

QUASI-OPTIC RF POWER TRANSMISSION LINE FROM A FEM OSCILLATOR TO THE MODEL OF THE CLIC ACCELERATING STRUCTURE *

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Abstract

Experimental investigation of a copper resonator lifetime under multiple action of 30 GHz power pulses is now carried out by the collaboration of CLIC team (CERN), FEM group of JINR (Dubna) and IAP RAS (Nizhny Novgorod). A quasi-optic two-mirror transmission line is used between the FEM oscillator and test cavity. Two oversized waveguides based on the wavebeam transformation (Talbot effect) are installed at the FEM output and at the input of the test cavity module. They provide the Gaussian transverse distribution of the radiation inside the mirror transmission line and sufficiently reduce the RF field amplitude at the input and output vacuum windows to eliminate breakdown. The FEM output waveguide is also optimized to decrease the influence of the reflected wave on the FEM oscillator regime.

The update of the RF line elements and improvement of the alignment technique allowed us to increase the power transmission factor almost to the designed level.

The transmission line must provide the possibility of precise RF diagnostics including the pulse shape of incident, reflected and transmitted power and radiation spectrum for each pulse from many millions. Diagnostic equipment and a distributed asynchronous system for data acquisition from the experimental facility built under client-server principle are introduced.

INTRODUCTION

One of the strict limits on the accelerating gradient in future linear colliders is the fatigue of the copper wall due to multiple action of powerful RF pulses [1]. Experimental investigation of this limitation at the frequency of 11.4 GHz is carried out in SLAC for several years [2]. A similar research at the frequency of 30 GHz is prepared now by collaboration of CLIC team (CERN) [3], JINR (Dubna) and IAP RAS (Nizhny Novgorod). The nearest goal is a wall temperature rise 200 K with the statistics of 10^6 pulses. The source of RF power is JINR–

IAP FEM oscillator with Bragg resonator which provides the 25 MW / 150 ns pulses with spectrum width not greater than 30 MHz [4, 5] at the operating mode TE_{11} . The breakdown-safe mode TE_{01} has been chosen as the operating mode of the tunable copper test cavity which simulates the CLIC accelerating structure.

A key element of the experimental facility is the RF power transmission line. It should provide the high efficiency, elimination of the breakdown at the vacuum windows, possibility for full diagnostics of the incident, reflected and transmitted RF power and radiation spectrum. Additional requirements are reducing the influence of reflected power at the regime of FEM oscillator and fast isolation of the test cavity from the input radiation when the FEM regime is not optimal.

CONTROL OF TRANSVERSE WAVEBEAM DISTRIBUTION

The overview of the RF transmission line is presented in Fig. 1. It contains FEM output horn with cylindrical insertion, long oversized waveguide with vacuum window inside it, diagnostic film with detectors of incident and reflected power, two quasi-optic focusing mirrors, movable reflector, long input waveguide with vacuum window, accepting horn with cylindrical insertion, TE_{11} to TE_{01} mode converter, test cavity, output horn with vacuum window and detector of the transmitted power.

It is well known that the Gaussian wavebeam is the most suitable one for quasi-optic focusing mirrors. In our line the Gaussian beam is formed at the oscillator output by the special horn with cylindrical insertion which provides the optimal phase shift between the initial TE_{11} mode (87% of power) and TM_{11} mode (13%) formed in the horn. The long output waveguide employs the phenomenon of wave-front self-reproduction in oversized waveguide (Talbot effect) [6]. While the Gaussian wavebeam is reproduced at the end of the waveguide, it is possible to find the cross-section with almost uniform amplitude of the RF field to install the vacuum window and eliminate the breakdown. It is also possible to reduce the influence of the reflected wave on the FEM oscillator regime.

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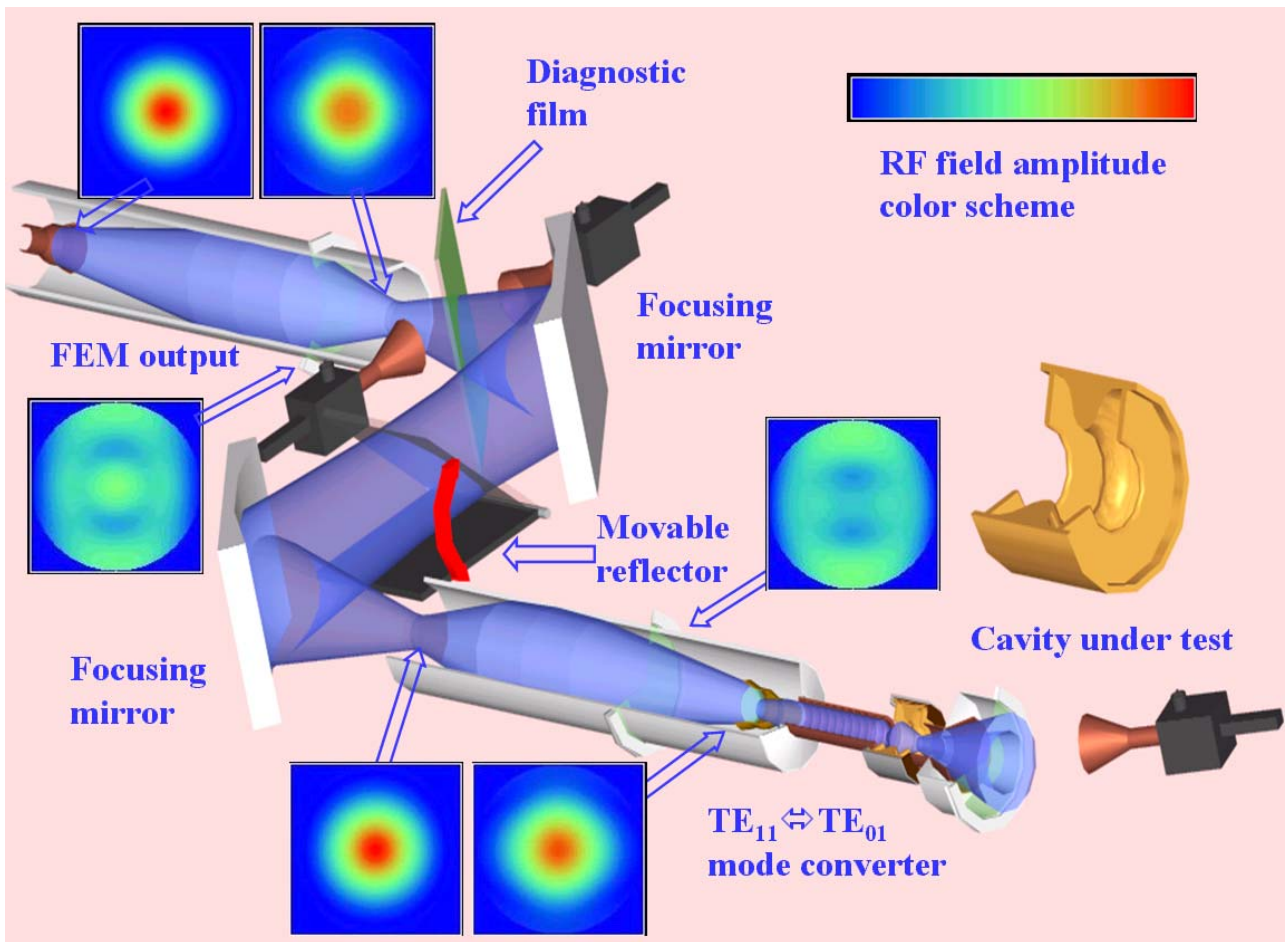


Figure 1: Overview of the quasi-optic RF transmission line.

The thin film is installed between the FEM output waveguide and the first mirror at the angle of 45° with respect to the wavebeam. Small reflection from both sides of the film makes it possible to non-destructive control of both incident and reflected power pulses.

The distant-controlled movable reflector can be lifted from its conventional horizontal position and direct the radiation upward. It isolates the testing cavity from radiation when the radiation parameters don't match the requirements of the experiment.

The second part of the transmission line is symmetrical to the first one. The only difference is the position of the input vacuum window closer to the input horn which allows us to reduce the volume of the vacuum chamber of the test cavity. The input horn with cylindrical insertion restores the pure TE_{11} mode at the input of the mode converter. The calculated transverse profiles of the RF field amplitude in several points of both waveguides are demonstrated in Fig. 1.

A new system of optical laser alignment of the transmission line has been introduced. According to the results of cold measurements, we managed to reduce loss of the power delivered to the test cavity. The power transmission factor obtained was close to the designed level.

An image of the wavebeam cross-section obtained behind the test cavity using the monitor of wavebeam position and size [FEL03f] is illustrated in Fig. 2. The intensity profile looks as well-expressed TE_{01} -like distribution.



Figure 2: Cross-section image of the wavebeam behind the test cavity.

DIAGNOSTIC EQUIPMENT AND DATA ACQUISITION SYSTEM BASED ON TCP/IP SOCKETS

The experimental facility is equipped with 3 detectors of RF pulse which control the incident, reflected and transmitted power. The parameters of each pulse from the required millions must be registered and stored in order to obtain correct value of the RF load at the cavity wall. The spectrum of the radiation also must be measured and registered in each pulse. We use a heterodyne spectrum meter with on-line fast Fourier transformation realized by the additional chip in the digital oscilloscope Tektronix TDS3032. Built-in procedure of the oscilloscope measures the spectrum width of the radiation. The oscilloscope also measures the pulse parameters of incident power. The oscilloscope sends the results to the computer via Ethernet switch using HTTP protocol. Other RF pulses as well as electron beam currents and pulses of accelerating voltages are measured by the analog-to-digital converters with resolution time of 10 ns in CAMAC standard. We also have slow ADC to control the magnetic fields in the linear induction accelerator and FEM oscillator.

A distributed asynchronous object growing multi-channel system for data acquisition from the experimental facility has been built under client-server principle.

The system unites the servers of linac subsystems capable of maintaining autonomous operability of manifold equipment with different operating speed and master client computer collecting information on the whole system for subsequent processing and analysis. Such an organization allows one to reach stability relatively to faults of single servers, the flexibility, expanding capability due to the modularity principle and open system architecture.

The system of data acquisition has been built realized as several server programs and a single multi-client program employing API sockets in asynchronous regime.

CONCLUSIONS

A quasi-optic transmission line is designed for providing the high efficiency, elimination of the breakdown at the vacuum windows, possibility for full diagnostics of the incident, reflected and transmitted RF power and radiation spectrum. Additional requirements are reducing the influence of reflected power at the regime of FEM oscillator and fast isolation of the test cavity from the input radiation when the FEM regime is not optimal. Multiple transformation of the transverse distribution of the wavebeam is used in the line.

A new technique of optical laser alignment of the transmission line has been introduced. According to the results of cold measurements, we managed to reduce loss of the power delivered to the test cavity. The power transmission factor obtained was close to the designed level.

RF pulse diagnostic equipment and a distributed asynchronous system for data acquisition from the

experimental facility built under client-server principle make it possible to register parameters of each pulse from required statistics of 10^6 pulses which is necessary to obtain correct value of the RF load at the cavity wall.

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