PROTOTYPE FILE OF BUNCH SELECTOR

R. Bossart

INTRODUCTION

The purpose of the bunch selector has been described by the design study TN-49, fig. 7-7. By means of the bunch selector you can select the fraction of the beam to be ejected from the accelerator. The bunch selector then generates the timing pulses of the pulse forming network for the kicker magnet.

The accelerator of Serpukhov produces a chopped proton beam of 30 clusters or bunches circulating in the synchrotron ring with the speed of light. The bunches pass through the kicker magnet in intervals of 170 ns, i.e. at a frequency of about 6 MHz. This frequency of the bunches is synchronous to the radiofrequency signal RF used throughout in the timing system.

Any number of subsequent bunches can be extracted from the accelerator into the experimental area. The remaining bunches circulate in the synchrotron ring and are extracted by a later ejection. There may be up to three or six partial ejections. simply called shots, during one magnet cycle of the accelerator.

OPERATION

The lay-out of the front panels is dictated by the operational aspects of the fast ejection system. According to the design study TN-49, proposals have been prepared for a system capable of 3 shots which can be extended later for 6 shots. The front panels are represented by fig. 1, 2 and 3. For 3 shots one

chassis with 3 plug-in units is needed for the preselection of the ejected bunches. For 6 shots a second chassis of 3 shots is added. The ejected bunches are monitored on the front panel "Display Ejected Bunches" mounted on a separate chassis. For every shot, the lamps of the ejected bunches are turned on.

Fig. 4 shows the perspective of a bunch selector plug-in unit. The first bunch and the number of ejected bunches can be selected either by the local or remote digital switches. The mode local or remote is controlled by the push-buttons "local" and "remote". The Nixie tubes indicate the actual preselection. The flash-lights "front", "clip" and "tail" signal the trigger pulses for the front gap, clipping gap and tail gap of the programmed shot. The lamp "error" alights, if a bunch has been preselected for ejection by more than one plug-in unit.

SEQUENCE OF PULSES

The ejection is initiated by the C-ejection pulse of the kick-parameter chassis, see fig. 5. At the same time, a RF-train of 1999 pulses is transmitted to the bunch selector plug-in unit. The bunch selector counts the RF-train by a preset counter, which generates the trigger pulse for the front gap after 1000 + a pulses, if a means the preselected first bunch to be ejected. After 1000 + a + b pulses the trigger pulse for the clipping gap is generated, if b means the number of the ejected bunches. The tail gap of the pulse forming network has to be triggered 15 RF-periods before the clipping gap, i.e. the tail trigger pulse is generated after 985 + a + b pulses of the RF-train.

In order to display the ejected bunches, a pulse train "shift" of 60 pulses is transmitted to the display chassis as clock pulse for a shift register of 30 flip-flops.

CIRCUIT DESCRIPTION OF THE BUNCH SELECTOR PLUG-IN UNIT

The bunch selector plug-in unit shall consist of the following functional parts, see fig. 6:

- digital preselection A and display B of first bunch. The preselection is either local or remote.
- digital preselection C and display D of ejected bunches. The preselection is either local or remote.
- arithmetical adder E computing the preselection of the clip trigger pulse, see fig. 7.

- arithmetical adder F calculating the preselection of the tail trigger pulse, see fig. 8.
- parallel counter G of the RF-train.
- digital comparator H to detect the coincidence between the preselection F for the tail trigger and the content of the counter G.
- digital comparator I to detect the coincidence between the preselection E for the clip trigger and the content of the counter G.
- digital comparator K to detect the coincidence between the preselection A of the front trigger and the content of the counter G.

The main functional parts A.....K are interconnected by logic gates as indicated in fig. 6. Some of them are high speed integrated circuits to avoid excessive propagation delay times of the RF-train. Care has to be taken for the lay-out of the printed circuit for all paths of the RF-train.

The following input signals are connected by coaxial cables to the rear-side of the bunch selector plug-in unit:

-"Start"from the accelerator, establishing the zero condition at the beginning of every magnet cycle of the accelerator. The start pulse opens the gate L for the RF-train.

-"RF-train"from the accelerator drives the parallel counter G by the gate L and acts on the coincidence gates N, O and P.

-"Program"from the program sequencer permits the plug-in unit to generate the trigger pulses for the pulse forming network. The gates L and M of the RF-train are opened by a positive signal of the program input.

-"Interlock"from the interlock system inhibits the plug-in unit to generate the trigger pulses by closing the gates L and M. The ejection is inhibited too, if the preselection of the first bunch or the ejected bunches is zero.

Input signal	Amplitude	Pulse width	Input impedance
Start	+ 20 V	1 µs	10 K
RF-train	+ 4 V	80 ns	1 K
Program	+ 4 V	DC	1 TTL
Interlock	+ 4 V	DC	1 TTL

The input amplifiers of the start pulse and RF-train adapt these signals to TTL levels, see fig. 9 and 10.

The bunch selector generates the output signals to trigger the front gap, the clipping gap and the tail gap.
Every time a trigger pulse sorts, the one-shots OS signal it to the operator by means of a flash-light. The trigger pulses are sorted out at two levels:

- inverted TTL signal for the or-gate and the display logic in the display chassis.
- positive blocking oscillator signal, fig.11, for external use, e.g. scope triggers.

The pulse train"shift" starts after 1000 pulses of the RF-train and lasts for 60 RF-pulses. It is transmitted to the display logic in the display chassis.

Output signal	Amplitude	Pulse width	Load impedance
Front/BO	+ 20 V	1 µs	75 ohms
Clip/BO	+ 20 V	1 µs	75 "
Tail/BO	+ 20 V	1 µs	75 "
Front/TTL	+ 4 V	80 ns	5 TTL
Clip/TTL	+ 4 V	80 ns	5 TTL
Tail/TTL	+ 4 V	80 ns	5 TTL
Shift	+ 4 V inverted	80 ns	10 TTL

The output pulses are connected at the rear-side of the plug-in unit by means of BNC-connectors to the display chassis.

CIRCUIT DESCRIPTION OF THE DISPLAY OF EJECTED BUNCHES

There are 30 lamps on the front panel of the display chassis, see fig. 3. Each lamp switched on represents a bunch which has been ejected. All lamps can be switched on by the push-button "lamp test" to check the display.

Every lamp is driven via a lamp driver by a flip-flop, see fig. 12, all 30 flip-flops together form a serial input/parallel output shift register. The shift register is clocked by the signals "shift" of the individual bunch selector units. The shift pulses have to be delayed for about 60 ns in order to enter first the serial information into the shift register.

The serial information entering the flip-flop 30 is generated by a set-reset flip-flop composed of two high speed gates SN 74H30N. The flip-flop is set by the front trigger pulses and reset by the clip trigger pulses of the TTL level. The set-reset flip-flop delivers a logical "1" signal to the flip-flop 30 of the shift register, during the bunches are ejected by the kicker magnet. Every time a bunch is ejected, one flip-

flop more is switched on. The pulse train "shift" shifts the information to the left side of the register. At the end of the shift-train, the information stands in the correct position of the shift register and the lamps corresponding to an ejected bunch are turned on.

It is worth to notice that this display monitors the ejected bunches in real time and it is no more a static repetition of the pre-selection by the digital switches. Of course, it would be possible to use the bunch signals of the pick-up station in the ejection channels to monitor with the same shift register the bunches which have really been ejected.

An error signal is produced, if you want to eject a bunch, which has already been ejected by a previous shot. The error is detected simply by the coincidence of the set-reset flip-flop and flip-flop 1 of the shift register. The error is identified by the running shift-train and transmitted to the corresponding plug-in unit "bunch selector", where a lamp is switched on. The error signal lasts until a correct ejection is executed.

The display of ejected bunches is capable to monitor up to 6 partial ejections or shots during one magnet cycle. All lamps are switched off at the beginning of a new magnet cycle. They are switched on gradually, as ejection takes place.

AUXILIARY CIRCUITS

The display chassis contains the auxiliary circuits for the trigger split, fig. 13, and possibly other devices. The trigger split collects by three or-gates the trigger signals of the individual bunch selector plug-in units. The output signals "front trigger", "clip trigger" and "tail trigger" are transmitted by fast blocking oscillators to the front master gap, clipping master gap and tail master gap.