High power RF system for transverse deflecting structure
XFEL TDS INJ

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Abstract. The high power RF system (HPRF) is designed for RF feeding of the transverse deflecting structure of the transverse deflecting system XFEL TDS System INJ of the European X-ray Free Electron Laser. The HPRF system includes klystron, waveguide ceramic windows, directional couplers, waveguide vacuum units, spark detector and waveguide line. Operating frequency is 2997.2 MHz. Peak input power is up to 3 MW. The HPRF system has been developed, manufactured and assembled in the XFEL Injector building. The total length of the waveguide line is 55 m from the klystron at the -5 floor to the transverse deflecting structure at the -7 floor. All designed RF parameters have been obtained experimentally at low RF power level.

1. Design and manufacture of the HPRF system

There are three transverse deflecting systems in the X-ray Free Electron Laser (XFEL) for monitoring the longitudinal phase space and the emittance of the accelerated electron beam. The first TDS System INJ is located in the injector. The transverse deflecting structure is located in the injector tunnel at the -7 floor at longitudinal coordinate z=53 m from cathode. There is no space for the klystron and the modulator close to the structure. Therefore they are located at the -5 floor. It means the waveguide line connecting the klystron and the transverse deflecting structure is long (55 m) and quite a bent. Design of the transverse deflecting systems XFEL TDS INJ is shown in Fig. 1.

The HPRF system includes klystron, waveguide ceramic windows, directional couplers, waveguide vacuum units, spark detector and waveguide line [1, 2]. The filling of the waveguide line is following: a) Nitrogen at pressure up to 3 bar abs. from klystron to window 1; b) air at atm. pressure from window 1 to window 2 (the second option is technical vacuum in case of break-down problems); c) ultra-high vacuum from window 2 to transverse deflecting structure.

The first Nitrogen filled part of the waveguide line includes H-bend with spark detector and gas filling port, E-bend, directional coupler 1 and window 1. The second air filled part of the waveguide line includes window 1, straight waveguides, E-bends, H-bends, four waveguide vacuum units for connection of the ion pumps and window 2. The third vacuum filled part includes window 2 and
straight waveguide. An additional waveguide part is the waveguide load connected to the output of the transverse deflecting structure.

![Figure 1. Design of the transverse deflecting systems XFEL TDS INJ.](image)

1.1. Klystron

CPI klystron VKS-8262HS is used for the RF power generation (Figure 2). Main parameters of the klystron are: 3 MW peak power, 2997.2 MHz operating frequency, 110 kV voltage, 72 A current.

1.2. Window

Special waveguide double-mode ceramic window has been designed for the TDS systems [1]. The picture of the window is shown in Figure 3. Main parameters are a) electric field on the ceramic surface is 4 times less than in the regular waveguide, b) bandwidth is 70MHz@30dB and 40MHz@40dB.

![Figure 2. Klystron.](image)

![Figure 3. Window.](image)
1.3. Directional coupler
The directional coupler has been designed for the TDS Systems specially. The filling of the directional
coupler is to be air or vacuum. Therefore it has been designed as vacuum tight unit. It includes ceramic
disk brazed to the waveguide separating inner volume of the directional coupler.
The directional coupler is to monitor forward and reflected power. Main parameters of the directional
coupler are: coupling -65 dB, directivity 34 dB. Directional coupler is shown in Figure 4.

1.4. Waveguide vacuum unit
The waveguide vacuum unit consists of straight waveguide with set of transverse slots on the smaller
side of the waveguide and ConFlat flange for ion pump connection. The waveguide vacuum unit is
shown in Figure 5.

1.5. Waveguide line
The waveguide line includes straight waveguides, E-bends, H-bends (see Figure 6-8). One of the H-
bend is provided with the port for connection of the spark detector and with the gas filling port. All
connections of the waveguide units are realized with high vacuum DESY type rectangular flange with
copper gasket.

1.6. Load
Sendust coated waveguide load is used as a dummy load at the deflecting structure output [1]
(Figure 9). Measured reflection is $S11 = -47$ dB.
2. Assembly and test of the HPRF system

The whole RF power supply system has been assembled and tested at low RF power level. Assembled system is shown in Figure 9. RF test at low RF power level shows that reflection from input flange of the waveguide line with the transverse deflecting structure is $S_{11}=-42\text{ dB}$ at operating mode (Figure 10).
Figure 9. Assembled and tested HPRF system.

Figure 10. Measured reflection S11 v.s. frequency.

References
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