# A MICROPROCESSOR CONTROLLED LEVEL GAUGE FOR USE IN PETROL ROAD TANKERS

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## INTRODUCTION

This paper discusses the design of a microprocessor controlled level gauge for use in the storage tanks of petrol road tankers. The sensor is based on an original concept used by Marconi for measuring the electrolyte level in batteries. This basic design was refined and improved upon by Sira and Drum Instrumentation Ltd with long term research being carried out by the City University. The device is now in full scale scale production by Drum Instrumentation Ltd and is marketed under the name of "DRUM-STIC". It is intended as a direct replacement for the more conventional wooden dipsticks that are still widely used in the UK for the measurement of liquid level.

## MEASURING PRINCIPLE

The sensor is a tuned electromechanical resonant device that is made by means of attaching pairs of piezo electric crystals to the orthogonal axes of an extruded aluminium rod. One piezo of each pair is used to vibrate the rod in a given axis, and the other acts as a receiver. A phase locked loop circuit is used to hold the electromechanical circuit onto the resonant frequency. In addition to the information obtained from the two pairs of piezo's, the rod also has two sensors at each end which measure the temperatures of the fuel and the air above the fuel. A separate densitometer is also used as part of the sensor system. In all 5 transduced signals are available, two level signals, two temperature signals and the density information.

When the rod is vibrated the resonant frequency depends upon a number of factors. In particular the temperature profile along the length of the rod (as determined by the two temperature sensors), and the mass of fuel that is in direct contact with the vibrating rod. A mathematical model has been developed that determines the true level of fuel in the tank from the measured variables. This level data is then converted into a volume by means of a tank shape calibration table.

## THE ROLE OF THE MICROPROCESSOR

A 6805 based microcomputer is housed in the head of each level transducer, and it is responsible for carrying out a number of functions. It is reasonable to argue that this measurement system could not have been developed without the use of a microprocessor, because even though the necessary computations could have been achieved on any reasonable computer, it would not have been possible to package the necessary processing power into the level gauge itself.

The raw measurands are three frequency signals and two analogues. Being a digital device the microprocessor is well suited to monitoring pulsed inputs and measuring their frequencies to an accuracy that is determined by it's real time clock. In addition to this straight forward function the microprocessor is also used to improve the integrity of the measured signals. The main problem with a resonant circuit is that it can vibrate in a number of different harmonic modes. The desired mode of operation, and therefore the

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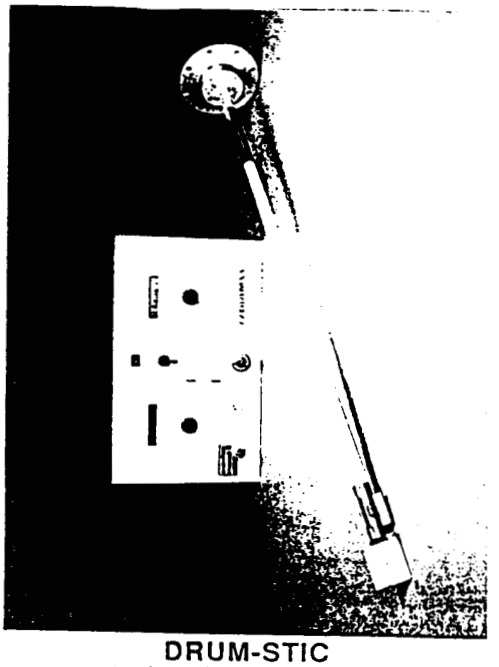
frequency range is well known. The microprocessor therefore as well as reading the frequencies also ensures that they are within range. If they go out of range, either due to loosing lock, or going into the wrong harmonic mode, the processor takes over control of the phase lock loop circuitry and pulls the device back into the correct operating range. What with pumps switching off and on, foot valves operating and just by being accidentally kicked, the level gauge has to put up with a lot of mechanical interference and noise. This self checking and self correcting function is therefore essential for the reliable operation of the sensor.

The microprocessor reads the the analogue inputs via an ADC. In order to reduce the cost of manufacture non linear temperature devices are used, however this is no problem to a microprocessor as it is able to scale, offset and linearise any unusual sensor as long as the transfer function can be reasonable expressed. The relationship between density and the frequency input signal is usually in the form of a quadratic, and the microprocessor again has little problem in linearising this raw data .

The fuel level is derived by means of a complex mathematical function of the five measurands (the two rod vibration frequencies, the fuel and air temperatures and the fuel density). This calculation is easily carried out by the resident microcomputer. Each level gauge is also fitted with a calibration table that contains the details of the shape of the fuel tank, this information is used to convert the level information into a fuel volume reading which can then be transmitted to a central display or computer. The facility to add a calibration table means that the basic level gauge assembly can be mass produced, and then configured for a specific tank simply by the addition of a calibration PROM.

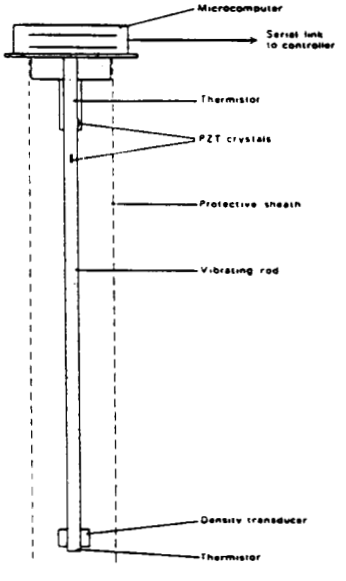
The final task of the microcomputer is to format all the input and output data into a data package which is transmitted via a serial line to a remote computer. This is usually a purpose designed display and control unit unit that is mounted on the side of the road tanker.



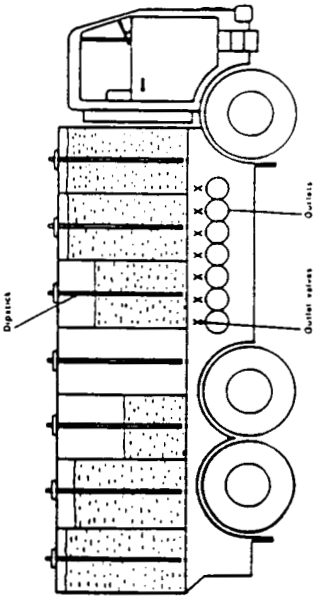
**DRUM-STIC**
petrol tanker level sensor

*Traditional, now obsolete method of measurement.*

Traditional dip stick




Principle of operation




Complete tanker installation