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Frequency-Controlled Impedance Matching System for Microwave Heating

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Microwave is an excellent way to heat up a small spot, for example, cancer on body organs and tissues. When a target tissue is heated and dried, the load impedance changes. The impedance mismatch makes efficiency degradation of heating. Therefore, we propose a frequency-controlled impedance matching system for high power applications.

The system consists of six main components that are a voltage control oscillator (VCO), a radio frequency power amplifier (PA), a circulator, a diode sensor module, a frequency-sweep variable matching circuit (MC), and a microcomputer module, as described in figure 1. The VCO generates a continuous wave (CW) in the frequency range between 2.4 and 2.5 GHz. The PA emphasizes the power of CW to approximately +45dBm. The output of the PA is injected into the diode sensor module through the circulator. The circulator protects the PA from power surge in case of trouble on the system. When impedance of a load is different from impedance at the end of the RF cable, a standing wave is occurred by a reflection of the signal at the end of the cable. This standing wave is detected by four diodes on the module shown in figure 2. When the frequency of the CW signal is changed, the impedance at the end of the RF cable is also changed as described in figure 2 right. This is because the amount of the phase shift at the cable is related to the frequency, and the effect of MC is also related to the frequency. The micro-computer controls oscillation frequency of the VCO to minimize the standing wave by referring to the output voltage of the diodes. The control criterion is defined by

$$\underset{2.4GHz<f<2.5GHz}{\arg\min} \frac{V_a^2+V_b^2+V_c^2+V_d^2}{(V_a+V_b+V_c+V_d)^2} \tag{1}$$

where the V_a, V_b, V_c, V_d are the aligned output voltage of diodes. An alignment is applied to compensate for an error of coupling factor on a capacitor between the diode and RF line, and to reduce the difference of the characteristics between the devices. When the system finds the best frequency to minimize the formula 1, impedance matching at the end of the cable is well established. It means that the system achieves high efficiency of heating and protects the PA from undesirable reflection. As it is easy to make a sensor and an MC with high power capability, we conclude that this system configuration has an ability to apply for high power systems.

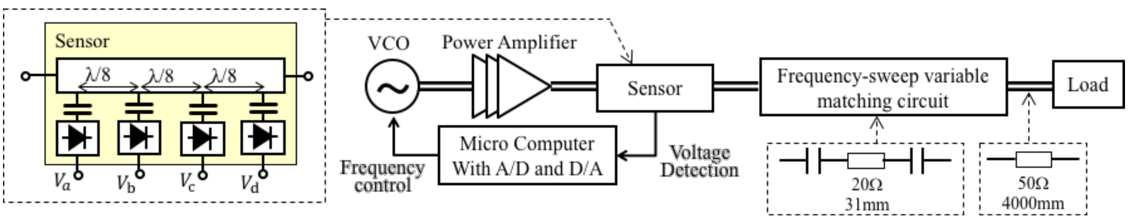

Figure 1. Block diagram of the frequency-controlled impedance matching system

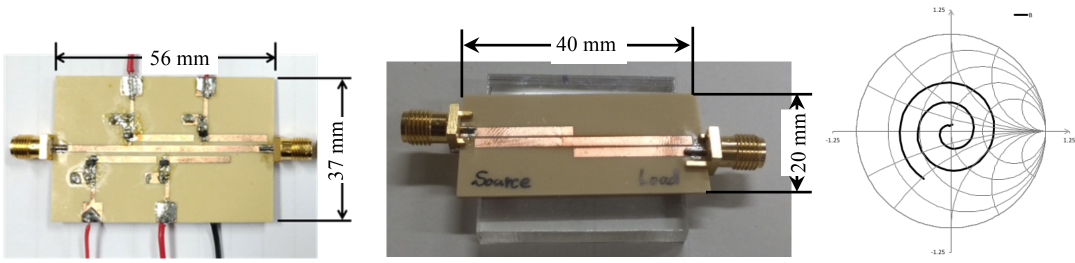

Figure 2. Sensor module (left), matching circuit (center), and frequency response of impedance (right)