Scully MODBUS
User Guide

Scully Intellitrol®2 Overfill Prevention Control

scully

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Caution: The intent of this manual is to allow a user to view and, in some cases, to modify certain Intellitrol registers using a RS485 serial port with a Modbus Protocol.
The Intellitrol's control function is to manage the state of the relay outputs and the Modbus is simply a means of obtaining status of that monitoring.

The Modbus interface is NOT intended for the use as an alternative to the customer relays.
The Intellitrol's primary purpose is to monitor the Truck Sensors and Ground (optional), verify Truck ID (VIP) (optional), and the Deadman switch (optional). When deemed safe, the Intellitrol will allow the flow of product by closing its relay outputs contacts. Because these functions have a higher priority than communications, there are no assurances made as to when any status updates are available as responses to a Modbus command. This delay can result in a long time between when a sensor is detected as wet and the non-permit status being available via the Modbus. Because of this delay,
the user must never use the Intellitrol Modbus interface for monitoring and control of the product valves by other than the Intellitrol's relay outputs.

1. Overview

This document describes the communications protocol supported by the Intellitrol rack controller to support the exchange of control and status information with Terminal Automation System (TAS) software. The Intellitrol supports an RS-485 communications line. The inter-unit or network protocol implemented is based on the Modicon, Inc. "Modbus™" industrial automation control protocol.
The Scully Intellitrol Communications Protocol is designed to comply with The Modicon Modbus Protocol Reference Guide (PI-MBUS 300 Rev J) of June 1996 where possible. Consult the Reference Guide for Modbus details not specified in this document. The Intellitrol rack controller unit uses Modicon defined Modbus function 2 to read single bits, and functions 3, 6 and 10 to read and write 16-bit integers. Functions 0x41 - 0x5B are Scully extensions to the Modbus protocol to support the Intellitrol rack controller units.
Extensive dynamic status information on the internal state of the Intellitrol rack controller is available for TAS operations to monitor, log, and/or display.

The Intellitrol is a slave device. This means that the Intellitrol will only respond to commands and never send status over the Modbus without first receiving a request.

This document is intended to provide information on the Modbus Commands required by the Intellitrol user. If the reader needs functionality not specifically mentioned, please contact Scully.

All Modbus commands and responses are in hex format. ASCII Modbus packets are not supported. The Intellitrol Modbus supports addresses between 1 and 99.

1.1 Associated Documents

- Modicon Modbus Protocol Reference Guide (PI-MBUS 300 Rev J) June 1996.
- Intellitrol Technical Manuals
- PIDX Product Code Standard 04-101-15-45-2010 Revision July 18th, 2017

1.2 Communications Interface

The Scully Modbus protocol supports the following:

1. Half Duplex RS-485 Multidrop.
2. 19200, 9600, 4800, 2400, and 1200 baud.
3. Modbus RTU (straight binary).
4. 8 bits with even, odd or no parity bit.

1.3 Communications Response Time

Intellitrol rack controller units typically respond to bus master (TAS) query messages within milliseconds of the last character of the command message. However, units may transmit the response message as late as one second after the query message depending on the Modbus function and/or present rack controller task being executed.

The bus master should wait at least this long before processing a time-out. A bus collision and garbled data will occur if the bus master transmits its next query before one second has elapsed and the rack controller unit has not responded. Time consuming commands such as erasing the vehicle list may cause the rack controller unit to return the ACKNOWLEDGE exception message. The SLAVE DEVICE BUSY exception message will be returned if the bus master attempts communication before the rack controller unit completes its current task.

The bus master should wait a minimum of 100ms between query messages to allow for the Intellitrol to perform its basic tasks. Failure to wait may result in messages not being responded to.

A minimum response time can be programmed via the *Modbus Minimum Response Time* register to allow the bus master time to turn the line around between master message and slave response.

This is the Master TX to Master RX time, not to be confused with TX to TX time. This is time waited by the slave, not the Master. When sending broadcast messages, the bus master must wait at least one second before sending the next message.

Unknown function codes, out of range addresses, hardware failures (e.g. stuck bits in EEPROM), and similar problems will cause an exception response in accordance with Modicon manual Appendix A. EEPROM write failures will return the Memory Parity Error exception code.

1.4 Compatibility with Other Equipment

Other Modbus RTU equipment (e.g. card readers, meters, etc.) will operate with Intellitrol rack controller units on the same communication line so long as each Modbus unit is assigned a unique Modbus Address. Each rack controller has jumpers to select an address in the range of 0 to 99. Modbus RTU messages always start with the Modbus address as the first byte of the message. Scully rack controller units support a special **broadcast** address of 128 decimal (80 hex). Any message transmitted to address 128 will be accepted by all Scully rack controller units on the communication line. To prevent bus contention, the rack controller units never reply to broadcast messages. The rack controller broadcast address differs from the standard Modbus broadcast address of zero. Intellitrol rack controller units cannot be assigned address 128 and ignore messages broadcast to address zero.

Scully recommends not putting non-Modbus RTU equipment on the same serial line as the Modbus with the Intellitrol. A "mixed" protocol bus can be very difficult to troubleshoot if any unit malfunctions. Since Modbus RTU is binary, the attention and/or end of message characters for the non-Modbus unit may appear accidentally and randomly inside Modbus messages. This may confuse non-Modbus equipment, causing them to issue error messages to traffic not directed to them, resulting in communication errors and bus contention. Using only the Modbus RTU protocol on the same serial line is a more conservative design practice which will reduce the probability of intermittent bus contention.

2. Normal Modbus Message Format

All Modbus command messages start with an address byte, followed by a function code (command) byte, optionally followed by data, and terminated with a two-byte CRC-16. All Modbus responses follow the same form; the response address byte is the address of the slave unit responding and not the address of the master (the master doesn't have an address, it's just the Master), and the function byte is just echoing back the command function byte. A response message with bit 7 of the function code byte set is an exception response. No Modbus command message ever sends a function code with bit 7 set.

BYTE	FIELD	MEANING
0	Address	Normal Modbus unit address selection byte 01 - 63 (hex)
1	Function Code	Normal Modbus function code byte 00 - 7F (hex)
. . .	...data...	Normal Modbus message data, if any
n-1, n	CRC	Normal Modbus CRC-16 bytes

3. Modbus Functions

Modbus functions are specified by the second byte of the query message. Below is a summary of the functions supported.

CODE	FUNCTION
0x02	Read Input Status
0x03	Read Multiple Registers
0x05	Force Single Bit
0x06	Write Single Register
0x10	Write Multiple Registers
0x46	Write Multiple Vehicles
0x47	Read Multiple Vehicles
0x49	Read Event Log
0x4A	CRC Multiple Vehicles
0x4B	Write Bypass Keys
0x4C	Read Bypass Keys
0x50	Report Compartment Volume
0x53	Read TIM Builder Info
0x54	Write TIM Builder Info
0x55	Read Third Party
0x56	Write Third Party
0x59	Insert Vehicle
0x5A	Remove Vehicle
0x5B	Read Number of Probes

Modbus Functions

3.1. Function Code 02 Read Input Status

The Scully rack controller units maintain status information readily available via the Input Status Bits. The Input Status Bits are the primary operating status bits.

The Intellitrol presents the Input Status Bits through the Modbus Read Input Status Bits command and are the same as Status-A Register 0x104 and Status-B Register 0x105.

The TAS may check these bits to determine the presence of a truck, and the status of the unit's hardware.

Address	Function	Start Bit #MSB	Start Bit LSB	Bit Count MSB	Bit Count LSB	16 Bit CRC
01 - 63	02	00	00	00	10	CRC

Example Query Message: Reading Status Bits 0 - 15

Address	Function	Byte Count	Data Bits 0-7	Data Bits 8-15	16 Bit CRC
01 - 63	02	02	4E	00	CRC

Example Response Message Reading Status Bits 0 - 15

BIT	MEANING IF READ BACK AS 1
0	Fault (Service LED blinking on the Intellitrol).
1	Truck is seen to be connected to the unit by the firmware. The truck is considered present while in bypass.
2	Communications established with TIM or IntelliCheck.
3	At least one Truck Serial Number is Authorized
4	Rack controller unit is in a bypass state
5	Rack controller unit is idle (and non-permissive).
6	Rack controller is permissive.
7	Rack controller is non-permissive (but bypassable).
9	Channel 5 resistance is higher than expected
12	Deadman switch is closed.
13	Diode ground is enabled
14	Resistive ground is enabled
15	Connected to Intellicheck
17	Problems with EEPROM
18	This bit is set if the ADC times-out during a conversion.
19	Checksum failure occurred in shell program code.
20	On board Dallas™ real time clock/calendar failure occurred.
21	Stuck bits in CPU registers or stuck U1 I/O pins.
23	Checksum failure in Kernel firmware program code occurred.
24	Problems with one or more onboard voltage levels.
26	Error communicating with TIM
28	The Ground Fault Detection subsystem cannot verify proper ground (earth) connection on the truck.
29	The rack controller is in “Special Operations” mode
30	The rack controller is “Shutdown” and will not permit, although it continues to otherwise operate normally.
31	Problems detected with permit relay(s).

Input Status Bits (32)

3.1.1. [Input Status Bit 00] Fault
The Fault bit indicates that the rack controller needs service. Typically, this means that the rack controller firmware has detected a software or hardware problem that is keeping the unit from normal and safe operation.

3.1.2. [Input Status Bit 01] Truck Present
The Truck Present bit indicates that the rack controller has detected “something” on one or more of the sensor channels or the pin-9 Ground may appear grounded.

3.1.3. [Input Status Bit 02] Truck Talk
The Truck Talk status bit indicates that the rack controller unit has successfully established communications with an active on-truck unit such as a TIM.

Truck Talk set means that the *Truck Serial Number* register is meaningful (e.g., a TIM was sensed; a truck serial number of FFFFFFFFFFFF (hex) would then indicate that the TIM or the communications was faulty).

3.1.4. [Input Status Bit 03] Truck in VLIST
The Truck in VLIST bit means that the truck serial number (as reported in the *Truck Serial Number* registers (0x10A – 0x10C) is in the unit’s Vehicle List.

3.1.5. [Input Status Bit 04] Bypass
The rack controller has one or more bypass conditions currently in effect. The *Bypass State* register (0x115) contains the current active bypass information.

3.1.6. [Input Status Bit 05] Idle
The Idle status bit indicates that the rack controller unit currently has no truck connected, and is not permitting, but is operating normally.

3.1.7. [Input Status Bit 06] Permitting
The Permitting status bit indicates the rack controller unit is actively permitting.

3.1.8. [Input Status Bit 07] Non-Permissive
The Non-Permissive status bit indicates that the rack controller unit is not permitting due to a bypassable fault condition. This is not set when idle or when the non-permit is due to a monitored deadman switch.
The *Non-Permit Reasons* register (0x11A) can be read to determine what is preventing the rack controller from entering the permissive state.

3.1.9. [Input Status Bit 09] Channel 5 High Resistance
The Channel 5 High Resistance status bit indicates that the Channel 5 connection resistance is higher than expected.

3.1.10. [Input Status Bit 12] Deadman OK
The Deadman OK status bit indicates that the unit is configured to require the Deadman Switch, and that the switch appears to be properly closed or engaged.

3.1.11. [Input Status Bit 13] Diode GND
The Diode GND status bit indicates that diode ground is enabled.

3.1.12. [Input Status Bit 14] Resistive GND
The Resistive GND status bit indicates that resistive ground is enabled.

3.1.13. [Input Status Bit 15] Intellicheck
The Intellicheck status bit indicates that the unit is connected to an Intellicheck.

3.1.14. [Input Status Bit 17] Bad EEPROM
The Bad EEPROM status bit indicates that the rack controller has detected one or more errors in dealing with the on-board EEPROM non-volatile memory store. Typically, this is not a fault condition, the unit continues to operate in a normal and safe manner. It may indicate a simple “data error” retrieving a truck serial number from the Vehicle List, for example (requiring bypassing VIP authorization for that truck serial number).

3.1.15. [Input Status Bit 18] ADC Time-Out
The ADC Time-out status bit indicates that a problem has been detected with the on-board Analog-to-Digital converter.

3.1.16. [Input Status Bit 19] Shell CRC Error
The Shell CRC Error status bit means that the firmware has detected a bad firmware program image.

3.1.17. [Input Status Bit 20] Clock Error
The Clock Error status bit indicates that the rack controller cannot correctly read the on-board (battery-backed where legal) real-time calendar clock. This is typically not a Fault condition, unless the rack controller is running in “DateStamp” mode, which required accurate Date/Time information.

3.1.18. [Input Status Bit 21] Bad CPU
The Bad CPU status bit indicates that there are Stuck bits in CPU registers or stuck U1 I/O pins.

3.1.19. [Input Status Bit 23] Kernel CRC Error
The Kernel CRC Error status bit means that the firmware has detected a bad firmware “kernel” image.

3.1.20. [Input Status Bit 24] Voltage Error
The Voltage Error status bit indicates that the rack controller firmware self-test diagnostics has detected one or more bad voltages in the unit.

3.1.21. [Input Status Bit 26] TIM Data Line Fault
The TIM Data Line Fault status bit indicates that there is an error communicating with TIM.

3.1.22. [Input Status Bit 28] Ground Fault
The rack controller unit has detected a Ground Fault condition.

3.1.23. [Input Status Bit 29] Special Ops Mode
The Special Ops Mode status bit indicates that the rack controller is running in Special Operations mode. This means that a special hardware jumper has been installed, directing the unit to perform non-standard operations. The two currently defined “Special” operations are to erase the Bypass Key List, and to add a new bypass key to the List.

3.1.24. [Input Status Bit 30] Shutdown
The Shutdown status bit indicates that the rack controller has been locked by a shutdown command. This means that the rack controller will not permit and cannot be bypassed. The rack controller otherwise operates normally, responding to trucks connecting, and to Modbus commands. A recover command must be sent to bring the Intellitrol out of a shutdown state.

3.1.25. [Input Status Bit 31] Relay Error
The Relay Error status bit indicates that the rack controller firmware has detected a problem with the permit relay(s). The relay(s) can be shorted (“permitting” when shouldn’t be) or broken (not “permitting” when should be).

3.2. Function Code 03 Read Multiple 16-Bit Registers

Function code 03 reads one or more 16-bit registers. Function code 03 query and response messages are in accordance with the Modicon Manual chapter 2.

Address	Function	Start Reg # 0 - 7	Start Reg # 8 - 15	Reg Count 0 - 7	Reg Count 8 - 15	16 Bit CRC
01 - 63	03	01	00	00	02	CRC

Example Query Message Read Registers 100 and 101

Address	Function	Byte Count	Reg 100 Data 0 - 7	Reg 100 Data 8 - 15	Reg 101 Data 0 - 7	Reg 101 Data 8 - 15	16 Bit CRC
01 - 63	03	04	4F	4E	D7	69	CRC

Example Response Message Read Registers 100 and 101

The Intellitrol utilizes the Modbus Register Set as a mechanism for the passing of information to the Terminal Automation System. Mostly, the registers are used by the Intellitrol for presenting data to the TAS.

All register values are presented to the network in big-endian format. Multiple-register values similarly are big-endian format (i.e., more-significant bytes come first). Certain sub blocks of registers present a string of data bytes, again in big-endian format (i.e., first byte is high-order byte of first register; second byte is low-order byte of firs register, etc.).

Register #	Read / Write	Range	Description
0005	R	—	Firmware Version
0008	R / W	0 - 60	Time (seconds) to wait for TAS
0009	R / W	120 - 3600	Bypass time-out (seconds)
000A	R / W	0 - 9999	Terminal ID
000B	R / W	0 - 1024	Modbus command response wait (milliseconds)
000E	R / W	0 - 5	Authorization mode control
0020 - 0023	R	—	48-bit Serial number
0024	R	—	Hardware Version Number
0025	R	—	Hardware jumpers, etc.
0026	R	—	Software jumpers, etc.
002D	R	—	Number of probes on current truck. Intellitrol 2 only
0069	R	—	Service A Flags
006A	R	—	Service B Flags
006D	R	—	Ground Status
007B	R / W	0 - 1	VIP Passive Mode enable
007C	R / W	0 - 3	This register sets the high threshold for a good resistive ground. 0 - 2k ohm, 1 – 100 ohm, 2 - 5k ohm, 3 - 10k ohm
007E	R / W	0 - 1	When this register is set to 1 the Intellitrol will blink the green permissive LEDs during the sensor identification loop to indicate a good ground.
007F	R / W	0 - 255	Compartment Count Display Time
0080	R / W	0 - 255	Active Deadman Enable
0081	R / W	0 - 30	Active Deadman Open Time
0082	R / W	0 - 600	Active Deadman Close Time
0083	R / W	0 - 60	Active Deadman Warning Time
0084	R / W	0 - 255	Enable unload terminal mode
0085	R / W	0 - 65535	Max unload time
0086	R / W	0 - 31	Select which certificates are used
0087	R / W	0 - 255	Enable compartment count comparison between truck and TIM value
0088	R / W	0 - 255	Select which compartments to compare to TIM value
0089	R / W	0 - 255	Enable writing fuel type to TIM on connect
008A - 008B	R / W	0 - 65535	Default fuel type to write to TIM
0100 - 0101	R / W	—	32-Bit current date & time in UNIX format, reference epoch 1-Jan-1970.
0104	R	—	Dynamic status bits 0 – 15 (same as Input Status bits)
0105	R	—	Dynamic status bits 16 – 31 (same as Input Status bits)
010A - 010C	R	—	48-Bit Truck ID / serial number
010D - 0114	R	—	Individual tank/probe state (one byte per probe/channel)
0115	R	—	Bypass status flags
0116 - 0118	R	—	48-Bit Bypass Key serial number
0119	R	—	Time unit has been in bypass mode (seconds)
011A	R	—	Flags indicating why non-idle unit is non-permissive
0120	R	—	Number of 5-wire compartments detected on currently connected vehicle

3.2.1. [Register 0005] Firmware Version

The Version register contains the version number of the running program. The program (or firmware) is the main control program of the rack controller.

The version number is a three-part number in the format Major Version in top 4 bits + Minor Version in next four bits + Edit Version in low 8 bits. For example, version 1.7.0 would be 170 hex.

The Major Version number indicates the primary release or feature set. The Minor Version indicates the maintenance (or bug fix) level of release within the Major Version release. The Edit Version increments with each release.

3.2.2. [Register 0008] Wait for TAS Delay

This Read/Write register causes the rack controller to wait a specified time (0 to 60 seconds) before attempting to authorize a truck. This delay gives the TAS time to read the truck register, do a lookup on a truck number, and decide to explicitly authorize or not authorize the truck. If the TAS should go down or otherwise not exert explicit VIP Mode control, the rack controller will take over and consult the onboard vehicle list after the wait for TAS time has expired. A wait time of zero (default) disables this feature. While in TAS Delay, the VIP Standby LED will flash.

Intellitrols will be shipped with the wait for TAS delay set to zero seconds.

3.2.3. [Register 0009] Bypass Active Time

This Read/Write register sets the desired bypass active time-out.

This register determines the maximum amount of time the unit can remain bypassed from the presentation of a bypass key or from a TAS issued bypass command. Bypass ends when the truck departs.
The Intellitrol will allow the full 16-bits' worth of timer value (FFFF hex), or about 18 hours as the maximum bypass active time.

Intellitrols will be shipped with Bypass Active Time set to 3600 seconds (1 hour).

3.2.4. [Register 000A] Terminal Number

This Read/Write register is the desired terminal identification number (0 - 9999). This register is only required for DateStamp systems (See Modbus functions Write Company ID Name and Write Password) but is allowed anytime.
Newly manufactured VIP's and Intellitrols will be shipped with the terminal number set to 0.

3.2.5. [Register 000B] Modbus Minimum Response Delay

This Read/Write register is the desired Modbus minimum response delay time (milliseconds 0 to 1024). This minimum response time is the time that the unit will be guaranteed to delay before initiating transmission of any Modbus Response message. A response time of 100 will force the rack controller to wait at least 100 milliseconds before transmitting the response to any Modbus query message. A response time of 0 allows the rack controller to respond as soon as it can (typically 30 milliseconds).

Intellitrols will be shipped with the minimum response time set to 100 milliseconds.

3.2.6. [Register 000E] VIP Mode Control

The Read/Write VIP Mode Control register allows the TAS to exert explicit control over VIP operation. The VIP subsystem can only be in one of the modes below. Changing the mode cancels the previous mode. This register only affects VIP operation (e.g. setting this register will not allow the Intellitrol to permit if a wet truck is attached).

This register is normally used when the TAS validates a vehicle with its database. During the time the unit is in TAS Delay, the VIP Standby LED will flash. When the TAS writes to the VIP Mode Control register, the Standby LED will stop flashing and the VIP subsystem will respond to which mode was selected. If the wait for TAS timer times out before the TAS sets the mode register, the

VIP subsystem will determine truck authorization from its onboard vehicle list.

When the TAS is not involved in the validation process, but only for vehicle list maintenance, the Local Operation Mode is selected. This mode is the power up and reset default mode.

The current mode is indicated when the register is read. As an example, setting the mode to unauthorized when a vehicle is not at the rack, will cause a read back indicating local operation, because a remote unauthorize ceases when the truck departs.

MODE	OPERATION	MEANING
0	Local Operation	Normal operation without any Modbus override. Permits trucks from the vehicle list or date from TIMs or Bypass keys.
1	Remote Bypass	Will cause the unit to bypass the VIP function and act as if a bypass key had just been touched to the bypass port on the unit. When the truck departs or timer expires, the unit resumes local operation mode. The bypass will be logged.
2	Remote Unauthorization	Will cause the unit to not authorize the present vehicle. When the truck departs, the unit resumes local operation mode.
3	Remote Authorization	This is equivalent to setting the remote bypass mode for the VIP function, with the exception that no entry of the bypass will be made in the log. When the truck departs, the unit resumes local operation mode.
4	Permanent Authorization	Will cause the unit to authorize (VIP override) until the mode is changed via Modbus or reset.
5	Passive ID Mode	Disables VIP function and enables Passive ID Mode. The terminal will be able to see all TIMs.

VIP Mode Control Bit Assignments

3.2.7. [Registers 0020 - 0023] Unit Serial Number

The Unit Serial Number register(s) contain the rack controller unit's 64-bit serial number. The Intellitrol uses the onboard 48-bit serial number as the Unit Serial Number (register 20 will always read back 0).

3.2.8. [Register 0025] Config-A

The Config-A register is used to read the setting of the feature's hardware jumpers. Generally, changing any of these jumpers will set the unit into a fault condition until the unit is reset.

Some of the hardware jumpers are further qualified by software control. This means that the Intellitrol firmware may selectively disable the hardware jumper function. Further, some of these software-controllable features are master-controlled by a Features Enable Password. The VIP, Ground Fault Detection, and Deadman Switch operations (or subsystems) are in this group. For one of these features to be enabled, all three controls must be active -- the hardware jumper must be in place, the software enable must be on, the unit's features must be enabled at the factory.

BIT	MEANING
0002	Enable the Truck Here logic.
0004	Enable the VIP subsystem code.

0008	Enable the Ground-Fault-Detection subsystem.
0010	Boot up in Special Operations mode for manually adding bypass keys.
0020	Boot up in Special Operations mode and erase the internal EEPROM Bypass Key List.
0040	Enable the Deadman Switch subsystem code.
0100	The 8-compartment jumper is installed; the Intellitrol will utilize all 8 channels.
0200	The European voltage-limiting jumper is installed.
0400	The European Pin-9-as-ground jumper is installed.

Config A Register Bits

3.2.9. [Register 0026] Config-B

The Config-B register is the software analog of the hardware jumpers register. This register allows the TAS system to inquire of the unit what software features are enabled. Each bit in the Config-B register parallels the corresponding bit in the Config-A hardware-jumpers register.

Some of these software-controllable features are further controlled by a Features Enable Password. VIP, Ground, and Deadman Switch operation are in this group. For one of these features to be enabled, all three controls must be active -- the hardware jumper must be in place, the software enable must be on, and the unit's features must be enabled at the factory.

BIT	MEANING
0002	Enable the Truck Here logic.
0004	Enable the VIP subsystem code.
0008	Enable the Ground-Check subsystem code.
0010	Boot up in "Special Operations" mode for manually adding bypass keys to the internal Bypass Key List stored in EEPROM.
0020	Boot up in "Special Operations" mode and erase the internal EEPROM Bypass Key List.
0040	Enable the Deadman Switch subsystem code.

Config B Register Bits

3.2.10. [Register 002D] Number of Probes

This is available only on the Intellitrol2. This is the detected number of sensors for 5 wire sensors and for 2 wire sensors a reflection of the state of the 6/8 compartment jumper. A value of 0x00 indicates no vehicle connected and a value of 0xFF that the connected vehicle has a wet sensor.

Note: If the truck is equipped with an Intellicheck and connected via the optic socket (5-wire) the number of probes will always be 1.

3.2.11. [Register 0069] Service-A Flag

The Service-A register contains additional error/status flags. Any Service-A flag bit set results in the rack controller entering a "Fault" state.

3.2.12. [Register 006A] Service-B Flag

The Service-B register contain further error/status flags. Any Service-B flag bit set results in the rack controller entering a "Fault" state.

3.2.13. [Register 006D] Ground Status

The Ground Status register contains the rack controller's Ground Fault Detection subsystem's current status in the low-order byte; the high-order byte is reserved and reads back as 0. The Ground status byte is bitmapped as follows:

BIT	MEANING
01	Ground Fault detected.
10	No test performed (Ground fault detection may be disabled).

20	The Ground Bolt sense line (Pin 9) is shorted to ground.
40	The Ground Fault Detection circuitry failed.
80	Ground Fault test aborted.

Ground Status Register Bits

3.2.14. [Register 007B] VIP Option

This provides an alternative control of the VIP system. When this register is set to 1 and the system has VIP disabled, the Intellitrol will attempt to read the vehicle TIM and display read status. No serial numbers will need to be stored in the controller VIP's list, but any TIM number read will be available to the TAS.

The Intellitrol will not include the VIP in the PERMIT decision but the VIP AUTHORIZED, UNAUTHORIZED and STANDBY LEDs will function as normal.

The following describes the controller's operation for various situations.

1. Prior to truck connection, the VIP STANDBY led is ON, NON-PERMISSIVE. Modbus TIM serial number registers (10A-10C) will contain 0.
2. When the Intellitrol connects to a truck, the controller attempts to read the TIM.
   a. If the serial number can be read, the VIP AUTHORIZED led is ON, and the Controller will be PERMISSIVE, if the overfill sensors are dry and grounding is ok. The serial number is stored in Modbus TIM serial number registers.
   b. If the serial number cannot be read correctly, possibly a bad connection, the VIP UNAUTHORIZED led will be ON, and the Controller will be PERMISSIVE if the overfill sensors are dry and grounding is ok. The Modbus TIM serial number registers will contain FFFFFFFFFFFF. The driver should reconnect plug.
   c. If the TIM cannot be detected, possibly a broken wire, the VIP STANDBY led will be ON, and the Controller will be PERMISSIVE if the overfill sensors are dry and grounding is ok, the Modbus TIM serial number registers will contain 0. The driver should reconnect the plug.
3. In situations b & c above, a VIP Bypass operation will not be required to PERMIT the Intellitrol.
4. The cable will be considered disconnected when the Intellitrol can no longer detect a truck signal of any type. After a 5 second disconnection, the Modbus TIM serial number register will be written as 0.

3.2.15. [Register 007C] Resistive Ground Tolerance

Available only on Intellitrol 2 this provides a method for setting the highest resistance level acceptable for a good vehicle ground connection when automatic ground type detection is selected via J8 and a ground bolt is not detected. The accepted register values and corresponding resistance levels are shown below.

Value	Resistance level
0	Near 2k ohm, default value which matches Intellitrol
1	Near 100 ohm, recommended by API
2	Near 5k ohm,
3	Near 10k ohm, specified by EN 13922

Resistive Ground Level Register

CAUTION: A Truck Identification Module (TIM) will present a resistance of near 2.2k ohms which is a good ground in the higher tolerance levels. Loading racks which may see vehicles with TIMs should avoid these settings. Racks which require vehicles to have TIMs should remove the J8 Ground Bolt jumper which will cause the Intellitrol to accept only the ground bolt connection as a valid ground.

3.2.16. [Register 007E] Enable Good Ground Display

Available only on Firmware 1.14 and later this provides a positive indication of grounding prior to truck sensor type being determined. This register is only valid on Intellitrols with the ground proofing feature enabled. With this register set to a 1, while the Intellitrol is trying to determine the vehicle sensor type, the PERMIT LEDs will flash at a ½ second rate if the ground is good.

3.2.17. [Register 007F] Compartment Count Display Time

Register 7F was added to support Intellitrol2's 5-wire compartment count. This register is only valid on Intellitrol2. This register holds the time in seconds which the compartment count should be flashed on initial 5-wire vehicle connection. Only values between 0 and 31 and 0xFF are allowed. A value of 0xFF disables the flashing of the display.

3.2.18. [Register 0080] Enable Active Deadman

Registers 80 - 83 were added with Intellitrol firmware version 1.6.35 to provide an active deadman function. Register 80 enables the function with any non-zero value, a zero disables the function.

3.2.19. [Register 0081] Active Deadman Open Time

Register 81 holds the maximum number of seconds the deadman switch can be open prior to a fault being reported. This time is used for both the active and standard deadman functions. System permit, when the deadman function is active, is not allowed with a deadman fault. Only values 1 - 30 are allowed; the default is 3.

3.2.20. [Register 0082] Active Deadman Close Time

Register 82 holds the maximum number of seconds the deadman switch can be closed prior to a fault being reported. This time is used only for the active deadman function. System permit, when the deadman function is active, is not allowed with a deadman fault. Only values 10 - 600 are allowed; the default is 120.

3.2.21. [Register 0083] Active Deadman Warning

Register 83 holds the number of seconds prior to a deadman fault being reported that a warning will be issued. This time is used only for the active deadman function. This value is used with register 82 to warn the deadman user that the switch must be opened to prevent a fault. This register value must be at least 15 less than register 82. If the register 82 value is less than 20 the register 83 value is ignored. Only values 10 - 60 are allowed; the default is 15.

3.2.22. [Register 0084] Enable Unload Terminal

Register 84 enables unload terminal mode.

3.2.23. [Register 0085] SuperTim Max Unload Time

Register 85 holds the max unload time.

3.2.24. [Register 0086] SuperTim Certificate Date Enable Mask

Register 86 holds the value to select which certificates to compare with the TIM data.

3.2.25. [Register 0087] Enable Compartment Count Check

Register 87 enables compartment count comparison between Intellitrol and the TIM data.

3.2.26. [Register 0088] SuperTim Fuel Type Check Mask

Register 88 holds the value to select which compartments to compare the fuel type with the TIM data.

3.2.27. [Register 0089] Enable Auto Write Fuel Type Flag

Register 89 enables automatically writing the fuel type to the TIM data on connection with a truck.

3.2.28. [Register 008A - 008B] SuperTim Default Fuel Type

Register 8A - 8B hold the value of the default fuel type to write to the TIM data.

3.2.29. [Registers 0100 - 0101] UNIX Date/Time

These Read/Write registers allow setting and fetching the date and time. These two registers taken together implement a single 32-bit unsigned integer value. The value is in UNIX Date/Time format and should be set or read in one command. UNIX format is the number of seconds since midnight January 1, 1970 GMT. Valid dates & times are settable within the years 1992 through 2050.

The 32-bit time is nominally specified as GMT (Greenwich Mean Time) or UCT (Universal Coordinated time).

3.2.30. [Register 0104] Status-A

The Status-A register provides the same information Input Status Bits 0 - 15 which are readable via function code 02.

Input Status Bits 0 - 15 are the primary “active unit status” flags and serve as the starting point for a TAS to determine the status of a rack controller unit.

3.2.31. [Register 0105] Status-B

The Status-B register provides the same information as Input Status Bits 16 - 31 which are readable via function code 02.

3.2.32. [Registers 010A - 010C] Truck Serial Number

This register is only available on Intellitrols that have purchased and enabled VIP.

The Truck Serial Number registers contain the currently connected truck’s serial number, if any. This register is meaningful only when the Status-A STSA_TRK_PRESENT bit (0x104 bit2) is set. A value of 0 means there is no truck serial number, a value of FFFFFFFFFFFF means the serial number has not yet been determined or VIP feature is not enabled. Any other value is the truck’s authorization serial number (e.g., TIM). The layout of the truck’s serial number in the three Truck Serial Number registers is:

Register 10A		Register10B			Register 10C
Truck S/N MSB	Truck S/N	Truck S/N	Truck S/N	Truck S/N	Truck S/N LSB

Truck Serial Number Registers

3.2.33. [Registers 010D - 0114] Probe State

The Probe State real-time registers contain the current state of each of the 16 finite state machines used to determine what state a “logical” probe (as opposed to a physical “channel”) is in. Probes 9 - 16 are meaningful only for 5-Wire-Optic style probes.

Register 10D	Register 10E - 113	Register 114
Probe 1 State, Probe 2 State	Probe states	Probe 15 State, Probe 16 State

Probe State Registers

VALUE	DEFINITION
0	Initial unknown state.
1	Truck probe wet (not oscillating).
2	Truck probe dry (oscillating).
3	Cold thermistor probe (not oscillating).
4	Warm thermistor probe (not oscillating).
5	Bad probe on truck, channel/probe open
10	Random or unspecified fault (e.g., oscillations around 7 volts)
11	Channel/Probe shorted to ground
12	Channel/Probe shorted to another probe or other power source

Probe State Register Definitions

3.2.34. [Register 0115] Bypass State

The Bypass State real-time register contains the current bypass state flags. The Bypass State register is only meaningful when the Status-A STSA_BYPASS flag is set. The Bypass State register is bitmapped as follows:

VALUE	DEFINITION
0x01	Overfill Bypass
0x02	Ground Fault Bypass
0x04	Reserved
0x08	VIP Bypass
0x10	Reserved
0x20	Reserved
0x40	Reserved
0x80	Reserved
0x0100	Bypass Hot-Wired
0x0200	Waiting to Bypass
0x0400	Bypass Prohibited (Timer expired)
0x0800	Bypass Prohibited (Dry once)
0x1000	Bypass key present
0x2000	Reserved
0x4000	Reserved
0x8000	Reserved

Bypass Register Bit Definitions

The low-order byte contains the mask of bypassable conditions that are currently bypassed. The high-order byte contains related-to-bypass flags:

The Bypass Hot-Wired flag indicates that the rack controller has determined that the bypass key has been hardwired and will be ignored.

The Waiting to Bypass flag indicates that the rack controller is in the initial connection overfill wait timer.

This timer prevents premature attempts at bypassing probes that simply haven’t warmed up yet or otherwise settled down. The timer is set at 60 seconds for thermistor probes (you cannot bypass a “wet” thermistor probe until at least 60 seconds have elapsed after initial truck connection) and 20 seconds for all optic probe configurations.

The Bypass Prohibited (Timer expired) flag indicates that the rack controller Bypass Timer has expired (the unit has been in bypass condition too long). The unit cannot be further bypassed; the truck must disconnect.

The Bypass Prohibited (Dry once) flag indicates that the unit was successfully dry for long enough that the unit will not allow an overfill bypass. This is predicated upon the idea that overfill bypass is to “get around” faulty probes, and that once the probes are believed to work (are “dry” for “long enough” to think they work properly), that any further overfill bypass will result in a fuel spill. The truck must disconnect.

The “Bypass Key Present” flag indicates that a bypass key is currently present and being read.

3.2.35. [Registers 0116 - 0118] Bypass Serial Number

The Bypass Serial Number register contains the last bypass key serial number used to put the unit into active bypass state. The Bypass Serial Number register is only meaningful when the Status-A STSA_BYPASS flag is set.

Register 116		Register 117		Register 118	
Bypass S/N MSB	Bypass S/N	Bypass S/N	Bypass S/N	Bypass S/N	Bypass S/N LSB

The bypass serial number layout

3.2.36. [Register 0119] Bypass Time

The Bypass Time register contains the current elapsed time (in seconds) that the rack controller has been in a bypass state. The Bypass Time register is only meaningful when the Status-A STSA_BYPASS flag is set.

3.2.37. [Register 011A] Non-Permit Reasons

The Non-Permit Reasons dynamic register contains flags detailing why the rack controller unit is currently not permitting. The Non-Permit Reasons register is only meaningful when the Status-A STSA_TRK_PRESENT flag is set.

The Non-Permit Reasons register is bit-mapped as follows:

BIT	MEANING
0x01	overfill (sensors in a non-dry state)
0x02	ground fault detected
0x04	Reserved
0x08	VIP fault (unauthorized or unreadable TIM)
0x10	Reserved
0x20	Reserved
0x40	Reserved
0x80	Deadman switch fault
0x0100	Reserved
0x0200	Waiting to bypass
0x0400	Bypass prohibited (timer expired)
0x0800	Bypass prohibited (Dry Once)
0x1000	Reserved
0x2000	Non-Permit due to Special Ops mode
0x4000	Non-Permit due to system fault
0x8000	Non-Permit due to Shutdown state

Non-Permit Register

The low-order byte (except the Deadman Switch) contains the mask of bypassable conditions that are currently not bypassed. The high-order byte contains flags as follows:

- The “Waiting to Bypass” flag indicates that the rack controller is in the initial connection overfill wait timer.
- This timer prevents premature attempts at bypassing probes that simply haven’t warmed up yet or otherwise settled down. The timer is set at 60 seconds for thermistor probes (you cannot bypass a “wet” thermistor probe until at least 60 seconds have elapsed after initial truck connection) and 20 seconds for all optic probe configurations.
- The Bypass Prohibited (Timer expired) flag indicates that the rack controller Bypass Timer has expired (the unit has been in bypass condition too long). The unit cannot be further bypassed; the truck must disconnect.
- The Bypass Prohibited (Dry once) flag indicates that the unit was successfully dry for long enough that the unit will not allow an overfill bypass. This is predicated upon the idea that

overfill bypass is to get around faulty probes, and that once the probes are believed to work (are dry for long enough to think they work properly), that any further overfill bypass will result in a fuel spill. The truck must disconnect.

- The Special Ops mode flag indicates that the rack controller unit was booted up in either Add Bypass Key or Erase Bypass Keys mode and thus by definition will never permit.
- The Fault flag indicates that the rack controller unit is in a Fault condition, and thus cannot permit.
- The Shutdown flag indicates that the unit is in Shutdown mode, and thus will not permit, even though the unit otherwise appears to be operational.

3.2.38. [Register 0120] Number of Probes

This is the detected number of 5 wire sensors.

3.3. Function Code 05 Intellitrol Force Bit Assignments

The Modbus Force Single Bit function is used by the Intellitrol rack controller units as a general action/reaction command facility.

#	COMMAND	MEANING	Force Bits
0000	Shutdown	Enable/disable “Shutdown” state	0000 / FF00
0002	Recover	Restore “Normal” state, clear “Shutdown” state	FF00
0003	Erase Vehicle List	Erase the EEPROM-resident Vehicle List	FF00
0004	Erase Log	Erase Bypass/Event Log	FF00
0006	Hardware Reset	Reset the unit.	FF00
0012	Erase Bypass Key List	Erase the EEPROM-resident Bypass Key List	FF00
0013	Erase EEPROM	Erase and Reinitialize all EEPROM partitions	FF00

Force Bit Command Values

Address	Function	Force Bit		Force Data		16-bit CRC
01 - 63	05	00	03	FF	00	CRC

Force Bit Query and Response Message

3.3.1. [Force Code 00] Shutdown

The Shutdown action locks the Intellitrol in a non-permit state until force code 0002 is sent or the unit is restarted.

3.3.2. [Force Code 02] Recover

The Recover action unlocks the Intellitrol and allows it to be able to permit again.

3.3.3. [Force Code 03] Erase Vehicle List

The Erase Vehicle List action reinitializes the Vehicle List. Upon completion, all vehicle serial numbers have been erased from the rack controller. The Intellitrol will allow an Erase Vehicle List operation only when the unit is in Idle state (no truck is connected).

NOTE: A block marked as invalid cannot be erased; the entire EEPROM must be erased (force code 13) to correct an invalid block. Erasing the Vehicle List may take one or two seconds.

3.3.4. [Force Code 04] Erase Log

The Erase Log action reinitializes the onboard Event log. Upon completion of the Erase Log operation, the EEPROM-resident log has been reinitialized — all previous stored log information is lost. The entire EEPROM must be erased (force code 13) to correct an invalid block.

3.3.5. [Force Code 06] Hardware Reset

The Hardware Reset function is equivalent to pressing the hardware reset button on the microprocessor board. The rack controller unit will undergo a full reset condition. Actual operation of the Reset command depends on the hardware involved.

3.3.6. [Force Code 12] Erase Bypass Key List

The Erase Bypass Key List action erases (reinitializes) the Bypass Key List in EEPROM.

3.3.7. [Force Code 13] Erase EEPROM

The Erase EEPROM action completely reinitializes the entire EEPROM non-volatile memory storage. All EEPROM partitions are erased and reinitialized to their default values.
This command is only allowed if the rack controller is in Idle state (no truck is connected).
A CPU reset will automatically occur as a result of this command as all reference values have been lost and must be rediscovered.

3.4. Function Code 06 Write Single 16-Bit Register

Function code 06 query and response messages are in accordance with the Modicon Manual chapter 2. The 16-bit registers are listed in section *16-Bit Control and Data Registers*.

Address	Function	Reg # MSB	Reg # LSB	Data MSB	Data LSB	16-bit CRC
01 - 63	06	00	7E	00	00	CRC

Write Single Register Query Message

Address	Function	Reg # MSB	Reg # LSB	Data MSB	Data LSB	16-bit CRC
01 - 63	06	00	7E	00	00	CRC

Write Single Register Response Message

3.5. Function Code 10 Write Multiple 16-Bit Registers

Function code 10 (hex) writes one or more 16-bit registers. Function code 10 query and response messages are in accordance with the Modicon Manual chapter 2. The 16-bit registers are listed in section *16-Bit Control and Data Registers*.

Address	Function	Reg # MSB	Reg # LSB	Reg Count MSB	Reg Count LSB	16-bit CRC
01 - 63	10	01	00	00	02	CRC

Write Multiple Register Query Message

Address	Function	Reg #		Reg Count		Byte Count	Data Reg 100		Data Reg 101		16-bit CRC
01 - 63	10	01	00	00	02	02	2D	1C	5C	78	CRC

Write Multiple Register Response Message

3.6. Function Code 46 Write Multiple Vehicles

Function Code 46 (hex), writes multiple elements into the Vehicle List. All numbers are in hex in the example below. In the VIP, bypass key serial numbers are stored within the Vehicle List. Note that write messages should not contain more than 9 vehicle numbers for a VIP rack controller.

Address	Function	Element Number		Number of Elements		ESN 1					
01 - 63	46	12	34	00	02	00	11	22	33	44	AA
ESN 2										16 Bit CRC	
00	11	22		33	44	AA				CRC	

Write Multiple Vehicles Query Message

Address	Function	Element Number		Number of Elements		16 Bit CRC
01 - 63	46	12	34	00	02	CRC

Write Multiple Vehicles Response Message

3.7. Function Code 47 Read Multiple Vehicles

Function Code 47 (hex), reads multiple elements from the Vehicle List.

Address	Function	Element Number		Number of Elements		16 Bit CRC
01 - 63	47	12	34	00	02	CRC

Read Multiple Vehicles Query Message

Address	Function	Element Number		Number of Elements		Byte Count	ESN 1					
01 - 63	47	12		34	00	02	00	11	22	33	44	AA
ESN 2									16 Bit CRC			
00	11	22		33		44	AA		CRC			

Read Multiple Vehicles Response Message

3.8. Function Code 49 Read Event Log

The Event Log is 1024 entries in size. All Event Log entries share a common format header, but each distinct event type has its own private (event-specific) data structure.

Each Event entry consists of 32 bytes of information. The Event type is the first byte.

The second byte is a Type-specific sub-code byte. It may be a bitmapped set of flags or an 8-bit integer code.

The Repeat Mask is an initially-ones (FFFF hex) bit mask used to indicate how many times the Event repeated. To keep from filling up the Event Log with redundant entries, some events can repeat themselves — merging a bunch of events into a single entry. Each successive repeated event clears the lowest-order 1 bit in the mask. Once the mask is completely zeroed, successive repeated events are simply discarded. A value of FFFF (hex) indicates the event occurred once, FFFE (hex) indicated the event occurred twice, while 0000 indicates that the event has occurred 17 *or more* times.

The Time longword is the UNIX-style 32-bit GMT time (ref epoch of January 1, 1970) of the occurrence of the *first* event.

The Info block is the Type-specific event data. Each event type has a different private event data block stored in the event log entry. Only the first event entry logs the private data, subsequent repeated events' private event data are discarded.

The CRC is the Modbus-style CRC-16 calculated *solely* on the Info block.

Address	Function	Element Number		16 Bit CRC
01 - 63	49	00	12	CRC

Read Event Log Query Message

Address	Function	Element Number		Type	Subtype	Repeat Mask		Start Time				Hardware Revision	
01 - 63	49	00	12	02	20	FF	FC	5D	C9	7D	30	15	00
Kernel Version		Shell Version		Jumpers		Config2		Reserved			16 Bit CRC		
00	00	17	00	81	4C	01	44	00	…	00	CRC		

Read Event Log Response Message

3.8.1. [Event Type 01] EEPROM Initialized

Event Type code 01 (hex) logs EEPROM "Format/Initialization" events.

BYTE	DEFINITION
0 - 1	Unit Hardware Revision Level
2 - 3	Firmware Kernel version
4 - 5	Firmware Shell version
6 - 7	Hardware Jumpers ("Config-A" register)
8 - 9	More configuration ("Config-B" register)

Event Log Type 01

3.8.2. [Event Type 02] System Reset

Event Type code 02 (hex) records System Reset events. System Reset events which occur within a 4-hour window are repeated as a single event in the Event Log.

BYTE	DEFINITION
0 - 1	Unit Hardware Revision Level
2 - 3	Firmware Kernel version
4 - 5	Firmware Shell version
6 - 7	Hardware Jumpers (“Config-A” register)
8 - 9	More configuration (“Config-B” register)

Event Log Type 02

3.8.3. [Event Type 03] Bypass Activity

Event Type code 03 (hex) records bypass activity involving the rack controller.

BYTE	DEFINITION
0 - 5	Bypass Key Serial Number (FFFFFFFFFFFF for TAS)
6 - 11	Truck Serial Number (if any)

Event Log Type 03

3.8.4. [Event Type 04] Hardware Error

Event Type code 04 (hex) records system hardware errors. Hardware Events which occur with a 4-hour window are repeated and logged as a single event.

The event Subtype byte identifies the specific hardware error being logged. The Info block format depends on the Subtype identifier. The subtypes are:

BYTE	DEFINITION
0	FLASHRAM (Kernel and/or Shell) CRC-16 failure
1	Error detected with relay operation

Event Log Type 04

3.8.4.1. [Hardware Error Subtype 00] Firmware CRC-16 Fault

The Firmware CRC failure Info blocks contains the following information:

BYTE	DEFINITION
0 - 1	Proper Firmware Kernel CRC-16 value
2 - 3	Actual Firmware Kernel CRC-16 value
4 - 5	Proper Firmware Shell CRC-16 value
6 - 7	Actual Firmware Shell CRC-16 value

Event Log Type 04 Subtype 00

3.8.4.2. [Hardware Error Subtype 01] Relay Fault

The Relay Fault Info blocks contain the following information:

BYTE	DEFINITION
0	Backup Relay State Byte
1	Main Relay State Byte

Event Log Type 04 Subtype 01

3.8.5. [Event Type 05] Voltage Error

Event Type code 05 (hex) records erroneous voltages detected by the firmware self-test diagnostics. The Voltage Error Info blocks contain the following information:

BYTE	DEFINITION
0 - 1	Raw 13-Volt value (millivolts)
2 - 3	Reference Volt value (millivolts)
4 - 5	Probe Bias Voltage (millivolts)
6 - 7	Channel 1 voltage (millivolts)
8 - 9	Channel 2 voltage (millivolts)
10 - 11	Channel 3 voltage (millivolts)
12 - 13	Channel 4 voltage (millivolts)
14 - 15	Channel 5 voltage (millivolts)
16 - 17	Channel 6 voltage (millivolts)
18 - 19	Channel 7 voltage (millivolts)
20 - 21	Channel 8 voltage (millivolts)

Event Log Type 05

3.8.6. [Event Type 06] Impact Sensor Tripped

Event Type code 06 (hex) records impacts to the rack controller unit itself. The Impact Info block contains the following information:

BYTE	DEFINITION
0 - 5	Bypass Key Serial Number, if any
6 - 11	Truck Serial Number, if any

Event Log Type 06

3.8.7. [Event Type 07] Overfill Info

Event Type code 07 (hex) records Overfills. This event is logged when a probe detects a wet sensor. The Overfill block contains the following information:

BYTE	DEFINITION
0	What kind of probe was wet
1 - 16	Report probe state
17 - 21	Truck Serial Number

Event Log Type 07

3.8.8. [Event Type 08] Maintenance Error

Event Type code 08 (hex) records maintenance errors. This event is logged when high resistance is detected in the truck connection. The Maintenance block contains the following information:

BYTE	DEFINITION
0 - 1	Channel 5 resistance is higher than expected

Event Log Type 08

3.9. Function Code 4A CRC Multiple Vehicles

The CRC Vehicle List command is used to obtain a rack controller-derived Modbus CRC-16 value for a logically contiguous subset of the Vehicle List. This CRC value can be used by the TAS to decide whether the rack controller's Vehicle List is correct and up to date.

Address	Function	Start Index		Element Count		16 Bit CRC
01 - 63	4A	01	F4	00	64	CRC

CRC Multiple Vehicles Query Message

Address	Function	Start Index		Element Count		Vehicle List CRC Value		16 Bit CRC
01 - 63	4A	01	F4	00	64	65	AA	CRC

CRC Multiple Vehicles Response Message

3.10. Function Code 4B Write Bypass Keys

The Write Bypass Keys command is used to write one or more Bypass Authorizer serial numbers to the control unit's onboard EEPROM-resident Bypass Authorizer List. The format and operation of Write Bypass Keys (function 4B) is identical in operation and construction to Write Multiple Vehicles (function 46).
The Intellitrol by default has room for up to 32 Bypass Authorizer serial numbers; to determine the actual size of the Bypass Authorizer List, read the Bypass Key Block Size register (0AC), and divide by the size of a stored bypass key element (8).

Address	Function	Element Number		Number of Elements		Bypass Key 1					
01 - 63	4B	12	34	00	02	00	11	22	33	44	AA
Bypass Key 2						16 Bit CRC					
00	11	22		33	44	AA	CRC				

Write Bypass Keys Query Message

Address	Function	Element Number		Number of Elements		16 Bit CRC
01 - 63	4B	12	34	00	02	CRC

Write Bypass Keys Response Message

3.11. Function Code 4C Read Bypass Keys

The Read Bypass Keys command is used to read one or more Bypass Authorizer serial numbers from the control unit's onboard EEPROM-resident Bypass Authorizer List. The format and operation of Read Bypass Keys (function 4C) is identical in operation and construction to Read Multiple Vehicles (function 47).
The Intellitrol by default has room for up to 32 Bypass Authorizer serial numbers; to determine the actual size of the Bypass Authorizer List, read the Bypass Key Block Size register (0AC), and divide by the size of a stored bypass key element (8).

Address	Function	Element Number		Number of Elements		16 Bit CRC
01 - 63	4C	12	34	00	02	CRC

Read Multiple Vehicles Query Message

Address	Function	Element Number	Number of Elements		Byte Count	Bypass Key 1					
01 - 63	4C	12	34	00	02	00	11	22	33	44	AA
Bypass Key 2						16 Bit CRC					
00	11	22	33		44	AA	CRC				

Read Multiple Vehicles Response Message

3.12. Function Code 50 Report Compartment Volume

This command will send back the volume of the compartment requested.

Address	Function	Compartment Number	16 Bit CRC
01 - 63	50	0C	CRC

Report Compartment Volume Query Message

Address	Function	Compartment Number	Compartment Volume				16 Bit CRC
01 - 63	50	0C	00	00	00	00	CRC

Report Compartment Volume Response Message

3.13. Function Code 53 Read Builder Info

This command will read builder info from the TIM. Refer to section 3.14.1 for subcommands.

Address	Function	TIM Builder Info Command	16 Bit CRC
01 - 63	53	05	CRC

Read Builder Info Query Message

Address	Function	TIM Builder Info Command	TIM Builder Info Data	16 Bit CRC
01 - 63	53	05	……	CRC

Read Builder Info Response Message

3.14. Function Code 54 Write Builder Info

This command will write builder info to the TIM. Refer to section 3.14.1 for subcommands.

Address	Function	TIM Builder Info Command	TIM Builder Info Data	16 Bit CRC
01 - 63	54	05	……	CRC

Write Builder Info Query Message

Address	Function	TIM Builder Info Command	16 Bit CRC
01 - 63	54	05	CRC

Write Builder Info Response Message

3.14.1. TIM Builder Info

#	REGISTER NAME	Read / Write	DESCRIPTION
01	Carrier Name	R	Name of the carrier company
02	Carrier Address	R	Address of the carrier company
03	Contract Number	R	Carriers contract number
04	Operating Service	R	Operating service's name
05	Driver ID	R	ID of the driver
06 - 15	Allowable Volume Compartment 1 - 16	R	Allowable volume of compartment 1 - 16
16	Vapor Tight Certificate Type	R	Certificate type for the vapor tightness certificate. For vapor tightness type this value will always be 1.
17	Vapor Tight Certificate Date	R	Expiration date for the vapor tightness certificate
18	Vapor Tight Certificate Number	R	Vapor tightness certificate number
19	Safe Pass Certificate Type	R	Safe loading pass certificate type. For safe loading pass type this value will always be 2.
1A	Safe Pass Certificate Date	R	Safe loading pass certificate expiration date
1B	Safe Pass Certificate Number	R	Safe loading pass certificate number
1C	Certificate 3 Type	R	Certificate 3 type
1D	Certificate 3 Date	R	Certificate 3 expiration date
1E	Certificate 3 Number	R	Certificate 3 number
1F	Certificate 4 Type	R	Certificate 4 type
20	Certificate 4 Date	R	Certificate 4 expiration date

#	REGISTER NAME	Read / Write	DESCRIPTION
21	Certificate 4 Number	R	Certificate 4 number
22	Certificate 5 Type	R	Certificate 5 type
23	Certificate 5 Date	R	Certificate 5 expiration date
24	Certificate 5 Number	R	Certificate 5 number
25	Table Valid	R	A flag to indicate if the TIM data is valid
26	Table Revision	R	The revision number of the TIM data
27	Alternate TIM ID Valid	R	A flag to indicate the alternate TIM ID is a valid ID. If this flag is a 0x33 the alternate TIM ID is valid.
28	Alternate TIM ID	R	Alternate TIM ID
29	Number of Compartments	R	Number of compartments on the truck
2A	Compartment Volume Units	R	Volume units for the compartments
2B	Trailer ID Number	R	Trailer ID number
2C	Compartment Config	R	Current configuration of the compartments
2D	Vapor Interlock Type	R	Trucks vapor interlock type
2E - 3D	Compartment 1 - 16 Types Allowed	R	Product types allowed in compartment 1 - 16
3E	Max Loading Temperature	R	Maximum loading temperature
3F	Temperature Units	R	Temperature units
40	Compartment 1 Type Loaded	R / W	Fuel type loaded into compartment 1
41	Compartment 1 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 1
42	Compartment 1 Volume Loaded	R / W	Volume of fuel loaded into compartment 1
43	Compartment 2 Type Loaded	R / W	Fuel type loaded into compartment 2
44	Compartment 2 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 2
45	Compartment 2 Volume Loaded	R / W	Volume of fuel loaded into compartment 2
46	Compartment 3 Type Loaded	R / W	Fuel type loaded into compartment 3
47	Compartment 3 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 3
48	Compartment 3 Volume Loaded	R / W	Volume of fuel loaded into compartment 3
49	Compartment 4 Type Loaded	R / W	Fuel type loaded into compartment 4
4A	Compartment 4 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 4
4B	Compartment 4 Volume Loaded	R / W	Volume of fuel loaded into compartment 4
4C	Compartment 5 Type Loaded	R / W	Fuel type loaded into compartment 5
4D	Compartment 5 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 5

#	REGISTER NAME	Read / Write	DESCRIPTION
4E	Compartment 5 Volume Loaded	R / W	Volume of fuel loaded into compartment 5
4F	Compartment 6 Type Loaded	R / W	Fuel type loaded into compartment 6
50	Compartment 6 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 6
51	Compartment 6 Volume Loaded	R / W	Volume of fuel loaded into compartment 6
52	Compartment 7 Type Loaded	R / W	Fuel type loaded into compartment 7
53	Compartment 7 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 7
54	Compartment 7 Volume Loaded	R / W	Volume of fuel loaded into compartment 7
55	Compartment 8 Type Loaded	R / W	Fuel type loaded into compartment 8
56	Compartment 8 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 8
57	Compartment 8 Volume Loaded	R / W	Volume of fuel loaded into compartment 8
58	Compartment 9 Type Loaded	R / W	Fuel type loaded into compartment 9
59	Compartment 9 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 9
5A	Compartment 9 Volume Loaded	R / W	Volume of fuel loaded into compartment 9
5B	Compartment 10 Type Loaded	R / W	Fuel type loaded into compartment 10
5C	Compartment 10 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 10
5D	Compartment 10 Volume Loaded	R / W	Volume of fuel loaded into compartment 10
5E	Compartment 11 Type Loaded	R / W	Fuel type loaded into compartment 11
5F	Compartment 11 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 11
60	Compartment 11 Volume Loaded	R / W	Volume of fuel loaded into compartment 11
61	Compartment 12 Type Loaded	R / W	Fuel type loaded into compartment 12
62	Compartment 12 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 12
63	Compartment 12 Volume Loaded	R / W	Volume of fuel loaded into compartment 12
64	Compartment 13 Type Loaded	R / W	Fuel type loaded into compartment 13
65	Compartment 13 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 13
66	Compartment 13 Volume Loaded	R / W	Volume of fuel loaded into compartment 13
67	Compartment 14 Type Loaded	R / W	Fuel type loaded into compartment 14

#	REGISTER NAME	Read / Write	DESCRIPTION
68	Compartment 14 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 14
69	Compartment 14 Volume Loaded	R / W	Volume of fuel loaded into compartment 14
6A	Compartment 15 Type Loaded	R / W	Fuel type loaded into compartment 15
6B	Compartment 15 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 15
6C	Compartment 15 Volume Loaded	R / W	Volume of fuel loaded into compartment 15
6D	Compartment 16 Type Loaded	R / W	Fuel type loaded into compartment 16
6E	Compartment 16 Batch ID Loaded	R / W	Fuel batch date code loaded into compartment 16
6F	Compartment 16 Volume Loaded	R / W	Volume of fuel loaded into compartment 16
70	Terminal Name	R / W	Name of the terminal for the last load
71	Terminal Address	R / W	Address of the terminal for the last load
72	Terminal Gantry Number	R / W	Gantry number for the last load
73 - 77	Fault Log	R	Fault entry
78	Service Center Name	R	Name of the last service center
79	Service Center Address	R	Address of the last service center
7A	Builder Name	R	Name of the company that built the truck
7B	Builder Address	R	Address of the company that built the truck
7C	Truck Serial Number	R	Trucks serial number
7D	Truck VIN	R	Trucks vehicle identification number
7E	Truck Build Date	R	Date the truck was built
7F	Truck Weight Units	R	Weight unit for the vehicle weight
80	Truck Gross Vehicle Weight	R	Weight of the vehicle
81	Intellicheck Type	R	Is an Intellicheck being used
82	Overfill Sensor Type	R	Are overfill sensors being used
83	Retained Sensor Type	R	Are retained sensors being used
84 - 93	Compartment 1 - 16 Build Volume	R	Compartment 1 - 16 tank volume
94	Scully Sensors	R	Are Scully sensors installed
95	Tank Model Number	R	Model number of the tank
96	Max Working Pressure	R	Maximum tank pressure
97	Allowable Working Pressure	R	Working tank pressure
98	Pressure Units	R	Pressure units
99	Bulkheads	R	Number of bulkheads on a truck
9A	Tank Profile	R	Profile description of truck tanks
9B - B2	Overfill Sensor 1 - 24 Length	R	Length of sensor 1 - 24

3.15. Function Code 55 Read Third Party Data

This command allows companies to read proprietary information from the SuperTIM. This way the information will follow the truck. One example could be an electronic copy of the last invoice. There is 5K bytes reserved for this (0C00 – 1FFF).

Address	Function	Memory Address		Data Length	16 Bit CRC
01 - 63	55	0C	00	01	CRC

Read Third Party Data Query Message

Address	Function	Memory Address		Data Length	Third Party Data	16 Bit CRC
01 - 63	55	0C	00	01	……	CRC

Read Third Party Data Response Message

3.16. Function Code 56 Write Third Party Data

This command allows companies to write proprietary information to the SuperTIM. This way the information will follow the truck. One example could be an electronic copy of the last invoice. There is 5K bytes reserved for this. Data Field must not exceed 70 bytes.

Address	Function	Memory Address		Data Length	Third Party Data	16 Bit CRC
01 - 63	56	0C	00	01	……	CRC

Write Third Party Data Query Message

Address	Function	Memory Address		Data Length	16 Bit CRC
01 - 63	56	0C	00	01	CRC

Write Third Party Data Response Message

3.17. Function Code 59 Insert Vehicle

This command inserts a TIM ID number or alternate TIM ID into the VIP vehicle list. The list can store up to 5000 TIM ID's.

Address	Function	TIM ID Number						16 Bit CRC
01 - 63	59	00	00	01	21	39	EB	CRC

Insert Vehicle Query Message

Address	Function	Index		TIM ID Number						16 Bit CRC
01 - 63	59	00	00	00	00	01	21	39	EB	CRC

Insert Vehicle Response Message

3.18. Function Code 5A Remove Vehicle

This command deletes a TIM ID number or alternate TIM ID from the vehicle list.

Address	Function	TIM ID Number						16 Bit CRC
01 - 63	5A	00	00	01	21	39	EB	CRC

Remove Vehicle Query Message

Address	Function	Confirmation		16 Bit CRC
01 - 63	5A	FF	FF	CRC

Remove Vehicle Response Message

3.19. Function Code 5B Read Number of Probes

This command reads the number of probes connected to the Intellitrol. Returns FFFF if no truck is connected.

Address	Function	16 Bit CRC
01 - 63	5B	CRC

Read Number of Probes Query Message

Address	Function	Number of Probes		16 Bit CRC
01 - 63	5B	00	0C	CRC

Read Number of Probes Response Message

4. Modbus Exception Response Messages

Except for broadcast messages, when a master device sends a query to a slave device, it expects a normal response. One of four possible events can occur from the master's query:

1. If the slave device receives the query without a communication error, and can handle the query normally, it returns a normal response.
2. If the slave does not receive the query due to a communication error, no response is returned. The master program should process a time-out condition for the query.
3. If the slave receives the query but detects a communication error (parity or CRC), no response is returned. The master program should process a time-out condition for the query.
4. If the slave receives the query without a communication error but cannot handle it (e.g. if the request is to read a non-existent register), the slave will return an exception response informing the master of the nature of the error.

When an error occurs, an exception response message is returned. The message is generated by setting the most significant bit (bit 7) in the function code byte. This byte is returned along with the address, the generated exception response code, and 16-bit CRC.

RESPONSE #	RESPONSE NAME	DEFINITION
00	No Modbus Error	Command executed correctly. No exception response error code was returned.
01	Illegal Function	The function code received in the query is not an allowable action for the slave.
02	Illegal Data Address	The data address received in the query is not an allowable address for the slave.
03	Illegal Data Value	A value contained in the query date field is not an allowable value for the slave.
04	Slave Device Fault	An unrecoverable error occurred while the slave was attempting to perform the requested action.
05	Acknowledge	The slave has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a time-out error from occurring in the master.
06	Slave Device Busy	The slave is engaged in processing a long duration program command. The master should retransmit the message later when the slave is free.
07	Negative Acknowledge	The slave cannot perform the program function received in the query. This code is returned for an unsuccessful programming request using function code 13 or 14 decimal. The master should request diagnostic or error information from the slave.
08	Memory Parity Error	The slave attempted to read extended memory but detected a parity error in the memory. The master can retry the request, but service may be required on the slave device
09	TIM Command Error	Defective or missing TIM
0A	Not a Super TIM	The Dallas chip in the TIM is not a DS1996
0B	Valid Error	The Truck Builder Table Valid location did not contain 0x55AA

0C	Invalid Compartment Number	Number of compartments exceed the maximum number of 16
0D	SPI Loader Family Error	The SPI EEPROM memory ID in the program loader puck is not 0x13 or 0x14
0E	SPI Write Error	Error trying to write to the Program Loader Puck
0F	SPI Read Error	Error trying to read the Program Loader Puck
10	TIM Memory Size or Data Length Error	Invalid address or the data length is greater than 70 bytes
11	TIM Write to Scratch Pad Error	Error occur when writing to the scratch pad area in the DS1996
12	TIM Verify Scratch Pad Error	Error occur when verifying the data written to the scratch pad area in the DS1996
13	TIM Copy Scratch Pad Error	Error occur when transferring the data from the scratch pad to the memory in the DS1996
14	Valid Flag Not Valid for This Entry	The Super TIM entry is not valid
15	Reading Intellitrol Serial Number Error	Error trying to read the Dallas Serial number in the Super TIM
16	Error Allocating Memory	Error occurred when trying to allocate memory
17	I2C Bus Error	An error was detected when trying to access an I2C device
18	Read Real Time Clock Error	Error when trying to read the DS1371 real time clock
80	No Response	Did not receive a response

5. Modbus Command CRC Generation

The following procedure is used to generate the 16-bit CRC sent and received with every Modbus command:

1. Load a 16-bit register with FFFF hex (all 1's). Call this the CRC register.
2. Exclusive OR the first message byte with the CRC register low-order byte. Put the result in the CRC register.
3. Shift the CRC register one bit to the right (toward the LSB), zero-filling the MSB. Extract and examine the LSB.
4. If the LSB was 0: Repeat step 3 (another shift).
5. Otherwise, if the LSB was 1: Exclusive OR the CRC register with A001 hex.
6. Repeat steps 3 through 5 until 8 shifts have been performed. When this is done, a complete 8-bit byte will have been processed.
7. Repeat steps 2 through 6 for the next 8-bit byte of the message. Continue doing this until all bytes have been processed.
8. The final content of the CRC register is the CRC value.
9. The CRC value is appended to the Modbus message low byte first followed by the high byte.

For more information about CRC generation read “Modicon Modbus Protocol Reference Guide” (PI-MBUS 300 Rev J) June 1996, Appendix C. The Intellitrol uses the table method to calculate the CRC.

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