ToughEye-1700™ Modbus-RTU Interface Reference Guide

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Modbus-RTU Version	2.3
ToughEye-1700™ Compatible Firmware	3.3.0

Change History

Version	Change Summary
1.0	Initial release.
1.1	Changed System Error Status (EREG) bit flag order to reflect the controller's settings.

Table of Contents

Introduction

This document outlines the ToughEye-1700™ Modbus-RTU interface, implemented through the RS-232 protocol, including register definitions and functionality.

Firmware Version Compatibility

This document is based on ToughEye-1700™ Modbus-RTU version 2.3, which runs on ToughEye-1700™ controller firmware version 3.3.0.

If running on an older controller firmware version, or unsure what version is being run, please refer to the relevant resources found here, with corresponding documentation found here. For further information or assistance please contact ExcelSense technical support at support@excelsensetechnologies.com.

When running an older controller firmware version on the ToughEye-1700™, some features or data (holding registers or coils) may not be available.

Modbus-RTU Settings

Modbus Settings

Device ID Address

The default Modbus-RTU device ID address is **0x01**. This is modifiable through the DIDR holding register on the Modbus server.

Modbus Data Addresses

All data addresses in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. For example, the coil known as “coil 1” in a programmable controller is addressed as coil 0x0000 in the data address field of a Modbus message.

Internal Modbus Server Update Rate

Data stored in the Modbus registers and coils is scanned by the host system's running program approximately every 20 milliseconds. The maximum recommended scanning rate by a Modbus-RTU client is 100ms.

RS-232 Settings

The ToughEye-1700™ device hosts a Modbus-RTU server, running with the following settings:

Baud Rate (bps)	38400
Data Bits	8
Stop Bits	1
Parity	None
Flow Control	None

Supported Function Codes

The supported Modbus-RTU function codes are given below:

Function	Code
Read Coils	0x1
Write Single Coil	0x5
Write Multiple Coils	0xF
Read Multiple Holding Registers	0x3
Write Single Holding Register	0x6
Write Multiple Holding Registers	0x10

Data Memory Mapping

The following table details all coils and registers available on the Modbus interface.

Note: *Data is considered non-volatile if its value is stored onto local non-volatile memory, unaffected by loss of system power. Conversely, data is considered volatile if its value is lost in the event of a power cycle. Volatile data is significant only during the running program, whereas non-volatile data impacts system behaviour permanently.*

Holding Registers

Name	Addr	Dir	Description
Device ID (DIDR)	0x00	I/O	Modbus device ID register. → *Default value: 1* → *Data Type: unsigned byte (0 ~ 255)* → *Accepted Range: 1 ~ 255* → *Volatility: Non-volatile*
System State (SREG)	0x0D	O	System state register. → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*
System Error Status (EREG)	0x0E	O	System error status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*
Self-Clean Subsystem Status (SCSR)	0x0F	O	Self-clean subsystem status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*
Thermal Subsystem Status (THSR)	0x10	O	Thermal subsystem status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*
Lifetime Cycle Count MSW (LCCH)	0x11	O	Life cycle count, most significant word (MSW) register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Non-volatile*
Lifetime Cycle Count LSW (LCCL)	0x12	O	Life cycle count, least significant word (LSW) register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Non-volatile*
Cycle Timeout (CTOR)	0x14	O	Cycle timeout register → Indicates the shortest allowable delay between

			consecutive cleaning cycles → *Default value: 55* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Non-volatile*
Last Cycle Time (LCTR)	0x16	O	Last cycle runtime register → Indicates duration of the latest cleaning cycle in seconds → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*
Main Board Temperature (MBTR)	0x18	O	Main board temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*
Remote Sensor 1 Temperature (R1TR)	0x19	O	Remote sensor 1 temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*
Remote Sensor 2 Temperature (R2TR)	0x1A	O	Remote sensor 2 temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*
Thermal Load (THLR)	0x1B	O	Thermal device current readout register. → Indicates the thermal device current draw, in milliAmps → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: 0 ~ 150* → *Volatility: Volatile*
Thermal Duty (TDYR)	0x20	O	Thermal device duty cycle readout register. → Indicates the thermal device duty cycle percentage → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: 0 ~ 100* → *Volatility: Volatile*
LED Run Mode (LRMR)	0x27	O	LED run mode register. → Indicates the running mode of the LED thermal device → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Non-volatile*

Firmware Version, Major Register (FVMR)	0x29	O	Firmware version major register. → Indicates the running controller firmware version's major index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Firmware Version, Minor Register (FVNR)	0x2A	O	Firmware version minor register. → Indicates the running controller firmware version's minor index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Firmware Version, Patch Register (FVPR)	0x2B	O	Firmware version patch register. → Indicates the running controller firmware version's patch index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Modbus Version, Major Register (MVMR)	0x2C	O	Modbus version major register. → Indicates the running Modbus-RTU version's major index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Modbus Version, Minor Register (MVNR)	0x2D	O	Modbus version minor register. → Indicates the running Modbus-RTU version's minor index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*

Coils

Name	Addr	Dir	Description
Power Type (PTPC)	0x0D	O	Power type output coil → Indicates the power source type as DC or PoE+. → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*
Power Level (PLVC)	0x0E	O	Power level output coil → Indicates if the power level is nominal (25W) or low power (12W) → *Default value: 0* → *Data Type: boolean*

			→ *Volatility: Volatile*
System Ready to Clean (RDYC)	0x0F	O	System ready to clean coil → Indicates whether or not the system is ready to accept a cleaning trigger → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*
Optics Status (OPSC)	0x10	O	Optics status coil → Indicates the power status of the optical module → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*
Thermal Heating Status (THSC)	0x11	O	Thermal heating status coil → On cameras equipped with a resistive heater as the thermal device (non-integrated light variants), indicates the power status of the heater → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*
Self-Clean Trigger (SCTC)	0x15	I	Self-clean trigger coil → When set high, this coil sends a self-clean trigger command to the device. The unit will respond to this command based on the system state. → This coil is reset by the device upon completion of a cleaning cycle. In the case that a cycle was not started, this coil must be reset by the client. → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

Data Descriptions

Holding Register Data

DIDR - Device ID Register

Device ID (DIDR)	0x0	I/O	Modbus device ID register. → *Default value: 1*

			→ *Data Type: unsigned byte (0 ~ 255)* → *Accepted Range: 1 ~ 255* → *Volatility: Non-volatile*

The Device ID Register holds the Modbus-RTU device ID. This product's ID is by default set to **0x01**.

This value will get stored into non-volatile memory for the next system startup. Note: upon changing Modbus settings like the device ID, a system reboot is required.

SREG - System State Register

System State (SREG)	0x0D	O	System status register. → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*

The System State Register holds a value indicating the current system state. The state of the system can be interpreted as shown below:

Bit	7	6	5	4	3	2	1	0	
0x0D	-	-	-	ERROR	CLEAN DISABLED	CLEANING	READY FOR CYCLE	INIT	**SREG**
R/W	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	

State	Description
INIT	System is initializing, configuring its internal settings as well as the Modbus-RTU server.
READY FOR CYCLE	The system is ready for a cleaning trigger input. → The system has fully initialized, primed, and confirmed to be in an operable temperature range. → No errors are detected, and the system is not in a CYCLE_TIMEOUT condition.
CLEANING	The system is currently performing a cleaning cycle.
CLEANING DISABLED	Cleaning is currently disabled. → The system has sensed one or more of the following: 1. The cleaning subsystem is currently in the Cycle Timeout state → To confirm, check SCSR register

	2. The temperature is too cold for a cleaning cycle[1] → To confirm, check EREG and WITR registers 3. The temperature is too hot for a cleaning cycle → To confirm, check EREG and WITR registers 4. One or more errors, related to either the thermal or self-cleaning subsystems, have been detected within the system → To confirm, check the EREG register
ERROR	Error detected. → The system has detected one or more error(s) related to the thermal and/or self-cleaning subsystems. → Check the EREG register bitmask definitions below for detailed error detection descriptions

EREG - System Error Status Register

System Error Status (EREG)	0x0E	O	System error status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*

The System Error Register holds data that displays all errors detected within the system. The error bits within the register are shown below:

Bit	15	14	13	12	11	10	9	8	
0x0E	-	-	-	MTHW	MTSD	MOVC	-	MINE	EREGH
R/W	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	

Bit	7	6	5	4	3	2	1	0	
0x0E	-	-	-	ETHW	SOTP	SUTP	HDRV	TMPS	EREGL
R/W	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	

State	Description
TMPS	Temperature Sensor Fault Flag → If set, this flag indicates that a temperature sensor fault has been detected. → If set, the thermal subsystem is disabled (i.e. thermal regulation disabled).

[1] *If the system reads its control temperature sensor output to be lower than the critical falling threshold value, it will enter the CLEANING_DISABLED state. The thermal subsystem will work to raise the temperature back to the safely operable range. Once the temperature is sensed to be above its critical rising threshold, the system can resume self-cleaning unless the system senses any errors.*

	→ This flag is non-latching: once the error condition is resolved, this flag will be asserted low by the system, and the thermal subsystem resets and returns to normal operation. → *Default value: 0*
HDRV	Heater Driver Fault Flag → If set, this flag indicates that a fault is detected in the heater driver circuitry resulting in driver shutdown (i.e. the heater is disabled). → Fault conditions: driver over-temperature, over-current, under-voltage. → This flag is latched: it remains set until a system power cycle is performed. → *Default value: 0*
SUTP	System Undertemp Error Flag → If set, this flag indicates that the system is in an under-temperature state. Refer to the product manual for system threshold values. → When the internal control temperature sensor reading is below the system under-temperature threshold, this flag is set by the system → If this flag is set, the system is in an error state where thermal regulation and self-cleaning will be disabled. → This flag is non-latching: once the system control temperature is measured to be above this low limit, the thermal subsystem will resume normal operation, and this flag will be asserted low by the system. Once the temperature is above a safe cleaning threshold, the actuation subsystem will be enabled and self-cleaning cycles can be performed. → *Default value: 0*
SOTP	System Overtemp Error Flag → If set, this flag indicates that the system is in an over-temperature error state. Refer to the product manual for system threshold values. → When the internal control temperature sensor reading exceeds the system over-temperature threshold, this flag is set by the system. → If this flag is set, the system is in an error state where self-cleaning will be disabled → This flag is non-latching: once the system control temperature is low enough for safe self-cleaning, this flag will be asserted low by the system and the self-cleaning subsystem will resume normal operation. → *Default value: 0*
ETHW	Electrical Thermal Warning Flag → If set, this flag indicates that the system has detected that the local on-board temperature has risen above the over-temperature warning threshold. Refer to the product manual for system threshold values. → This flag is non-latching: if the temperature is below this threshold, this flag is automatically reset by the system. → This flag indicates a system warning, not an error. This means that the system reaction to this flag being set is different from the other flags in this register. If this flag is set, the system will enter a thermal optimization state where a minimum time between cycles (CTOR) will be enforced. Once this

	flag is reset, the system exits this thermal optimization state and resets the CTOR value to what it was prior to entering this state. → *Default value: 0*
MINE	Motor Initialization Error Flag → If set, indicates that a motor driver initialization error was detected at system startup. → If detected, self-cleaning functionality is disabled. → This flag is latched: it remains set until a system power cycle is performed. → *Default value: 0*
MOVC	Motor Overcurrent Error Flag → If set, this flag indicates that the system has sensed an over-current condition on one or more of the motor coils. → If detected, self-cleaning functionality is disabled. → This flag is latched: it remains set until a system power cycle is performed. → *Default value: 0*
MTSD	Motor Thermal Shutdown Flag → If set, this flag indicates that the system has sensed that the motor driver IC's junction temperature has reached its absolute maximum allowable limit. → If detected, self-cleaning functionality is disabled. → This flag is latched: it remains set until a system power cycle is performed. → *Default value: 0*
MTHW	Motor Thermal Warning Flag → If set, this flag indicates that the system has sensed that the motor driver IC's junction temperature is close to its absolute maximum allowable limit. → If detected, self-cleaning functionality is disabled. → This flag is non-latching: once the error condition is resolved, this flag will be asserted low by the system, and the self-cleaning subsystem will resume normal operation. → *Default value: 0*

SCSR - Self-Clean Subsystem Status Register

Self-Clean Status (SCSR)	0x0F	O	Self-clean subsystem status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*

This register holds a value indicating the current self-clean subsystem state, interpreted as shown below:

Bit	7	6	5	4	3	2	1	0	
0x0D	-	-	-	ERROR	TIMEOUT	RUNNING	IDLE	INIT	SCSR

R/W	R	R	R	R	R	R	R	R
Initial Value	0	0	0	0	0	0	0	0

State	Description
INIT	Self-clean subsystem is initializing, configuring its internal settings as well as the Modbus-RTU server.
IDLE	The self-clean subsystem is ready for, but not currently running, a self-cleaning cycle → The subsystem has fully initialized, primed, and confirmed to be in an operable temperature range. → No errors have been detected within the subsystem
RUNNING	The self-clean subsystem is running a self-cleaning cycle.
TIMEOUT	The self-clean subsystem is in cycle timeout. → The subsystem has ran a self-clean cycle recently within the timeout window, as defined by the cycle timeout register (CTOR) → The self-clean subsystem state machine will exit the timeout state once the timeout window has expired
ERROR	Error detected within the self-clean subsystem → The system has detected one or more error(s) related to the self-cleaning subsystem. → Check the EREG register for list of error(s)

THSR - Thermal Subsystem Status Register

Thermal Subsystem Status (THSR)	0x10	O	Thermal subsystem status register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*

This register holds a value indicating the current thermal subsystem state, interpreted as shown below:

Bit	7	6	5	4	3	2	1	0	
0x0D	-	-	ERROR	DISABLED	OVER TEMP	UNDER TEMP	TEMP IN RANGE	INIT	THSR
R/W	R	R	R	R	R	R	R	R	
Initial Value	0	0	0	0	0	0	0	0	

State	Description

INIT	Thermal subsystem is initializing, configuring its internal settings as well as the Modbus-RTU server.
TEMP IN RANGE	Thermal subsystem has sensed that the temperature is in the desired operating range for the self-clean and thermal subsystems. → Neither self-clean nor thermal subsystems are disabled due to thermal error conditions → No errors have been detected within the subsystem
UNDER TEMP	Thermal subsystem has detected that the temperature is below the desired operating range for the self-clean subsystem. → Self-clean subsystem is disabled due to thermal undertemp condition → Thermal subsystem is actively working to heat the unit → Thermal subsystem state machine will exit this state and enter the TEMP IN RANGE state once the internal temperature is in the desired operating range.
OVER TEMP	Thermal subsystem has detected that the temperature is above the desired operating range for the self-clean subsystem. → Self-clean subsystem is disabled due to thermal overtemp condition → Thermal subsystem is limiting or disabling its thermal device to naturally cool the system → Thermal subsystem state machine will exit this state and enter the TEMP IN RANGE state once the internal temperature is in the desired operating range. → If the temperature still continues to rise above the system thermal error threshold, the subsystem will enter the ERROR state
DISABLED	Thermal subsystem internal temperature regulation is disabled → Thermal subsystem is not actively regulating the internal temperature → Thermal subsystem will not prevent the self-clean subsystem from running even if the internal temperature is not within the desired operating range. → No errors have been detected within the thermal subsystem. If errors are detected, the thermal subsystem state machine will enter the ERROR state
ERROR	Error detected within the thermal subsystem → Thermal subsystem has detected one or more error(s) → Check the EREG register for list of error(s) → The thermal state machine will enter the INIT state once all errors have been resolved.

LCCH - Lifetime Cycle Count High Word Register

Lifetime Cycle Count MSW (LCCH)	0x11	O	Life cycle count, most significant word (MSW) register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)*

			→ *Volatility: Non-volatile*

The Lifetime Cycle Count High Word Register holds the most significant two bytes of data pertaining to the lifetime cycle count of the system.

The base data type of the cycle count variable is a 4-byte unsigned long (32 data bits). The value of the cycle count can be determined by performing the following mathematical operations:

$$cycleCount\_32bits = (val_{LCCH} << 16) + val_{LCCL}$$

Note: *Due to system memory optimizations, the system's internal memory stores cycle counts to the nearest 5 cycles (i.e. the internal non-volatile memory is only updated on every 5 cleaning cycles), however the Modbus registers are updated on every cycle completion.*

LCCL - Lifetime Cycle Count Low Word Register

Lifetime Cycle Count LSW (LCCL)	0x12	O	Life cycle count, least significant word (LSW) register → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Non-volatile*

The Lifetime Cycle Count Low Word Register holds the least significant two bytes of data pertaining to the lifetime cycle count of the system.

The base data type of the cycle count variable is a 4-byte unsigned long (32 data bits). The value of the cycle count can be determined by performing the following mathematical operations:

$$cycleCount\_32bits = (val_{LCCH} << 16) + val_{LCCL}$$

Note: *Due to system memory optimizations, the system's internal memory stores cycle counts to the nearest 10 cycles (i.e. the internal non-volatile memory is only updated on every 10 cleaning cycles), however the Modbus registers are updated on every cycle completion.*

CTOR - Cycle Timeout Register

Cycle Timeout (CTOR)	0x14	O	Cycle timeout register → Indicates the shortest allowable delay between consecutive cleaning cycles

			→ *Default value: 55* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Non-volatile*

The Cycle Timeout Register holds the value of the system cycle timeout. This value sets the minimum allowable time interval between consecutive cleaning cycles.

The value of the data stored in this register is in units of seconds, and its base data type is a 2-byte unsigned integer (16 data bits).

Note: *This value is measured from the start of a cycle to the start of the next cycle.*

LCTR - Last Cycle Time Register

Last Cycle Time (LCTR)	0x16	O	Last cycle runtime register → Indicates duration of the latest cleaning cycle in seconds → *Default value: 0* → *Data Type: unsigned word (0 ~ 65,535)* → *Volatility: Volatile*

The Last Cycle Time Register holds the duration of the last cycle, in seconds. The base data type is a two-byte unsigned integer (16 data bits).

This value can be used by the Modbus client software to quantify system performance over time.

MBTR - Main Board Temperature Register

Main Board Temperature (MBTR)	0x18	O	Main board temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*

This register holds the local temperature, in degrees Celsius, measured on the main board of the system. The base data type is a signed two-byte integer (1 sign bit, 15 data bits).

This temperature value is used by the system to set/reset the ETHW flag, which is dependent on local board-level temperature.

R1TR - Remote Sensor 1 Temperature Register

Remote Sensor 1 Temperature (R1TR)	0x19	O	Remote sensor 1 temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*

This register holds the temperature, in degrees Celsius, of the hardware listed below.

Sensor Name	Sensor ID	Standard Units	LED-Equipped Units
Remote Sensor 1	RM1	Optical Sensor Module Temperature	LED PCB On-board Temperature

The base data type is a signed two-byte integer (1 sign bit, 15 data bits).

This temperature value is used by the thermal control system to regulate the internal system temperature to within a desirable operating range.

R2TR - Remote Sensor 2 Temperature Register

Remote Sensor 2 Temperature (R2TR)	0x1A	O	Remote sensor 1 temperature readout register. → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: -50 ~ 150* → *Volatility: Volatile*

This register holds the temperature, in degrees Celsius, of the hardware listed below.

Sensor Name	Sensor ID	Standard Units	LED-Equipped Units
Remote Sensor 2	RM2	Not used	LED Driver PCB On-board Temperature

The base data type is a signed two-byte integer (1 sign bit, 15 data bits).

This measurement does not affect the thermal subsystem’s temperature regulation, and is only used for information purposes.

THLR - Thermal Load Register

Thermal Load (THLR)	0x1B	O	Thermal device current readout register. → Indicates the thermal device current draw, in milliAmps → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: 0 ~ 150* → *Volatility: Volatile*

This register holds the value of the current draw, in milliamps, of the equipped thermal device, corresponding to the mapping below.

Device	**Standard Units**	**LED-Equipped Units**
Equipped Thermal Device	Resistive Heater	LED Driver PCB

The base data type is a signed two-byte integer (1 sign bit, 15 data bits).

This value can be used by the Modbus client software to monitor thermal performance.

TDYR - Thermal Duty Register

Thermal Duty (TDYR)	0x20	O	Thermal device duty cycle readout register. → Indicates the thermal device duty cycle percentage → *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Expected Output Range: 0 ~ 100* → *Volatility: Volatile*

This register holds the value of the duty cycle produced by the thermal regulation algorithm to control the equipped thermal device.

The base data type is a signed two-byte integer (1 sign bit, 15 data bits).

This value can be used by the Modbus client software to monitor thermal performance.

LRMR - LED Run Mode Register

LED Run Mode (LRMR)	0x27	O	LED run mode register. → Indicates the running mode of the LED thermal device

			→ *Default value: 0* → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Non-volatile*

This register holds the value corresponding to the currently configured LED run mode. This register has no effect on standard non-LED units.

The table below can be referenced to identify the run mode from the register data.

LRMR Value	LED Run Mode	Mode Description
0	Normal	The thermal subsystem aims to maintain an operating temperature of 60°C.
1	Normally Disabled	The thermal subsystem aims to maintain an operating temperature of 15°C.
2	Shutoff	The thermal subsystem aims to maintain an operating temperature of 0°C.

FVMR, FVNR, FVPR - Controller Firmware Version Registers

Firmware Version, Major Register (FVMR)	0x29	O	Firmware version major register. → Indicates the running controller firmware version's major index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Firmware Version, Minor Register (FVNR)	0x2A	O	Firmware version minor register. → Indicates the running controller firmware version's minor index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Firmware Version, Patch Register (FVPR)	0x2B	O	Firmware version patch register. → Indicates the running controller firmware version's patch index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*

The data in the FVMR, FVNR, and FVPR registers hold the major, minor, and patch version numbers for the running ToughEye-1700™ controller module firmware.

Below is an example of how this data is read:

FVMR	FVNR	FVPR	Firmware Version
3	3	0	Version 3.3.0

MVMR, MVNR - Modbus-RTU Version

Modbus Version, Major Register (MVMR)	0x2C	O	Modbus version major register. → Indicates the running Modbus-RTU version's major index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*
Modbus Version, Minor Register (MVNR)	0x2D	O	Modbus version minor register. → Indicates the running Modbus-RTU version's minor index value → *Data Type: signed word (-32,768 ~ 32,767)* → *Volatility: Volatile*

The data in the MVMR and MVNR registers hold the major and minor version numbers for the Modbus-RTU protocol currently running on the device.

Below is an example of how this data is read:

MVMR	MVNR	Modbus-RTU Version
2	3	Version 2.3

Data Coils

PTPC - Power Type Coil

Power Type (PTPC)	0x0D	O	Power type output coil → Indicates the power source type as DC or PoE+. → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

The Power Type Coil is used as an output to indicate the power type used to power the device. Reading a 0 value indicates that the power source is derived from a DC power supply and reading a value of 1 indicates that the power source is derived from a PoE+ power supply.

PTPC - Power Level Coil

Power Level (PLVC)	0x0E	O	Power level output coil → Indicates if the power level is nominal (25W) or low power (12W) → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

The Power Level Coil is used as an output to indicate the power level sensed by the system. A value of 0 indicates that the power source is only capable of delivering 12W (standard PoE Power Supply) and a value of 1 indicates that the power supply is capable of delivering the nominal 25W.

RDYC - System Ready Coil

System Ready to Clean (RDYC)	0x0F	O	System ready to clean coil → Indicates whether or not the system is ready to accept a cleaning trigger → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

The System Ready Coil is used as an output to indicate to the Modbus client that the system is ready for a self-cleaning cycle. This is a redundant indicator in the system, as the SREG register will indicate the same condition if set to 0x8. The user can either check this coil status or the SREG register status to determine the current ready state of the system.

If this coil is asserted high (i.e. set to 1) by the system, it implies the following conditions are met:

1. The system temperature is within the safe operating range
2. No errors are detected throughout the system
3. The system is not currently in a cycle timeout state (i.e. enough time has elapsed since the last cleaning cycle)

OPSC - Optical Status Coil

Optics Status (OPSC)	0x10	O	Optics status coil → Indicates the power status of the optical module → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

The optical status coil indicates the power status of the optical module. If set high by the device, this indicates that the camera sensor module is currently being powered by the controller module after detecting an operable thermal condition.

This coil can be used as diagnostics data to monitor camera power integrity.

THSC - Thermal Heating Status Coil

Thermal Heating Status (THSC)	0x11	O	Thermal heating status coil → Indicates whether or not the thermal subsystem is currently heating the system → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

The Thermal Heating Status Coil indicates if the thermal subsystem is currently enabled and heating the system. Refer to the Quick Start Guide for details on the thermal system operation.

This is a useful coil for the Modbus client software to read in the following use cases:

1. When validating the power draw of the system given the expected ratings of the system. ***Note:*** *During self-cleaning, the system subsystem pauses regulation as a power optimization feature.*
2. When determining why cleaning is disabled.
    a. This can occur when the following are true:
        i. The system state register, SREG, indicates that self-cleaning is currently disabled

ii. However, the error register, EREG, is showing that there are no errors currently detected by the system
iii. Also, enough time has elapsed since the last cleaning cycle (based on the CTOR register) so the system should not be in a cycle timeout state.

b. When the above conditions are true, the THSC coil along with the WITR register can indicate if the system senses that the control temperature is below the critical threshold to enable self-cleaning cycles.

SCTC - Self-Clean Trigger Coil

Self-Clean Trigger (SCTC)	0x15	I	Self-clean trigger coil → When set high, this coil sends a self-clean trigger command to the device. → *Default value: 0* → *Data Type: boolean* → *Volatility: Volatile*

This coil enables a serial method for triggering a self-cleaning cycle. When the coil is set and the command is sent, the device will respond based on its current system state. For example, if it is ready to cycle, it will perform a cleaning cycle. However, if the self-cleaning subsystem is disabled for any reason, the command will be rejected.

Upon completion of a cleaning cycle, the device resets the coil. If a cleaning cycle was not performed, the coil must be reset by the client.