IMPROVED ANALOG SCANNERS FOR THE ISR COMPUTER

by

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1. **THE PERFORMANCE OF THE PRESENT SYSTEM**

It will be useful to start by listing the characteristics of the present system.

Input voltage range: ±2.5 v.
(In practice at least 3 volts can be handled.)

Method: Integrating digital voltmeter technique with reed-relay scanner on the input.

Integration periods: 10, 20, 100, 200 milliseconds.

Resolution: least significant binary digit in the number sent to the computer depends on the integration period, as follows:

\[
\begin{align*}
T &= 10 \text{ milliseconds, } \Delta v = 1 \text{ millivolt} \\
T &= 20 \quad " \quad \Delta v = 0.5 \text{ millivolts} \\
T &= 100 \quad " \quad \Delta v = 100 \mu\text{V} \\
T &= 200 \quad " \quad \Delta v = 50 \mu\text{V}
\end{align*}
\]

Precision: The zero offset seems in practice to have a drift of \((2\sigma)\) about 100 \(\mu\text{V}\).

The gain is set by a standard cell at 1.0191 volts and is stable to \(10^{-4}\) for long periods.

Linearity errors are below 100 \(\mu\text{V}\) in the 0 to 1 V region, and below about 300 \(\mu\text{V}\) up to 2.5 volts input.

Noise rejection: Using 20 milliseconds or longer for the measurement time, the rejection of signals at mains frequency and harmonics is very high.

There is a high-frequency rejection of series-mode noise given by the integration technique, for example >40 dB at frequencies above 500 Hz when using an integration time of 100 milliseconds.

Common mode rejection: 120 dB from d.c. to 60 Hz. Common mode voltage should normally be limited to 10 volts, but in special cases (by prior agreement, and not to be...
encouraged) the system can handle steady common-mode levels of 50 volts.

Input impedance: 1000 megohms shunted by 2000 pF. Signal source resistance should be below 10,000 ohms if possible, and preferably balanced to earth.

Input arrangements: Groups of 10 pairs in a 26-core cable arrive at the scanner, with 28 pin Burndy female plugs on the cable. Other input cabling arrangements, particularly for small groups of signals, are accommodated in an interconnection unit below each scanner.

Scanners and channels: Each scanner has two channels, A and B, which are read simultaneously. There is a scanner in each equipment building A1 to A8, with extra scanners in A2 and A7, and also one in the SRC cellar (SRC-0).

System capacity: The standard scanner has 320 inputs, split equally between A and B channels.

Reliability: This system has been working continuously since 1970 and has proven to be extremely reliable and trustworthy. In that respect it would be very difficult to find any better.

2. IMPROVEMENTS PLANNED FOR THE PRESENT SCANNING SYSTEM

2.1 Gain Range

There are quite a few applications where rather low signal voltages are being measured. The scanner is therefore having to be used on the 100 millisecond range to achieve the desired resolution. Vacuum gauge signals are one example of this. To achieve high resolution at high speed we propose to add a gain-control facility to each converter. The development is minimal as the converter already has a range switch for 1 volt, 100 mV and 10 mV scales. It would not be feasible to turn the knob by remote control so we shall install a
relay-operated gain change, using a mercury-wetted reed to achieve the required life.

The second range will be ±250 millivolts full scale. We expect to obtain a similar precision to the present range: our tests have indicated that the user should not expect an absolute accuracy better than 100 μV including zero drift, although use can be made of the improved resolution in comparing readings from the same scanner.

Gain control for the two channels in each scanner will be selected independently. Existing programs will not need any changes.

The modification will be introduced in January 1973.

2.2 Scanner Capacity

The new ion chambers and a few additions to the vacuum monitoring system will almost completely fill the allocated capacity of the scanners. We therefore wish to add to the capacity. The technique chosen is a 4-bit extension to the sub-address, which will theoretically extend the capacity in each building from 320 to 5120 inputs. No changes are envisaged to the bulk of the address allocations already made, but the new facility will be employed for the new ion chambers (scanners 2, 4, 5 and 7) and probably also for the sodium gas curtain temperature monitor system (scanner 5).

The users will see no significant differences in the scanners.

The scanner hardware will be purchased from a manufacturer, out of his standard range, in contrast to the present system which uses scanner cards developed by ourselves. The rear panels will be modified to take ISR standard connectors, but the internal hardware will be untouched. The unit we expect to purchase will be Camac compatible.
3. NEW SCANNING SYSTEM

It has been realised from the start of the ISR project that the low speed of operation of scanners relying on relays and integrating d.v.m. techniques is a major drawback. Against this we considered the accuracy, insensitivity to noise and immunity to damage by transients very useful. This system has an equivalent resolution of 16 bits. Fast 16 bits converters are nowadays available but they are extremely expensive. Moreover it is doubtful that, once installed and remote signal sources connected, the real resolution would exceed 13 or 14 bits.

But it is felt that there is a need for a new, high-speed analog input system, and that the time is now ripe to specify something which can be purchased, or built out of commercially available modules, at a reasonable cost.

Specifications are being established now, in a preliminary form, for a high-speed, all solid state, Camac compatible system. This will be modular in concept, and easily linked to any computer in the future, if we need to alter radically the configuration of our computer system. (We expect to use the new system for data acquisition in the pulsed TT2 beam line.)

Specifications:

- Input voltage ranges: ±4.096 V
- ±1.024 V
- ±0.256 V

Method: Successive approximation or fast double ramp.

Total conversion time including multiplexing, settling time and intermediate storage: around 60 msec. The conversion of a group of 16 signals would take about 1 msec.
Resolution: 12 bits plus polarity.

Least significant bit represents 1 mV, 250 µV or 62 µV according to the input voltage range selected.

Precision: integral linearity: 0.01% of full scale.
zero drift: <0.025% of full scale at 25°C during 8 hours
temp. coeff. 0.005%/°C
scaling drift: <0.025% of full scale at 25°C during 8 hours
temp. coeff. 0.005%/°C.

Effective precision can be improved by software calibration.

Common mode rejection: 100 dB DC -> 100 Hz

Input impedance: differential input impedance >100 MΩ

Input arrangement: 16 differential inputs directly accessible by the converter. Different groups of 16 signals can be connected to the input by external (slower) multiplexing.

System capacity: unlimited extension possible by the use of external (Camac driven) multiplexing.