THE RF PHASE AND AMPLITUDE MONITORING SYSTEM OF THE VEPP-5 PREINJECTOR

D. Yu. Bolkhovityanov, E. A. Gusev, V. V. Oreshonok, O. V. Pirogov, D. P. Sukhanov,
Budker Institute of Nuclear Physics, Novosibirsk, Russia.

Abstract

The VEPP-5 500 MeV preinjector has some 2856 MHz power klystrons and others RF devices to drive the accelerating modules. The amplitude and phase control of the RF power for the energy doubler device (SLED) and for the preinjector accelerating section is necessary. The system of the RF parameters manipulation and of the precision monitoring is created. A description of this system parameters and architectures, of the available diagnostic tools and of the experimental results is given.

INTRODUCTION

The RF phase and amplitude monitoring system of the VEPP-5 preinjector block diagram is presented on the Figure 1.

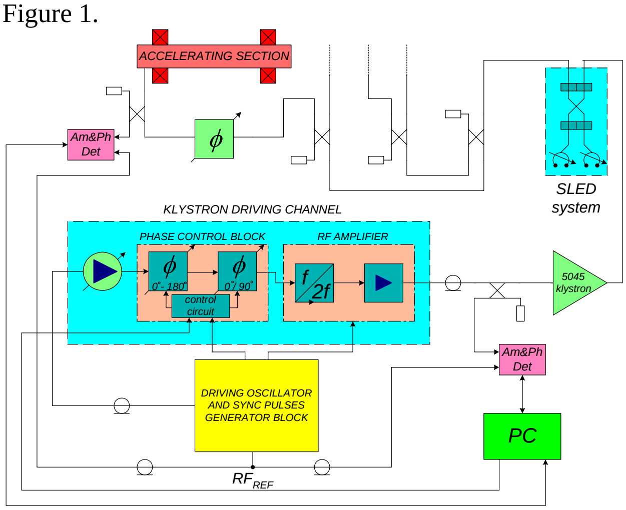

Figure 1: The RF phase and amplitude monitoring system block diagram.

RF power of the 2nd subharmonic (1428MHz) preinjector operating frequency comes from the driving oscillator to the klystron driving channels [1]. RF power is yielded to a phase control block through the controlled attenuator, which allows to adjust amplification level in the klystron driving channel. Phase control block is intended to manipulate the RF signal phase for the power multiplier system (SLED) and to control the RF signal phase at the klystron output.

The RF amplifier doubles the frequency to 2856 MHz (preinjector operating frequency), forms 5 μs pulse and raises the RF power up to the klystron excitation level. Control signals with appropriate delays come from the sync pulses generator.

The RF pulses are then transferred from each klystron's output to the SLED power multiplier devices. Pulse power raise is performed by means of energy accumulation in SLED resonators with the subsequent supplied signal re-emission after the phase reversal. The RF power from the multipliers is transferred to the accelerating sections through the system of 3dB waveguide directed couplers. Those have powerful mechanically-adjustable waveguide phase shifters to provide appropriate phase shift between the accelerating sections.

Monitoring of the RF power phase and amplitude at the accelerating sections input is performed by a system of the amplitude and phase measurements. In order to test phase control device, an additional amplitude and phase detector is installed at the klystron input through the directed coupler. Information about amplitude and phase difference between the reference signal channel and the RF power channel goes to computer in digital form for subsequent processing.

PHASE CONTROL BLOCK

RF power phase control system of the klystron driving channels is a number of two-channel devices performed in the CAMAC standard. The system operating frequency is 1428 MHz. Each channel (see Figure 2) controls one klystron operation and consists of:

- 0 / 90 degree two-state phase shifter for the RF signal phase reversal, which is necessary for the SLED system operation;
- 0 – 180 degree analog signal controlled phase shifter for the accelerating sections RF power phase tuning;
- phase shifters control circuits.

Phase control block performances are shown in Table 1.

Table 1: Phase control block performances.

Parameters	Values
Operating frequency, GHz	1.428
0 – 180 degree adjustable phase shifter	
Phase control range, degree	0 - 180
Attenuation in control range, dB	0.2 – 0.8
Phase setting accuracy, degree	0.5
0 / 90 degree phase shifter	
Phase switching time, nsec	less than 20
Attenuation irregularity, dB	0.7
Phase setting accuracy, degree	0.5

Phase shifters are made with the microstrip technology and consist of 3-dB quadrature directional coupler which is symmetrically loaded with two varicap modules connected to the control circuit. Adjustable 0 – 180 degree phase shifter is controlled by the DAC through the scaling amplifier. Two-state phase shifter control circuit forms two-state control signal with the rise time of about 10 nsec after the triggering external synchropulse.

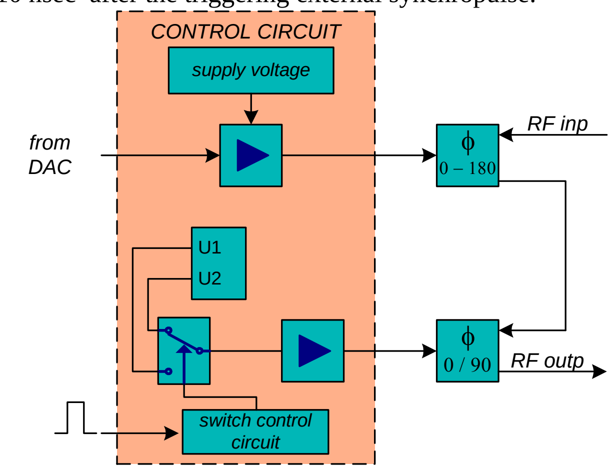

Figure 2: Block diagram of the phase control block channel.

All adjustable phase shifters of the phase control system are controlled by the 16 bit DAC.

AMPLITUDE AND PHASE MEASUREMENTS

Amplitude and phase measurements system (see Figure 3) is intended for the RF signals amplitude and relative phase measurements on the VEPP-5 preinjector operating frequency of 2856 MHz.

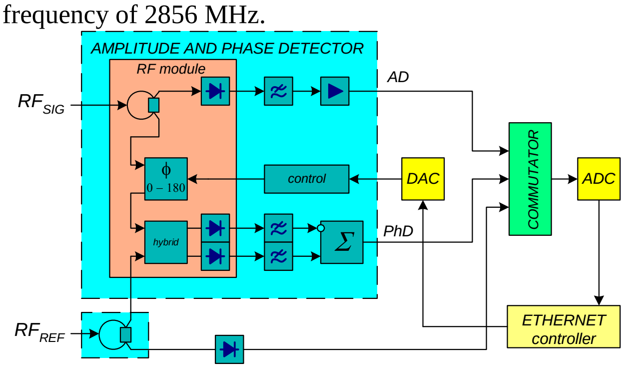

Figure 3: Amplitude and phase measurement system with one detector block diagram.

This system is performed in the CAMAC standard and includes:

- two-channel amplitude and phase detector block with the control circuit;
- 16 bit DAC;
- two-channel 8 bit ADC with 200 MHz sampling frequency per channel;
- two-channel commutator 4 to 1;
- reference RF power delivery and measurement devices.

Through the RF module signal input power divider the RF signal comes to the amplitude and phase channels of the detector block. The amplitude detector output contains the information about the measured RF signal amplitude and shape. This information comes through the commutator to the ADC. In the phase channel of the block the RF signal comes to the phase detector through the adjustable phase shifter which is intended for the increase of the phase measurements accuracy and for the measurable phase range expansion. The phase detector output signal is proportional to the phase difference between the reference signal and the measurable RF pulse. For the reference signal amplitude monitoring additional amplitude detector is used. The amplitude and phase detector block and the reference channel amplitude detector output data comes to the PC through the ADC.

Table 2: Amplitude and phase measurements system performances

Parameters	Values
Operating frequency, GHz	2.856
Phase and amplitude measurement accuracy, %	1
Upper sampling frequency, MHz	50

PRESENT STATUS

As accelerating sections are put into operation on the VEPP-5, monitoring systems become more and more important. Phase and amplitude measurement and control systems can operate either standalone, or can be used with the feedback. Example of phase control program is presented on the Figure 4. Figure 5 shows the phase and amplitude measurement sample.

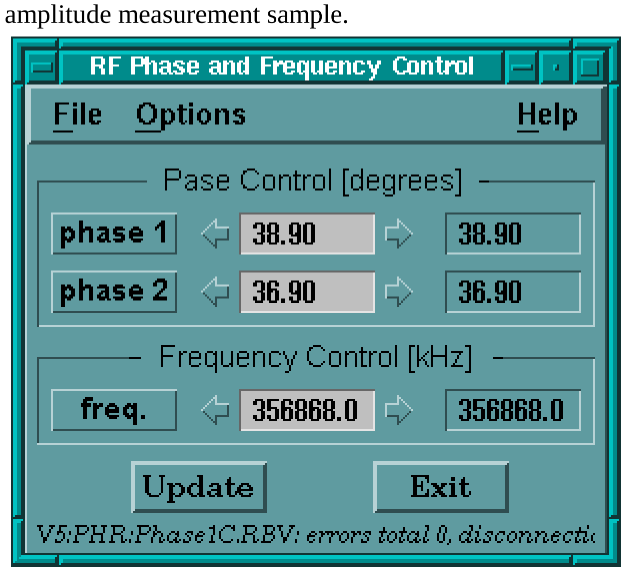

Figure 4: View of a phase control window.

Control software runs on a Linux PC. This software has a client-server distributed architecture (so-called “3-layer standard model"), which allows remote measurement and control.

Figure 5: Phase and amplitude measurements of the RF power at the klystron input.

REFERENCES

[1] "The VEPP-5 project", Budker Institute of Nuclear Physics, Novosibirsk, 1995.