Injection-Locked CW Magnetron for a wirelessly-powered TV

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***Abstract*— It is shown a wireless power transfer system that transmitted microwave drove the power and video signal of a TV which worked as a wirelessly-powered TV. At the transmitter, we modulated a video signal on a 2.45 GHz sine wave via frequency modulation, a 2.45 GHz injection-locked magnetron could amplify the frequency modulation signal. Utilizing injection locking method, we injected the modulated signal to a 2.45 GHz magnetron and the magnetron amplified this modulation signal. At the receiver, we rectified the microwave energy to the power source and demodulated this microwave to the video signal of the TV. The wireless power transfer distance was 3.5 meters. At the aid of the transmitted microwave, we successfully rectified 48 W DC power and demodulated the video signal.**

Keywords—Magnetron, injection-locked, wireless power transfer, frequency modulation, rectification

I. INTRODUCTION

Magnetrons as low cost and high efficiency microwave sources, are widely applied in heating areas such as microwave ovens. According to Alder's equation [1], our research group has reduced the noise of the magnetron and developed the phase-controlled magnetron as the transmitter of a wireless power transfer system [2]. Using an injection-locked magnetron, the transmission of phase-shift-keying (PSK) data at 2 Mb/s has been achieved via Tahir et al. [3]. In the recent study, a full-wave voltage doubler circuit which improved the power source of a microwave oven, was used as the power source of the injection-locked magnetron. A 4 Mbps transmission of the frequency-shift-keying (FSK) data was achieved [4]. Moreover, we evaluated several modulation performance of the 2.45 GHz and 5.8 GHz band injection-locked magnetron which achieved at 10 Mbps (Po/Pi: 13.43 dB) [5]. These research results show that the magnetron noise can be limited in a low level, which is good enough for wireless power transfer and communication.

In this study, we utilized this injection-locked magnetron as the transmitter of the wirelessly-powered TV system. At the receiver, through the received antenna and rectifier the microwave was rectified to the DC power and was demodulated to the video signal, as the power source and signal of the TV.

II. EXPERIMENTAL ARRANGEMENT

We build a 2.45 GHz microwave power transfer TV system which was shown in Fig. 1. At the transmitter, the FM modulator (Pakite PAT240) which can modulate the video signal and audio signal on the 2.45 GHz band microwave (Bandwidth: 2 MHz). The modulated signal was amplified to 10 W then was injected to a 2.45 GHz magnetron. The magnetron was locked with the injection signal and output the modulation signal via a circulator to a horn antenna. Here, the full wave voltage doubler was improved from the power source of a microwave oven. It is able to keep the magnetron oscillate in continuous wave [4]. The ripple rate of magnetron anode voltage is 4.16% and the oscillation frequency of magnetron was shifted less 3 MHz bandwidth. By the 10 W injection power, the magnetron worked in an injection-locked state.

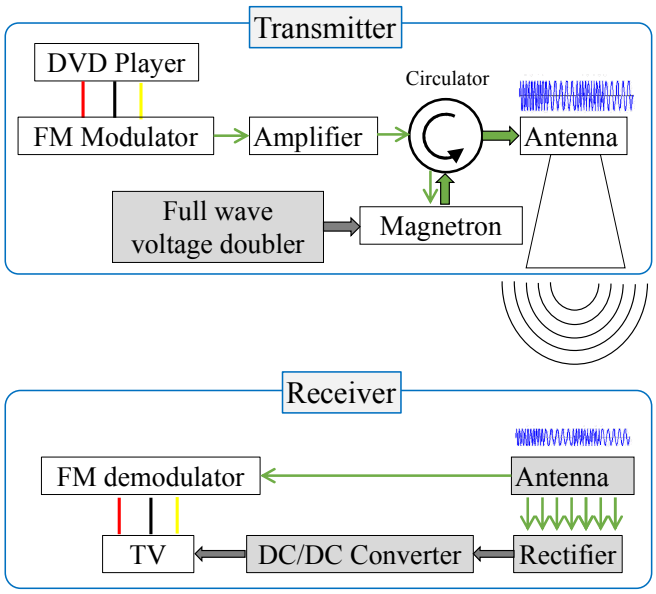

Fig. 1 Wirelessly-powered TV system diagram.

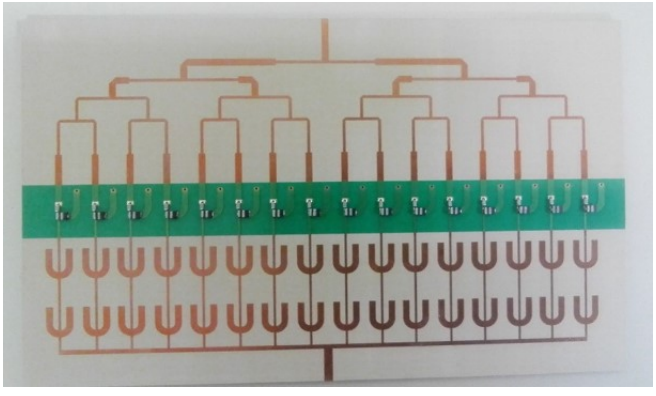

Fig. 2 Photo of a 2.45GHz rectifier circuit board

At the receiver, we set 54 patch antennas, each one connected to a rectifier circuit. The photo of a rectifier circuit[6] is shown in Fig. 2. The rectifier circuit efficiency with different load and input power are shown in Fig. 3 and Fig. 4, respectively. Through the experimental data, the maximum rectifier efficiency was 51.7% when it worked at 60 Ω load and 1.8 W input power. A rectifier circuit was connected to the demodulator (Pakite PAT240). The other 53

rectifier circuits outputs are connected to a DC/DC converter in parallel. The DC/DC converter limited the voltage lower than 16 V which is the TV work voltage. The video signal and audio signal of the demodulator was connected to the TV. The distance between the transmitter and the receiver was 3.5 m. The other parameters are shown in Table. I.

When the transmitter was activated, the TV was turned on by microwave power and the DVD data was properly displayed on the wirelessly-powered TV. 48W DC power was supplied to the TV and the demodulator. The photo of a wireless power transfer system of TV as shown in Fig. 5. As a wireless power transfer system, it requires a low power loss or a high transfer efficiency, which contains microwave conversion efficiency, antenna transfer efficiency and rectifier efficiency. In this system, the rectifier circuit didn't work at the optimal load which can be improved. We also can improve the transfer efficiency via improving the effective antenna aperture.

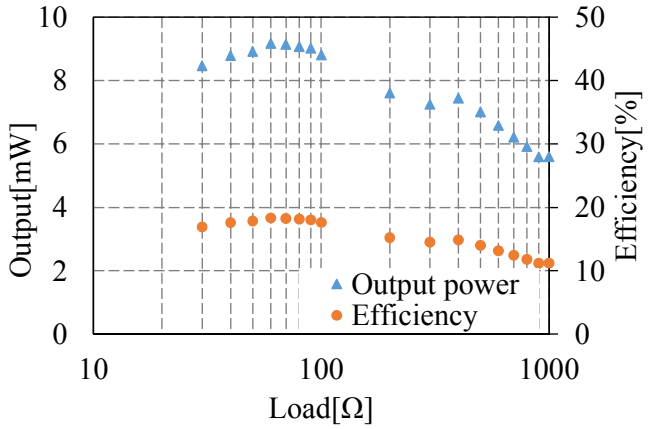

Fig. 3 Rectifier efficiency of the rectifier circuit with different load(input 50mW).

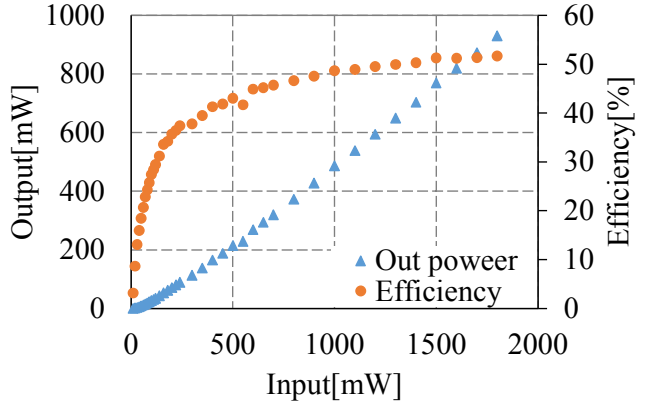

Fig. 4 Rectifier efficiency of the rectifier circuit with different input power(load:60Ω)

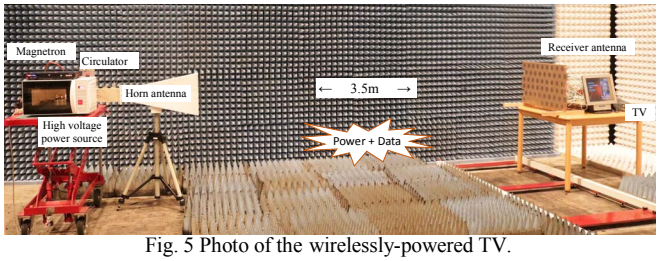

Fig. 5 Photo of the wirelessly-powered TV.

TABLE I. PARAMETERS OF THE WIRELESSLY-POWERED TV

Magnetron	2M236-M42(Panasonic)
Anode Current	140 mA
Anode Voltage	-3.68 kV(DC)
Filament Current	7.4 A
Filament Voltage	3.35 V(AC 60Hz)
Injected Power	10 W
Output Frequency	2.448 GHz-2.450 GHz
Output Power	329 W(RF)
Rectified Power	48 W(DC)
Modulation	Frequency ,Modulation
Transmitter Antenna	Gain 16 dBi (SPC)
TV	LL-M1550A (Sharp)

III. CONCLUSIONS

We developed a wireless power and video transfer system for the wirelessly-powered TV in the microwave band. It demonstrated that a 2.45 GHz injection-locked magnetron could transmit the microwave power and the video signal by frequency modulation. Through the transmitted microwave, we successfully rectified 48W DC power for the TV and demodulated the video signal.

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