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MEASUREMENT OF RF PARAMETERS IN THE PS

[Update for Annex 4 of PS/RF/Note 94-24 (Min.)]

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1. BASIC PRINCIPLE

The aim is to provide at the end of every machine cycle a set of measurements which completely characterize the operation of the RF systems. Voltage, frequency and phase have to be measured on all RF installations. The precise list of parameters is given in the following Table.

PARAMETER	NUMBER	INTERFACE MODULE (VME)
Voltage (programmed and detected) on all systems	- ferrite cavities : 2 x 11 - 200 MHz system: 2 x 1 - 200 Mhz capt. eff.: 1 - 114 MHz system: 2 x 1 - (40 MHz cavities: 2 x 1) - (80 MHz cavities: 2 x 1)	2 Sample & Holds (MPV959) 2 ADCs (MPV908)
Frequencies	- Revolution : 1 - 200 MHz : 1 - 114 MHz : 1 - (40 MHz) : 1	4 Dual Port RAMs
Harmonic Numbers	11	5 + 1/2 Dual Port RAMs
Ferrite cavities phases w.r.t. reference revolution frequency	11	2 TDCs (V488)

All these measurements are acquired at the rythm of the PS C train (1 ms clock) between C200 and PX.ELFT for a total of up to 2340 for a 3.6 s cycle (LHC). During the dead time between cycle, the DSC will process these raw data and provide computation results to the clients on the network.

<u>Important:</u> no control of the acquisition timings through the network. The idea is that all measurement systems in the PS should run with the same sampling clock, and with fixed triggers, so that various application programmes can simultaneously access to the data without disturbing each other.

2. PROCESSING

The frequencies and voltages measured on the 200 MHz, 114 MHz and 40 MHz systems simply have to be multiplied by a scale factor. The total voltage on each of these frequencies is directly acquired.

The parameters concerning the ferrite cavities need a more involved treatment. The harmonic number and the phasing of these cavities is highly variable and changing from cycle to cycle. Processing is required to reconstruct the total voltage experienced by the beam.

Definitions

n	Time sample index
i	Cavity index
s	Particle polarity (+1 or -1)
$Vd_i(n)$	Voltage detected on cavity i
$Vp_i(n)$	Voltage programmed on cavity i
$f_{rev}(n)$	Revolution frequency
$h_i(n)$	Harmonic number of cavity i
hl(n)	List of harmonic numbers at sampling time n
$V\Sigma d(n,hl(n))$	Total voltage measured on harmonic hl at sampling time n
$\phi\Sigma(hl(n))$	Phase of sum voltage on hl w.r.t. f_{rev}
$V\Sigma p(n,hl(n))$	Total voltage programmed on harmonic hl at sampling time n
$\tau_i(n)$	Time interval from zero crossing on cavity i to reference revolution train
$T\%_i$	Distance in % circumference of cavity i w.r.t. the reference cavity
θ_i (h)	Ideal phase of cavity i w.r.t. the reference cavity on harmonic h
$\phi_i(n)$	Phase of cavity i w.r.t. f_{rev}
$\Delta\alpha_i(n)$	Phase error on cavity i at time n

The reference cavity is arbitrarily defined as cavity 66. The list of cavities and their distances expressed in fraction of the PS circumference are given below.

Cavity	11	36	46	51	56	66	76	81	86	91	96
i	1	2	3	4	5	6	7	8	9	10	11
$T\%_i$	.45	.70	.80	.85	.90	0	.10	.15	.20	.25	.30

Formulae

Ideal phase for cavity i on harmonic h w.r.t. the reference cavity:

$$\theta_i(h) = 2\pi \cdot h \cdot s \cdot T\%_i \mod(2\pi)$$

Phase measured on cavity i w.r.t. f_{rev}:

$$\phi_i(n) = 2\pi \cdot \tau_i(n) \cdot h_i(n) \cdot f_{rev}(n) \mod(2\pi)$$

Total voltage measured on harmonic hl(n):

$$XV\Sigma d(n, hl(n)) = \sum_{\text{i of cavities on hl}} [Vd_i(n) \cdot \cos(\phi_i(n) - \theta_i(hl))]$$

$$YV\Sigma d(n, hl(n)) = \sum_{\text{i of cavities on hl}} [Vd_i(n) \cdot \sin(\phi_i(n) - \theta_i(hl))]$$

$$V\Sigma d(n, hl(n)) = \sqrt{XV\Sigma d(n, hl(n))^2 + YV\Sigma d(n, hl(n))^2}$$

Phase of sum voltage on hl w.r.t. f_{rev}:

$$\phi\Sigma(hl(n)) = \mathrm{Arg}\left(XV\Sigma d(n, hl(n)) + j \cdot YV\Sigma d(n, hl(n))\right)$$

Phase error on cavity i operating on hl:

$$\Delta\alpha_i(n) = \phi_i(n) - \theta_i(hl) - \phi\Sigma(hl) \mod(2\pi)$$

Total voltage programmed on harmonic hl(n):

$$V\Sigma p(n, hl(n)) = \sum_{\text{i of cavities on hl}} Vp_i(n)$$

Complementary information

Grouping of cavities at a given time n is governed by the harmonic number measured at that moment on each cavity.

Phase and harmonic data on a cavity with a negligeable voltage ($V_d < 1$ kV) must be discarded from the various summations.

Only integer harmonic numbers are authorized on cavities developping a meaningfull voltage ($V_d > 1$ kV). If a non-integer harmonic number is measured on such a cavity, a warning message has to be displayed.

3. RESULTS DISPLAY

The amount of data transfered on the network is likely to be important...

The basic displays required have been already published and are reproduced in the present note. Frequency graph, second marker and graphics "zoom between markers" are expected extensions
of that elementary request.

Distribution :

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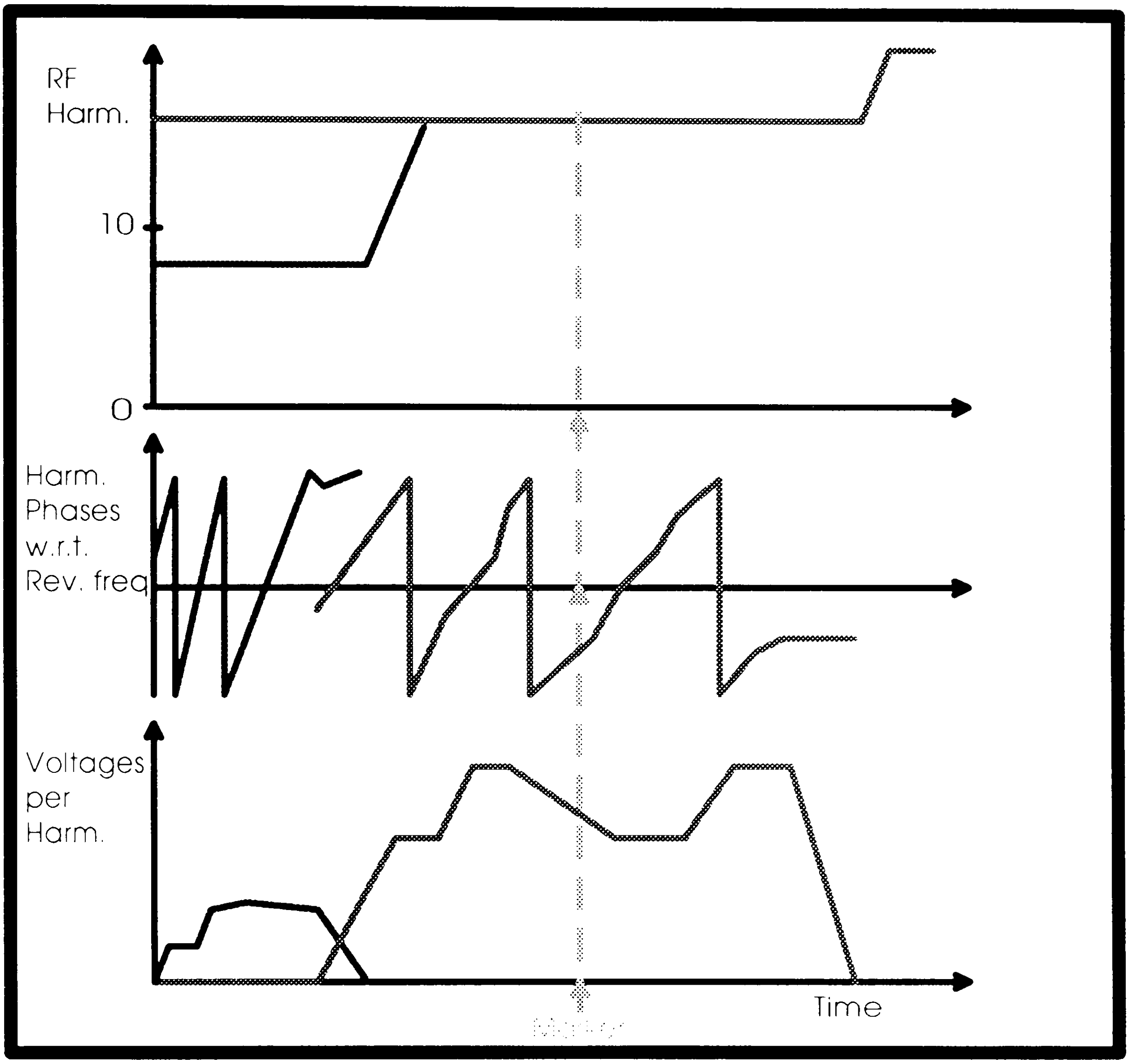
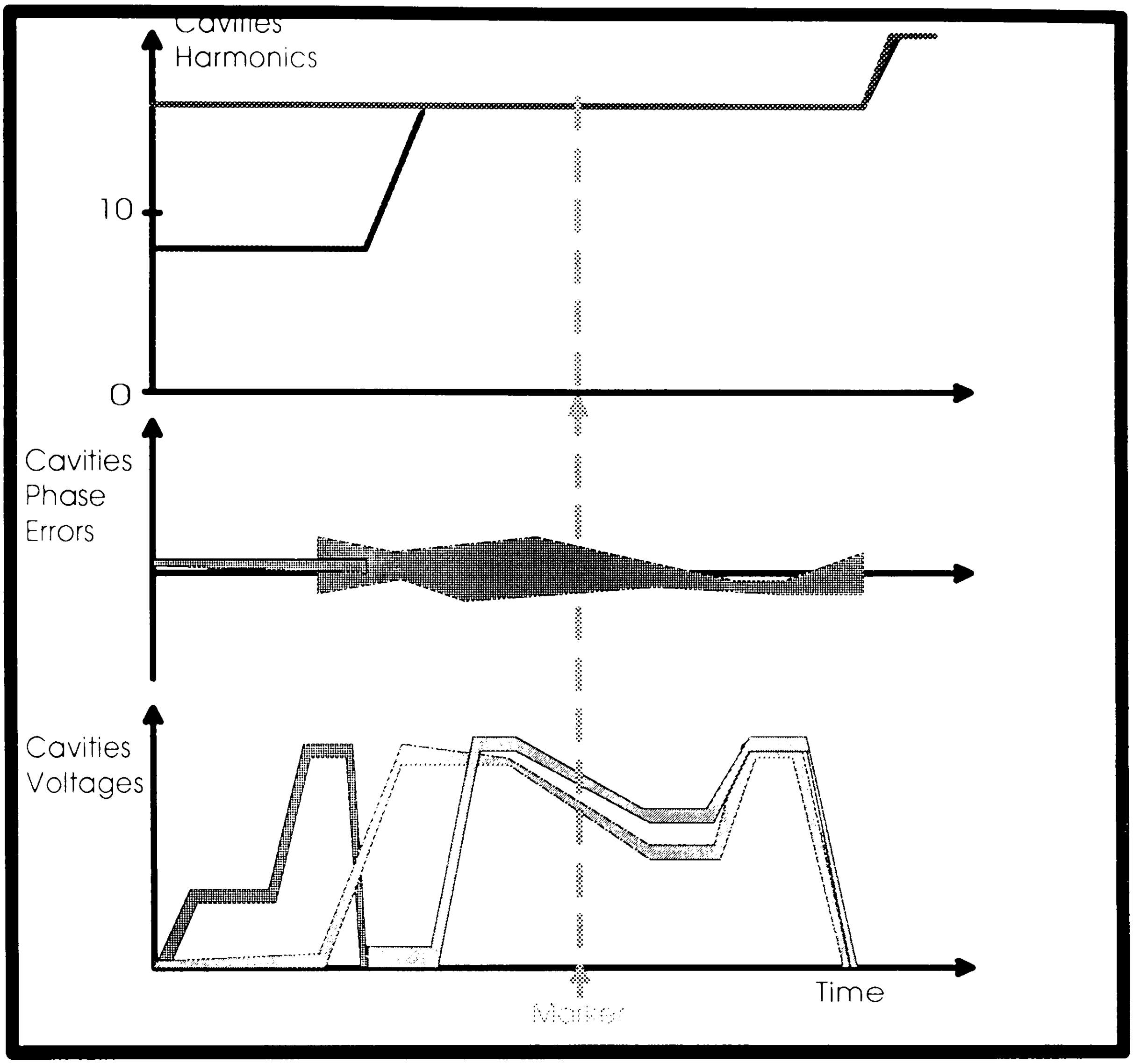


Values @ Marker : C 564			
Harm.	V prog.	Vdet.	Phase
16	128	115	67

GLOBAL RF MEASUREMENTS DISPLAY

R.Garoby 1/11/94



Values @ Marker : C 564				
Cavity	V prog.	Vdet.	H nb.	Phase
11	15.0	15.2	16	-10
36	15.0	14.7	16	5
46	15.1	15.0	16	8
51	15.0	15.3	16	13
56	14.9	14.9	16	-15
66	15.0	15.0	16	- 3
76	14.9	14.7	16	2
81	15.0	15.1	16	5
86	15.0	14.8	16	20
91	15.2	14.0	16	12
96	15.0	15.1	16	- 12

CAVITIES MEASUREMENTS DISPLAY

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