ABSTRACTS (MASTER THESIS)

Study on a phase-controlled magnetron for wireless power transfer

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Introduction

Magnetrons have been widely used as microwave heating applications typified as microwave ovens. The advantages of magnetrons include high efficiency, low cost, and high output power. However, the magnetrons as transmitters have a wide bandwidth, difficult phase control, poorly stable output frequency, and high phase noise. We developed a 5.8 GHz phase controlled magnetron (PCM) system which can control the output phase in a stable frequency and output power. With 5 W (Pi/Po: -18.2dB) injection power, the phase-locked stability of the PCM was lower than ±1°.The response time was less than 100 μs. The PCM output could be varied from 160W to 329 W in a phase and power stability state with 10 W (Pi/Po: -15.2dB) injection power.

The results of simulations and experiments

In this study, utilizing the injection locking method and the phase locked loop method (PLL). The injection locking method is injecting a reference signal to the magnetron to lock the oscillation frequency. Therefore, controlling the reference signal parameters achieves the frequency and phase synchronization of the magnetron output. An analog phase shifter was set to control the phase of the injection signal in the 5.8 GHz PCM. The magnetron output is fed back to control the phase shifter, then a feedback loop is constituted for controlling the phase. This PLL method does not require the characteristics of the anode current and the magnetron oscillation frequency. We designed and demonstrated a 5.8 GHz PCM system. In this system, the gain margin Gm was 38.6 dB and the phase margin Pm was 63.7°. A photo of the 5.8 GHz PCM is shown in Fig. 1.

The anode current was set 150 mA to make the magnetron worked in the rated condition. The injection power was 5 W. The output power was 329 W within 1% stability. The filament current of the magnetron was 7.4 A by AC 3.35 V. Before the PLL circuit worked, we observed the phase of the magnetron output with the noisy. When turning on the PLL circuit, the magnetron was in a phase-locked state. The measured magnetron phase and power are shown in Fig. 2. The noise disappeared and the output power was in a stable state. Here, the phase of magnetron output was locked in a narrow range. Figure 2 shows the phase when the PLL circuit was working. The phase-locked stability was lower than ±1◦.

Fig.1: Photo of a 5.8 GHz PVPCM system (1: 5.8 GHz magnetron, 2: directional coupler, 3: dummy load, 4: current meter, 5: circulator, 6: spectrum analyzer.)

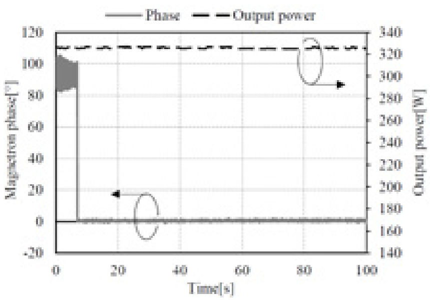

Fig.2: Magnetron phase and output power when the PLL circuit start working.