SSI Technologies - Application Note AT-AN4
Acu-Trac™ Fuel Level Sensor
Product Overview

Product Description

The Acu-Trac™ Fuel Level Sensor is a non-contact sensor that is a direct replacement for level senders on tanks with depths up to ≤ 1.5 meters (59 inches).

The Fuel Level Sensor offers a choice of outputs (analog current loop; ratiometric voltage; or non-ratiometric voltage).

The Fuel Level Sensor has the additional capability of processing real time fuel data and messaging on a J1708 data link for both on vehicle and off vehicle communications.

The Fuel level sensor provides the user flexibility to program for tank configuration, digital filtering, sensor mounting offset, gauge drive output full and empty endpoints and communication mode.

Product Features

- **J1708 Messaging:** 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:

    1) Fuel Purchase Optimization
    2) Low Fuel Warnings to Prevent Running Out of Fuel
    3) Fuel Fraud Detection
    4) Fuel Tax Odometer Support
    5) Fuel Tax Idle Fuel Rebates
    6) Fuel Usage Report containing Tank MPG and Idle Fuel

- **More Accurate:** 2 % of tank volume
- **More Reliable:** Acu-Trac™ Fuel Level Sensor 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™ Fuel Level Sensor mounts to the same opening as the resistive float sender, but does not 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 tank capacity, depth, shape, and orientation.
- **Level or Volumetric Measurements**
- **Gauge Drive Outputs:** User programmable full and empty endpoints.

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- **Chemical compatibility:** Acu-Trac™ Fuel Level Sensor works with a wide variety of media including diesel, motor oil, and 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.
- **NEMA 4 Rating**
- **CE Mark Class B Rating**

Real Time Data Transmission

The Acu-Trac™ Fuel level sensor operates in one of three user selectable J1708 communication modes – Standard J1708; J1708 Burst mode or Fuel Data Broadcast Mode. The Fuel Level Sensor is constantly monitoring the liquid level within the tank and also the vehicle broadcasts over the RS-485 bus. The Fuel Level Sensor uses the 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.

The standard TIA/EIA RS-485 serial data bus enables the Fuel level sensor to communicate and share data in real time with the other modules on the vehicle bus with Message Transmitter Identifications (MID) ≥ 128. The Acu-Trac™ Fuel Level Sensor uses the Fuel Broadcast Communication mode and uses MID 41.

Refer to Acu-Trac™ Application Note AT-AN1 for more details on communication modes and AT-AN7 for more information on on-vehicle data messaging details.

The Acu-Trac™ Fuel level sensor enhances Fuel Optimization with remote construction equipment and trucking fleet communication systems such as Qualcomm. Fuel optimization is the process to route trucks so as to take advantage of local and regional differences in fuel price, taxes and user fees.

Inherit in the fuel optimization system is a necessary form of guard banding to assure that the fuel gauge inaccuracies and the driver biases do not result in a downtime or an extra stop due to lack of fuel. Adding this guard band reduces the truck's driving range. Thus the optimization process is impaired by this loss of range.

The Acu-Trac™ Fuel level sensor solves this problem by delivering improved accuracy and by allowing the fuel optimization software to remotely access current fuel data automatically without dispatch or driver intervention. The Acu-Trac™ Fuel Level Sensor can be programmed to automatically transmit fuel data by any of the following events:

1. Requested by a Fuel Command
2. Fuel Added
3. Fuel Lost
4. Idle Fuel
5. PTO Fuel
6. Low Fuel Warning

This automated process eliminates the driver bias and coupled with the Fuel Level Sensor's improved accuracy, provides an opportunity to reduce the level of the fuel optimization software guard banding required.

Advantages of Fuel Optimization Data

Acu-Trac™ Fuel Level Sensor works in conjunction with Qualcomm OmniTRACS® system, to provide fuel-related data such as fuel level and drive MPG on request. In addition, the Acu-Trac™ Fuel Level Sensor provides real-time notification of fuel adds, fuel losses, idle fuel, idle fuel warnings, and more.

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The Acu-Trac™ Fuel Level Sensor is ideal for use in the following applications:

1) Fuel Purchase Optimization

The Acu-Trac™ Fuel Level Sensor's Add message sends in Fuel Level, Drive MPG, location of each fuel purchase and Odometer at the time of each fuel add. Data from the fuel add message is used by the fuel optimization software to create an optimized route with fueling recommendations.

2) Low Fuel Warnings to Prevent Running Out of Fuel

The Acu-Trac™ Fuel Level Sensor's Low Fuel message is sent out based on a configurable fuel threshold. The message contains the Fuel Level, MPG and Truck Location.

3) Fuel Fraud Detection

The Acu-Trac™ Fuel Level Sensor's Fuel Loss message is sent out based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Lost, Time/Date and Truck Location.

The Acu-Trac™ Fuel Level Sensor's Fuel Add message is sent out based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer and Truck Location.

Data from these messages are used by the fuel optimization software to create a Fuel Purchase Exception Report.

4) Fuel Tax Odometer Support

The Acu-Trac™ Fuel Level Sensor's Fuel Add message is sent out based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer and Truck Location. This data is used for Fuel Tax Odometer support.

5) Fuel Tax Idle Fuel Rebates

The Acu-Trac™ Fuel Level Sensor's Idle/Tamper Fuel message is sent out based on a configurable fuel threshold. The message contains the Idle Fuel Used, Tamper Fuel, Time/Date, Odometer and Truck Location.

6) Fuel Usage Report containing Tank MPG and Idle Fuel

The Acu-Trac™ Fuel Level Sensor's Fuel Add message is sent out based on a configurable fuel threshold. The message contains the Fuel Level, Fuel Added, Time/Date, Odometer, and Truck Location.

All J1708 Modes Messaging

The Acu-Trac™ Fuel Level Sensor broadcasts and receives commands over the SAE J1708 data link. 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 Fuel Level Sensor J1708 messages can be grouped into 5 basic categories:

1. Data Link Escape Messages
2. Data Messages – Standard PIDs
3. Data Messages - Timed Broadcasts
4. Transport Protocol Messages
5. 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 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.

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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).

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 3 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.

Refer to the following Acu-Trac™ Application Notes AT-AN1 and AT-AN7 for more details on J1708 Messages.

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™ Fuel Level Sensor 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.

Electrical Interface

The Acu-Trac™ Fuel Level Sensor is available with a choice of either a 12V or 24V operating voltage.

The output can be either a current loop analog output (4-20mA) or a ratiometric voltage output (0.5 Vdc to 9.5 Vdc) and non-ratiometric voltage output.

A 9600 Baud RS-485 serial data interface is provided for transmission of fuel data to other modules on the bus.

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Electrical Connection Options

Electrical Connection Options Include:

- Integral Packard Electric connector which mates with Packard part number 12146045 and Packard Terminal 12048074.
- 2.5 meter cable with pig tail connections.

Electrical Connections:

- Electrical Ground
- Supply Power
- (B) RS485 Serial Data
- Analog Output
- (A) RS485 Serial Data

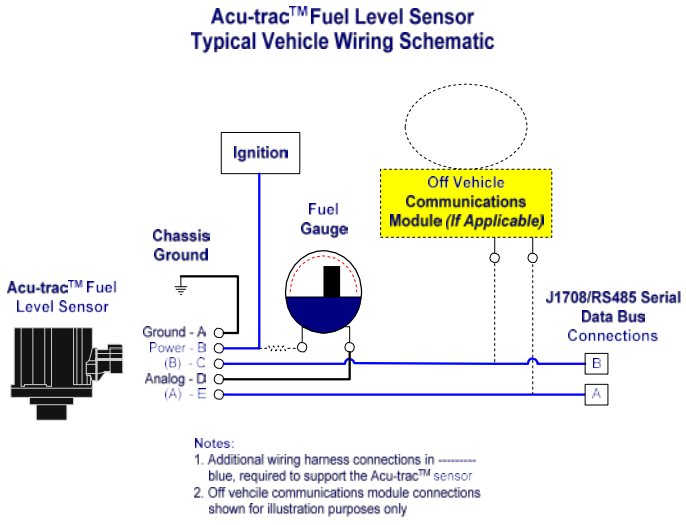

Figure 1 Typical Vehicle Wiring

Mounting

Mechanical package options include:

- Standard SAE 1810 5 Hole bolt pattern Standard Mounting (shown in the Figure 4)
- NPT mount

  ¾" Thread

When mounting, it is important to place the Fuel Level Sensor in the center of the tank parallel to the liquid level and with no obstructions in the beam path to the liquid.

Cone Angle

Acu-Trac™ Fuel Level Sensor mounting that is not perpendicular to the liquid causes a reduction in sensor performance. As shown in Figure 2, the amount of returned sound energy is dependent on mounting cone angle.

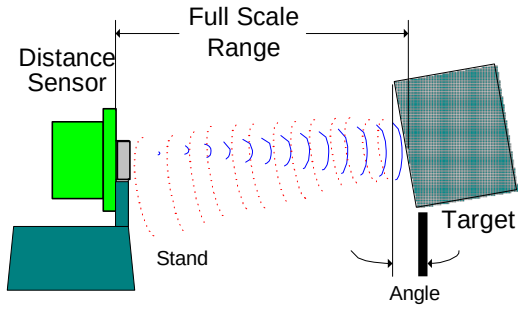

Figure 2 Mounting Considerations.

The Acu-Trac™ Fuel Level Sensor maximum operating range (tank depth) decreases with angle. The maximum cone angle is 6 °.

If the Acu-Trac™ Fuel 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™ Fuel Level Sensor will hold its output voltage

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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™ Fuel Level Sensor can be uniquely configured using a standard Windows™ based PC and the Acu-Trac™ configuration software kit. The kit includes a RS-485 to J1708 converter, Acu-Trac™ 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™ Fuel Level Sensor has the following user programmable features:

1) Digital Filtering Time Constant
2) Tank Configuration
3) Sensor Mounting Offset
4) Gauge Full and Empty Endpoints
5) Communication Mode

Digital Filtering Time Constant

Motion of the liquid media, can impact the performance of a Fuel Level Sensor. Wave motion creates noise in the measured data because the Fuel 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™ Fuel Level Sensor has a user programmable digital filter to reduce error caused by sloshing liquids. 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 Fuel Level Sensor enabling volumetric fuel quantity or depth. The following volume and level proportioning operational modes are available:

1) Linear Level (% of capacity – distance)
2) Cylindrical Level (% of capacity – area)
3) Rectilinear (% of capacity – area)

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.

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Electrical Specifications

Supply Voltage	12V (10-16 V) OR 24V (11-34V)
Output Options	Ratiometric Voltage (12V) (0.5 to 9.5 Vdc) OR Non-Ratiometric Voltage (24V) OR Current (4-20 mA)
Range	Up to 1.5 m (59 inches)
Accuracy	2 % of tank volume
Operating Temp Range	-40 to 85 ° C
Storage Temp Range	-50 to 105 ° C
Output Sink Current	50 mA max

***Note:** Acu-Trac™ Fuel Level Sensors are not intended for use with gasoline.

Tested Conditions

Input Supply Transients	Reverse Battery -2x Volts Over Voltage 2x Volts
Transients	Load Dump 120 Volts ESD 15 KV
EMI	Conducted 25 V/m Radiated 40 V/m Emissions 50DBuV/m max
Mechanical Shock	20 G Shock
Drop Test	1 meter Drop Test
Vibration	4 Grms 12 hrs each axis
Humidity	
Thermal Cycle	400 hrs (-40 to 85°C)
Salt Fog	96 hours
Thermal Shock	6 cycles (-40 to 85°C)
Chemical Compatibility	Diesel Fuel, Motor Oil, urea (ADBLUE), Water, Potable Water, Ethanol, Hydraulic Fluid, Engine Coolant.

Note: Acu-Trac™ is CE (European Conformity) and NEMA 4 (National Electrical Manufacturers Association Accreditation) Certified.

Other Specifications

SAE 5 Bolt Torque	10-15 in/lbs
¾" Threaded Torque	3 ft/lbs
Cone Angle	+/- 6 degrees
Dead Band (Top only)	2 inches (max)

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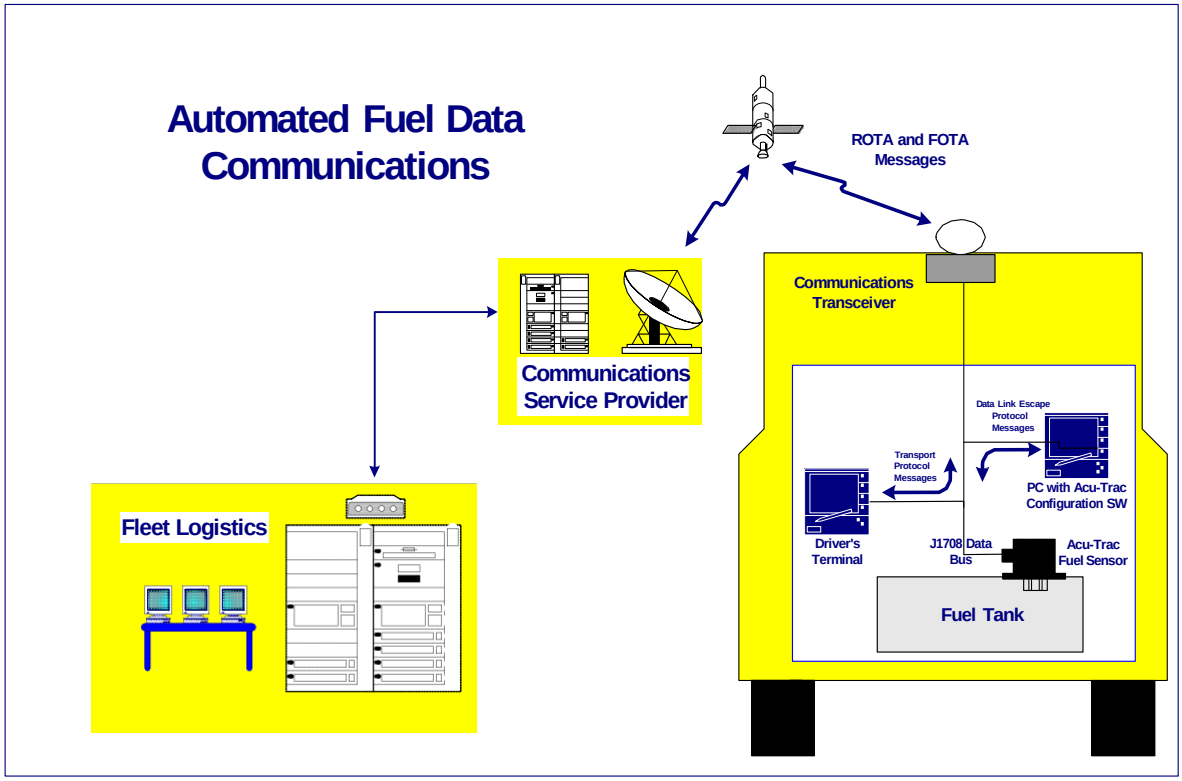
Figure 3 Real Time Communications System



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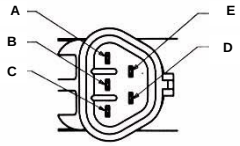
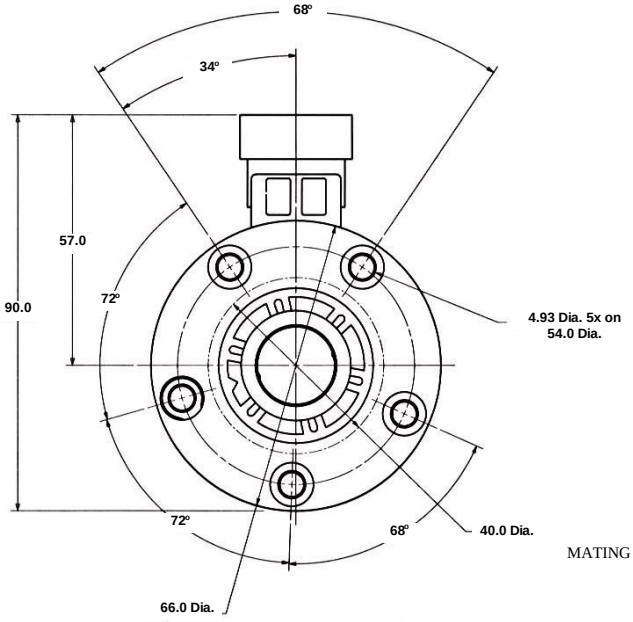
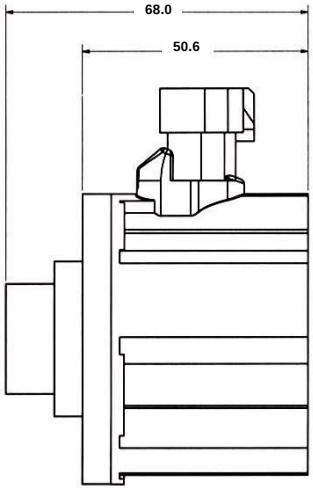
PIN #	NAME	DESCRIPTION
A	GRND	GROUND
B	PWR	SUPPLY VOLTAGE
C	B	RS 485 SERIAL DATA
D	ANALOG	SENSOR ANALOG OUTPUT
E	A	RS 485 SERIAL DATA







MATING CONNECTOR: DELPHI CONNECTOR PART NO. 12146045
(NOT SHOWN) WITH DELPHI TERMINAL PART NO. 12048074

Figure 3 Mounting

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