Acu-Trac® Product Overview

Product Overview

The Acu-Trac® family of ultrasonic fluid level sensor is non-contact fluid level sensors that are a direct replacement for level senders on tanks with depths up to ≤ 3.0 m. The ultrasonic fluid level sensor provides a choice of either analog current loop (4-20 mA) or voltage outputs (ratiometric or non-ratiometric) with the additional capability of processing real time fuel data and messaging on a J1708 data link.

Product Features

- **More Accurate:** 2% of tank volume.

- **More Reliable:** Acu-Trac® is non-contacting. Resistive float sender have a wiper that slides across a resistive strip that with time can wear and cause intermittent or complete loss of the signal.

- **Non-Invasive:** Acu-Trac® mounts to the same opening as the resistive float sender, but does not protrude into the tank.

- **Easier to Install:** Acu-Trac® has no components to protrude into the tank.

- **Digital Filtering:** User programmable time constant in digital filtering eliminates errors due to fluids sloshing in mobile tanks.

- **Tank Profiling:** User programmable strapping tables for unique tank shapes.

- **Chemical Compatibility:** Acu-Trac® works with a wide variety of media including diesel, motor oil, hydraulic fluid and black water.

- **Self Test/Diagnostics:** Power up test verifies sensor is operating properly and diagnostic messages are sent over the RS-485 bus.

- **Real Time Fuel Data:** Real time fuel data over the J1708 data link for both on vehicle and off vehicle communication.

- **Remote, Real Time, Automated Fuel Data Reporting:** Works with mobile communication systems to reduce operating costs and improve fuel efficiency in the following applications: Fuel purchase optimization, low fuel warnings to prevent running out of fuel, fuel fraud detection, fuel tax odometer support, fuel tax idle fuel rebates, fuel usage report containing tank MPG and idle fuel.

- **NEMA and CE Mark Class B Ratings**

Measurement Technology

The traditional resistive float sender uses a potentiometer attached to a float at the end of an actuating arm to provide a level indication. This technology interfaces with the instrument cluster's fuel gauge which is typically a coil driven needle gauge. As the resistive float sender's resistance changes with level, the current through the coil in the gauge changes causing a deflection of the needle. This approach has been used for many years.

Acu-Trac® uses ultrasonic technology to generate a high frequency sound wave and measure the time for the echo to reflect off of the liquid's surface and return. The distance from the level sensor to the fuel is calculated based on the speed of sound. The measured distance is converted into a voltage that drives the fuel gauge based on a strapping table contained in the level sensor.

The measured distance is converted into a percentage of tank capacity (Full to Empty), and volumes in gallons based on the geometry of the tank.

Cone Angle

Acu-Trac® ultrasonic fluid level sensor mounting that is not perpendicular to the fluid causes a reduction in sensor performance. As shown in Figure 1, the amount of returned sound energy is dependent on mounting cone angle.

The Acu-Trac® NEMA4 ultrasonic level sensor maximum operating range (tank depth) decreases with angle. The maximum cone angle is 6°.
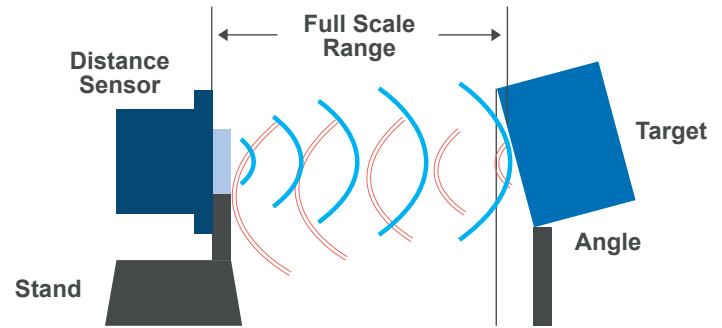

Figure 1: Mounting Considerations

If the Acu-Trac® ultrasonic fluid level sensor is pointed into free space (outside of operating cone angle), no echo will be received. Under this no echo condition, the Acu-Trac® level sensor will hold its output voltage constant. If the no echo condition persists for 8 minutes, the Acu-Trac® level sensor will set both the voltage output and the digital word to empty.

User Programmable Parameters

The Acu-Trac® ultrasonic fluid level sensors can be uniquely configured using a standard Windows based PC and the Acu-Trac® Level Sensor Configuration Kit. The kit includes a RS-485 to J1708 converter, AcuTrac® Level Sensor Configuration Tools Software and instructions. The configuration tools software allows each system to be customized to accommodate any tank size or shape. The Acu-Trac® ultrasonic fluid level sensor has the following user programmable features:
· Digital Filtering Time Constant
· Tank Configuration
· Sensor Mounting Offset
· Gauge Full and Empty Endpoints
· Communication Mode

Digital Filtering Time Constant

Motion of the liquid media, can impact the performance of an ultrasonic level sensor. Wave motion creates noise in the measured data because the level sensor measures one distance at the wave peak and another distance during the wave troughs.

In certain highway and marine applications, this difference can be as high as 30% of full scale especially when traveling on curvy roads or in choppy waters.

Acu-Trac® ultrasonic level sensor has a user programmable digital filter to reduce error caused by sloshing fluids. The digital filter is user programmable for a time constant between 0 and 40 seconds.

Tank Configuration

The tank's capacity, depth, shape and orientation can be programmed into the sensor enabling volumetric fuel quantity or depth.

Sensor Mounting Offset

The sensor mounting offset is the distance in inches from the mounting face of the level sensor to the top of the tank. Calculation of percent of capacity excludes this distance. Sensor mounting offset is used to accommodate unusual tank implementation.

Gauge Full and Empty Endpoints

The gauge drive outputs full and empty endpoints can be independently programmed. The user has the option of programming either a linear output mode or a table output mode.

In the linear output mode, the sensor automatically proportions the output to a linear straight line fit based on the measured fuel volume.

In the table output mode, the user sets up a look up table in the sensor. This mode of operation is typically used to set up a non-linear gauge without knowing the characteristics of the gauge. The user would simply hook up the gauge and use the Learn Gauge Dialog on the Acu-Trac® Level Sensor Configuration Software to dial in the settings for empty, ¼, ½, ¾, and full.

Both modes support guard band settings. The empty guard band allows the user to set the percent of the fuel left in the tank when the level sensor is to indicate an empty reading. The full guard band allows the user to set the percent of fuel to drop below before the gauge leaves the full indication.

Communication Modes

The Acu-Trac® ultrasonic fluid level sensor in addition to constantly monitoring the fluid level within the tank, monitors the vehicle broadcasts over the J1708 data link. The ultrasonic fluid level sensor uses data from the vehicle broadcasts to calculate a running average for Miles per Gallon (MPG) over the last 16 hours of operation, PTO Fuel Consumed, and Idle Fuel Consumed.

Acu-Trac® NEMA4 ultrasonic fluid level sensors use a J1708 data com link (RS-485 bus) for real time remote data transmissions. The standard TIA/EIA RS-485 serial data bus enables the fluid level sensor(s) to communicate and share data with other modules located on the data link.

The Acu-Trac® ultrasonic fluid level sensor responds to fuel level requests either using a standard J1587 protocol PID 254 on the RS-485 bus or will transfer the data over a remote communication network such as Qualcomm.

There are four user selectable communication modes:

- RS485 Burst Mode generates a Distance Measurement message based on fuel measurements and broadcasts the message twice a second.

- J1708 Burst Mode generates PID 96 Fuel Capacity message based on fuel measurement and broadcasts the message 10 times per second.

- Standard J1708 generates the PID 96 Fuel Capacity message and broadcasts it every 10 seconds.

- Fuel Data Broadcast Mode generates the PID Fuel Capacity message and broadcasts it every 10 seconds.

RS-485 Mode Messaging

The Acu-Trac® ultrasonic fluid level sensor broadcasts and receives commands over the RS-485 bus. The ultrasonic fluid level sensors are able to communicate and share data with other modules on the vehicle bus with Message Transmitter Identifications (MID) ≥ 128.

The ultrasonic fluid level RS-485 Mode messages can be grouped into three basic categories:

- Setup and Programming Commands
- Data Messages - Timed Broadcasts
- Diagnostic Messages.

The Setup and Programming Commands are used to program the ultrasonic fluid level sensor for the tank's particular size, shape and installation.

Up to 10 Acu-Trac® ultrasonic fluid level sensors may be on the same bus.

RS-485 Mode Messaging Continued

Note: Only 1 Acu-Trac® sensor can be programmed at a time. Bus contention will occur as the MID for the Acu-Trac ultrasonic fluid level sensor is always 143.

The Timed Broadcasts conveys measurement data from the ultrasonic fluid level sensor to other modules on the bus.

The Diagnostic Message is reported instead of the Timed Broadcast Message whenever the ultrasonic fluid level sensor has identified an active sensor fault.

Refer to Acu-Trac® Application Notes AT-AN5 for more details on RS-485 Mode Messaging.

Setup and Programming Commands

The Acu-Trac® ultrasonic fluid level sensor can be programmed on a Windows based PC with the Acu-Trac® Level Sensor Configuration Kit.

The following Setup and Programming Commands are used to program the ultrasonic fluid level sensor:

- **Analog Gauge Drive**
    - DAC output voltage at Tank Capacity Limit
    - Capacity Limit

- **Measurement Filter Time Constant**
    - Filter Time Constant (0 to 40 seconds)

- **Tank Capacity (in gallons)**

- **Tank Size, Shape and Measurement Mode**
    - Tank Diameter (Cylindrical) or Depth (Rectangular)
    - Tank Air Gap
    - Tank Width
    - Measurement Operation Mode Selection
        - Analog Output
        - Measurement Modes

Refer to the Acu-Trac® Level Sensor Configuration Tools Software help manual for details on programming.

Data Message – Timed Broadcast

For the RS485 Burst Mode, the ultrasonic fluid level sensor automatically transmits every .5 seconds a Distance Measurement message.

The Distance Measurement Data message containing the following information:

• Percentage of Capacity Value
• Measurement Value
• Sensor Serial Number

All J1708 Modes Messaging

The Acu-Trac® ultrasonic fluid level sensor broadcasts and receives commands over the SAE J1708 data link. The ultrasonic fluid level sensor is able to communicate and share data with other modules on the vehicle bus with Message Transmitter Identifications ≥ 128.

The ultrasonic fluid level sensor J1708 messages can be grouped into 5 basic categories:

• Data Link Escape Messages
• Data Messages – Standard PIDs
• Data Messages – Timed Broadcasts
• Transport Protocol Messages
• Diagnostic Messages

Setup and programming commands are sent in the Data Link Escape Message protocol when using a PC and the Acu-Trac® Level Sensor Configuration Tools Software or in the Transport Protocol messages when sent from the off vehicle communications.

The Data Link Escape (PID 254) Messages are usedbto program parameters (tank's particular size, shape and installation) into the sensor and to provide a simple alternative means to acquiring fuel data over the J1708 data link.

The Data Messages – Standard PID messages convey measurement data from the ultrasonic fluid level sensor to other modules on the bus.

The Timed Broadcasts conveys the PID 96 Fuel Level message from the ultrasonic fluid level sensor to other modules on the bus.

In addition to setup and programming commands, the Transport Protocol Messages (PID 197 and PID 198) are used to report and route fuel data through remote (off vehicle) communications equipment. The Transport Protocol Messages are sent from the ultrasonic fluid level sensor to the Mobile Communication Terminal (MCT).

All J1708 Modes Messaging Continued

The Acu-Trac® ultrasonic fluid level sensor communicates real time data messages via the MCT in the form of Qualcomm Messages (ROTA and FOTA) to off vehicle communication centers. Refer to Figure 2 for a better understanding of data messaging transfers in the Fuel Data Communication System.

Qualcomm Messages (ROTA and FOTA) use non SAE standard binary packet messages enabling the ultrasonic level sensor to communicate via the vehicle MCT over satellite communication channels integrated into the J1708 data link.

The ROTA data message, is a free form data package containing measurement data from the ultrasonic fluid level sensor.

The FOTA Satellite Communications Parameters message contains programming instructions from the off vehicle communication system for the ultrasonic fluid level sensor.

The Diagnostic Message is reported instead of the Timed Broadcast Message or the Data Message whenever the ultrasonic fluid level sensor has identified an active sensor fault.

Refer to Acu-Trac® Application Note AT-AN7 for more details the J1708 Mode Messaging.

Data Link Escape Messages

The Data Link Escape (PID 254) messages are used to program parameters (tank's particular size, shape and installation) into the sensor and to provide a simple alternative means to acquiring fuel data over the J1708 data link.

The following Setup and Programming Commands can be programmed into the Acu-Trac® Level Sensor via a Windows based PC using the Acu-Trac® Level Sensor Configuration kit.

- **Analog Gauge Drive**
    - DAC output voltage at Tank Capacity Limit
    - Tank Capacity Limit
- **Measurement Filter Time Constant**
    - Filter Time Constant (0 to 40 seconds)
- **Tank Capacity (in gallons)**
- **Tank Size, Shape and Measurement Mode**
    - Tank Diameter (Cylindrical) or Tank Depth (Rectangular)
    - Tank Air Gap
    - Tank Width
    - Measurement Operation Mode Selection
        - Analog Output (Voltage; Current Loop; Linear; Non-Linear)
        - Measurement Mode (Linear distance; Cylindrical level; Linear level; Table Lookup)

Refer to the Acu-Trac® Level Sensor Configuration Tools software help manual for details on programming.

Data Message – Standard PIDs

The Acu-Trac® ultrasonic fluid level sensor acquires data off of the J1708 data link, calculates the vehicles average fuel economy over the last 16 hours of operation, calculates the remaining fuel volume and communicates that data along with the fuel tank size on command.

This data is used by Fuel Optimization systems to project the vehicle's fuel needs so as to optimize the route taken, thereby reducing fuel related costs.

The ultrasonic fluid level sensors are able to communicate and share data with other modules on the vehicle bus with Message Transmitter Identifications ≥ 128.

The ultrasonic fluid level sensor uses the following information from these PID messages:

PID Message	Data Used by Acu-Trac®
84	Road Speed
89	Power Take Off
92	Percent Engine Load
194	Diagnostic Status
234	Software PN & Revision Level
243	Make Model & Serial Number
245	Total Vehicle Distance
250	Total Fuel Used

The ultrasonic fluid level sensor generates and transmits a PID 96 Fuel Capacity Data Message to other modules located on the bus.

In the Standard J1708 and J1708 Burst Modes, the ultrasonic fluid level sensor has a MID of 143. In the Fuel Data Broadcast Mode, the ultrasonic fluid level sensor has a MID of 41.

Data Message – Timed Broadcast

In the J1708 Standard Mode and the Fuel Data Broadcast Mode, the sensor automatically transmits the standard PID 96 (Fuel Capacity Data Message) once every 10 seconds.

In the J1708 Burst Mode, the sensor automatically transmits the standard PID 96 message 10 times every second.

The PID 96 message contains the following information:

• Percentage of Capacity Value

Qualcomm Messaging

The ultrasonic fluid sensor is able to communicate this data via the MCT over satellite communication channels integrated into the J1708 data link with off vehicle construction equipment and transportation fleet communication services such as Qualcomm OmniTRACS®. Refer to Figure 2.

Note: The Qualcomm Mobile Communication Terminal (MCT) must be programmed to recognize the existence of the Acu-Trac® ultrasonic fluid level sensor on the J1708 data link.

Return Over the Air (ROTA) Data Message

The MCT interrogates the ultrasonic fluid level sensor over the J1708 data link and then generates and transmits a ROTA Fuel Data Message when requested by a Fuel Command or automatically by certain events.

A Fuel Data message is transmitted for the following:
· Requested by a Fuel Command
· Fuel Added
· Fuel Lost
· Idle Fuel
· PTO Fuel
· Low Fuel Warning

The fuel data message generated by the ultrasonic fluid level sensor will be dependant on the communication option parameters set in the FOTA message. The fuel data messages are described in the Transport Protocol Message section later in this document.

FOTA – Satellite Communication Parameters

The Satellite Communication parameters contained within the Forward Over The Air (FOTA) message sent by the MCT to the ultrasonic fluid level sensor establish which event conditions the sensor should respond to and which fuel data message to generate.

The Satellite Communication parameters are summarized below:
· Satellite Communications Options Parameter
    • Reset
    • Minimize Message
    • Idle Transmit
    • PTO Transmit
    • Lost Transmit
    • Added Transmit
    • Tamper Transmit
    • Low Fuel Transmit
· Fill/Loss Parameter
· Idle/PTO Notification Parameter
· Tamper/Low Fuel Notification Parameter

Transport Protocol Messages

The Acu-Trac® ultrasonic fluid level sensor recognizes and generates non SAE standard binary packet messages.

PID 197 Connection Management Message facilitates off vehicle communications equipment such as Qualcomm OmniTRACS®. PID 197 messages contain Request to Send; Clear to Send; and End of Message.

PID 198 is used to send binary data. There are two forms of binary data sent: Setup and Programming Command Messages and Fuel Data Messages.

PID 198 Setup and programming Messages are used to program the ultrasonic fluid level sensor for the tank's particular size, shape and installation.

Refer to Acu-Trac® Application Notes AT-AN7 for a detailed description of the PID 198 setup and programming messages. A summary follows:

- **Analog Gauge Drive**
    - DAC output voltage at Tank Capacity Limit
    - Tank Capacity Limit

- **Measurement Filter Time Constant**
    - Filter Time Constant (0 to 40 seconds)

- **Tank Capacity (in gallons)**

- **Tank Size, Shape and Measurement Mode**
    - Tank Diameter (Cylindrical) or Tank Depth (Rectangular)
    - Tank Air Gap
    - Tank Width
    - Measurement Operation Mode Selection
        - Analog Output (Voltage; Current Loop; Linear; Non-Linear)
        - Measurement Mode (Linear distance; Cylindrical level; Linear level; Table Lookup)

- **Distance to Empty Data**
    - Distance to Empty
    - Fuel Quantity (in gallons)
    - MPG

- **Fuel Optimization Data**
    - Tank Volume
    - Fuel Quantity (in gallons)
    - MPG

Transport Protocol Messages Continued

- **Idle/PTO/Fill/Loss Data**
    - Cumulative Idle Fuel Consumed
    - Cumulative PTO Fuel Consumed
    - Cumulative Fuel Consumed with no data link
    - Cumulative Fuel Removed from the tank

- **Idle/Satellite Communications Parameters Programming**
    - Satellite Communication Option Parameter
    - Fill/Loss Notification Parameter
    - Idle/PTO Notification Parameter
    - Disabled/Low Fuel Notification Parameter

In addition to setup and programming commands messages, PID 198 protocol is used to transmit Fuel Data Messages.

The following data items are sent in response to the **Fuel Request Command**:
- Fuel Level (in gallons)
- Average MPG over the last 16 hours
- Fuel Tank Capacity (in gallons)
- Idle Fuel
- PTO Fuel
- Tamper Fuel
- Lost Fuel
- Added Fuel
- Transmit Reason
- Fuel Temperature
- Life to Date Total Fuel
- Life to Date Total Distance

The ultrasonic fluid level sensor can be configured to automatically reset the data on a successful transmission of the data. (The MCT must set the reset bit to 1 in the FOTA communication options Parameter.)

The ultrasonic fluid level sensor supports two modes of operation based on the Minimize Message bit in the Communications Parameter word. If the Minimized Message bit is disabled, the ultrasonic fluid level sensor will send out the Fuel Data Message (described above) on each event.

If the minimized message bit is enabled, the ultrasonic fluid level sensor will send the minimized fuel event based message listed below dependant on the controls bits sets in the Communication Options Parameter:

- **Fuel Add Message (Added Transmit Set)**
    - Percent Fuel Quantity Remaining
    - MPG
    - Fuel Added
    - Fuel Added Odometer

Transport Protocol Messages Continued

- **Fuel Loss Message (Lost Transmit Set)**
    - Fuel Loss

- **Idle Tamper Message (Idle Transmit Set)**
    - Idle Fuel Quantity
    - Tamper Fuel Quantity

- **Sensor/ECM Exchange Message (Tamper Transmit Set)**

- **Low Fuel Return Message (Low Fuel Transmit Set)**
    - Percent Fuel Quantity Remaining
    - MPG
    - Fuel Added Odometer

- **PTO Return Message**
    - PTO Fuel Quantity

- **Fuel Data Message**
    - Fuel Quantity Remaining
    - MPG

Diagnostic Message

For all four communication modes, the Acu-Trac® ultrasonic fluid level sensor will perform a diagnostics self test following a reset or during a power up. The sensor checks the following areas:

- Temperature Sensor
- Ultrasonic Sense Element
- Analog Drive (Transducer)
- Non Volatile Memory (NVM)
- NVM Checksum

The Diagnostic Status Message is used to denote a fault status. This message will define whether a fault has occurred, and if so, whether the fault is still active or if it is inactive. The diagnostic status byte is coded as follows:

> No Faults (Code = 0);
> Active Fault(s) (Code = 44);
> Inactive Fault(s) (Code = 98)

An active status means that a fault has been detected and is still active. An inactive status means that a fault was detected but has since been cleared and is no longer present.

Diagnostic Message Continued

For all communication modes, when the Acu-Trac® ultrasonic fluid level detects a fault, the data messages will stop broadcasting the data message and broadcast the PID 194 diagnostic message. The ultrasonic fluid level sensor will continue to check and recheck the fault until the fault clears and becomes inactive.

Once the fault becomes inactive, the sensor will broadcast the diagnostic message code one more time, with an inactive fault code and then resume normal operation. The fault occurrence is retained in NVM and can be retrieved by polling the sensor over the J1708 data link.

Note: The Acu-Trac® Level Sensor Configuration Tools Software uses different fault code values. They are as follows:

> No Faults (Code = 0);
> Active Fault(s) (Code = 1);
> Inactive Fault(s) (Code = 2)
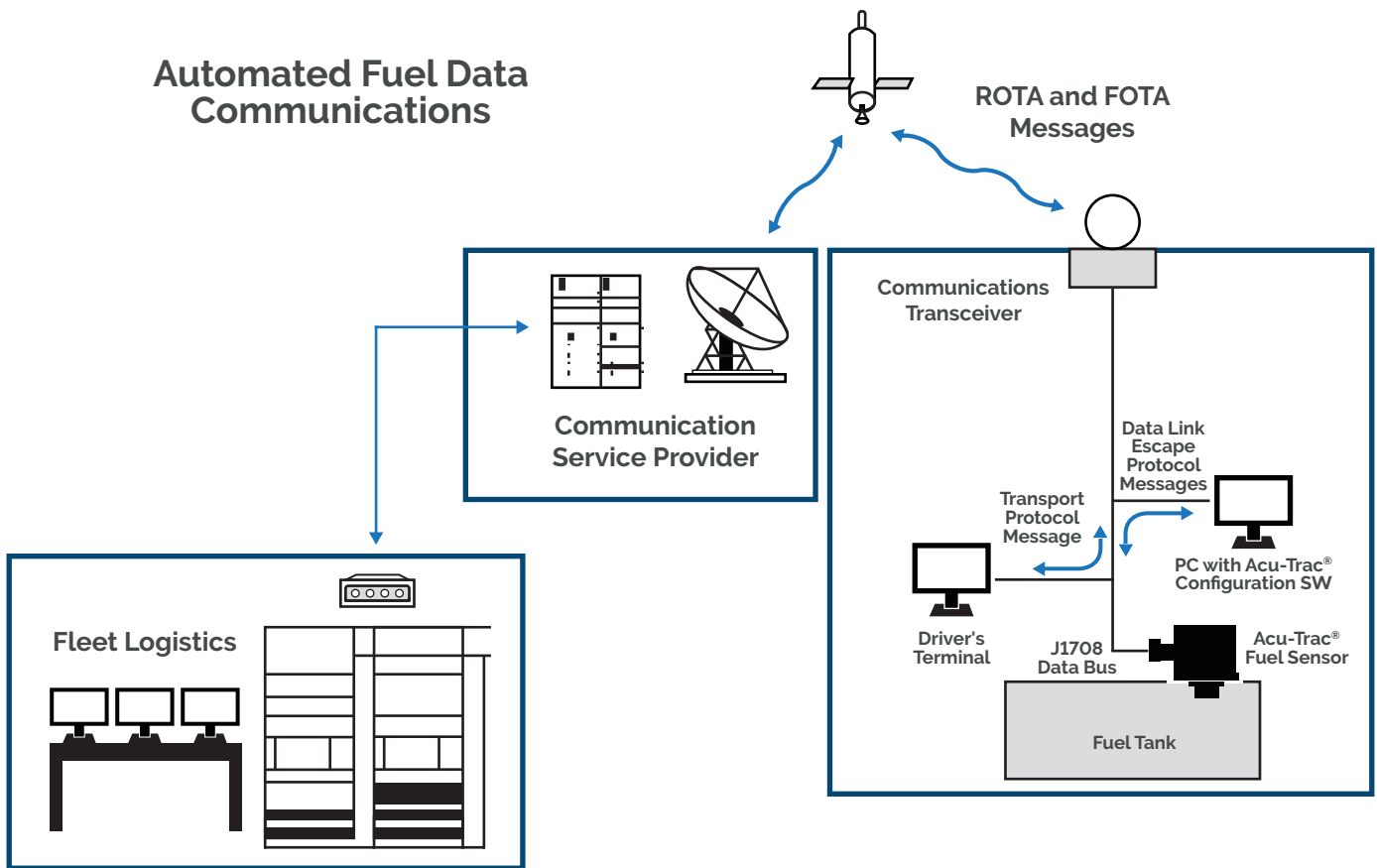
Figure 2: Real Time Communications System

Automated Fuel Data Communications

ROTA and FOTA Messages

Communications Transceiver

Communication Service Provider

Data Link Escape Protocol Messages

Transport Protocol Message

Fleet Logistics

PC with Acu-Trac® Configuration SW

Driver's Terminal

J1708 Data Bus

Acu-Trac® Fuel Sensor

Fuel Tank

Table 1: RS485 Burst Communication Mode Messages Summary

Setup & Programming Messages	**Level Sensor Configuration Software (PC to Sensor)** • Analog Gauge Drive • Measurement Filter Time Constant (0 to 40) • Tank Capacity (in gallons) • Tank Size, Shape and Measurement Mode
Data Message	**Distance Measurement Data:** • Percent of Capacity Value • Measurement Value • Sensor Serial Number
Transmission	Data Message is broadcasted **twice a second** in the RS485 mode
Diagnostic Message	**PID 194 Diagnostic Message:** No Fault (code = 0); Active Fault(s) (code = 44); Inactive Fault(s) (code = 98) **Acu-Trac® Level Sensor Configuration:** No Fault (code = 0); Active Fault(s) (code = 1); Inactive Fault(s) (code = 2)

Table 2: All J1708 Communication Mode Messages Summary

Setup & Programming Messages	**Level Sensor Configuration Software (PC to Sensor)** **Data Link Escape (PID 254) Messages (PC to Sensor)** • Analog Gauge Drive • Measurement Filter Time Constant (0 to 40) • Tank Capacity (in gallons) • Tank Size, Shape and Measurement Mode **FOTA – Satellite Communication Parameter Message (Satellite to ECM)** • Satellite Communications Options Parameter (Reset; Minimize Message; Idle Transmit; PTO Transmit; Lost Transmit; Added Transmit; Tamper Transmit; Low Fuel Transmit) • Fill/Loss Parameter • Idle/PTO Notification Parameter • Tamper/Low Fuel Notification Parameter **Transport Protocol Messages PID 198 (ECM ↔ Sensor)** • Analog Gauge Drive • Measurement Filter Time Constant (0 to 40) • Tank Capacity (in gallons) • Tank Size, Shape and Measurement Mode • Distance to Empty • Fuel Optimization Data • Idle/PTO/Fill/Loss Data • Idle/Satellite Communication Programming Parameters
Data Message	**PID 96 Fuel Capacity Data Message** • Percent of capacity value **Transport Protocol Messages PID 198 (ECM ↔ Sensor)** **ROTA – Fuel Data Message (ECM to Satellite)** This fuel data message is a free form binary message generated by the sensor when requested by the off vehicle communication center via a FOTA message or when driven by a particular event. The message sent is dependant on the communication option parameters settings. (Settings were sent by the off vehicle communication center through FOTA message). In general, these messages will contain one or more of the following data items: • Fuel Level (in gallons) • Average MPG over the last 16 hours • Tank Capacity (in gallons) • Idle Fuel • PTO Fuel • Tamper Fuel • Lost Fuel • Added Fuel • Transmit Reason • Fuel Temperature • Life To Date Total Fuel • Life To Date Total Distance
Transmission	**Fuel Data Message (PID 96) are broadcast:** once every 10 seconds when in either the J1708 Standard or Fuel Data Broadcast modes or 10 times every second when in the J1708 broadcast mode. **Transport Protocol Messages (PID 198)** are sent when requested or driven by an event.
Diagnostic Message	**PID 194 Diagnostic Message:** No Fault (code = 0); Active Fault(s) (code = 44); Inactive Fault(s) (code = 98) **Acu-Trac™ Level Sensor Configuration:** No Fault (code = 0); Active Fault(s) (code = 1); Inactive Fault(s) (code = 2)

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