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HOW TO SELECT A SUITABLE PLUG-IN A/D BOARD

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This contribution contains a brief description of technical parameters of plug-in boards for a personal computer. The second part of this contribution comprises recommended methods for selecting and buying these boards.

At the present time, the digitalisation of analog signals is almost always a part of dynamical measurements. The most accessible mean regarding the price is represented by A/D boards for personal computers (see [1]). The typical diagram of A/D board is drawn in Fig. 1. The main part is formed by the A/D converter, which transforms the instantaneous value of electric voltage into an integer number. The quality of the A/D converter determinates, to a great extent, even the price of the complete board. In current cases, the board usually contains only one A/D converter. In order to enable digitalisation of more than one analog signal, a multiplexer is preconnected in front of this A/D converter. This multiplexer gradually switches input signals of separate channels to the converter.

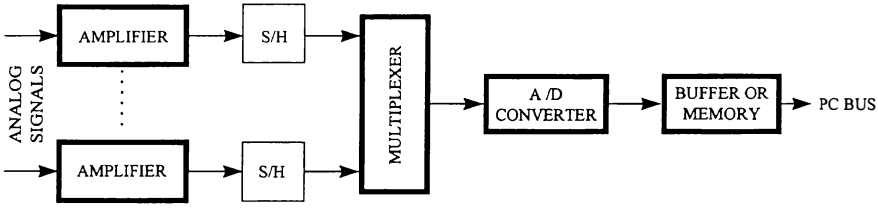

FIG. 1 - A/D BOARD WITH MULTIPLEXER

In principle the boards can be divided into two groups, as follows:
a) Boards containing only a small buffer, i.e. max. tens of kilobytes,
b) Boards containing large memory, up to several megabytes.

Ad a) When using these boards, it is presumed, that at the highest sampling rates the data are stored into internal memory of computer in course of the sampling. The limiting factor determining the maximum sampling rate in this case is the type of

the bus used (see below). At the present time, the boards with ISA or EISA buses are in the market and even boards with PCI bus begin to appear.

It is evident, that the boards with ISA bus are used for lower sampling rates - approximately up to 500 kS/sec. The boards with EISA bus are used for high sampling rates - up to several tens of megasamples per sec. At the present time, the boards with PCI bus are offered for sampling rates up to 1 MS/sec.

At lower sampling rates, the data can be stored onto disc or onto another record medium as early as in course of the sampling.

Ad b) When using these boards, it is presumed, that at the highest sampling rates the data are stored into quick memory on board in course of the sampling. In this case, the length of uninterrupted sequence of data sampled is defined by the memory capacity of board. When using lower sampling rates, the data can be stored into internal memory of the computer or onto a disc in course of the sampling.

For selecting the A/D board, it is necessary to know at least a rough meaning of basic parameters, which are given in technical specification. These parameters are explained in further part of this contribution (see [1], [2], [3]).

Sampling rate

A/D converter linearly transforms the voltage interval of the input analog signal <-U; +U> into an interval of integers <0; (2^n - 1)>. This process is named as a sampling of a signal. Transformations of voltage levels to an integer are usually carried-out in regular time intervals t_s. The reciprocal value of the t_s time interval is sc. sampling rate. This sampling rate gives number of transformations of analog signal to an integer for one second. Its unit is therefore [Samples/sec.] or shortly [S/s]. Selection of sampling rate depends upon the maximum frequency f_{max}, which we expect in the spectrum of the signal measured. If we shall process the signal within the frequency area, the following inequality must be fulfilled: $(2 \,.\, f_{max}) \leq f_s$ (this is a sc. Shannon - Kotelnikov's theorem). If we process the signal within the time area, usually the inequality $(10 \,.\, f_{max}) \leq f_s$ is required.

Main attention is to be paid to selection of sampling rate. If we select too low sampling rate, then it comes to signal distortion (sc. aliasing), which cannot be ever removed from the signal sampled. If we, on the contrary, select too high sampling rate, we are then forced to work with uselessly big volumes of data. So far discussed sampling rate represents the frequency of data in one channel measured. Provided, the A/D board contains a multiplexer (which is the majority of cases), the sc. inter-channel sampling rate is usually given in the technical specification, which actually gives the number of conversions carried-out by the A/D converter per second. If we, therefore, sample more than one channel, the data sampling rate from a certain channel will be a quotient of the inter-channel sampling rate and of the number of channels sampled.

When selecting the boards an attention is to be paid, that at some types the maximum inter-channel sampling rate depends

- on amplification of input signal (i.e. to input signal voltage range pre-set) or,
- on number of channels sampled.

Usually one value is given for sampling of only one channel and the other (the lower one) for sampling of two or more channels.

The sampling rate given in technical specification relates to a channel only at boards, which have no multiplexer and which have A/D converter for each channel (see Fig. 2). This design appears only at boards for higher sampling rates (usually beyond 1 MS/s). These boards belong, however, into higher price category.

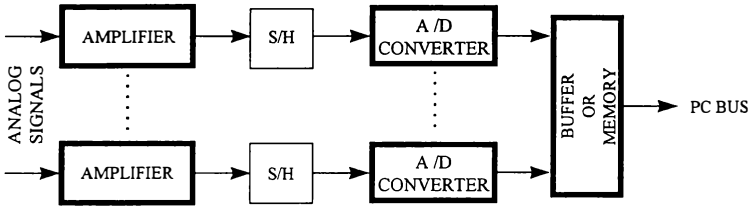

FIG. 2 - A/D BOARD WITHOUT MULTIPLEXER

Quantization Error of A/D Converter

The analog signal on input side of the A/D converter can reach all the values from the input voltage range pre-set. Number values of output n-bit side of the converter can, however, reach 2^n discrete values from <0; $(2^n - 1)$> interval, only. The „precise" number value gained by linear transformation of input voltage level must be, therefore, rounded off to the nearest integer. The difference between the rounded off value and the unrounded one represents the quantization error. This quantization error decreases with increase of bits of the converter output number, but the price of the A/D board grows. At several types of boards, it is possible to pre-set the resolution on the output of A/D converter (e.g. within a range of 12 to 16 bits). With a dependence upon the resolution used, even the maximum sampling rate is evidently changed.

Sample and Hold

Those A/D boards, which have only one A/D converter, take samples gradually from defined channels. The time sequence on output of A/D converter has, therefore, the following form:

1^{st} sample from 1^{st} channel, 1^{st} sample from 2^{nd} channel, 1^{st} sample from 3^{rd} channel, ...
2^{nd} sample from 1^{st} channel, 2^{nd} sample from 2^{nd} channel, ...

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n^{th} sample from 1^{st} channel, n^{th} sample from 2^{nd} channel, ...

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Separate samples of this sequence are, therefore, timely shifted by the sampling interval, which, however, means, that the n^{th} samples of all the channels are not taken in the same moment. In many cases this shift of time is negligible. But, if we need , that the samples of all the defined channels might be timely synchronised, the A/D boards has to be fitted with a circuit, which is designated as „S/H" (Sample / Hold) or „T/H" (Track / Hold) - see Fig. 1. This circuit „freezes" in fact the voltage

levels of analog signals on their outputs in the moment of sampling and these levels can be then sequentially converted to integers.

Range of Input Voltages

Ranges of input analog voltages can be usually set either by change-over switches of the board proper or by means of software. At simplier boards, the pre-set range of input voltages is common for all the channels. The more improved types of boards make it possible to set the ranges of input voltages individually for separate channels. This is of advantage namely in cases, when we need to simultaneously sample such signals, whose voltage ranges are very different. As it was already said, at some types of boards, the maximum sampling rate links to the range of input voltages - the decreased range of input voltages also lowers the sampling rate.

Connection of Analog Inputs

The following ways of analog inputs connection are used most frequently:

– single-ended,
– differential.

Some types of A/D boards have only one of these inputs, other make possible both types of connection. Provided the board contains both these types of connection, the maximum number of channels sampled for differential connection is half than for single ended connection.

Synchronising the A/D Boards

The most frequent type are the A/D boards with 16 single ended analog input channels. If we need to simultaneously sample more channels, it is possible in some cases to put two or more A/D boards of certain type into the computer. One of these boards as the controlling one starts the sampling of the other boards with the aid of the synchronising line.

Bus

If the board does not contain sufficiently large memory, we must transport the sampled data into computer memory or on a disc in course of the sampling. In such a case it is necessary to respect the limited throughput of the computer bus. Most frequent one is the ISA bus, whose width is 16 bits and maximum throughput 4 MB/s. More powerful one is the EISA bus, whose width is 32 bits and maximum throughput 33 MB/s. The EISA bus did not take too possession and at the present time the personal computers are equipped with a quick bus of PCI type, where the data can be transported with a speed up to 132 MB/s.

Maximum throughput of the bus can be usually used only at transfer of data from the board into internal memory of computer . If we want to store the data onto a disc in course of sampling, the throughput of the disc controller and the speed of disc are the main limiting factors.

How to Proceed at Selection of Suitable A/D Board?

Before the proper selection of the board, we must define the set of expected typical problems, which are to be solved by using the A/D board selected. This set

must contain even such problems, which appear occasionally only, but which have extreme requirements at least onto one of the following parameters:

- Number of simultaneously sampled channels,
- Maximum sampling rate expected in spectrum of sampled signal (which results in maximum sampling rate on one channel and inter-channel sampling rate),
- Accuracy of the analog signal digitalisation (which results in necessary resolution of A/D converter at the digital side or, in requirement concerning in possibility of input measuring range change),
- Maximum length of record, which is to be sampled without any interruption (which results in possibility of defining the required magnitude of memory on the board or in the computer and/or, in defining the necessary space on disc being usable for storing one record),
- Possibilities of starts and ends of sampling record.

Now we can look for such types of A/D boards offered , which would suit with their parameters to all the problems contained in the above mentioned set of typical problems. If we find such boards, we must finally decide, which firm we will buy the device from. If not, we must try to divide the set of typical problems into the smallest possible number of subsets and to allocate to each subset at least one A/D board, which would be possible to solve the given group of problems with the aid of its parameters.

Further important factor consists in selecting the software for sampling. Every type of A/D board is now standardly delivered in common with a driver for most current programming languages or for simple sampling programme. Besides this, each of the board producers offer further more perfect products, both in a form of libraries or ready-made programmes with different stages of elaboration. The user must, therefore, decide, whether he develops his own programme for sampling or for pre-processing the data sampled and/or, whether he buys a ready software packet.

Selection of deliverer must be also a part of decision about buying an A/D board. This question cannot be underestimated, since, regarding our experiences, the niveau of technical services of the firms offering the computer and measuring technique is on a very low level at the present time. The following points summarise, therefore, some recommendations, how to proceed when selecting and dealing with a deliverer of an A/D board:

1) Try to gain the highest possible quantity of written technical documentation. Study these materials carefully and then try to test, whether the firm agent knows the basic technical parameters by heart or, whether he is able, at least, to find them in the catalogue, which you have received from him.

2) Try to find out the commercial and technical background. It is important, when solving the problems, which usually appear at beginning phase of using the device. Eliminate small firms formed by one or two persons and having the only business space in unused room of their flat. Try to find out, whether the device selected does not form a marginal part of assortment offered by the firm.

3) When selecting the firms, prefer those, which are able to demonstrate you, that the required type of the A/D board really fulfils the declared technical parameters (max. sampling rate, max. length of uninterrupted record etc.).

4) Try to negotiate with deliverer to test operation of A/D board on your computer before ordering. Every firm will namely affirm you, that its device is quite compatible with IBM PC Standard and that its device will cause no troubles. It is true, that the devices delivered are in principle compatible with given standard, but excepting some small deviations, which, however, cause, that the bought A/D board will be without any function on your PC. Then, you will hardly demonstrate, whether this incompatibility is at the side of PC or A/D board.

5) Try to gain contacts from delivering firms to customers, which have bought the same or similar type of the board, you have selected.

6) The order is to be filled with as precise as possible specification of the A/D board ordered. Many devices have namely various configurations, which in principle influence their usable properties.

7) Order together with A/D board also assembly into your PC, its debugging and testing at extreme parameters of sampling. These requirements should be precisely specified in written order.

8) Before closing down an order study claim and guarantee conditions of the delivering firm. Their contents demonstrate the relation between the firm and the customer. Inform yourself about the guarantee services and about after-guarantee ones of the firm.

For a basic orientation in our market, we finally put addresses of three firms, which you would not omit to contact, when selecting the deliverer of an A/D board:

DEWETRON PRAHA, s.r.o., Dubečská 4, 100 00 Praha 10
TECTRA a.s., Domkovská 2342/43, 193 00 Praha 9
UEI, PRŮMYSLOVÁ A LABORATORNÍ ELEKTRONIKA, s.r.o., Novodvorská 1010/14, 142 00 Praha 4.

References

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[2]Kotas M.: Technical Equipment for Measurement of Dynamical Quantities and their Future Development in Department PAP. Research Report. ŠKODA Výzkum s.r.o. Pilsen, December 1995 (In Czech).
[3]Practical Analog Design Techniques. Analog Devices, USA, 1995.

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