Study on Microwave Power Transmission System with Active Integrated Antenna

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Development of Microwave Power Transmission (MPT) System with huge phased arrays (diameter: 1.0km~2.6km), very accurate beam control (less than 0.0001 degree), high overall efficiency and light weight is necessary to realize Space Solar Power System (SSPS) economically. To satisfy these requirements, a Phase Controlled Magnetron (PCM) is considered to be suitable for a microwave transmitter. The PCM, developed by our research group, takes advantages of high power, high DC-RF conversion efficiency, low cost, and light weight. A typical output power from the PCM is more than 300W, while an output power from one antenna element is less than 1W for SSPS parameters. Power dividers and phase shifters after the PCM output are necessary to satisfy SSPS parameters and it leads to disadvantages. The power dividers and the phase shifters are inserted after the high power microwave output, thus an insertion loss in these elements is critical for overall efficiency. Therefore, the loss following to the PCMs must be reduced to realize the PCM-based MPT system.

In this paper, a Slot-coupled Active Integrated Antenna (AIA) system is proposed as one of the solution of the MPT system for SSPS, which is composed of a waveguide slot as a power divider, an AIA as an active device part (a low-loss phase shifter / a high efficiency amplifier) and a planar antenna. By using an electromagnetic coupling between the AIA and the waveguide slots, thin and light AIA structure can be realized. One of the important factors of the slot-coupled AIA is a coupling factor of the electromagnetic coupling between microstrip lines and waveguide slots. In the study, improvement of the coupling factor is studied. By tuning the electromagnetic coupling structure and the waveguide dimensions, the coupling factor of more than 90% is achieved for 2-element model (Fig.1). Measurement results show good agreement with the electromagnetic simulations.

A design and a fabrication of an amplifier for the AIA part are also studied. In a design of the power amplifier integrated with AIA, the reduction in size is one of the important points to construct 2-dimensional, compact, and thin AIA array structure. From the view point of the device characteristics, good grounding, heat handling and output matching are also important to realize the stable high power output, and to avoid breakdown of the device. These key points are well examined and considered in the design. As a basic design, a compact amplifier with low-power HEMT is designed and fabricated. The operating point of class AB is chosen to improve the efficiency of the amplifier. Measured PAE (Power Added Efficiency) of the basic amplifier is 47% at 0dBm input power. As a next step, a drive-stage amplifier for a high-power AIA is designed and fabricated. Through the design and the fabrication, sufficient compactness is achieved and the operation as an amplifier is demonstrated (Fig.2).

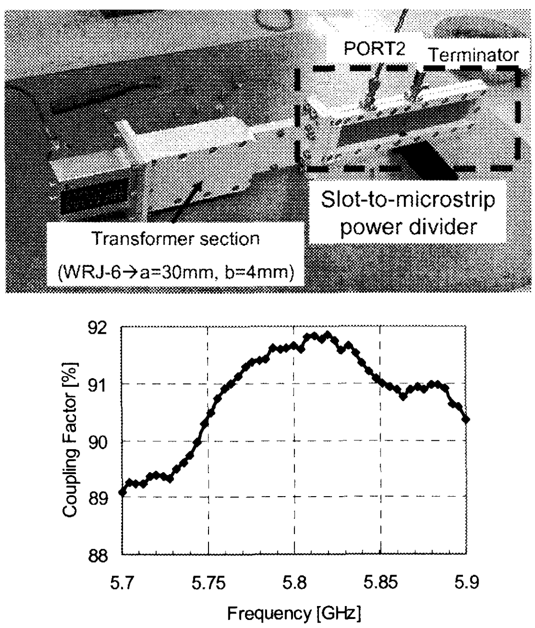

Fig. 1 Experimental Result of New Waveguide Power Devider

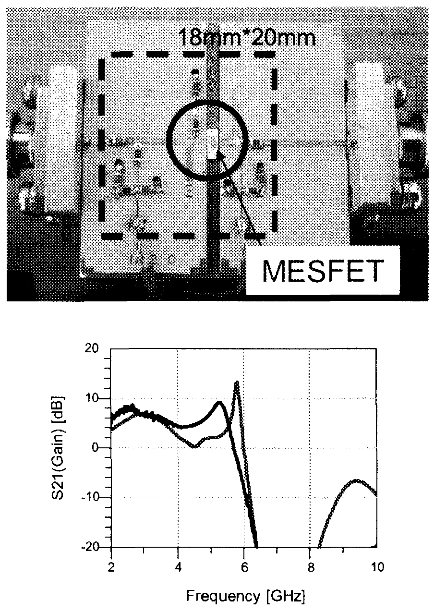

Fig.2 Experimental Results of AIA Power Amplifier (red line: simulated curve, blue line : measured curve)