LAYOUT OF THE ANKA RF SYSTEM

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Abstract

At the research center in Karlsruhe, FZK, the new 2.5 GeV synchrotron radiation light source **ANKA** is under construction which is dedicated to the LIGA technique. The 500 MHz RF system consists of two 250 kW klystrons, the waveguide system, four ELETTRA cavities and the low level electronics. Each klystron is feeding two cavities.

1 INTRODUCTION

The synchrotron radiation source ANKA generates an electron energy of 2.5 GeV. The storage ring has a circumference of 110.4 m. According to the bending radius of a dipole magnet (5.559 m) and the magnetic field strength of a deflecting dipole (1.5 T) the energy loss during one turn is 622 keV. The future installation of insertion devices in the storage ring will lead to a total energy loss of 662 keV.

In comparison with other synchrotron radiation sources the layout of the ANKA RF system has the characteristic that it is well suited to store beam currents of more than 400 mA (due to higher order mode shift) with a long lifetime and without influences of bunch instabilities.

Two 250 kW klystrons will be used to feed totally four ELETTRA cavities operating at a frequency of 499.65 MHz. The low level electronic which consist of a frequency loop, an amplitude loop and a phase loop guarantees a stable operation with a high reliability.

2 GENERAL PARAMETERS

Table 1 contents the most important parameters of the storage ring ANKA, the RF parameters and the cavity parameters.

2.1 Parameters for the Operation at ANKA

For a circulating beam current of 400 mA a beam power of 265 kW is required. That means per cavity a power of 66 kW is requested.

It is foreseen to operate ANKA with beam currents up to 400 mA. Therefore different overvoltage factors (1.9 and 3.6) can be choosen to get a large energy acceptance. The coupling factor (3.5) is fixed to the optimized coupling for the highest current. The resulting maximum cavity power at maximum voltage (2.4 MV) is in the order of 53 kW and the maximum window power is 125 kW. At DESY it has been tested that the ceramic window is able to transfer this high power into the cavity. For four cavities a total generator power of 500 kW has to be installed.

To fight against the multibunch instabilities at high currents in the storage ring a special developed cooling system will be installed on the ELETTRA cavities [1] to allow a temperature stabilization better than 0.1°C in a temperature range between 40° and 70°C.

Table 1: Parameters of the RF System

Storage Ring Parameters	Symbol / Unit	Value
Beam energy	E_0 [GeV]	2,5
Energy loss per turn with ID	U_o [keV]	662
Beam current (maximum)	$I_{0,max}$ [mA]	200 / 400
Harmonic number	h	184
Revolution frequency	f_0 [MHz]	2,7155
Momentum compaction factor	α	$8{,}1 \cdot 10^{-3}$
Energy spread	$(\sigma_e / E)_0$	$9 \cdot 10^{-4}$
Damping time (longitudinal)	τ_ε[msec]	1,4
RF Parameters	**Symbol / Unit**	**Value**
Frequency	f_{RF} [MHz]	499,652
Synchrotron frequency	f_s [kHz]	41,8
Synchronous phase	Φ_s [°]	148 / 164
Energy acceptance	$(\Delta E/E)_{max}$ [%]	1,5
Bunch length	σ_ε [mm]	9,8
Overvoltage factor	q	1,9 / 3,6
Cavity voltage	U_{cav} [kV]	315 / 600
Number of cavities	N_{cav}	4
Cavity Parameters	**Symbol / Unit**	**Value**
Shunt impedance	R_S [MΩ]	3,4
Unloaded quality factor	Q_0	≥ 40.000
Coupling factor	β	3,5
Cavity power	P_{cav} [kW]	15 / 53
Beam power	P_{beam} [kW]	33 / 66
Window power	P_{window} [kW]	48 / 119
Generator power (total)	P_{gen} [kW]	250 / 500
Temperature stability	ΔT [°C]	≤ ± 0,1
Tuning range of the temperature	T [°C]	40 - 70
Phase stability	Δ φ [°]	± 0,5
Amplitude stability	ΔU/U [%]	1

2.2 Parameters of the Power Plant

To achieve an total RF output power of 500 kW two 250 kW (cw) klystrons with a gain of 40 dB and with an efficiency of more than 62% will be used. The complete transmitter which consist of the klystron, the pre-amplifier, the high voltage power supply and the waveguide and transmission system will be controlled via a Bosch SPS. The high voltage power supply delivers –52 kV and 9 A and is well matched to the klystron.

Table 2 shows the parameters of the 250 kW klystron and the parameters of the high voltage power supply (HVPS).

Table 2: Parameters of the Klystron and the HVPS

Klystron Parameters	Symbol / Unit	Value
Frequency	f_{RF} [MHz]	499.65
Bandwidth at nominal rating	f [MHz]	± 1.0
RF nominal output power	P_{RF} [kW]	> 250
Test RF output power	P_{Test} [kW]	270
Duty cycle		CW
Gain at nominal power	dB	40
Efficiency at 400 kW dc (i.e. 50 kV, 8 A)	%	> 62.5
Efficiency at 370 kW dc	%	> 60
Efficiency at 250 kW dc	%	> 57
Minimum continous collector dissipation capability with or without RF drive	P [kW] CW	468
Maximum RF radiation at 250 kW output power	I [mW / cm^2]	1
X-Ray emission, less than	I [μSv/h]	< 5
Maximum magnetic field at 1.5 m from klystron axis	B [mT]	< 0.5
Guaranteed high voltage operating hours	T [h]	> 10.000
Klystrons in operation	N_K	2
High Voltage Power Supply Parameters	**Symbol / Unit**	**Value**
Nominal dc voltage, max.	U_n [kV]	- 52
Range of adjustment	kV	- 20 ... - 52
Nominal current	I_n [A]	9
Long term stability	%	0.5
Absolute accuracy	%	1
Reproducibility	%	0.5
Voltage ripple	%	< 0.4
Max. energy in the klystron on short circuit	E [Ws]	20

3 SETUP OF THE RF SYSTEM

The principle setup of the complete RF system is shown in figure 1.

In a distribution rack the RF is generated with a signal generator. Via a power splitter the RF is distributed to the two ANKA power plants and to the RF of the injector.

Each power plant consists of a 50 W pre-amplifier and a 250 kW klystron. For the operation of the klystron some small power supplies are necessary for the ion getter pump, focus coils and cathode heating. The RF power has to be transfered via a waveguide system to the two ELETTRA cavities. The amplitude loop and the phase loop are located in the low level rack 1 and exist one times per power plant [2].

Each of the four cavities has its own frequency loop, which is located in the low level rack 2.

In the case of an emergency a RF switch in the distribution rack acts directly on the pre-amplifier and dumps the beam. For safety of each plant a RF switch in the low level rack 1 is used to switch off the RF power.

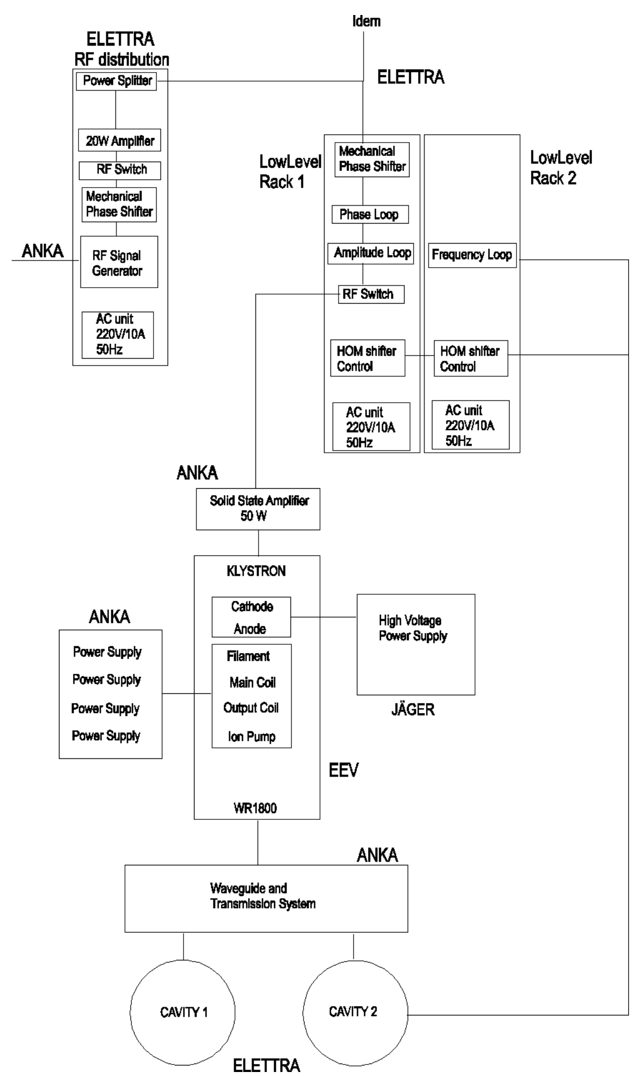

Figure 1: Setup of the ANKA RF System

4 SETUP OF THE WAVEGUIDE SYSTEM

Figure 2 shows the top view of the waveguide system at the storage ring ANKA. The complete rectangular waveguide system has the designation WR 1800.

A bi-directive coupler is used to measure the forward power coming out of the klystron. For interlock purposes it is important to measure the reflected power at that point because a reflected power could damage the klystron. The following bellow is used to get a mechanical decoupling between the klystron and the downstream waveguide system and to get enough space between the klystron and the circulator, as shown in the layout.

A three port circulator must be installed to protect the klystron. In one port of the circulator, a dumy load has to be installed for dissipating the reflected power and avoid it going to the klystron. The dummy load must be able to dissipate a peak power of 250 kW for thirty seconds. The power dissipation for a cw power should be in the order of 100 kW. A loop coupler to read the power going to the load has to be installed for interlock purposes.

Downstream the circulator a bi-directive coupler has to be installed for taking the signals for the amplitude loop.

A magic T must be installed to split the power from the klystron (250kW) for feeding two cavities (each 125kW). This magic T (which is a folded T) fulfill the reason that the distance of the center of the two collinear arms must be 900 mm, because the installation space of the two ELETTRA cavities in the storage ring is fixed to 900 mm according to 1.5 times the wavelength of 600 mm. An identical load as in the circulator is installed on the fourth port of the magic T.

The next components in the parallel arms are 90° E bends, straight sections and further 90° E bends to reach the proper height for feeding the cavities from the top. Two bellows should be brought in the horizontal waveguide lines. The reason is to compensate thermal expansions in the waveguide and to get an easy handling in the symmetric setup during the installation of the waveguide system. Before the coupling into the cavity in both arms bi-directive couplers have to be installed. With this couplers the signals are taken for the frequency loops and for interlock reasons. At this point one determine the reflected power coming from the cavity.

The input coupler at the cavity needs a 6 1/8’’ coax connection. Therefore one need a waveguide to coax transition. The coupling loops in the cavities must be installed with a phase difference of 180° in order to get the correct phasing in the storage ring due to the 900 mm distance of the cavities.

5 STATUS OF THE RF SYSTEM

The cavities and the low level electronic are ordered at Sincrotrone Trieste. The first cavity is under construction and will be tested in autumn 1998 at the factory [3]. All cavities and the low level electronics will be delivered in June 1999. The 250 kW klystrons are ordered at EEV Ltd. The delivery and the site acceptance test which includes a 50 hour run test must take place in spring 1999. The power supplies for the klystrons are ordered at the german company Jäger Elektrotechnik GmbH. This power supply will be constructed at the ANKA site in the beginning of 1999. The waveguide system will be ordered very soon after this conference. The next step is the specification and order of the pre-amplifiers and the signal generator.

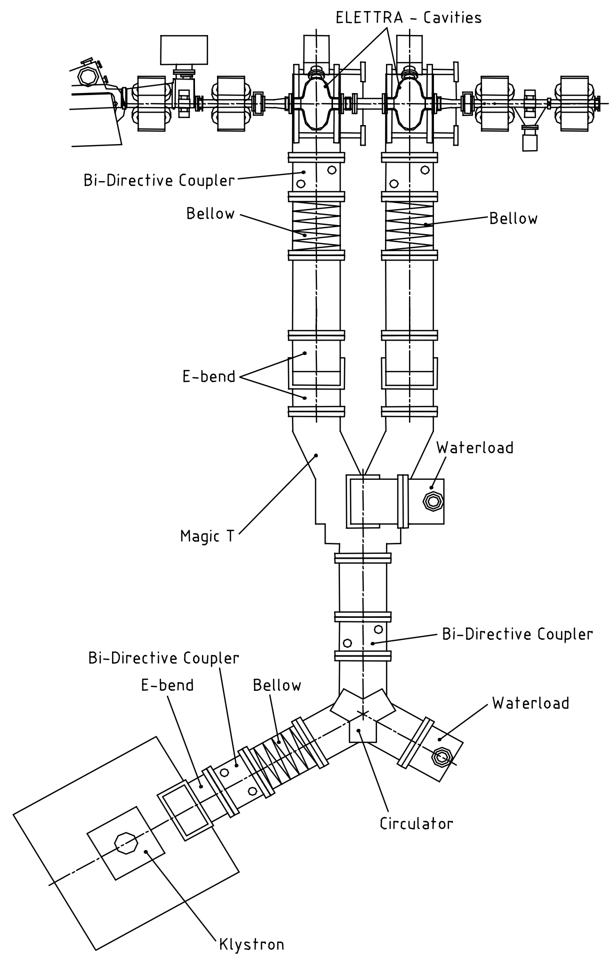

Figure 2: Top View of the Waveguide System

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