ADBLUE QUALITY CONTROL USING ULTRASONIC SENSOR

A PROJECT REPORT

Submitted by

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of

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BONAFIDE CERTIFICATE

Certified that this project report **"ADBLUE QUALITY CONTROL USING ULTRA SONIC SENSOR"** is the bonafide work of **LAKSHMANAN. R [13BEC081]** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr.Lakshmanan R. IV B.E (Electronics and Communication Engineering)** student from Kumaraguru College of Technology has undergone his project work at Pricol Limited.

Department	:Pricol Advanced Engineering.
Project	:Quality Control of AdBlue Solutions.
Guide	:Mr.Suresh Mariappan.
Period	:December 01, 2016 to April 06, 2017.
Performance	:Good

We wish him all success in his future endeavors.

For Pricol Limited,

K.Sampathkumar

Senior Manager – HR

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ABSTRACT

Europe Union has established certain rules in order to reduce the contribution of vehicle engines to the Nitrogen Oxide (NOx) in air. SCR (Selective Catalytic Reduction) is one of the methods adopted by the vehicle manufacturers to meet the Europe union rules. It reduces NOx emissions using ADBLUE in the exhaust flow. ADBLUE is an aqueous solution made with 32.5% pure urea and 67.5% de-ionized water. In order to be sure that systems are not compromised, it is essential to control the **ADBLUE quality** in the tank. This work demonstrates that it's possible to determine the quality of ADBLUE depending on the Urea. And also it explains importance of ADBLUE solution and how it is used in Automobile Industry.

ABBREVIATIONS

DEF	Diesel Exhaust Fluid
MSP	Mixed Signal Processing
TDC	Time to Digital Converter
MCU	Micro Controller Unit
SPI	Serial Peripheral Interface
JTAG	Joint Test Action Group
NTC	Negative Temperature Coefficient
UART	Universal synchronous receiver transmitter
RTD	Resistive Temperature Detection
SCR	Selective Catalyst Reduction
LCD	Liquid Crystal Display
ADC	Analog to Digital convertor
AFE	Analog Front End
QC	Quality Control
QA	Quality Assurance
PTC	Positive Temperature Coefficient

1. INTRODUCTION

Scientific researches demonstrate that NOx emissions contribute to the formation of fine particles and ozone smog that cost billions annually causes illnesses, deaths and environmental problems. The **Selective Catalytic Reduction** (SCR) is one of the most used techniques for meeting the emission standards. It consists on converting the nitrogen oxides into nitrogen and water in the presence of ADBLUE. The **Quality** of **ADBLUE** should be controlled against the adulteration and dilution of Urea with other substances. Detection of ADBLUE quality is crucial for scientific research as it's an aqueous solution scalable for adulteration especially with water. Many works were done in order to detect the quality of ADBLUE which are based on the ultrasonic, acoustic resonance, optical refractometry and near Infrared technologies. But using ultrasonic is one of the best method. It was shown that the speed of ultrasonic varies if the urea's ratio varies. Using **Ultrasonic** is a powerful technique which can be used to characterize liquids by measuring the time and speed in the solution. Also **Temperature** of a ADBLUE is determined by a thermistor. So this is a suitable method for concentration monitoring.

2. HARDWARE DESCRIPTION

2.1 SIMPLE BLOCK DIAGRAM :

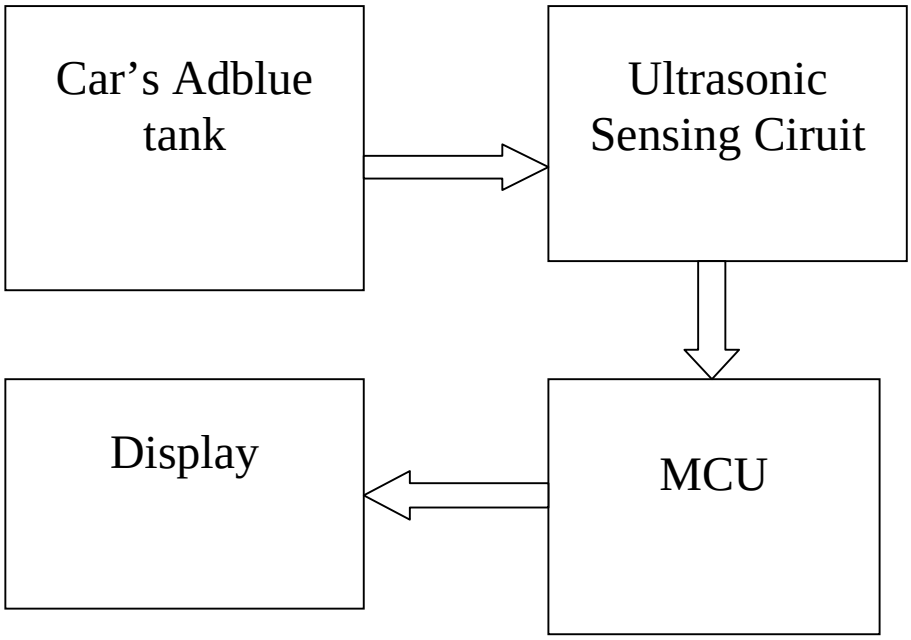

Figure 2.1 Block diagram

2.2 Functional block diagram :

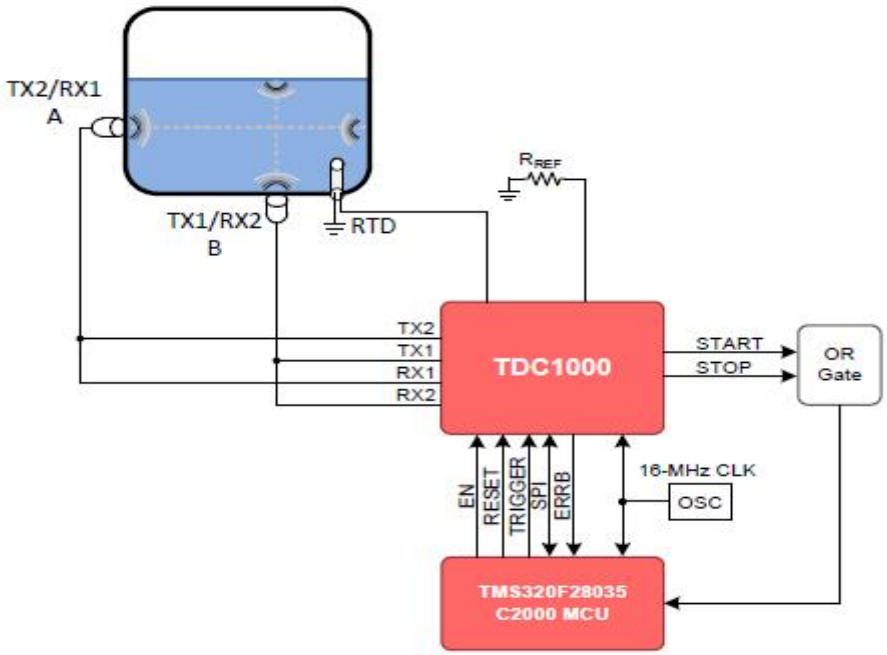

Figure 2.2 Functional Block Diagram

2.3 Component interface :

The interfaces between components and functional blocks has given below. There are numerous parallel and series connections used here and also Serial and Parallel inputs outputs takes a major role in this schematic diagram. Also usage of registers plays a major role here. The last main thing is Clock circuit and its synchronization with other components and blocks.

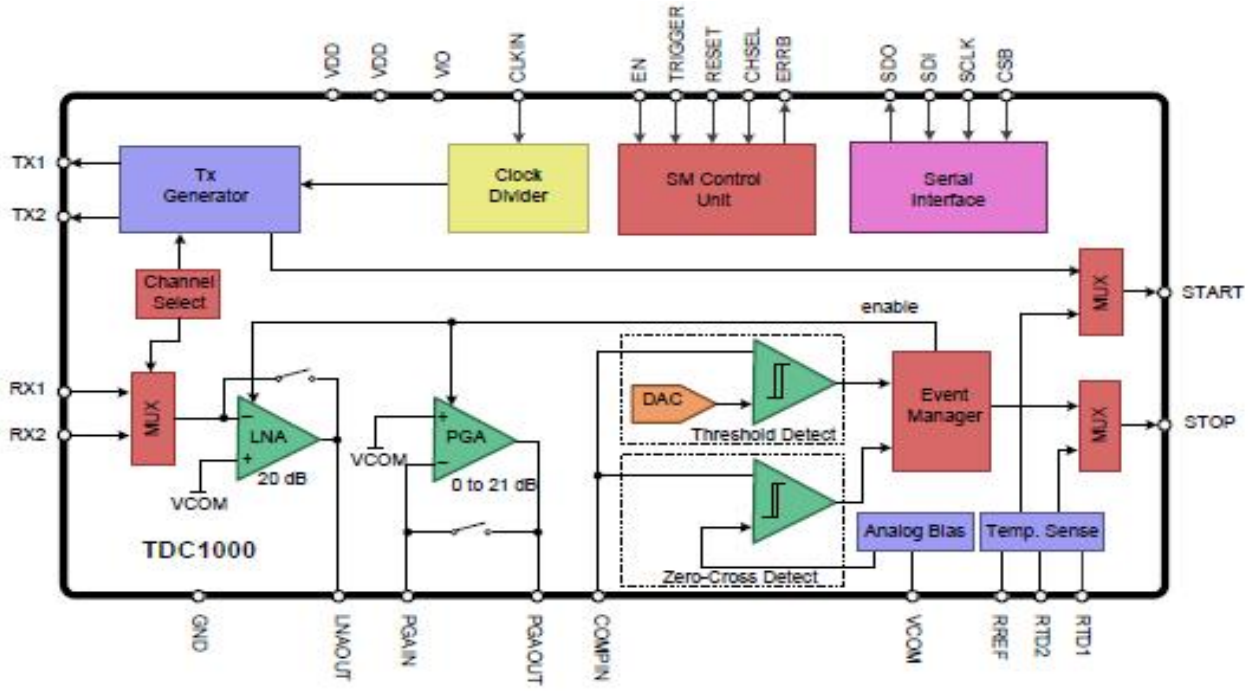

Figure 2.3 Component Interface

2.4 HARDWARE MODULES REQUIRED

The list of components, it's part numbers and manufacturers are listed and given below (shown in table 2.1)

Table 2.1 Hardware modules required

S.NO	COMPONENT	PART NO	MANUFACTURER
1.	Thermistor	NTCLE100E3	VISHAY BC COMPONENTS
2.	ANALOG FRONT END	TDC1000	TEXAS INSTRUMENTS
3.	MCU	MSP430F5528	TEXAS INSTRUMENTS
4.	16 *2 LCD display	LM16200SYBCLY	LAMPEX
5.	USB type B mini	-	TEXAS INSTRUMENTS

From the table we can conclude that most of the components are manufactured by Texas Instruments. The Evaluation Module is specially manufactured by that is Texas Instruments(monopoly).

2.5.1 TDC1000 PIN DIAGRAM :

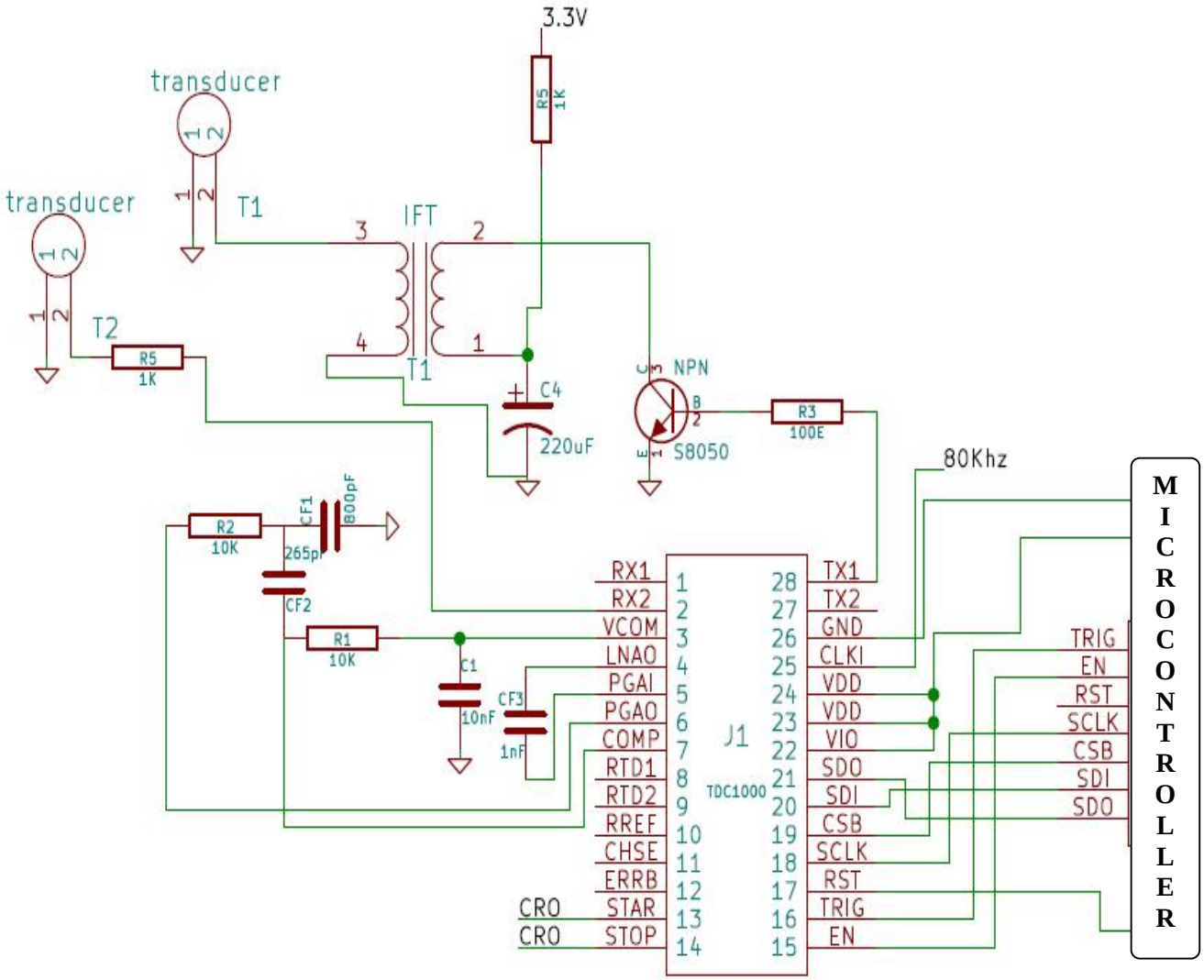

Figure 2.4 TDC1000 PIN DIAGRAM

2.5.2 MSP430F5528 PIN DIAGRAM :

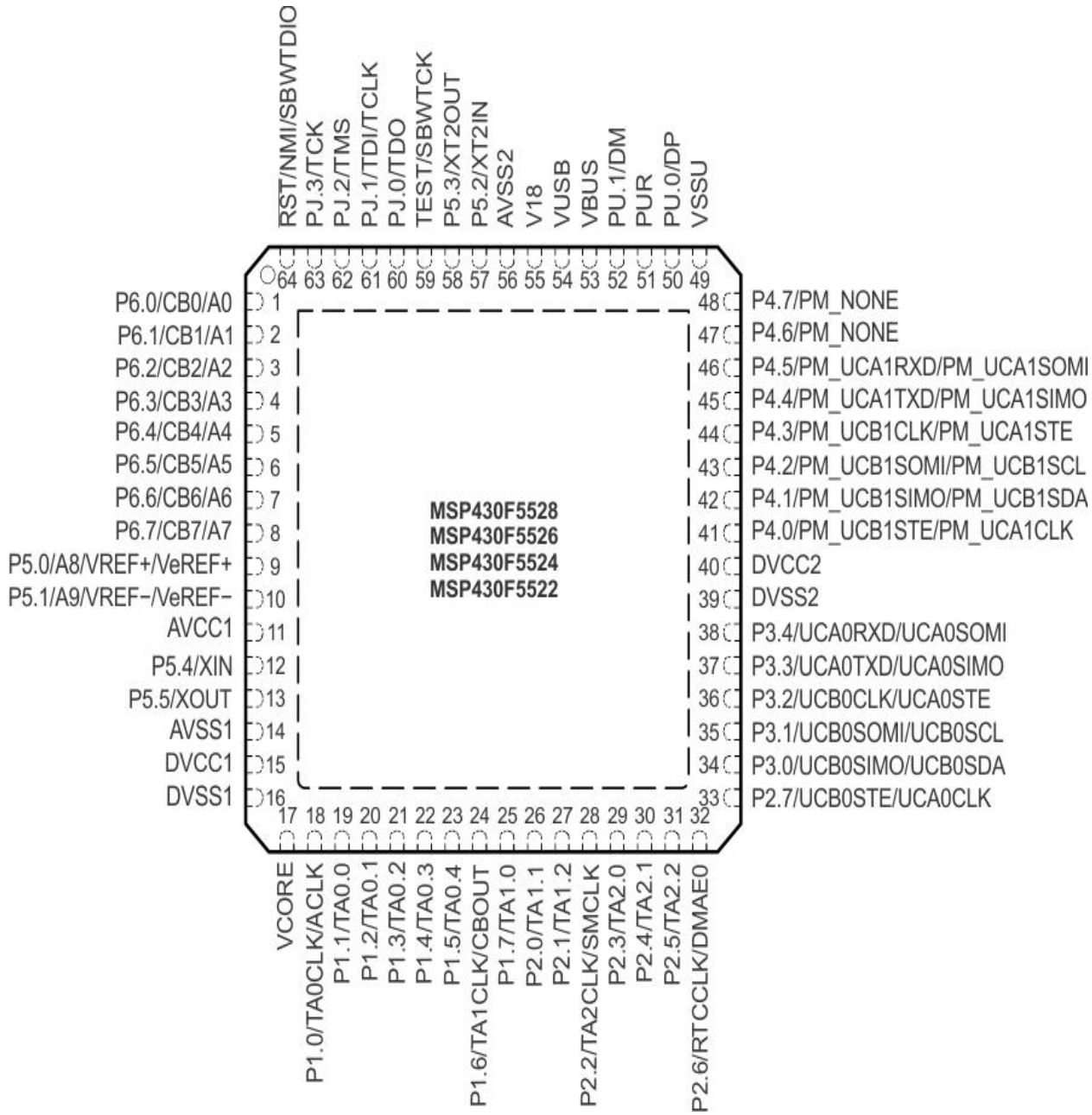

Figure 2.5 MSP430F5528 PIN DIAGRAM

2.6 TDC1000-TDC7200 EVM

The TDC1000-TDC7200EVM is an evaluation module (EVM) that allows users to evaluate the operation and performance of the TDC1000 ultrasonic analog-front-end with TDC7200 time-to-digital converter. The board can be used for many time-of-flight applications such as gas, water, and heat flow meter, fluid level detection, concentration and fluid identification, and proximity or distance measurements. The EVM allows for two ultrasonic transducer connections, and two RTD connections for temperature measurements. It uses the on-board MSP430F5528 to process data and a user-friendly GUI interface to display the data.

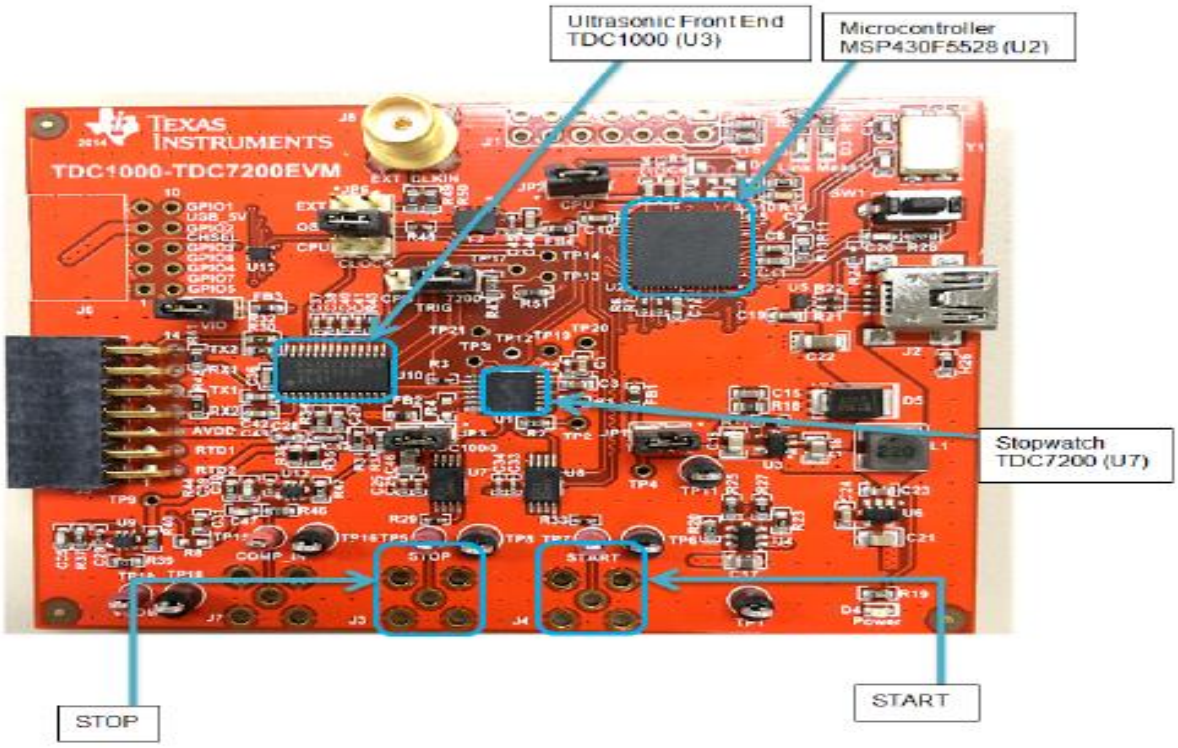

Figure 2.6 TDC1000-TDC7200 EVM

2.7 ULTRASONIC TRANSDUCER

Part Number: SMD15T21R111WL

Piezo Electric Ceramic Disc Transducer. Both electrodes on one side (R configuration). Thickness mode vibration.This product is compatible with Texas Instruments **TDC1000-TDC7200 EVM** which is a fully integrated analog front-end (AFE) for ultrasonic sensing measurements of level, fluid identification/ concentration, flow, and proximity/ distance applications common in automotive, industrial, medical, and consumer markets. When paired with an MSP430/C2000 MCU, power, wireless, and source code, TI provides the complete ultrasonic sensing solution

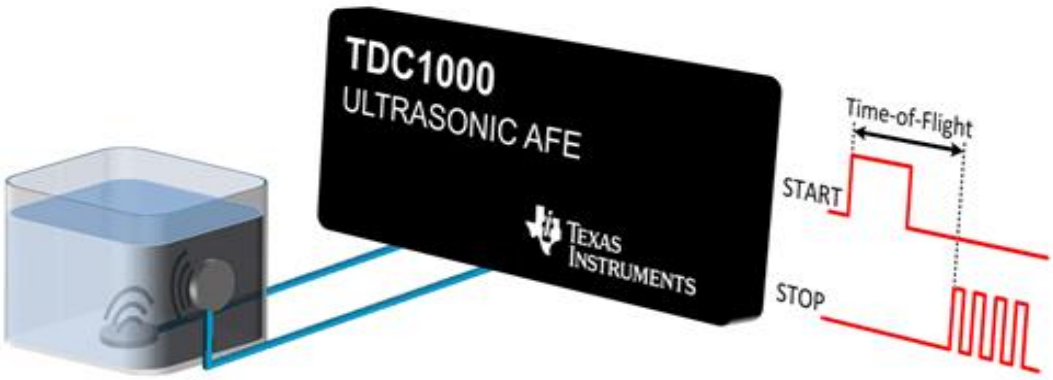

Figure 2.7 Ultrasonic Sensor mounted Adblue tank

3. EXPERIMENTAL DESCRIPTION

3.1 CONCENTRATION MEASUREMENT

The Ultrasonic sensor provides conncentration measurements via Time-of-flight principle as per diagram 3.1. The **temperature** measurement is performed using a NTC type **thermistor** contained in the sensor housing located at the bottom of the tank. The quality measurement uses ultrasonic technology to generate a high frequency sound wave and measure the time for the echo to reflect off the urea's surface and return. The distance from the sensor to the urea is calculated based on the speed of sound in urea. The measured distance is converted into a quality percentage of urea tank volume based on a strapping table programmed inside the sensor.

The concentration measurement is mainly based on measuring the speed of Ultrasonic sound in the liquid. The speed of sound is measured by generating an ultrasonic signal and bouncing it off a fixed **reference distance.** The characteristics and specifications are shown in table 3.1

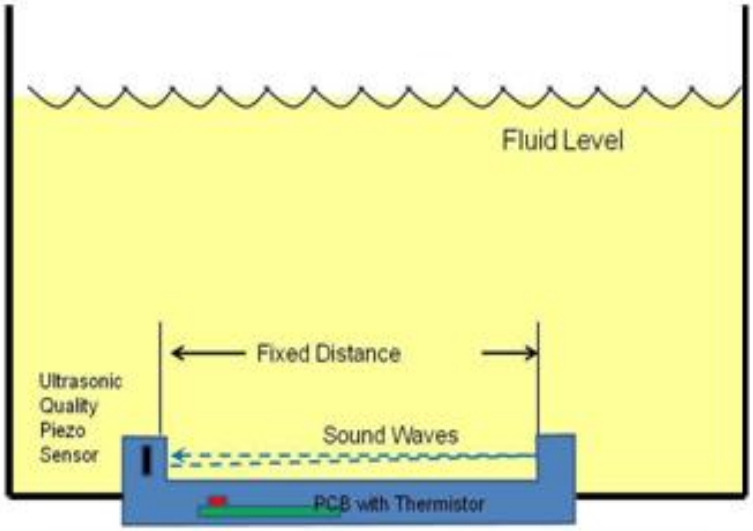

Figure 3.1 Concentration Measurement

3.2 FORMULA :

The actual speed of an object is calculated by following formula.

Speed = 2* Distance / time

From that we can derive the Distance formula. The calculated formula is given below. The constant 2 is used because of the wave not only transmitted but also received.

Distance = Speed * time /2

3.3 TEMPERATURE MEASUREMENT

In this experiment we are using thermistor to measure Temperature of a ADBLUE solution as per figure 3.2. We can use either RTD or NTC type thermistor. The efficiency of a RTD is higher than NTC type thermistor. The part number of the thermistor is **SMD15T21R111WL.** It has some characteristics and specifications as shown in table 3.2 The resistance of a thermistor varies with variance in environment temperature.

This part includes a reference resistor to help to find temperature of a ADBLUE. Reference resistor is a constant value and will not vary with variance in temperature. So whenever temperature changes thermistor will compare its resistance with reference resistor and find the accurate temperature value. Then by using ADC temperature value is converted to digital value and then transferred to user display for indication

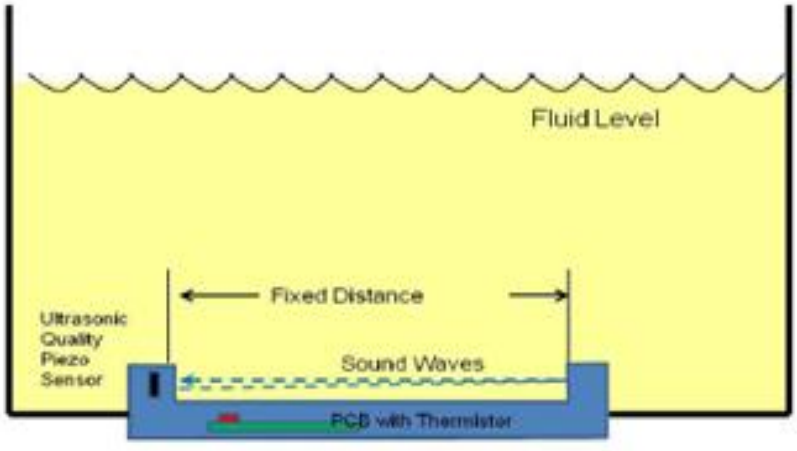

Figure 3.2 Temperature Measurement

3.4 .1 CONCENTRATION SENSOR SPECIFICATIONS

Table 3.1 Concentration sensor

Measurement range	0% to 40% (urea saturates above 40%)
Operating Temperature	-5°C to 70°C(works when in liquid state)
Sensing Resolution	0.25% over full scale
Sensing Accuracy	+/- 3% concentration percentage
Response Time	Less than 5 seconds.

3.4.2 TEMPERATURE SENSOR SPECIFICATIONS

Table 3.2 Temperature sensor

Operating Temperature	-40°C to 85°C
Sensing Resolution	1°C
Sensing Accuracy	+/- 3°C
Response Time	Less than 5 minutes

4. FEATURES

- Immediate notification that the tank has been completely filled with diesel.
- Immediate notification of greater than 10% dilution with water.
- OBD check of the concentration sensor using the level sensor on a completely full tank.
- OBD check of the level sensor using the concentration sensor on an empty tank.
- Redundant notification of a completely empty tank (both level and concentration sensor).
- Level measurement unaffected by fluid properties (capacitive sensors are impacted by dielectric constant shifts).
- Concentration sensor unaffected by fluid motion or temperature.

- Level sensor accuracy of +/- 3 mm. (Reed switch sensor accuracy is physically limited by the number of reed switches that can be placed within the tube. Typical reed sensors have a resolution of about 22 mm).

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

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

5. RESULTS

1. This is a diagram indicating ADBLUE range in the tank through the Dashboard.

Figure 5.1 ADBLUE indication

2.ADBLUE graphic indication through the dashboard

Figure 5.2 ADBLUE indication

3.ADBLUE indication to user about to refill the solution in case of minimum level.

Figure 5.3 ADBLUE indication

6. CONCLUSION

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

Temperature sensor Ultrasonic Concentration Sensor is an optimal choice for Urea tank applications. Temperature indication is provided to allow the Dosing Control Unit(DCU) to thaw the urea tank in cold conditions. Quality is provided as driver information and to allow the DCU to induce the driver to add / remove urea. Concentration is provided to guarantee the liquid in the tank is the proper concentration of urea.

7. REFERENCES

1. Datasheet of **TDC1000 - TDC7200EVM** by Texas Instruments.
2. Datasheet of **TDC1000 Analog Front End** by Texas Instruments.
3. **DEF** concentration measurement and its applications by Vishay.