AN MOPA RF SYSTEM OF INS SF CYCLOTRON

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Introduction

The existing rf system of the INS SF cyclotron employs a self-excited oscillator[1] and supplies rf power to the dee in the frequency range of 7.3 to 17.5 MHz. There has been a constant demand for extended frequency up to 22.5 MHz. The maximum rf power, which excites the rf dee voltage up to 85 KV at a frequency of 20.5 MHz, is estimated to become 150 KW. A master oscillator and power amplifier (MOPA) rf system was proposed and its construction was begun last year. A new rf system is also expected to perform improved stability, improved reliability and simplification of operation procedures, especially in changing an operation frequency.

A test bench has been constructed and a preliminary performance of the whole system is being studied.

MOPA rf System

An MOPA rf system, shown in Fig. 1, features a final power amplifier (PA), an rf wideband driver amplifier, current controlled attenuators and a master oscillator (MO), rf dee voltage regulation loop and automatic rf phase regulation loop. A personal computer is used for automated settings in interfacing with digital instruments through IEC-IB.

Final Power Amplifier

For our final power amplifier, we choose a plate tank of the coaxial resonator of 1/4 λ mode, an all pass network of a grid rf circuit and the RCA 4648 tetrode. A plate tank is very flexible for adjusting the plate load impedance. A 50 Ω, 50 KW water cooled resister is coupled to the PA plate tank via 18 pF capacitor. Whenever the cyclotron resonator is detuned, this load absorbs an excess rf power and protects against break-down in the plate tuning capacitor and the rf coupling capacitor between the PA and the main resonator. An all pass network of a bridged-tee configuration, shown in Fig.1, has been successfully developed at the ORIC[2] and eliminates most circuit tuning in frequency range of 7 to 23 MHz. This circuit dissipates an rf power of four times in π-network for the same rf grid voltage and the high gain characteristics of a power tube is then desired. The 4648 has a gain superior to other power tubes. Besides, the 4648 has the low feedback capacitance of 0.6 pF and is expected to be operated without neutralization in our frequency range. The plate tank is copied from the ORIC one.[3] A movable short and four vacuum variable capacitors in the plate tank are driven with powerful pulse motors. A screen bypass is disc capacitors assembled as double-decker Kapton sandwich, in which a 3 mil Kapton film is used.

A plate load impedance is chosen to be 350 Ω. Settings of dc power supplies are designed to be 14.5 KV in plate p.s., 1100 V in screen p.s. and -110 V in control grid p.s.. The PA output power of 150 KW is estimated to be achieved in an rf grid voltage of 75 $V_{r.m.s.}$.

Phase Regulation Loop

The rf signals from capacitive pick up in the grid, plate and dee are converted into 455 kHz signals in I.F. amplifier in which the superheterodyne method is used. The phase between 455 kHz signals is measured with a phase-meter and its analog output drives a pulse motor through a drive unit. An automatic tuning system demodulates a phase between the grid and dee signals, and a phase between the grid and plate signals, separately.

Dee Voltage Regulation Loop

A double pick up dee voltage detector, which has been developed at the RCNP AVF cyclotron, is used. This can generate an exact dee voltage signal

which is an insensitive to the dee motion.[4] The output is compared with the reference signal in a feedback amplifier. A difference between them is fed to a current controlled attenuator and the rf dee voltage is then regulated.

Control System

A control system embodies all circuitry needed for the following functions in four operation modes.

1. Preset : Position of six motor-driven elements, which are shown in Fig. 1 as symbol of M, is set preceding to an rf excitation.
2. Pretuning : The resonant frequency of the cyclotron is tuned automatically in a sweep mode operation of the rf signal synthesizer. This procedure is made without applying the plate and screen voltages.
3. Baking : Pulsing in rf excitation is made for baking out of the cyclotron resonator.
4. Power drive : CW operation is automatically switched to a pulsing through multipactoring.

Test Bench Results and Discussion

A test bench consists of all the system but the main resonator and the plate power supply. A plate p.s. for a test bench has an only capability of 2.5 KV and 1.5 A. An rf output power of the PA is fed to the 50 Ω, 50 KW load resister in the plate tank on the resonant condition. A power of a few hundred watt has been delivered to the resister in the frequency range of 7 to 23 MHz with an automatic phase regulation. No parastic oscillation is met until now.

Considering a preliminary result on a test bench, we have decided to start installation of an MOPA rf system in the cyclotron this September.

References

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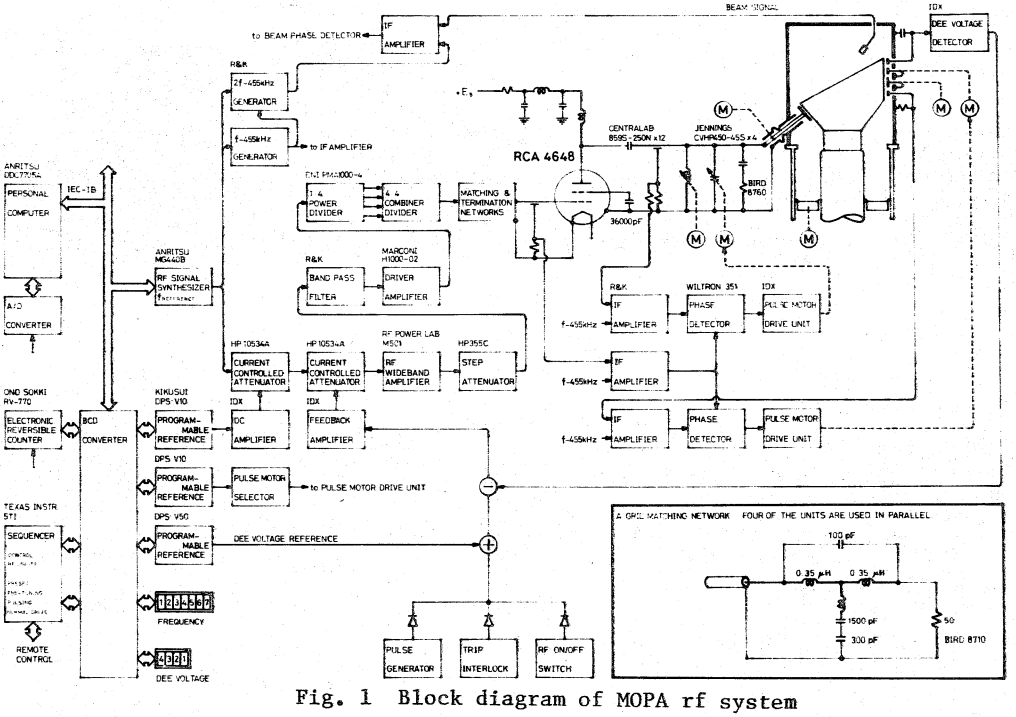

Fig. 1 Block diagram of MOPA rf system