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Transducers with the improved anti-interference ability for automated ship's systems

SUMMARY

The paper discusses the problem of improving the anti-interference ability of transducers applicable to automated ship's systems , especially to those of marine engine room. A variety of detection methods and types of sensors for some physical quantities is presented and illustrated by examples. Mechanisms of interference penetration into measuring circuits of automatic control loops and main reasons of disturbing factors generation under ship's conditions are shortly pointed out. Some methods and technical means to eliminate them, such as a choice of appropriate measurement method, a way of signal processing and also constructional and technological solutions are discussed. Special attention is paid to integrated and smart sensors and their application in ship's hostile environment. Finally, some conditions concerning the use of such transducers in microcomputer monitoring systems are formulated.

INTRODUCTION

Modern ship considered as a control object consists of three basic, usually automated, systems [1]: navigation, power engineering and cargo system. Among them the power engineering system, dealing mainly with marine engine room, plays a decisive role in correct and reliable operation of navigation and cargo systems, it means that it is of a fundamental importance for safe and effective functioning of the ship. Nowadays automated marine engine room (AMER) is a standard generally accepted in ship technology. To automatically control a power engineering system it is necessary to currently determine operation parameters of main engine and electric generator drives (speed, torque,power e.t.c.), characteristic parameters (fuel quality, exhaust gas content e.t.c.), as well as parameters which decide on working conditions of main engine and its piping systems, mainly expressed by temperature, level of liquids and flow quantity in characteristic points of the systems.

To perform the measurements transducers are usually applied in automatic control loops, being the parts of automated systems. All the transducers are characterized by an approximately fixed relationship between a current output signal and a measured quantity. Moreover, a galvanic seperation between the controlled network or device and the output signal of 4...20 mA standard current value is usually required.

The marine engine room environment is difficult and hostile for measurements due to many interfering factors e.g. mechanical vibrations induced by the main engine, non-periodical sea wave shocks, electromagnetic fields generated by many electric devices inside metallic ship's hull as well as environment factors due to weather and ship's route changes.

To cope with those difficulties some selected measuring techniques and protective means are usually used. However the most important is an appropriate choice of :

- measurement method and/or signal processing and
- design solutions.

The following parameters are usually taken among others into consideration: temperature, pressure, liquid level, flow quantity, oil mist density, viscosity and speed. All of them are measured and processed by means of transducers. This paper is mainly focused on temperature, pressure and level measurement as an important criterion and also as a decisive factor of the safe and reliable exploitation of the marine engine room.

TEMPERATURE MEASUREMENTS

Temperature is the main parameter to be measured in AMER. Many kinds of thermometers could be used such as resistor, thermocouple, thermistor and integrated temperature sensor. A popular kind is the Pt100 thermometer, stipulated by IPTS68 (amended in 1975) as a standard thermometer for the range of 13,81 K...630,74 °C, with high accuracy and good repeatability. The output quantity of the Pt100 is resistance variable which could be directly transferred over a long distance or changed into current quantity before being transmitted.

Resistance Variable Processing

Two problems appear in resistance transmission:

- lead impedance error and
- common mode interference

To solve them the arrangments shown in Fig.1. can be used.

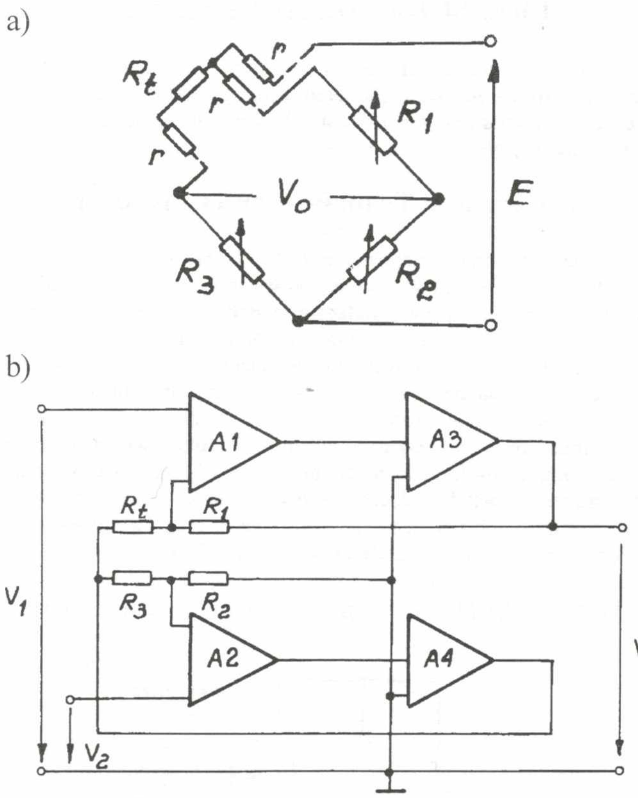

Fig.1. Diagrams of the arrangements used in solving the resistance transmission problems:(a) Three-wire Wheatstone Bridge, (b) Dynamic Bridge Amplifier

The first problem could be improved by adopting three-wire thermometer and Wheatstone bridge detection circuit. From Fig. 1(a) where r is the lead impedance, the following relation can be got:

$$V_0 = E\left(\frac{R_t + r}{R_3 + R_t + r} - \frac{R_1 + r}{R_2 + R_1 + r}\right) \qquad (1)$$

As $R_2 = R_3$ the V_o ,caused by the lead impedance, can be reduced to zero by adjusting $R_1 = R_t$.

As far as common mode interference is concerned close attention should be paid to those measurement points which are far away from the monitoring device. Complex ground current may cause a common mode signal value as high as several Volt to several ten Volt.

A remedy is the use of isolation shielding technique [2]. The signal source and conditioning amplifiers are individually shielded against floating so that the input common mode current could be restrained only a little. Some IC devices of double floating protection with optoelectronic technique applied [3] show a higher performance and flexibility.

Another metod is that of non-isolation kind. The dynamic bridge amplifier circuit belongs to it. The operational amplifiers shown in Fig. 1(b) have a high input impedance, high linear gain and high CMRR. The circuit's CMRR is proportional to the closed loop gain K which can easily reach 120 dB. The whole circuit does not require high precision resistors.

Temperature-to-current converter

A better transmission form is current quantity, which is of high interference rejection ability, no lead error, and suitable for multiple display and collection.

The current converters are adopted in some important temperature measurement points such those in the entrance of lubricant oil and fresh water pipe lines of the main engine.

Normally such a converter is based on the three-wire bridge detection circuit, which ensures high sensitivity and lower error proneness if only is it balanced. But if so, the current I_{Rt} passing through RTD (Pt100) will be higher and produce electro-thermal effect bringing a new error.

The I_{Rt} is suggested to be less than 6 mA in high accuracy applications in order to limit the error caused by thermal effect to a value of less than 0,1 °C. For that reason a new current converter shown in Fig. 2 was investigated in the AMER laboratory [4].

Operational amplifier is of the constant current output, therefore the current in RTD is irrelative to the temperature measured, but the V_{01} value varies in linear proportion to the change in the RTD. The operational amplifier A2 is a zero adjusting circuit. The resistance R_w is used to adjust the V_{03} output value up to 10 V when the measured temperature is just 100 °C. A4 and A5 elements are adjusted to output signal in 4...20 mA mode.

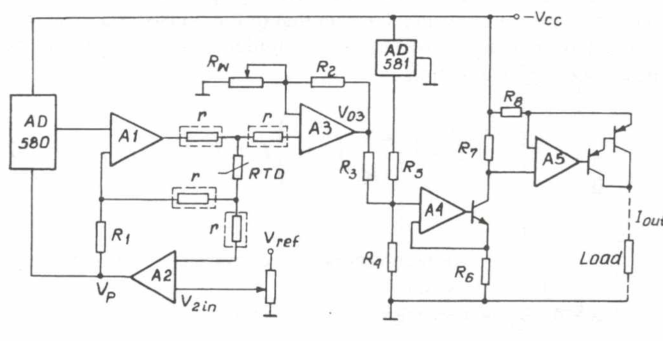

Fig.2. Temperature-to-Current Converter diagram

The input impedance of the operational amplifier is high enough to cause the input current dropping to zero. So even long wires do not affect results of the temperature measurement.

By adjusting R_w resistance to make V_{2in} = $-I R_{t0}$ the following relationship is obtained:

$$V_{03} = \left[\left(R_3 / R_2 + 1\right)I\right]\Delta R \qquad (2)$$

It proves that V_{03} is directly in linear proportion to ΔR. The operational amplifier A4 is a supercircuit for V_{03} and the criterion voltage signals are sent from AD581.

If suitable values of precise resistors are selected, the following condition: I_{out} = (1,6 V_{03} +4) mA can be satisfied.

It yields at 0 °C: V_{03} is 0, thus I_{out} is 4 mA; but at 100 °C: V_{03} is 10 V thus I_{out} is 20 mA.

In this circuit, the OP-07 element is used as an amplifier, but AD 580L element as the criterion voltage source. The converter's accuracy of 0,5% is achievable in the laboratory test conditions.

Integrated temperature sensors

Semiconductor devices are very sensitive to temperature changes; it makes construction of integrated temperature converters which generate voltage or current output signal with a value proportional to the absolute temperature (PTAT) possible [5]. A general equation determining the temperature coefficient of p-n junction forward voltage can be expressed as follows [5]:

$$TCU_F = \frac{dU_F}{dT}\bigg|_{I_{F=const}} = -\left[\frac{(1205mV) - U_F}{T} + \left(0.26mV/^oC\right)\right] \qquad (3)$$

In an active area transistor, collector current is related to base-emitter voltage by a simple exponential dependence:

$$I_C = I_{EO}\exp\left(U_{BE}/U_T\right) \qquad (4)$$

For two identical transistors T_1 and T_2 , it can be obtained:

$$\Delta U_{BE} = U_{BE1} - U_{BE2} = U_T \ln\frac{I_1}{I_2} = \frac{kT}{q}\ln\frac{I_1}{I_2} \qquad (5)$$

If it is arranged that current ratio I_1/I_2 is constant, then ΔU_{BE} is directly proportional to the absolute temperature. Dependence of ΔU_{BE} of the transistor pair on temperature is the operation basis of the majority of integrated temperature sensors.

Moreover, for two-pin sensors 10 mV/°C sensitivity is easily achievable. Maximum temperature error of these sensors does not exceed 1 °C in the entire measurement range of -55...+150 °C for LM 135A sensor and -40...+100 °C for LM 335A sensor version [5].

Another PTAT version is the integrated temperature sensor with current output signal proportional to the absolute temperature, described by the equation (6) and illustrated in Fig.3.

Assuming all transistors identical, except of the T3 transistor with the active area A_3 greater than that of the transistor T_4, A_4, the current output signal of the sensor under consideration can be described by the equation :

$$I = \left(\frac{2k}{qR_1} \ln w \right) T = CT \qquad (6)$$

where:

C - temperature-current conversion coefficient, [A/°C]

$w = A_3/A_4$ - transistor active area ratio

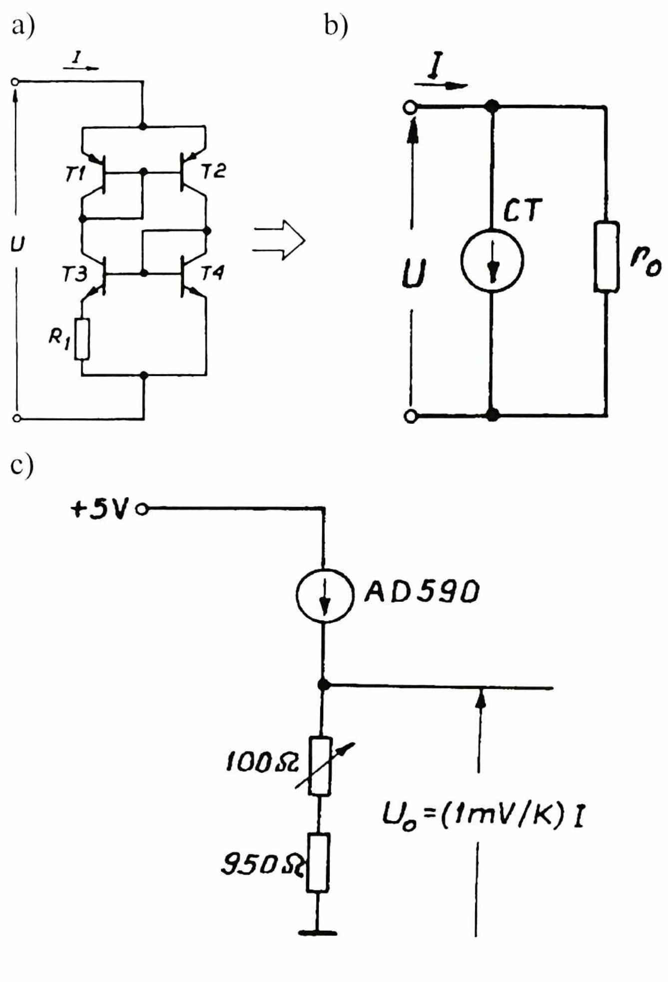

Fig.3. Two-pin integrated temperature sensor with current output signal proportional to absolute temperature:
a) basic diagram,
b) equivalent diagram for $U>2U_{BE} \approx 1,7$ V, r_o - dynamic resistance,
c) example of application

Two-pin integrated temperature sensor, generating current proportional to absolute temperature, with construction similar to that presented in Fig.3, is accessible as AD 590 integrated circuit of Analog Devices[5]. Applying this solution (Fig. 3c) with AD 590K integrated circuit used to construct temperature transducers, +0,5°C measurement accuracy within the measurement range of -55...150°C is very easy to achieve.

PRESSURE MEASUREMENTS

The pressure measurement range in AMER is very wide, normally from 0 to 100 MPa. Traditional pressure meters usually are of a low accuracy, even the standard pressure gauge is only of the accuracy within 0,16%...0,4%.

Differential Transformer Transducer

The differential transformer transducers are often used in remote monitoring. A kind of the solution, shown in Fig. 4, is fitted with the Bulden tube as a primary detector which transforms the liquid pressure, measured at various points, to the displacement quanitity x. The linear transformer converts the displacement into electric signal by the electro-magnetic coupling, without any mechnical contact. The secondary winding forms a single ring which is shifted up when rising pressure. In consequence the mutual inductance M_1 between the ring and L1winding increases, meanwhile M_2 inductance between the ring and L2 winding decreases. As the Bulden tube is of a better linearity in small displacement range the signal output from the inductive bridge can be easily expressed as follows:

$$\Delta u_o(t) = \Delta M(x) di_2 / dt = 2k' x \omega I_2 \cos(\omega t + \varphi) \qquad (7)$$

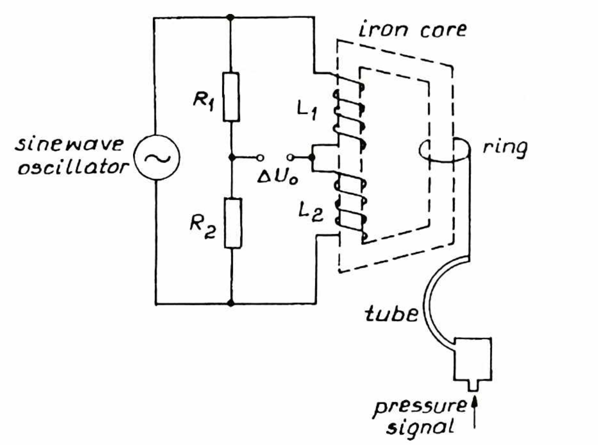

Fig. 4. SMP-2LB Pressure Transducer

The output signal passing through a phase sensitive rectifier and amplifier stage is converted into DC current signal with 4...20 mA standard value.

Strain Transducer

This transducer is based on the linear relationship of strain gauge resistance and the strain exerted onto the gauge. With very simple structure, it has good resolution, high response frequency, and is able to work in an abominable environment. The NBS of USA had calibrated it with standard weight in local comparison test, it proved that the strain gauge sensor accuracy can be very high, according to the NBS tests. It is expected to become the standard dynamic pressure gauge.

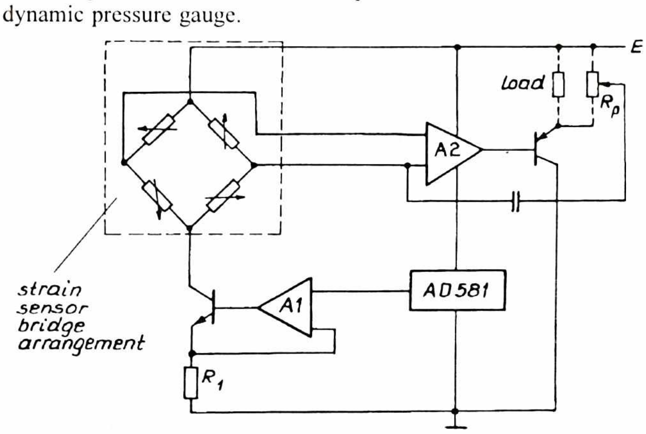

Fig. 5. Strain - Pressure Converter

The working temperature range of a general use strain sensor is within -20°C...100°C. If made of special materials it can work in the range of -100°C...270°C or 800°C...1000°C.

The cylinder combustion pressure sensor of the GT22 type (made by Autronica AS, Norway) can work in high temperature (300°C) and high pressure (200 bar) conditions with natural air cooling applied.A detection circuit for strain and pressure sensors is also the Wheatstone bridge shown in Fig. 5. Its resistance is very low, thus the bridge is still in balance even in a large dynamic signal range. So the converter linearity is much better than that of the RTD detection circuit. Normally the bridge circuit is supported by a constant current source to eliminate the temperature influence on strain and pressure sensors [5], [6].

Integrated pressure sensors

Two basic types of silicon pressure sensors are applied. The first, most popular type, is based on piezoresistive effect, i.e. an influence of mechanical strain on electric resistance. In the second , a main integrated sensor version, a flat capacitor is applied, one of the electrodes of which is a thin membrane. A distance between the membrane and the second electrode is dependent on pressure and therefore capacity measurement can be used for pressure determination.

Piezoresistive pressure sensors are characterized by their sensitivity, expressed as resistivity change related to mechanical distortion. For strain equal to 10^{-6}cm/cm, the resistivity changes (and also the resistance changes) amount to 125 ppm (0,0125%) for the n type silicon , and 175 ppm (0,0175%) for the p type silicon .

LX05 and LX06 devices type (made by Sensym, Inc.) are shown in Fig. 6 [5] as an example of the silicon piezoresistive integrated pressure sensors (see Fig. 5).

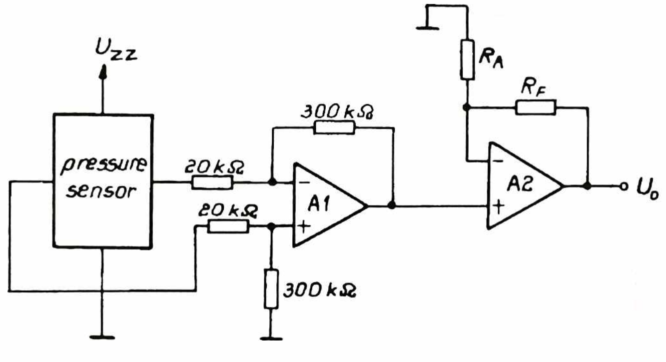

Fig 6. Scheme of LX05 and LX06 silicon integrated pressure sensors

Sensitivity of the LX0503 and LX0603 converters is between 300 and 1000 mV/MPa and measurement pressure range is from 0 to 0,2 MPa [5].Another example of the silicon piezoresistive pressure sensor are devices of MPX type (made by Motorola) where diffussion resistors of p type are applied. Sensitivity of these converters amounts to 1200 mV/MPa for MPX 50, 600 mV/MPa for MPX 100 and 300 mV/MPa for MPX 200 element. Measurement pressure ranges of the converters are 0...0,05 MPa, 0...0,1 MPa and 0...0,2 MPa , respectively.

An integrated pressure sensor can be applied as a hybrid solution. e.g. LX14 device (for example, that made by National Semiconductor) which consists of a pressure sensor in bridge arrangement, temperature compensation arrangement, two amplifiers and stabilized voltage supply, all contained in a single casing.

LIQUID LEVEL MEASUREMENTS

Mechanical measurement methods

Liquid level determination is a weak link in process control. Traditionally the mechanical measurement methods are used in ships which introduce large error and are unsuitable for remote monitoring and control.

The level switch of float ball type of a very simple structure and high reliability is useful for extreme liquid level determination, widely used in various tanks. Its output is contact signal which is unsuitable for continuous monitoring. Besides, the viscosity of measured medium affecting the ball surface destroys the synchronous shift of the float ball along with that of liquid level, which leads to insensitive area and motion error.

A magnetic float liquidometer is shown in Fig. 7. Its float rises or drops along with the liquid level, turning the movable magnetic contacts, it cuts off different resistors, thus the given resistance is accordingly changed to the level. Normally its range is only from 0 to 600 mm, which is suitable for e.g. an oil boiler. But the accuracy of such a device is very low.

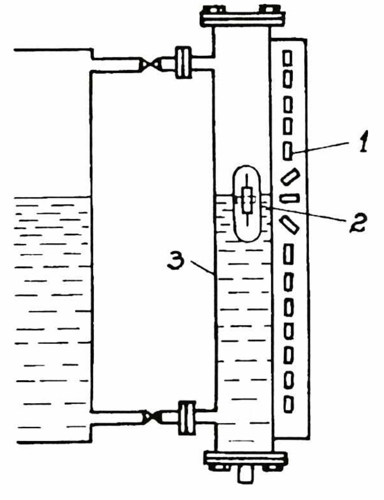

Fig. 7. Magnetic Float Liquidometer: 1. Turnable indicator / contact, 2. Magnetic float, 3. Tube linked to container

Ultrasonic sensors

Ultrasonic sensor is a kind of non-contact device which measures objects and distance by using an electrostatic or ceramic piezoelectric transducer to send out ultrasonic waves in a series of pulses. DCU10 device (made by Lundahl Instrument Corp., USA) is one of the successful products, microprocessor controlled, with analog and digital outputs. It has wide measurment range from 0,3 ft to 70 ft and good resolution of 0,01 ft, with 29 easy-to-use programmable modes. Measurement results are not distraced by colours, sizes, surface textures, or ambient light.

Capacitor sensors

This type of sensors is intrinsically safe and especially suitable for the application in tankers. A sealed capacitor cell is used in it to directly detect the pressure corresponding to the liquid level, thus eliminating possible troubles due to vibration and impact. The sensors of 1151 series containing a pressure converter (made by Rosemount Company, USA) have high accuracy of 0,25% and good repetition in the range from 0 to 70 kG/cm^2.

All the new sensors described above are expected to replace the traditional mechanical measurement instruments in the near future.

SMART SENSORS

On smart sensor application

Development of the microprocessor technique has provided good conditions for constructing of new generation of the smart sensors where the software becomes the integral part of the measuring devices and procedures, e.g. programmable compensation of errors. The application of the smart sensors and transducers [7, 8] has opened new possibilities in remote and high accuracy measurements. Moreover, these elements are very useful for construction of analog and digital signal processing lines and also in implementation of the autonomous multipoint measuring systems and the computer aided integrated measuring systems [9]. Smart sensor application is the main trend in transducer technology development in the years to come.

Smart Sensor of Cylinder Combustion Pressure

Strain sensor is quite good in typical pressure measurement applications. But in the case of high temperature application, e.g. in the measurement of cylinder combustion pressure, strain resistance is not only affected by the measured pressure, but also by the change of temperature. The bridge resistance of pressure sensors can vary by as much as 8%...9% over the temperature range of -40°C...125°C. Therefore the output signal is a function of both pressure and temperature.

Recently smart sensors have been developed with the microcontroller used to compensate the influence of temperature. They can be effectively applied in a high performance engine control. In Fig. 8 the structure of smart sensor is shown where pressure is the main measured signal [7].

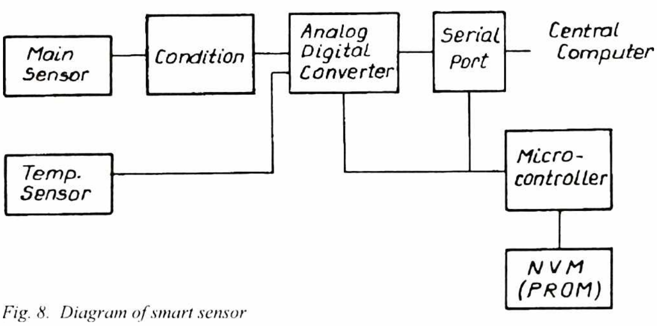

Fig. 8. Diagram of smart sensor

Having passed through the signal condition stage and A-to-D converter the digital signal is fetched by the microcontroller. Meanwhile the temperature information is also delivered through another channel. Using these two signals, the microcontroller is able to compensate for any temperature effect on the main sensor by using the compensation data stored in the Non Volatile Memory (NVM). The National Semiconductor Co., USA, has developed an advanced monolithic microcomputer and PROM of very small size (smaller than US 5 cents coin), which can be easily sealed in a small device. The COP888CF microcomputer contains 8 channels of 8-bit A-to-D converter, one 16-bit CTC, one Watchdog and one serial port. It is of a high performance, e.g. in preprocessing, it caltulates a 3rd degree polynomial in 16-bit accuracy to compensate the measured pressure value within 2,8 ms.

Inteligent Liquidometer

Taking into account the strain sensor's advantanges, such a sensor could be selected to measure liquid level. But a problem is the changeable medium density when applying different kinds of medium or caused by climatic zone and season alternations. Thus sensor's accuracy entirely depends on the density compensation, e. g. the measurement error may reach 2.5% when passing from fresh to sea water, and even as high as 20% when passing from diesel oil to heavy oil.

A novel method suitable for different liquids is based on the use of two strain pressure sensors, fixed at some distance Δl from tank bottom, as shown in Fig. 9.

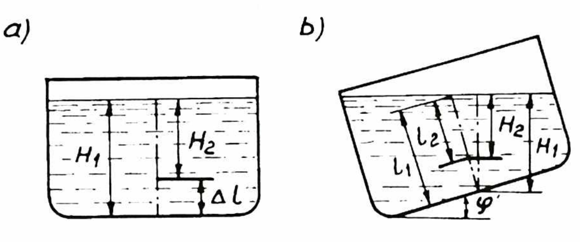

Fig. 9. Level determination with the use of two sensors

The influence of density is eliminated due to proportional operation of the sensors. Another useful result is that the level measurement error caused by ship's inclination can be compensated if the sensors are set in the centre of the tank. When the ship is inclined by the angle φ', then the following relation is valid:

$$\frac{p_1}{p_2}=\frac{H_1}{H_2}=\frac{l_1\cos\varphi'}{l_2\cos\varphi'}=\frac{l_1}{l_2} \tag{8}$$

and finally:

$$l_1=\frac{p_1\Delta l}{p_2-p_2} \tag{9}$$

The distance l_1 independent of φ' is that required. The diagram of an inteligent liquidometer consisting of 0808 A-to-D converter, MCS - 48 chip, decode circuit and LED displays, with included conditioning, is shown in Fig.10 [9]. A digital filter subroutine is arranged in software to overcome the level error caused by wave surge.

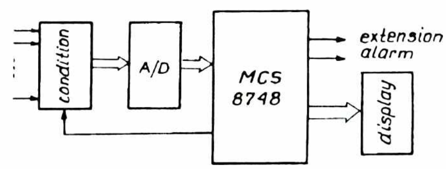

Fig. 10. Diagram of an intelligent microcomputer-based liquidometer

In practice, the density change can be accounted for as follows. Suppose that the indicated value of p_1 is measured as p_0, and the indicated level value of H_1 as H_0, both of them are stored in RAM, then ρ is calculated as:

$$\rho=\frac{p_0}{H_0 g} \tag{10}$$

By then the level is changed, the pressure is changed as well. Supposing the pressure is p' now, the corresponding H' can be obtained even with the use of a single sensor as:

$$H'=\frac{p'}{\rho\cdot g}=\frac{H_0 p'}{p_0} \tag{11}$$

This method is also useful for ship draft determination. During ship voyage external water pressure consists of static and dynamic pressure components. The static component caused by the water depth stands for the measured draft h. But the dynamic component due to the water flow speed v only introduces the measurement error. The theoretical consideration of the relationship p = p (h,v) is not helpful here. All what should be done is to build the compensation data base of p (h) values measured under different flow speeds. In fact the curves p=p (h) with v=const could be measured in the deep pool simulator.

This kind of device is of good linearity, good repeatability and good accuracy, e. g. the sensor of CGY13 type (made in China) is of 0,05% accuracy, and if combined with the intelligent liquidometer, it shows the total measurement error of less than 0,2%.

CONCLUSIONS

Ship's hostile environment, especially that in marine engine room, makes application of transducers with the improved anti - interference ability necessary. Suitable selection of their types, balanced with price and performance depending on a given need, is the first important issue. Errors are caused not only by sensors, but also by many other factors. To reduce or eliminate them, additional compensation relating to secondary factors must be considered.

For example use of smart sensors for cylinder combustion pressure or liquid level measurements is possible to compensate changes due to disturbing factors, i. e. temperature or medium density, respectively.

For temperature measurement, the main error due to the transfer and transmission of physical quantities, lead offset, common mode signal rejection and the non-linearity error of detection bridge itself, should be considered. Integrated sensors, apart from their minimal dimensions and technological advantages, can very easily cooperate with other parts of automatic control loops as they do not usually contain mechanical elements prone to damage.

The current transmission is more advantageous than other modes due to its high rejection ability against contact potential, contact resistance and voltage noise. This form of signal transmission is generally accepted as a standard also applicable to smart / intelligent systems.

In ship applications the device reliability is more important than its accuracy. The situation often results from that the transducers are important elements of microcomputer monitoring systems which fulfill many functions deciding on ship's safety and correctness of her exploitation processes.

The analysis of the transducer application in AMER showed that such new solutions for signal transmission and processing as: smart - inteligent sensors and transducers, optoisolator technique, digital signal processing, specialized and sophisticated software used to improve anti-interference ability of measuring and control systems, are generally accepted.

NOMENCLATURE

C - temperature-current conversion coefficient
H_1, H_2 - liquid heads in a tank shown in Fig. 9.
I_2 - inducted current connected with pressure transducer operation
I_C - transistor collector current
I_{Eo} - saturation current of emitter junction
k - Boltzmann constant
l_1, l_2, Δl - distances defined in Fig. 9.
$\Delta M = M_1 - M_2$ - difference of mutual inductances
p, p′, p_0, p_1, p_2 - measured pressures
q - elementary charge
R_t - temperature sensor resistance
ΔR - temperature sensor resistance deviation from its nominal value
T - measured temperature
U_{BE} - base-emitter voltage
U_T - thermokinetic potential
V_{cc} - supply voltage
V_{ref} - reference voltage
x - displacement
v - flow speed
w - transistor active area ratio
φ - phase angle
φ′ - ship's heel angle
ρ - medium density
ω - pulsation
AD581, AD580L, MCS-48 - integrated circuit type symbols
AMER - automated marine engine room
CMRR - common mode rejection ratio
CTC - counter/timer circuit
IC - integrated circuit
IPTS'68 - international practical temperature scale adopted in 1968
LED - light emitting diode
NBS - National Bureau of Standards
NVM - non volatile memory
PROM - programmable read-only memory
PTAT - integrated temperature converters generating voltage or current output signal with a value proportional to the absolute temperature
RTD - resistance temperature detector
TCU_F - temperature coefficient of forward voltage of p-n junction

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Appraised by Józef Lisowski, Prof.D.Sc.

Conferences

WTM

Ship technology development problems

The symposium on „ Ship technology development problems " was held at Szczecin Technical University, Maritime Technology Faculty, on 6 October 1995, organized on the occasion of prof. Eugeniusz Skrzymowski 70th birthday and 47th professional and scientific activity anniversaries. It was owing to his efforts that the once the Ship Research Institute, later Maritime Technology Faculty, was created. Prof. Skrzymowski has been the Head of The Shipbuilding Engineering Department since its very begining and managed the Institute and the Faculty for many years.

Many distinguished persons took part in the jubilee ceremony,among others: dr M. Tałasiewicz, President of Szczecin Province, Rectors of Technical University, Szczecin University and Maritime University representing the Council of University Rectors in Szczecin.

98 scientists and industry representatives, among them 8 persons from abroad, 46 of Polish universities, 12 of Szczecin Shipyard Co and 8 of other shipbuilding firms took part in the symposium. The symposium proceedings, edited by Technical University of Szczecin and Polish Academy of Sciences, contains 19 papers dealing with ship design, modern shipbuilding processes, underwater technology, ship safety and reliability.

The arrangement of the symposium would not have been possible without a substantial support kindly rendered by sponsors such as The Scientific Research Committee, Szczecin Shipyard Co, Marine Shiprepair Yard Co in Świnoujście and Gdańsk Shipyard Co.

XVII International Symposium on Power Plants

On 19÷20 October 1995 a traditional symposium, already XVIIth, gathering power plant specialists from scientific and education centres of Gdańsk, Gdynia and Szczecin was held at Technical University in Szczecin. It was organized by Ship Power Plant Department, Faculty of Marine Technology which celebrates its 30th anniversary this year.

Almost 100 pariticipants took part in presentation and discussion of 34 papers which generally dealt with the designing, testing and operating of ship power plants and their components.

The papers were devoted to the following topics:

- Ship power plant development appraisal in view of energy, economic and ecological aspects
- Modelling of ship power plant equipment operation
- Simulation of some processes in power plant performance
- Diagnostics of power plant systems and their elements
- Investigation of energy and lubrication processes
- Prediction methods of power plant real working conditions applicable to various types of ships
- Detrimental phenomena in ship diesel engine operation
- New technical materials
- Didactic and research laboratory stands

10 guests, who arrived from Denmark, Egypt, Germany, Russia and Ukraine, presented 6 papers. The most interesting was that proposing a new power plant concept with combustion engine supplied from wood gasifier.