THE ADVANCED PHOTON SOURCE HIGH POWER RF TEST STAND

Radio Frequency Group - Accelerator Systems Division

The Advanced Photon Source (APS) High-Power RF Test Stand is designed to provide a development, test and conditioning platform for accelerating cavities and cavity accessories such as tuners, couplers, HOM dampers, waveguide components, medium and high power amplifiers and for testing 352 MHz, 1.1 MW klystrons into a 1 MW continuous-wave (CW) rf load. It consists of a test bunker, which provides shielding from x-ray radiation produced by the device being tested, cooling water distribution manifolds to provide easy connection to supply and return cooling water lines, a complete equipment interlock system designed to measure test parameters and protect the device under test, an ultra-high vacuum pumping system to achieve, maintain, and measure vacuum levels down to 5×10^{-10} Torr, and a personnel safety interlock system which prevents personnel entry to the test bunker while rf power is applied to the device under test. The test stand also includes a complete VXI-based low-level rf system, which provides amplitude and phase monitoring and control, including cavity-tuning functions. The test stand can be monitored and controlled locally or from remote locations utilizing the network-based Experimental Physics and Industrial Control System (EPICS).

TEST STAND RF POWER SOURCE

- The rf power source for the test stand at present time is the APS RF1 storage-ring 1.1 MW CW rf station, operating at 352 MHz. RF1 serves as the test stand power source when not needed for storage-ring operation.
- Switching RF1 between the test-stand input and the storage-ring RF cavities is achieved via a four-port, WR2300 waveguide switch.
- Dual 1-MW WR2300 waveguide shutters isolate the rf input to the test stand when access to the device under test is desired.
- Design and construction of a dedicated RF system for the Test Stand is presently underway. This dedicated system will eliminate the reliance of RF1 as a power source.

RF test stand operator console.

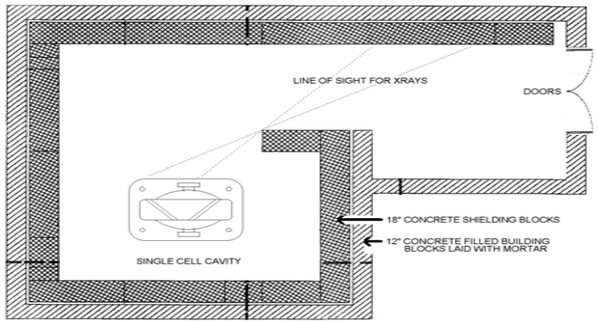
Four-Port Waveguide Switch.

RF1 Station Powering RF Test Stand.

1 MW Klystron.

STRUCTUAL DESIGN

- The test stand bunker building has been constructed to protect against x-ray emission produced by high-vacuum rf structures under test.
- The bunker walls are 32-inches thick, with a 2-inch air gap between two discrete concrete-composition layers. The inner walls are standard 18-inch-thick dense concrete shielding block, dry-laid.
- The outer walls are 12-inch-thick solid concrete building blocks, laid with mortar. An 8-inch solid cast concrete ceiling, supported by the outer walls, is utilized to reduce x-ray sky-shine radiation from the bunker.

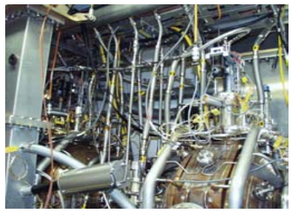


Test bunker top view.

MECHANICAL SYSTEM

- The ultra-high vacuum system consists of a 520-ℓ/second turbo pump in tandem with a 400-ℓ/second ion pump/non-evaporative getter combination. An 9-inch gate valve provides turbo and roughing system isolation.
- A filtered (0.5 μm) 300-GPM, de-ionized water system provides cooling to the rf cavity and associated components.
- Supply/return line differential pressure is maintained at 100 psi, and a three-way mixing valve achieves temperature control.

Storage Ring RF Cavity Vacuum System.

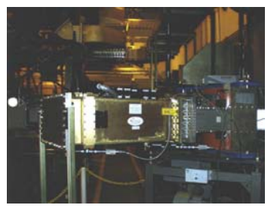


RF Cavity Water Distribution.

SUMMARY OF ACCOMPLISHED WORK

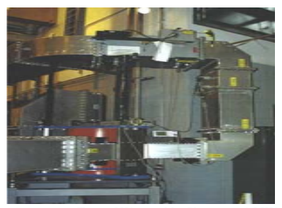
- **The construction of the APS High-Power RF Test Stand was completed in June 2001.**
- The facility was commissioned to 100 kW in early 2002.
- The test stand has been utilized to rf process and condition new APS storage ring high power rf cavity couplers and tuners to 100 kW to produce an inventory of spare critical cavity components to support APS operation.
- The test stand was also used to perform 1MW CW rf acceptance tests on the first article WR2300 waveguide shutters.

The concept of these waveguide shutters was developed by APS RF Group in order to provide personnel protection from accidental exposure to rf and x-ray radiation from the rf systems. This is accomplished by providing a movable electromagnetic short inside the waveguide. Because of the personnel protection requirement, the first-article shutters were extensively tested for rf leakage and their capability to withstand full power output (1MW) output at 352 MHZ in both open and closed states. These shutters provide a minimum of 80 dB isolation.

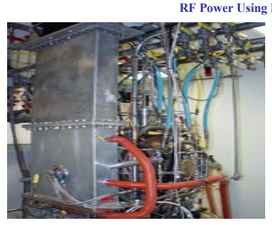


1 MW CW RF Power Test of Waveguide Shutter in Open State .

1 MW CW RF Power Test of Waveguide Shutter in Closed State.



Acceptance Test of Waveguide Shutter at 1 MW RF Power Using RF Circulator.

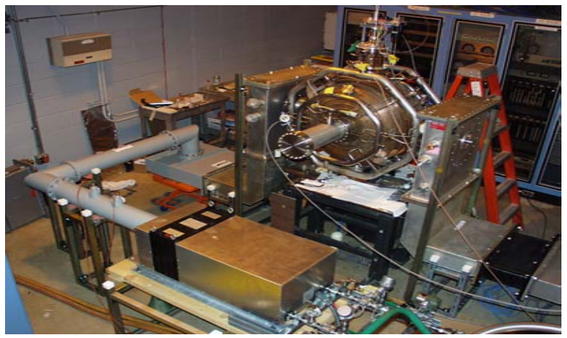


Single-Cell RF Test Cavity Assembly.

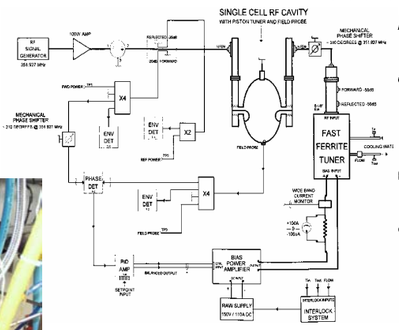
Cavity Mechanical Tuner Assembly.

FUTURE PLANS

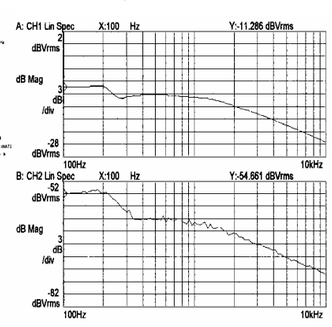
- Develop automated RF conditioning and data collection software.
- Develop and test E and H-probe higher order mode (HOM) dampers.
- High-gradient surface studies with emphasis on field emission, “dark” current, and RF breakdown.
- Testing and conditioning the APS 1.1 MW CW klystrons.
- Development and testing of new medium and high power rf amplifier systems.
- Development and testing of superconducting rf cavity and associated systems.
- Testing of ferrite devices to tune rf cavities. This would improve the performance of the APS booster synchrotron and storage ring by providing enhanced control of rf cavity operation.



Ferrite Tuner Low Power Test Setup.



Schematic of the Ferrite Tuner Test Setup.



Phase shift and current response plots. The upper trace is tuner bias current, and the lower trace is relative rf phase shift .

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