SMARTLINK® DS

Modbus Manual

Revision 1.1

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Table of Contents

SMARTLINK DS Modbus Manual

1 Introduction

1.1 Purpose

The purpose of this manual is to document the Modbus communications interface to a SMARTLINK DS actuator.

1.2 Scope

This document describes how the Modbus protocol is used in the SMARTLINK DS communications interface. This interface is provided for digital control and monitoring of the actuator. The following topics will be covered in this manual:

- Physical interface
- Message format
- Supported Modbus functions
- Exception codes
- Modbus register descriptions
- Modbus report slave ID message description
- Modbus read file record description
- Example master controller positioning sequence

The SMARTLINK®DS Intelligent Control Actuator Series Technical Catalog should be used in conjunction with this manual since it provides more detailed information on actuator control, user interface, and configuration functions that relate to many of the Modbus registers discussed in the following sections.

1.3 Intended Audience

This document is intended for Maxon end user and OEM customers who are developing a custom DCS or PLC-based program to control and monitor a SMARTLINK DS actuator and who have a working knowledge of the Modbus protocol.

1.4 References

The following documents are referenced by this document:

SMARTLINK®DS Intelligent Control Actuator Series Technical Catalog https://www.maxoncorp.com/Files/pdf/English/E-Smartlink_DS/ E-SL_Durastep-i-complete_section_rev_Dec_2013.pdf
MODBUS Application Protocol Specification V1.1b, December 28, 2006, http://www.Modbus-IDA.org
MODBUS over Serial Line Specification and Implementation Guide V1.02, December 20, 2006.

1.5 Terms, Acronyms and Abbreviations

Below are the terms, acronyms, and abbreviations used within this document.

Term, Acronym, Abbreviation	Defintion
ADU	Application Data Unit is the Modbus standard name for the entire message frame. Additional data that is dependent on the network type is encoded along with the PDU from the Application layer to form the message frame.
Modbus	Modbus is a serial communications protocol originally published by Modicon for use with its programmable logic controllers (PLCs). Recognized as an industry standard protocol for RS-485 serial communication.
RTU mode	Remote Terminal Unit mode is a serial transmission method with an 8-bit binary coding system defined by the Modbus protocol standard.
Frame	Contiguous sequence of data transmitted that represents a single transaction or packet. It is the complete Modbus message placed on the network.
Function code	Modbus message field that identifies the purpose of the message
PDU	Protocol Data Unit (PDU) is the network independent part of a Modbus message frame or packet sent. This part is encoded/decoded by the Application layer.
Big endian	Modbus representation of addresses and data items. The most significant byte (MSB) of a 16-bit number is transmitted first followed by the least significant byte (LSB).
Little endian	Representation of the Modbus 16-bit CRC number transmitted at the end of every frame. The LSB is transmitted first followed by the MSB.
U8, S8	Unsigned and signed 8-bit data format
U16, S16	Unsigned and signed 16-bit data format
U32	Unsigned 32-bit format

2 General

The Modbus capability provided in the SMARTLINK DS actuator conforms to the Modbus over Serial Line Specification guide, V1.02. The actuator functions as a Modbus slave (server) and responds to a single Modbus address to service the requests of the Modbus master (client) on the RS-485 network. The Modbus communications interface permits actuator configuration, position control, and diagnostic monitoring.

3 Physical Interface

3.1 Medium

The physical interface is a 2-wire electrical RS-485 (EIA-485) network that must be connected to a Modbus master device. A third conductor is also required as a common signal ground for the other two wires.

SMARTLINK DS includes a 3-terminal connector that interfaces to the RS-485 signals as shown in the table below.

Table 1. RS-485 Signals

Signal	Terminal Label
Data + (a)	RS485 In+
Data - (b)	RS485 In-
Common (c)	RS485 COM

Maxon recommends RS-485 twisted-pair cabling with the electrical characteristics summarized in the following table.

Table 2. RS-485 Cable Electrical Requirements

Characteristic	Specification
Total Number of Conductors	3 or 4 (2-pairs)
Outer Shield	Aluminum foil w/100% coverage
Outer Shield Drain Wire	22 AWG or greater
Nominal Characteristic Impedance	100-120 Ohms (@ 0.5-10 Mhz)
Maximum Attenuation @ 1 MHz, 20C	5.5 dB/1000 ft. or greater
Mominal Mutual Capacitance of a Pair	17 pF per ft. or less

The SMARTLINK DS Modbus communication interface has been qualified with several commercially available cables shown in the table below.

Table 3. Qualified RS-485 Cables

Cable Mfg - Part Number	Description
Belden 3106A	3-wire, Shielded, UV-resistant, Non-Plenum, -20C to +60C
Belden 82842	2 pair, Shielded, Plenum, -20C to +75C
Belden 89842	2 pair, Shielded, Plenum, -70C to +150C
Maxon P/N 59829	2 pair, Level 4, Shielded, Non-Plenum, 0C to +75C
Connect-Air P/N W222P-1005	2 pair, Level 4, Shielded, Non-Plenum, 0C to +75C

3.2 RS-485 Network Topologies

For ease of field installation and communication troubleshooting, the recommended Modbus network topology for SMARTLINK DS is a "star" arrangement with the following requirements:

- The Modbus master (DCS or PLC) controller is the central node and should include a Modbus network termination resistor.
- Each SMARTLINK DS should be connected individually to the master controller with its own dedicated cable run with a length of no greater than 500 feet.
- Each SMARTLINK DS should leave the termination jumper installed which is the factory default shipping configuration.
- A star arrangement with a maximum of 6 SMARTLINK DS actuators is recommended with a total cabling length no greater than 2000 feet.
- The SMARTLINK DS Modbus communications interface is NOT polarized. Network polarization at the master controller is not required but is recommended for noise immunity, particularly on long cabling runs.

If a distance of greater than 500 feet is required between the Modbus master and any SMARTLINK DS Modbus device, a multi-drop (daisy-chain) bus configuration can be implemented, however, all 2-wire, EIA/TIA RS-485 multipoint system requirements must be followed as described in the Modbus over Serial Line (V1.02) specification. In addition, for multi-drop bus configurations, the SMARTLINK DS AC power input option is recommended because of the voltage drop issue associated with long cable runs for the DC powered units.

3.3 Data Signaling

The SMARTLINK DS Modbus physical layer has the RS-485 data signaling characteristics summarized in the following table.

Table 4. Data Signaling Summary

Characteristic	Setting(s)
Speed	9600 or 19200 bits per second
Bits per character	11 bits
Data bits	8 bits
Start bits	1 bit
Stop bits	1 bit
Parity	1 bit: even or odd
Duplex	Half duplex

3.4 Message Frame

The SMARTLINK DS data link layer of the communications interface follows the MODBUS serial standard for frame format and operation. The Modbus serial transmission mode is RTU (Remote Terminal Unit). Modbus ASCII mode is not supported. The SMARTLINK DS message format characteristics are summarized in the table below.

Table 5. Data Link Layer Parameters

Characteristic	Setting(s)
Transmission mode	RTU (Remote Terminal Unit)
Coding system	8-bit binary
Error check	Frame check = 2-byte CRC-16
Byte transfer order	Big Endian
Bit transfer order	LSB (Least significant bit) first
Response timeout	65 ms (RD or RD-WR); 115ms (RD-WR_CMD)
End of frame	4.1ms or longer
Interframe gap	less than 4.1ms
Turnaround time	10ms minimum
Maximum registers read	40 registers
Maximum registers written	20 registers

The CRC in the frame is generated using the polynomial defined in the Modbus over serial line standard: $G(X) = x^{16} + x^{15} + x^2 + 1$. The least significant byte of the CRC is encoded in Little Endian format with the first after the PDU followed by the most significant byte.

4 Application Interface

The SMARTLINK DS application interface is based on the Modbus application layer. Only a subset of the Modbus function codes is supported as shown in the table below.

Table 6. Supported Modbus Function Codes

Function code	Purpose	Comment
3	Read Holding Registers	Can be use interchangeably with function code 4
4	Read Input Registers	Can be use interchangeably with function code 3
6	Write Single Register	
16	Write Multiple Registers	
17	Report Slave ID	Used to verify slave module device type/configuration
20	Read File Record	Read safety feedback packet

Configuration and status data is accessed as 16-bit holding registers in this interface but is stored in memory as a U8, S8, U16, or an S16 data format. All 32-bit data items are accessed as two consecutive 16-bit holding registers, i.e., each item uses 2 register address spaces. All registers can be accessed as a single register or up to 40 consecutive registers for a read. Data is mapped into logical groups for

efficient register access with room for future expansion and this is why address gaps exist in the SMARTLINK DS register map summary table below.

Table 7. SMARTLINK DS Modbus Register Summary

Start Addr (Dec)	End Addr (Dec)	Number of Registers	Modbus Register Category	Description
1	19	19	**User Configuration**	Changing any user configuration parameter requires the unit to be in manual mode and in an "unlocked" access state; See Modbus user command registers #30 and #31 to change the operating mode and enter a passcode (if the unit's lock function has been enabled).
20	29		***(Reserved)***	---
30	39	10	**User Commands**	A write request to any of the user command registers will initiate an action that can be confirmed by reading the same or a related register.
40	49		***(Reserved)***	---
50	59	10	**Position Control & Status**	Registers provide the capability to command and monitor actuator position.
60	99		**(Reserved)**	---
100	121	22	**Input/Output and Operational Status**	All analog and digital actuator hardware data as well as alarm and lockout status.
122	129		**(Reserved)**	---
130	136	7	**Modbus Diagnostics**	These Modbus diagnostic registers include counters that can be used to identify field communication problems.
137	299		**(Reserved)**	---
300	371	72	**Alarm History**	Non-volatile alarm event counters and a buffer that holds the last 6 alarm events.
372	399		**(Reserved)**	---
400	471	72	**Lockout History**	Non-volatile lockout event counters and a buffer that holds the last 6 lockout events.
472	499		**(Reserved)**	---
500	529	30	**Actuator Life Data**	Non-volatile counters that can be used to monitor the positioning, run time, reset events, and fatal errors over the life of the actuator.
530	599		**(Reserved)**	---
600	606	7	**Manufacturing Configuration**	Non-volatile data that is set during manufacturing such as gear ratio, position quadrant limits, calibration status, and CRC codes.
607	899		**(Reserved)**	---
	Total:	**249**		

4.1 Register Types

The following table summarizes the Modbus register types. The Modbus response timeout increases to 115 milliseconds when a write is performed on a Read-Write Command register. This additional response time is required by the actuator to confirm the initiation of the requested action before sending the message response.

Table 8. Register Type Summary

Register Type	Abbreviation	Internal Data Types	Read Timeout	Write Timeout
Read Only	RD	Read only of U8, S8, U16, or S16 data	65 ms	65ms
Read-Write	RD-WR	Read or write of U8, S8, U16, or S16 data	65 ms	65ms
Read-Write Command	RD-WR_CMD	Same as RD-WR but a write initiates an action	65 ms	115 ms

4.2 Exception Codes

An exception code may be transmitted as part of a slave response to a Modbus read or write request. The following table includes all standard Modbus exception codes that are supported, unused, and Maxon custom-defined SMARTLINK DS exception codes.

Table 9. Modbus Exception Codes

Exception Code (decimal)	Name	Description
1	Illegal Function	Illegal function code or action requested
2	Illegal Data Address	Register address out of bounds
3	Illegal Data Value	Data in query field is not allowable
4	Slave Device Failure	Slave device command or action requested failed
5	Acknowledge	Slave device request is in process
6	Slave Device Busy	Slave device request cannot be processed at this time
8	Memory Parity Error	Not used
10	Gateway Path Unavailable	Not Used
11	Gateway Failed To Respond	Not used
17	Access Failure	(Maxon defined) Invalid request access level
19	Illegal Write Data	(Maxon defined) Invalid write input data
20	Command Disabled	(Maxon defined) Command request is disabled

4.3 User Configuration

Modbus user configuration registers are described in the table below. Changing any user configuration parameter requires the unit to be in manual mode and in an "unlocked" access state. In the following section, see user command registers #30 and #31 to change mode and enter a passcode.

Table 10. Modbus User Configuration Registers

Modbus Address (Dec)	Register Name	Register Type	Description
1	Rotation	RD-WR_CMD	0 = Sets Counter Clockwise (CCW) to close; Default setting 1 = Sets Clockwise (CW) to close Rotation is defined as shaft movement towards the 0% position when viewing the actuator shaft
2	High Position Proven (HPP) Threshold	RD-WR_CMD	0 = Disables HPP, setting value to 1040 (or 104.0 degress); Default setting 1 = Sets threshold at current position S16 value; units = 0.1 degrees
3	Low Position Threshold (LPP) Threshold	RD-WR_CMD	0 = Disables LPP, setting value to -40 (or -4.0 degress) 1 = Sets threshold at current position S16 value; units = 0.1 degrees
4	Max Position User	RD-WR_CMD	1 = Sets maximum user defined position to current position
5	Min Position User	RD-WR_CMD	1 = Sets minimum user defined position to current position
6	Ma Output Mode	RD-WR_CMD	Configures the analog hardware mA output: 0 = % of user defined full scale span; 4mA = 0%, 20mA = 100%; Default setting 1 = Rotary degress; 4mA = 0 degrees, 20mA = 100 degrees
7	Actuator ID	RD-WR_CMD	User defined ID number; 1-255 range; Default = 1
8	Loss-Of-Signal Position	RD-WR_CMD	0 = Disables LOS, setting value to -40 (or -4.0 degress); Default value 1 = Sets Ma Loss-Of-Signal to current position S16 value; units = 0.1 degrees
9	F-Terminal Position	RD-WR_CMD	0 = Disables F-terminal, setting value to -40 (or -4.0 degress); Default value 1 = Sets F-terminal position to current position S16 value; units = 0.1 degrees
10	Setpoint Source	RD-WR	0 = Ma input signal is used as the position command setpoint source 1 = Serial digital input \is used as the position command setpoint source
11	Language	RD	Future use
12	RS-485 Mode	RD-WR	0 = ASCII (Manufacturing Only) 1 = Modbus: 19.2k baud, even parity, 1 stop bit 2 = Modbus: 19.2k baud, odd parity, 1 stop bit 3 = Modbus: 9.6k baud, even parity, 1 stop bit 4 = Modbus: 9.6k baud, odd parity, 1 stop bit
13	Modbus Address	RD-WR	Default Address = 11; Range 1-247
14	Alarm Mode	RD-WR	1 = Alarm Relay indicates both alarm (0.5 Hz on/off) and lockout conditions; Default value 0 = Alarm Relay indicates only lockout conditions
15	Brake Enable	RD-WR	1 = Enables brake function when motor loss-of-sync is detected; Default 0 = Disables (inhibits) brake function
16	DeadbandMa	RD-WR	Control deadband in 0.1 degree units Range 1-5 (0.1 - 0.5 degrees); Default = 0.2 degrees
17	Reserved (Future)	RD	-
18	Reserved (Future)	RD	-
19	User Passcode	RD-WR	Stored user passcode that can be read only if unit is in "unlocked" state; Valid range 0-9999; Default = 0 for disabled lock function, i.e. unit will remain unlocked until non-zero value is entered and Lock Unit command is executed via register #39.

4.4 User Commands

A Modbus write request to the user command registers, summarized in the table below, will initiate an action that can be confirmed by reading the same or a related register.

Table 11. Modbus User Command Registers

Modbus Address (Dec)	Register Name	Register Type	Description
30	Passcode Entry	RD-WR_CMD	The passcode entry command is used to "unlock" the unit to a user access level that permits changing configuration data. This command is disabled if the stored User Passcode (0), Modbus Register #19, has not been changed from its default value of zero. If the passcode, written to this register, matches the stored passcode, the lock state, Modbus register #111, is updated. Valid passcode range: 0-9999
31	Mode	RD-WR_CMD	Actuator operating modes: 0 - Restart 1 - Control (active positioning to specified position setpoint source) 2 - Manual (local positioning to user specified setpoint) 3- Lockout (position control disabled with LPP/HPP/Alarm relays de-energized) 4- Test (mode for manufacturing/service only) Permissible write values: 1 (Control), 2 (Manual), and 3 (Lockout)
32	Reset Logs	RD-WR_CMD	1 = Resets alarm and lockout event history and event counters, Modbus registers #300-311, 320-325, 330-341, 350-355, 360-365, 400-406, 420-425, 430-441, 450-455, and 460-465. Disabled in Control mode
33	Reset Mfg Config	RD-WR_CMD	1 = Resets the stored configuration to the original factory values HPP and LPP relays will be disabled. Re-commissiong the position proven thresholds will be required; Disabled in Control mode
34	Abort Command	RD-WR_CMD	1 = Stops any command or position move in process. If in Control Mode with the mA input command enabled, any motor movement will be stopped and Manual mode will be entered.
35	Motor Power	RD-WR_CMD	Intended as a field diagnostic function ONLY. This command should be used only when the actuator is NOT under load and the shaft requires manual repositioning due to a failure. be positioned manually. 1 = Motor drive power ON 0 = Motor drive power OFF Disabled in Control mode
36	Lockout Move	RD-WR_CMD	Open-loop diagnostic position move command when there is no position feedback due to a failure or if the shaft position is located outside of the 100-degree potentiometer "quadrant". This command is only enabled when the unit is in Lockout Mode. Input data range: -200 to +200; units are 0.1 degrees
37	Position Command (with manufacturing limits)	RD-WR	Position control setpoint in 0.1 degree units that is limited by the maximum and minimum manufacturing positions which are electronic "end stops". To use this command, unit must be in either: 1.) Manual mode if the Setpoint Source configuration setting is the mA (analog) input signal, or 2.) Control mode if the Setpoint Source configuration setting is the digital serial (RS-485) input Valid range: Min Mfg Position (Register #602) to Max Mfg Position (Register #601)
38	Reset Lockout	RD-WR_CMD	1 = If the unit is in Lockout Mode, a reset of the lockout condition is made. If the unit is not in Lockout Mode, the command fails. Successful completion of the command can be verified by reading mode status, Modbus register #31.
39	Lock Unit	RD-WR_CMD	1 = If the Lock function is enabled (i.e. User Passcode , Register #19, is non zero), this command forces the passcode entry to a 0, "locking" or disabling modification of user configuration parameters and inhibiting all user commands.

4.5 Position Control and Status

The following table summarizes the Modbus registers that are used for controlling and monitoring position in degrees or as a percent of user-defined span, i.e. % open.

Table 12: Modbus Position Control and Status Registers

Modbus Address (Dec)	Register Name	Register Type	Description
50	Ma Position % Open Command	RD	Status of the mA position command in units of 0.1 % open. Valid range: 0 - 1000; Example: 1000 = 100.0 %
51	Serial Position % Open Command	RD_WR	When the user configuration register, Setpoint Source, is set to a 1 for digital (RS-485 Modbus) control, a write to this register will establish the position setpoint in units of 0.1% open. Valid register range: 0 - 1000; Example: 100.0 % = 1000
52	Control Position % Open Feedback	RD	Control position status in units of 0.1% open; Updated every 50 ms. Register range: -3277 to 3277 (-327.7% to 327.7%) Register value indicating a feedback fault: -9990 (-999.0%)
53	Safety Position % Open Feedback	RD	Position status in units of 0.01% open; Value is updated and validated every 50ms by the safety feedback subsystem and is delayed by up to 50 ms with respect to Register #52. Register range: -32768 to 32767 (-327.68% to 327.67%)
54	Ma Position Command	RD	Status of the mA position command in units of 0.1 degrees. Example: 100.0 degrees = 1000 register value
55	Serial Position Command	RD_WR	Position setpoint command in units of 0.1 degrees; Limited by the maximum and minimum user-defined position which define the operating full span. To use this command, unit must be in either: 1.) Manual mode if the Setpoint Source configuration setting is the Ma input signal, or 2.) Control mode if the Setpoint Source configuration setting is the digital serial input Valid register range: Min User Position (Register #5) to Max User Position (Register #4)
56	Control Position Feedback	RD	Position status in units of 0.1 degrees; Value is updated every 50 ms. Register range: -40 to 1040 (-4.0 to 104.0 degrees) Register value indicating a feedback fault: -999 (-99.9 degrees)
57	Safety Position Feedback	RD	Position status in units of 0.01 degrees; Value is updated and validated every 50ms by the safety feedback subsystem. This feedback status is delayed by up to 50 ms with respect to Register #56. Valid register range: -40 to 1040 (-4.0 to 104.0 degrees) Register value indicating a feedback fault: -999 (-99.9 degrees)
58	Position Control Command Status	RD	Position control command (or setpoint) status in units of 0.1 degrees Value is updated every 50 ms.
59	Redundant Position Feedback 'B'	RD	Redundant position feedback 'B' in units of 0.1 degrees; Value is updated every 50 ms. Register range: -40 to 1040 (-4.0 to 104.0 degrees) Register value indicating a feedback fault: -999 (-99.9 degrees)

4.6 Input / Output and Operational Status

The following table summarizes the Modbus registers related to actuator I/O and operational status.

Table 13. Modbus I/O and Operational Status Registers

Modbus Address (Dec)	Register Name	Register Type	Description
100	mA Input	RD	Analog position command input current in microamp units 4 mA = 4000; Valid range: 0-25000
101	mA Output	RD	Analog position feedback current output in microamp units 4 mA = 4000; Valid range: 0-25000
102	Internal Temperature	RD	Internal housing temperature in 0.1 degrees Centigrade units 250 = 25 degrees C
103	DC Input Voltage	RD	DC input bus voltage in 0.1 volt units; 240 = 24 Vdc
104	Motor Sense Current #1	RD	Motor winding #1 sense current in 0.1 Amp units The register value is only valid when the motor is not moving
105	Motor Sense Current #2	RD	Motor winding #2 sense current in 0.1 Amp units The register value is only valid when the motor is not moving
106	High Position Proven	RD	1 = High Position Proven relay is energized 0 = High Position Proven relay is de-energized
107	Low Position Proven	RD	1 = Low Position Proven relay is energized 0 = Low Position Proven relay is de-energized
108	Alarm\ Relay Drive	RD	1 = Alarm\ relay is energized 0 = Alarm\ relay is de-energized
109	F-Terminal Input State	RD	1 = F-Terminal input is in the ON state 0 = F-Terminal input is in the OFF state
110	4-20mA LOS Command	RD	1 = 4-20mA LOS Command is TRUE 0 = 4-20mA LOS Command is FALSE
111	Lock State	RD	Access "lock" state status: 0 = Locked; 1 = User; 2 = Service/OEM; 3 = Factory
112	Alarm Bit Status	RD	Alarm bit definitions: 0x0001 = DC voltage 0x0002 = Position feedback 0x0004 = Non-volatile memory 0x0008 = Control hardware 0x0010 = Safety system #2 0x0020 = Microprocessor reset 0x0040 = Position control 0x0080 = Motor synchronization 0x0100 = Internal temperature 0x0200 = Software execution 0x0400 = Safety system #1 0x0800 = Safety system #3
113	Lockout Bit Status	RD	Lockout bit definitions: 0x0001 = Position feedback 0x0002 = Non-volatile memory 0x0004 = Control hardware 0x0008 = Safety system 0x0010 = Position control 0x0020 = Motor synchronization 0x0040 = User lockout test
114	RS-485 Status	RD	RS-485 mode status: 0 = Custom ASCII 19.2Kb, no parity, 2 stop bits (Manufacturing ONLY) 1 = Modbus 19.2K baud, even parity, 1 stop bit 2 = Modbus 19.2K baud, odd parity, 1 stop bit 3 = Modbus 9.6K baud, even parity, 1 stop bit 4 = Modbus 9.6K baud, odd parity, 1 stop bit

Table 13. (continued) Modbus I/O and Operational Status Registers

Modbus Address (Dec)	Register Name	Register Type	Description
115	Reserved	--	Future use
116	Reserved	--	Future use
117	Reserved	--	Future use
118	Reserved	--	Future use
119	Reserved	--	Future use
120	Event Display Flag	RD	1 = alarm or lockout condition displayed on local LCD 0 = no alarm or lockout displayed on local LCD
121	Event Display Index	RD	If Event Display Flag (Modbus register #120) = 1, the alarm or lockout condition display message on the local LCD is defined as follows: 0 = "ALARM:24Vdc " 1 = "ALARM:Position " 2 = "ALARM:Memory " 3 = "ALARM:Ctrl H/W " 4 = "ALARM:Safety #2 " 5 = "ALARM:Reset " 6 = "ALARM:Pos Ctrl " 7 = "ALARM:Motor Sync " 8 = "ALARM:Temp " 9 = "ALARM:Software " 10 = "ALARM:Safety #1 " 11 = "ALARM:Safety #3 " 12 = "LKOUT:Position " 13 = "LKOUT:Memory " 14 = "LKOUT:Ctrl H/W " 15 = "LKOUT:Safety " 16 = "LKOUT:Pos Ctrl " 17 = "LKOUT:Motor Sync " 18 = "LKOUT:User Test "

4.7 Communication Diagnostics

The following table includes all Modbus diagnostic counters that can be used to identify field communication problems.

Table 14. Modbus Communication Diagnostic Registers

Modbus Address (Dec)	Register Name	Register Type	Description
130	Modbus Bus Message Counter	RD_WR	Counter (16-bit) for all valid messages seen on the network "bus", including ones that are addressed to the unit
131	Modbus Bus Comm Error Counter	RD_WR	Counter (16-bit) for corrupted messages seen on the network "bus"
132	Modbus Bus Overrun Counter	RD_WR	Counter (16-bit) for messages with a receiver character overrun error
133	Modbus Slave Exception Error Counter	RD_WR	Counter (16-bit) for messages addressed to the unit with a Modbus exception error
134	Modbus Slave Message Counter	RD_WR	Counter (16-bit) for valid messages addressed to the unit
135	Modbus Slave No Response Counter	RD_WR	Counter (16-bit) for messages addressed to the unit with no Modbus response
136	Modbus Slave Busy Counter	RD_WR	Counter (16-bit) for messages addressed to the unit for which it returned a Slave Device Busy exception response

4.8 Alarm History

The Modbus alarm history registers, summarized in the following table, provide non-volatile event counters, an event log that holds the last 6 alarm event IDs, and an associated time stamp for each log event. The alarm and lockout history can be reset by the Modbus user command register #32.

Table 15. Modbus Alarm History Registers

Modbus Address (Dec)	Register Name	Register Type	Description
300	Alarm Event Total - 24VDC	RD	Non-volatile counter (16-bit) of 24VDC alarm events
301	Alarm Event Total - Position Feedback	RD	Non-volatile counter (16-bit) of position feedback alarm events
302	Alarm Event Total - Non-volatile Memory	RD	Non-volatile counter (16-bit) of non-volatile memory alarm events
303	Alarm Event Total - Control Hardware	RD	Non-volatile counter (16-bit) of control hardware alarm events
304	Alarm Event Total - Safety System #2	RD	Non-volatile counter (16-bit) of safety system alarm #2 events
305	Alarm Event Total - Reset	RD	Non-volatile counter (16-bit) of microprocessor reset alarm events
306	Alarm Event Total - Position Control	RD	Non-volatile counter (16-bit) of position control alarm events
307	Alarm Event Total - Motor Synchronization	RD	Non-volatile counter (16-bit) of motor synchronization alarm events
308	Alarm Event Total - Internal Temperature	RD	Non-volatile counter (16-bit) of internal temperature alarm events
309	Alarm Event Total - Software Execution	RD	Non-volatile counter (16-bit) of software execution alarm events
310	Alarm Event Total - Safety System #1	RD	Non-volatile counter (16-bit) of safety system alarm #1 events
311	Alarm Event Total - Safety System #3	RD	Non-volatile counter (16-bit) of safety system alarm #3 events
312-319	Reserved	--	Future use
320	Alarm Event #0 ID	RD	Non-volatile alarm history event #0 ID. This alarm log entry is the most recent event of a 6-deep event buffer, #0 through #5. If the value of the time stamp associated with this logged event (Modbus Register #330 and #331) is zero, no alarm event has occurred. Valid ID range is 0 to 11 with the following ID definitions: Alarm Event ID #0 = 24VDC Alarm Event ID #1 = Position Feedback Alarm Event ID #2 = Non-volatile Memory Alarm Event ID #3 = Control Hardware Alarm Event ID #4 = Safety System #2 Alarm Event ID #5 = Reset Alarm Event ID #6 = Position Control Alarm Event ID #7 = Motor Synchronization Alarm Event ID #8 = Internal Temperature Alarm Event ID #9 = Software Execution Alarm Event ID #10 = Safety System #1 Alarm Event ID #11 = Safety System #3
321	Alarm Event #1 ID	RD	Non-volatile alarm history event #1 ID Refer to Register #320 description for ID # defintions
322	Alarm Event #2 ID	RD	Non-volatile alarm history event #2 ID Refer to Register #320 description for ID # defintions
323	Alarm Event #3 ID	RD	Non-volatile alarm history event #3 ID Refer to Register #320 description for ID # defintions
324	Alarm Event #4 ID	RD	Non-volatile alarm history event #4 ID Refer to Register #320 description for ID # defintions
325	Alarm Event #5 ID	RD	Non-volatile alarm history event #5 ID. This alarm log entry is the oldest event of the 6-deep event buffer, #0 through #5. Refer to Register #320 description for ID # defintions

Table 15. (continued) Modbus Alarm History Registers

Modbus Address (Dec)	Register Name	Register Type	Description
326-329	Reserved	--	Future use
330	Alarm Event #0 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #0 time stamp; Units are seconds for the entire 2-register, 4-byte time value
331	Alarm Event #0 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #0 time stamp; Units are seconds for the entire 2-register, 4-byte time value
332	Alarm Event #1 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #1 time stamp; Units are seconds for the entire 2-register, 4-byte time value
333	Alarm Event #1 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #1 time stamp; Units are seconds for the entire 2-register, 4-byte time value
334	Alarm Event #2 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #2 time stamp; Units are seconds for the entire 2-register, 4-byte time value
335	Alarm Event #2 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #2 time stamp; Units are seconds for the entire 2-register, 4-byte time value
336	Alarm Event #3 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #3 time stamp; Units are seconds for the entire 2-register, 4-byte time value
337	Alarm Event #3 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #3 time stamp; Units are seconds for the entire 2-register, 4-byte time value
338	Alarm Event #4 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #4 time stamp; Units are seconds for the entire 2-register, 4-byte time value
339	Alarm Event #4 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #4 time stamp; Units are seconds for the entire 2-register, 4-byte time value
340	Alarm Event #5 Time LSW	RD	Least signficant word (LSW) of 32-bit alarm event #5 time stamp; Units are seconds for the entire 2-register, 4-byte time value
341	Alarm Event #5 Time MSW	RD	Most signficant word (MSW) of 32-bit alarm event #5 time stamp; Units are seconds for the entire 2-register, 4-byte time value
342-369	Reserved	RD	Future use
370	Alarm Log Index	RD	Index to most recent alarm log event; Valid range is 0 to 5 and this corresponds to Modbus event log registers #320 to #325
371	Alarm Log Count	RD	Alarm log count provides the number of event logs currently used

4.9 Lockout History

The following Modbus lockout history registers, summarized in the following table, provide non-volatile event counters, an event log that holds the last 6 alarm event IDs, and an associated time stamp for each log event. The alarm and lockout history can be reset by the Modbus user command register #32.

Table 16. Modbus Lockout History Registers

Modbus Address (Dec)	Register Name	Register Type	Description
400	Lockout Event Total - Position Feedback	RD	Non-volatile counter (16-bit) of position feedback lockout events
401	Lockout Event Total - Memory	RD	Non-volatile counter (16-bit) of non-volatile memory lockout events
402	Lockout Event Total - Control H/W	RD	Non-volatile counter (16-bit) of control hardware lockout events
403	Lockout Event Total - Safety	RD	Non-volatile counter (16-bit) of safety system lockout events
404	Lockout Event Total - Position Control	RD	Non-volatile counter (16-bit) of position control lockout events
405	Lockout Event Total - Motor Synchronization	RD	Non-volatile counter (16-bit) of motor synchronization lockout events
406	Lockout Event Total - User Test	RD	Non-volatile counter (16-bit) of user test lockout events
407-419	Reserved	--	Future use
420	Lockout Event #0 ID	RD	Non-volatile lockout history event #0 ID. This alarm log entry identifies the most recent event of a 6-deep event buffer, #0 through #5. If the value of the time stamp associated with this logged event (Modbus Register #430 and #431) is zero, no lockout event has occurred. Valid ID range is 0 to 6 with the following ID definitions: Lockout Event ID #0 = Position Feedback Lockout Event ID #1 = Non-volatile Memory Lockout Event ID #2 = Control Hardware Lockout Event ID #3 = Safety System Lockout Event ID #4 = Position Control Lockout Event ID #5 = Motor Synchronization Lockout Event ID #6 = User Test
421	Lockout Event #1 ID	RD	Non-volatile lockout history event #1 ID Refer to Register #420 description for ID # defintions
422	Lockout Event #2 ID	RD	Non-volatile lockout history event #2 ID Refer to Register #420 description for ID # defintions
423	Lockout Event #3 ID	RD	Non-volatile lockout history event #3 ID Refer to Register #420 description for ID # defintions
424	Lockout Event #4 ID	RD	Non-volatile lockout history event #4 ID Refer to Register #420 description for ID # defintions
425	Lockout Event #5 ID	RD	Non-volatile lockout history event #5 ID Refer to Register #420 description for ID # defintions

Table 16. (continued) Modbus Lockout History Registers

Modbus Address (Dec)	Register Name	Register Type	Description
426-429	Reserved	--	Future use
430	Lockout Event #0 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #0 time stamp; Units are seconds for the entire 2-register, 4-byte time value
431	Lockout Event #0 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #0 time stamp; Units are seconds for the entire 2-register, 4-byte time value
432	Lockout Event #1 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #1 time stamp; Units are seconds for the entire 2-register, 4-byte time value
433	Lockout Event #1 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #1 time stamp; Units are seconds for the entire 2-register, 4-byte time value
434	Lockout Event #2 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #2 time stamp; Units are seconds for the entire 2-register, 4-byte time value
435	Lockout Event #2 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #2 time stamp; Units are seconds for the entire 2-register, 4-byte time value
436	Lockout Event #3 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #3 time stamp; Units are seconds for the entire 2-register, 4-byte time value
437	Lockout Event #3 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #3 time stamp; Units are seconds for the entire 2-register, 4-byte time value
438	Lockout Event #4 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #4 time stamp; Units are seconds for the entire 2-register, 4-byte time value
439	Lockout Event #4 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #4 time stamp; Units are seconds for the entire 2-register, 4-byte time value
440	Lockout Event #5 Time LSW	RD	Least signficant word (LSW) of 32-bit lockout event #5 time stamp; Units are seconds for the entire 2-register, 4-byte time value
441	Lockout Event #5 Time MSW	RD	Most signficant word (MSW) of 32-bit lockout event #5 time stamp; Units are seconds for the entire 2-register, 4-byte time value
442-469	Reserved	--	Future use
470	Lockout Log Index	RD	Index to most recent lockout log event; Valid range is 0 to 5 and this corresponds to Modbus event log registers #420 to #425
471	Lockout Log Count	RD	Lockout log count provides the number of event logs currently used

4.10 Actuator Life Data

The Modbus registers, summarized in the following table, are provided for actuator life monitoring of run time, positioning, resets, and fatal errors. These registers are non-volatile and cannot be reset.

Table 17. Modbus Actuator Life Data Registers

Modbus Address (Dec)	Register Name	Register Type	Description
500	Run Time LSW	RD	Least signficant word (LSW) of 32-bit total run time; Units are seconds for the entire 2-register, 4-byte time value
501	Run Time MSW	RD	Most signficant word (MSW) of 32-bit total run time; Units are seconds for the entire 2-register, 4-byte time value
502	Move Counter LSW	RD	Least signficant word (LSW) of 32-bit position move counter
503	Move Counter MSW	RD	Most signficant word (MSW) of 32-bit position move counter
504	Move Degree Total (0.01 Degs)	RD	Overflow counter in units of 0.01 degree for 32-bit total move degree counter in registers #505 and #506 Valid range = 0 to 99 (0.00 to 0.99 degrees)
505	Move Degree Total LSW	RD	Least signficant word (LSW) of 32-bit total move degree counter
506	Move Degree Total MSW	RD	Most signficant word (MSW) of 32-bit total move degree counter Units are degrees for the entire 2-register, 4-byte time value
507	Loss-of-Sync Counter	RD	Loss of (motor) synchronization event counter (16-bit)
508	Reserved	--	Future use
509	Reserved	--	Future use
510	Last Reset Event	RD	Last reset event flag definitions: 0x0001 = Power-on reset 0x0004 = Brown-out reset 0x0008 = Watchdog reset
511	Watchdog Reset counter	RD	Counter (16-bit) of watchdog resets
512	Power-up Reset Counter	RD	Counter (16-bit) of power-on resets
513	Brown-out Reset Counter	RD	Counter (16-bit) of brown-out resets
514	Other Resets Counter	RD	Counter (16-bit) of resets other than watchdog, power-up, and brown-out resets
515	Fatal Fuse Error Counter	RD	Counter (16-bit) of fuse corruption errors
516	Fatal Flash Error Counter	RD	Counter (16-bit) of flash corruption errors
517	Fatal RAM Error Counter	RD	Counter (16-bit) of RAM corruption errors
518	Reserved	RD	Future use
519	Reserved	RD	Future use
520	Move Histogram <= 0-19.9 degree LSW	RD	Least signficant word (LSW) of 32-bit counter for moves within specified 20-degree window.
521	Move Histogram <= 0-19.9 degree MSW	RD	Most signficant word (MSW) of 32-bit counter for position moves within specified 20-degree window.
522	Move Histogram 20-39.9 degree LSW	RD	Least signficant word (LSW) of 32-bit counter for position moves within specified 20-degree window.
523	Move Histogram 20-39.9 degree MSW	RD	Most signficant word (MSW) of 32-bit counter for position moves within specified 20-degree window.
524	Move Histogram 40-59.9 degree LSW	RD	Least signficant word (LSW) of 32-bit counter for position moves within specified 20-degree window.
525	Move Histogram 40-59.9 degree MSW	RD	Most signficant word (MSW) of 32-bit counter for position moves within specified 20-degree window.
526	Move Histogram 60-79.9 degree LSW	RD	Least signficant word (LSW) of 32-bit counter for position moves within specified 20-degree window.
527	Move Histogram 60-79.9 degree MSW	RD	Most signficant word (MSW) of 32-bit counter for position moves within specified 20-degree window.
528	Move Histogram 80- >= 100 degree LSW	RD	Least signficant word (LSW) of 32-bit counter for position moves within specified 20-degree window.
529	Move Histogram 80- >= 100 degree MSW	RD	Most signficant word (MSW) of 32-bit counter for position moves within specified 20-degree window.

4.11 Manufacturing Configuration

The following Modbus registers include manufacturing configuration data and CRCs for safety and non-volatile EEPROM data storage.

Table 18. Modbus Manufacturing Configuration Data Registers

Modbus Address (Dec)	Register Name	Register Type	Description
600	Gear Ratio	RD	Planetary gear ratio; Valid values: 70 and 210 (70:1 and 210:1)
601	Max Position Mfg	RD	Maximum position or virtual "hard stop"; Units in 0.1 degrees
602	Min Position Mfg	RD	Minimum position or virtual "hard stop"; Units in 0.1 degrees
603	Commissioned Data CRC (CSD)	RD	Commissioned safety data packet (CSD) 16-bit CRC
604	Mfg Safety Data CRC (MSD)	RD	Manufacturing safety data packet (MSD) 16-bit CRC
605	EEPROM CRC	RD	EEPROM (all user and mfg configuration/calibration data) 16-bit CRC
606	Calibration Status	RD	The least significant nibble represents manufacturing (as shipped) calibration status: 0x0001 - Calibration complete 0x0002 - Manufacturing position limits have been set 0x0004 - Analog (mA) calibration has been performed 0x0008 - Manufacturing defaults have been saved The most significant nibble represents user/service calibration status: 0x0010 - Calibration complete 0x0020 - Manufacturing position limits have been set 0x0040 - Analog (mA) calibration has been performed 0x0080 - Manufacturing defaults have been saved

4.12 Report Slave ID

A Report Slave ID Modbus function, customized for SMARTLINK DS, is provided for verification of manufacturing-related data and operational status. The complete Modbus ADU frames for the Report Slave ID request and response are shown in the following two tables.

Table 19. Report Slave ID Request Message Format

Data	Size (bytes)	Value / Description
Device Address	1	1-247 = Modbus slave address
Function Code	1	17 = report slave ID function code
CRC	2	Modbus 16-bit CRC

Table 20. Report Slave ID Response Message Format

Data	Size (bytes)	Value / Description
Device Address	1	1-247 = Modbus slave address
Function Code	1	17 = report slave ID function code
Byte count	1	78 = Number of bytes following except Modbus CRC
Slave ID	1	32 = SMARTLINK DS Actuator ID
Run indicator status	1	255 = ON (Control or Manual Mode); 0 = OFF
Actuator ID	1	1-255 = user configuration data for numeric actuator identification
Gear ratio	1	70 or 210: indicating a 70:1 or 210:1 ratio
Firmware version #1	2	Control firmware version = value / 1000
Firmware version #2	2	Safety firmware version = value / 1000
CED CRC	2	Configuration EEPROM data (CED) 16-bit CRC
CSD CRC	2	Commissioned safety data (CSD) 16-bit CRC
MSD CRC	2	Manufacturing safety data (MSD) 16-bit CRC
Reference record #1A	16	Reference record TBD (future)
Reference record #1B	16	Reference record TBD (future)
Reference record #2A	16	Reference record TBD (future)
Reference record #2B	16	Serial Number in ASCII format: YYWW-XXX where YY = 2-digit year, 0-99 WW = 2-digit week number, 1-52 XXX = 3-digit unit number, 0-999
CRC	2	Modbus 16-bit CRC

4.13 Feedback Safety Data

For control applications that are safety critical and require fail-safe actuator reporting of shaft position, the Feedback Safety Data (FSD) packet should be read periodically by the master controller using the Modbus Read File Record function. Specific details on how to verify the contents of the FSD are described in the section, Example Master Controller Positioning Sequence. The complete Modbus ADU frames for the read file record message request and response are shown in the following two tables.

Table 21. Read File Record #1 Feedback Safety Data (FSD) Request

Data	Size (bytes)	Value / Description
Device address	1	1-247 = Modbus slave address
Function code	1	20 = read file record function code
Byte count	1	7 = number of request data bytes to follow
Reference type	1	6 = read file reference type
File number	2	1 = Safety Feedback Data (SFD) packet file number
Record number	2	0 = record number (used as starting address data
Record length	2	6 = length of file record in 16-bit words
CRC	2	Modbus 16-bit CRC

Table 22. Read File Record #1 Feedback Safety Data (FSD) Response

Data	Size (bytes)	Value / Description
Device Address	1	1-247 = Modbus slave address
Function Code	1	20 = read file record function code
Byte count	1	24 = number of response data bytes to follow
File data length	1	14 = number of bytes in response data inluding next 2 items
Reference type	1	6 = read file reference type
Actuator ID	1	1-255 = user configuration data for numeric actuator identification
Safety data ID	1	12 = safety data ID that represents FSD packet
Packet counter	1	1-255 = counter incremented every 50ms for "fresh" data indication
FSD CRC	2	Feedback Safety Data (FSD) 16-bit CRC
Safety position % open feedback	2	Safety validated position feedback in units of 0.01% open. Value is updated and validated every 50ms by the safety feedback subsystem and is delayed by up to 50 ms with respect to Modbus Register #52. Valid range: -32768 to 32767 (-327.68% to 327.67%) Register value indicating a feedback fault: -999 (-99.9%)
Safety position feedback	2	Safety validated position feedback in units of 0.1 degrees. Value is updated and validated every 50ms by the safety feedback subsystem. This feedback status is delayed by up to 50 ms with respect to Register #56. Valid register range: -40 to 1040 (-4.0 to 104.0 degrees) Register value indicating a feedback fault: -999 (-99.9 degrees)
Safety processor mode	1	Safety microprocessor operating modes: 1 = Monitor; 2 = Proving Lockout; 3 = Lockout
Relay status	1	Relay bit postions / ON state definitions: High Position Relay = 0x01 Low Position Relay = 0x02 Alarm (Not) Relay = 0x04
Pad	1	"0" pad for word alignment
CRC	2	Modbus 16-bit CRC

5 Master Controller Positioning Techniques

The following Modbus master controller positioning techniques are recommended for applications in which there is a requirement for detection of an actuator failure that could result in false reporting of the output shaft position. This is a common requirement for a PLC or DCS-based system that controls air and fuel valve actuators within a parallel positioning combustion system. In addition to the application recommendations below, the master controller must have the hardware and software capability to place the system in a fail-safe state after an actuator failure is detected. Specifically, the system should be designed in a manner that complies with software/functional safety requirements such as ANSI/UL 1998 Software Class 2, UL/IEC 60730-1 Software Class C, or other similar safety standards as appropriate for the end application.

5.1 Position Setpoint Source

For continuous position control by an upstream master controller, the position setpoint source parameter of SMARTLINK DS should be configured during unit commissioning for serial Modbus control. Refer to the description of the Setpoint Source register #10 in the User Configuration section above or the SMARTLINK®DS Intelligent Control Actuator Series Technical Catalog for local display commissioning of this parameter.

5.2 Position Command

The serial position command (in 0.1 degree units), register #55, should be used for commanding the actuator to a new position. This register is less ambiguous than commanding the actuator via the position % open command, register #51. The actual position of the shaft will be different for the same percent open command if the min or max travel configuration is changed after initial actuator commissioning.

5.3 Position Feedback

After the position command register #55 is sent, the master controller should poll the actuator with a multiple register read (of three contiguous registers): Register #55, Serial Position Command, Register #56, Control Position Feedback, and Register #57, Safety Position Feedback. This poll is used to verify the position command and the actual position of the shaft using both feedback values for comparison. In addition, the Feedback Safety Data (FSD) packet should be periodically read back to validate the feedback data in a fail-safe manner.

5.4 Example Modbus Master Positioning Sequence

The following table provides an example Modbus master command request sequence with the actuator starting at 10.0 degrees. The sequence includes Modbus command write/read requests as well as a verification of the feedback data with a Read File Record request.

Time (ms)	Master Controller Action	Feedback (degs)	Setpoint (degs)	DS Modbus Command Request
0	Change position setpoint to 10.5 degrees	10.0	10.5	Function code 6: Write a 105d to Register #55, Serial Position Command
100	Determine if actual position is achieved within 0.1 degrees of the command position setpoint. Verify the safety position feedback is within 0.3 degrees of the control position feedback.	10.2	10.5	Function code 4: Read 3 consecutive registers - Register #55, Serial Position Command, Register #56, Control Position Feedback, and Register #57, Safety Position Feedback.
200	Repeat previous action. Position feedback is now within 0.1 degree of commanded position setpoint and the actuator control loop is now satisfied.	10.4	10.5	Repeat previous request. Function code 3 can be used interchangeably with function code 4.
300	Change position setpoint to 10.6 degrees.	10.4	10.6	Function code 6: Write a 106d to Register #55, Serial Position Command
400	Determine if actual position is achieved within 0.1 degrees of the command position setpoint. Verify the safety position feedback is within 0.3 degrees of the control position feedback.	10.6	10.6	Function code 4: Read 3 consecutive registers - Register #55, Serial Position Command, Register #56, Control Position Feedback,and Register #57, Safety Position Feedback.
500	Read the safety feedback packet periodically to confirm the SMARTLINK DS safety feedback system is functioning correctly. The following fault-detection actions are recommned: - Calculate the FSD (Feedback Safety Data) CRC and compare with the received FSD CRC to verify the integrity of the data. - Verify the actuator ID received matches the ID of the intended actuator being controlled. - Verify the Safety Data ID equals 12, the factory-defined ID of a SMARTLINK DS actuator. - Verify the packet counter has changed from the previous counter reading indicating the data is "fresh". (The packet counter is incremented by the SMARLINK DS safety feedback system every 50 milliseconds.) - Verify the position feedback in degrees received within the packet is within 0.3 degrees of the commanded position setpoint and control position feedback, read previously from Registers #55 and #56. - Verify the SP (Safety Processor) mode is equal to 1 indicating a monitoring mode. If any of the above safety packet criteria fails a pre-determined number of times out of an application-dependent sample size, the master controller should take appropriate action to ensure a fail-safe system state.	10.6	10.6	Function code 20: Read file record #1 The SMARTLINK DS feedback safety packet verification process should be performed by the master controller at a periodic rate that prevents an unsafe system condition caused by an actuator at an incorrect or unknown position. The FSD (Feedback Safety Data) CRC16 is calculated on the following 9 data bytes order in this manner: U8 Actuator ID, U8 Safety Data ID (= 12), U8 Packet Counter, S16 Position (in 0.1% Open units), S16 Position (in 0.1 degrees), U8 Safety Processor (SP) Mode, U8 Output Relay States The FSD packet includes the data above plus the FSD CRC16 which is transmitted after the packet counter. Refer to the Read File Record #1 Feedback Safety Data (FSD) section of this manual for more detailed information on the FSD data structure transmitted.