PERFORMANCE OF THE HIGH POWER RF SYSTEM OF THE NBS-LOS ALAMOS RACETRACK MICROTRON*

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Introduction

The high power RF system for the NBS-LANL Racetrack Microtron (RTM) consists of four CW linac sections powered by a single 500 kw CW klystron at 2380 MHz. The power level and phase in each linac section is regulated by a feedback network that controls high power waveguide power dividers and phase shifters as well as the RF klystron drive. A block diagram of this system is shown in Figure 1. The desired RF power and phase levels in each section are set by the RTM computer control system. Application programs within the RTM control computer allow fast power-up of all four linac sections under computer control. These programs, which monitor forward power, reverse power, and vacuum in each section, also significantly shorten the time needed to RF process a linac section after a vacuum pump down.

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RF System Description

There are four separate linac sections in the RTM. Two are in the injection line and two are in the microtron. The first linac in the injection line is the capture section, a 1.1 meter long, tapered β (0.55 to 0.95) section with an energy gain of 1.3 MeV. The nominal power level of the capture section with no beam loading is 25 kW. The other linac in the injection line is the preaccelerator section, a 2.7 meter long, tapered β (0.95 to 0.99) section with an energy gain of 3.7 MeV. The nominal power level of this section with no beam loading is 63 kW. The two linacs in the microtron are each 4 meter long, β = 1 sections with an energy gain of 6 MeV. Their unloaded RF power levels are 100 kW each.

The RTM RF system uses two separate control methods for power and phase regulation. The feedback control loop of the capture section monitors the phase and power level in the capture section via a 50 dB

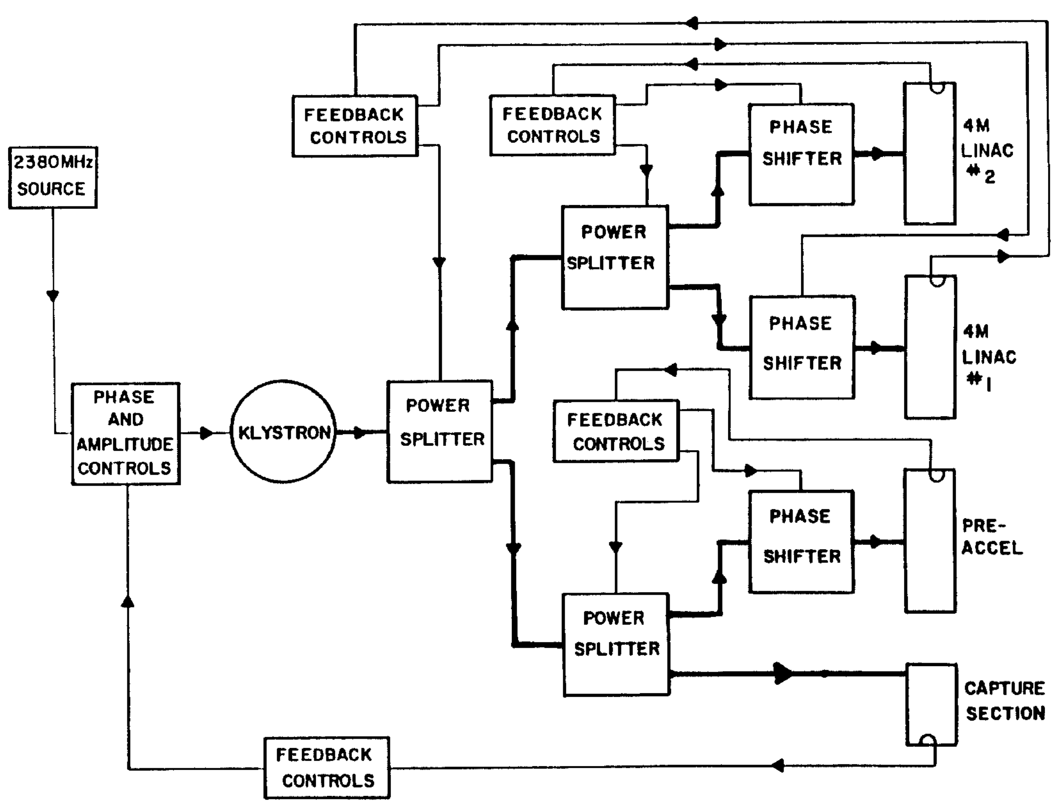

Figure 1. Block diagram of RTM RF control system.

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coupling loop and varies the input signal to the klystron to reach the desired values. This control loop uses low-level (≈1 watt) amplitude and phase controls with an open loop gain bandwidth of 40 kHz. It is described in Reference 1. The other three linac sections use high power waveguide power splitters and phase shifters as their control elements. The waveguide power splitters allow a < 1% to 99% power split. The waveguide phase shifters have a 140° range. Since these waveguide elements employ large mechanical shifters with stepping motor drives, the control loops containing these elements have an open loop gain bandwidth of 3 Hz. As the power level in the preaccelerator or in either of the two microtron linacs is changed, the RF drive to the klystron is controlled by the capture section control loop to maintain the proper total power requirements of the RF system. Because the capture section control loop has a much faster response time than the other three linac sections, there are no control problems in increasing power. A complete description of the high power waveguide feedback system is presented in Reference 2.

A separate temperature control system is used on each linac section to maintain the RF resonance at the operating frequency of 2380 MHz. These temperature control systems vary the cooling water flow into each linac section to maintain resonance at all RF power levels. A block diagram of this control system is shown in Figure 2. A description of this system is presented in Reference 3.

Computer Control System

The RTM uses a computer control system[4] to monitor and control all accelerator parameters. All accelerator devices have hardware protection to prevent damage. The status of all hardware protection interlocks is monitored by the computer control system. Software may be written to allow computer automated monitoring and control of any combination of the accelerator parameters. The program AUTORF ramps the power up from zero to preset values for all four linac sections simultaneously. The program monitors forward and reverse power and vacuum in each linac while increasing power. For faster starts, the program increases the RF frequency by 400 kHz for cold (smaller) linac structures and returns to 2380 MHz as the linac sections approach full power. If the reverse power in any linac section rises above a preset point as RF power increases, the program halts the power ramp-up and searches for an RF frequency that minimizes the total RF reverse power. The program also stops the power ramp-up when any of the linac structure pressures rises above a preset value, making the program useful for RF power conditioning after a vacuum pump down. Typically, it takes 3-5 minutes to increase RF power from zero to full power in all four sections simultaneously, after conditioning.

RF Stability Measurements

RF power and phase stability were measured at 50 dB coupling ports in each linac section with all sections powered. A vector voltmeter was used for the phase measurements and an RF power meter was used for the power measurements. The measured power stability was +/-0.1% for 1000 seconds, while the measured phase stability for the same time interval was +/-0.3°. The short term stability was approximately half of these values.

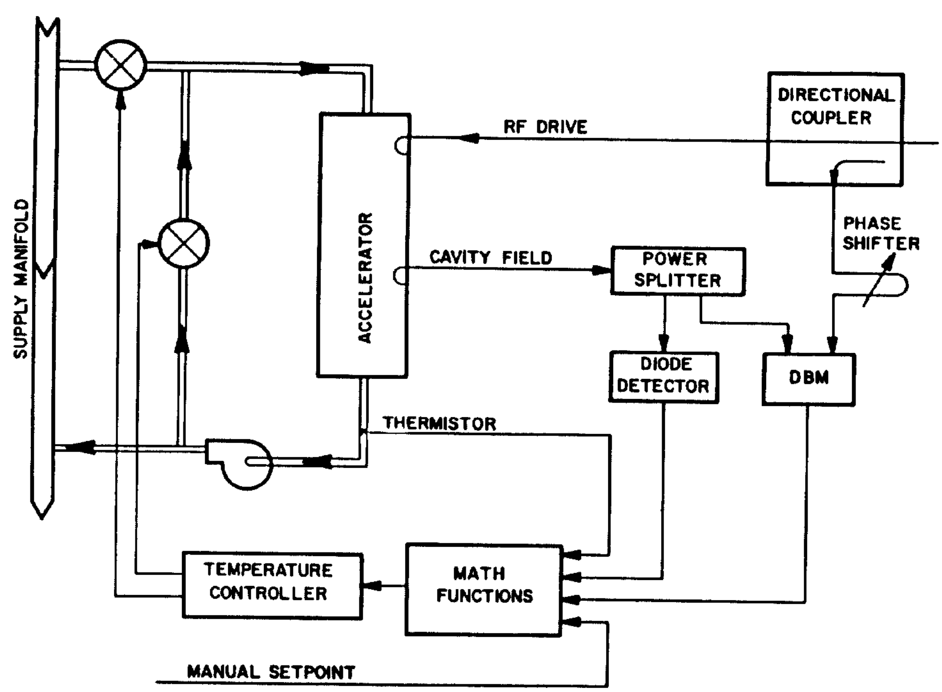

Figure 2. Block diagram of RF resonance control system.

References

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