We have developed such a multichannel analyser built around an SDK 85 Intel kit which uses an 8018 microprocessor chip. The general philosophy of our design can be implemented with almost any other 8 bit microprocessor, and improvements can be added if faster microprocessors are used. The system was built and tested with 128 channels but can be easily expanded with small software changes to 256 or even 512 channels. The hardware diagrams are shown in Fig. 1 and Fig. 2. The SDK85 microcomputer is shown in Fig. 1 with the analog signal circuit connected to the I/O ports.

![Fig. 1 Analog board connected to the SDK85.](image)

![Fig. 2 Analog circuit diagram. Only seven I.C.'s a transistor, a FET and a few resistors are used.](image)
This circuit is implemented with only six standard low cost integrated circuits, all easily available, one FET and a few resistors. The integrated circuits are non critical and can be replaced by similar CMOS devices reducing power consumption to a few mW. Block A is the comparator, B the stretcher, C the analog gates and D the constant current source. Block A is built around a single inexpensive LM339 quad comparator. The pull-up output resistors are connected to the +5V supply so that TTL compatible outputs are generated. The increase in rise time due to the the use of this lower voltage is of no practical consequence and allows direct connection to the ports. The value of the output capacitance is such that the delay in the high to low transition is of the order of the microprocessor test period of that input line in order to guarantee that the microprocessor never misses the outputs of the two comparators. The stretcher configuration is a common one. The values of resistors and C₀ can be tailored to suit the shape of the input signal. However slow, this stretcher is good enough for most applications. The gating block C was built with Texas Instruments TL 601 and TL610 integrated linear gates. Its transient and computing performances were found to be accurate enough. Because of the non availability of an integrated current source with good transient performance, an operational amplifier and a FET were used to linearly discharge the stretcher capacitor. The use of a double pole switch S₃ reduces transient charge transfers during switching.

Fig. 3 is the flowchart of the main program. To be ready to accept pulses the microprocessor turns on S₃ quickly discharging C₀. Afterwards it connects the input signal to the stretcher and makes a test to C₁ output. If an input signal already exists the program is reinitialized and the signal is rejected to avoid conversion errors. If not the microprocessor tests the output of C₁ waiting until a pulse arrives. Then it waits until the pulse has decayed and checks for overloading, testing the output of C₂. If at any moment the signal exceeds the overload level the pulse is ignored and the program reinitialized. Otherwise S₁ is turned off, the hardware interrupt enabled and S₃ connects C₂ to the linear current source. After this, the microprocessor executes a number of "no operation" instructions that depends on the pulse amplitude, until an interrupt occurs. Then the digital value of the amplitude of the pulse is extracted from the content of the program counter which is proportional to the discharge time. This technique gives an improvement on the counting speed over conventional iterative algorithms because jump instructions are avoided and the "no operation" instruction is faster than the "increment" one. After the interrupt the cell memory corresponding to that channel number is incremented, the microprocessor outputs the content and number of the channel to the X-Y DAC's and it is ready for a new conversion cycle. If the live display feature is unnecessary the output instructions can be omitted.

Subroutines for CRT display, plotter, LED display, channel selection and printer were developed and successfully used. A fully software supported keyboard was equally incorporated in the prototype.

The measured differential linearity for pulses with risetime about 1 μs was about 1% and was limited by the stretcher. Average deadtime was about 200μs. Fig. 4 shows a
typical spectrum obtained with a $^{60}$Co source. The counting rate was about 2000 pulses per second.

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References


Fig. 4 Spectrum obtained from a $^{60}$Co source using a NaI(Tl) detector.