KICKING PROTONS, FAST AND CHEAP

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Introduction

The CERN 800 MeV PS Booster with four parallel rings needs an extensive kicker magnet system for injection (IK) into, and ejection (EK) from each ring, for the recombination (RK) of the four beams into one single beam and for injection into the CPS (PS IK).

The requirements on these kicker systems are high reliability, low jitter, fast rise or fall time, flat top uniformity within $\pm 2\%$, easy operation, control and service.

Main Parameters of Kicker Magnets

System	IK	EK	RK	PS IK
Number of identical systems	4	4	3	1
Aperture (mm)	70 · 120	70 · 115	53 · 110	54 · 150
Magnet length (m)	0.95	1.95	1.60	0.80
Integrated field (Tm)	0.01	0.041	0.037	0.018
Deflection angle (mrad) at energy (MeV)	10 50	8.3 800	7.5 800	3.7 800
Rise time (ns)	--	50	50	--
Fall time (ns)	110	--	--	50
Magnet voltage (kV)	15	30	30	30
PFN voltage (kV)	30	30	30	60
System current (kA)	0.6	4.8	4.8	3

Special Aspects of Pulse Generators

For all main switch applications, hydrogen thyratrons (CX1154) were used to avoid pressurized spark gaps; their application posed several problems such as :

- Current rise limited to approx. 100 A/ns per tube affecting either the economical use of the tube or the fast rise time.
- Self-triggering at fast rising anode voltages, due to the anode-grid capacitance, a difficulty encountered in all tail-clipper applications.
- Voltage creeping in for a time of 0.5 μ s during switching, as the anode-cathode voltage decreases from initially 1.5 kV to about 100 V after 0.5 μ s. This effect deteriorates the pulse flat top quality.

- An anode delay time drift due to reservoir voltage variations of more than 30 ns over the lifetime of the tube affecting the triggering precision.

Satisfactory performance has nevertheless been obtained due to the following technical solutions :

- By using a saturating ferrite loaded pulse steepening line, a 30 kV - 5 kA step pulse with 100 ns rise-time could be shortened to 5 ns.

20 ns/div.
before and
after
steepening

- An anode grid coupling opposing to the capacitive grid current

$$I_{ga} = C_{ga} \cdot \frac{dU_a}{dt}$$

the current

$$I_2 = -r \cdot C \cdot \frac{dU_a}{dt}$$

For a 40 kV-CX1154 tube, this correction is satisfactory up to a 35 kV-pulse rising within 50 ns.

The capacitance C, of the same order of magnitude as C_{ga} , represents a small additional charge only for the grid driving circuit.

- An additional polarization of the anode, produced by an auxiliary supply and applied through a capacitor in parallel with a set of semiconductor diodes, compensates for the initial anode-cathode voltage drop immediately after firing the thyatron.