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Electronic Device for Monitoring Electrical and Non-electrical Measurands

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Introduction

The measurement process is as old as life is. Nowadays measurement processes increased both in quantity and quality. Intelligent measuring device (IMD) connected with computer tend to develop rapidly for several reasons. First, for economic reasons, these modern measurement devices are cheaper, simply by removing LCD's or analogical indicators, and second for performance reasons. As for the performance we notice that classic displays have limited range of characters and color palette [1,2]. From the functional point of view IMD's take advantage of the computer facilities, these new measurement devices perform complex mathematical calculus is very short time capture, store and display a supervisory look ahead policy of the measurands, etc. We notice that IDM's reduce the design time, the graphical user interfaces (GUI) configurations allowing both rapid analytical and graphic analysis of the measurands.

Also one may notice that using a microcontroller (or a digital signal processor), the electrical scheme of IMD reduces the number of electronic components and also increases the reliability and speed of data flow. An aspect that must be considered for IMD's in the implementation of ASK/OOK techniques using RF power detecting and a few discrete components. Amplitude shift-keying (ASK) is a popular modulation technique used in digital data communications, especially in low frequency RF application. The source transmits a large amplitude carrier when sends a “1” and a small amplitude carrier for “0” [3]. On-off keying (OOK) modulation is a further simplification of this method, where the source simply sends no carrier when it wants to send “0”. ASK and OOK basically and used in short-distance wireless applications, and they are seen a future development of our electronic device for monitoring electrical and non-electrical measurands. OOK is in already popular in battery operated, portable applications as such systems can save energy and transmit power when not sending “0”. Carrier frequencies involved can vary depending an the application, such as 2MHz in some low frequency communications in base-station to about 433 MHz in short range communications that make use of the industrial scientific and medical (ISM) band [4].

Various wireless technologies such as Bluetooth, Zig-Bee and Wi-Fi are used in today's consumer world. These protocols offer means of secure communication between device, and typically operate in the 2.4GHz ISM band using combination of frequency shift keying (FSK), phase shift-keying (PSK), and amplitude shift keying (ASK). These security offered by these approaches includes channel happing and spread-spectrum modes of communication and also improve the noise immunity. All these methods spend energy when sending both a “1” and a “0” [5].

As a disadvantage, these protocols have a relatively high complexity and cost of implementation. Simple ASK/OOK hardware implementations become a straight forward choice for several reasons: low cost of implementation, low power consumption leading to extremely long life in battery operated applications, access to a point-to-point wired infrastructure and wireless infrared type of link. Security can be overlaid this link by incorporating bidirectional interrogation schemes between transmitter and receiver. ASK offers better noise immunity compared with OOK, but higher power consumption than OOK.

The rest of the paper is organized as follows in section 2 we give a short description of the electronic measurement device hardware. The software support of our device is presented in section 3 and the embedded structure of this measurement device is shown section 3. In section 4 are given some concluding remarks.

Hardware structure of the measurement device

a) Frequentmeter

Our device (Fig. 1) has a personal computer (PC) interface that's permits measurements of high voltage signals as well as low voltage ones. The electrical scheme is based on an 8-bit microcontroller PIC16f648A that ensures the serial communication with the PC.

The serial communication by RS232 port supports a date flux speed of 19200 bps, 8 data bits, 1 bit stop and parity (full duplex). Computer interface is economic and ensures various facilities for the operator. The precision clock is ensured by a quartz-crystal of 20MHz. When measuring the frequency we have taken into account the delays caused by the program routines of microcontroller. A voltage divider ensures a wide range of the measured signals amplitude.

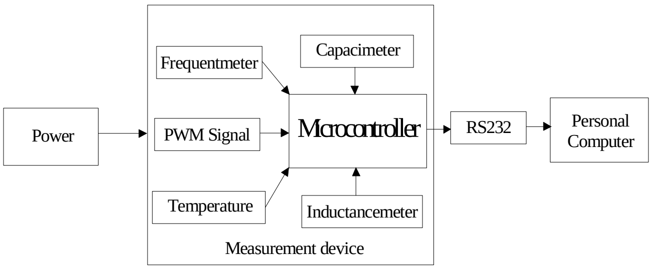

Fig. 1. Block diagram of the measurement device

b) Inductancemeter

If these are many types of multimeters that have been integrated the function of capacimeter, there are only a few that measure inductance. The basic principle of our inductancemeter is to determine the output frequency of an LC oscillator as capacitance C is known. The resonance frequency is of LC oscillator is given by Thomson's formula:

$$F = \frac{1}{2\pi \cdot \sqrt{L \cdot C}}, \quad (1)$$

where L – the inductance, C – the capacitance of the LC oscillator.

The range of inductance measured with our device is of 1nH to 1H by using a trigger Schmitt in the oscillator loop.

c) Capacimeter

The capacimeter measurement principle is similar to the inductancemeter. The range of the measured capacities is of 1 pF to 1 mF.

d) Temperature measurement

Most temperature sensors are produced in capsule type TO92 or in SMD technology. Expanding the measurement area a possible by mounting multiplying sensors on wire shape that form a network generic entitled “”1-Wire”.

These devices have the possibility of being supplied directly on the bus. We used Dallas DS18B20 temperature sensors connected to PC via the serial interface built with PIC16F648A microcontroller. We also used moisture and atmospheric pressure sensors in order to have a correlation between temperature moisture and atmospheric pressure.

This correlation helps us to have realistic measurements by using the Bedford graphs [6], e.g. for obtaining the effective rectified temperature. This kind of measurement gives an accurate relation between the insulated protection clan of the electronic device and the environment where they work.

e) ASK signal receiver and analyzer

Our system detects ASK signal by using RF power detector MAX 9933. ASK receiver front ends typically comprise three blocks an input band pass filter to discern the carrier frequency from a broadband input noise spectrum, am envelope detector to extract the information of interest and a comparator to obtain binary outputs for PC software analyzer. The comparator trigger threshold is derived from the output of the envelope detector; this enables the threshold level to auto scale with receiver signal level.

Our implementation uses a MAX 9933, an RF power detector that read input signals with a 45 dBV dynamic range and delivers a voltage proportional to signal level from 50 dBV to 13 dBV. This device is sensitive to very small signals allowing the ASK receiver to discriminate between small input “0” and “1” signal levels.

Due to this performing sensitivity and to the fact that the device is connected to a PC, one may perform qualitative analysis of measured signal, considering that voltage distortion 4% or more are commonplace [7, 8].

Thus, the standard total harmonic distortion power analysis must consider the Edition 2 of the IEC 61400-4-7 measurement standard, which looks at just the integer harmonics (e.g. the inter-harmonics should be “grouped” into the harmonics levels) [9].

Software support of the measurement device

The ability to communicate is essential everywhere. The language used for communications with embedded systems (e.g. PIC 16f648A microcontroller) is the assembly language and is compiled into the microcontroller memory is shown in Fig. 2.

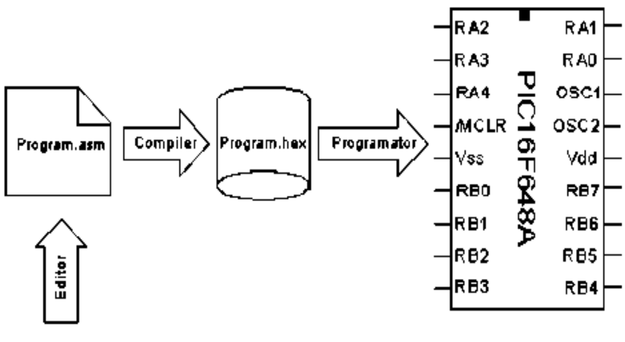

Fig. 2. Communication of the microcontroller

Basically we created the software to connect and collect data from eight power and temperature measurement device. Through the subroutine Application Selector, built in Visual Basic, one continues to display all measuring devices that are available for the process parameters in question. It also provides an at-glance understanding of their relevance to the application parameters you have provided by encoding each device with a traffic-light colour. On request, Application Selector will set our relative characteristics of selected options in table form. Subroutine Basic Selector provides on expanded list of options, this allows measuring devices to be researched at any stage of the engineering process or by people with different levels of expertise.

Embedding the electronic device

The electronic device is embedded in a board framed by 16.5x13 cm, witch are mounted connectors (see fig. 3). We have noted with **Ind** connector related to inductance measurement, with **Cap** the connector related capacity measurement, with **Freq** the connector for frequency measurement. We introduced a two position switch that makes difference between internal and external frequency. When the switch is in position **Int** one may measure the frequency of the internal oscillator in order to measure capacity and/or inductance by using formula (1).

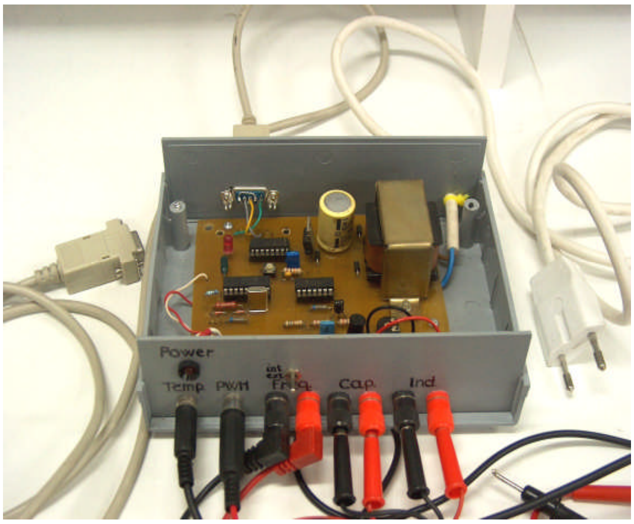

Fig. 3. Measurement device

When the switch is in position **Ext,** one may measure frequency of external signals. The connector OOK gives a rectangular signal with variable filing factor. The connector **Temp** is configured as a port for measuring the environmental parameters (e.g. temperature, humidity, atmospheric pressure). Due to the fact that the electronic device (e.g. the interface) is capable to perform various mathematical calculi only few of then are allocated to the PC, so that we may capture, analyze and display electrical and non-electrical measurands effectively in real time.

Conclusion

This paper introduces a complex measurement device that deals with both electrical and non-electrical measurands. Although we call it "complex measurement device" it is implemented by using a minimal hardware and this aspect makes it very accessible. The term "complex" refers to the fact that due to the fact that our device is connect to a computer, it performs measurements related to the environment parameters (e.g. temperature, humidity, atmosphere pressure) and that makes it a "real" measurement device. Further work will focus on increasing the measurands and the analysis complexity: for example, determining automatically the insulation protection class to a certain electric device by monitoring its electrical parameters for an interval of time in its real working environment.

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Complex measurement device is introduced that deals with both electrical and non-electrical measurements. It was designed and built in discrete event systems (DES) laboratory. The measurement device deals with electrical and non-electrical measurands and functions such as: capacimeter, frequentmeter, ASK signal parameters, environment parameters (e.g. ambient temperature, humidity and atmospheric pressure). This device communicates with a computer via serial port and provides a friendly user interface built in "Visual Basic Software". Ill. 3, bibl. 9 (in English, summaries in English, Russian and Lithuanian).

Ц. Цюфудеан, Ц. Филоте, Ц. Буздуга. Электронное устройство для наблюдения электрических и неэлектрических величин // Электроника и электротехника. – Каунас: Технология, 2009. – № 7(95). – С. 51–54.

Описывается сложное устройство, позволяющее определить параметры окружающей среды (температуру, влажность, атмосферное давление), а также электрические параметры (частоту, емкость). Устройство с компьютером соединяется при помощи последовательного порта, а удобный использователю интерфейс, создан используя «Visual Basic». Ил. 3, библ. 9 (на английском языке; рефераты на английском, русском и литовском яз.).

C. Ciufudean, C. Filote, C. Buzduga. Elektroninis įtaisas elektriniams ir neelektriniams dydžiams stebėti // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 7(95). – P. 51–54.

Pristatytas diskretinių įvykių laboratorijoje (DES) sukurtas sudėtingas matavimo prietaisas, galintis matuoti tiek elektrinius, tiek neelektrinius dydžius. Juo galima matuoti tokius parametrus, kaip talpį, dažnį, ASK signalo parametrus, aplinkos parametrus (aplinkos temperatūrą, drėgnį ir atmosferos slėgį). Įtaisas su kompiuteriu komunikuoja per nuosekliąją jungtį, o patogi vartotojui grafinė sąsaja sukurta naudojant „Visual Basic" programavimo kalbą. Il. 3, bibl. 9 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).