RF ACTIVITIES OF ACCEL INSTRUMENTS IN ASIA-PACIFIC

M. Pekeler, K. Dunkel, M. Peiniger, C. Piel, H. Vogel, P. vom Stein
ACCEL Instruments GmbH, D-51429 Bergisch Gladbach, Germany

Abstract

Since the foundation of ACCEL Instruments, Asia-Pacific has been an important market for RF, magnet and x-ray beam line devices. For the RF activities, pioneering work was done for JAERI, where complete superconducting RF modules where designed, built, tested and delivered. An important step for industrialization of superconducting RF modules was done, when NSRRC decided in 2000 as the first Light Source, to contract turn key superconducting 500 MHz modules of the Cornell design to ACCEL. Similar modules have been delivered in the meantime to CLS, Cornell and DLS and three more will be delivered to SSRF in Shanghai next year. Peking University is planning to use a Rossendorf design superconducting RF module housing two 1.3 GHz TESLA cavities for the operation of their FEL project. On the normal conducting RF systems, a complete 3 GHz 100 MeV linac has been delivered to ASP together with the 500 MHz booster cavities and the LLRF system. Booster cavities and LLRF system will be also delivered for SSRF. For SOREQ in Israel, ACCEL is developing a complete superconducting 40 MeV proton/deuteron linac. The first stage of this linac is currently under delivery and installation.

SUPERCONDUCTING 500 MHZ MODULES FOR JAERI

In the Asia-Pacific region, ACCEL is so far mostly supplying complete accelerator systems rather then single accelerator components like cavities or couplers. A good example already from the early 90's is the supply of turn key superconducting accelerator modules for JAERI.

Figure 1: Superconducting accelerator module housing one 5-cell 500 MHz module completely assembled and tested prior shipment to JAERI site.

JAERI decided in 1991 to order 4 superconducting 500 MHz modules, two modules housing a single cell cavity and two modules housing a 5 cell cavity. The complete design of the module was done in industry. As the modules are operated at a very low duty cycle of maximum 3 %, the RF losses are below 1 W and the modules were designed for as low as possible static losses. Two thermal shields at 20 K and 70 K were designed and each module is able to be cooled by a power of 4 W cryocooler at 4.5 K.

All modules were RF tested in house prior delivery and then shipped to JAERI site in 1993. The modules are still in operation at an operating gradient of 5 MV/m with Q values above 10^9. A RF coupler with external Q tunable from 10^5 to 10^9 was developed. Fig 1 shows one module prior delivery to JAERI site.

SUPERCONDUCTING 500 MHZ MODULES FOR LIGHT SOURCES IN TAIWAN AND SHANGHAI

In 2000 NSRRC decided as the first Light Source to take benefit of superconducting cavities. The decision finally was made to order two superconducting 500 MHz modules of the Cornell type design. ACCEL had agreed with Cornell University on a technology transfer and was thus able to produce those modules as a turn key system including the SRF electronics and the cryogenic valve boxes needed for helium bath pressure and level control In the same year also the Canadian Light Source and Cornell University itself ordered two more modules each. Diamond Light Source ordered three more modules in 2003 and Shanghai Light Source three more in 2005.

All modules are delivered with guaranteed values of about 2 MV accelerating voltage and can provide more than 250 kW of RF power to the beam. The cryogenic loss (static loss plus RF dissipation) is specified to be below 100 W. All modules for NSRRC, CLS, Cornell and Diamond are delivered; the first module for Shanghai Light Source will be shipped in the middle of 2007.

The cavities and the windows of the SRF module are tested separately prior assembly and have passed the acceptance test already. Figure 2 shows one of the NSRRC module prior shipment to Taiwan and during installation into the NSRRC storage ring.

During the last 6 years, the Cornell type module has developed into a product and the SRF electronic has been further improved and upgraded with state of the art data logging (S7) and interlock application. The installation, integration with helium plant and klystron and taking into operation of a module can be done within a time period of 4-6 weeks.

Figure 2: Completely assembled and tested first superconducting 500 MHz module with valve box and SRF electronics ready for shipment to NSRRC (above) and during installation into the NSRRC storage ring (bottom)

SUPERCONDUCTING 1.3 GHZ MODULES FOR FEL APPLICATION

For FEL application calling for a linac of about 100 MeV, Forschungszentrum Rossendorf developed a superconducting 1.3 GHz module based on TESLA technology developed within the TESLA collaboration for the Tesla Test facility (TTF) linac. In contradiction to the TTF modules, the Rossendorf module only hoses two TESLA cavities and can be operated in cw mode

Figure 3: Superconducting Rossendorf style 1.3 GHz module prior shipment to Daresbury. Peking University is planning to use this module for their FEL application.

ACCEL agreed with Rossendorf on a technology transfer and can deliver those modules with guaranteed voltage of 25 MV/module.

Two modules were delivered to Daresbury laboratory for the 4GLS test facility and are currently under commissioning. Peking University is considering using this module for their FEL. A decision is expected within this year. One of the two modules shipped to Daresbury is shown in Figure 3.

TURN KEY 3 GHZ INJECTOR LINAC AND BOOSTER CAVITIES FOR ASP

For the Australian Synchrotron project ACCEL has delivered in 2005 a turn key injector linac and the booster cavities including the LLRF control system.

Figure 4: Normal conducting 3 GHz linac (top) and 500 MHz booster cavity (bottom) installed at the Australian Synchrotron project.

The design of the 3 GHz linac is identical to the linac delivered for the Swiss Light Source and the Diamond Light Source. The accelerating structures were developed at DESY within the development of the normal conducting version of a TeV linear collider in the early 90’s. The main linac parameters are to be agreed upon at the beginning of the project and are to be demonstrated on site during the acceptance tests.

The normal conducting 500 MHz 5-cell booster cavities were originally also designed by DESY. ACCEL manufactures this cavity on a regular basis and has built so far more than 40 of such cavities. They can provide a voltage of up to 2 MV to the beam and are operated at about 50-70 kW RF power. The cavities are delivered on request with their own analogue LLRF system. A digital LLRF system is currently studied. The installations at the Australian Synchrotron project are shown in Figure 4.

TURN KEY 176 MHZ MODULE FOR CW PROTON/DEUTERON ACCELERATION

At the SOREQ research center in Israel, a linac is currently under construction and commissioning that was designed and built completely in industry. The linac will finally have an energy of 40 MeV and accelerate protons and deuterons in continuous wave mode and currents up to 4 mA.

Figure 5: ECR ion source (top) and RFQ (bottom) installed at the SARAF accelerator of the SOREQ institute in Israel

The project is divided into two phases. In the first phase, already contracted, a 7 MeV injector will be installed consisting out of an ECR ion source, a normal conducting 176 MHz continuous wave 250 kW RFQ and a first superconducting 176 MHz module housing 6 halfwave resonators and 3 superconducting focusing solenoids.

In case the first phase can be concluded successfully it is planned to install more superconducting modules to reach the final energy of 40 MeV.

Figure 5 shows the ECR source and the RFQ installed at the SARAF facility.

All six superconducting 176 MHz cavities were RF tested in a vertical bath cryostat at a temperature of 4.5 K at ACCEL prior integration into the module. All cavities safely exceeded the design specification of 25 MV/m peak electric surface field. The RF losses at those field levels were lower than the specified 10 W for each cavity. Also the superconducting solenoids were tested prior integration and a magnetic field of more than 6 T was demonstrated. The assembly of the module was done at the end of last year. Figure 6 shows the module at an intermediate assembly step. The module was shipped to the SARAF site and is currently being cooled down with the refrigeration plant. The high power RF test and the first beam operation are planned for spring 2007.

Figure 6: Assembly of the superconducting 176 MHz accelerator module for proton/deuteron acceleration. The module houses 6 halfwave resonators and 3 superconducting solenoids