DIGITAL SYSTEM FOR VIBRATION ANALYZES

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Abstract: The vibrations analyze for mechanical gear is a new method for determining the defects. The vibrations analyze is used in predictive maintenance of monitored gears. The proposed system allow signal acquisition from two vibration sensors (accelerometers) and data transmission to the computer for analysis.

Keywords: vibrations, IEPE accelerometer, acquisition system, USB communication, analysis

1. The predictive maintenance

The predictive maintenance compares measured parameters tend to technological limits and is intended to detect, analyze and correct potential problems before they occur. Predictive approach can be applied to any equipment problems that can measure various parameters such as vibration, temperature, pressure, voltage, current or resistance [1].
There is a limit in terms of technology for an occurred problem to be detected during routine checks. Also, the technical possibilities must provide the ability to detect the problem before equipment failure. Correcting the problem occurred is predictive maintenance.

2. System description

For monitoring equipment with mobile mechanical pieces, the main parameters followed are vibrations and temperatures. The proposed system is a system which allow simultaneous acquisition with 50.000 samples/sec rate of vibrations from two measurement points. The block structure of the system is presented in figure 1.

The measurement module

One channel from the measurement module is composed by a vibrations sensor and a signal conditioning circuit for the sensor.
Accelerometers are widely used in industry for measuring vibration in rotating machinery, moving vehicles, aircraft, and in structures. Virtually all accelerometer devices use the force generated by moving a seismic mass to measure acceleration of the mass. The displacement of the mass or the force developed by the motion of the mass is detected and measured by a very wide range of sensors, such as electromagnetic, magnetic reluctance, piezoelectric, piezoresistive, potentiometric, capacitance, strain gauge. New types of accelerometers and integrated sensor systems are now replacing more traditional vibration sensors for a number of reasons such as lower cost, better performance, rugged design, and smaller size [2].
Piezoelectric sensors use Newton's Second Law (F=ma) and the piezoelectric effect to measure acceleration of a mass. A piezoelectric accelerometer contains a "seismic mass" mounted so that the force applied to the mass by movement of the housing "squeezes" or stresses a natural quartz crystal or manmade piezoelectric ceramic measuring element.

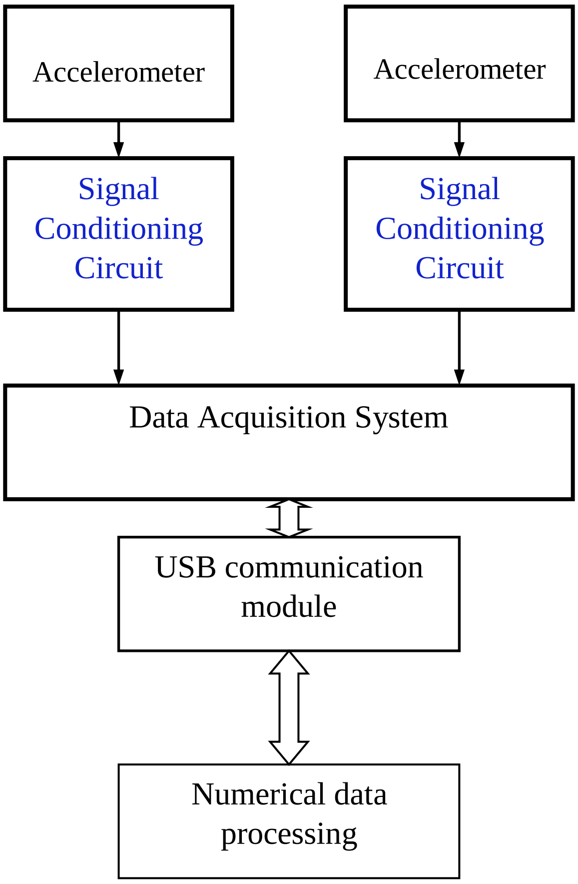

Fig.1 Structure of the proposed system

The pressure on the measuring element produces an electrical charge within the material that is proportional to the force applied — the piezoelectric effect. This force, in turn, is proportional to acceleration (F=ma). The charge output is a high impedance signal that can be measured directly or amplified and conditioned by other electronic circuits. When supplied without additional signal conditioning circuits, the unit is called a "charge sensor". It is characterized by a very high inner impedance, low output signal, and no steady-state response. When the device is supplied with built-in preamplifier/impedance converter, it is called an Integrated Electronic Piezo-Electric sensor (IEPE sensor). For vibrations measurement was used IEPE type accelerometers with two sensibility: 100mV/g and 10mV/g, used according with vibrations amplitude.

IEPE sensors have built-in signal conditioning circuits that have low impedance output electronics compatible with a two-wire constant current supply providing a DC voltage bias. IEPE sensors are very popular in most industrial applications except those with special requirements such as static (zero Hz) sensing, high temperature applications, or process control applications requiring 4-20 mA current outputs. The output of a 2-wire IEPE accelerometer is an AC voltage on a DC voltage bias. The DC bias can be removed by inserting a capacitor in series with the output signal. The IEPE unit also requires a constant current supply. The structure of the implemented conditioning system is presented in figure 2.

The conditioning system include three DC to DC conversion circuits:

- A Step-Up type convertor to obtain +24V, required by current source;
- A Step-Down type convertor to obtain +6V, required by the Vcc input of the instrumentation amplifier and the other circuits;

- A Positive to Negative Converter to obtain -6V, required by the Vss input.

The instrumentation amplifier has the possibility to adjust the gain in there ranges: 1-10, 10-50, 50-100, according with the application.

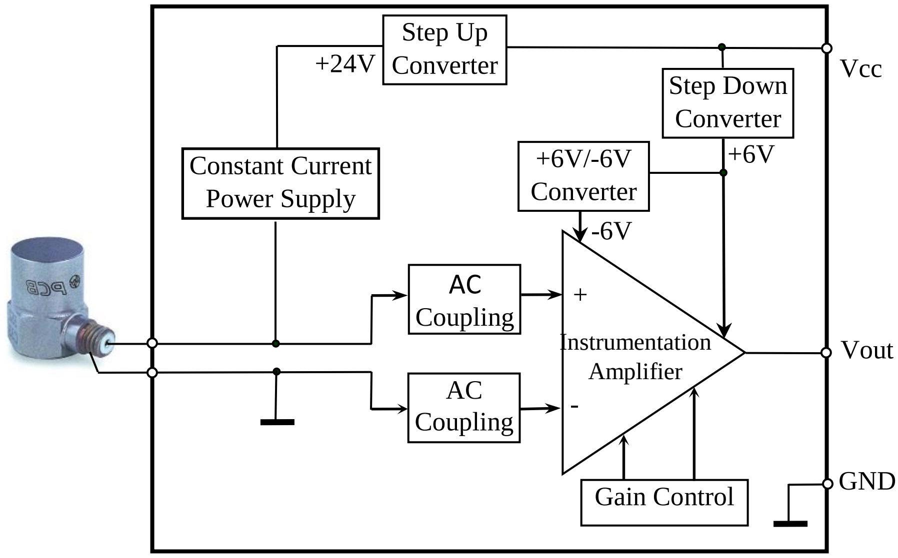

Fig.2 Structure of the Signal Conditioning Circuit

The acquisition system

To achieve big conversion rate was selected the solution to use for each channel a 128Koctets RAM memory as buffer. Also, to increase the acquisition rate, the ADC converter was selected to communicate directly with the RAM memory, so the microcontroller of the system has only to generate the required clock signal.

Thus, the AP89S52 type microcontroller initiate the RAM memory with the address were the data will be stored, activate the two converters according with command received from the computer and, then generate the clock pulses until complete the number of required conversions. The structre of the acquisition system is presented in figure 3.

The AD Converter used is the MCP3301 type. The MCP3301 13-bit A/D converter features full differential inputs and low power consumption in a small package that is ideal for battery-powered systems and remote data acquisition applications. Incorporating a successive approximation architecture with on-board sample and hold circuitry, the 13-bit A/D converter is specified to have ±1 LSB Differential Nonlinearity (DNL) and ±1 LSB Integral Nonlinearity (INL) for B-grade devices and ±2 LSB for C-grade devices [3].

The industry-standard SPI serial interface enables 13-bit A/D converter capability to be added to any microcontroller. The MCP3301 features a low current design that permits operation with typical standby and active currents of only 50 nA and 300 µA, respectively. The device is capable of conversion rates of up to 100 ksps with tested specifications over a 4.5V to 5.5V supply range. The reference voltage can be varied from 400 mV to 5V, yielding input-referred resolution between 98 µV and 1.22 mV.

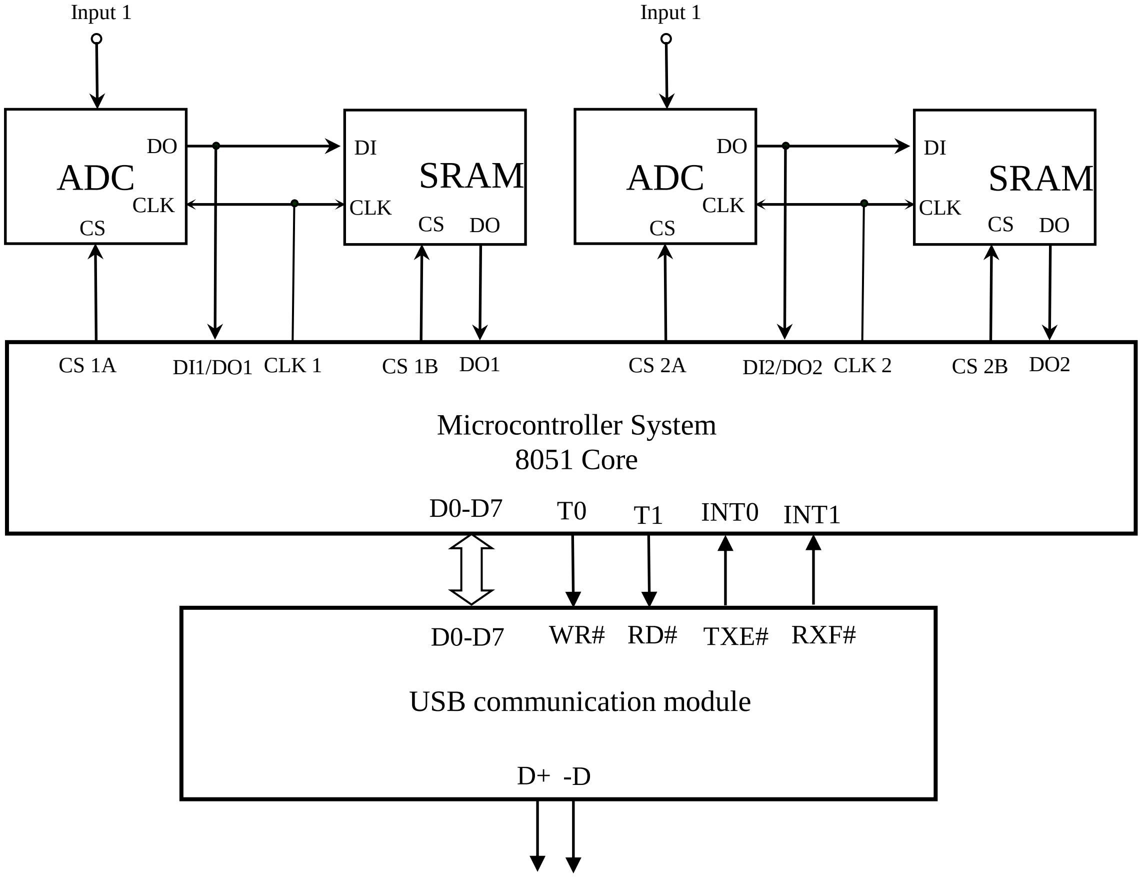

Fig.3 Structure of the Data Acquisition Systems

The RAM memory is the 23LCV1024 type from Microchip. The Microchip 23LCV1024 is a 1 Mbit Serial SRAM device. The memory is accessed via a simple Serial Peripheral Interface (SPI) compatible serial bus. The bus signals required are a clock input (SCK) plus separate data in (SI) and data out (SO) lines. Access to the device is controlled through a Chip Select (CS) input. Additionally, SDI (Serial Dual Interface) is supported if your application needs faster data rates. This device also supports unlimited reads and writes to the memory array, and supports data backup via an external battery/coin cell connected to VBAT (pin 7)[4].

Thus can achieve acquisition rate as 100.000 samples/sec, which is equivalent with acquisition signal for 0.5 sec. Using a large RAM memory or a small conversion rate can acquire signal for a large time period.

For a fast data transfer to the computer was used the USB communication. For this type of communication was used the UMFT240XA FTDI module.

The UMFT240XA is a development module for FTDI‟s FT240XQ, one of the devices from FTDI‟s range of USB to serial data interface integrated circuit devices. FT240X is a USB to 245 FIFO interface with a battery charging feature, which can allow batteries to be charged with a higher current from a dedicated charger port (without the FT240X being enumerated). In addition, asynchronous and synchronous bit bang interface modes are available. The internally generated clock (6MHz, 12MHz, 24MHz and 48MHz) can be brought out of the on one of the CBUS pin to be used to drive a microprocessor or external logic [5].

The UMFT240XA is a module which is designed to plug into a standard 0.3" wide 24 pin DIP socket. The UMFT240XA is fitted with a FT240XQ, all the features of the FT240X can be utilized with the

UMFT240XA. In addition to the features listed in the FT240X datasheet, the UMFT240XA has the following features:

- Small PCB assembly module designed to fit a standard 7.62mm wide 24 pin DIP socket.
- On board USB „mini-B" socket allows module to be connected to a PC via a standard A to mini-B USB cable.
- Functionally configurable using solder links. The default solder links setup enables the module to function without peripheral wires or application board. Other configurations enable external power supply options and variation of logic reference levels.

CONCLUSIONS

The main advantages of this system are:

- simultaneous acquisition of two channels for vibrations signal;
- a big acquisition rate, up to 100.000 samples/sec;
- a fast data transfer system with the computer using the USB port;

A major disadvantage is the small acquisition time, only 0.5sec. But, using a large RAM memory or a small conversion rate can acquire signal for a large time period

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