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zoli[x], F.L. Fabbri, G. Levy, G. Mannocchi[x], M. Pallotta, P.
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SYSTEM REMOTELY PROGRAMMABLE HIGH VOLTAGE P.M.
POWER SUPPLY.

1. - INTRODUCTION.

In recent years high energy experimental apparatus have drama
tically grown, requiring a large number of detectors like plastic scintil
lators, 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 photo
production and η_c Primakoff effect[1,2], we have adopted an innova
tive design approach to supply and control the detectors's high volt-
age. 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 kilome-
ters of high voltage cable. The conventional H.V. system usually
presents functional disadvantages, such as limited resolution, diffi-
culty in remote control and monitoring, and the adverse influence of
one shorted output upon all others.

The FRAM 77 system comprises 64 indipendently controlled ge
nerators 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 sta
tus. 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 faci
lity is designed also to guard against a possible catastrophe caused by power
failures, computer errors, software bugs or operator errors ; more-
over, 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 as-
sembled 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 elec-
tric ones).

The system is controlled through four coaxial cables by a mas-
ter control unit (M.C.U.), a special pourpose 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 trasmission to the remote control unit
  of pertinent CAMAC or console commands.

- Acquisition and decoding of status information from the remote con
  trol 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.

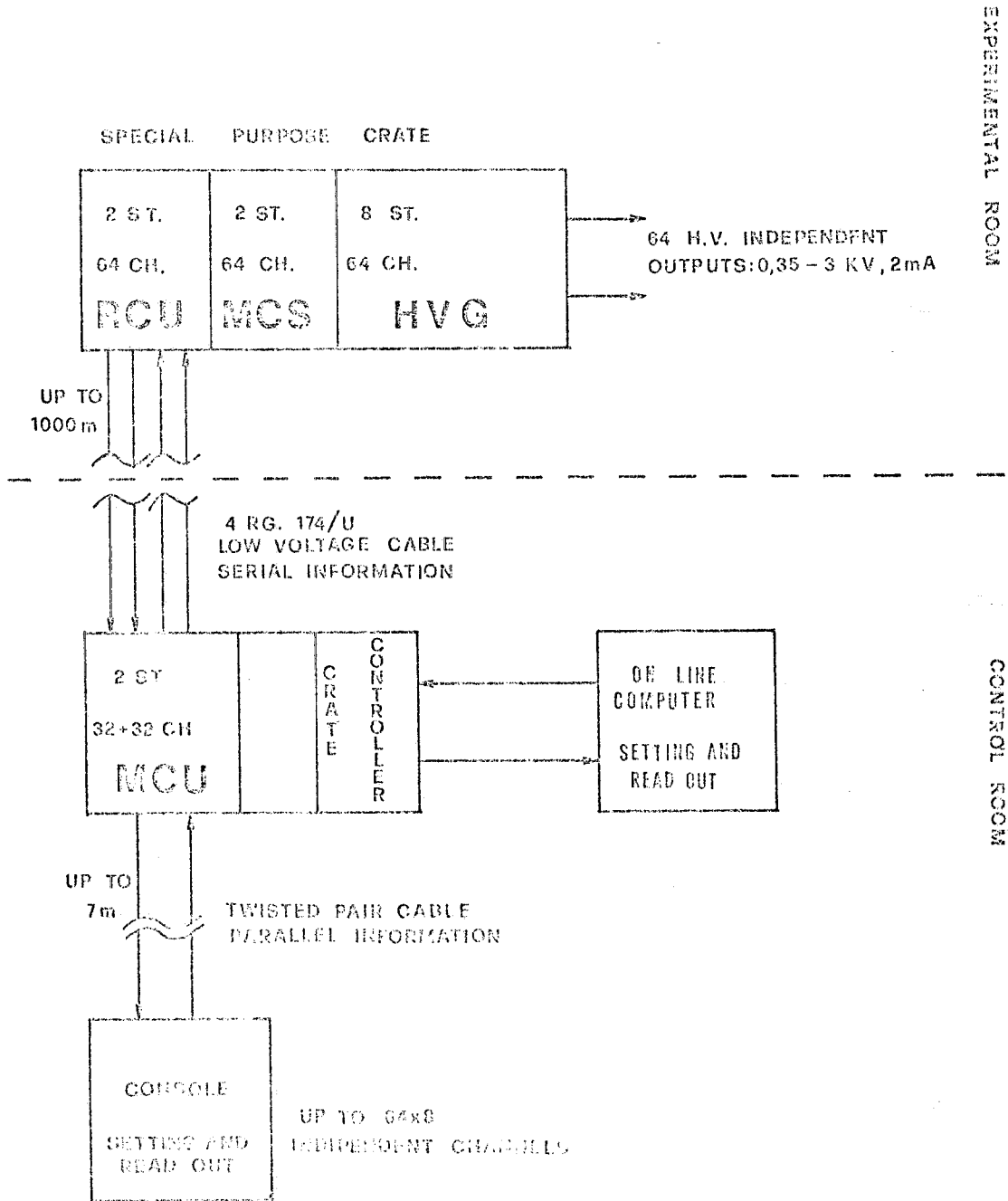### 3.2. - Remote Control Unit (R.C.U.)

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.. Ho
wever,upon command reception,the control memory system is remo-
ved 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 continuosly trasmitted
to M.C.U.

ORGANIZATION OF FRAME 77 SYSTEM

SPECIAL PURPOSE CRATE

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

64 H.V. INDEPENDENT
OUTPUTS: 0,35 – 3 KV, 2 mA

EXPERIMENTAL ROOM

UP TO
1000 m

4 RG. 174/U
LOW VOLTAGE CABLE
SERIAL INFORMATION

2 ST 32+32 CH MCU		C R A T E	CONTROLLER

ON LINE
COMPUTER

SETTING AND
READ OUT

CONTROL ROOM

UP TO
7 m

TWISTED PAIR CABLE
PARALLEL INFORMATION

CONSOLE

SETTING AND
READ OUT

UP TO 64x8
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 multiple-
  xed 12 bit digital-to-analog converter and 64 analog memories (ca
  pacitors). 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 pur
  poses.

- ADC card, where 64 monitoring voltages are converted by a multi-
  plexed 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 vol
tage proportional to the setting voltage.

3.5. - Console.

The console is a special purpose device which provide the follow
ing 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 vol-
    tages of the 16 channels of the selected group.
  - To monitor, by two leds, the status of the 16 channels of the se-
    lected group about the ON/OFF H.V. status and the Console/Com
    puter settability.

- Setting operation.

  The setting operation allows to accomplish the following indepen-
  dent functions :

a) - Generates a MASTER RESET signal on the 16 channels of the se-
     lected 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 chan-
  nel;
- SWITCH ON : of the H. V. generator for the selected channel;
- DISABLE COMPUTER : set the chosen channel to be able to ac-
  cept commands of change (of the voltage value) only by console;
- ENABLE COMPUTER : set the chosen channel to be able to ac-
  cept 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 digi-
  tal 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 :
$\leqslant 3 \times 10^{-4}$ no load to full load.

STABILITY :
TEMPCO $\leqslant$ 200 ppM/$^{\circ}$C, 10 to 40°C. Long term drift $< 2 \times 10^{-4}/$
/day after warm up.

NOISE AND RIPPLE :
$\leqslant 1.5 \times 10^{-4}$ of output or 100 mV whichever is greater.

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

PROGRAMMING :
by 12 bits straight binary word. Conversion factor : 1 V/step ad
justable to within $\pm 0.03\%$. Differential linearity : $< \pm 1$ V. Sett
ing 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 $\pm 0.05\%$.
About four reading/sec per channel.

SWITCH OFF TIME :
τ = 80 ms with R_{LOAD} = 1.5 MΩ , τ = 2.75 s with R_{LOAD} =
= ∞.

SETTLING TIME :
$\leq$ 200 ms to within 0.1 % for a $\pm$ 100 V step change at 2 KV.

ALLOWABLE SHORT CIRCUIT DURATION :
$\geq$ 10 s; there is also a fast type fuse for current on primary
of trasformer $\geq$ 1.2 A.

DIGITAL TRANSMISSION :
The information is transmitted in serial format by two 50 Ω co
axial cables (RG-174/U) with TTL levels for both links. The
M. C. U. can trasmit to R. C. . up to 40.000 commands per se
cond. 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 indivi-
dual 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 assig
ned. Last, the CAMAC subaddresses select the channel.

READ OUT CONTROL :
The status of each channel is stored in a RAM in the CAMAC in
terface and is continuously updated by the remote unit. The lat
est 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

             R13 UNDERFLOW (R13=0 means that the HV read
                 ing is in two complement format)

             R14 0N/OFF

             R15 ENABLE COMPUTER.

STATUS II : R1-R12 H. V. set-point reading

             R13, R14, R15 like status I.

CAMAC FUNCTION CODE (all require N, A and S1) :

F(0) : read STATUS I - GROUP I

F(1) : read STATUS II - GROUP I

F(4) : read STATUS I - GROUP II

F(6) : read STATUS II - GROUP II

F(10) : write GROUP I $\}$ set through write lines (W1-W12) the

F(17) : write GROUP II $\}$ chosen high-voltage digital value

F(12) : increase GROUP I $\}$ increase by one the previous

F(14) : increase GROUP II $\}$ high-voltage digital value

F(28) : decrease GROUP I $\}$ decrease by one the previous

F(30) : decrease GROUP II $\}$ high-voltage digital value.

REFERENCES.

(1) - S.R. Amendolia et al., Frascati report LNF-74/7 (1974), and
     CERN/SPSC/74/15 (1974).

(2) - S.R. Amendolia et al., Frascati report LNF-74/51 (1974), and
     CERN/SPSC/74-83/P6 (1974).