PHASE LOCK LOOP AND ASSOCIATED COMPONENTS FOR THE RADIO FREQUENCY SYSTEM OF THE PF STORAGE RING PART-II

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In order to achieve phase stable radio frequency power for the RF cavities of the PF storage ring[1], phase lock loops for the individual klystrons as well as for different RF cavities are to be employed. The basic phase lock loop consists of three units; a phase detector, a filter and loop amplifier, and a voltage controlled oscillator (VCO). A double balanced mixer is a convenient way of making a phase detector provided two identical frequency, constant amplitude signals are applied to the mixer resulting in a DC output voltage proportional to the phase difference. Figure 1 shows a composite feedback system where the klystron power is varied by the amplitude modulator and the phase detector is replaced by the mixer. The automatic gain control (AGC) amplifier is needed to provide constant amplitude to the mixer when the klystron power is varied. The programmable offset voltage (DC) applied to the loop amplifier is intended to compensate the intrinsic phase characteristic of the AGC.

A wide-band high performance RF amplifier with AGC has been constructed using Watkins-Johnson TO-8 cascadable amplifiers, WJ-G1 attenuator modules and a few external components. The dynamic range of the AGC amplifier is 40 dB minimum and a gain control feature is provided to set the output power level to +7 dBm maximum. The scheme of the amplifier is shown in Figure 2. The control voltage V_c for the WJ-G1 attenuator modules is obtained from the RF detector and the associated circuits. The amplitude and phase response of the AGC are illustrated in Figures 3 and 4. The dynamic range is -37 to +10 dBm. The output power variation is within ±0.1 dB and the phase linearity is within ±0.5° for 10 MHz bandwidth. The electrical performance at 500 MHz is summarized in Table 1.

Table 1 Electrical Performance at 500 MHz

Frequency	500 MHz
RF Output	+2 dBm*
Dynamic Range	-37 to +10 dBm
VSWR In/Out	<1.5:1
Harmonics	>25 dB Down
Phase Change (for the Dynamic Range)	55°
For 10 MHz Bandwidth	
Phase linearity	±0.5°
Amplitude variation	±0.1 dB
Group delay	10 nsecond
DC Supply	15 V at 250 mA

* Output can be set between -5 to +7 dBm by adjusting R4

The AGC amplifier's dynamic range is 47 dB which means that in the feedback loop shown in Figure 1, for a klystron power variation of 4.0 W to 200 kW, the AGC performance is adequate. A double sided printed circuit board is used to construct the AGC and the 50 Ω line impedance of the amplifier is obtained by microstrip line[2].

References

1) Photon Factory Design Manual (1979).
2) Reference Data for Radio Engineers, 177, Sixth Edition, Chapter 8, pp 24-25.

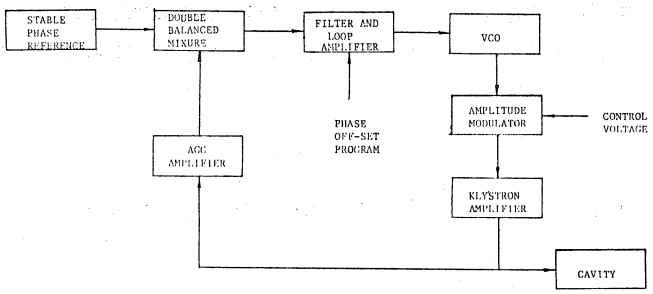

Figure 1. Block Diagram of Composite Feedback System.

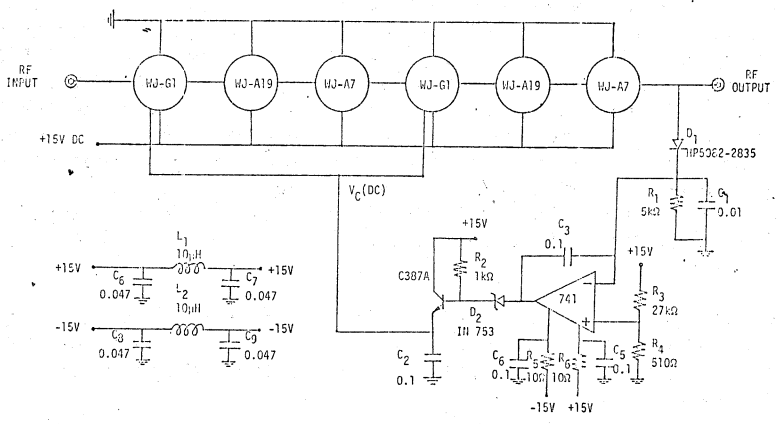

Figure 2. Schematic of Automatic Gain Control Amplifier.

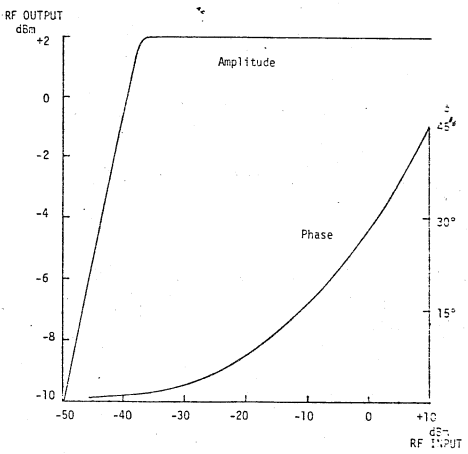

Figure 3. Amplitude and Phase Variation of the Automatic Gain Control Amplifier vs Input Power.

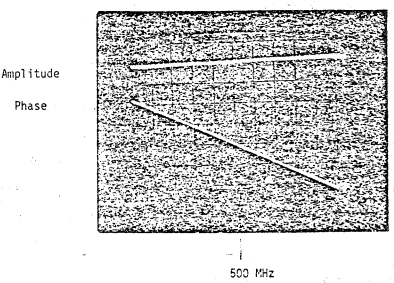

Figure 4. Amplitude and Phase Variation of the AGC Amplifier for 500±5 MHz bandwidth. Input Power is -20 dBm and Output Power at 500 MHz is +2 dBm.
Vertical Scale for Amplitude 0.25 dB/division
Vertical Scale for Phase 10°/division