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Author: Prof. Nobuyuki Kaya
Kobe University, Japan

Mr. Takuya Nakata
Kobe University, Japan
Mr. Ryo Takamatsu
Kobe University, Japan

DEVELOPMENT OF MMIC FOR THREE DIMENSIONAL PHASED ARRAY ANTENNA

Abstract

Many satellites are being launched to the low Earth orbit, for example, the SpaceX Starlink satellites. All the satellites must be communicated with the ground stations for the control and data acquisition. The ground stations are required to communicate simultaneously with many satellites. The purpose of this study is to develop the three dimensional phased array antenna for the various applications including the ground antennas and the onboard ones. We have already built the first pilot models of the receiving antenna at the frequency ranges of X and S-band and succeeded in receiving the signals from the satellites.

The three dimensional phased array antenna consists of a large number of antenna elements, each of which is composed of an omnidirectional antenna element and an RF circuit of a low noise amplifier, a phase shifter, and a frequency mixer. In the development of the S-band antenna, the antenna element and the RF circuit were integrated to make the RF circuit work a part of the antenna. However, since the RF circuit was composed of discrete ICs, the size became large. In the X band, where the wavelength is 1/4 shorter than the S band, the size of the RF circuit is already too large for the X band, so that the RF circuit disturbs the antenna pattern with deep notchs. Therefore, if the RF circuit can be integrated into a dedicated MMIC of 3 mm square or less, the RF circuit may not disturb the antenna patterns. We designed the dedicated MMIC for S band and X band, and evaluated the performance by simulation. It was taped out on March 10, 2021 to the shuttle service of the GlobalFoundries company of the United States.

The new fabricated MMIC consists of the low-noise amplifier directly connected to the antenna element, the mixer to down-convert the frequency of RF waves, and the phase shifter to control the phase of the LO signals. Since this is the first design and manufacture, each function is evaluated individually, and the overall characteristics are evaluated by adding external circuits. Therefore, it was designed so that the power supplies could be separated individually to eliminate interferences from the other circuits and to evaluate the performances. The fabricated MMIC indicates the effective performances for the three dimensional phased array antenna, that will be reported in my presentation.