Cavity Simulator for European Spallation Source

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ABSTRACT

European Spallation Source will be the brightest neutron source in the world. It is being built in Lund, Sweden. Over 120 superconducting cavities will be installed in the facility, each regulated by an individual LLRF control system. To reduce the risk of testing systems on real cavities a Cavity Simulator was designed. It reproduces the behavior of superconducting cavities used in the medium and high beta sections of ESS’ Linac. The high power RF amplifiers and piezo actuators’ parameters are also simulated.

Based on the RF drive and piezo control signals the Cavity Simulator generates the RF signals acquired by the inputs of the LLRF control system. This is used to close the LLRF feedback loop in real time. The RF front end of the Cavity Simulator consists of vector modulators, down-converting circuits, and a set of fast data converters. The cavity response simulation is performed in a high speed FPGA logic by a dedicated firmware, that was optimized to minimize the processing time. The device also generates clock, LO, and the 704.42 MHz reference signals to allow for system tests outside of the accelerator environment.

In this contribution the design of the Cavity Simulator, description of the algorithms used in the firmware, and measurement results of the device are presented.

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MODEL

The hardware consists of an FPGA module, an analog module and a piezo module. The FPGA module generates the RF signals and acts as the central controller. The analog module contains the RF amplifiers and the piezo actuators. The piezo module generates the piezo control signals. The data conversion module is responsible for converting the analog signals to digital and vice versa. The down-conversion module is used to down-convert the RF signals. The reference generation module generates the reference clock and LO signals.

FIRMWARE

The firmware is implemented in a high speed FPGA logic. It contains the algorithms for the RF simulation, the fast data conversion, and the clock and LO generation. The firmware also contains the algorithms for the piezo control, the RF amplifiers, and the reference generation.

PHOTO

The transmission characteristics of the cavity are measured using a network analyzer. The cavity is excited with a single mode with 0 and 10 kHz detuning. The transmission is shown in the frequency range of 704.47 to 704.54 MHz. The cavity filling and decay are also measured. The cavity filling is shown for a single mode with a Q factor of 700,000. The cavity decay is shown for a single mode with a Q factor of 700,000.

GROUP DELAY

The group delay is measured for a single mode with and without smoothing. The group delay is shown in the frequency range of 704.47 to 704.54 MHz. The group delay is shown for multiple modes with 0, 0.5, 0.9, 1.5, 2.4, and 3 MHz offsets.

CONTACT

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