Geoda: Conformal Adaptive Antenna of Multiple Plannar Arrays for Satellite Communications

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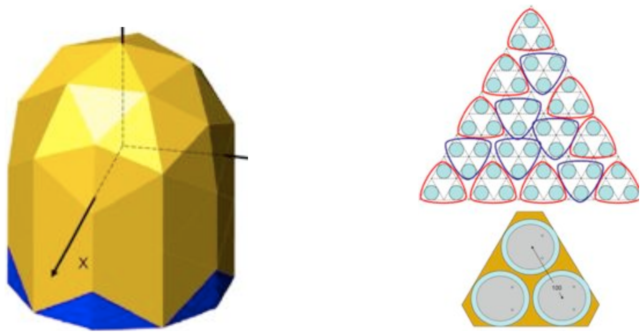
Introduction

This is a brief of the development of a new multiple-array antenna, working on the 1.7 GHz band. The main purpose of the project is to establish communications between a satellite constellation and the terrestrial station. Signals from the constellation will be followed by the antenna by means of an adaptive beam system.

The antenna has two different parts. The first one is based in a cylinder 1.5 meters height. The second one is a poliedric of thirty triangular-shaped faces based on a dodecahedron. Each face of a dodecahedron has pentagonal shape, but, in order to obtain triangular arrays, pentagons have been substituted by pyramids. According to that, every face of the Geoda is covered by similar triangular arrays of circular stacked patches. Arrays are composed by forty-five double stacked circular patches



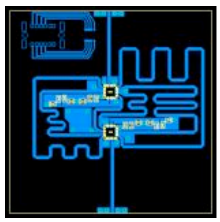
(a) Antenna structure (b) Cell distribution

Figure 1: General Structure of the antenna and the Array

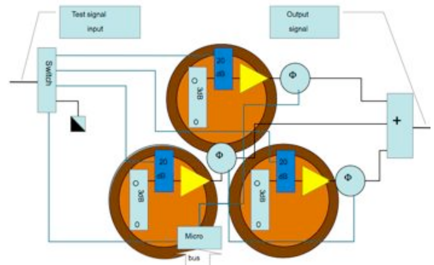
with their own RF circuit chain. The electronic subsystem and the radio-frequency circuits (consisting in a balanced branch – line circuit, low noise amplifiers and the phase shifters) are located under the radiating elements and under a ground plane made of aluminium. The ground plane separates the patches from the input signal circuits in order to obtain an isolation condition between the two parts of the structure. The elements of the array are grouped in three-elements subarrays called cells and will be presented as the elementary control units . In this document the active subarray, its phase control network, the electronic subsystem and its integration in a reduced space are shown and discussed.

Unitary cell composition

The single element of the cell is the double stacked patch, that has been shown in previous papers [1][2]. Each patch has its own hybrid coupler, test-signal extraction circuit, six steps phase shifter, and a low noise amplifier. A three way Willkinson combiner is used to sum the signals, and in its output the signal is amplified again. The high integration requirement is the main problem of this design, in addition to the RF circuits the electronic subsystem should be taken into account. The purpose of this integration is to obtain a modular design in order to manipulate and to control each cell separately. There are some changes in this version compared to the previous



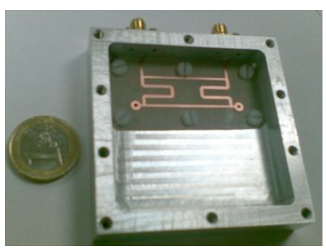
(a) Phase shifter



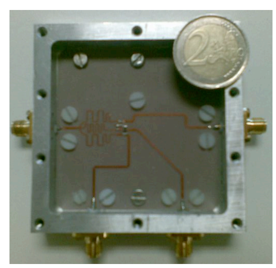
(b) Elemental cell

Figure 2: Basic scheme of the cell and phase shifter

one: the hybrid coupler is smaller since the new substrates is thiner; the patches have been re-dimensioned to adjust the center of the band; the phase shifter has been reduced due to the same reason and its meanders have been adapted to the unused space. The return losses of the two stacked patches are less than 25dB and the ports



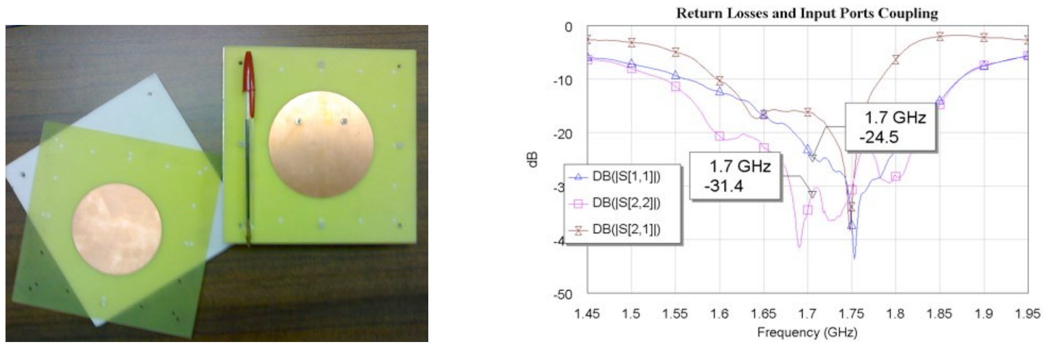
(a) Branch-line Circuit



(b) Output Isolation in output ports

Figure 3: RF Circuits

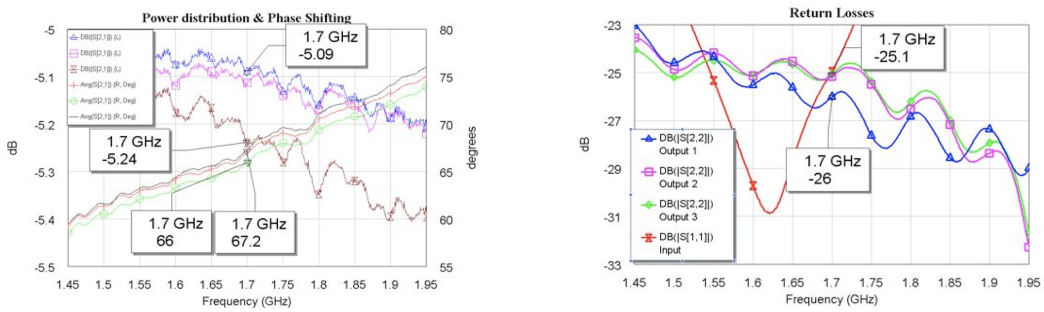
isolation is better than 20dB. In the other hand, the measurements of the hybrid coupler have revealed its nice behavior, since the outputs amplitudes difference is 0.4dB and the phase difference is ninety degrees at 1.7GHz. Similar to previous version, branch-line coupler and fed patch are connected by means of two vertical vias that cross the ground plane and all the dielectric layers. In this way, the circular polarization is achieved. The electrical capabilities of the assembly (balanced coupler - patches) are shown in fig.4(b). The test-signal extraction circuit consists in a 25dB coupler placed next to the hybrid system. The Willkinson circuit is designed in microstrip technology and the branches resistors are in star configuration. In this way, the power is equally divided from the main incoming power branch (fig. 5(a)). The received signal from each antenna is sent to the main brach, so antenna branches are isolated each other. Therefore, each cell has the output of RF signal and three testing outputs. In order to obtain the reception threshold the RF signals



(a) Single Element

(b) Return Losses and Polarization Isolation. (Port 1:LHCP Port2: RHCP)

Figure 4: Single element patches and return losses



(a) Willkinson Power Distribution

(b) Willkinson return losses

Figure 5: Willkinson circuit´s behaviour

are amplified by means of a LNA placed in the active branchline input. Then, the combined RF signal should be amplified due to the inherent power loss of the combiner circuit. So, the level of the RF signal composition is increased with a master LNA.

Electronic Subsystem: phase control and amplifiers managements

Every cell has its own electronic control subsystem which main tasks are the phase shifters management, calibration signals and LNA feeding currents control. A microprocessor is the responsible of the switching bits needed to select first the main signal or the test one, and then to select the required phase shifting. The selected switches are PE4260 Peregrine Semiconductor (1input - 6 outputs, 3 switching control bits) . The table 1 contents the needed bits for the system. There are fifteen

Required Bits

Input Signals (measure)	Output Signals (control)
3 bits for LNA input voltage measure	6 bits per phase shifter
3 bits for LNA input current measure	1 bit per LNA

Table 1: Needed Bits

cells per array panel and thirty panels per antenna subpart , so additional control levels are required. In this way, it is necessary to connect every cell microprocessor with the master microprocessor of the panel. Then, a main antenna processor will control all the array microprocessors by means of a PC. Some proposals have been studied and the standard bus I2C has been selected, since it allows a high level addressing capabilities. This standard is a serial bus that needs another cable, since data and clock are sent separately. It uses a 7-bit addressing system with 16 reserved addresses, what implies 112 nodes. It can work in four ways: low-speed mode, 10kbits/s; standard-mode, 100 kbits/s; fast-mode, 400kbits/s; high-speed mode, 3.7 Mbits/s. Normally, there is only one master processor in the bus but it is possible to find more than one in special configurations.

Algorithms

Simultaneously, some adaptive algorithms have been developed in order to adapt the radiation properties of the different arrays: *Spatial Reference Algorithms, Autocalibration Algorithms* and *Beam Former Algorithms*. More specific information about this development could be found in [3] .

Acknowledgment

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