

# THE ELECTRONIC SYSTEM DESIGN AND REALIZATION FOR 1<sup>ST</sup> SET 500MHZ KEKB SRF MODULE HIGH POWER TEST

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## Abstract

This article reports the home-made electronics circuits for capture the various electronics signals and control functions on KEKB SRF modules which are used for site acceptance test of superconducting cavity. The adjustment of parameters during 1<sup>st</sup> SRF high power acceptance can also be used for the update of the 2<sup>nd</sup> electronics. The modular electronics system will provide the advantages of fast repair, preparing spare parts easily, short installation time and flexible adjustment.

The hardware of the whole electronics system is mainly designed by CPLD, PLC and Display meters. The Military Standard connectors are used for signals connection. There are always junction boxes for signal transmission test and convenient signal jumping for ensuring the correct signal source. In safety interlock, there are Fast Interlock Sum (0-10us) and slow ready chain (50ms-150ms). The complete system realizes the real time monitor and protection of the new superconducting resonant cavity.

## INTRODUCTION

The RF system of Taiwan Photon Source decided to adopt Japan, KEKB type SRF module as its RF cavity which as manufactured by Mitsubishi Heavy Industry (MHI). The vertical test is done in KEK. Since MHI did not provide turn-key solution for the SRF module, the electronics such as Break-Out-Box (BOB) integrating with SRF module are designed and made by NSRRC and transported to KEK for signals connection test. The BOB is transported back to Taiwan with SRF module after cold and vacuum tests. The home-made electronic signal monitoring systems and safety systems are used for cryogenic and high power test for the performance verification of superconducting cavities. In the meanwhile, the electronics system can integrated with the whole other sub-systems and to be installed in the storage ring for long term operation.

## THE INFRASTRUCTURE AND WORKING FLOW

### Baking System and Clean Room

The vertical test, vacuum leakage, cryogenic cool down and Q0 tests were all done at Japan (KEK). The assembly for coupler, SBP, LBP and cryogenic pipes will be continued after shipping to Taiwan. High power test shall be done in horizontal test area in NSRRC.

The end groups assembly needs ultra-pure Class 10 clean room built in RF lab in NSRRC. Before assembling

end groups on SRF cavity, high temperature 150°C baking was done for LBP and SBP first for 1week then 55°C constant temperature water baking for high order mode (HOM) damper for two months to ascertain the best vacuum condition of HOM. ( Fig.1)

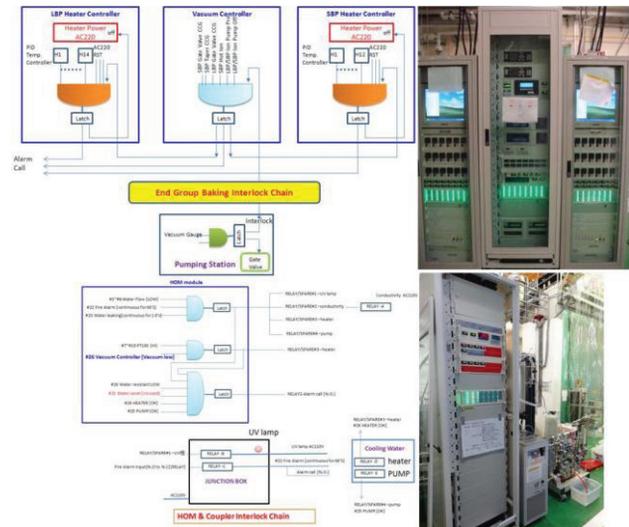


Figure 1: Ready chain for HOM baking and cooling water system.

Assembling coupler inside cavity needs a clean booth, which can prevent dust pollution and help work easier. 5 phase step motor was thus used to pull up and down the coupler within the clean booth. The motor has speed rate 1:600, model PK596AE-H50, Orientalmotor. Design the manual controller for driver. RKD514LA, Orientalmotor. (Fig.2)

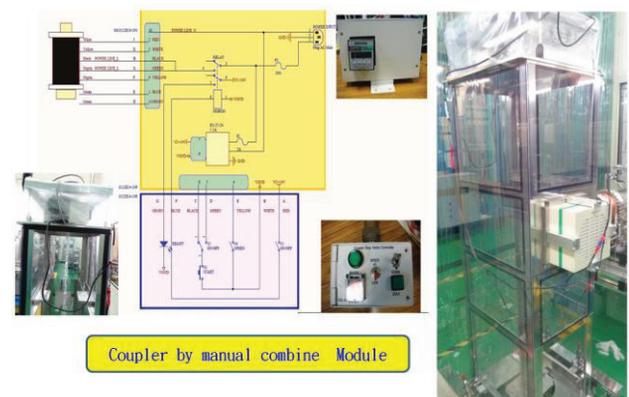


Figure 2: Clean Booth for coupler assembly.

The electrical power for baking system is provided by 3Φ4W. In long term baking, a set of 40 kVA UPS was

installed for support short term baking (220V) and high power water cooler when electrical power was interrupted. Besides, two sets of 20 kVA UPS were also set for cryogenic and controlling electronics to provide general electrical power to data acquisition system to monitor water quality, water resistance and liquid level. These data could be accessed by the whole electronics in control area. The FETEK PLC controller controls the electrical power for heater of baking system while PID temperature control meters keep the temperature in constant. 48 channels ready chain contributes safety interlock. Long term local data logging system was set by PICO (24BITS/16CH) with some upgrade circuits (input range extends from +2.5V to +10V) and laptop. After these baking procedures, the end group and HOM were moved to clean room for assembly.

*The Design of Break Out Box*

When the SRF module was moved to horizontal test area, the internal signal would be process by BOB (Fig. 3) first and then sent back to control area. BOB is a cabinet of 60x60x52 cm. The cabinet is designed for processing and amplifying the signals for lower noise and less EMI interference. The signals will be transmitted back to control area through 30-40 meter long cables. The BOB cabinet includes step motor driver and control card, enforced electrical power interrupt module, The four wire temperature of 16 channel modules (PtCo, 2mA(Fig. 4)), 8 channel water flow transformers, 6 channel PT100 temperature modules, 2 channel e-probes, 8 channel pressure current transformers, Type-T temperature of 64 channel modules (Fig.5), 8 channel PIN diode module and 2 channel arc detectors(Fig.6). Manually stepping motor control module was also accompany with SRF module for reading of Tuner force and its movement.

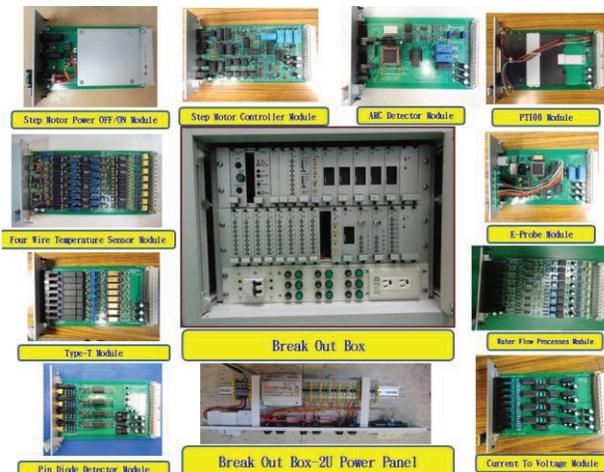


Figure 3: BOB Rack for SRF Cavity.

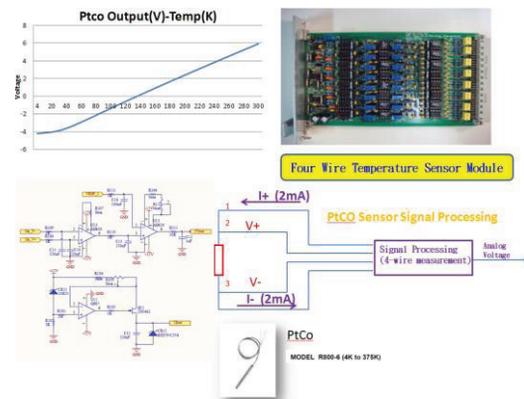


Figure 4 : PtCo module.

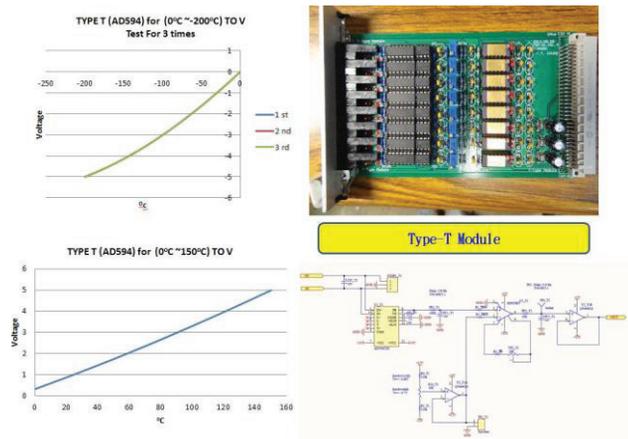


Figure 5: Type T module.

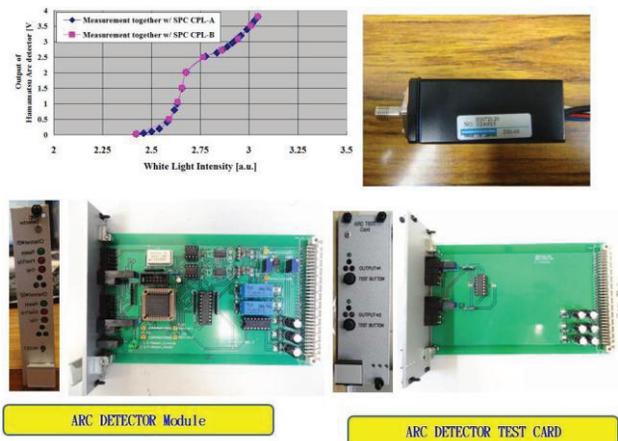


Figure 6: ARC Detector module and test card.

*Integration Electronics with Cryogenic Valves*

Liquid helium and nitrogen were transferred from TLS cryogenic system to valve box in RF lab. The electronics facility would need integration cryogenic valve box with control area. Hence, the whole cryogenic electronics includes Cryo Area trip, spring relief valve, PID valve

box controller, 40 channel interlock, heater control, liquid helium level control, PICO data acquisition devices, warmer, CLTS and pressure transducer, alarm system for mobile phone and oxygen concentration detectors. (Fig.7)

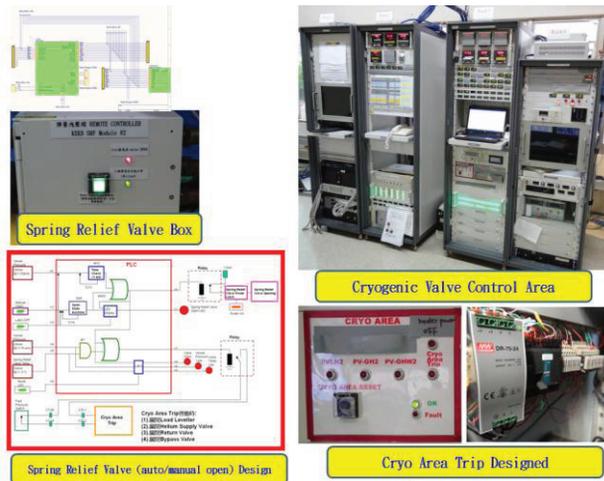


Figure 7: Cryogenic valve control at test panel.

Cryogenic area protection was an important function for safely isolate cavity system and vessel from outside. The safety interlock is determined from suction line pressure, fast pressure switch and activation of spring relief valve.

Spring Relief Valve can release the helium vessel pressure if the vessel liquid helium evaporates to be air by quench or other reasons. Over pressure of the He vessel would damage the burst disk if spring relief valve is malfunction. In over pressure status of the helium vessel, spring relief valve must be opened to air to release the pressure for keep the cavity structure to be safe.

This is a key point for pressure safety protection in which the controller would be designed correctly and added a new function for manual open. When the controller is in auto-status, the spring relief will be opened when the LHe supply pressure gets over the 18.7 Psia and keeps for 180s. Besides, if the personnel needs for maintain system or release the over-limit He vessel pressure (from experience), the manual open can be the solution. Manual Open needs standard operation procedure which can prevent unexpected helium releasing from the miss action of the personnel.

Keeping constant power would be applied on the heater inside the cavity. However, when the cavity has quench or Cryogenic system fails; the heater needed be turned off. Besides, we increased its reliability by additionally monitoring heater temp critical point, LHe pressure and bypass pressure.

### Cabinet for Vacuum

Many vacuum gauges need to be installed on SRF module, hence, the cabinet includes cold-cathode vacuum gauge, hot ion gauge, Convectron vacuum gauge, MKS

metal ion gauge, ion pumps for real time monitor and interlock protection with ready chain.

### 300kW Transmitter

The RF power source for SRF modules high power tests was a 300kW transmitter consists of a Thomson high voltage (55kV/12A) switching power supply and a Thales klystron (310kW).

### Control Area

The control area consists of LLRF control modules and SRF electronics. LLRF is analog design including amplitude and phase PI control for deforming cavity to lock frequency and gap voltage. SRF electronics (Fig.8) provide 5 sets of 240 channel ready chain as well as dual-color display DIDO modules, 16 channel fast comparator (5-10us), 24 channel interlock sum modules (5-10us) and 24 channel slow interlock sum (50-100ms). Besides, 70 set display meters are also installed. Arc test module, Reset module and RUN&PROCESSING mode changing modules are also included.



Figure 8: SRF electronics 1<sup>st</sup>.

## SUMMARY

The 1<sup>st</sup> set SRF cavity has successfully passed the horizontal high power test by using these home-made electronics. This had proved the electronics system can satisfy the requirement for SRF operation. Some small problems like: the temperature sensor would have value drift and variation due to improper grounding of whole circuits. Isolation for these electronics would be applied in next upgrade. Besides, the fast comparator would have some delay when trip event happened. The first version electronics design still had some small bugs. The accuracy and precision would be further improved in 2<sup>nd</sup> SRF test.