8/31/83
R. Shafer

Main Ring Split-Plate Position Electrodes / Sensitivity

A) Transverse sensitivity

The main ring position electrodes are split-plate (diagonally-cut rectangular boxes). Their dimensions are approximately

Pickup	Width	Height	length
Horizontal	130mm	44mm	137mm
Vertical	105mm	54mm	127mm

Based on these dimensions, and the assumption that the plates are ideal split plate pickups, the "A" and "B" signals should have the following response:

Signal	Horizontal pickup	Vertical pickup
A =	$V_0(65+x)$	$V_0(27+x)$
B =	$V_0(65-x)$	$V_0(27-x)$

Hence the db response per mm displacement in x is

$$\left(\frac{A}{B}\right)_{db\ at\ x=1} = 20\log\left(\frac{A}{B}\right)_{x=1} = 0.27\ db/mm\ \text{(Horizontal)}$$

$$= 0.64\ db/mm\ \text{(Vertical)}$$

these numbers compare well to measured values of 0.24 db/mm (H) and 0.55 db/mm (V) [see M.R. Operations Bulletin 837 R. Gerig (4/6/81). These values should also be compared to the

Tevatron directional coupler pickups (circular aperture = 70mm) which have a sensitivity of 0.67db/mm.

B) Signal intensity

In this case we want to calculate the peak voltage V_m in the 53 MHz component from each electrode when the centered beam has 1×10^{10} protons per bunch (ppb). The equation for this is identical to the Dobler pickup (See BPM Design Note #9, eqn 5:

$$V_{pu}(t) = \left(\frac{Z_0}{2}\right) F\, I_0 \left\{ \exp\frac{-(t-t_0)^2}{2\sigma^2} - \exp\frac{-(t+t_0)^2}{2\sigma^2} \right\} \qquad (1)$$

where Z_0 = characteristic impedance of cable and also of shunt back termination. Hence signal current sees impedance $Z_0/2$.

F = Fraction of wall currents flowing on inner surface of pickup (= 1/2 for 180° azimuthal coverage).

$I_0 \exp{-t^2/2\sigma^2}$ = beam current for beam bunch of width σ (rms).

t_0 = electrical length of pickup plate.

For the Main Ring pickups, $Z_0 = 75\,\Omega$, $F = 1/2$, and $t_0 \sim 4.4\times10^{-10}$ sec.

Fourier analysis leads directly to eqn 13 of BPM Design Note #9:

$$V_m = 2 Z_0 F \langle I_b \rangle \sin(m\omega_0 t_0) \exp\left(\frac{-m^2\omega_0^2\sigma^2}{2}\right) \qquad (2)$$

where for the Main Ring, $Z_0 = 75\,\Omega$

$F = 1/2$

$\langle I_b \rangle = 85\text{ma}$ for 1×10^{10} ppb, $\omega_0 = 53\times2\pi$ MHz

$\omega_0 = 2\pi \times 53$ MHz

m = harmonic # of 53 MHz

σ = rms bunch width $\cong$ 1 nsec.

Note that for short pickups (as is the case here) $\sin(m\omega_0 t_0) \Rightarrow m\omega_0 t_0$, giving into a 75 ohm cable:

$$V_m = 2 Z_0 F m \omega_0 t_0 \langle I_b \rangle \exp\left(\frac{-m^2\omega_0^2\sigma^2}{2}\right) \qquad (3)$$

$$= .935 \text{ volts} \times \exp(-.0107) = .925 \text{ volts}$$

If a series 25 ohm resistor is used to impedance match into a 50 ohm termination, then

$$V_m' = \frac{2}{3} V_m = 0.615 \text{ volts peak at } 1\times10^{10} \text{ ppb.}$$

This value is very similar to the number for the Dabler pickup as presented in BPM Design Note #9. It does <u>not</u> include any cable attenuation losses.

It should be noted in eqn 3 above that the product $F t_0$ appears. hence the signal strength is proportional to the azimuthal coverage x the length. Therefore it is immaterial whether one considers a split plate as 100% coverage for half the length or 50% coverage for the full length of the pickup assembly.