DESIGN AND DEVELOPMENT OF RF SYSTEM FOR VERTICAL TEST STAND FOR CHARACTERIZATION OF SUPERCONDUCTING RF CAVITIES

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Abstract

RRCAT is developing a Vertical Test Stand (VTS) to test and qualify 1.3 GHz/650 MHz, SCRF Cavities in collaboration with Fermi National Accelerator Laboratory (FNAL) under Indian Institutions' Fermilab Collaboration. The technical details for VTS is being provided by FNAL, USA. The RF System of VTS needs to provide stable RF power to SCRF cavity with control of amplitude, relative phase and frequency. The incident, reflected, transmitted power and field decay time constant of the cavity are measured to evaluate cavity performance parameters (E, Qo). RF Power is supplied via 500W Solid State amplifier, 1270-1310 MHz being developed by PHPMS, RRCAT. VTS system is controlled by PXI Platform and National Instruments LabVIEW software. Low Level RF (LLRF) system is used to track the cavity frequency using Phase Locked Loop (PLL). The system is comprised of several integrated functional modules which would be assembled, optimized, and tested separately. Required components and instruments have been identified and procurement for the same is underway. In-house development for the Solid State RF amplifier and instrument interfacing is in progress. This paper describes the progress on the development of the RF system for VTS.

INTRODUCTION

Vertical test stand will be used to quantify SCRF cavities by measuring the cavity quality factor (Q) and its variation with respect to temperature (T) and electric field gradient (E). The RF System for the VTS is responsible for providing a stable RF Power with control over amplitude and phase to the SCRF cavity. To achieve E greater than 35 MV/m, the RF power requirement for a cavity with Q = $5x10^9$ will be ~250 W at 1.3 GHz. Assuming various losses due to RF cabling, connections RF system is being developed for a targeted power of 500W CW.

RF SYSTEM DESIGN

The RF System has a modular design and consists of following functional modules:

- RF Source/VCO/PLL
- Transmitted Power Network
- Power Measurement
- High Power Amp/Switching Network
- Diode Detector interface/Buffer Amplifier

This allows each module to be constructed and tested separately before installation and integration.

To characterize the SCRF Cavity, RF system provides 250W CW power at 1.3 GHz to the cavity inside the cryomodule. The CW incident and reflected power are measured by using a dual directional coupler and the transmitted power to the cavity is measured using a Field Probe. The cavity frequency and other test conditions are also measured and recorded using LabVIEW based automated data acquisition and control system and the cavity parameters (E, Q, Q vs E, Q vs Temp etc) are then calculated. Fig. 1 illustrates the working of RF system through a simplified block diagram.

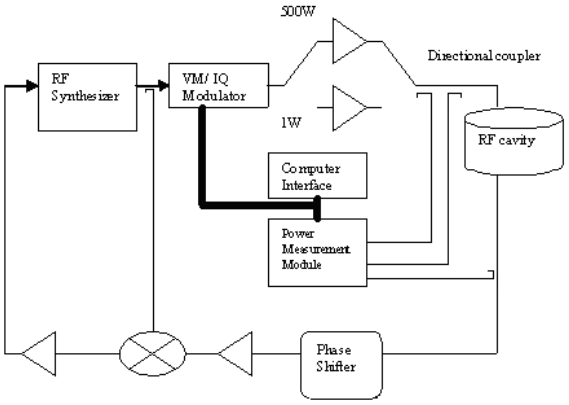

Figure 1 Block diagram of VTS RF System

The radiation produced due to field emission or multipacting are measured using radiation monitors and recorded. Some safety interlocks for personnel are necessary which are incorporated into the RF system.

500W RF Amplifier Design

We have developed S-Band pulsed amplifier system up to 300W, which have been employed at existing accelerator facilities at RRCAT. Based on our experience a 1270-1310 MHz, 500W CW amplifier design has been done for the present application. The design is based on high power LDMOS transistors which are combined in parallel to achieve the desired power. At present we have developed a 2W driver stage. Devices for high power stages have been identified and are under procurement.

DAQ AND CONTROL SYSTEM

Data acquisition and control system is based on interfacing of different instruments via GPIB and Multifunction DAQ card on PXI bus and PXI controller running Windows with LabVIEW based DAQ/control software.

DAQ Hardware comprises of PXI Chassis NI 1042Q, PXI Controller and PXI 6229 Multifunction DAQ Card. The DAQ system provides the following interfaces

GPIB: Power Meters, Frequency counter, RF synthesizer.
Analog input: Diode Detectors & VCO error signal.
Analog output: Vector Modulator for I /Q signals.
D/O: Digital attenuator, AM (RF pulsing) switch and Transmitted power network amp switching.

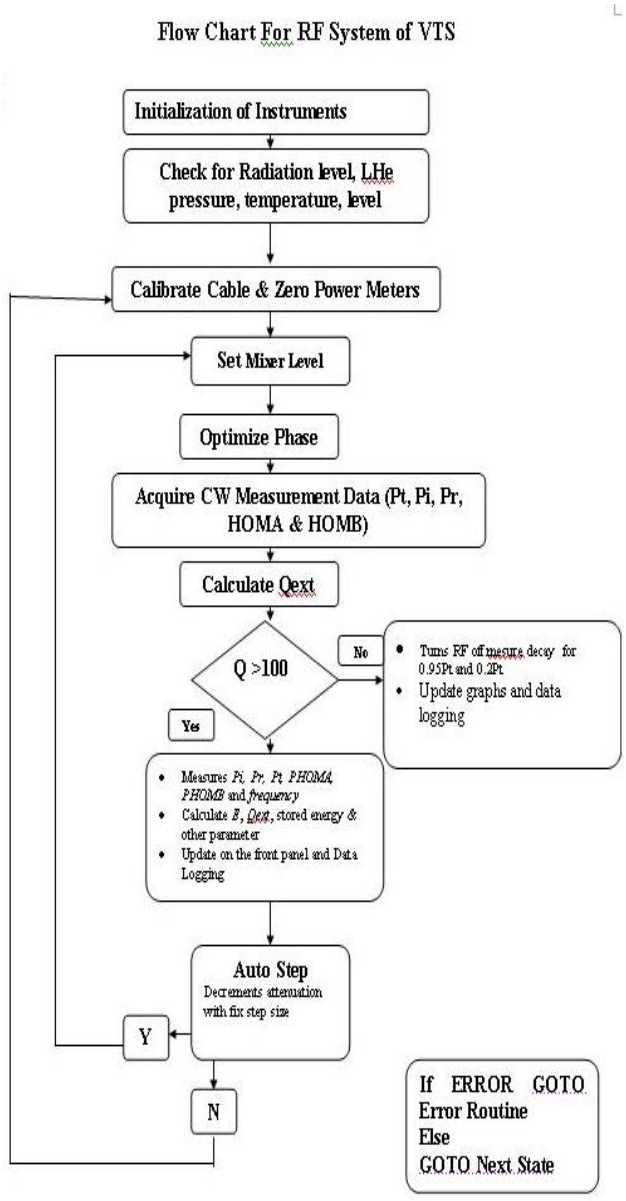

Figure 2 Algorithm for data acquisition and control software

DAQ Software

The software has a multi-threaded state-machine architecture written in LabView, consisting of two distinct state machines (**A&B**). **B** provides I/Q modulation @ 10Hz, **A** provides remainder of control, DAQ, utilities, analysis @ 0.5Hz.
Fig. 2 describes the simplified algorithm of the data acquisition and control software.

DEVELOPMENT STATUS

The VTS is being developed in collaboration with the FNAL, USA. The initial technical details provided by FNAL have been studied, some changes were deemed necessary in the architecture as some of the instruments are obsolete now. 500W amplifier used in the RF system is being developed in house for which the procurement of high power devices is underway and till date we have developed driver stage for the high power amplifier.

We are in final stages of our procurement for most of the instruments and devices, some have already been received. The software received from FNAL has been investigated. Power supplies required for the RF system have been designed and are under fabrication.

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