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SPECIFICATION FOR A REAL-TIME COMPUTER FOR USE WITH THE CERN 2METRE-LIQUID HYDROGEN BUBBLE CHAMBER AND ASSOCIATED PARTICLE BEAM

PREAMBLE

A small fast digital computer or automator is required to act as a data logging and process control device for the CERN 2m bubble chamber and associated particle beam.

The tenderer is requested to tabulate his replies or comments to the clauses of the specification given below and should supply a complete set of reference manuals if he has not already done so.

The tenderer should pay particular attention to the input multiplexing system and analogue to digital conversion. A full description of the input-output capabilities of the computer is required giving all details of the signal dialogue between the computer and any external device e.g. special operator console.

1. Minimum requirements for the computing system

1.1 The computer shall be a stored programme, general purpose binary computer. It must be capable of continuous reliable operation for 6 week periods with a few days between these periods for checks and maintenance. The computer will be situated in the bubble chamber control room and should be well shielded against electrical disturbances and must operate in ambient temperatures at least between 10 and 40°C. All equipment must operate from a main supply of 50 c/s 220 V (or 380 V 3 phases). Please state total power load.

1.2 A directly addressable core memory of capacity equivalent to 8 k is required expandable in modules (if possible). Please quote price of additional modules with ancilliaries. The minimum word length should be 18 bits. If extra parity bit is an option, please quote price. The core cycle should not be longer than about 2 μs.

1.3 The central processor should have a small but powerful order code, and facilities including:

1.3.1. Automatic priority interrupt system allowing

- Direct Memory Access
- Data Channel requests
- A Multilevel priority interrupt under programme control.

1.3.2. Indexing register and indirect addressing possibilities.

1.3.3. Arithmetic element

- Fixed point addition and subtraction
- Multiply, divide, normalize - and logical operations.

Please quote price of the equipment if additional.

1.3.4. Input/output facilities.

1.3.5. An operator/maintenance console with a display of internal registers and with facilities for manual programme intervention, including sense switches.

1.3.6. Real-time clock necessary for chamber expansion pressure programme and logs.

1.4 Peripheral equipment.
This equipment, for which details as well as the name of the manufacturer should be given is the following.

1.4.1. Input/output typewriter for communication with the central unit.

1.4.2. Output typewriter for data logging purposes, this typewriter will also be used for alarm values (written in a different colour).

1.4.3. A paper tape reader-punch combination (please give full details of the code).

1.4.4. Analogue values input system including

- Amplifiers for low level signals (e.g. thermo-couple differential voltage)
- Multiplexer for about 150 values
- A/D converter. Give common mode rejection performance for DC and AC of all frequencies up to 10K c/s.

1.4.5. Special operator panel
The tenderer should comment on the possible incorporation of a control panel which would permit process operators, non-specialized in computer technique, to carry out certain operations without recourse to the main control console e.g.

Demand for chamber log.
" " beam "
Change of certain parameters, temporarily storing previous value
Change of some alarm limits, " " " "
Command X-Y recorder.

An indication of price should be given.

2. Functions of the Computer

2.1 Modes of Operation

Chamber Cooldown
Chamber Warmup
Chamber Standby (Cold)
Chamber Operating
Beam Monitoring
Beam Tuning.

2.2 Routines

2.2.1. During chamber cooldown and warmup modes (see fig. 1) - the computer will measure temperatures of chamber optical components (some 30 points) every 30 minutes, as detailed in the following table.

No. of points	Description	Values		Precision	Alarm Level	Scan Frequency	Remarks
		Range	Form				
2 x 2	Reference Temp.	300°K-25°K +1mV to -6.2 mV	Anal.	1 o/o		each 30 min.	Thermocouples Cu/Constantan
2 x 8	Diff.Temp. Flash side	.01mV to 0.65mV	Anal.	4 o/o	$\Delta T >$ 20°K	each 30 min.	Thermocouples in pairs
2 x 5	Diff.Temp. Camera side	.01mV to .65mV	Anal.	4 o/o	$\Delta T >$ 20°K	each 30 min.	

It must be possible to command the reading and recording of the above values by external signal.

2.2.2. Chamber Standby (Cold)

Chamber Body, Cooling Loops, Liquifier } It must be possible to print out on demand temperatures indicated by up to 40 Copper-Constantan thermocouples

during the chamber modes: Cooldown, Warm up, Standby (Cold). These values are available as analogue voltages.

2.2.3. Chamber Operating

(a) Control:

Timing of chamber expansions.
The bubble chamber operates in conjunction with the CERN proton synchrotron which provides a burst of high energy particles every two seconds. During this burst the bubble chamber will be operated up to 3 times by a temporary pressure drop. The timing diagram (Figs. 2 and 3) gives quantitative information regarding this cycle.
The computer must find the time of the minimum of each pressure drop and check that this time is midway between the beam pulses and the flash pulses (within limits of approximately 100 μs).
The pressure drop is measured by a transducer with a frequency response extending to 10 kc/s. The pressure signal has some 100 μV noise at 100 kc/s superimposed.

(b) Monitoring of various chamber parameters.
We may divide chamber parameters into two groups:
Group I:
These parameters must be scanned at each cycle of chamber operation and the latest value stored.
Group II:
Group II parameters must be scanned at longer intervals (about 1 minute) and the latest values stored.
The computer will store high and low limits for most parameters in both groups and should any parameter not be within its limits the computer must print out its value in red (and give an Alarm Signal). For details see the following list (page 4).

(c) At fixed intervals (4 hours or more) or on demand the latest values of all these parameters must be printed out as a process log.

CHAMBER PARAMETERS

GROUP	No. of points	Description	Readings Value	Readings Form	Precision	Alarm Level	Scan Frequency	Remarks
I	6	Pilot Valves	0 or 1	D	-	≠ 1 or ≠ 0	each cycle	Checks Valve performance
	1	ΔP Expansion	600mV	Anal.	1 o/o	high + low	" "	
	1	ΔV Expansion	900mV	Anal.	1 o/o	high + low	" "	
	1	Beam Arrival Time	<60mS	D	~50 μS	high + low	" "	
	1	Flash Delay	.6tolmS	D	1 o/o	high + low	" "	
	3	Flash Intensity	10mV	Anal.	1 o/o	low	" "	
	3	Alarm	0 or 1	D	-	-	" "	
II	2	Static Chamber Pressure	500mV	Anal.	0.1 o/o	high + low	each minute	The primary measurement is at
	2	Chamber Temperature	400mV	"	0.05 o/o	high + low	" "	
	2	Chamber Temp. Gradient	.1°C	"	5 o/o	high	" "	present pneumatic
	2	Main Vacuum	20mV	"	1 o/o	>10^{-4} torr	" "	Normally ~10^{-6} torr
	2	Valvebox Vacuum	20mV	"	1 o/o		" "	
	2	Liquifier Vacuum	20mV	"	1 o/o		" "	
	1	Magnet Current	500mV	Anal.	.05 o/o	high + low	each minute	10,000 amps.
	1	Correction Coil Current	600mV	"	.05 o/o	high + low	" "	1,200 amps.
	2	Reference Voltage	117mV	"	.1 o/o	high + low	" "	
	3	Hall Voltage	117mV	"	.1 o/o	high + low	" "	
	1	Differential Field	10mV	"	1 o/o	high + low	" "	
	1	Magnet N cooling water Temp.	50mV	"	1 o/o	high	each 20 secs	65°C
	1	" S " " "	50mV	"	1 o/o	high	" " "	65°C
	28	Magnet Pancakes-Temperature	70°C	"	1 o/o	high	" " "	70°C
	1	Magnet N cooling water flow	100mV	"	1 o/o	low	" " "	1,000 litres/min
		" S " " "	100mV	"	1 o/o	low	" " "	
		Correct.Coil N cooling water flow	100mV	"	1 o/o	low	" " "	110 litres/min
		" " S " " "	100mV	"	1 o/o	low	" " "	
other information	1	Expansion Number	-	D	6 dec.	-	Print in all chamber and Beam Logs	
	1	Reel "	-	D	3	-		
	1	Photograph "	-	D	4	-		
	1	Date	-	D	-	-		

2.2.4. Beam Monitoring

Beam parameters to be monitored can also be divided into two groups:

GROUP	No.of points	Description	Value	Form	Precision	Alarm Level	Scan Frequency
I	5	Drive and Reference		D	1 o/o	high + low	each cycle
	5	RF Separator 2 phases -3 powers		BCD	4 decades	high + low	each cycle
	3	Particle Counters		BCD	4 decades	low	each cycle
II	30	Magnets and Quadrupoles	800mV	BCD	4 decades (0.1 o/o)	± 1 o/o	each minute
	3	Separator Voltage	100mV	BCD	1 o/o	± 5 o/o	
Other Information	3	Separator Flashover Counter	Numerical	BCD	4 decades	-	to be printed at each Beam Log or on demand
	10	Horizontal Collimator Position		BCD	3 decades		
	10	Vertical Collimator Position		BCD	3 decades		
		Counters					
	8	Monitor		D	4 decades		
	8	Burst Number		D	4 decades		
	8	No.of particles		D	4 decades		
	8	Horizontal Position		D	3 decades		
	8	Vertical Position		D	3 decades		
	2	Temperature of cable between cavities		Anal.			

It is also proposed that the computer should print out a histogram showing the variation of intensity throughout the beam pulse.

The parameters of a tuned beam will be recorded on punched tape to facilitate subsequent setting-up of a similar beam.

3. Further desirable information

The tenderer should give information on the following items, stating whether the features mentioned are standard or optional:

3.1 Parity checking and what happens in case of parity error.

3.2 Is some sort of memory protection available or necessary.

3.3 Any additional feature of the computer which the tenderer feels is worthy of special consideration.

3.4 Consequences of computer power supply failure.

3.5 Price and delivery delay of further available peripheral equipment.

4. Programming

4.1 An adequate compiler programme for symbolic assembly must be provided. The tenderer should state what assistance he is prepared to offer in setting up, and in instructing CERN personnel in the use of the computer.

4.2 The proposal should include a comprehensive software description including the assembly programme compiler, library routines and equipment diagnostic routines.
Final programming manuals, assembly drawings, flow charts and debugged programmes shall be delivered with the computer.

4.3 A complete set of circuit schematics, logic diagrams and other engineering information for servicing and modifying the equipment must also be provided.

GENERAL

The tenderer should indicate what assistance he will give in installing and commisioning the equipment at CERN, and what additional charges if any would arise in the event of prolonged difficulties in commisioning.

The tenderer should state clearly the extent and terms of the guarantee that he will furnish for the material. The guarantee period shall start from the date of acceptance of the material by CERN. This date will be agreed mutually by CERN and the supplier.

CERN would expect delivery 4 months after the placing of a firm order or letter of intent. A shorter delay would be a favourable factor in the choice of a supplier.

The tenderer should indicate clearly the terms and conditions for maintenance of the equipment after the expiry of the initial guarantee, and indicate the location of the nearest main service depot, with comprehensive spare parts service and engineering assistance. The procedure for requesting urgent engineering assistance in event of equipment failure should be specified, together with an indication of delay.

The tenderer should give a complete breakdown of the total price. This should include the optional extras as well as all standard items, and any special equipment.