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THE FAK CONTROLS USING THE DTS AND THE PS EJECTION COMPUTER

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1. Introduction

This note describes how the new Full Aperture Kicker system (FAK) will be controlled using the DTS and the PDP-11 ejection computer. The system concept includes the possibility for the FAK to work completely alone on local-manual control from the ejection building.

2. DTS - FAK system structure

The FAK system (1) controls rely on the PDP-11 and DTS together with the computer facilities (2) in the MCR. The data flux between the kicker modules and the PDP-11 is always under control of the Central Unit of the DTS (3). The individual FAK modules have the following units which are linked directly to the DTS Highway Extension.

a) CB : COMMAND BOX

b) MU : MEASURING UNIT

c) SU : SERVO UNIT

Fig. 1 shows the system structure intended. It also gives the possibility in the future to control the beam shaving equipment in a similar manner.

3. Parameter list

The Full Aperture Kicker system has 9 identical modules for making the multi-shot ejection from the PS. The essential FAK parameters, listed below, resulted from a study of the proposed control scheme (4).

a) Control parameters (Received by the Command Box)

MODULE ON
MODULE OFF
MODULE STANDBY
MODULE RESET
SET SERVO REFERENCE

b) Acquired parameters (Sent by the MEASURING UNIT)

MODULE STATUS DATA WORD
MODULE INTERLOCK DATA WORD
MODULE TIMING DATA WORD
MODULE TEST DATA WORD
MODULE VOLTAGE VALUES.

The information contained in a module status data word is listed below :

POWER ON MODULE
MODULE ON REMOTE CONTROL
MEAS. UNIT + 5V IN LIMITS
MEAS. UNIT + 15 V IN LIMITS
MEAS. UNIT - 15 V IN LIMITS
SERVO MOTOR ON
MODULE IS OFF
MODULE GOING TO ON
MODULE GOING TO STANDBY
MODULE WARNING
MODULE IS ON
MODULE AT STANDBY
MODULE HT IL
MODULE OIL SYSTEM IL

The information contained in a Module Interlock data word :

MODULE OIL FLOW
MAIN SWITCH GRID CURRENT
DUMP SWITCH GRID CURRENT
CURRENT PROTECTION
MS FAULTY SHOT PROTECTION
DS FAULTY SHOT PROTECTION
MS STABILIZER PROTECTION
DS STABILIZER PROTECTION
LOAD RESISTOR OIL PRESSURE
LOAD RESISTOR OIL TEMPERATURE
PULSE LENGTH COMPARATOR
LOCAL HT SWITCH
OVER HT PROTECTION
LOCAL SECURITY

The following information is contained in a Module Timing data word :

DELAY TIMER ELAPSED
MODULE TIMING ENABLED

PSU SHOT 1 ARRIVED FROM MCR
PSU SHOT 2 ARRIVED FROM MCR
PSU SHOT 3 ARRIVED FROM MCR
PSU SHOT 4 ARRIVED FROM MCR
MAIN SWITCH PULSE ARRIVED FROM MCR
DUMP SWITCH PULSE ARRIVED FROM MCR
MAIN SWITCH JITTER OUT OF RANGE
DUMP SWITCH JITTER OUT OF RANGE

4. DTS performance (5)

The DTS highway is composed of two uni-directional buses, one for acquisition and the other for the control of digital data.

a) Data word = 13 bit address with a 16 bit value

b) A scanning system with 2^{12} words capacity

c) Scanning cycle = 0.1 seconds

d) Word rate = 7 to 23 µsecs.

Signals produced in the DTS Central Unit (CU) :

AD : Address advance
SY : Synchronization } on the acquisition bus
SD : Strobe date - on the control bus.

Signals produced in the Measuring Unit (MU)

B : Busy
F : Forget } on the acquisition bus
NC : Not Connected

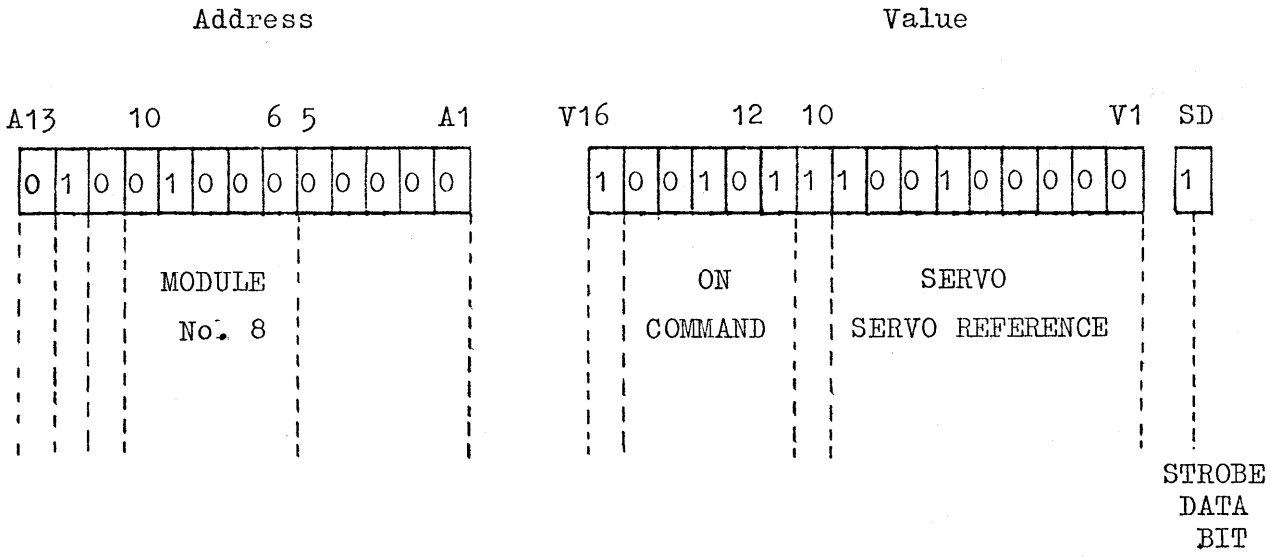
5. The Command Box (CB)

Control words are generated in the PDP-11 or the manual control unit. The control word is sent via the DTS to the FAK modules where it is recognized by a command Box Comparator in one of the modules. The comparator output gates the value data to either the command monostables or the reference buffer store, depending on the decoded value information. A block diagram of the Command Box is given in Fig. 2.

Using the DTS word format, a control word example can be built up.

a) Example:

Command FAK module 8 to go to "ON" state and set its SERVO reference to 80 kV makes the following command word



A1 - 5 = WHAT (= "0" FOR THIS UNIT)
A6 - 9 = WHERE (SPECIFIES WHICH MODULE)
A10 = "0" (NOT YET USED)

A11	=	IDENTIFICATION = "0" FOR KICKERS
A12	=	INDICATES A CONTROL WORD = "1"
A13	=	TEST BIT (NORMALLY = "0")
V1-10	=	SERVO REFERENCE VALUE
V11	=	LOAD REFERENCE BIT = "1"
V12-15	=	COMMAND BITS
V16	=	LOAD COMMAND BIT = "1"

6. The MEASURING UNIT (MU)

This generates data words when addressed by the DTS Central Unit. The data words contain the digitized information coming from a FAK module; Status, Interlock, Timing and Voltages etc...

Status and Interlock words and one Test word are static data, stored in buffer registers which are refreshed every DTS cycle. The Timing word, also static, is refreshed once every PS cycle since it is ejection program dependent.

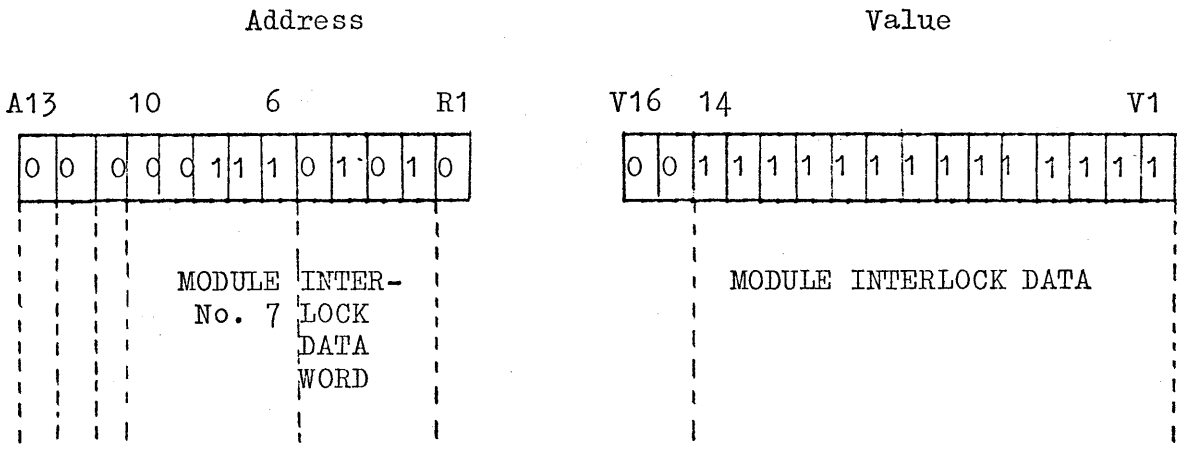
The voltage values are digitized by an ADC and stored in a memory. This voltage data is read out together with the shot and module address onto the DTS acquisition bus. In total, there are 4 static data words together with 4 voltage words for each module. These words are multiplexed onto the common acquisition highway from the buffer registers and memory by the Sequence Controller and Address Generator. Static data is available for the DTS at any time. The voltage data however, is gathered according to the PS ejection program, which does not always correspond to the DTS cycle. To avoid any interference, whenever a voltage measurement takes place, a warning is given to the Sequential Controller. This warning arrives some microseconds before the voltage data word is read out and is told to skip that word. In the next DTS cycle it will be read out with the other data.

Each MU has a local display for reading out manually the values of voltage at the module, and without the DTS working. Voltage data

from each shot together with the status bit from the ADC are sent via line drivers to the Servo Unit. Both the Command Box and the Measuring Unit will have spare channels and some diagnostic aids built into them. The MU block diagram is shown in Fig. 3.

a) Example :

The DTS Central Unit asks MODULE 7 to send its INTERLOCK data word :



A1	=	(not used yet = "0")
A2-5	=	WHAT (Species voltage, interlock, status etc...)
A6-9	=	WHERE (Species which module or system)
A10	=	(not used yet = "0")
A11	=	IDENTIFICATION = "0" for KICKERS
A12	=	INDICATES DATA WORD = "0"
A13	=	TEST BIT (Normally = "0")
V1-14	=	MODULE DATA WORD (in this case the INTERLOCK WORD)
V15-16	=	(not used yet = "0")

7. The SERVO UNIT (SU)

This is used to set the operating HV of the Pulse Forming Network

(PFN) and to stabilize the module against drift and other slow changes affecting voltage. This is achieved by having the feedback loop between the low voltage input and high voltage output of a module. The voltage corrections are made on the low voltage power unit of the modules resonant power supply (6).

The Servo Unit can accept a reference value sent via the DTS or a locally made reference on the Servo itself with BCD switches. An internal cycle counter decides which of the measured voltage words sent from the MU will be compared against the reference in use. Errors between them that are greater than the built in dead band are corrected by means of servo potentiometer. Large and small errors are separately recognized and the servo potentiometer correcting time is selected accordingly from two preset delay circuits.

The coarse control (commanded directly from the reference input) enables large changes of voltage to be made quickly without passing through the comparator and waiting for the servo potentiometer to respond. The final error is, however, always corrected by this potentiometer after a few machine cycles. The selection of local or DTS reference values is made by the Mode Selector switch, which also transfers the other module controls to the selected control point. The Servo Unit block diagram is shown in Fig. 4.

8. DTS EXTENSION

All FAK module Measuring Units and Command Boxes are connected directly to the existing DTS via a DTS Highway extension. This extension will have 16 acquisition inputs and 16 control outputs enabling it to cope with other future ejection equipment such as additional modules or the Beam Shaving system.

9. The Computers

a) The PDP-11 Ejection Computer

This will be used for the following work :

(i) Data logging
(ii) Surveillance
(iii) Diagnosis
(iv) The generation of messages for the IBM 1800
(v) Interpretation of IBM messages to enable control between the MCR and the ejection equipment.
(vi) To run fixed programs for maintenance and on-line control, e.g.: optimization of parameters

b) The IBM 1800 Controls Computer

It will treat the whole ejection scheme as part of the PS Program, e.g.: generating complete setting-up information to enable the man-ejection process conversation to take place.

10. Schedule

A time schedule is given in Fig. 5, showing the important dates that will have to be met. The hardware arrival dates are shown and should give about 6 months for installation, setting-up and de-bugging the whole system.

11. List of References

(1) A Design Proposal for a Full Aperture Kicker System for the PS.
D. Fiander - MPS/SR/Note 71-3.

(2) Minutes of Meeting No. 4 of the Controls Committee
J.H.B. Madsen - 19.6.1972

(3) A Proposal for an Ejection Maintenance Assistance System (EMAS). H. Kugler - MPS/SR/Note 71-8.

(4) FAK System Controls. P. Pearce and D. Fiander - MPS/SR/Note 72-17

(5) (DTS) Data Transmission System (handwritten note - not yet published). D. Bloess.

(6) A Resonant Charging Pulsed Power Supply for Kicker Magnet Pulse Forming Networks. D. Fiander and P. Pearce MPS/SR/Note 69-11.

(7) Minutes of a Discussion on the FAK Controls. J.H.B. Madsen, 15.6.1972.

Distribution : open

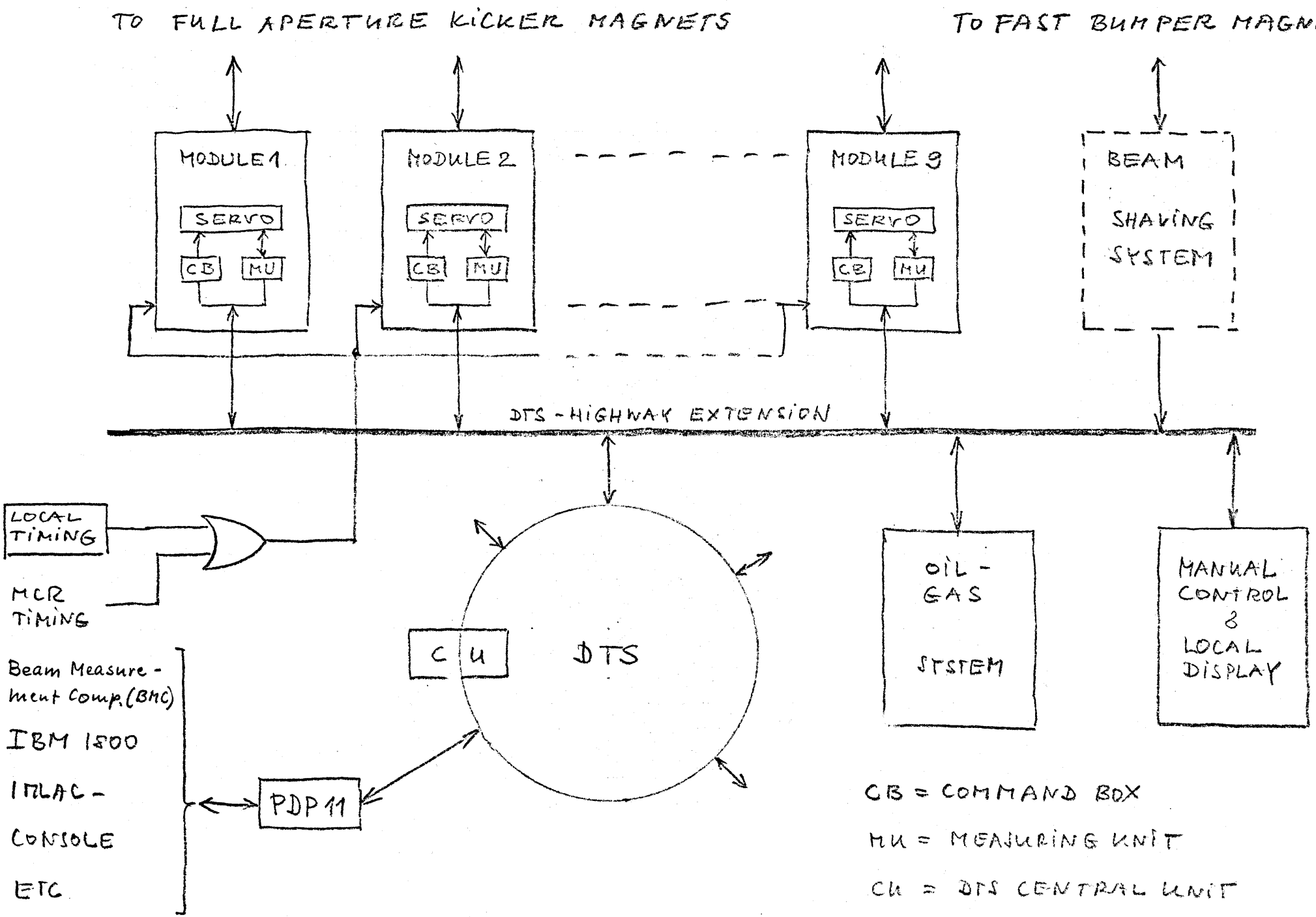


FIG. 1. DTS - FAK - SYSTEM STRUCTURE

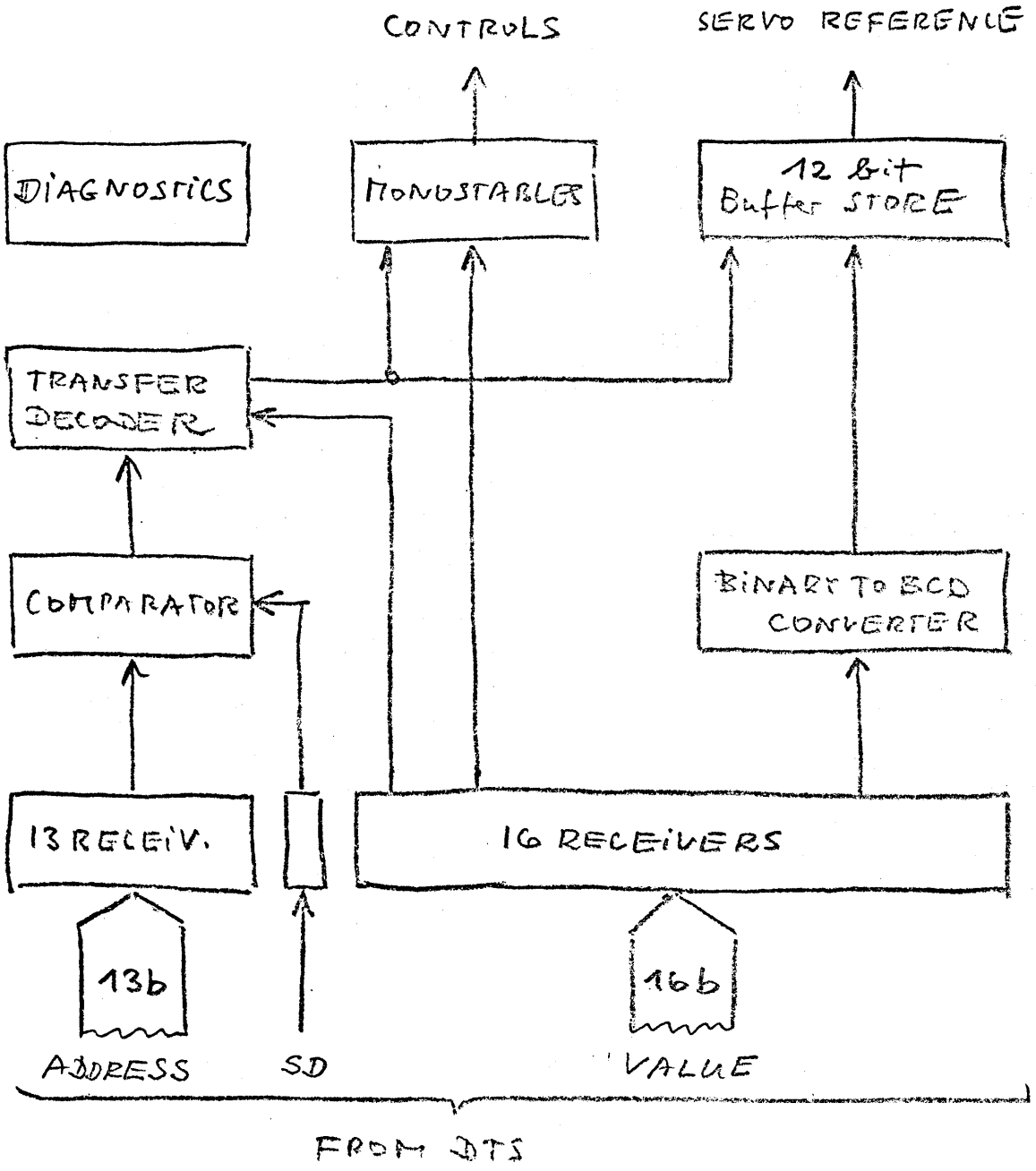


FIG 2. COMMAND BOX (CB)

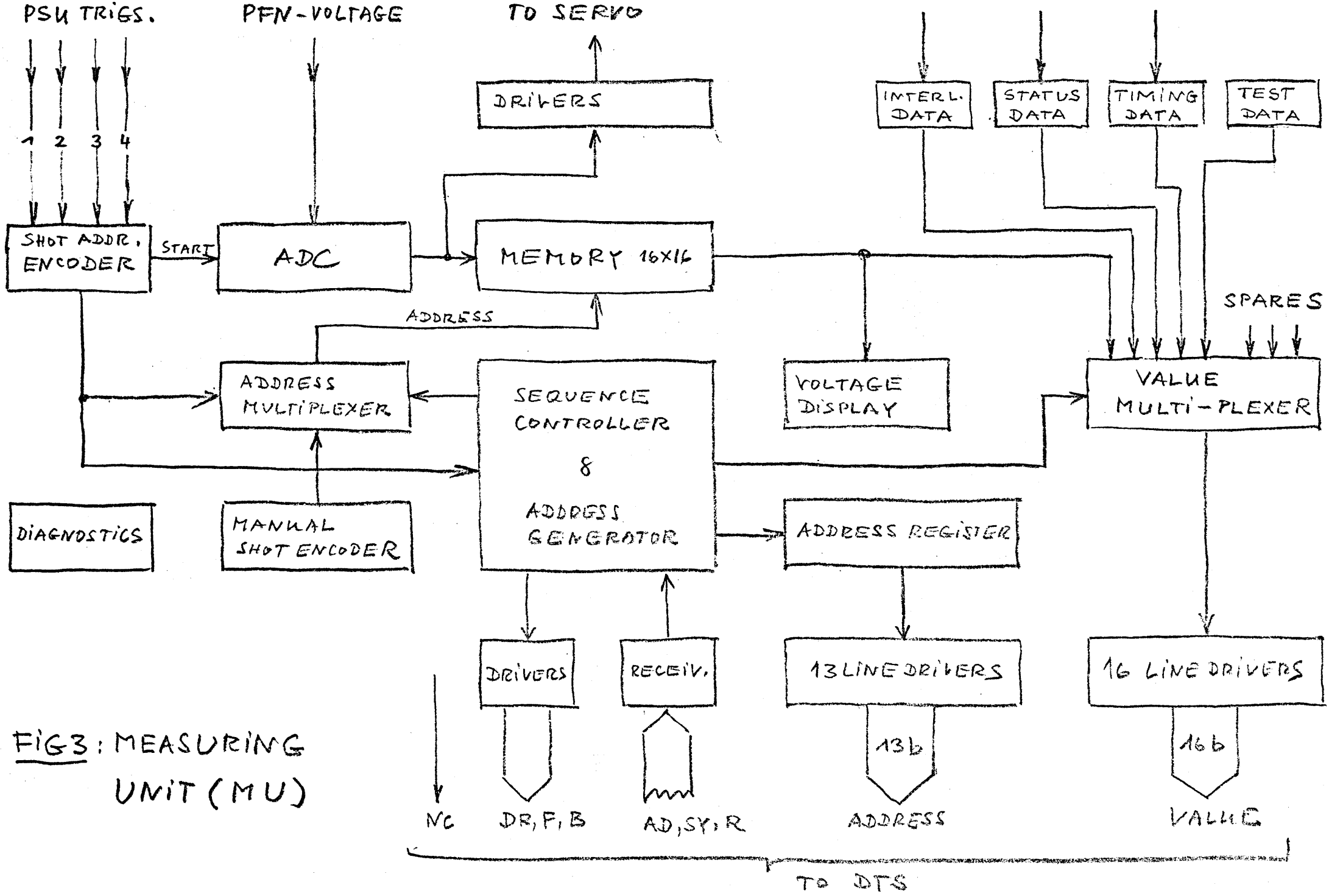


FIG3: MEASURING UNIT (MU)

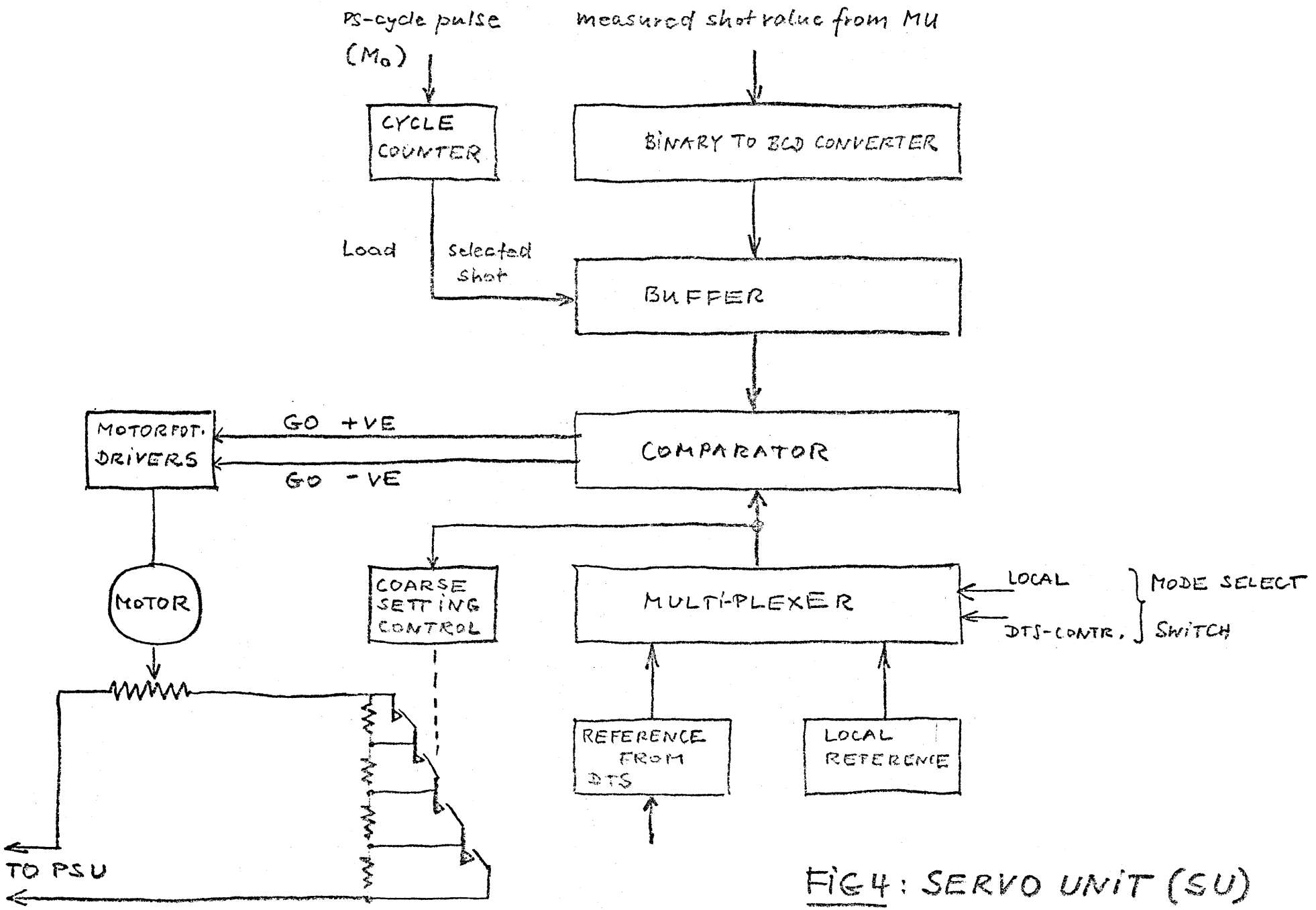


FIG 4 : SERVO UNIT (SU)

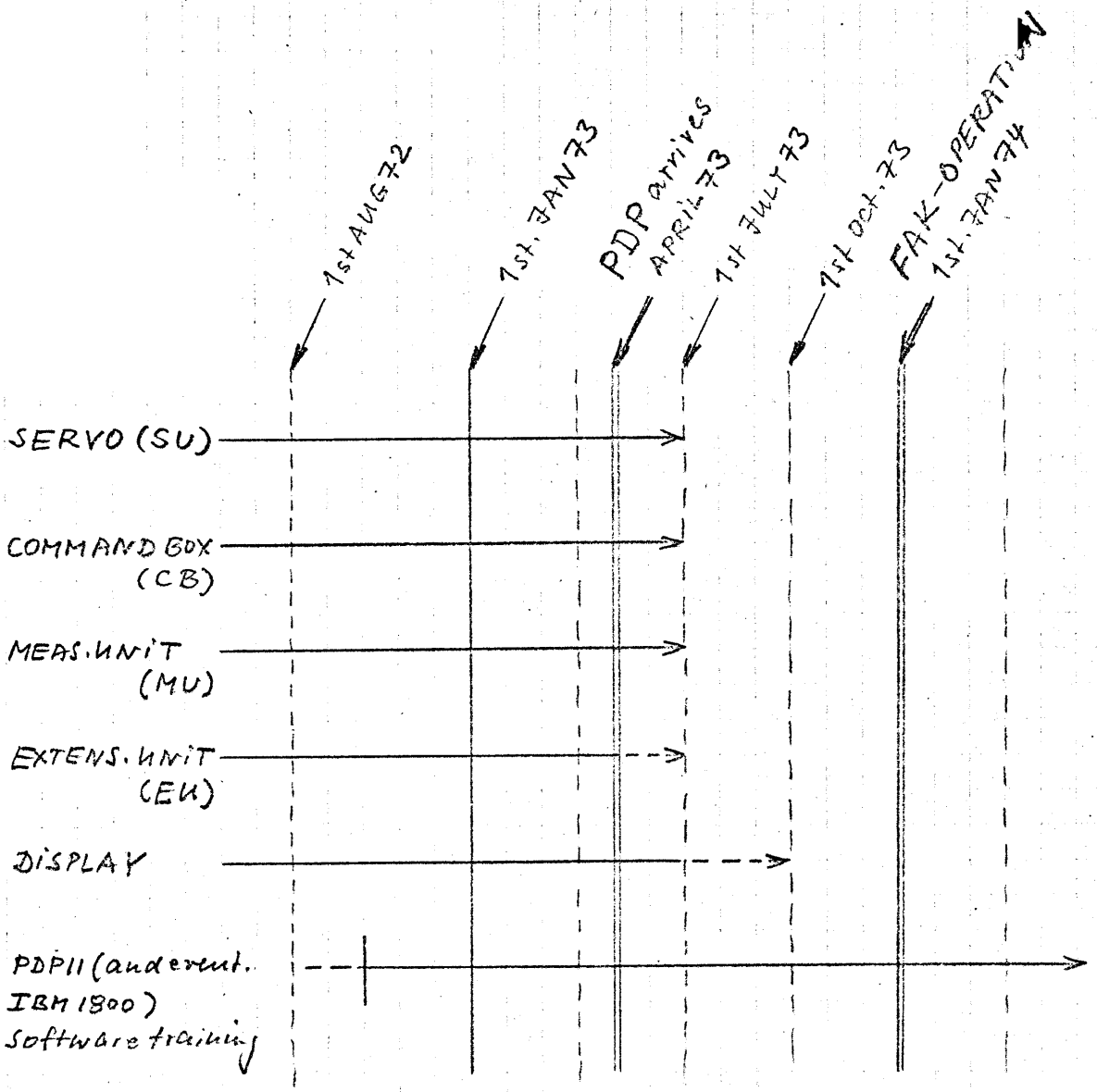


FIG. 5: TIME SCHEDULE