# SOME ASPECTS OF PHASE DISPLACEMENT METHOD

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*Abstract*

The experiments to improve a slow extraction low frequency duty factor by using the RF phase displacement method have been carried out at U-70. A low frequency ripple of extraction intensity times less for the whole range of frequencies up to 500 Hz. The main magnetic field is responsible for more moderate suppression of extraction intensity ripple. More correct calculations of low frequency duty factor through the RF phase displacement method are presented.

## 1 INTRODUCTION

The low frequency duty factor for conventional extraction is [1]:

$$\tau_0 = \frac{(\int I(t)dt)^2}{T_s \int I^2(t)dt} \quad = \frac{1}{1+\frac{1}{2}(\frac{\delta\dot{Q}_\omega}{\dot{Q}_0})^2}$$

where $\dot{Q}_0$ is initial speed (for example due to changing of main accelerator field B), $\delta\dot{Q}_\omega$ - component due to ripple in power supplies.

Principle of RF phase displacement method [1] is to icrease speed of resonance passing, i.e. $\dot{Q} = K_0\dot{Q}_0 + \delta\dot{Q}_\omega$, where $K_0$ is improvement factor:

$$K_0 = \sqrt{\frac{\pi}{|\Gamma|}} \tag{1}$$

$|\Gamma|$ is linked to RF voltage per turn by:

$$V|\Gamma| = 2\pi R\frac{d(B\rho)}{dt}$$

and low frequency duty factor for extraction by RF phase displacement method is:

$$\tau = \frac{1}{1+\frac{1}{2}(\frac{\delta\dot{Q}_\omega}{K_0\dot{Q}_0})^2} \tag{2}$$

## 2 MORE CORRECT CALCULATIONS.

Initial theory [1] suppose that $K_0$ is constant, but really $K_0$ $\neq$const=K(t) due to ripple of main magnetic field, and so $\dot{Q} = K(t)\dot{Q}_0 + \delta\dot{Q}_\omega$, where K(t)$\dot{Q}_0 \propto \sqrt{\dot{B}(t)}$, $\dot{B}(t) = \dot{B}_0 + \delta\dot{B}(t)$. Instead (2) we have:

$$\tau = \frac{1}{1+\frac{1}{2}(\frac{\delta\dot{B}_\omega}{2\dot{B}_0} + \frac{\delta\dot{Q}_\omega}{K_0\dot{Q}_0})^2} \tag{3}$$

We can see that the suppression factor of some initial intensity ripple defined not only $K_0$, but also by strength of disturbation of time derivative of $\dot{B}_0$. If we have $K_0 \gg 1$ then extremely small possible intensity ripple is $\frac{\delta\dot{B}_\omega}{2\dot{B}_0}$.

## 3 NUMERICAL EXAMPLE FOR U-70.

The experiments to improve a slow extraction low frequency duty factor by using the RF phase displacement method have been carried out at U-70 [2]. At picture 1 are presented:

line 1- spectrum of extraction intensity for conventional extraction (low frequency duty factor $\approx$ 0.75)

line 2- spectrum with RF switch on ($\tau \approx 0.97$).

In our conditions theoretical improvement factor $K_0$ (1)is

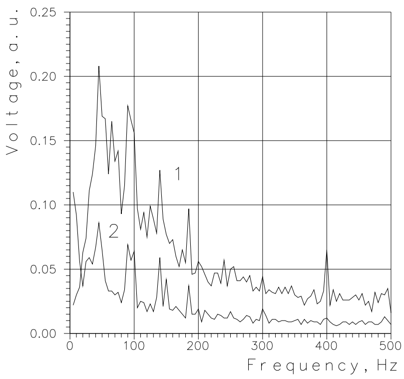


Figure 1: Spectrum of slow extraction intensity

about 40. Taking into consideration the width of resonance in $\frac{\Delta p}{p}$ due to change with betatron amplitude this value changed to $\approx$37. As may be seen from fig.1, suppression is modified over frequencies: for field frequencies (i.e. 46,92,140,185 Hz) improvement factor is 2$\div$3, for other frequencies is 4$\div$6. The experimental improvement factor for whole range of frequencies is about 3.4. Such great discrepancy between theoretical and experimental values must be explaned. As we suppose, explanation of this discrepancy is presented above (section 2). At fig.2 is presented voltage ripple at the power supply of main magnet ( for U-70 we have $\delta\dot{B}_\omega \approx 0.37V_\omega$, in our experiments $\dot{B}_0 = 20$ Hs/sec.

With this data extremely possible theoretical improvement

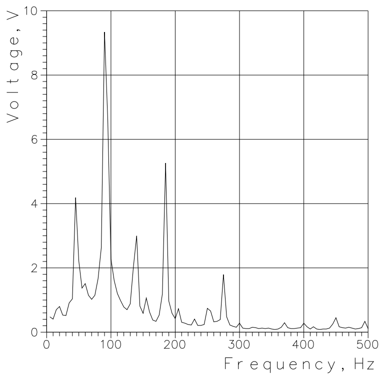


Figure 2: Voltage ripple at power supply

factor (3) is about 6.5.

## 4 REFERENCES

[1] Cappi R., Steinbach Ch.// CERN/PS/OP 80-10. Geneva, 1980.

[2] Afonin A., Maksimov A... "The experiments on improvemet of low frequency duty factor for slow extraction at U-70." XIV Conf. on High Energy Accelerators (abstracts). Protvino, 1994, p.142.