MULTICHANNEL ANALOG DATA ACQUISITION SYSTEM

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The process of collecting information from sensors or measurement systems with analog output is very complex. The accuracy of the measurement is dependant on the involved system. It has the purpose of intensification, digitalization and processing of the received data. All the process should be consistent with the parameters of the processed signal such as its polarity and amplitude, and also the frequency. For the basis of the system computing unit, used also for control of the whole system is MSP430F149 – low power 16 bit RISC microcontroller.

1. INTRODUCTION

The presented „Multichannel analog data acquisition system" is intended for measurement of electric signals, correspond to processes of testing and diagnostic of transport vehicles. The input signals for the system are usually from sensors or measurement bridges. These signals are characterized with relatively low level of the amplitude and frequency in the range up to fifty kilohertz. The process of measurement and treatment of the analog signals is done during normal working of the transport vehicle. The environment is very noisy, which in addition makes the accuracy of the measurement worse. By this reason it is necessary to use noise resistant method for processing of analog signals.

At first all the analog signals should be normalized. Due to the input signals could be with polar amplitude, it is necessary to convert them in accordance with parameters of the analog to digital converter. The primary processing of analog signals consists of amplifying and filtering.

The whole configuration and managing of the analog to digital converter is done by a microcontroller. After the analog to digital converting has been finished, the microcontroller reads the information and accomplishes the appropriate mathematical processing of the data. The so processed data can be sent to a workstation or written in a non-volatile memory.

2. REALIZATION OF THE SEPARATE BLOCKS OF THE SYSTEM.

As it was mentioned, the purpose of the system is for measurements in industrial hardly noisy environment.

Due to the signal of the noise has common mode character, it is necessary the input amplifier block to enhance the differential component of the signal, and to reject the common mode one.

The microcontroller MSP 430F149 has a 12 bits analog to digital converter with eight channel analog multiplexer. Through it additional eight analog input channels are realized.

2.1 Differential input amplifier block

In the present system the whole processing of the input analog signals – amplifying, filtering is done over two differential signals. In this way the accumulated noise is presented in the both differential channels as a common mode signal. During the amplifying of the signal the noise is rejected from the complex signal with the coefficient of common mode rejection of the amplifier. The fruitful differential signal is amplified. Due to this criteria, in the present system a differential operational amplifier is chosen – AD8138 from Analog Devices (fig. 1.0).

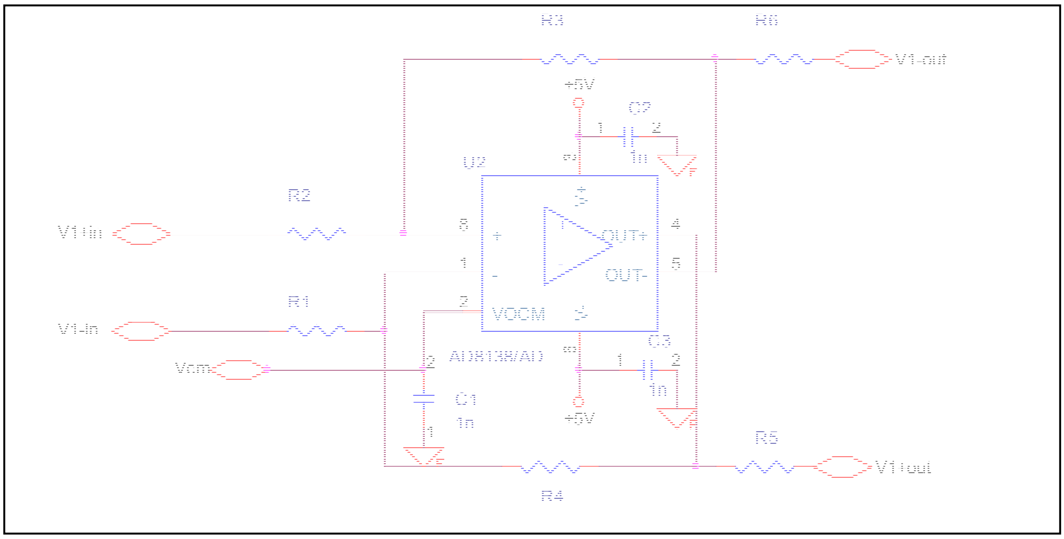

fig. 1.0

The result output voltage can be calculation on the basis of the equation (1):

$$Vout_{diff} = (V_{V1+OUT} - V_{V1-OUT}) \qquad (1)$$

The common mode voltage is a result from equation (1):

$$Vout_{CM} = \frac{(V_{V1+OUT} + V_{V1-OUT})}{2} \qquad (2)$$

The closed-loop gain for every one of the two differential channels are:

$$Gn_{+} = \frac{V_{io\_ADC+}}{V_{inp+}} = \frac{V_{inp+}.R_3}{R_2}.\frac{1}{V_{inp+}} = \frac{R_3}{R_2} \qquad (3)$$

$$Gn_{-} = \frac{V_{io\_ADC-}}{V_{inp-}} = \frac{V_{inp-}.R_4}{R_1}.\frac{1}{V_{inp+}} = \frac{R_4}{R_1} \qquad (4)$$

The input V_{OCM} is for a dc offset. In this case, it is the same as the reference voltage of the analog to digital converter, which is 2.5V. By this approach this offset

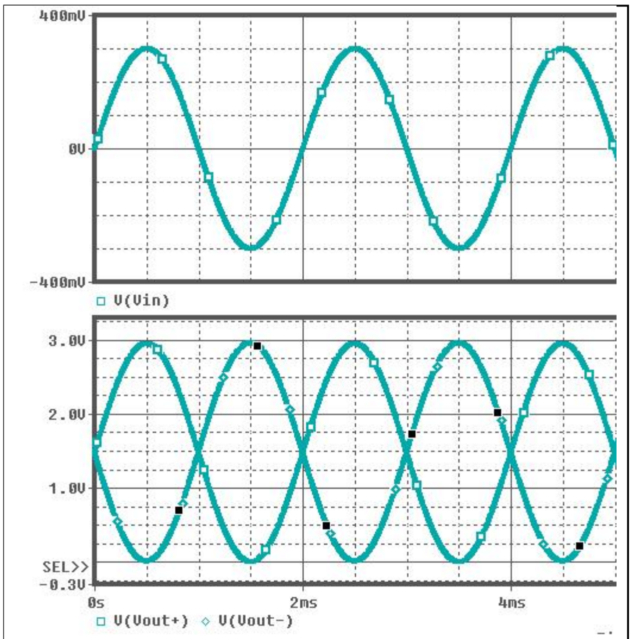

fig. 1.1

of the amplified signal, which could have different polarity is converted in a one with one polarity, in accordance with the parameters of the analog to digital converter (fig. 1.1). As it can be seen from the figure the closed-loop gain is about ten times, and the output differential signals are symmetrical to the reference voltage.

There are four such blocks in the system.

2.2. Buffer amplifier block.

The second amplifier block has conducive function. Its aim is to amplify the input signal before to pass it to the built in the microcontroller ADC. It is built on the basis of integral circuit AD8026 – four operational amplifiers with close-loops. The schematic of the block is shown in (fig. 1.2).It hasn't got the possibility for working with differential signals like the previous one, that's way it must be used only for additional measurements, where there is no noise presented, or the precision is less necessary.

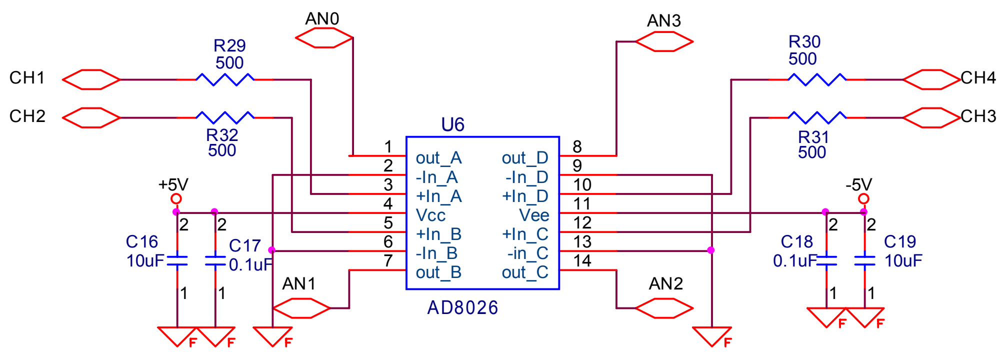

fig1. 1.2

The gain coefficient of the amplifier block is G=2,67, and the bandwidth is 20MHz.

2.3. Reference voltage.

The necessity reference voltage for the analog to digital converter as well as the differential amplifier, originates the indispensability of this module. This reference voltage block for 2,5V is built on the basis of integral regulator TL431. It has low consumption and good temperature stability – 30ppm/ºC.

2.4. Interface for connection with a personal computer.

For the transfer of the calculated data from the measurement there are several opportunities for interface:

- The universal synchronous/asynchronous receive/transmit - (UART). The microcontroller MSP430F149 has two UART interfaces. The communication with them can be done with system interrupts, which gives a good opportunities to work in real time. The disadvantage with this interface is the limitation of the communication speed - up to 115200bps.
- USB interface – gives possibilities for information exchange with up to 12Mbps. This afford an opportunity to sent the measured data to a personal computer in real time with low overhead.

The USB interface is built on the basis of a special integral circuit FTDI245BM (fig. 1.3). It has built in stack for USB communication, compatible with specification USB 1.1. The maximum speed of communication for this chip is up to 8Mbps. It has built in buffers – for receiving 128 bytes FIFO, and for sending 384 bytes FIFO. It can be directly interfaced to a 3.3V powered microcontrollers, in accordance with the power supply on the VCC_IO pin. In this way the interfacing between the microcontroller and USB interface chip is done with out any external components.

The integral circuit has a separate interfacing for a serial EEPROM. It can be used for storing special information such as USB device descriptors.

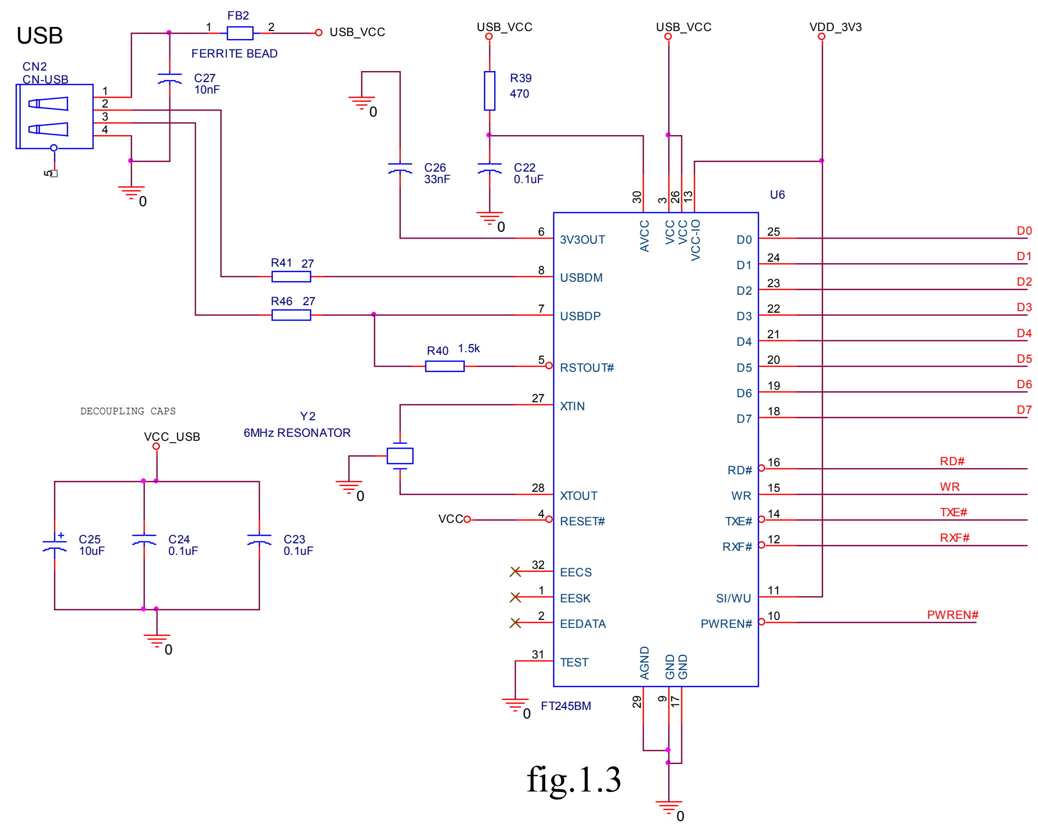

fig.1.3

3. BASIC SOFTWARE MODULES

The whole realization of system function are dependent on the principle for real time working of the system. That's why the communication with external modules – analog to digital converter, USB interface, are implemented on system interrupts.

The USB chip is loaded in parallel. The status of the internal receive or transmit buffers is watched by the external interrupts on the ports 1 and 2 of the microcontroller fig. 1.4

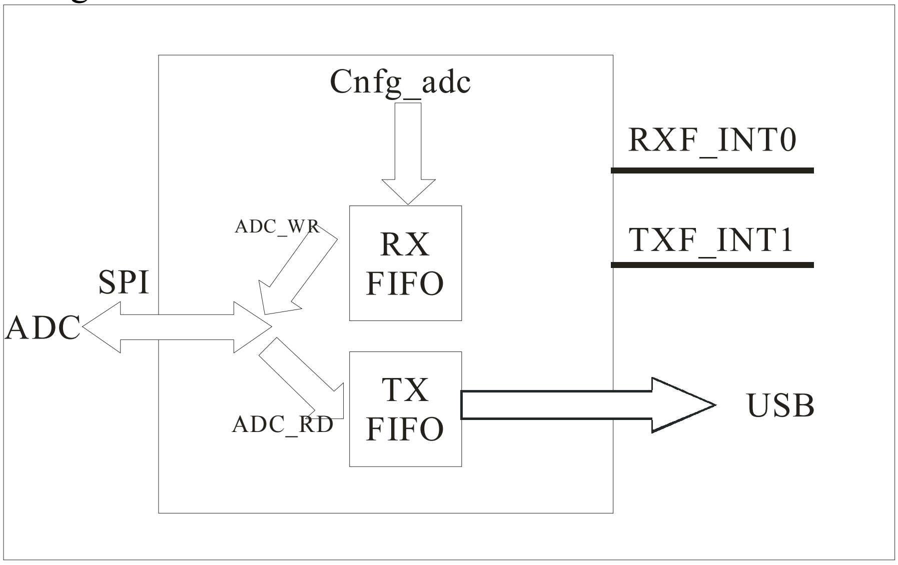

fig. 1.4

There are two FIFO buffers. The first TX_FIFO – which is used for accumulating of the data, which are ready for sending to the workstation via USB interface. The second one RX_FIFO is used for sending configuration parameters to the converter from the managing microcontroller.

4. EXPERIMENTAL RESULTS

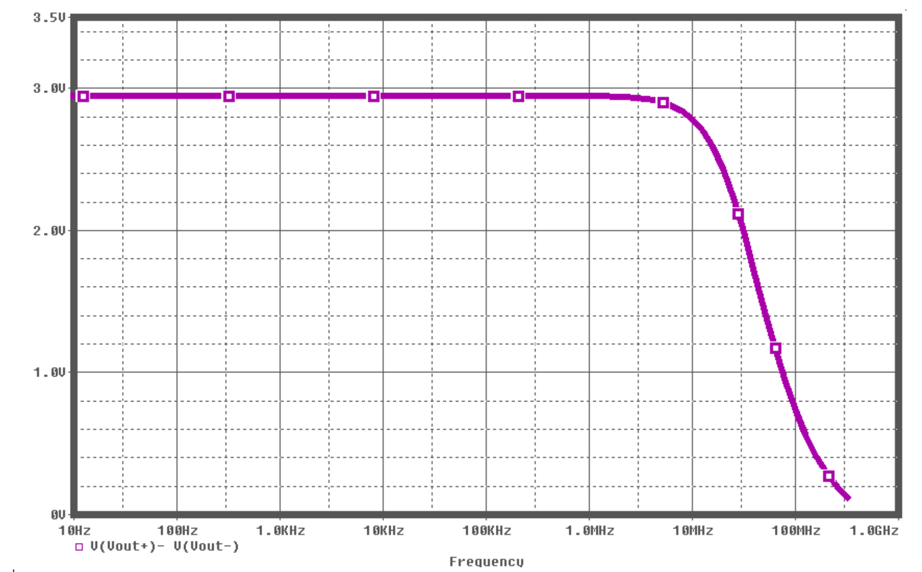

fig. 1.5 Amplitude to frequency response of AD8138

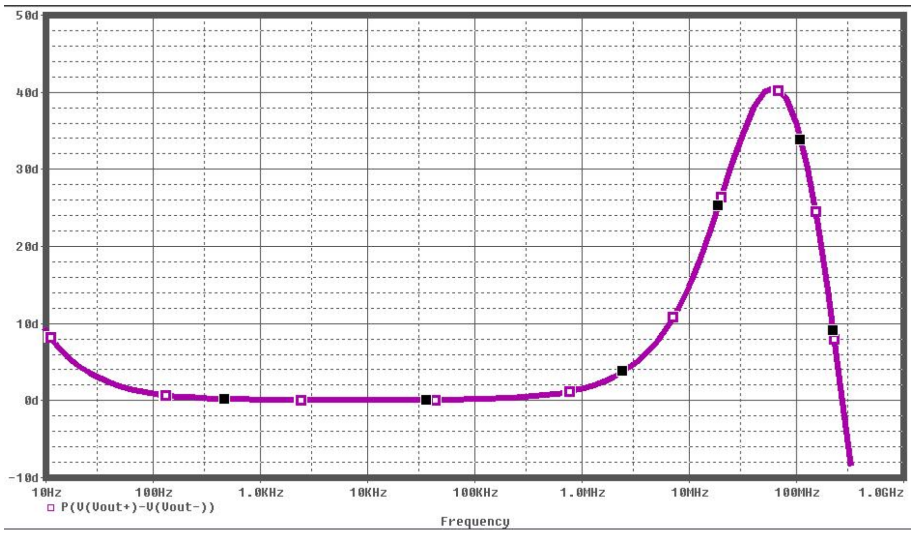

fig. 1.6 Phase to frequency response of AD8138

5. CONCLUSION

The presented multichannel analog data acquisition system is suitable for measurement of signals in real time during control and diagnostic of transport vehicles. The amplitude of the signals is in the range ±1V and frequency up to 50kHz. It gives opportunities for working in hard noisy environments and has low energy consumption.

The implemented USB interface gives up opportunities for communication with workstation with speed up to 920kbps. This make the system expedient for measurement in real time.

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