Active transmitarray antenna with SiGe BiCMOS vector modulator MMICs for E-band

Antti Lamminen, Jehki Pusa, Arto Rantala, Mikko Kaunisto, Mikko Varonen, Mikko Kantanen, Jan Holmberg, Jussi Säily, Dristy Parveg, Hans Toivanen, Jouko Aurinsalo
VTT Technical Research Centre of Finland

Introduction

We present an active 64-element E-band (71−76 GHz) transmitarray antenna (TA) using monolithic microwave integrated circuit (MMIC) vector modulators (VM) for both amplification and phase shifting (Fig. 1). The TA including MMICs are integrated on a multilayer PCB. Instead of a standard planar TA, a stackable concept is proposed, in which only a linear sub-array needs to be designed (Fig. 2). A 2D array is implemented by stacking multiple identical PCBs separated by mechanical blocks, which provide the needed element spacing in vertical dimension. The main benefit of the concept are the relaxed requirements for the PCB dimensions as the small element spacing on the PCB, here 2.5 mm, needs to be fulfilled only in 1D. Other benefits are scalability and heat management as the mechanical structure made from metal acts also as a heat sink.

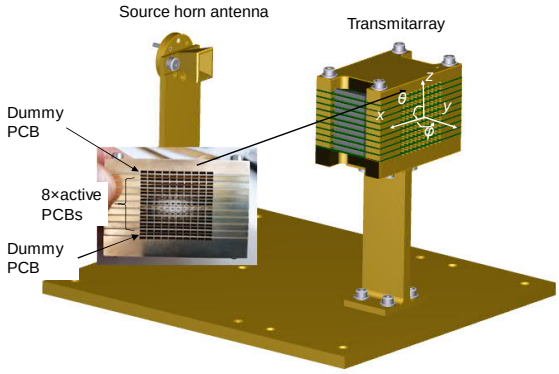

Fig. 1. E-band transmitarray. Stack of 8×8 transmitarray with source horn antenna and mechanical supports.

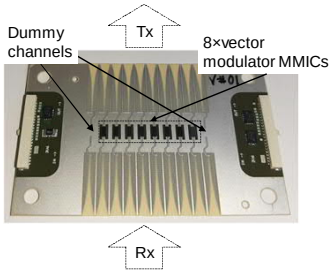

Fig. 2. Printed circuit board (PCB) for 1×8 sub-antenna array.

Antenna design

Each TA unit cell has a Rx antenna, a VM chip, and a Tx antenna. The antenna design is based on a finline inside a square waveguide (Vivaldi antenna) radiating in free space. Array element separation is 2.5 mm ($0.6\lambda_0$ at 72 GHz). Feasible scanning range without grating lobes is about ±30 deg.

Results

A single Vivaldi element has its simulated input return loss $|S_{11}|$ below -10 dB from 62 GHz at least up to 90 GHz and maximum antenna gain of about 6 dBi at 71−76 GHz. For the 8×8 array, the gain is about 23 dBi. Measured radiation patterns at 71.5 GHz are presented in Fig. 3. The main beam is electrically steered between ±30° in E- and H-planes with the maximum scan loss of about 1.7 dB and 1.3 dB. Based on measurements, an EIRP of about +40 dBm is estimated for the TA.

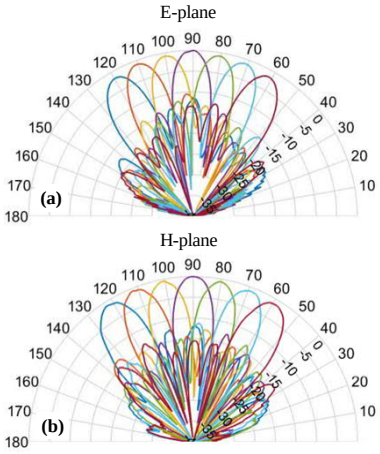

Fig. 3. Measured radiation patterns at 71.5 GHz in (a) E-plane and (b) H-plane.

Conclusion

- Active 64-element transmitarray antenna using SiGe BiCMOS vector modulator MMICs presented for E-band (71−76 GHz)
- Antenna array is scalable in size due to quasi-optical feeding and stackable PCB design
- Beam steering is demonstrated in E- and H-planes at 71.5 GHz between ±30° angles
- Effective isotropic radiated power (EIRP) of +40 dBm measured
- As for the future development, the array could be scaled up in size or frequency, such as D-band (110−170 GHz) for future 6G wireless communications applications

Contact: Antti Lamminen, Research Scientist
Tel. +358 40 832 7659, antti.lamminen@vtt.fi