

# MICROWAVE FEEDING SYSTEM ELEMENTS OF SUPERCONDUCTING LINEAR COLLIDER CAVITIES

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The calculation and experimental results for a magic tee with movable choke plungers in E- and H-arms for tuning the coupling-factor and RF phase of high-power accelerating cavities are presented. The investigations were carried out at 1.3 GHz. The so-called E-H tuner shall provide the possibility of independent external Q-factor and RF phase adjustment for the TESLA cavity structures.

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## 1. INTRODUCTION

The high-power RF distribution system of the electron-positron collider TESLA [1] is designed to ensure independent external Q-adjustment of each superconducting cavity by a factor of 10 and also adjustment of independent cavity RF phases. A further demand is the individual adjustment possibility of the cavity power feed. For this item adjustable waveguide couplers are provided.

For Q and phase adjustment it is planned to use E-H-tuners. An E-H-tuner is a Magic-T with a variable shorting plunger in each of the E- and H-arms. Such a tuner allows an arbitrary load impedance transformation within the whole Smith-chart area. In practice it is possible to transform a reflection factor  $> 0.9$  to a reflection factor of 0 and to shift the RF phase over the  $\pm 180^\circ$  range. The transmission  $S_{21}$  can be adjusted between 0.98 and 0.03.

For matching the RF power distribution system to cavities with different quench thresholds, the investigation of adjustable hybrid couplers is underway. For the TESLA machine it is planned to feed 18 cavities with one 5-MW klystron-output. Therefore waveguide couplers having different coupling factors between 1/18 (12.6dB) and 1/2 (3.0 dB) with an adjustment range of  $\pm 20\%$  ( $\pm 1$  dB) are necessary. The directivity should not be less than 25 dB. In a first step an adjustable 3 dB and 12.5 dB hybrid couplers are investigated because of their maximum and minimum adjusting range.

## 2. E-H TUNER

Fig.1 shows a magic tee, matched to reflection factor of  $< -28$  dB, using inductive irises in the E- and H-arms (3 and 4 respectively) [2].

The EH-tuner parameters dependence on manufacturing inaccuracy simulation was done. The maximum tolerance is 0.5...1 mm. The fully operational EH-tuner prototype was manufactured and tested. The calibration was done and the main rf parameters were measured. EH-tuner was matched by irises for reflection factors  $S_{11}$  from all ports less than  $-30$  dB. Being matched EH-tuner was calibrated in low power rf network including waveguide to coaxial adapters and Agilent Network Analyzer 8752. The calibration procedure included scattering matrix parameters  $S_{11}$  and  $S_{21}$  amplitude and phase

measurement in the whole plungers moving range being equal half of wavelength.

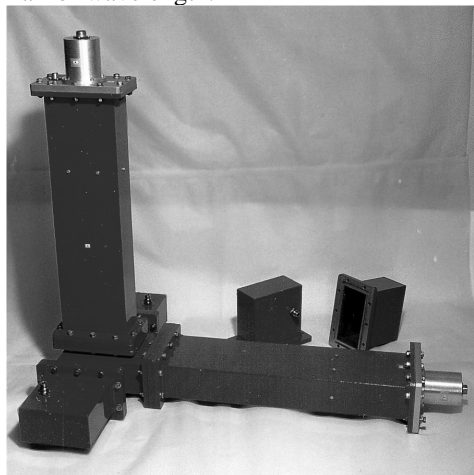


Fig.1: Magic tee, matched using inductive irises

The calibration was done automatically under control of specially developed with LabVIEW computer code. The calibration results are presented on fig.2. They form the set of circles while one circle corresponds to one plunger moving at the other hold its position. The curves cover the whole diagram area. This indicates that the EH-tuner developed is capable to provide practically any coupling between feeding waveguide and accelerating cavity, provide the necessary external quality factor or match any load. There are two different plungers positions yielding arbitrary load match as demonstrated on fig.3.

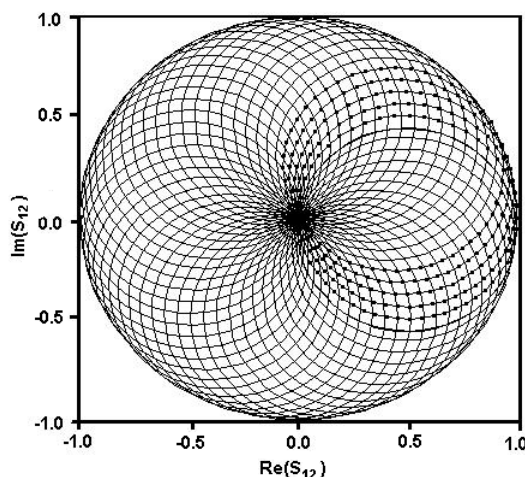


Fig.2 Calibration results - S12

The necessary power capability for the E-H tuner is 280 kW x 1.3 ms pulse power with a totally reflecting load. This corresponds to 1100 kW to a matched load. Therefore it is important to provide optimum conditions for the short circuit current at the sliding shorts and minimum field strength at sparking endangered locations.

The maximum field strength inside all the gaps does not exceed 65% of the incident wave. The transmission ratio RF leak / RF input is -65 dB in this design.

The choke plungers are motorized by stepping motors. In a calibration mode the computer moves both plungers successively over the full sliding range defined by limit sensors and measures the S-matrix via a network-analyzer. Plunger positions and associated S-parameters are stored in a computer table. In the normal operating mode the user can define desired S-parameters, coupling factors or phases, which are then adjusted automatically by the computer-controlled plungers.

The fully operational EH tuner prototype including the waveguide tee, two movable plungers with actuators, electronic control unit and the necessary software and technical documentation were passed to DESY for high power tests.

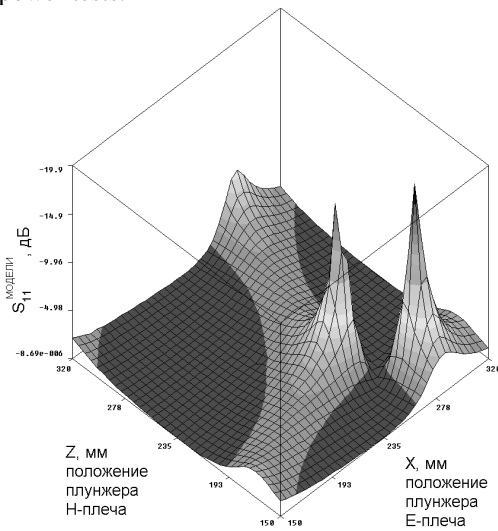


Fig.3. EH-tuner with load S11 reflection coefficient versus plunger position.  $|S_{11H}| = 0,82$

### 3. ADJUSTABLE HYBRID COUPLERS

In order to demonstrate the coupler proposed suits for the whole rf power feeding system the computer simulation was done for two couplers with directivity of 12.6 dB and 3 dB. The simulation was done with HFSS ver. 5.5 code.

Adjustable directional couplers for independent adjustment of RF input power for the TESLA cavity structures are investigated. The calculations show that the described principle allows the design of a hybrid coupler with an adjustable coupling factor over a range of 2 dB with the directivity more than 29 dB - Table. The parameters are defined as following:

$$R = S_{11}^2 \quad C = S_{14}^2 \quad D = \left[ \frac{S_{14}}{S_{12}} \right]^2$$

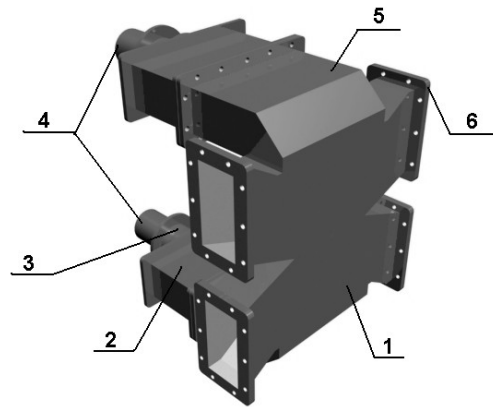


Fig.4: Adjustable direction coupler with inductive plungers

(1 – waveguide bridge, 2 – waveguide with movable plunger, 3 – plunger positioning system with end switches, 4 – step motor, 5 – waveguide bend, 6 – standard flange)

Parameter	3dB coupler	12,5dB coupler
Coupling factor C adjusting range, dB	2...4	11.5...13.5
Plungers moving range, mm	32	18
Directivity D in full tuning range, dB, less than	36	29
Input reflection coefficient in adjusting range, dB, less than	-39	-29

The waveguide with the plunger width is large than the standard waveguide. Because of this fact the H<sub>10</sub> and H<sub>20</sub> could propagate and the special plunger design was necessary to ensure its electric strength. The small moving range of 30 mm allowed the membrane-type plunger usage. It is more compact and easier to manufacture as compared to the choke type. The membrane-type plunger designed for hybrid coupler designed is presented in fig.5. Two plungers are simultaneously positioned with step motors.

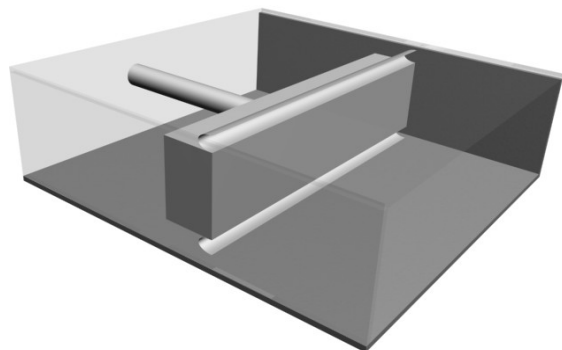


Fig.5. Membrane based plunger for adjustable hybrid-coupler. Waveguide type 276 x 82.55 mm

#### REFERENCES

1. R. Brinkmann, G. Materlik, J. Rossbach, A. Wagner. *Conceptual Design of a 500 GeV  $e^+e^-$  Linear Collider with Integrated X-ray Laser Facility*, DESY 1997-048, ECFA 1997-182, v.1.
2. M.A.Egorov, V.I.Kaminsky, D.A.Zavadtsev, A.A.Zavadtsev Characteristics Calculation of Directional Coupler for Accelerator High-Power Feedes // *Proc. of the 17-th Particle Accelerator Conference, Alushta, Ukraine*. 2001.

#### ЭЛЕМЕНТЫ СИСТЕМЫ СВЧ ПИТАНИЯ СВЕРХПРОВОДЯЩИХ РЕЗОНАТОРОВ ЛИНЕЙНОГО КОЛЛАЙДЕРА

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Приведены результаты расчета и экспериментального исследования ЕН согласователя и регулируемых направленных ответвителей, рассчитанные на работу на частоте 1,3 ГГц при импульсной мощности 1...5 МВт. ЕН-согласователь позволяет независимо изменять внешнюю добротность сверхпроводящих ускоряющих резонаторов линейного сверхпроводящего коллайдера TESLA и фазу волны, подводимой к резонаторам. В качестве такого согласователя импедансов используется согласованный двойной волноводный тройник, в плечах Е и Н которого предусмотрены подвижные короткозамыкатели.

#### ЕЛЕМЕНТИ СИСТЕМИ НВЧ ЖИВЛЕННЯ НАДПРОВІДНИХ РЕЗОНАТОРІВ ЛІНІЙНОГО КОЛЛАЙДЕРА

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Приведено результати розрахунку й експериментального дослідження ЕН-узгоджувача і регульованих спрямованих ответвителей, розраховані на роботу на частоті 1,3 ГГц при імпульсній потужності 1...5 МВт. Ен-узгоджувач дозволяє незалежно змінювати зовнішню добротність надпровідних прискорюючих резонаторів лінійного надпровідних коллайдера TESLA і фазу хвилі, що підводять до резонаторів. У якості такого узгоджувача імпедансів використовується погоджений подвійний хвильовий трійник, у плечах Е і Н якого передбачені рухливі короткозамикачі.