UPDATING THE LONGITUDINAL COUPLING IMPEDANCE MEASUREMENT PLATFORM FOR BEPC *

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Abstract

This paper describes the updating of the longitudinal coupling impedance measurement platform for BEPC. The platform uses the principle of the coaxial line method to measure the longitudinal coupling impedance. Instead of the using of the reference pipe, a TRL calibration based impedance measurement method is applied. By this means, the design and fabrication of a reference pipe for every device under test can be omitted. The transition factor of the matching section is provided. The software for the data acquisition and post-process are reprogrammed by the LabVIEW.

INTRODUCTION

Longitudinal coupling impedance is one of the main driving terms of the longitudinal instability in a storage ring. Bunch measurement is commonly used to acquire the impedance of a vacuum component in the storage ring. The longitudinal coupling impedance measurement platform for BEPC was developed by Tsinghua University from 2001[1]. The platform uses the principle of coaxial line method to measure the longitudinal coupling impedance. Similar to most impedance measurement platform, that platform includes a vector network analyser (VNA), a pair of matching section, and a reference pipe (REF), which have the same cross section and length with the device under test (DUT). That means for every DUT, a reference pipe should be fabricated. In order to analysis the impedance of a storage ring, several components with difference length needed to be measured, several reference pipe need to be fabricated.

The updated platform includes most of the component except the reference pipe. Instead, a TRL calibration based longitudinal coupling impedance measurement are applied, so the transition factor of the reference pipe can be calculated. This paper describes the updating of the platform.

THE MEASUREMENT PLATFORM

The measurement platform includes a vector network analyser; a pair of special RF connector with the function of strengthens the inner conductor, a pair of matching sections, the inner conductor, the data acquiring system and the post-processing software. The layout of the platform is shown in figure 1.

Figure 1: Layout of the longitudinal coupling impedance measurement platform

Special RF Connector [2]

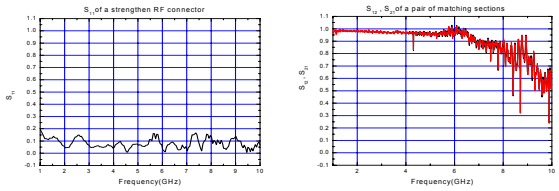
The special RF connector is designed to accomplish the following functions:

- A good transmission performance
- A mechanical structure to strengthen the inner conductor
- A good repeatability and consistencies

The reflection factor of the connector is shown in figure2-a.

Gradual Changing Transition Tapper

In order to increase the signal to noise of the system, the matching section is careful designed with double cosine function. The transmission factor of the matching section is shown in Figure 2-b.



a) b)

Figure 2: Characters of the platform component
a) S_{11} of the special RF connector
b) S_{12}, S_{21} of the matching section

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VNA, DAQ and data post-process

The updated longitudinal coupling impedance measurement platform uses a HP8510C vector network analyser. The measured data is transferred to a PC via a GPIB card. The user interface and post-process program is written by LabVIEW.

TRL CALIBRATION

Typical TRL Calibration

TRL is one of the standard calibration method [3]. The error model of the TRL calibration is shown in Figure 3.

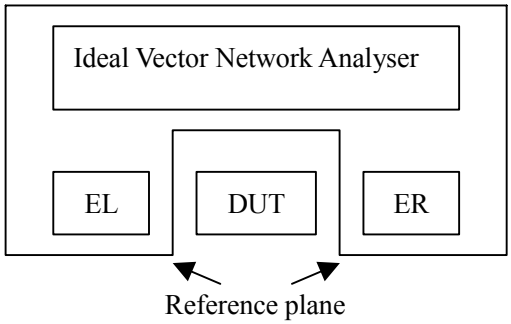


Figure 3: Error model of TRL calibration

The error of the measurement system is expressed by the error matrix: EL, ER. And the isolation error is assumed small enough to be omitted. So the task of calibration is to calculate the 8 components expressing the system error by a sequence measurement of the standard calibration kit. And then de-embedded the S parameter of the DUT by the error matrix and the measurement of the DUT.

The standard measurements for the TRL calibration are THRU, LINE and REFLECT. The advantage of the TRL calibration is that the length of the line and the reflect factor of the reflection standard are allowed to be unknown.

TRL Calibration for the Longitudinal Coupling Impedance Measurement Platform [4]

In order to avoid the fabrication of the reference pipe for every device under test, the TRL calibration method is used in the design of the platform. The reference planes are selected to be the plane between the DUT and the matching section. The character of the matching section and the strengthen RF connector are included in the error matrix. The standard measurement of the THRU, LINE and REFLECT are sketched in Figure 4. The calibration result is strongly depended on the repeatability of the measurement system.

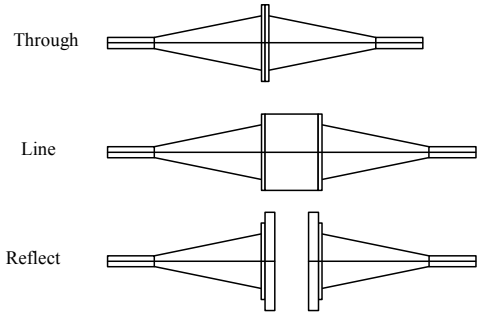
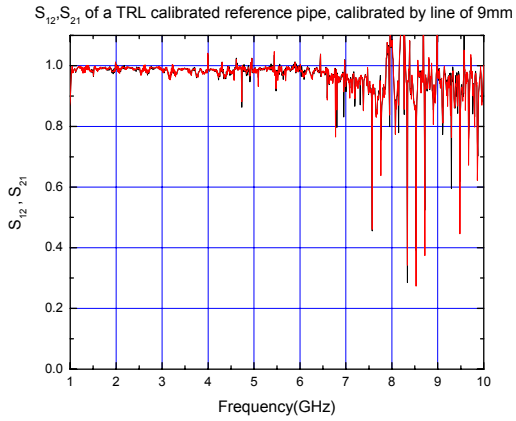


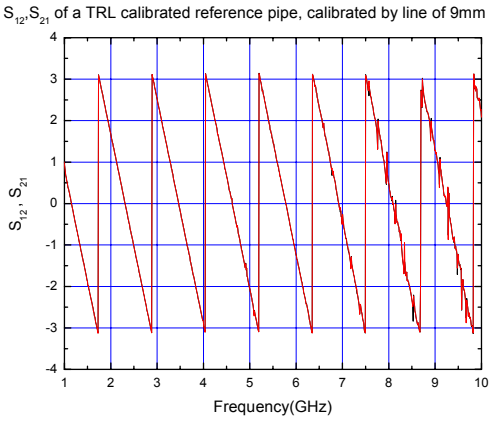
Figure 4: The standard measurement for the platform

Calibrated Data of Reference Pipe with Difference Length

For the impedance measurement platform for BEPC, two lines standard with difference length are tested on the platform. The length of one line standard is 9mm, and the other is 50mm.

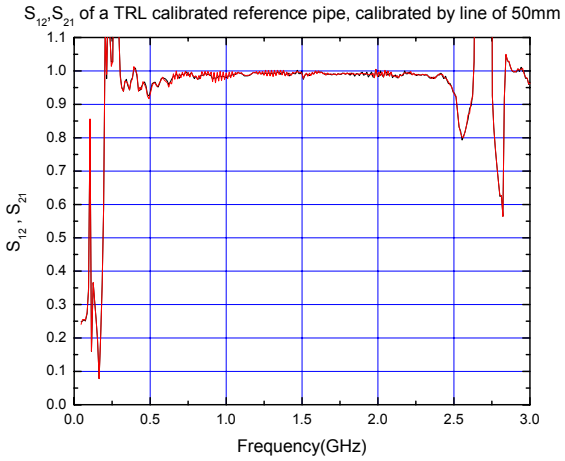


a)

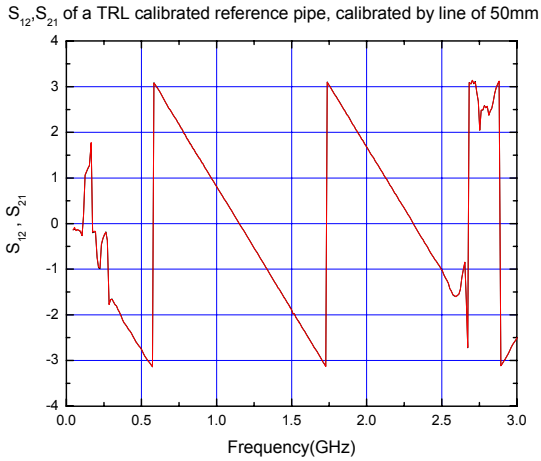


b)

Figure 5: S_{12}, S_{21} of a TRL calibrated reference pipe, calibrated by line of 9mm. a) amplitude b) phase



a)



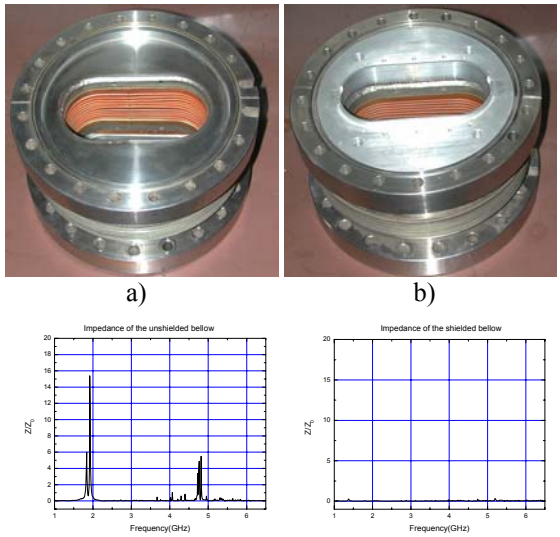
b)

Figure 6: S_{12}, S_{21} of a TRL calibrated reference pipe, calibrated by line of 50mm. a) amplitude b) phase

The S parameter of a reference pipe with length of 255mm is measured and calibrated. The S_{12} and the S_{21} of reference pipe calibrated by the line of 9mm is shown in Figure 5. And the S_{12} and the S_{21} of reference pipe calibrated by the line of 50mm is shown in Figure 6. The longer line can but only be used in a lower frequency range. The calibration of TRL with 50mm line can be used in the frequency range of 0.3 to 2.5 GHz, while the calibration of the TRL with 9mm line can be used in the frequency range of 1 to 7 GHz. The amplitude and the phase of the S_{12} and S_{21} are very close to the theoretical value in the available frequency range. By the means of TRL calibration, the S parameter of a reference pipe with any length can be calculated theoretically. That means the fabrication of the reference pipe can be omitted.

MEASUREMENT OF TWO BELLOWS

The impedance of a bellow with and without the side cavity shielded is measured and compared. The difference of the bellow is shown in figure 7-a, b, and the impedance is shown in Figure 7-c, d. The impedance of the bellow with side cavity have the sharp peak and the shield removed most of them.



a) b)

c) d)

Figure 7:
a),b) the bellow without/with the side cavity shielded.
c),d) the measured impedance of the bellows (in Z0)

RESULT

The longitudinal impedance measurement platform is updated:

- The TRL calibration method is applied in the platform
- The VNA is changed to be a HP8510C
- The data acquirement, calibration, post-process and user-interface are rewritten in LabVIEW program

Another longitudinal coupling impedance measurement for BEPCII project is designed by Tsinghua University base on the updated platform describes above. The matching section and other components are fabricating and the system going to be finished next month.

REFERENCES

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