SSI Technologies – TULC Application Note

Temperature Ultrasonic Level and Concentration Sensor
## for Urea, Diesel Exhaust Fluid (DEF), AdBlue Tanks

UREA (DEF and Adblue) Tank Applications

Governments around the world are creating legislation to control and reduce the amount of pollutants that can be released into the environment especially from the burning of fossil fuels.

Starting in January 2010, Diesel Exhaust Fluid (DEF) tanks became standard equipment for most new diesel trucks, buses, sport utility vehicles and automobiles in the U.S. Tractors, bulldozers, and other non-road vehicles will follow to meet the new EPA standards.

Running without DEF or with contaminated DEF, results in an engine exceeding the permitted emission levels and the vehicle operator subject to fines. The DEF level in the tank is usually monitored by a level sensor that interfaces with some form of On Board Diagnostics (OBD) system. The OBD system usually supports warning actions (low DEF level light and de-rating of engine performance) and emission limit enforcement actions (engine shutdown or blocking engine restart after shutdown).

SSI's Temperature Ultrasonic Level and Concentration Sensor (TULC) is an optimal choice for DEF tank applications. Temperature indication is provided to allow the Dosing Control Unit (DCU) to thaw the DEF tank in cold conditions. Level is provided as driver information and to allow the DCU to induce the driver to add DEF. Concentration is provided to guarantee the liquid in the tank is the proper concentration of DEF.
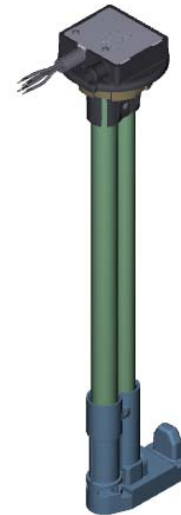
Temperature Ultrasonic Level and Concentration Sensor

TULC Sensor Basic Operation

The TULC sensor provides temperature, level, and concentration measurements via the J1939 CAN bus. The temperature measurement is performed using a thermistor contained in the sensor housing located at the bottom of the tank. The level measurement uses ultrasonic technology to generate a high frequency sound wave and measure the time for the echo to reflect off the DEF's surface and return. The distance from the liquid level sensor to the DEF is calculated based on the speed of sound in DEF. The measured distance is converted into a percentage of tank volume based on a strapping table programmed inside the sensor.
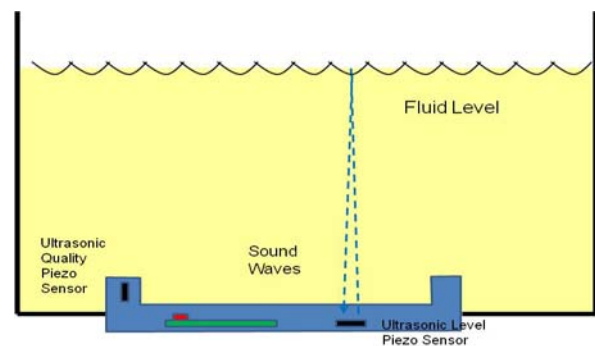
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CE ISO 9001 CERTIFIED QUALITY MANAGEMENT SYSTEM RoHS

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The concentration measurement is based on measuring the speed of sound in the liquid. The speed of sound is measured by generating an ultrasonic signal and bouncing it off a fixed reference distance Speed of Sound = Time divided by twice the distance.
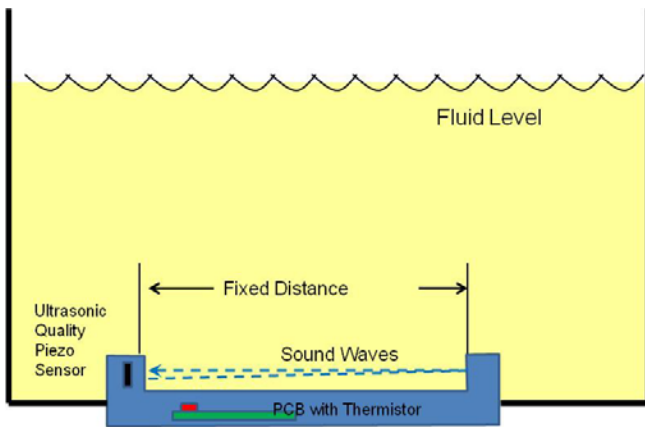
As shown in the graph below, speed of sound can be used to identify both the concentration percentage and common automotive fluids.
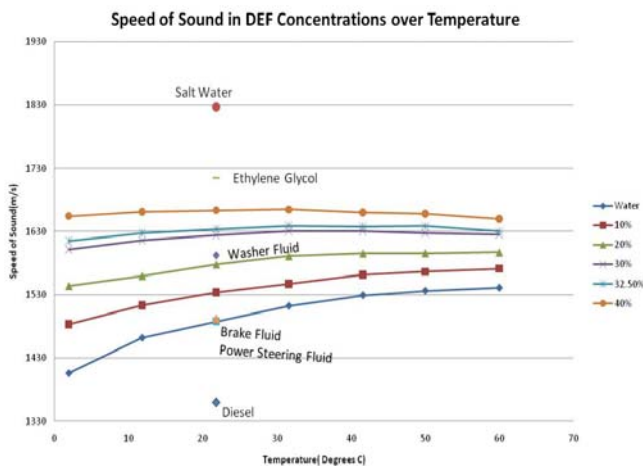
Summary of TULC Sensor Advantages

- Concentration sensor works with real world environmental factors such as aged urea, tank debris, bubbles, moving fluid, etc.

- Concentration sensor detects diesel and indicates common automotive fluids as out of range.

- High accuracy level sensor to meet Euro IV OBD C consumption monitoring requirements.

- Sensor contains OBD checks of concentration sensor, level sensor, and temperature sensor.

- Sensor supports CAN bus datalink anti-tampering requirements CAL ID and CVN.

- Redundant notification of a completely empty tank (both level and concentration sensor).

- Level measurement unaffected by fluid properties.

- Digital filtering eliminates errors in level reading due to DEF sloshing due to vehicle motion.

- Tank Profiling: Factory programmable strapping tables for volumetric tank profiling.

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Concentration Sensor Specifications

Measurement range	0% to 50% (DEF saturates above 50%)
Operating Temperature	-11°C to 70°C (works when in liquid state)
Sensing Resolution	0.25%
Sensing Accuracy	+/- 3% concentration percentage
Response Time	Less than 30 seconds.
Concentration Output	J1939 PGN 64923 SPN 3516 (byte 2)
Concentration FMI	J1939 PGN 64923 SPN 3520 (byte 5)
Reagent Type	J1939 PGN 64923 SPN 3521 (byte 6)

Level Sensor Specifications

Measurement range	20 mm to 850 mm from sensor face at the bottom of the tank.
Operating Temperature	-11°C to 85°C (works when in liquid state)
Angle Performance	+/- 15 Degrees (Increased angle performance configurations available)
Sensing Resolution	0.4% over full scale
Response Time	Less than 240 seconds.
Sensing Accuracy	+/- 5 mm
Level Output	% Tank Volume per J1939 PGN 65110 SPN 1761 (byte 1) Fluid Level in mm per J1939 PGN 65110 SPN 3517 (byte 3)
Level FMI	J1939 PGN 65110 SPN 3532 (byte 5)

Temperature Sensor Specifications

Operating Temperature	-40°C to 85°C
Sensing Resolution	1°C
Sensing Accuracy	+/- 3°C
Response Time	Less than 60 seconds
Temperature Output	J1939 PGN 65110 SPN 3031 (byte 2) J1939 PGN 64923 SPN 3515 (byte 1)
Temperature FMI	J1939 PGN 65110 SPN 4365 (byte 6) J1939 PGN 64923 SPN 3519 (byte 4)

Other Specifications

Input Supply	8-32 Volts Switched Power
Power Consumption	70 mA nominal.
Wiring Harness	Up to 1 meter pigtail per J1939-15 Deutsch DT04-4P Pin-Out: Cavity 1 = green, CAN 1939 – Cavity 2 = yellow, CAN 1939 + Cavity 3 = black, ground Cavity 4 = red, ignition
Input Supply Transients	Reverse Battery -36 Volts +/- 600 Volt Transients
Transients	Load Dump 120 Volts, ESD 15 KV thru air
EMI	100 V/m
Storage	-50°C to 95°C
Aged Urea Compatibility	12 days in Aged Urea at 60°C
Chemical Compatibility	Gasoline, Diesel Fuel, Motor Oil, Water, Ethanol, Hydraulic Fluid, Engine Coolant

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J1939 Interface

The TULC product is SAE J1939 compliant. It uses a fault tolerant TJA 1040 transceiver chip to interface to the bus. The TULC does not include a bus terminating resistor. The data rate is 250 kbits/seconds. The TULC uses source address 0xA3.

The TULC product is re-programmable over the J1939 bus and using proprietary PGNs to perform the programming.

CAN Database follows:

PGN	18FD9BA3H
Name	Concentration
Units	%
Scale Factor	0.25
Offset	0
Start Bit	8
Bit Length	8
Minimum	0
Maximum	63.75
OBD Sensor Failure Detected	Output set to 0xFE (63.5 scaled).
No Echo Condition	Output set to 0xFB (62.75 scaled). No echo conditions occur when the sensor is dry (empty tank), covered with debris, or frozen.

PGN	18FD9BA3H
Name	Concentration Failure Mode Indicator
Units	Enumerated
Scale Factor	1
Offset	0
Start Bit	32
Bit Length	8
Minimum	0
Maximum	255
Values	3 = OBD Sensing Element Failed Open. 11= OBD Internal Failure. 31=Device Functioning Properly

PGN	18FD9BA3H
Name	Temperature
Units	Degrees C
Scale Factor	1
Offset	-40
Start Bit	0
Bit Length	8
Minimum	-40
Maximum	215
OBD Sensing Element Failed Open/Short	Output set to 0xFE (214 scaled).

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PGN	18FD9BA3H
Name	Temperature FMI
Units	Enumerated
Scale Factor	1
Offset	0
Start Bit	24
Bit Length	8
Minimum	0
Maximum	255
Values	3 = OBD Sensing Element failed open. 4 = OBD Sensing Element failed shorted. 31=Device Functioning Properly

PGN	18FD9BA3H
Name	Reagent Type
Units	Enumerated
Scale Factor	1
Offset	0
Start Bit	40
Bit Length	8
Minimum	0
Maximum	255
Values	0=Concentration is greater than 36%. 1=Concentration is less than 29%. 2=Diesel 3=Mixture is between 29% and 36%. 13=Fluid reading is out of range 14=No readings available.

PGN	18FE56A3H
Name	Level
Units	%
Scale Factor	0.4
Offset	0
Start Bit	0
Bit Length	8
Minimum	0
Maximum	102
OBD Sensor Failure Detected	Output set to 0xFE (101.6 scaled).
No Echo Condition	Output set to 0xFB (100.4 scaled). No echo conditions occur when the sensor is dry (empty tank), covered with debris, or frozen.

PGN	18FE56A3H
Name	Level 2
Units	Mm
Scale Factor	0.1
Offset	0
Start Bit	16
Bit Length	16
Minimum	0
Maximum	6425.5
OBD Sensor Failure Detected	Output set to 0xFE00 (6502.4 scaled).
No Echo Condition	Output set to 0xFB00 (6425.6 scaled). No echo conditions occur when the sensor is dry (empty tank), covered with debris, or frozen.

SSI Technologies, Inc.

SSI Technologies – TULC Application Note
Temperature Ultrasonic Level and Concentration Sensor
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PGN	18FE56A3H
Name	Level FMI
Units	Enumerated
Scale Factor	1
Offset	0
Start Bit	32
Bit Length	8
Minimum	0
Maximum	255
Values	3 = OBD Sensing Element Failed Open. 11= OBD Internal Failure. 31=Device Functioning Properly

PGN	18FE56A3H
Name	Temperature FMI
Units	Enumerated
Scale Factor	1
Offset	0
Start Bit	40
Bit Length	8
Minimum	0
Maximum	255
Values	3 = OBD Sensing Element failed open. 4 = OBD Sensing Element failed shorted. 31=Device Functioning Properly

PGN	18FE56A3H
Name	Temperature
Units	Degrees C
Scale Factor	1
Offset	-40
Start Bit	8
Bit Length	8
Minimum	-40
Maximum	215
OBD Sensing Element Failed	Output set to 0xFE(214 scaled)

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