

EXTERNAL A/D CONVERTER USING THE UNIVERSAL SERIAL BUS (USB)

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A versatile low cost analog to digital conversion unit built from commercially available components that connects to a standard PC or Notebook via the Universal Serial Bus was developed. With a sampling rate of 10 kHz, 8 bit resolution and the potential for a large number of channels the system can be used for analog data acquisition in research, classroom and field environments. The A/D converter has been successfully used for the testing of gymnastics landing surfaces.

KEY WORDS: analog to digital conversion, universal serial bus.

INTRODUCTION: The aim of the present project was the development of a data acquisition system to convert digitally an analog signal, read the data in a PC and then derive relevant parameters. In the application presented here, the signal of an accelerometer was used to obtain parameters required for the testing of gymnastics landing surfaces (Gros, Leikov 1994). Popular measuring systems combine PC, special A/D converter board, and elaborate software. They are expensive and difficult to customise. The use of notebooks requires PCMCIA cards with a rather limited number of channels and conversion rate. External devices connected via the serial RS232 port have insufficient sampling rates for most applications. The Universal Serial Bus (USB) is a promising alternative. It has sufficient bandwidth: even low-speed devices have transmission rates $> 1,5$ Mb/s and thus outperform the baud rates possible via the serial port by a multiple. Mobility and ease of operation are unsurpassed: the cable can be hot plugged and only a simple device driver has to be copied onto the hard disk prior to the first use. This feature provides the basis necessary to ensure versatility. In the present paper a testing device for gymnastics equipment serves as example to show an easy way to import and process analog signals to a PC via the USB port:

METHODS: The MAX186, an eight channel A/D converter commercially available from MAXIM is commonly connected to the RS232 port. The integrated circuit achieves a conversion time of 10 . While data from the MAX186 can be processed directly through the serial port, additional hardware is required for use with the USB port. The reason is, that the USB bus structure relies on a single master, i.e. all activity is controlled from the PC. The slave devices must synchronise to the data stream. All processes including synchronisation, encoding and data checks are performed by specialised integrated circuits. Each USB device contains a Serial Interface Engine (SIE) dedicated to this job. The connected microprocessor only supplies data to the SIE. One commercially available circuit is the EZUSB (Figure 1).

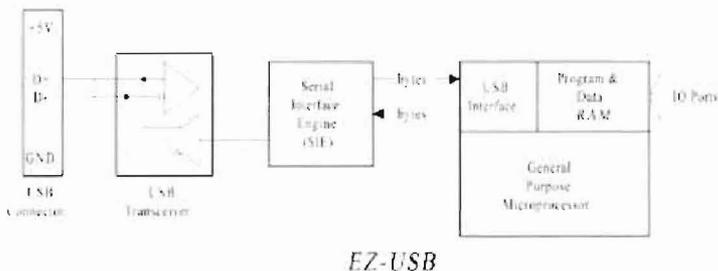


Figure 1. The serial interface engine in microcontroller AN2131 (Cypress).

Thus, serial operation of the MAX186 and the EZUSB form in principle the desired A/D converter via USB. A developer's kit can be ordered from AK Modul-Bus Computer Inc.

through the internet (<http://www.modul-bus.de>). On the software side the structure is equally simple. The two important modules required to communicate with the EZUSB and the microcontroller through the software are integrated into the hardware. For most conceivable applications it is not necessary to modify those parts. Only the master program has to be written either in DELPHI or any kind of C, at very low level programming for simple applications. The data is stored in a format usable by any analysis program.

RESULTS AND DISCUSSION: For the present application (test of gymnastics landing surfaces) the accelerometer signal was passed to the MAX186 via an optocoupler to facilitate amplification of the signal and to completely separate the transducer circuit from the PC hardware. No further electronic components are required. The software composed of the main program, the USB routine, and the input routine take care of the data acquisition. The input routine manages the AN2131 microcontroller who controls the MAX186. This IC reads and converts the analog data and writes to the memory of the EZUSB. The data acquisition routine is controlled by the USB routine. This part of the software mainly manages the USB hardware and is responsible for addressing, encoding, and transfer of the data from buffer memory to the Computer RAM reserved by the main program. From here all further storage and processing of the data as required by the user is performed. Simple user coding ensures versatility and adaptability of the software for simple or complex applications. Data can be stored onto hard disk in any suitable format. Import to spreadsheets facilitates subsequent data transformation and visualisation. In the case of the test system for gymnastics landing mats, diagrams for acceleration, velocity and displacement are displayed. The peak force, maximum deformation of the mat, and the rebound height are computed. The main program

```
//main procedure
begin
  ProgReset;           //microcontroller and max186 reset
  DiagrammInit;       //initiate diagramm
  ProgStart;           //start encoding and write in microcontroller RAM
  Sleep (200);
  ProgReset;
  for n:= 0 to 3 do begin //read 3 channels
    ReadRamBytes ((512+n*1024),1024); //read microcontroller RAM
    for i:= 0 to 1023 do Buffer[n*1024+i] := InBuffer[i]; //write to software buffer
  end;
  Plot (0)             //subroutine for dataplotting
end;
```

Figure 2. The main program written in Borland Delphi 6

is written in Delphi (Figure 2). However, it is possible to use other high level languages such as C, C++, VB for this same purpose.

The measurement system presented here has the following specifications:

- Sampling rate: 10 kHz (10000 samples per second),
- Input voltage: 0 to 4 V DC,
- Resolution: 8 bit (equivalent to 16 mV).

The present system has 8 channels, however, by cascading USB devices up to 127 devices can be connected to the port. Thus the potential number of channels is more than sufficient. The total hardware cost is about 200 US\$ for the 8 channel system. The sum of all features described above makes the external analog to digital converter using the Universal Serial Bus as interface to a standard PC or notebook highly competitive in terms of performance, price, and ease of operation.

CONCLUSION: Integration of the hardware into a small casing yields a highly portable, inexpensive and versatile data acquisition system. The excellent cost / performance ratio, combined with the flexibility in terms of customisation of the software and PC used, make the

system described here attractive for scientific and classroom use as well as for field measurements.

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