

# SSI Technologies - Application Note AT-AN2

## Acu-Trac™ NEMA 4 Liquid Level Sensor

### Product Overview

#### Product Description

The Acu-Trac™ NEMA4 liquid level sensor is a non-contact sensor that is a direct replacement for level senders on tanks with depths up to  $\leq 1.5$  meters (59 inches).

The NEMA4 liquid level sensor offers a choice of outputs (analog current loop; ratiometric voltage; or non-ratiometric voltage).

The NEMA4's RS-485 bus allows real time processing of fuel data and messaging over the RS-485 bus

The RS-485 bus also provides the user flexibility to program the NEMA4 sensor for tank configuration, digital filtering, sensor mounting offset, gauge drive output full and empty endpoints and communication mode.



#### Product Features

- **More Accurate:** 2 % of tank volume
- **More Reliable:** Acu-Trac™ NEMA4 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™ NEMA4 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 strapping tables for unique tank shapes.
- **Chemical compatibility:** Acu-Trac™ NEMA4 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 on vehicle communication.
- **RS-485 Messaging:** Three types of messages are provided on the RS-485 bus – setup and programming commands, timed data broadcast message, and diagnostic messages.
- **NEMA 4 Rating**
- **CE Mark Class B Rating**

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#### 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™ NEMA4 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™ NEMA4 liquid 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 ratiometric voltage output (0.5 Vdc to 9.5 Vdc) or 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.

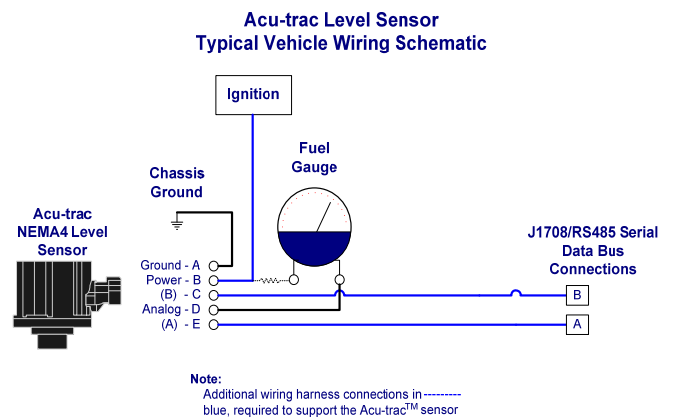
#### Electrical Connection Options

Electrical Connection Options Include:

- Integral Packard Electric connector which mates with Packard part number 12148045 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 Acu-Trac™ NEMA 4 Wiring**

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#### Mounting

Mechanical package options include:

- Standard SAE 1810 5 Hole bolt pattern Standard Mounting (shown in the Figure 3)
- NPT mount  
     $\frac{3}{4}$ " Thread

When mounting, it is important to place the NEMA4 liquid 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™ NEMA4 liquid 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.

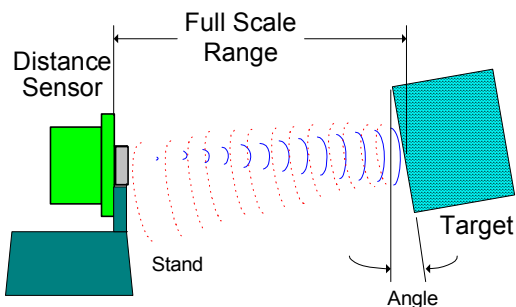


Figure 2

#### Mounting Considerations

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

If the Acu-Trac™ NEMA4 liquid 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™ NEMA4 liquid 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™ NEMA4 liquid 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™ NEMA4 liquid 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 liquid level sensor. Wave motion creates noise in the measured data because the liquid 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™ NEMA4 liquid 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.

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### Product Overview

#### Tank Configuration

The tank's capacity, depth, shape and orientation can be programmed into the liquid 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,  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , 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.

#### Real Time Data Transmission

The Acu-Trac™ NEMA4 liquid level sensor operates in a RS-485 Burst Communication Mode and uses MID 143. 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 liquid level sensor is constantly monitoring the liquid level within the tank and also the vehicle broadcasts over the RS-485 bus.

The standard TIA/EIA RS-485 serial data bus enables the NEMA4 sensor to communicate and share data in real time with the other modules on the vehicle bus with Message Transmitter Identifications (MID)  $\geq 128$ .

The NEMA4 liquid level sensor has three types of messages:

- 1) Setup and Programming Commands
- 2) Timed Broadcast Data Message
- 3) Diagnostic Message

The Setup and Programming Commands are used to program the NEMA4 liquid level sensor for the tank's particular size, shape and installation.

The Timed Broadcast Data Message transmits measurement data from the NEMA4 liquid level sensor to the other modules on the RS-485 bus twice a second.

The Diagnostic Message is reported instead of the Timed Broadcast Data Message whenever the NEMA4 liquid level sensor has identified an active sensor fault during its power up tests.

Refer to the Acu-Trac™ Application Note AT-AN1 and AT-AN5 for a detailed description of the RS-485 burst communication mode and messages.



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## Acu-Trac™ NEMA 4 Liquid Level Sensor

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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 volume
Operating Temp Range	-40 to 85 ° C
Storage Temp Range	-50 to 105 ° C
Output Sink Current	50 mA max

**\*Note:** Acu-Trac™ liquid 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 NEMA4 (National Electrical Manufacturers Association Accreditation) Certified.

#### Other Specifications

SAE 5 Bolt Torque	10-15 in/lbs
3/4" Threaded Torque	3 ft/lbs
Cone Angle	+/- 6 degrees
Dead Band (Top only)	2 inches (max)

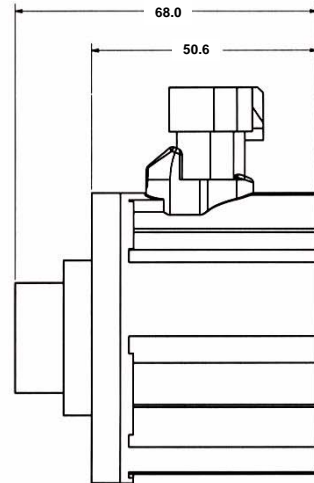
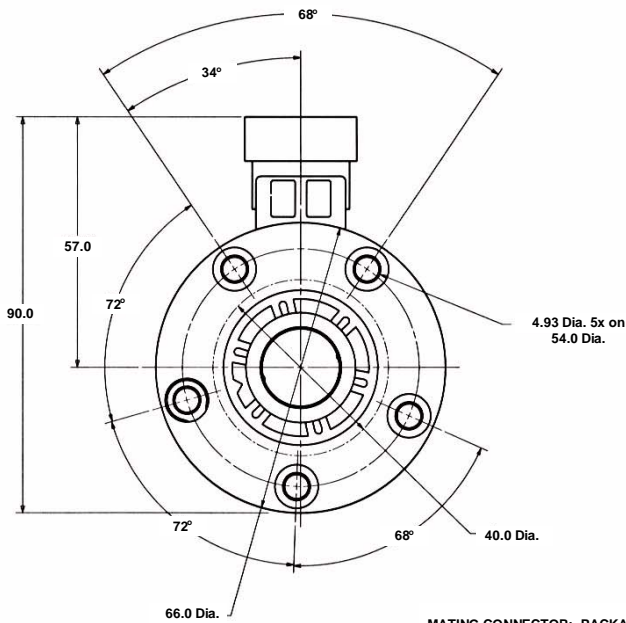
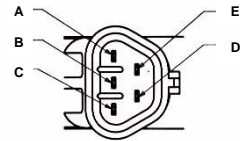


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PIN #	NAME	DESCRIPTION
A	GRND	GROUND
B	PWR	SUPPLY VOLTAGE
C	B	RS 485 SERIAL DATA
D	ANALOG	SENSOR ANALOG OUTPUT
E	A	RS 485 SERIAL DATA



MATING CONNECTOR: PACKARD ELECTRIC CONNECTOR PART NO. 12148045 (NOT SHOWN)  
WITH PACKARD ELECTRIC TERMINAL PART NO. 12048074

Figure 3 Mounting