

Scully MODBUS

User Guide



Scully Intellitrol®2 Overfill Prevention Control
Firmware Version 1.7.0



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Scully MODBUS - User Guide

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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.
- PIDX Product Code Standard 04-101-15-45-2010 Revision July 18th, 2017
- Intellitrol Technical Manuals

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 |

Modbus Functions

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

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

| 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

| 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 | Connection 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 |
| 19 | Checksum failure occurred in shell program code. |
| 20 | Onboard 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

Modbus Functions

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 FFFFFFFF (hex) would then indicate that the TIM or the communications was faulty).

3.1.4. [Input Status Bit 03] *Truck in Vehicle List*

The Truck in Vehicle List 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] *High Connection Resistance*

The High Connection Resistance status bit indicates that the 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 19] *Shell CRC Error*

The Shell CRC Error status bit means that the firmware has detected a bad firmware program image.

3.1.16. [Input Status Bit 20] *Clock Error*

The Clock Error status bit indicates that the rack controller cannot correctly read the on-board 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.

3.1.17. [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.

3.1.18. [Input Status Bit 23] *Kernel CRC Error*

The Kernel CRC Error status bit means that the firmware has detected a bad firmware “kernel” image.

3.1.19. [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.

3.1.20. [Input Status Bit 26] *TIM Data Line Fault*

The TIM Data Line Fault status bit indicates that there is an error communicating with TIM.

3.1.21. [Input Status Bit 28] *Ground Fault*

The rack controller unit has detected a Ground Fault condition.

3.1.22. [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.

3.1.23. [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.

3.1.24. [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 first 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 |

Modbus Functions

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 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. |

Modbus Functions

| | |
|------|---|
| 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 FFFFFFFF. 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. This allows the Intellitrol to check the time and date stamp of when the truck was loaded and not allow a permit if the fuel has been in the truck too long. To configure the unit for unload mode a 1 needs to be written to Modbus register 0x0084. The maximum time to allow for an unload is set by writing the time, in minutes, to Modbus register 0x0085. Both values only need to be written once and will be persistent through power cycles. If the unload maximum time is exceeded the unit will not permit without being bypassed. The unload time exceeded can be detected by bit 9 (0x0200) of Modbus register 0x68 being set. The unload terminal can also be programmed to not permit if the loaded fuel type does not match the allowable fuel type. To enable this, feature a bit mask of the compartments to check is written to Modbus register 0x88. Bit 0 is set if compartment 1 is to be checked, bit 1 for compartment 2 and so on. This value is also persistent through power cycles. If any compartment fuel type doesn't match bit 11 (0x0800) of register 0x0068 will be set. This is a bypassable condition. To determine which compartment type does not match a bit mask of miss matched types can be read from Modbus register 0x6B. If compartment 1 type does not match bit 0 will be set, if compartment 2 type does not match bit 1 will be set and so on.

3.2.23. [Register 0085]

SuperTim Max Unload Time

Register 85 holds the maximum time to allow for an unload. If the unload maximum time is exceeded while in Unload Mode, the unit will not permit without being bypassed. The unload time exceeded can be detected by bit 9 (0x0200) of Modbus register 0x68 being set.

3.2.24. [Register 0086]

SuperTim Certificate Date Enable Mask

Register 86 holds the value to select which certificates to compare with the SuperTIM data. The SuperTIM can store 5 certificate expiration dates. The Intellitrol will not permit if any of the selected certificates are expired. This fault is bypassable. Certificate 1 is the vapor tightness certificate, certificate 2 is the safe loading pass certificate. Certificates 3 to 5 are open for user definition. To enable this, feature a bit mask of the certificates to check is written to Modbus register 0x86. Bit 0 is set if certificate 1 is to be checked, bit 1 for certificate 2 and so on. This value is persistent through power cycles. The selected certificates expiration dates are compared to the current date to assure the certificate has not expired. If any have expired the unit will be non-permissive. If any selected certificate has expired bit 6 (0x0040) of Modbus register 0x68 will be set. To determine which certificate has expired a bit mask of expired certificates can be read from Modbus register 0x6F. If certificate 1 is expired bit 0 will be set, if certificate 2 is expired bit 1 will be set and so on.

3.2.25. [Register 0087]

Enable Compartment Count Check

The SuperTIM memory has the number of compartments stored in the builder data. The number of sensors detected by the Intellitrol can be compared to the number of compartments in the truck and permit will not be allowed if the counts don't match. This is a bypassable fault. To enable this feature, 1 should be written to Modbus register 0x87. This value is persistent through power cycles. If this fault is detected bit 10 of Modbus register 0x68 will be set. This check is bypassed if the SuperTIM data indicates that an Intellicheck is installed on the truck.

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 SuperTIM data. Bit 0 is set if compartment 1 is to be checked, bit 1 for compartment 2 and so on. This value is persistent through power cycles.

3.2.27. [Register 0089]

Enable Auto Write Fuel Type Flag

Register 89 enables automatically writing the fuel type to the SuperTIM 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 SuperTIM 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.

Modbus Functions

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 FFFFFFFF 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 | | Register 10B | | Register 10C | |
|----------------|------------|--------------|------------|--------------|----------------|
| Vehicle ID MSB | Vehicle ID | Vehicle ID | Vehicle ID | Vehicle ID | Vehicle ID 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.

Modbus Functions

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 | | Data Reg | | 16-bit CRC |
|---------|----------|-------|----|-----------|----|------------|--|----------|----|----------|----|------------|
| | | | | | | | | | | | | |
| 01 - 63 | 10 | 01 | 00 | 00 | 02 | 02 | | 2D | 1C | 5C | 78 | CRC |

Write Multiple Register Response Message

Modbus Functions

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 | | Vehicle ID 1 | | | | | |
|--------------|----------|----------------|--------------------|----|--------------|-----|----|----|----|----|
| 01 - 63 | 46 | 12 34 | 00 | 02 | 00 | 11 | 22 | 33 | 44 | AA |
| Vehicle ID 2 | | | | | 16 Bit CRC | | | | | |
| 00 | 44 | 33 | 22 | 11 | BB | CRC | | | | |

Write Multiple Vehicles Query Message (Shown for Two Vehicles)

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

Write Multiple Vehicles Response Message (Shown for Two Vehicles)

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 (Shown for Two Vehicles)

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

Read Multiple Vehicles Response Message (Shown for Two Vehicles)

Modbus Functions

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.

| 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

Modbus Functions

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 (See 3.2.33) |
| 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 | Connection 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

Modbus Functions

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 from the SuperTIM.

| 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

Modbus Functions

3.13. Function Code 53

Read Builder Info

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

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

Read Builder Info Query Message

| Address | Function | SuperTIM 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 SuperTIM. Refer to section 3.14.1 for subcommands.

| Address | Function | SuperTIM Builder Info Command | SuperTIM Builder Info Data | 16 Bit CRC |
|---------|----------|-------------------------------|----------------------------|------------|
| 01 - 63 | 54 | 05 | | CRC |

Write Builder Info Query Message

| Address | Function | SuperTIM 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 |

Modbus Functions

| # | 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 |

Modbus Functions

| # | 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 |

Modbus Functions

| # | 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 custom 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 custom 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

Modbus Functions

3.17. Function Code 59**Insert Vehicle**

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

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

Insert Vehicle Query Message

| Address | Function | Index | Vehicle 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 Vehicle ID number or alternate Vehicle ID from the vehicle list.

| Address | Function | Vehicle 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 the slave will return an exception response informing the master of the nature of the error.

| 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 data 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 Error | Defective or missing TIM |
| 0A | Not a Super TIM | The memory device on the truck does not support SuperTIM features. |
| 0B | Valid Error | The Truck Builder Table Valid location was not set correctly |
| 0C | Invalid Compartment Number | Number of compartments exceed the maximum number of 16 |
| 10 | Data Length Error | Invalid address or the data length is greater than 70 bytes |
| 14 | Not Valid for This Entry | The SuperTIM entry is not valid |
| 15 | Error Reading Serial Number | Error trying to read the Serial number in the SuperTIM |
| 16 | Memory Error | Error occurred when trying to allocate memory |
| 18 | Read Real Time Clock Error | Error when trying to read the 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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