DETUNING OF THE SLS-CAVITIES BY A BEAM-DUMP

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A beam loss in the SLS storage ring results in a temporary detuning of the accelerating cavities followed by a sudden increase of the reflected RF power up to values in excess of 80 kW. In the initial configuration this excessive reflected power was switching off the four cavities and the restart procedure needed at least 15 minutes. A simple new regulation system has been introduced to reduce the reflected power under the interlock limit while the tuning system is bringing the cavity into resonance. The RF is no more switched off and is within one minute ready again for the storage ring operation.

INTRODUCTION

The automatic tuning system keeps the cavities on resonance and a minimum reflected power. As the beam is switched on, the bunches are not travelling through the cavity at the highest value of the RF voltage but on the raising edge of it. The result will be a complex impedance seen from the coupling loop. This detuning of the cavity has to be continuously corrected by the tuning system.

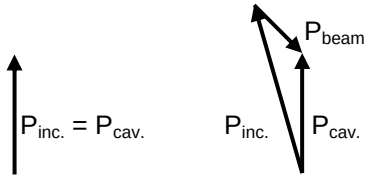

Fig. 1: Vectorial addition of the klystron power and beam power

BEAM-DUMP

By a beam-dump the phase of the reference RF signal is shifted to 180° for 250 µs [1]. The cavity voltage falls down to zero and builds up again with the new phase. The energy of the beam decreases and within 100 µs the electrons are dumped on the vacuum chamber wall. During this time the beam power and the klystron power will have nearly the same phase and it will lead to a small overshoot of the cavity voltage. After the vanishing of the beam, the beam power vector in the schematic of Fig. 1 is missing. The cavity is now detuned and almost the whole incident power reflected, reducing the cavity voltage. The tuning system tries to correct this mismatch, but this action needs about one minute. So the amplitude loop pushes more incident power to restore the RF voltage. But this will lead first to more reflected power, because of the detuned cavity, and the alarm limit will switch off the plant. The restart is then very time-consuming.

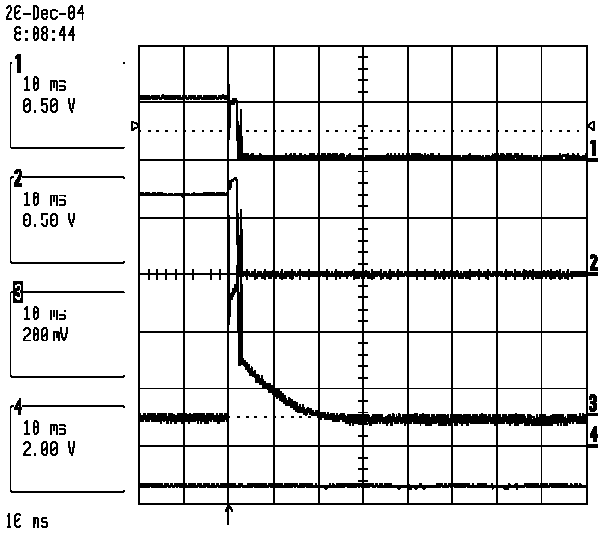

Fig. 2: Beam-dump at 350 mA. Measurement at SR2 with a resolution of 10 ms/division.
Ch1: Cavity voltage
Ch2: Incident power
Ch3: Reflected power
Ch4: Position tuning

After about 3 ms of reflection the plant is switched off and the cavity voltage goes to zero.

Normally the difference in the amplitude loop between set value and read value – the so-called *error value*- is computed and the result, the control signal, will be proportional to the incident RF power. Due to security a limitation of this control signal can be set to avoid a too large incident power.

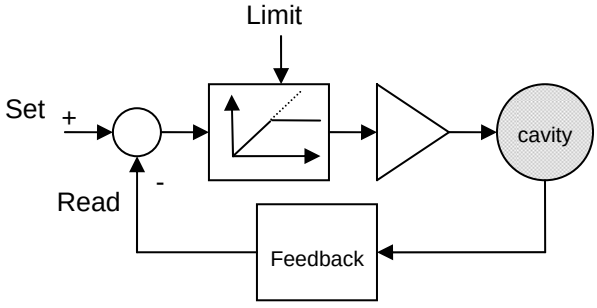

Fig. 3: Simplified amplitude loop with limitation of the control signal

IMPROVEMENTS

A control loop acting on the incident power has been introduced to keep the reflected power under the interlock limit to give the tuning system enough time to readjust the resonance of the cavity without break down.

The reflected power is rectified and applied with a negative sense – that means it will be subtracted- to the limitation.

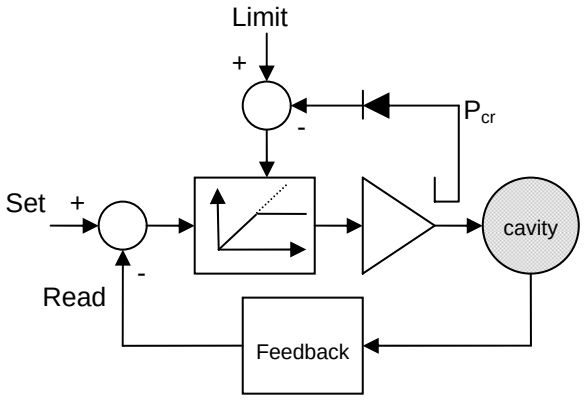

Fig. 4: Additional loop using reflected power

MEASUREMENTS

In case of detuning and high reflected RF power the limitation will be pressed down, the incident power reduced and so the reflected power maintained under the interlock limit.

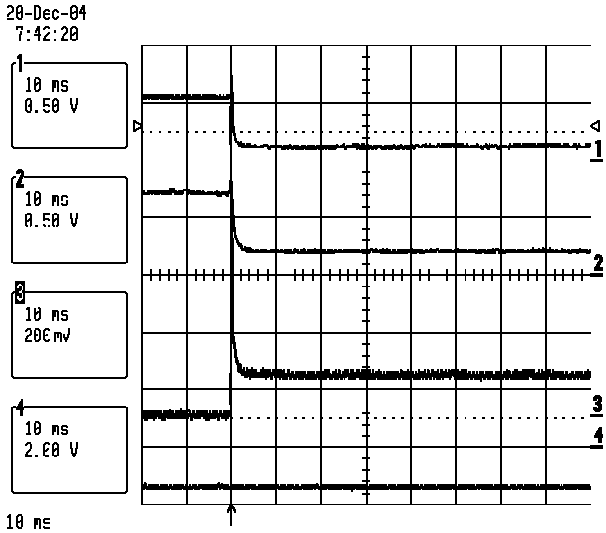

Fig. 5: Beam-dump at 350 mA. Measurement at SR2 with P_{cr} –loop (10 ms/division resolution)
Ch1: Cavity voltage
Ch2: Incident power
Ch3: Reflected power
Ch4: Position tuning

The RF power is reduced but not switched off.

After approximately one minute the cavity tuning will have restored the resonance position, the cavity voltage is at the operating value and the reflected power returned to a minimum level. The beam can be restarted.

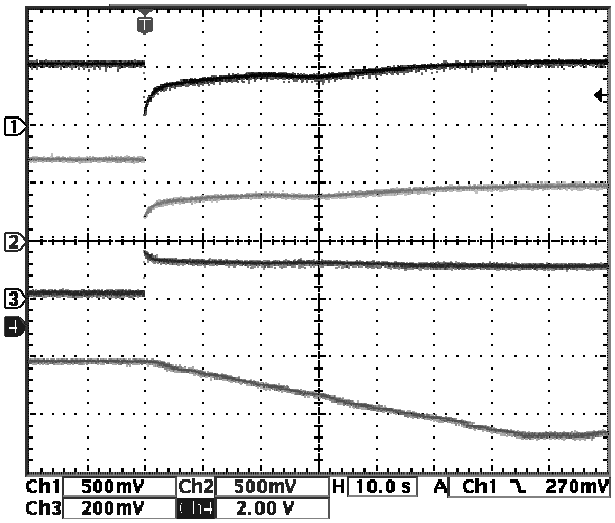

Fig. 6: Beam-dump at 350 mA. Measurement at SR2 with P_{cr} -loop.
Ch1: Cavity voltage
Ch2: Incident power
Ch3: Reflected power
Ch4: Position tuning

On Fig. 6, after the beam loss, the incident power needed for the cavity voltage alone will be restored after 6 divisions, corresponding to one minute.

The new control loop is active only when the reflected power exceeds the threshold value of 15 kW. In a normal working situation with low reflected power, the limitation is high enough to avoid interferences with the amplitude loop.

CONCLUSIONS

The new loop to control the maximum value of the reflected power is implemented in all four storage ring systems. In case of a beam loss, the cavities are not any more switched off, and are ready to accept a new beam injection within one minute. In the initial configuration the break down of the four RF plants lead to a delay of 15 minutes at least.

REFERENCES

[1] M. Gaspar, *Design of Beam Dump Relay*, PSI internal technical communication.