
1. INTRODUCTION.

In recent years high energy experimental apparatus have dramatically grown, requiring a large number of detectors like plastic scintillators, drift and proportional chambers, to be supplied and controlled at great distances.

In building the vertex detector for FRAM experiment, under assembly in the North Area of CERN SPS to study new particle production and $\eta_c$ Primakoff effect (1, 2), we have adopted an innovative design approach to supply and control the detectors' high voltage. The FRAM 77 system replaces the conventional high voltage supply, with less requirement of space for the distribution system and the monitor ADC system, avoiding the use of several kilometers of high voltage cable. The conventional H.V. system usually presents functional disadvantages, such as limited resolution, difficulty in remote control and monitoring, and the adverse influence of one shorted output upon all others.

The FRAM 77 system comprises 64 independently controlled generators adjustable from 0.35 KV to 3 KV and able to supply up to 2 mA. They are located as near as possible to the set-up, in slave stations. Standard LEMO cables provide an up and down link with a CAMAC control station needed to set and monitor the high voltage status. This control station is also interfaced to a manual console that

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enables the operator to bypass the computer. The remote control facility is designed also to guard against a possible catastrophe caused by power failures, computer errors, software bugs or operator errors; moreover, the failure of one supply has no effect upon the operation of the others.

2. - DESCRIPTION.

The basic system comprises 64 negative H.V. generators assembled into eight cards (H.V.G.), a digital-to-analog and analog-to-digital multichannel conversion unit (M.C.S.) and a remote control unit (R.C.U.).

All these modules are powered and linked together by a crate conforming to CAMAC mechanical specifications (but not to the electric ones).

The system is controlled through four coaxial cables by a master control unit (M.C.U.), a special purpose CAMAC module that links the console and the computer (by the CAMAC system) with the H.V. digital module (R.C.U.).

3. - MODULES DESCRIPTION.

3.1. - Master Control Unit (M.C.U.)

Uses two CAMAC stations and allows:

- Encoding in serial format and transmission to the remote control unit of pertinent CAMAC or console commands.

- Acquisition and decoding of status information from the remote control unit. The status word is stored in the suitable location (one per channel) in the system image memory. Several CAMAC functions allow reading the memory content.

3.2. - Remote Control Unit (R.C.U.)

The RCU houses a memory system containing for each channel:

- The chosen voltage value (12 bits).

- A status bit to allow the acquisition of information from computer.

- A status bit to Switch ON/OFF the H.V. generator.

The memory system is currently controlled by the M.C.S., However, upon command reception, the control memory system is removed from M.C.S. to allow modification of the selected channel content.

The information of each channel stored in the memory and the current H.V. value (digitized by M.C.S.) are continuously transmitted to M.C.U.
OREGANIZATION OF FRAM 77 SYSTEM

SPECIAL PURPOSE CRATE

2 ST. 2 ST. 8 ST.
64 CH. 64 CH. 64 CH.
RCU MCS HVG

64 H.V. INDEPENDENT OUTPUTS: 0.35 - 3 kV, 2 mA

UP TO 1000 m

4 RG. 176/U
LOW VOLTAGE CABLE
SERIAL INFORMATION

2 BY
32 - 64 CH.
MCU

UP TO 7 m
TWISTED PAIR CABLE
PARALLEL INFORMATION

ON-LINE COMPUTER
SETTING AND READ OUT

CONTROL ROOM

CONSOLE
SETTING AND READ OUT

UP TO 54 CH.
INDEPENDENT CHANNELS
3.3. - Multichannel Conversion System (M.C.S.)

Comprises two cards:

- DAC card, where digital value are converted into 64 voltage set-points. This is performed in a cyclic way by a single multiplexed 12 bit digital-to-analog converter and 64 analog memories (capacitors). A counter generates an address to recall the value stored in the memory system (in the R.C.U.). A common voltage limit, adjustable by a potentiometer, can be used for protection purposes.

- ADC card, where 64 monitoring voltages are converted by a multiplexed 12 bit analog-to-digital converter into digital words serially transmitted to R.C.U.

3.4. - H.V. Generator (H.V.G.)

Each of eight cards contains eight independent H.V.G. The H.V. generator is a switching mode flyback (time modulation) DC-DC converter. The converter has local feedback loop to keep an output voltage proportional to the setting voltage.

3.5. - Console.

The console is a special purpose device which provide the following read-out and setting facilities:

- Read-out operation.

The read-out operation allows:

- To select, with two rotary switches, the address. The first selects the channel (one of 16), within the group selected by the second one (one of 32).
- To monitor, by one 4-digit led display, the voltage setting of the selected channel.
- To monitor, by sixteen 4-digit led display, the actual output voltages of the 16 channels of the selected group.
- To monitor, by two leds, the status of the 16 channels of the selected group about the ON/OFF H.V. status and the Console/Computer settability.

- Setting operation.

The setting operation allows to accomplish the following independent functions:

a) - Generates a MASTER RESET signal on the 16 channels of the selected group causing:
- Switch off of H.V. generators;
- Writing of the word zero (= 0 volt) in the memory system of the R.C.U.;
- Setting of the 16 channels in the status of "disabled computer".
b) - Generates on the selected channel one of the following signals:
- SWITCH OFF: of the H, V. generator only for the selected channel;
- SWITCH ON: of the H, V. generator for the selected channel;
- DISABLE COMPUTER: set the chosen channel to be able to accept commands of change (of the voltage value) only by console;
- ENABLE COMPUTER: set the chosen channel to be able to accept commands only by computer;
- INCREASE 1: increase by 1 step the chosen high-voltage digital value;
- DECREASE 1: decrease by 1 step the chosen high-voltage digital value;
- INCREASE 10: increase by 10 steps the chosen high-voltage digital value;
- DECREASE 10: decrease by 10 steps the chosen high-voltage digital value.

4. - SYSTEM SPECIFICATIONS OF EACH H, V. CHANNEL.

OUTPUT VOLTAGE:
0.35 to 3 KV, variable by 1 V step; the lower limit is for 1.5 MΩ load resistor.

OUTPUT CURRENT:
0 to 2 mA.

VOLTAGE REGULATION:
≤ 3 x 10⁻⁴ no load to full load.

STABILITY:
TEMPCO ≤ 200 ppM/°C, 10 to 40° C. Long term drift < 2 x 10⁻⁴/day after warm up.

NOISE AND RIPPLE:
≤ 1.5 x 10⁻⁴ of output or 100 mV whichever is greater.

OVER VOLTAGE PROTECTION:
Adjustable by 10 turns potentiometer from 0 to ~ 3.1 KV, common to 64 channels (limits the programming voltages). Limit point monitoring: + 1 V/KV, 2 out = 1 KΩ, accuracy ~ ± 3% of full scale.

PROGRAMMING:
by 12 bits straight binary word. Conversion factor: 1 V/step adjustable to within ±0.03 %. Differential linearity: < ± 1 V. Setting outside the output voltage range of the generator or in excess of the voltage limit is ineffective.

H, V. reading:
by 12 bits straight binary word, 1 V/step. Accuracy: ±1 V ±0.05%. About four reading/sec per channel.
SWITCH OFF TIME :
\[ \tau = 80 \text{ ms with } R_{\text{LOAD}} = 1.5 \text{ M\Omega}, \quad \tau = 2.75 \text{ s with } R_{\text{LOAD}} = \infty. \]

SETTLING TIME :
\[ \leq 200 \text{ ms to within } 0.1\% \text{ for a } \pm 100 \text{ V step change at } 2 \text{ KV.} \]

ALLOWABLE SHORT CIRCUIT DURATION : 
\[ \geq 10 \text{ s; there is also a fast type fuse for current on primary of transformer } \geq 1.2 \text{ A.} \]

DIGITAL TRANSMISSION :
The information is transmitted in serial format by two 50 \( \Omega \) coaxial cables (RG-174/U) with TTL levels for both links. The M, C, U, can transmit to R, C, up to 40,000 commands per second. The M, C, U, receives about four updating status words per channel per second.

5. - CAMAC COMMANDS AND FUNCTIONS.

CAMAC ADDRESSING FORMAT :
The 64 channels are divided in two classes (low class, channels 1-32, and high class, channels 33-64) accessible by two individual N lines from control station, the low one and the high one. Each class is further divided in two groups of 16 channels (GROUP I, channel 1-16 and 33-48, and GROUP II, channel 17-32 and 49-64) to which different CAMAC functions are assigned. Last, the CAMAC subaddresses select the channel.

READ OUT CONTROL :
The status of each channel is stored in a RAM in the CAMAC interface and is continuously updated by the remote unit. The latest information is at any time ready for CAMAC readout.

CAMAC COMMAND :
\( X = 1 \) (command accepted, one for each class) is generated when a valid N, F and A command is generated.

STATUS READ OUT FORMAT :
Two kind of status are available for each channel:

STATUS I : R1-R12 actual H.V. reading
\( R_{13} \) UNDERFLOW (\( R_{13}=0 \) means that the HV reading is in two complement format)
\( R_{14} \) 0N/OFF
\( R_{15} \) ENABLE COMPUTER.

STATUS II : R1-R12 H.V. set-point reading
\( R_{13}, R_{14}, R_{15} \) like status I.
CAMAC FUNCTION CODE (all require N, A and S1):

\begin{align*}
F(0) & : \text{read STATUS I - GROUP I} \\
F(1) & : \text{read STATUS II - GROUP I} \\
F(4) & : \text{read STATUS I - GROUP II} \\
F(6) & : \text{read STATUS II - GROUP II} \\
F(10) & : \text{write GROUP I} \\
F(17) & : \text{write GROUP II} \\
F(12) & : \text{increase GROUP I} \\
F(14) & : \text{increase GROUP II} \\
F(28) & : \text{decrease GROUP I} \\
F(30) & : \text{decrease GROUP II}
\end{align*}

\{ \text{set through write lines (W1-W12) the chosen high-voltage digital value} \\
\text{increase by one the previous high-voltage digital value} \\
\text{decrease by one the previous high-voltage digital value.} \}

REFERENCES.


Nota del Servizio Documentazione:
Manoscritto definitivo pervenuto nel gennaio 1978.