN- Chaoyang District, Beijing 100012
P.R.CHINA

Tel.:+86 10 84929567 / +86 10 84929577
Fax:+86 10 52003739
info@kem-kueppers.com
www.kem-kueppers.cn

Southeast Asia:
KEM Küppers Elektromechanik GmbH
Representative Office (RO) Singapore
1003 Bukit Merah Central #06-32
Singapore 159836

UEN: T15RF0080G

Tel.: +65 6274 1130
info@kem-kueppers.com
www.kem-kueppers.cn

Europe:
KEM Küppers Elektromechanik GmbH
Liebigstraße 5
DE-85757 Karlsfeld
Germany

Tel.: +49 8131 593910
info@kem-kueppers.com
www.kem-kueppers.com

Manufacturer

KEM Küppers Elektromechanik GmbH
Liebigstraße 5
DE-85757 Karlsfeld
Germany

Tel.: +49 8131 593910
info@kem-kueppers.com
www.kem-kueppers.com

AW-Lake Company
2440 W. Corporate Preserve Dr. #600
Oak Creek WI 53154
USA

Tel.: +1 414 574 4300
sales@aw-lake.com
www.aw-lake.com