ACTIVE INTEGRATED FDF-ANTENNAS FOR MOBILE SATELLITE AND CELLULAR COMMUNICATIONS

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INTRODUCTION

Research and development of affordable low-cost electronically scanned antennas are currently of great importance since appearance of such antennas is expected by variety of rapidly developing mobile radiocommunication systems (GPS, DBS TV, ACTS, Globalstar, Iridium, Teledesic, Spaceway, Odysey, Cellular CDMA,).

Conventional phased array antennas made of discrete elements do not meet simple design and beam control requirements and can not be acceptable. Up-to-date microstrip-patch antennas are mainly synphase one (without electrical scanning) and in scanning options pin-diode phase-shifters involve complicated beam steering technique, significant switching noise and losses. These problems become especially difficult to overcome on mm-waves because of very small interelement dimensions. Thus new principles and design ideas have to be proposed.

ANTENNA DESIGN AND OPERATION

To improve the situation a new class of integrated microstrip patch active FDF-antennas (MP-FDF-antennas) with ferrite beam control have been developed. The antenna is a combination of FDF-structure and patch antenna aperture supplied by microwave amplifier elements and fed by microstrip power dividing network. FDF-structure integrates in one unit different electrodynamic functions - waveguiding, phase-shifting, microwave power distribution and electromagnetic coupling with microstrips. Passive radiating electrically controlled FDF-structures have been discussed in [1-3].

Two options of active MP-FDF antennas are presented.

First option design principle is demonstrated by 1D-scanning depicted in Fig.1. It consists of electrically controlled FDF-power dividing unit 1,2,3,4,8 with slot coupling elements 6, HEMT amplifiers 7 and radiating patches 9. FDF-structure contains two thin ferrite layers 1,2 with dielectric rod 3 and one common control winding 8 placed between ferrite layers. Coupling slot elements 6 are etched in metallization 5 of upper ferrite plate 1, the opposite side of FDF-structure is covered with the metal screen 4 to avoid radiation. The magnetization of ferrite plates leads to effective propagation constant variations of electromagnetic wave traveling along FDF-waveguide and thus to electrical scanning. FDF-waveguide has a significant value of electrically controlled phase shift and therefore provides wide angle sector of scanning at acceptable loss level.

In the second option a frequency conversion has been used. It contains additional frequency up-converters connected to amplifier outputs (not shown), second electrically controlled FDF-power dividing unit for heterodyne phase-shifting and 2-D scanning. In this type of antenna radiators operate at specified low frequency (e.g. 2GHz) but phase shifting and microwave power distribution is realized at a higher intermediate frequency (20-40

GHz) with the help of FDF-structure. Phase shifting is accomplished in intermediate signal circuit (1D-scanning by first current) and in heterodyne circuit (2D-scanning by second current). As a result completely integrated antenna design is obtained with very simple control (only 2 control currents providing 2D-scanning).

MP-FDF-antenna in Fig.1 is mostly intended for higher frequencies applications (Ku-V-bands), while second one - for lower frequencies (L -X-bands) to reduce FDF-waveguide sizes and weight.

The MP-FDF-antenna theory have been developed for calculation of antenna electrical parameters, FDF-structure optimization and microstrip-to-FDF coupling analysis.

Experiments have been arranged for Ku-band DBS TV 1D-scanning FDF-antenna which was used as scanning feed for cylinder parabola. It showed good agreement with theory and promising antenna electrical parameters: 35 dB-gain, ±40 deg. scanning range, 1.1 dB - noise figure.

Antennas have multilayer planar design and very simple control - 1D-scanning needs one control current, 2-D scanning - two control currents only.

Advanced technology - PCB(Printed Circuit Block), MMIC (Microwave MM-wave Monolithic Integrated Circuit) and SPS (Substrate Plasma Spraying) Technology - may be applied for MP-FDF-antenna fabrication.

CONCLUSION

The feasibility of new class of affordable low-profile, low-cost and simply controlled phased arrays has been proved. Experiment hardware parameters are in a good agreement with theory and promise wide spectrum commercial applications.

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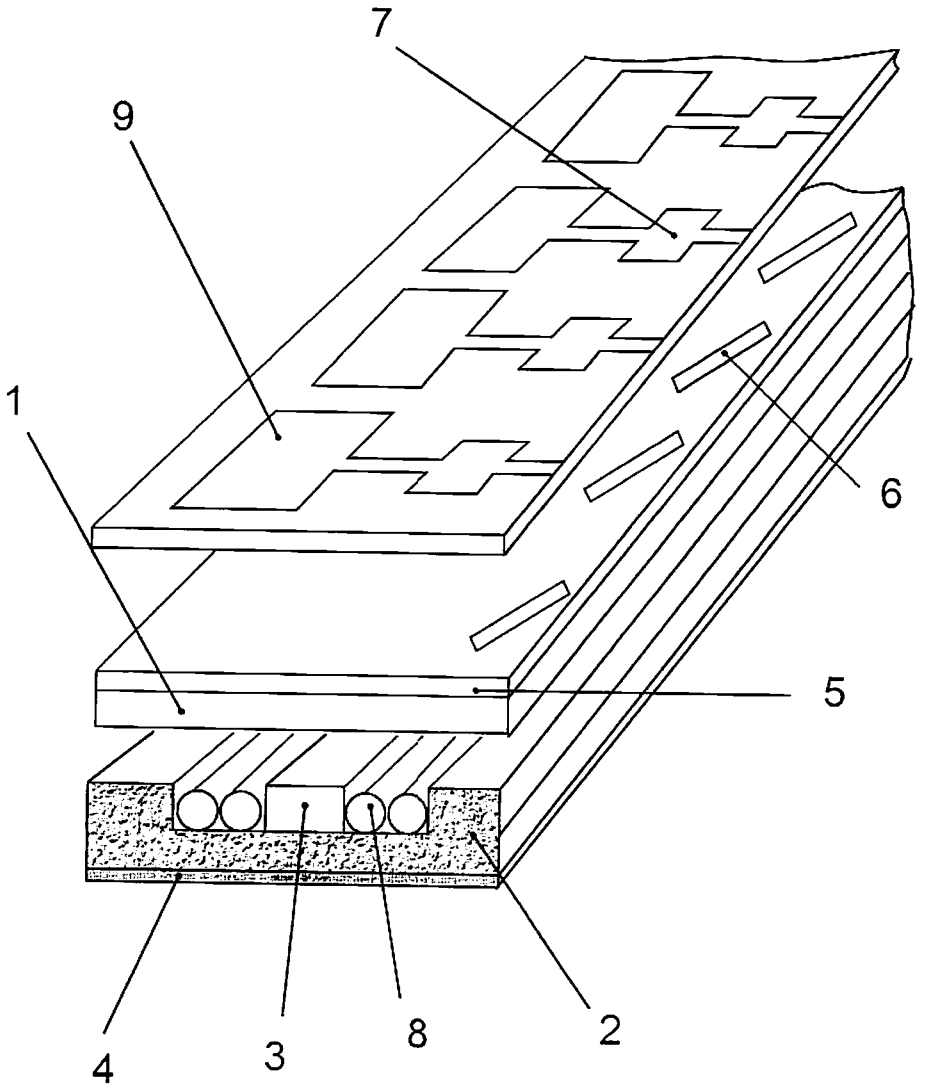

Fig.1

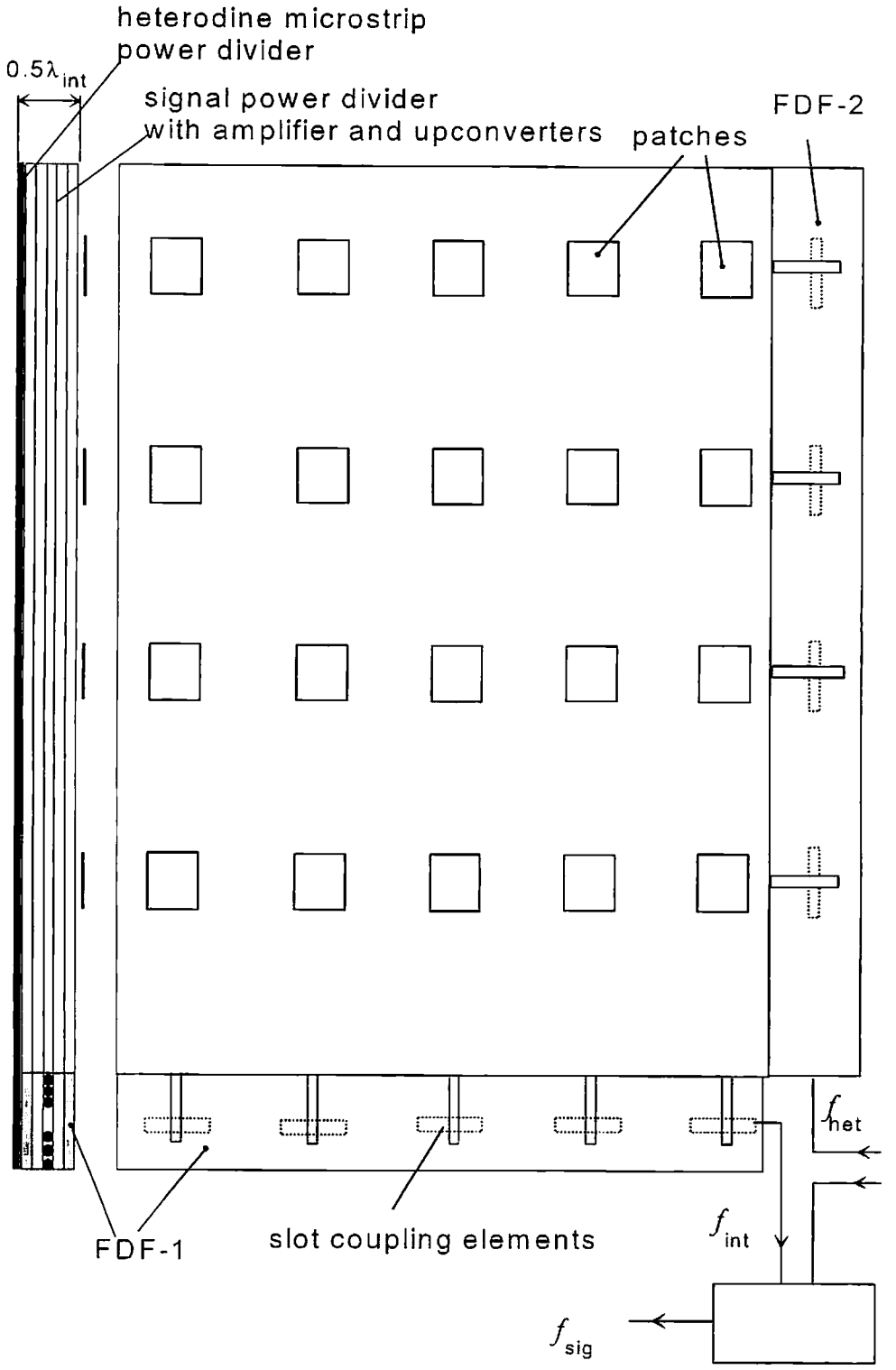
heterodine microstrip
power divider
0.5λ int
signal power divider
with amplifier and upconverters
patches
FDF-2
f het
f int
f sig
FDF-1
slot coupling elements

Fig.2