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THE EJECTION COMPUTER SYSTEM

by

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A) Tasks and their Priorities

The tasks of the Ejection Computer System (also called Ejection Maintenance Assistant System) will be as follows, in decreasing of priority :

1. A frequent (f_{max} = 10 Hz) surveillance of all significant parameters of ejection hardware (FAK, septum magnets, electrostatic septa and appropriate power supplies) and logging of changes of parameters.

2. Setting and changing of parameters.

3. Exchange of information between this real-time system and the PS control centre to achieve :

   3.1 input of parameter sets like beam losses or timing words,

   3.2 output of warnings in the case of faults of ejection hardware or programs,

   3.3 support of wanted sets of parameters (acquisition),

   3.4 setting and changing of parameters (control).

Surveillance means in detail :

Parameters (e.g. currents, voltages, etc.) are scanned by the DTS and loaded into core memory of the PDP 11. The computer compares the parameters with "good" values and generates fault messages or even stops running of an ensemble of ejection hardware if the parameters exceed the given limits or working ranges. Further, any command generated in the ejection system or coming from the control centre will be checked as to whether it is a permitted one.

B. Layout of the System

The layout is shown in Fig. 1. The upper half concerns the FAK, the lower half governs the computer and DTS components for septa and power supplies (until now, no command box for power supplies of electrostatic septa is considered). A brief description of the different DTS modules is given in E.

1. Master - Slave Relationship

A master - slave relationship will exist between the DTS and the computer; seen from the entire system, the computer is slave.

The DTS scans synchronized to the PS cycle. Every 100 ms it produces its data burst (300...400 words within 6-8 ms), the major part of which will be read into the 8 k core memory of the PDP 11 (a section of 1 k will be reserved) by direct memory access. On the output side (PDP 11 to DTS), the PDP 11 offers its data like any other DTS measuring unit. These words, about 150, will of course not reenter the computer on the PDP 11 input side.

2. Priorities in the PDP 11 and Software Program Outline

Following the task definitions and their priorities described in chapter A, the DTS will have absolute priority. During its action, no other non processor request (NPR) and no other software program is running in the computer (Fig. 2). When the DTS has finished the data transfer, the real time tasks, like scanning and checking of DTS parameters, will be performed at highest software priority level (10 to 15 ms duration). Afterwards, alarms and commands are prepared for the next DTS scan.

Within the rest of the 100 ms, services for the DEC-writer, communications with the PS computer system as well as other tasks can run.

When a new DTS cycle starts, all current low priority programs will be interrupted (INT 2), if non-processor transfers run, they will be interrupted hardwarewise. Continuation of the interrupted program-controlled tasks will take place in the second half of the next 100 ms interval. A block diagram of the main program is shown in Fig. 3. At the beginning of each PS cycle the program is initiated by another interrupt (INT 1) and the M-pulse counter is reset to zero. If no tasks remain to be operated upon, the PDP stays in a waiting routine until the next interrupt occurs.

3. Synchronization of the System

The ejection computer system is synchronized to the PS by the use of the M-train. Starting with M_1 the synchronizer will restart the DTS every

30 M-pulses. The synchronizer itself also determines how many scans can be performed per PS cycle. The last occurs at least 100 ms before the next M_1. If there is no M-train, the synchronizer automatically switches back to an internal clock working with a frequency of 10 Hz.

C. Man-System-Interface

Three different ways of interfacing will exist :

1. A maxi-console (e.g. IMLAC) in the MCR.
2. A function keyboard with selfscan-display (during the running-in of the FAK in the MCR).
3. The DEC-writer (equivalent to a teletype) in the central building.

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1. The MCR operator, familiar with the multi-computer and display system, will normally use the maxi-console to act on ejection hardware. The keyboard will be alphanumeric and a computer system oriented language will be used to excite commands.

2. For special runnings of hardware like MDs and maintenance purpose, a set of function push-buttons with a small 256 character wide display will be available. Commands are generated by assembling field functions which are arranged in a tree structure. A hardware oriented syntax is used (example : one wants to know the kick strength of area 1 - one generates the command by the use of the buttons : KICKERMAGNET - KICK - AREA 1 - DISPLAY - EXECUTE).

Due to the function orientation of this keyboard and its small display, it will be restricted in flexibility. However, for somebody working with this interface, the computer becomes fully transparent. It will be used mainly by "hardware" people.

3. The DEC writer is the link between PDP 11 and the programmer. Using the symboles behind the function keys in the DTS keyboard will make the DEC writer compatible with the DTS keyboard.

A proper man-system interaction is as important as the physical function of the hardware items itself. On one side it must be as flexible as desired by the operator, on the other side it should be as easy to understand and to operate as possible, in order to allow people who are no controls experts to use it.

Taking these facts into account, the man-machine interfaces of the ejection system should be understood as a first step towards the final state.

D. Strength of Coupling between Sub-Systems in the Ejection System and between Ejection System and PS Computer Complex

The strength of coupling between different parts in such a system is best understood by answering the question of what happens if the link fails.

1. No Communication between PDP 11 and PS Computer System

The ejection computer system will still work, however, it is no longer dynamically optimized with respect to the PS program. Further, no fault messages will occur on display systems other than those connected to the DTS.

2. No Communication between PDP 11 and DTS

The DTS still works and scans the information. For part of the ejection hardware like septum positions and magnet currents, one has a digital display on Nixie tubes in the MCR. Further, as long as the DTS remains interfaced to STAR, one also has the entire set of information in one of the PS computers (at the moment in the IBM 1800). With the help of the central unit and some knowledge of the address and data coding, one can display any information and access any command box to control the process from the central building.

The DTS keyboard and display will no longer work as it relies on the proper functioning of the PDP 11. Further, any surveillance and diagnosis of the system is excluded.

3. Faults in the DTS Components

If a command box fails, this results in an isolated fault which does not provoke a breakdown in the system; the appropriate hardware module has to be set and controlled manually.

If a measuring unit fails, the amount of breakdown in the system depends strongly on the type of the fault, for instance : if a word is not generated and prepared for a scan within 30 μs, this word is skipped and one out of ~ 400 parameters is lost. If a hang-up occurs (in DTS expression : the measuring unit does not finish its run by giving : forget me), the DTS automatically restarts its cycle after 100 ms. All information from modules coming after this unit in the daisy chain will be lost. This may cause serious lack of information. But the computer detects this loss of information with the help of testwords, automatically generated in all measuring units.

4. Faults in the DTS Central Unit

Under these circumstances, the ejection computer system is completely down. Ejection must be set and altered manually for most installations from the places where the power supplies or modules are placed. Ejection can still run, however with the help of specialized SR crew and a strong reduction of efficiency.

E) Brief Description of DTS Modules and Estimation of Data Fluxes

1. Modules and their Functions

Referring to Fig.1 (Ejection Computer System) one distinguishes 15 different DTS components :

1.01 FAK Measuring Unit (M.U.)
1.02 FAK Data Command Unit (D.C.U.)
1.03 Kick Selection Unit
1.04 Power Supply Monitor (P.S.M.)
1.05 Septum Position Monitor
1.06 Septum Position Limit Indicator
1.07 DTS Transmitter
1.08 Nixie Display (N.D.)
1.09 Command Box for Septum Positioning
1.10 Command Box for Power Supplies (C.B.)
1.11 DTS Keyboard
1.12 DTS Display
1.13 DTS-PDP-11 Interface
1.14 DTS-PS Synchronizer
1.15 Absolute Clock

1.01 FAK Measuring Unit (M.U.)

This unit collects and assembles data words to be transmitted on the DTS. These words are generated within the FAK module and come from its interlock unit, timing terminal unit and voltage measuring unit. The transmitted words will be :

1.011 interlock word

1.012 status word

1.013 module timing word

1.014 4 (max. 6) voltage words

1.015 module test word

which results in a word load of 10 words/cycle for the DTS. The word load is always given per module.

1.02 FAK Data Command Unit (D.C.U.)

This unit is the command interface between the DTS and a module. It receives from the DTS the following data :

1.021 voltage reference values

1.022 module commands (like: ON, OFF, STANDBY and RESET).

The voltage reference values are stored in the module servo unit, while the commands are acted upon in the module command unit. The word load for the DTS will be 1 word/cycle.

1.03 Kick Selection Unit (preliminary information)

The data the unit receives are instructions to set up the kick strength for each of the 4 areas of ejection. These instructions are stored in a local memory and enable the timing pulses to be routed to the desired modules for each ejection and so controlling the kick strength by number of modules. The words the unit will receive, are :

1.031 4 setting words

1.032 1 reset word

so the word load for the DTS will be 5 words/cycle.

The data sent from this unit concern :

1.033 4 data words for kick strength

1.034 1 data word for timing faults;

again the word load for the DTS will be 5 words/cycle.

1.04 Power Supply Monitor (P.S.M.)

This unit monitors the parameters of power supplies like SPG 1 or SPG 2. The main functions are to measure :

1.041 four times the current, $I(t_1)$, $I(t_2)$, $I(t_3)$ and $I(t_4)$ with respect to the start at time t_0.
The time marks t_2, t_3 are set by the MCR, t_1 is set locally and t_4 is fixed (ref. to Fig. 4 : current measurements within a pulse of SPG 1).

1.042 time intervals Δt like $\Delta t_1 = t_1 - t_0$, $\Delta t_2 = t_2 - t_0$, $\Delta t_3 - t_0$.

1.043 lower limit of repetition time, RT.

1.044 maximum flat top time, FT.

1.045 power supply status.

1.046 power supply interlocks

1.047 reference parameters like voltages.

This gives a word load of 20 words/cycle.

1.05 Septum Position Monitor

This unit measures septum positions like :

1.051 radial

1.052 vertical

1.053 angular positions of magnetic septa and

1.054 positions of anode

1.055 cathode and

1.056 angle of anode of electrostatic septa.

For 9 septa the set of position parameters can be obtained. The unit also produces test words, so the word load for the DTS is 30 words/cycle.

1.06 Septum Position Limit Indicator

This unit indicates whether the position changing motors reached the limits. It also gives information about the status of the different motors. The word load for the DTS will be 10 words/cycle.

1.07 DTS Transmitter

The transmitter functions as driver. It allows binary to BCD conversion and offers a bit pattern display for diagnosis of the data down stream in the DTS. One of its outputs is connected to the STAR interface.

1.08 Nixie Display (N.D.)

This unit displays the positions of 9 septum magnets and currents of power supplies like SPG 1 and SPG 2.

1.09 Command Box for Septum Positioning

The command box initializes position changes for max. 15 septa. The word load for the DTS is one word/cycle.

1.10 Command Box for Power Supplies (C.B.)

By this unit up to 14 different commands can be excited within one DTS cycle. 3 parameters (e.g. : changed by motor potentiometers) can be varied independently by long or short steps as well as in positive or negative direction with respect to a reference point. 11 parameters can be used for ON, OFF, STANDBY and other commands. Using a programme card, they even can be combined for special purpose. The word load for the DTS is one word/cycle.

1.11 DTS Keyboard

It is a function keyboard using a hardware-oriented syntax. By pushing a number of keys, a command is assembled. An example was given in C2. The DTS accepts one command per scan, giving a word load of 6 words/cycle.

1.12 DTS Display

This unit consists of a 256 character self-scan display. The word load is 129 words/cycle.

1.13 DTS-PDP-11 Interface

Seen from the DTS, this interface looks like a measuring unit and a command box. Just before the DTS (reset by the synchronizer) starts its scan, the interface becomes bus master for the PDP-11 and, during the DTS scan, a non processor data transfer takes place. After a slight re organization of the DTS address, the DTS words are directly loaded into the core memory of the computer. When the interface becomes measuring unit, a programme controlled request (by an interrupt) is routed to the computer.

If any output to the DTS is prepared, it is "popped off stack" and sent to this unit. Here it is assembled to DTS format and transmitted on the DTS. This can result in a word load of 150 words/cycle.

1.14 DTS-PS Synchronizer

The function of this unit is described in B3.

1.15 Absolute Clock

The PDP 11/45, as ordered, houses already a real-time clock. This clock will be used for scheduling of programmes. An absolute clock, not yet defined in detail, should give a reference to an absolute time (for data logging), it also should be presettable. The word load on the acquisition - as well as control bus of the DTS will be 2 or 3 words/cycle.

2, Data Fluxes

The word current I on the acquisition bus of the DTS is the sum I_1 of information coming from the different measuring units and the output I_2 of the PDP-11.

Referring to chapter E, one finds :

$$I_1 = 244 \text{ words/cycle}$$

$$I_2 = 152 \text{ words/cycle}$$

This results in a scan of ~ 400 parameters per DTS cycle. The average transfer rate will be 1 word/20 μs. I_1 asks for a non-processor data transfer of ~ 5 ms per DTS cycle.

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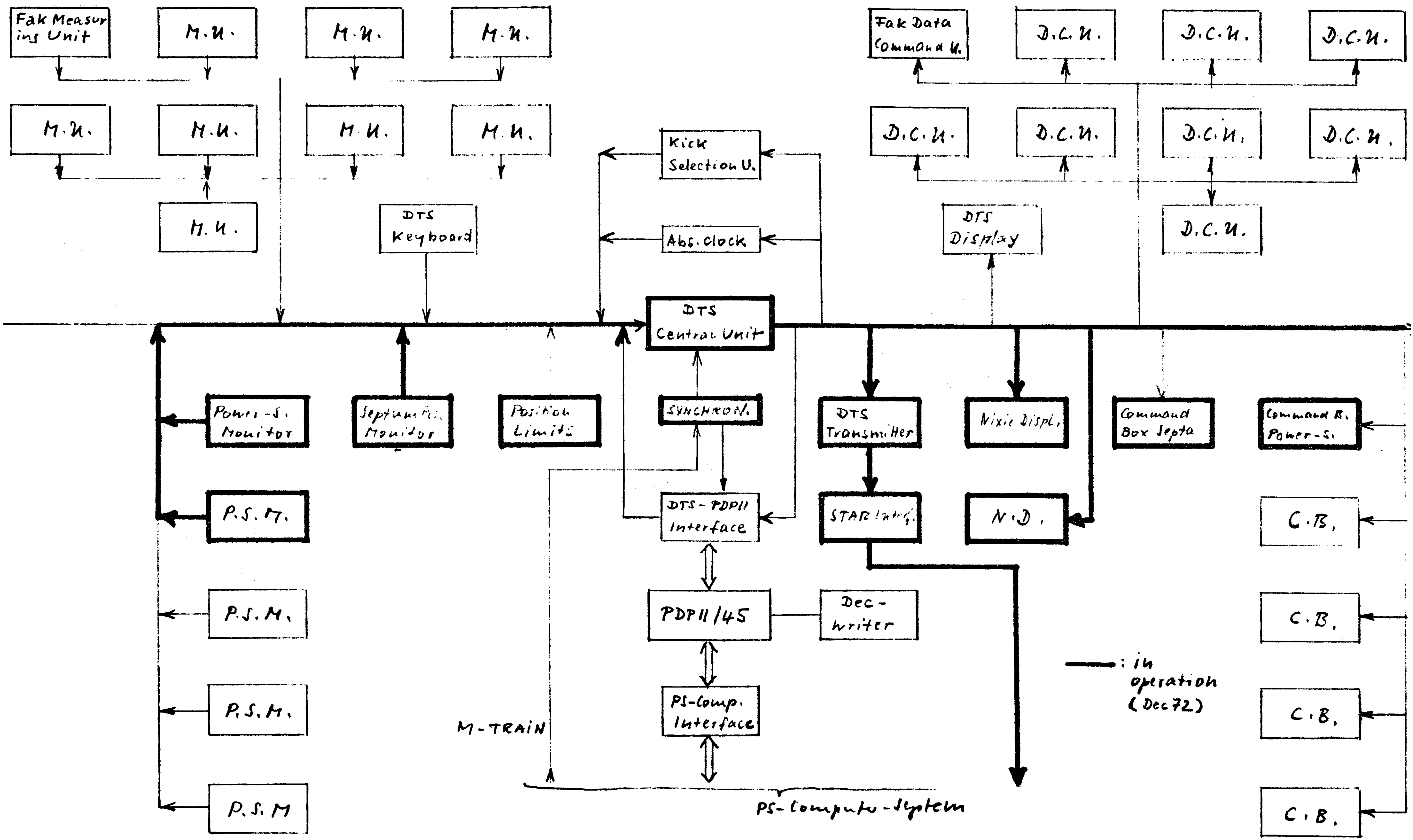

FIG. 1 : EJECTION COMPUTER SYSTEM

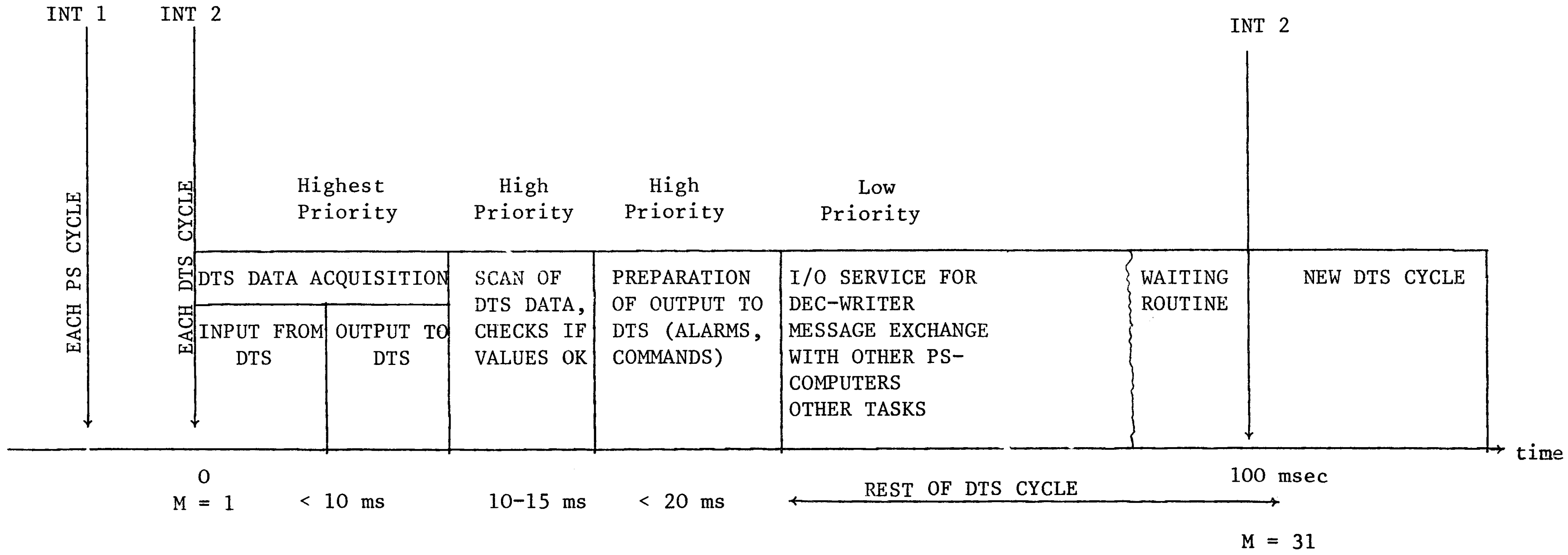

FIG. 2 : Job schedule in the PDP - 11

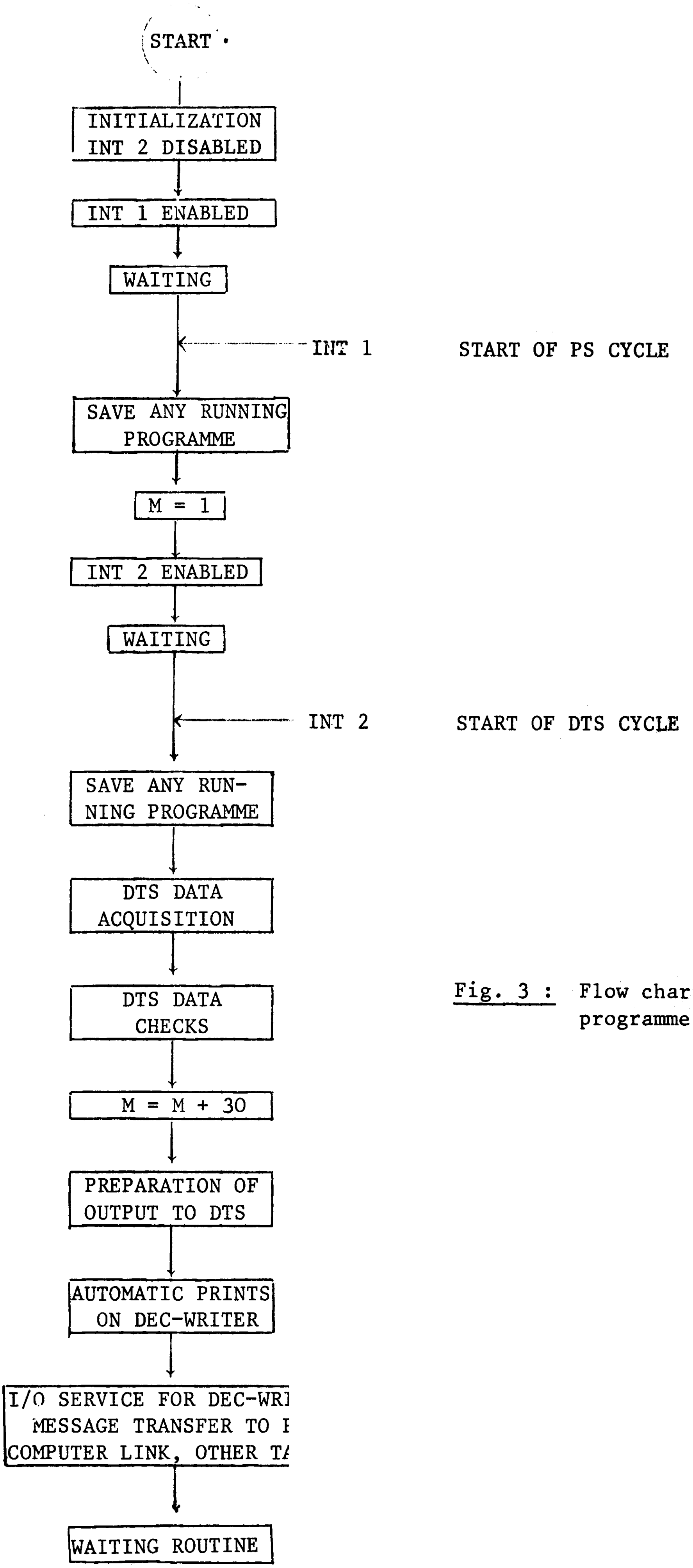

Fig. 3 : Flow chart of the main programme during PS run

t_0 = start

t_1 = set locally

$t_{2,3}$ = set by MCR

t_4 = stop

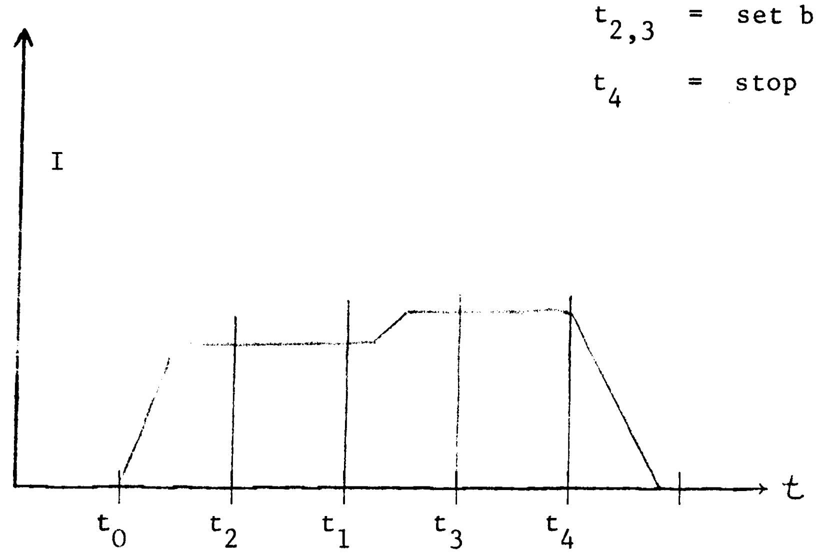

FIG. 4 : Current measurements within a pulse of SPG 1