EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

INPUT AND OUTPUT SYSTEMS FOR THE ISR CONTROL COMPUTER

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SUMMARY:

The current specifications for digital and analogue scanning systems are described, with information on the way in which signals have to be connected to the input terminals. The arrangements for connecting the analogue scanner and other devices to the computer, within the control room, are also outlined.
1. **DIGITAL SCANNING**

1.1. **Principles**

As far as the users will be concerned, the digital scanning system to be used for collecting large amounts of status information from the remote equipment buildings will be as described in the previous report, Ref. 1. As the central control logic is being purchased as part of the Argus computer, there are some differences in the manner of operation.

The status indications must be presented in the form of isolated contacts. The drive circuits will apply up to 50 volt impulses to each set of 24 contacts in turn, and pass about 20 mA through any closed contacts. The set of 24 contacts is of course chosen to match the computer word length.

The computer equipment will have three separate scanners, so that although each set of contacts is examined for a 1 ms period, the total scanning time for the complete system will be limited to about 112 ms. In this period, a block of core store will be completely updated, so that digital information may be obtained by any user program instantaneously, and will have been updated within the preceding 112 ms. Although continuous scanning of data which changes rarely might seem extravagant, the block of core store reserved for the data is only 356 words out of 16,384 and the input-output loading is very small indeed.

It is clear that this system must be reserved for data which can tolerate a computer response time of the order of a quarter of a second, and not for any high speed applications (which are discussed in section 5 below). Typical applications will be to monitor equipment on-off and fault indications, to collect data from interlock systems, to examine range switches on vacuum gauge control units, check valve positions etc...
1.2. **Layout of equipment**

The digital scanning units in the standard equipment buildings such as A3 will have a capability of 24 words of 24 bits, i.e. 576 signals. Each word must be connected to a 28-pin Burndy connector on one of two crates. There will be some cases where the connection will be made directly via a 26 core cable to the equipment generating the signals, but it will be normal to go through an interconnection unit where the digital and analogue signals will be marshalled into suitable groups. The cable to the interconnection unit, and the unit itself, will be the responsibility of the Controls Group. Digital signals (and other signals) will be wired to the interconnection unit in a manner to be agreed to suit the requirements. Where possible, the interconnection units should be located in the racks in which the signals are produced, to simplify the wiring.

In the 26-core cable two cores (No. 25 and No. 26) are used for a common drive to 24 contacts. In wiring to the various equipments, the same system may be used, but the two connections to any contact should follow the same route and avoid large loops so it may be necessary to change to individual wire pairs at a convenient point.

1.3. **Stand-by monitoring**

To aid in fault-finding, a monitor unit will be constructed which will provide indications in the SRC of any selected digital word.

1.4. **Alternative input units**

The specification insists on floating contacts. However, if it becomes absolutely necessary, it will be possible to replace the plug-in units carrying the isolating diodes by units containing more complex equipment, such as 24 small relays.
2. ANALOG SCANNING SYSTEM

2.1. Principle

The outlines of the system are as described in the earlier report, Ref. 1. The significant features are repeated here, for the sake of completeness.

The measurement system is based on the use of voltage-to-frequency converters, with a full scale input of ± 2.5 volts d.c. The output frequency is 100 kHz per volt input, and the measuring periods will be 10 ms, 20 ms, 100 ms, and 200 ms. The instrument will be capable of maintaining about 0.05% accuracy, and we shall provide calibration signals so as to be able to correct the readings for small drifts in zero and gain.

Two converters will be fitted in each auxiliary building, with a change-over switch so that measurements may be made if a fault occurs, although at a lower speed.

The "normal" integration time will be 20 ms, giving a count of 2000 per volt, or comfortably reaching 0.1% resolution. The 10 ms integration will only be used when a high speed, low accuracy measurement of relatively hum-free signals is needed. The longer periods are not intended for very high accuracy measurements, but rather for improving the resolution on small voltages such as sputter-ion pump current monitor signals.

The standard selection system in an equipment building will be able to handle up to 320 analog signals, in 160 pairs. Selection will be achieved by energising one of 160 pairs of reed relays through 26 wires, by a diode matrix technique.
A "two-pole plus guard" scanner is proposed although the guard may be linked to the low-potential side of the signal at the scanner or at the interconnection unit if desired. Neither side of the input should at any time deviate by more than 10 volts d.c. from the guard potential, which should itself be limited to about 50 volts d.c. from earth for safety reasons.

Each V/F converter will be connected to a binary up-down counter in the SRC, interfaced to the computer. For stand-by use a pair of decimal counters with displays may be switched to any scanner.

Manual selection of points for decimal display will be by pull-out trays, carrying a fully labelled 10 by 16 matrix and 26 selector buttons. Three modes of manual operation will be possible: picking off when a computer scan of the selected point occurs, using spare time in the computer scan cycle, and locking out the computer.

2.2. Layout

The relays for selection will be located close to the V/F converters in each equipment building. Plug-in cards containing 10 relays will be used, and the whole system will occupy 4 - 5 crates of 5 H units.

Input connections will normally be via 26-core screened cables, with two wires per signal. However, the scanner cards provide three-pole switching of each input, and in critical cases twin-screened input connectors can be used.

2.3. Computer interface

The analogue scanning systems in the various buildings will be run virtually independently, although they will use a common 1 ms pulse train for internal timing. There will be 11 or 12 scanners at first, but the system will be readily expandable. Single output instructions to any scanner will
specify the required channel and the measurement period. On completion of a measurement the equipment will generate a computer interrupt, common for all scanners, and a digital input word specifying which scanners are ready to be read by the computer.

An isolated and buffered input-output interface as described in section 5 below will be employed.
3. **CONTROLS**

3.1. **General**

It is rarely convenient or safe to link control channels with general purpose systems, as several users may wish to perform control actions at the same time, and could interfere with each other. These remarks apply particularly to major systems such as magnet power supply controls and r.f. controls.

3.2. **Extension to the analogue scanner**

Provision is made in the design of the analogue scanner to add a few control signals and status indications. These would be selected in parallel with the analogue selection, but by an independent relay. An example of this technique is the ISR auxiliary power supply control system, in which the analogue scanner in the power house is modified to act as two independent single-channel scanners, with status indications and controls added. This scheme is quite elaborate, and is described in a report to be issued shortly.
4. **INTERCONNECTION UNITS**

The standard interconnection unit will fit in a 19" rack, and will be 12 units high (about 53 cm). It will have four columns of AMP Faston terminal units, two for scanner connections and two for "user" connections. Each column will take 90 terminals. The total capacity will thus be as follows:

- up to 6 x 24 i.e. 144 digital signals.
- or up to 60 analogue signals
- or up to 4 x 24 digital signals and 20 analogue signals
- or other combinations of digital and analogue signals plus associated control signals.

Some of the terminals may be used for wiring which is not directly linked to the computer, for example where a control signal comes from some piece of equipment in the same cable as the computer signals. No rules can be laid down at this stage for standardisation of interconnection unit wiring, but several standard layouts will be used in buildings A1 - A8, and elsewhere if possible. An interconnection unit is illustrated in Figs. 1 and 2.
5. **HIGH-SPEED INPUT AND OUTPUT**

5.1. **Principles**

The systems described in sections 1, 2 and 3 above are all intended for slow, reliable operation of and measurements from remote equipment. There is also a need for much faster equipment, to link these and other systems to the computer. We propose to confine the use of very fast signals to the SRC.

The computer is provided with a standard interface which has 24 data output lines, 24 data input lines and 12 "address" lines which can specify the peripheral unit concerned. In addition, there are some timing pulses for controlling data transfer, interrupt lines, and control lines for the high-speed direct-memory-access system. Because this latter runs at core store speed (1 microsecond in our machine) and shares the data lines mentioned above, the interface wiring is limited in length and quite complicated.

For general-purpose use in CERN constructed equipment, apart from some very specialised units which must use the raw computer interface, it is proposed to construct a buffering unit, which will both slow down the timing and provide isolation between the computer earth and those of the various other systems involved. This buffered interface will only handle programmed input-output, so it may run at about a 10-microsecond cycle time quite comfortably. Up to 8 separate channels will be available.

The principle is shown in Fig. 2. The address portion of each programmed input-output instruction is decoded and the least significant 6 bits routed to one of several stores. The stored "sub-address" is then transmitted to the peripheral unit, where it is decoded and controls transfer of data into up to 64 output registers, and from up to 64 words of input signals.
If an output instruction is used, a strobe pulse is generated and this is used to transfer 24 bits of data into the peripheral registers. In the case of an input instruction, this data strobe is not generated.

From the programming point of view, the buffering of the interface has little effect on OUT instructions, which are still standard form. The only restriction is that the system should not be addressed by two successive instructions.

If a digital input is required, the `LDX (input)` function will be used, with a peripheral address in the same range as for outputs. This will gate the required data to the computer digital input unit, where it must be read by a further `LDX` instruction to addresses 300 to 307 octal. The filters in the digital input unit will produce a 3 microsecond delay, so the two instructions required to perform "buffered digital input" must be separated by at least one other instruction. In some cases it may be necessary to set interrupt lockout, so that the full instructions might be:

```
  0   OUT SETLOCKOUT
  0   LDX %5102
  0   OUT CLEARLOCKOUT
  5   LDX %303
```

This sequence would take about 17 microseconds, which is acceptable at the low data rates envisaged. It could be programmed as one ASTRAL macro-instruction.

5.2. Applications

The buffered interface can be used for the following systems:

1) Analogue scanner control, and ISR auxiliary magnet power supply controls.
2) Beam Transfer power supply controls.

3) Parts of the RF control and monitor system.

4) The collection of SEM monitor readings.

5) Control and display panels in the SRC.

5.3. Physical Details

The electronics for the buffered interface will be installed in 3 crates of 6 height each in one of two CERN racks adjacent to Computer Nr. 1.

These crates will also contain isolators for interrupt and busy lines and for other digital inputs. The input and output cables for the above and for most other connections to the ISR will be taken from the lower half of these two racks.

Each buffered output channel will use a 16-core cable for the strobe pulses and sub-address, a 48 core cable for the 24-bit output data and a 48-core cable for each 24 input lines. A certain flexibility will be allowed in data wiring, so as to provide for smaller cables where convenient, and to accommodate interrupt lines and other special signals.

A simplified form of the interface with one channel may be installed in Computer No. 2 for development purposes.

Remote terminals will vary in complexity, from a simple command pulse decoder on about four NPA-style cards, to storage and gating of many words of input or output. One useful standard unit will be a crate, again 6 units high, which can accommodate 9 up to 8 words of computer output or up to 8 words of computer input, with the total limited to 9 words. The system would resemble CAMAC, and in fact a CAMAC buffer card could be built to be driven by this system.
6. DEVELOPMENT AND INSTALLATION TIME SCALES

6.1. Detailed design work on the digital and analogue scanning equipment is well advanced, and some prototype units have been constructed for evaluation of the mechanical design. It is planned to have the first set of equipment ready for testing in A3 in October 1969, together with part of the SRC equipment which would be tested in A3. for convenience. The installation of the complete system should be completed by about May 1970, according to the installation plans for the other ISR equipment.

The SRC equipment will be installed by January 1970 and will be linked to the computer in February.

6.2. So that the analogue scanner can be connected to the computer as early as possible, the buffered interface equipment must be completed in November 1969 for testing soon after completion of the computer acceptance tests.

6.3. Programmes for data acquisition will be available in time to make use of the computer system from July 1970 onwards for magnet power supply tests and bake-out.

7. REFERENCE

Fig. 1 (Interconnection Unit)
Fig. 2 (Interconnection Unit - Detailed)
Figure 3
Simplified Block Diagram of Buffered Interface System