E-6

ISR-RF/JB/MO/ps

17th January 1973

ISR PERFORMANCE REPORT

Run 272, 20.12.72, 20 b - 1.8 10^{12}P/pulse

Test of a new signal processing unit for the transfer line BPMS

Introduction

The purpose of this experiment was to test a new circuitry to process the beam induced signals on the BT electrostatic PU's. The device is designed for PS pulse lengths up to 23 μs (fast and slow ejections).

Experimental device (Fig. 1)

The set-up used for the experiment consisted of:

(a) a present PU station (PU 449)

(b) a new head amplifier, in which the signals from each electrode put a ringing circuit into oscillation. The function is like a "ringing circuit integrator", so that the ringing-amplitude is a function of width and amplitude of the PU signals

(c) a band pass amplifier, $f_0 \sim 10$ kHz, $Q \sim 5$, $G = \sim 70$ dB

(d) a combination of an ultra linear fast rectifier and a hold unit.

Result

With this experimental processing unit, in connection with the small Beam-Position-Analog-Computer (designed by D. Cocq), we could measure the following beam position:

∿ -2 mm (Down), ∿ +3 mm (Right)

In addition we watched the signals at the input of the "rectifier and hold" unit with and without screen in the transfer line. We wanted to see if beam losses, inducing secondary emissions, perturb this PU circuitry.

Results: (a) Noise: Max. Noise-Value was between 10 mV_{pp} and 30 mV_{pp} (Pic. 3).

(b) Beam loss effects: We could observe that the signal shapes with and without screen in the transfer line are the same. The signal amplitude with screen in the line was slightly bigger than without screen (Pics. 1 and 2).

Possible reasons:

1. Injection instabilities (PS intensity jitter) which is most probable.
2. Radiation effects → larger PU-signals.
3. Observation errors.

Therefore this "ringing circuit integrator" seems to make the electrostatic PU insensitive to nearby beam losses (radiation). The electrode is directly to ground through the coil of the tuned circuit and charging up is therefore impossible.

(c) Resolution, sensitivity:

A signal of $\hat{e} = 1.25$ mV was detected on the electrodes, which corresponds to $\hat{e} = 7 \cdot 10^{-16} N$ Volt (beam in the centre).

The radial-sensitivity is $S_r = 0.0102 \hat{e} \ \frac{\text{Volt}}{\text{mm}}$

With $1.8 \cdot 10^{12}$P/pulse and signal to noise ratio of one, the smallest detected beam shift is then:

$$x_{min} = \frac{\hat{e}_n}{S_r} \qquad (\hat{e}_n = \text{peak noise voltage})$$

In the test we get $x_{min} = 0.6$ mm.

Conclusion

This test has demonstrated the feasibility of a transfer line BPMS for slow and fast ejection based on the "ringing circuit integrator". The resolution of the prototype circuitry was better than 1 mm for PS pulses of about $1.8 \cdot 10^{12}$P. This performance can easily be improved by optimization of the circuit design in order to reduce its noise level.

All BT PU's already in place will be equipped with an improved version of these new signal processing units (prototype) and connected to the computer. This hardware is compatible with the existing BT PU's programs. This will be done in about two months.

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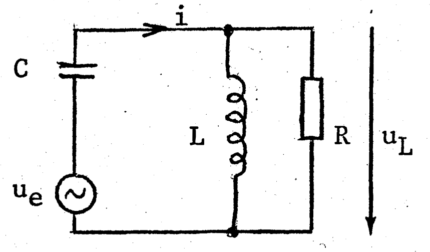
ANNEXE

Calculation of the Voltage u(t) across the ringing-circuit

Head ringing equivalent circuit:



$C \simeq C_r + C_{electrode}$ and $u(t) = u_L(t) + u_e(t)$ is the resulting voltage across the ringing circuit.

Simplified beam induced signal on the capacitor:

$$u_e(t) = U_0 \Big|_{t\,=\,0}^{t\,=\,T}$$

where $U_0 = \frac{Q}{4}\cdot\frac{1}{C} = \frac{N\cdot q\cdot \ell_{pu}}{4\cdot C\cdot V_0\cdot T} \simeq 8.25\cdot 10^{-21}\cdot\frac{N}{T}$

This circuit is a "ringing circuit integrator" because i_L is about proportional to the integral of $u_e(t)_{t\,=\,0}^{t\,=\,T}$ if $T < \frac{1}{4}$ of the ringing period and $R \gg \omega L$.

$$u = i\cdot Z$$

$\mathcal{L}$ Transf.:

$$U_e(p) = I(p)\left(\frac{1}{pc} + pL \parallel R\right)$$

we obtain:

$$U_L(p) \simeq U_0 \frac{p}{p^2 + p\frac{1}{cR} + \frac{1}{Lc}}\left(1 - e^{-pT}\right)$$

$\mathcal{L}^{-1}$ Transfor. and further calculation:

$$u(t) \approx -U_0 \left[e^{-\frac{1}{2CR}}\cdot \sin \omega\frac{T}{2}\cdot 2 \sin \omega\left(t - \frac{T}{2}\right) - \left(1 - 1(t - T)\right)\right]$$

$$u(t) = 8.25\cdot 10^{-21}\,\frac{N}{T}\left[\left(1 - 1(t - T)\right) - \left(2e^{-7.4\cdot 10^{2}\cdot t}\sin \Pi f_0 T\right)\cdot \sin(2\Pi f_0 t - \Pi f_0 T)\right]$$

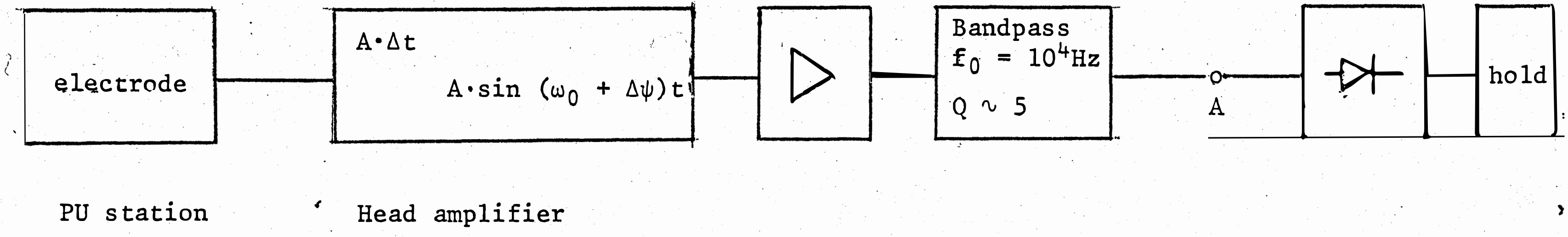
Calculated value at the fifth period:

with $T = 2.1\ \mu s$, $N = 1.8\cdot 10^{12}$

$\hat{U} = u(502\mu s) \simeq 0.8\ mV_{peak}$

measured: $\hat{U}(502\ \mu s) \simeq 1.25\ mV_{peak}$

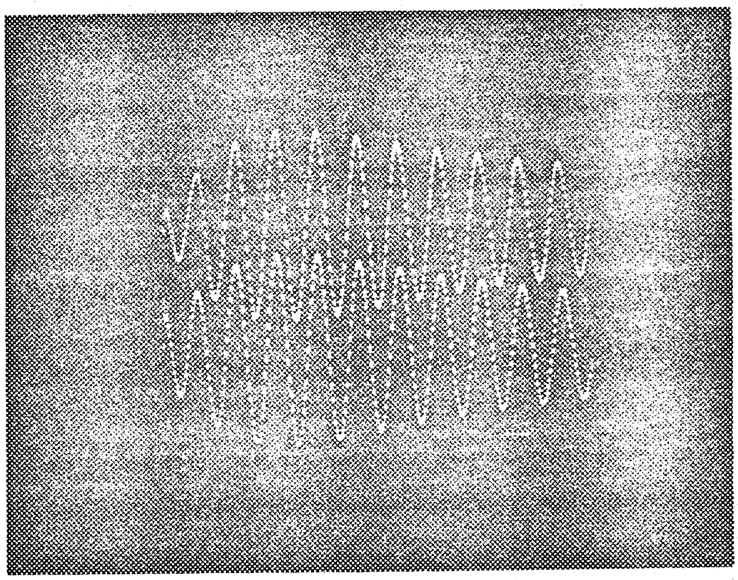
FIG. 1


electrode
$A \cdot \Delta t$
$A \cdot \sin\ (\omega_0 + \Delta\psi)t$
Bandpass
$f_0 = 10^4$Hz
$Q \sim 5$
A
hold
PU station
Head amplifier

Signals in A

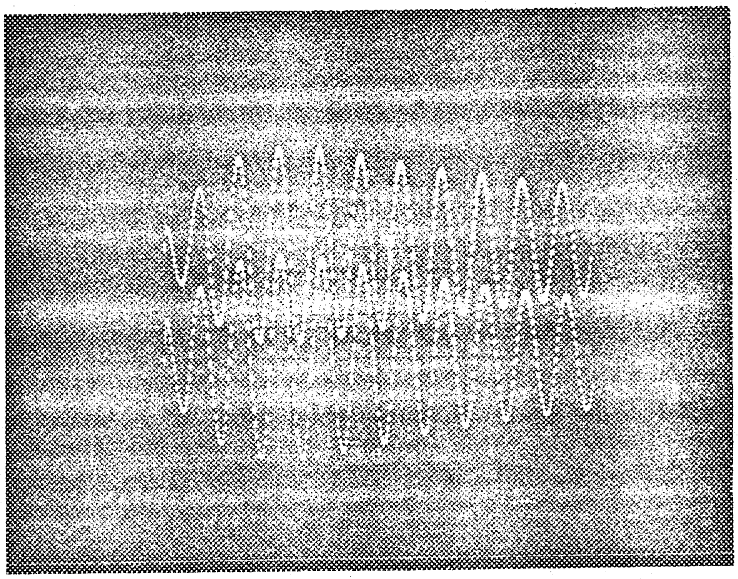
Electr. 1/2
1 V/div
0.1 ms/div

1.



Electr. 1/2
1 V/div
0.1 ms/div

2.



Electr. 1/2
noise
20 mV/div
50 µs/div

3.