

# THE RF POWER SUPPLY SYSTEM OF THE MCC-30/15 CYCLOTRON

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## Abstract

The RF power supply system for exciting the resonance system of the MCC-30/15 cyclotron is presented. The main parameters of the RF power supply system are: the 40.68 MHz operating frequency, the 25 kW output power (the continuous mode), the operating mode—continuous or pulse. The parameters of the RF power supply system, its schematic and characteristics of the main units are given.

The RF power supply system of the MCC-30/15 cyclotron is intended to excite the resonance system, which consists of two resonators galvanically coupled near the magnet axis. When designing the cyclotron, the operating frequency of the RF oscillations of the resonance system was chosen to be 40.68 MHz in compliance with the “All-Union norms for the allowed radio noise, 5-89”. At the chosen frequency the resonance system is completely located inside the inner cavity of the vacuum chamber and is fixed to the side surface of its casing. The resonance system is equipped with a capacitor for frequency tuning, an AFT trimmer, a double-electrode RF probe and a cooled RF power lead-in. The design loss power is less than 14 kW.

The RF power supply system consists of a control and stabilization module and an RF power amplifier.

The control and stabilization module is intended to generate a sinusoidal signal with an operating frequency, to choose the operating mode (continuous or pulse with a specified duty factor), to vary, measure and stabilize the accelerating voltage amplitude, to stabilize automatically the resonance system frequency as well as to supply the RF power to the buncher. Compared with the module to be used in the RF power supply system of the CC-18/9 cyclotron [1], new elements are used in this one.

The module comprises the following functional units:

- master oscillator (frequency synthesizer),
- synchronizer,
- detectors,
- stabilization unit of the accelerating voltage amplitude (ASA unit),
- unit for automated tuning of the resonance system frequency (AFT unit),
- power supply unit,
- RF amplifier of the buncher power supply,
- control unit.

A block diagram of the module is shown in Figure 1

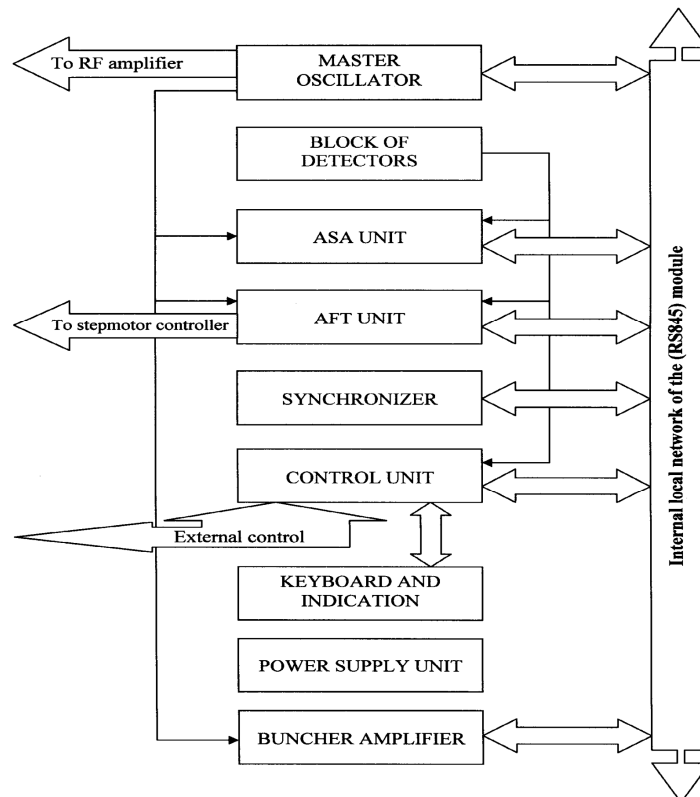


Figure 1: Block diagram of the control and stabilization module

The master oscillator is made on the basis of a two-channel direct digital frequency synthesizer (DDS), which uses an AD9958 microcircuit (produced by Analog Devices). The first channel is used to generate and to modulate the basic RF signal applied to the RF power amplifier; the second channel is used to generate and modulate an RF signal applied to the power amplifier of the buncher. A 20 MHz GK-62 piezoelectric oscillator of high stability produced by “MORION” Ltd is used as a source of the reference frequency. An RF signal filtered and amplified to a necessary level is sent to the ASA and AFT units.

The synchronizer is intended to form synchropulses necessary to ensure functioning of AFT and ASA units. Synchropulses of 50 Hz and 10 μs formed in the power supply unit are applied to the input of the unit synchronously with the frequency of the supply line. The synchronizer is built on the basis of the PIC16F73 microprocessor.

The detector unit is intended for an amplitude detection of the RF voltage across the dees and for measuring the phase difference of the incident wave and of the wave reflected from the reflectometer of the final stage of the power amplifier. From the measured voltage and phase, error signals for stabilization units are formed.

The ASA unit affects the excitation level of the RF power amplifier keeping a specified value of the voltage across the dees or deenergizing it in contingencies (for example, at breakdowns). The AFT unit controls the step motor of the resonance system trimmer drive.

The control unit is intended for periodic acquisition of data from the rest units of the module via the SPI internal interface and also for primary processing and transmitting necessary information to the control system of the cyclotron.

The buncher supply unit operates at a basic frequency of 40.68 MHz and is intended to amplify the signal sent from the frequency synthesizer output to a level of 60 V across a 50 ohm (36 W) load. The unit is based on a classic three-stage scheme of a push-pull broadband amplifier. The output stage uses field-effect transistors produced by Philips.

The control and stabilization module will be made as a standard 19” crate of height 4U (160 mm) and depth 300 mm (produced by SHROFF or RITAL). The crate is supposed to be installed in one of the RF power amplifier racks.

The RF power amplifier (Table 1) has been designed and delivered by the OEI Corporation, the USA.

Table 1: Technical characteristics of the amplifier:

Characteristics	Values
Operating frequency, MHz	40.68
-3dB range, KHz	400
Output power (continuous mode), kW	25
Operating mode	
- Continuous mode	
- Pulse mode:	
duty factor, %	1-99
pulse repetition rate, Hz	10-300
lengths of the leading and trailing pulse edges, μs	< 0.1
Supply line	380/400 V, 50 Hz, 4-wire (3 phases, neutral, ground)
Cooling	Water (1-input 1-output)
Calibrated measuring terminals 1:1000, incident and reflected power	
Remote control	RS485 or Ethernet Interface (on/off, status of interlocks, incident/reflected power, tube voltage/current).

The RF power amplifier is housed in two racks The RF power is transmitted to the resonance system via a flexible coaxial feeder.

## REFERENCES

- [1] V.P. Belov, P.V. Bogdanov, I.N. Vasilchenko et al., “The CC-18/9 Medical Compact Cyclotron”, Proc. The 11<sup>th</sup> Int. Conf. on Charged Particle Accelerators Applied in Medicine and Industry (ICAA’05), St.Petersburg, October, p.237 (2005).