PRODUCTION OF SUPERCONDUCTING ACCELERATOR MODULES FOR HIGH CURRENT ELECTRON STORAGE RINGS

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Abstract

For Diamond Light Source (DLS), ACCEL was contracted to produce three superconducting 500 MHz accelerator modules based on the Cornell CESR design. With the already six modules produced by ACCEL for Cornell University (CESR), NSRRC (Taiwan Light Source) and CLS (Canadian Light Source), this module can now be considered as a kind of standard product. In this paper we describe the basic parameters and guaranteed values of this module and will also report on the performance of delivered modules.

INTRODUCTION

The advantage of a superconducting cavity system compared to a normal conducting one can be found in detail in [1] and is summarised as follows:

- A very effective damping of the higher-order modes, resulting in reduced requirements on the RF feedback system of the storage ring.
- The capability to operate at high accelerating voltage and transfer high power to the beam, thereby reducing the number of required cavities in a storage ring.
- Negligible power dissipation in the cavity wall, allowing the use of all installed RF power for particle acceleration, thus reducing the overall power consumption of the accelerator.

These advantages make the superconducting cavity technology very attractive for high current electron storage rings like B-factories or 3rd generation Light Sources.

Within the frame of a technology transfer / license agreement, ACCEL can deliver turn key superconducting 500 MHz accelerator modules, designed originally in the 1990´s by Cornell University for their B-factory proposal and further developed at ACCEL by means of an engineering review during the contracts for NSRRC and CLS.

In addition to the SRF modules, we can and have delivered the cryogenic distribution valve box, the transfer lines between valve box and modules, the complete module instrumentation, the complete module electronics including cryogenic control like helium level and helium pressure control.

GERERAL SPECIFICATION AND GUARANTEED VALUES

The general specification of the SRF module is summarised in table 1.

Depending on the requirements of the customer we discuss and define the guaranteed values for accelerating voltage, cryogenic losses and power transferable to the beam, which can be as high as shown in table 1.

Subcomponents like cavities and RF windows are tested separately before assembly to the SRF modules. During the vertical rf test the cavities typically reach 12 MV/m [2]. Up to now no indication of performance degradation of the cavity after assembly to the modules was observed.

The high power windows are conditioned on a test stand up to a maximum of 125 kW at full reflection and up to 250 kW in travelling wave mode. If needed, the windows can be conditioned further with reduced duty cycle in travelling wave mode up to 400 kW.

Table 1: Typical operating parameters of the SRF 500 MHz accelerating module

Parameter	**Value**
Operating frequency	499,6 – 500.0 MHz
Tuning range	+/- 125 kHz
Tuning resolution	10 Hz
Helium vessel pressure	1200 +/- 1.5 mbar
Operating temperature	4.5 K
U_{acc},	> 2.4 MV
E_{acc}	> 8 MV/m
L_{acc}	0.3 m
unloaded Q @ E_{acc} = 8 MV/m	> $7 \cdot 10^8$
Standby losses at 4.5 K (RF off)	< 30 W
Cryogenic losses at 4.5 K and E_{acc} = 8 MV/m including 30 W standby losses	< 120 W
$Q_{external}$ of input coupler	2.3 +/- $0.3 \cdot 10^5$
maximum power transferable to the beam	> 200 kW

SRF MODULES FOR DIAMOND LIGHT SOURCE

For DLS in total three SRF modules will be delivered and installed into the storage ring. The Light Source can be operated with two modules, but a third cavity will reduce the voltage and power requirements for the individual cavities. In addition complete SRF electronics, the cryogenic valve box capable to deliver and control helium distribution to the three modules, and the transfer lines between the valve box and the modules will be delivered. The commissioning of the modules without beam is also within our scope.

The cryomodule was partly redesigned for the DLS contract in order to allow connection of a multi-channel transfer line for liquid helium input, gaseous helium return and liquid nitrogen input. The first design used three individual flexible lines between cryomodule and valvel box, but we choose a fixed multi-channel line as the distance between valve box and module is about 15 m at DLS in order to reduce the standby losses of the transfer lines significantly.

In addition there were small detailed design changes of module subcomponents in view of easier production and the module instrumentation is being reviewed.

Figure 1 shows the layout of the three modules in the straight of the storage ring. The total length for three modules is limited to 8.3 m. Large gate valves with inner diameter of 240 mm are connected to the modules and allow installation and removal of individual modules. Tapers are needed on the ends of the installation to fit to the DLS vacuum chamber. Between the tapers, the beam pipe inner diameter is kept constant at 240 mm.

The cavity production is scheduled to be completed in August 2004. The cavity tests and the window processing shall be completed within this year and the first module shall be ready for commissioning at DLS in April 2005

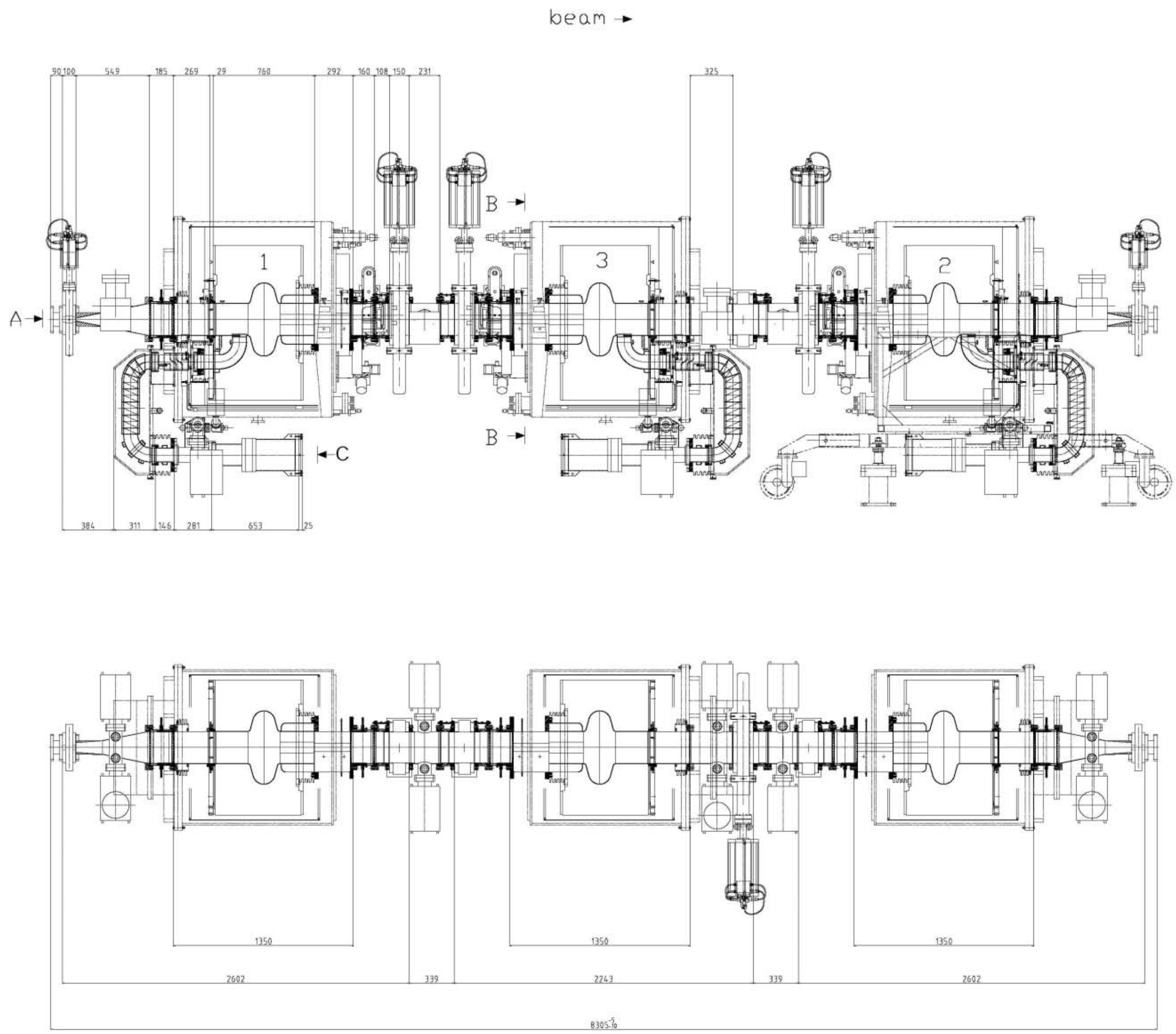

Figure 1: Layout of installation of three SRF 500 MHz accelerator modules in one straight of the Diamond Light Source. The total length for the installation is 8.3 m.

PERFORMANCE OF DELIVERED MODULES

In total we have delivered up to now four modules. Two modules were delivered to Cornell University. Both modules are installed in the storage ring CESR. They are both routinely and reliable operating well above the guaranteed value of 6 MV/m, the first SRF module since more than two years, the second SRF module since more than one year [3].

One module is delivered to the Canadian Light Source and is used for the commissioning of the Light Source. The module is operating since more than one year well at an operating gradient of about 7 MV/m. The performance of the module is reported to be very reliable [4]. The assembly of the second module is just finished. It will be shipped to CLS in this July. The second module will then be installed into the storage ring and will replace the first module which will serve as a spare.

One module is delivered to NSRRC. The module is just under commissioning with high power. The second module is under assembly and will be delivered at the end of this year. The installation of one module into the storage ring at NSRRC is scheduled for the end of this year. The second delivered module will serve as a spare.

Figure 2 shows one module delivered to NSRRC with the also supplied SRF electronics and valve box.

The assembly hall of the SRF modules at our premises can be seen in figure 3. Up to three SRF modules can be assembled in parallel.

Figure 2: Superconducting accelerator module for the Taiwan Light Source with valve box (left) and SRF electronics (right) prior shipment to NSRRC.

For the careful shipping of the modules a special shipping frame was constructed preventing the module form shock during transportation. Figure 4 shows one module for Cornell University assembled to the shipping frame.

Figure 3: Assembly area of the SRF modules at ACCEL. In the upper right part the clean room class 100 can be seen where the modules need to be assembled in whenever the cavity vacuum is touched.

Figure 4: Completed SRF module for Cornell University installed into shipping frame.

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