Millimeter-wave antenna array

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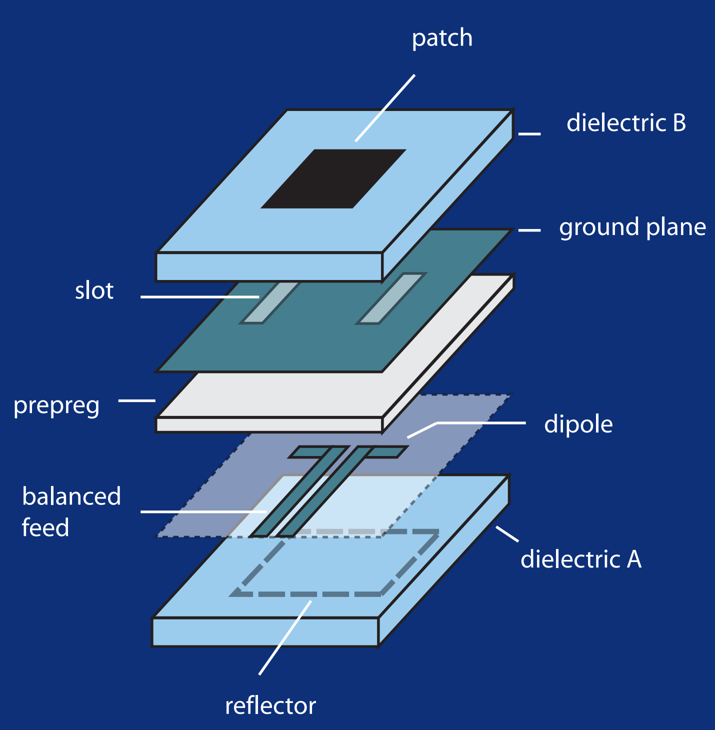


Fig. 1 - layout single-element antenna

/ Introduction

The increasing demand for bandwidth in wireless communication drives the transceiver systems to higher operating frequencies. The license-free band at 60 GHz receives much attention because of the almost unlimited amount of bandwidth that is available there. Moreover, the advances in silicon technology allow the design of low-cost electronics that operate at millimeter-wave frequencies. As a result, there is a need for low-cost antennas that exploit the bandwidth of about 5 GHz that is available and that can be connected with active electronics easily.

For a transmission of 2 gigabits per second in a bandwidth of 2 GHz, a signal to noise ratio (SNR) of 10 dB is required (for a bit error rate of 1E-6). In order to allow some margin for implementation losses, an antenna gain of 12 dBi is required on both the transmit and the recieve side (Table 1).

transmit power	12 dBm
antenna gain at transmitter	12 dBi
path gain (LOS) @ 10 meter	-88 dB
antenna gain at receiver	12 dBi
received power	**-52 dBm**
equivalent noise temperature	290 K
equivalent noise bandwidth	2 GHz
receiver noise figure	7 dB
receiver noise power	**-74 dBm**
obtained signal-to-noise ratio	22 dB
required signal-to-noise ratio*	10 dB
fading and implementation margin	**12 dB**

* for OFDM + QPSK + 3/4 conv. coding and BER of 1E-6

Table 1 - link budget example: 2 Gbps @ 10m

The antenna beam should be electronically steerable to be able to employ the antenna in changing environments. To fulfil these requirements, an antenna array configuration is proposed.

/ Antenna element

A novel design of a balanced-fed aperture-coupled patch antenna has been proposed as antenna element for the array. The antenna element can be realized in PCB technology. The geometry of the antenna is shown in Fig. 1. The balanced feed and the planar layout of the antenna allow for a suitable interconnection with a balanced amplifier. The aperture coupling avoids the need for vias and is used to increase the bandwidth.

In the design, the surface-wave excitation is minimized through the use of two distant coupling slots which cancel part of the surface-wave power, as proposed in [2] (Fig. 2). To improve the front-to-back ratio, a reflector element is introduced, following an idea presented in [3]. Both those design strategies are used together for the first time, to enhance the global efficiency of the antenna.

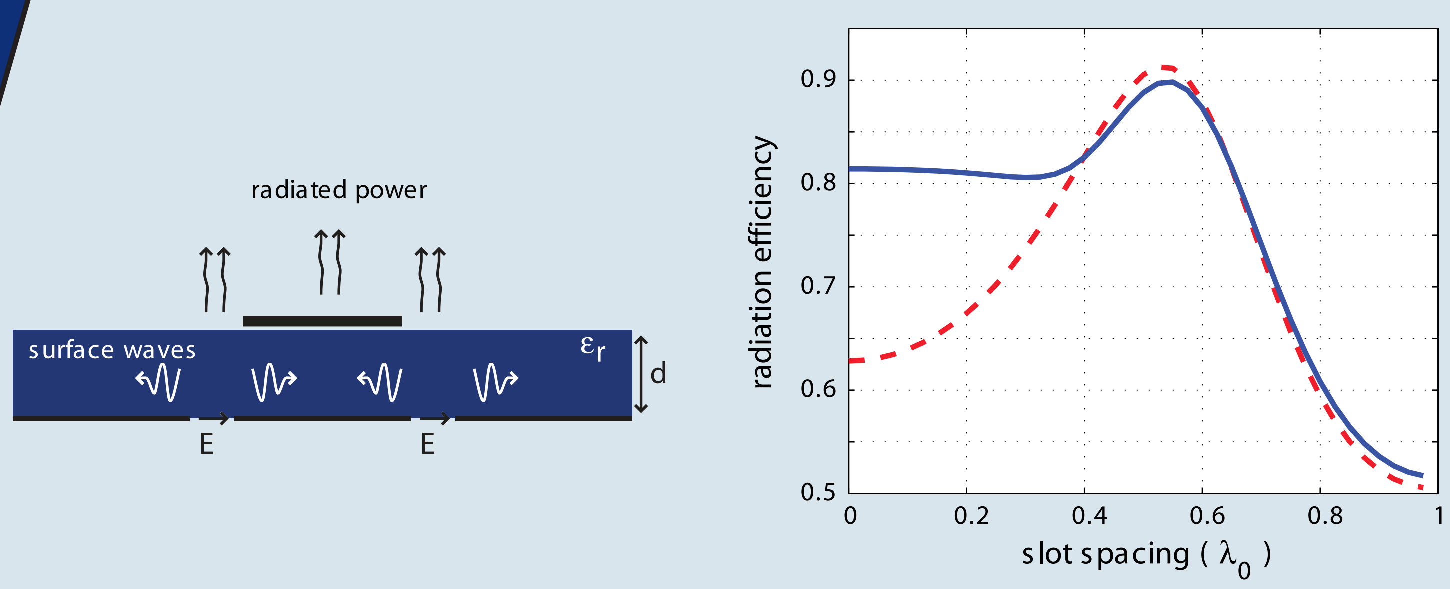


Fig. 2 - efficiency antenna as a function of slot spacing (slots + patch: solid, slots: dashed)

/ Antenna array

The antenna array that is proposed consists of 6 elements that are positioned in a circular configuration (Fig. 3). This provides sufficient gain and enables to scan the beam within a hemisphere.

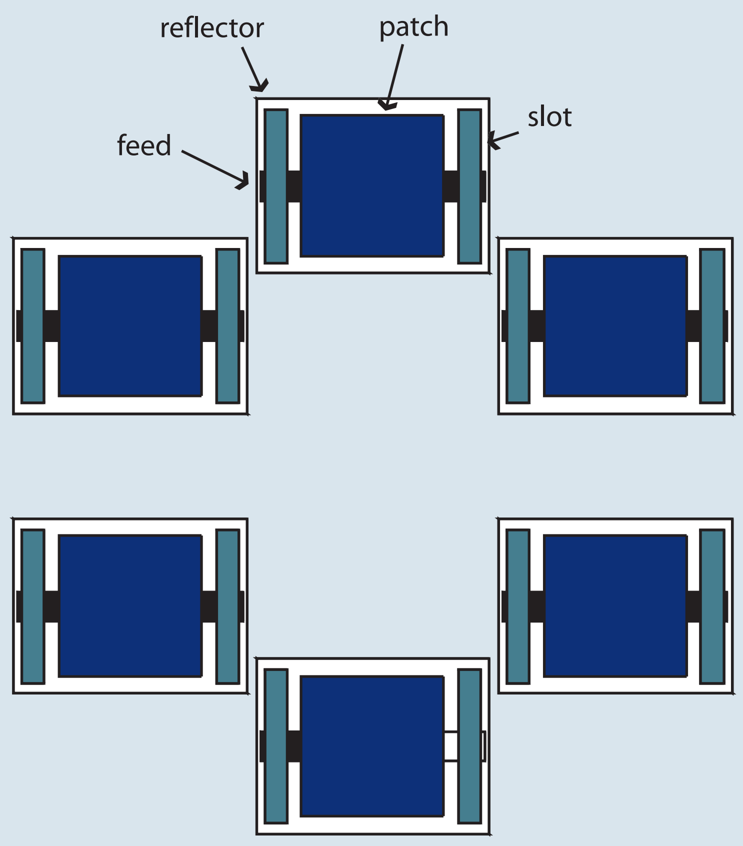


Fig. 3 - circular array configuration

The antenna elements are positioned such that the effect of mutual coupling between the elements is minimised. This results in a good scan performance (Fig. 4).

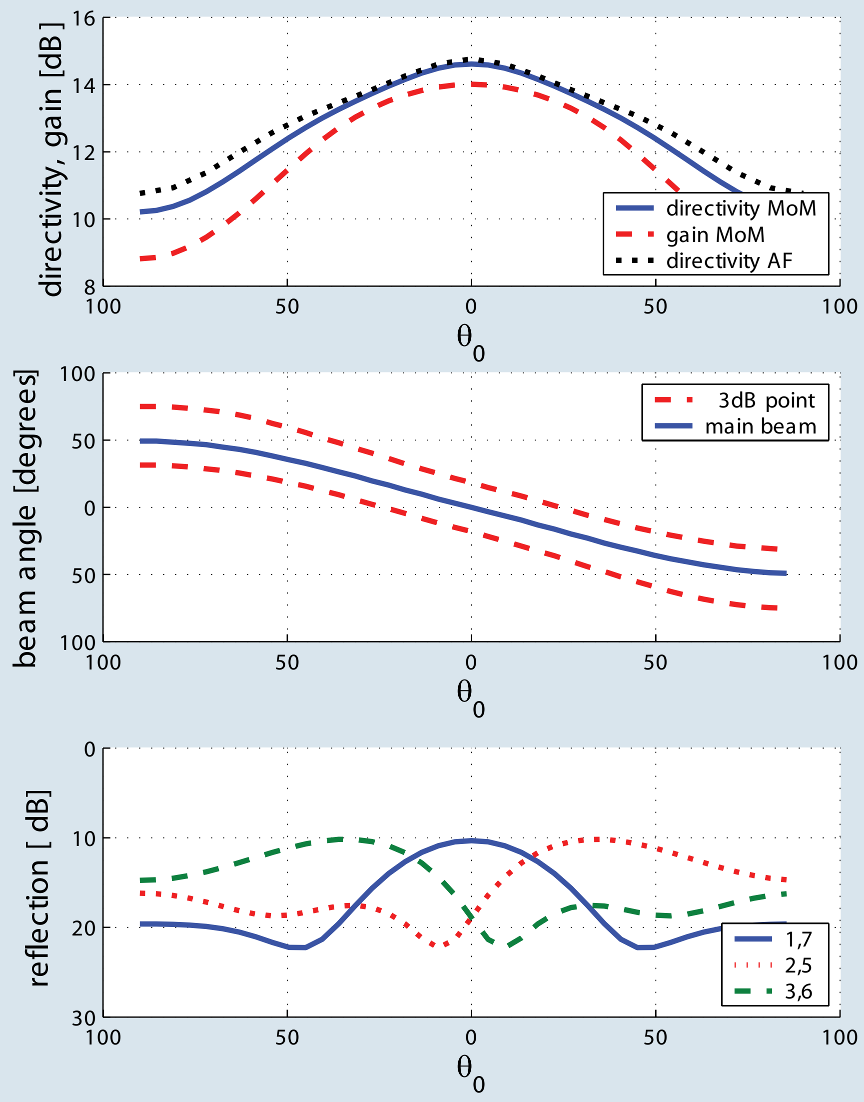


Fig. 4 -performance circular array for a scan in the E-plane

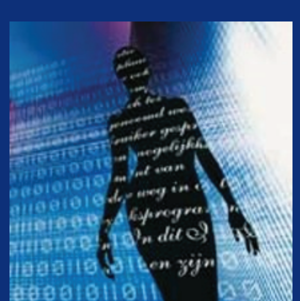
/ Conclusions

- A millimeter-wave antenna element has been designed that combines bandwidth and radiation efficiency. Moreover, it can be used in an array configuration.
- An array comfiguration has been proposed that allows beamforming within a hemisphere and that has sufficient gain for a reliable high-speed interconnection.

/ References

[1] G. V. Eleftheriades and M. Qiu, "Efficiency and gain of slot antennas and arrays on thick dielectric substrates for millimeter-wave applications: A unified approach," IEEE Trans. Ant. and Prop., vol. 50, pp. 1088–1098, August 2002.

[2] S. Targonski and R. Waterhouse, "Reflector elements for aperture and aperture-coupled microstrip antennas," in Antennas and Propagation Society International Symposium, vol. 3, pp. 1840–1843, IEEE, July 1997.



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