DAΦNE TECHNICAL NOTE

INFN - LNF, Accelerator Division

Frascati, September 6, 1995

Note: **CD-4**

DAΦNE TIMING: STATES

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In the first two sections of this note we give a description of the machine states from the timing point of view. In the third section we describe the relevant features of the electronic module that distributes the timing information all along the facility.

1. General Rules.

Table 1. DAΦNE Timing State Tokens

TOKEN	NAME	FAMILY
LTO	LINAC Triggers OFF	LINAC
LSB	LINAC Stand By	LINAC
LSP	Beam from LINAC to Spectrometer	LINAC
LBT	Beam from LINAC to BTF	LINAC
LAC	Beam from LINAC to Accumulator Ring (Accumulator Ring Injection)	LINAC
AST	Accumulator Ring Stored Beam	Accumulator Ring
AEX	Accumulator Extraction	Accumulator Ring
AMR	Accumulator Extraction & Main Rings Injection	Accumulator Ring
EMS	Electron Main Ring Stored Beam	Electron Main Ring
PMS	Positron Main Ring Stored Beam	Positron Main Ring
VMP	Pulsed Magnets DHPTT01 & DHPTT02 Pre-Trigger	Various

- Each *state* has 20 ms duration.

- More states can exist simultaneously. However some exclusions apply, see later.

- Each state has an associated bit in a *state word*. The latter includes also the particle mode (1 bit) (electrons or positrons) and the number of the main ring bucket to be filled (7 bit). This implies a total of 19 bit which can be arranged in two 16 bit words.

- The state words are composed in *state sequences* of arbitrary length that regulate the machine timing.

- A high level program must allow the construction of both state words and state sequences. It must automatically check the incompatibilities and the syntax rules pointed out in this note.

- Five families of states exist: LINAC (the state token first letter is L); ACCUMULATOR RING (letter A); ELECTRON MAIN RING (letter E); POSITRON MAIN RING (letter P); VARIOUS (letter V). States belonging to the same family cannot be simultaneous.

- All the single set of simultaneous states in the state sequence must include a LINAC state.

- The timing system does not control such complex sequences as, for example, DC magnet polarity inversion between positron and electron modes.

2. States Description.

1) LINAC TRIGGERS OFF (LTO).

The LINAC needs two different triggers: one for the electron gun cathode grid (**gun trigger**), the other for the system (modulators, PC pulser, etc.) (**system trigger**). In the LTO state no LINAC trigger will be enabled.

State Incompatibility: LSB, LSP, LBT, LAC, AEX, AMR.

2) LINAC STAND BY (LSB).

In the LSB state only the system trigger is enabled. This will allow to keep the pulsed systems within temperature with no accelerated beam.

State Incompatibility: LTO, LSP, LBT, LAC, AEX, AMR.

3) BEAM FROM LINAC TO SPECTROMETER (LSP).

The LSP timing state enables the trigger of the spectrometer pulsed magnet (DHPTS01) power supply, sending the beam into the energy analyzer magnet. The duration of the pulse produced by the above mentioned power supply is less than 20 ms, thus a pre-trigger is not necessary. The DHPTS01 power supply can operate at 2 Hz maximum rep. rate. **This implies that two consecutive LSP states must be separated each other by at least 24 timing states**.

State Incompatibility: LTO, LSB, LBT, LAC, VMP.

4) BEAM FROM LINAC TO BTF (LBT).

The LBT timing state enables the trigger for the diagnostics on the BTF line and the possible triggers needed by the external devices in the BTF hall. In order to transport the beam in the BTF it is necessary to turn on a DC dipole magnet. This operation is part of an asynchronous long time machine state sequence that does not interact with the timing system.

State Incompatibility: LTO, LSB, LSP, LAC, AEX, AMR, VMP.

5) BEAM FROM LINAC TO ACCUMULATOR RING (LAC).

The LAC timing state enables the triggers for the Accumulator injection.

State Incompatibility: LTO, LSB, LSP, LBT, AEX, AMR, AST, VMP.

6) ACCUMULATOR RING STORED BEAM (AST).

The AST timing state enables the beam-synchronous triggers in the Accumulator ring, needed by diagnostics and RF.

State Incompatibility: LAC, AEX, AMR.

7) PULSED MAGNETS DHPTT01 & DHPTT02 PRE-TRIGGER (VMP).

The power supplies of these pulsed magnets form a current pulse with a duration of 200 ms and the peak of these pulses must be synchronized with the Accumulator extraction. This implies that the **VMP timing state must precede the AEX and AMR states by 5 timing states** (100 ms). Moreover to prevent inadvertent passage of the beam inside these magnets during the switching operation, **the VMP state and the following 10 states (200 ms) must be compatible only with the LTO, LSB and LSP LINAC states**.

State Incompatibility: LBT, LAC, AEX, AMR.

8) ACCUMULATOR EXTRACTION (AEX).

The AEX timing state enables the triggers to allow extraction from the Accumulator. As previously pointed out, the **AEX state must be preceded by VMP by 5 timing states (100 ms)**. The AEX state enables (with a proper delay) also the trigger needed by the DHPTT01 power supply to restore the conditions before extraction. This reset takes 100 ms, implying that **the next LAC timing state cannot happen before 5 timing states (100 ms)**. Moreover, the DHPTT01 and DHPTT02 power supplies operate at 2 Hz maximum rep. rate. **This implies that two consecutive AEX states must be separated each other by at least 24 timing states**. Finally in order to avoid that, during this phase, the extracted beam goes back to the LINAC, the spectrometer magnet DHPTS01 must be turned on. **The LSP LINAC state is** therefore **mandatory when the AEX timing state is set**.

State Incompatibility: LTO, LSB, LBT, LAC, AST, AMR.

9) ACCUMULATOR EXTRACTION & MAIN RINGS INJECTION (AMR).

The AMR state performs the same functions of the previously described AEX state enabling in addition the triggers for the injection into the Main Rings.
It is worthwhile to remark that, as for the AEX case, also **two consecutive AMR states must be separated each other by at least 24 timing states**. Moreover, for the same reason, **24 timing states must separate the AEX state from the AMR (and viceversa)**.

State Incompatibility: LTO, LSB, LBT, LAC, AST, AEX.

10) ELECTRON MAIN RING STORED BEAM (EMS).

The EMS timing state enables the beam synchronous triggers in the Electron Main Ring. Read note in the PMS state description.

State Incompatibility: None.

11) POSITRON MAIN RING STORED BEAM (PMS).

The PMS timing state enables the beam synchronous triggers in the Positron Main Ring.

Note: It is not possible to have just one timing state for the stored beams in the main rings (as in the Accumulator case), if we want to allow for the following three different states:

- Stored beam in the Electron Ring only.
- Stored beam in the Positron Ring only.
- Stored beam in both the Rings.

State Incompatibility: None.

3. Machine State Dispatcher Module Description

The machine state word dispatcher module is performed by a VME slave board mapped in the A16/D16 space as two 16-bit registers. The module distributes a new state word every 20 ms. A machine state word can be built up by one or more 16-bit words (up to 100).

The board receives two 50 Hz square waves 90° apart from each other through two front panel BNC connectors. In this way it is possible to build a software finite-state machine with four 5 ms states inside the dispatcher module. Right at the beginning of one of these 5 ms states the machine state word is broadcasted through a 4 twisted pairs RS485 serial link to different receivers.

Timing precision in the machine state word distribution is limited by the following factors:

- 50 Hz phase jitter;
- dispatcher software uncertainty: 37.5 ns maximum;
- receiver software uncertainty: 12.5 ns maximum.