THE MANUFACTURING AND TESTS OF THE NEW VERTICAL FEEDBACK STRIPLINE AT SOLEIL

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Abstract

This paper describes the manufacturing and tests of the vertical kicker for the bunch-by-bunch transverse instability feedback system at Soleil. A careful design of this stripline and of its vacuum feedthroughs was aimed to maximize the excitation power and minimize the power taken from the beam. The simulations of two feedthroughs and two striplines are given for comparison. The first feedthrough has a titanium pin and the second one has a molybdenum pin. The first stripline is the one of the tune measurement, used for the transverse feedback system in waiting for the manufacturing of two striplines dedicated. The second one is the new vertical feedback (VFB) stripline. We also estimated the temperature inside this VFB stripline at high beam currents, especially on the ceramic-to-metal feedthroughs seals. Finally we report on the difficulties encountered with obtaining good feedthroughs.

INTRODUCTION

The bunch by bunch transverse feedback system needs two specific stripline kickers, one in each plane. The VFB kicker is presented in this paper whereas the horizontal kicker study is still in progress.

The VFB stripline has two electrodes no short-circuited and four feedthroughs, that is two per electrode (Fig.1).

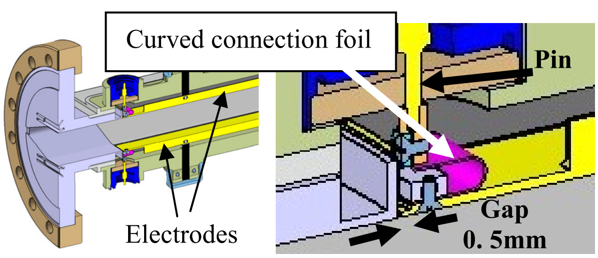

Figure 1 : Final VFB stripline.

Compared to the initial study of the VFB stripline, two main elements have changed [1]. The connection foil between the feedthrough and the electrode which was made of stainless steel has been replaced by one made of copper. Moreover, because of brazing problems, we had to replace the feedthroughs too. We report here on the problems encountered, and show the resulting performances.

First of all, this paper gives the difference of the reflection coefficient between simulations and measurements of the VFB stripline. The shunt impedance of the tune stripline and that of the VFB stripline have been also simulated. The temperatures reached at high beam current inside the stripline are presented too. Finally, the experimental results are given according to the bunch pattern modes and the chromaticity.

VFB STRIPLINE

Characteristic Impedance

The characteristic impedance of the VFB stripline has been matched to 50 Ω to limit reflections of signals coming from amplifiers. This impedance depends on electrode width and thickness, and also on the volume of the cavity between the electrode and the vacuum chamber. Figure 2 shows the satisfying agreement between simulation and measurement for the reflection coefficient (S11 parameter) [1].

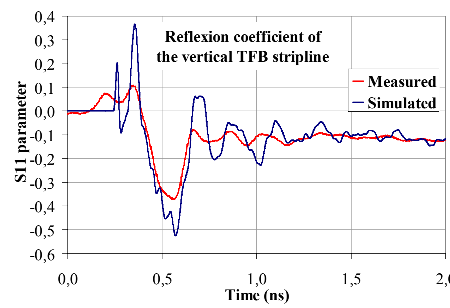

Figure 2: Reflection coefficient of the vertical stripline.

Shunt Impedance

The shunt impedance usually called R (not Z) is the ratio between the squared voltage seen by bunches (V) and twice the power from RF amplifiers (P).

$$R = \frac{V^2}{2P}$$

Higher the shunt impedance is, more amplifier power is transmitted to the kicker. The simulated shunt impedance versus frequency of the VFB stripline and that of the tune stripline are given in figure 3, [1] [2]. Both decrease proportionally to the frequency. The highest shunt impedance value has been found at the frequency of 50 MHz. It is of 66 kΩ for the VFB stripline and of 600 Ω for the tune stripline. If we consider only the shunt impedance, the VFB stripline needs a hundred times less amplifier power than the tune stripline for the same potential seen by the beam.

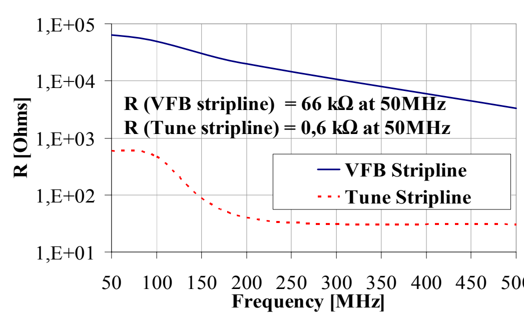

Figure 3: Simulated R versus frequency.

Coupling Impedance

The impedance seen by the beam, called also the beam impedance, has been simulated. It is negligible compared to that of the total impedance of the machine. [1]

STRIPLINE FEEDTHROUGHS

Brazing Problems Encountered

In a first time, we designed a new N-type feedthrough with a titanium pin and also a new geometry of the ceramic part. The titanium pin permitted to decrease the manufacturing time. And the new ceramic geometry permitted to optimize the signal reflection. The feedthrough of titanium pin type is presented in figure 4.

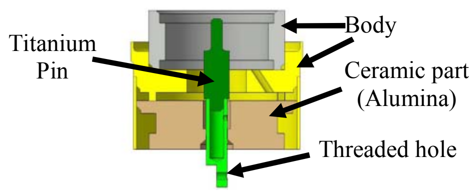

Figure 4: Feedthrough with a titanium pin.

The ceramic matter being constituted of titanium components, the ceramic does not need a plating to be brazed with the titanium pin. That is the reason this process reduces the manufacturing time. Unfortunately, the brazing inside and outside the feedthrough were not efficient. The ceramic brazing leaked either around the pin or around the body circumference.

After doing a "Penetrant Testing", cracks appeared through the ceramic confirming the brazing was bad. This test consisted in doing a bath of feedthrough in a fluorescent product. The product becomes fluorescent with a black light (light giving UV rays).

Because of these brazing problems, we studied another feedthrough (Fig.5). Already mounted in the tune stripline for the booster, its pin is made of molybdenum. And its ceramic geometry is more standard, it is a simple cylinder.

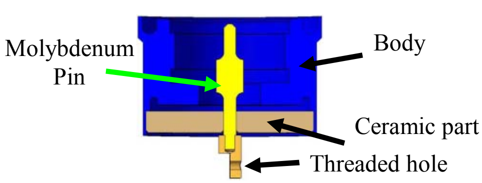

Figure 5: Feedthrough with a molybdenum pin.

However, we had to match it to be able to mount it in the VFB stripline, particularly its height and its pin by adding a tip. This tip has a threaded hole to fix the copper foil connecting the feedthrough to the electrode.

Feedthrough Characteristics

The simulated reflection coefficient for each type of feedthroughs is shown in figure 6 (S11 parameter). [2]

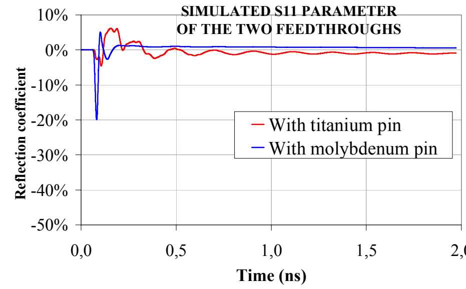

Figure 6: Simulated Feedthroughs reflection.

The performances reached with the feedthrough of titanium pin type are better than these of the feedthrough of molybdenum pin type. The reflection coefficient of the feedthrough of molybdenum pin type reached -20% before crossing the ceramic while the reflection of the other feedthrough did not exceed 5% in the same area. The signal is less disturbed with the feedthrough owning a titanium pin.

Although the feedthrough of titanium pin type is better, we decided to mount the feedthrough of molybdenum pin type in the VFB stripline. We made this choice because of the brazing problems and in order to make sure the feedthrough were good, with no risk of vacuum leaks.

THERMAL STUDY

Only one part of the wall current crosses electrodes of the stripline. This part is noticed as the *K* factor which depends on the electrode width and on the total circumference length of the chamber section. The estimated *K* factor is of 43.8% for the vertical TFB stripline.

The mean power P_D which is dispersed through each element in the VFB stripline depends on the stripline response, on the skin effect of each element, on the matter resistivity and on the thermal resistance (R_{th}). Taking into account all these parameters, the P_D value and the temperature T of each element have been calculated for the vertical stripline at the ambient temperature of 21°C (Table 1).

Table 1 : Calculated power and temperature in the VFB stripline

	Mounted Feedthrough	Copper foil	Electrode
R_{th} max (K/W)	12	34.8	526.5
P_D (mW)	258	70	128
Δt (°C)	3	2.4	67.6
T	24°C	23.4°C	88.6°C

The tune stripline has no heating. Thanks to its short-circuited electrodes, all the beam power is evacuated by the vacuum chamber body.

These results of the vertical stripline have been verified with the 3D ANSII code (Fig.7)

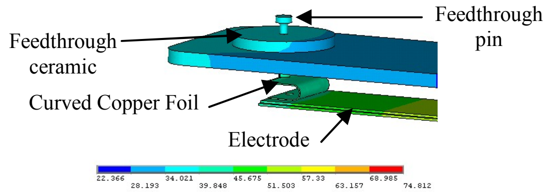

Figure 7 : Distribution of the temperature

The analytical calculation and the 3D simulation give the highest hot-point at the middle of the electrode. The temperature difference Δt between the feedthrough and the electrode is about 65°C by analytical calculation and about 50°C by 3D simulation. That discrepancy does not have any impact since we just want to know if there is a risk to melt brazing. The feedthrough temperature has to be controlled on line to make sure not to do vacuum leaks. However, be careful, because that is assumed the beam power crossing the stripline goes away at least by a cable or a load. With no charge connected to the stripline, feedthroughs could have vacuum leaks, particularly in upstream feedthroughs.

RESULTS

In order to make sure not to create vacuum leaks in the feedthroughs, we thought out a test protocol to inflict on them. This test has been done to all the feedthroughs. It consisted of ten thermal cycles from 200°C to -65°C with a stage of 20mn at each of these two temperature values. This protocol has been validated by the provider and SOLEIL.

In waiting for the horizontal feedback stripline, we use the tune stripline in the horizontal plane yet.

The first tests have been done by comparing the current instability thresholds obtained with the tune stripline and these obtained with the VFB stripline.

The curves of the current instability thresholds versus the vertical chromaticity (ξ_V) are presented figure 8 in

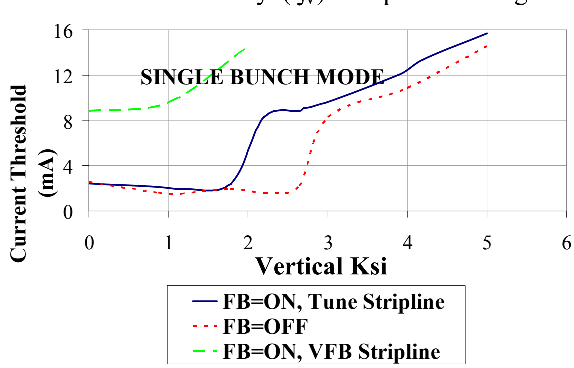

Figure 8: Current threshold versus vertical chromaticities, in single bunch mode.

single bunch mode. This graph also gives the behaviour of these thresholds according to the feedback is off. [3]

The VFB stripline has been also tested in ¾ filling pattern with a horizontal chromaticity (ξ_H) of 2.0. At a max beam current of 300mA and a chromaticity ξ_V =0, the beam stays stable.

These are the first results. We have to continue and complete them, particularly in the 8 bunches mode, in the 4 bunches mode and in some hybrids modes.

CONCLUSION

The transverse feedback system has been installed successfully at SOLEIL. Thanks to experts from other machines such as Spring8 and ESRF, the system has been able to work after only one year in commissioning. It works for users at a beam current of 300mA, in ¾ filling pattern with the chromaticities of two in the two planes.

Although the results obtained with the tune stripline were good, the VFB stripline increases the thresholds of current instabilities in the single bunch mode. Its high shunt impedance permits to improve strongly the kick efficiency on the beam. The VFB stripline installed in the tunnel is shown figure 9.

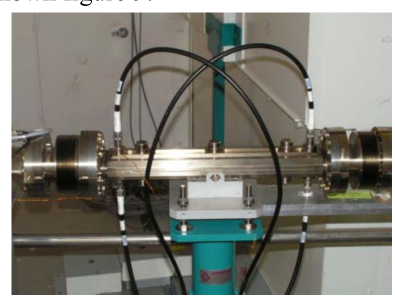

Figure 9: VFB stripline in the storage ring tunnel.

The manufacturing of its feedthroughs led to a large delay for its installation in the tunnel. In spite of the brazing problems, all difficulties have been overcome successfully. The VFB stripline has been finally installed in last February. As it was predicted, there is no heating in the stripline in the worst beam conditions.

The feedback system is stable and reproducible. A stop of the feedback, with zero chromaticity in the two planes, is not dangerous for the machine. The beam does not get lost at one point of the machine but uniformly around the ring.

In the next future, we foresee to use the feedback system to measure the tune on line and to kill the beam quicker than the scrapers.

We expect some best results with the horizontal feedback stripline being in study. This year, the beam current will reach 500mA. Then, the two transverse feedback striplines will be more important to keep a stable beam.

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