INSTALLATION, COMMISSIONING AND TEST RESULTS OF SUPERCONDUCTING RF MODULES FOR LIGHT SOURCES AND ELECTRON STORAGE RINGS

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Abstract

The production of superconducting 500 MHz modules for Taiwan Light Source, Canadian Light Source and Cornell University is almost finished. We discuss the current production status. We report on installation and commissioning work and discuss test results of completed modules. The module test results will be compared to the cavity test results. Operational experience with modules installed in the accelerator is given. One module test resulted in a failure of the RF window. An analysis of that test is included. ACCEL was recently contracted by Diamond Light Source on the production of three additional SRF modules.

STATUS OF PRODUCTION

For Taiwan Light Source, Canadian Light Source and Cornell University ACCEL is contracted to deliver in total 6 superconducting 500 MHz accelerator modules from the Cornell CESR type, designed for high beam current acceleration. Recently Diamond Light Source decided to contract ACCEL with 3 more accelerator modules. Those modules can transfer up to 200 kW each to the beam and allow maximum HOM damping. The guaranteed accelerator voltage of those modules is up to 2.4 MV. The maximum allowed cryogenic losses at those field levels is 140 W. More detailed information on the module design can be found in [1]. Beside the modules, we deliver the SRF electronics and controls and the cryogenic valve boxes and transfer lines. Therefore the scope also includes the control of the helium level and the pressure of the helium bath in the modules.

Figure 1: SRF accelerator module for the Taiwan Light Source with valve box (left) and SRF electronics (right).

The production and assembly area of the modules is shown in Figure 2.

Figure 2: 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.

The status of the 6 superconducting 500 MHz modules can be summarized as follows:

- All single components are produced
- All cavities successfully passed the vertical test. Production, Preparation for vertical test and cold RF test of the cavities in a bath cryostat is performed by ACCEL personnel. For the vertical test the cryogenic and RF facilities at Cornell University are used.
- All RF windows were processed on a separate test stand successfully.
- Two modules are delivered to Cornell University and successfully tested with high power RF and are operating in the synchrotron CESR, one for more than 12 months. Module related trips are at a rate of once every two weeks [2].
- One module for Taiwan Light Source has been tested at Cornell University with high power RF. The gradients reached during this test exceeded the design specifications by more than a factor of two. However it was discovered, that this module can not be operated with sufficient high power RF, because the external Q of the input coupler was

much smaller than expected. The reason for the wrong external Q was found to be a dent in the waveguide caused by the external pressure on the cavity wall during the room temperature pressure test. The high purity RRR niobium with a low yield strength of 50 MPa does not allow a pressure test at room temperature and 1.8 bar pressure difference from inside to the outside of the cavity. Therefore for future cavities the wall thickness of the waveguide will be enlarged from 3 mm to 4 mm. Note that the yield strength of niobium is much higher at cryogenic temperatures.

- One module for the Canadian Light Source was recently delivered, commissioned and is now ready for beam operation.
- The electronics and control racks for all 6 modules are finished.
- The valve boxes for Taiwan and Canadian Light Source are delivered and commissioned.

CAVITY TEST RESULTS

The test results of the 6 cavities are summarized in Fig 3. All cavities are limited by available RF power. Not shown are the first two cavity test results, where fields in the range of 7 MV/m were reached limited by field emission.

After this learning curve in 500 MHz cavity preparation and assembly, the next 6 cavity results where all excellent and very similar, showing the reliable and repeatable production and surface preparation of the cavities. The results are even more remarkable taking into account, that the cavities completely prepared for vertical test after buffered chemical etching and high pressure water rinsing, sealed and equipped with test antennas in clean room class 100 are shipped from Germany to the United States.

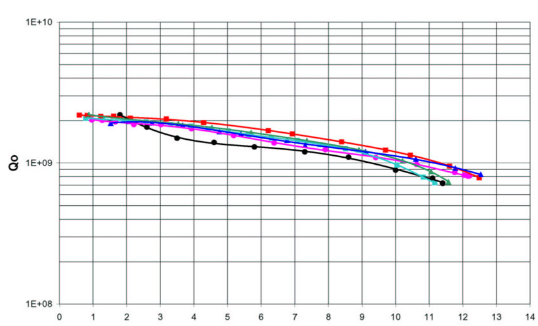

Figure 3: Vertical Test results of the six cavities produced for Cornell, Taiwan Light Source and Canadian Light Source

Figure 4: Preparation at ACCEL of a 500 MHz cavity for a vertical test. Up left: closed loop BCP, up right: high pressure rinsing, below: clean room assembly

INSTALLATION AND COMMISSIONING

After module assembly the modules are mounted on a special designed shipping frame for transport. The shipping frame is spring loaded and avoids vibration and shock impact of the module during loading, aircraft and road transportation.

Figure 5: Completed 500 MHz module installed into shipping frame.

After arrival, the modules are basically commissioned within a period of 4 working weeks.

During the first week the module is unpacked, installed into the tunnel and aligned.

During the second week, the cavity vacuum and the insulation vacuum is pumped and all leak checks are performed. The module is connected to the delivered electronics and the electronics are taken into operation.

In the third week the cryogenic transfer lines are installed between the module and the valve box. The module is cooled down and the low power RF measurements are done.

The fourth week is then used for RF processing and acceptance test.

Figure 6Figure 7 andFigure 8 show module test results of the two modules delivered to Cornell and the one module delivered to the Canadian Light Source. All cavities installed into the modules reached 8 MV/m accelerating gradient, which is equivalent to an accelerating voltage of 2.4 MV.

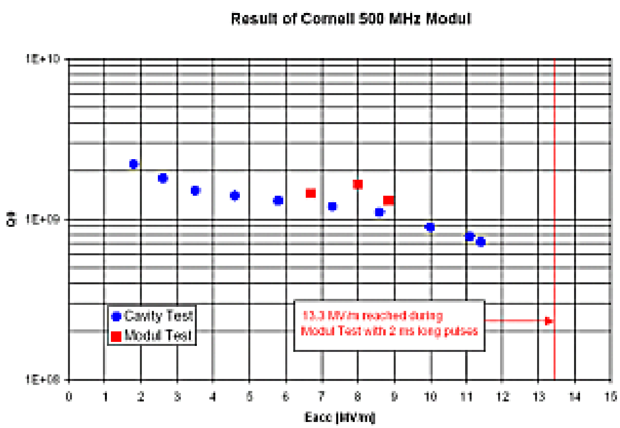

Figure 6: Module test result of Cornell module 1

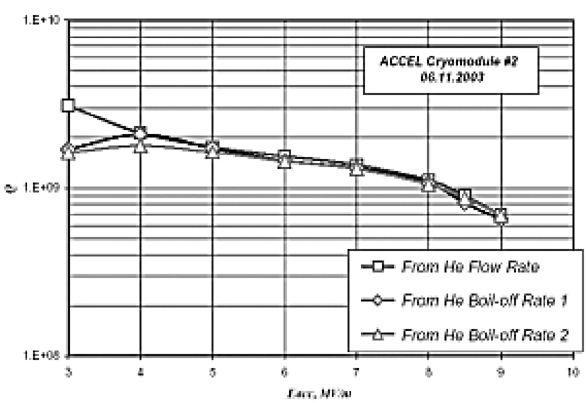

Figure 7: Module test result of Cornell module 2

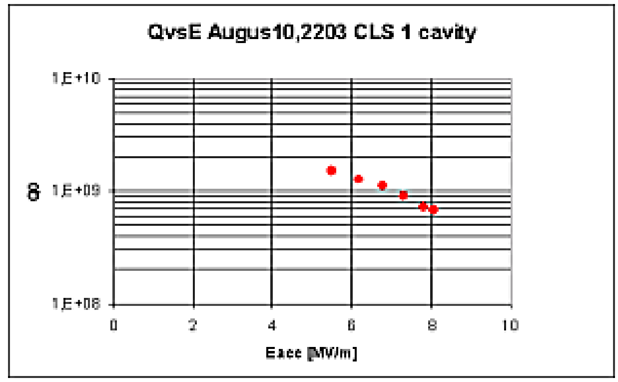

Figure 8: Module test result of CLS module 1

ACKNOWLEDGEMENT

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REFERENCES

[1] S. Belomestnykh, et al., “Operating Experience with Superconducting RF at CESR...”, 9th Workshop on RF Superconductivity, Santa Fe, Nov. 1999

[2] S. Belomestnykh, private communication.