

# INITIAL RESULTS FROM THE S-BAND RF GUN AT SRRC

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## Abstract

An S-band rf gun test bench had been constructed at SRRC (Synchrotron Radiation Research Center), Taiwan. It will be used for high power tests of various designs of S-band rf guns and will be developed for potential FEL (Free Electron Laser) applications in the future. The construction of the whole system and the preliminary results are reported.

## 1 INTRODUCTION

Through the international collaboration of rf gun project with U.C. Davis[1], a set of SLAC XK-5 klystron and some capacitors of pulse forming network (PFN) were made available for developing S-band rf gun in SRRC. A test unit of delivering few MeV electron beam from a single cell rf gun operating at 2856 MHz was planned. This consists of constructing a PFN for XK-5 klystron, fabricating a single cell rf gun cavity using recently acquired vacuum brazing furnace, assembling the rf power transmission line, and vacuum system. This test unit will be commissioned with high power processing of the rf gun. In this report, construction of the PFN will be described based on the specification given by the XK-5 driving criterion[2]. Considering the availability of existing 2856 MHz linac section in other laboratories and its potential application to a similar system of 2998 MHz, this PFN has been tested at full specification on single shot basis. Test with a repetition rate of 10 Hz or higher will be proceeded later. The PFN functional test result is also presented.

## 2 SYSTEM SET UP

### 2.1 Gun Cavity

We had designed a single cell S-band (2856 MHz) rf gun using the code URMEL. The cavity is a simple pill box type with 81.22mm inner diameter and 32.50mm cell length. A prototype copper cavity with a flat copper cathode of 15.50 mm diameter was fabricated, and cold tested in 1999[2]. Then we have constructed an OFE copper cavity of a similar design for the high power test purpose. This OFE copper cavity is without a cathode insert hole. Instead, we will use the central region of the copper wall as the photocathode in the future. A ceramic

gap and a stainless steel tube are connected to the exit port of the gun cavity. The dark current and beam current will be monitored by a current transformer mounted outside the ceramic gap. A blank flange covering the end tube will also be used as a Faraday cup to measure the current. The side view of the gun assembly is shown in Fig. 1.

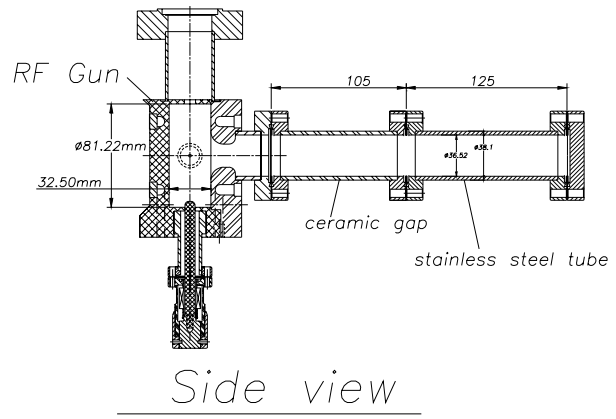


Figure 1: Side view of the gun and exit tube.

The cavity is equipped with a tuner and a field monitor. The tuning sensitivity of the tuner is around 0.9 MHz/mm and 0.4 MHz/turn. Figure 2 shows the transmission coefficient ( $S_{21}$ ) from the field monitor and the reflection coefficient ( $S_{11}$ ) of the cavity. The measured unloaded quality factor is 9928 for the brazed cavity. The coupling coefficient is 1.2 (over coupled). The cavity inner surface was polished at ITRI and the surface roughness is around 0.02  $\mu\text{m}$ .

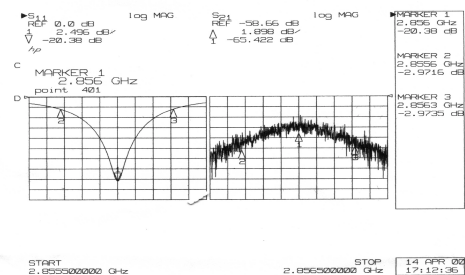


Figure 2: Reflection ( $S_{11}$ ) and transmission coefficients.

## 2.2 Waveguide system

The rf power transmission line consists of two 60 dB dual directional couplers (one is next to the XK-5 klystron and the other is next to the gun cavity), two pumpout waveguide sections, two H-plane bends, one circulator (30 dB isolation) with two rf windows on both ends, and a straight WR-284 waveguide section. The circulator is pressurized with SF<sub>6</sub> to 35 psig. Four little ion pumps (20 l/sec) are used in both pumpout sections to keep the vacuum pressure around  $7.5 \times 10^{-9}$  mbar before the rf power conditioning. A photograph of the whole system is shown in Fig. 3. A fast trip circuit consisting of the operational amplifier, comparator, and programmable logic circuit is used to protect the system. The circuit response time is 500 nsec. The vacuum trip level is set at  $4 \times 10^{-7}$  mbar, and the reflected power trip level is set at around 1% of the peak power.



Figure 3: Photograph of the whole system

## 2.3 RF power source system

The rf power source consists of a 1 kW driver klystron (Thomson tube TH2047) system, a 16 MW XK-5 klystron and the associated PFN system. The PFN functional block diagram is given in Fig. 4. A Spellman SR-6 module is used as the high voltage (HV) charging power supply to feed the capacitor bank of PFN. Triggering of PFN pulse is determined by the timing system of rf gun. The PFN pulse is further amplified at the entrance of XK-5 with a 1:12 ratio pulsed transformer. XK-5 cathode heater and grid bias are provided by supporting electronics. The final HV pulse applied to the

klystron is monitored with a voltage divider. RF signal is first chopped and integrated with protection circuit before sending into XK-5. Then, the high power rf signal is transmitted to rf gun cavity through WR-284 rectangular waveguide system. The technical specification and more details about this home made modulator are given in references [2] and [3].

Layout of RF Gun PFN Functional Block Diagram

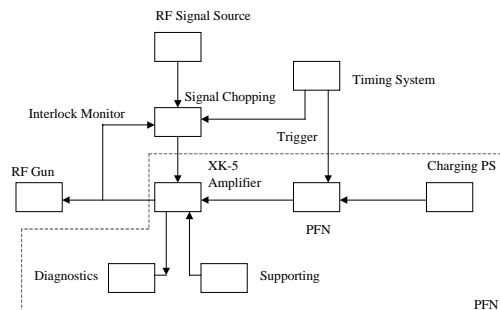


Figure 4: Layout of the PFN functional block diagram.

## 3 INITIAL TEST RESULTS

Three types of diagnostic tools were used to monitor the PFN output pulse, high voltage probe, pulsed current transformer, and voltage divider at the XK-5 klystron tank. The arrangement of the measurement probes is shown in Fig. 5.

Schematic Illustration of the Measurement Tools

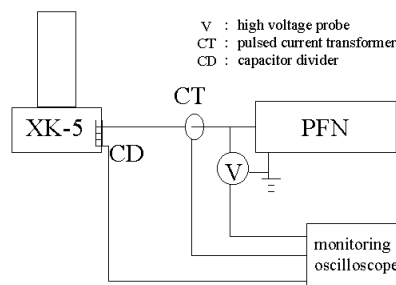


Figure 5: Block diagram of PFN measurements.

Typical example of the PFN output pulse taken at 30 kV charging voltage is shown in Fig. 6. The estimated ripple is about +/- 1%.

## 4 SUMMARY

A PFN for XK-5 klystron has been constructed according to the requirement of klystron. This PFN configuration was first simulated with PSpice and inductor at every section. The constructed PFN was tested with high voltage charging up to 33 kV. The measured PFN output pulse height was found to increase linearly with the charging voltage. This PFN was tuned to obtained +/- 1% flatness of 2  $\mu$ s pulse at 30 kV.

A single cell rf gun cavity has been fabricated and installed. The rf power transmission line has been successfully assembled. The vacuum of the whole system is kept around  $7.5 \times 10^{-9}$  mbar before rf processing. The first shot of the rf power into the cavity looks promising. The cavity resonant frequency is well tuned. The whole new rf system is working properly. The rf power will be increased gradually to find the highest attainable field gradient in this single cell rf gun very soon.

## 5 ACKNOWLEDGEMENTS

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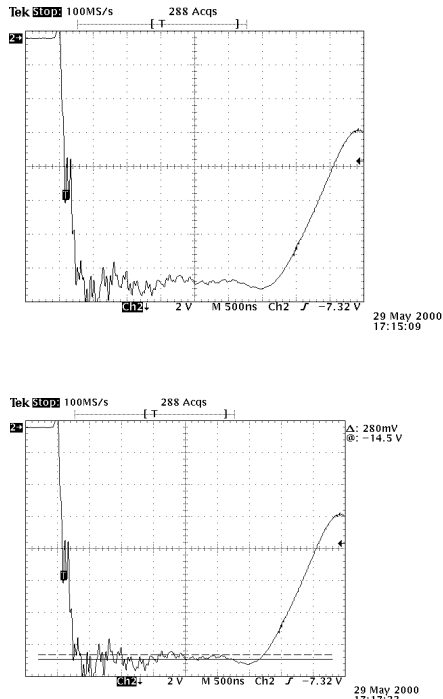


Figure 6: PFN output pulse at 30 kV charging voltage. The top figure is the data from the high voltage probe and the bottom one is from the pulsed current transformer.

The rf conditioning work has just been underway recently. We started at 3 kW rf power for tuning the cavity resonant frequency (at 23 °C) by minimizing the reflected power from the cavity. Figure 7 shows the minimized reflected rf power with the standard rabbit ear shape. The forward power into the cavity shown in Fig. 7 is 6 kW.

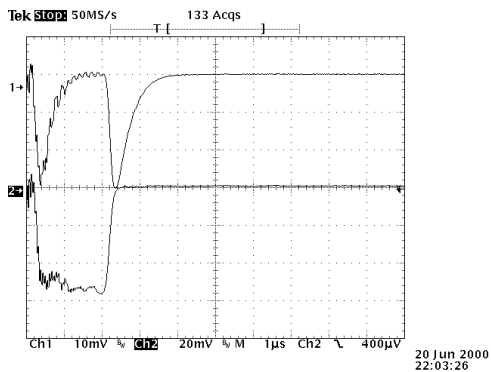


Figure 7: Reflected power signal (top) and forward power signal (bottom) of the gun cavity.