Secondment Report Form

Secondee	
Host Organization	Id: TNO
	Name: The Netherlands Organization for the Applied Scientific Research
Research Topic(s)	Design of a Compact Planar Filtering Antenna including a Frequency Selective Common Mode Rejection Module

ACTIVITIES DURING THE SECONDMENT

The design of an X-band phased array filtenna was proposed in [1]: the radiating element, constituted by capacitively-coupled dipoles, realizes the first pole of a three-order Tchebychev filter. The antenna and the band-pass filter have been integrated in a single module, sufficiently compact to fit within the array unit cell, as shown in Figure 1. Such an array has been shown to maintain good matching (-10 dB) when scanning in the *H*-plane up to 45°. However, for *E*-plane scanning common-mode resonances were observed into the differential lines of the filter due to the unbalanced excitation of the dipoles. The effect of common-mode propagation is highlighted in Figure 2, which shows the active reflection coefficient for broadside and *E*-plane scan to 15°: a common-mode resonance is visible at about 8.8 GHz.

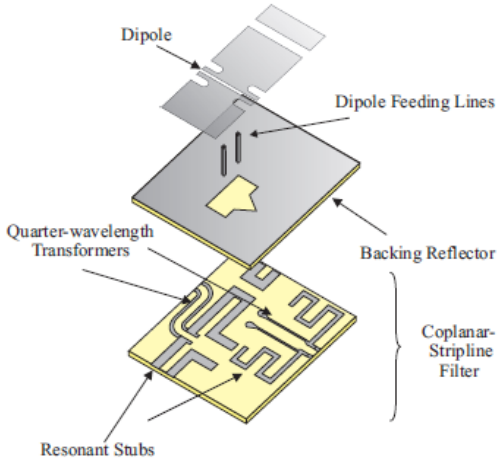

Figure 1 Exploded view of the array unit cell

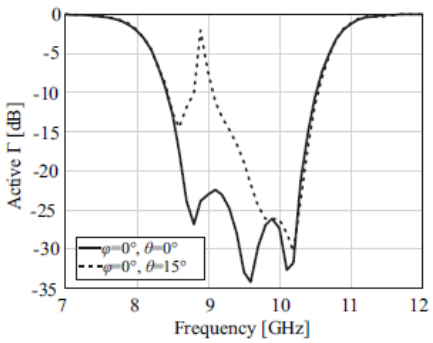

Figure 2 Filtenna active reflection coefficient for broadside and *E*-plane scan to 15°

The design of a planar X – Band hybrid ring (rat-race), with operational bandwidth spanning from 8.5 GHz to 10.5 GHz, has been previously proposed: operating as a combiner, the differential-mode signal (desired) is carried at the difference port, while common-mode signal (undesired) is absorbed at the sum port, closed on a matched load.

The hybrid-ring has been connected to the filtenna structure through a bi-wire line, as shown in Figure 3a. Electromagnetic simulations of the array unit cell performed by commercial tools assuming periodic boundary conditions, show that the output signal taken at the difference port is resonance-free also for E-plane scanning. Indeed, as a result of the combination of the hybrid-ring to the filtenna, the active reflection

coefficient does not show any resonance peak, as apparent from Figure 3b. As regards to the H-plane scanning, the structure is capable to reach 45°, as shown in Figure 3c.

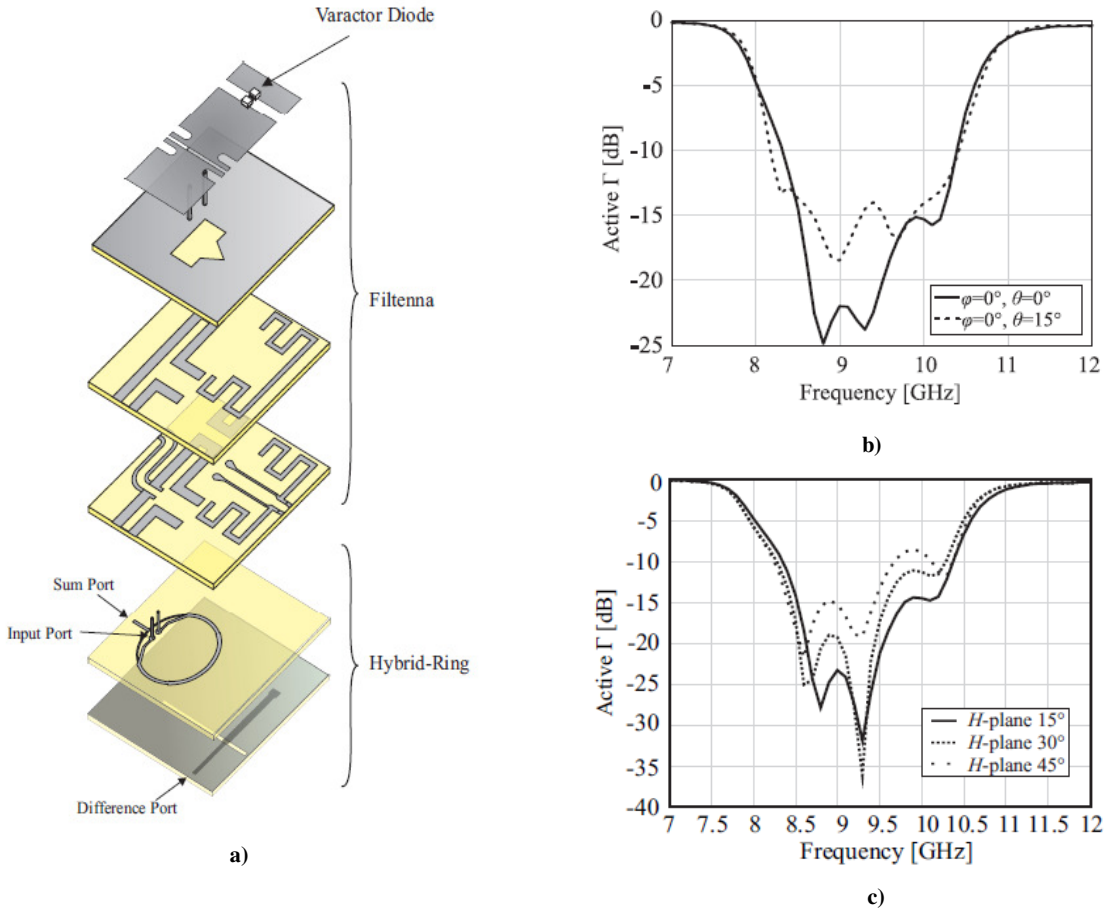

Figure 3. a) Exploded view of the array unit cell with the Hybrid-Ring connected to the filtenna structure. b) Active reflection coefficient of the combination of the filtenna module and rat-race for broadside and *E*-plane scan to 15°. c) Active reflection coefficient of the combination of the filtenna module and rat-race for *H*-plane scan up to 45°.

A more compact structure based on a novel design where part of the filtering is realized by the planar hybrid-ring has been developed.
The design of the phased-array filtenna has been based on the equivalent transmission line circuit of an ideal 3-pole Tchebyschev band-pass filter, shown in Figure 4.

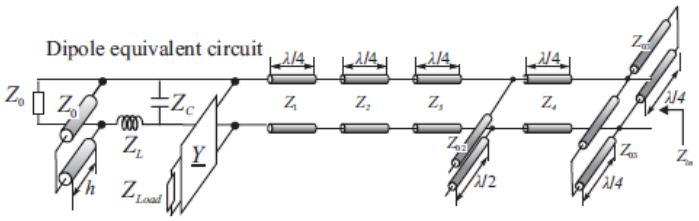

Figure 4 Transmission-line model of the implemented 3-pole Tchebyshev filter

The specific implementation of the model has been chosen in order to obtain a good matching level in the pass-band together with a close correspondence with the physical structure, depicted in Fig. 5a.
The first resonator of the filter is realized by the array radiating element, by properly tuning the equivalent circuit derived in [1]. The coupling between the first two resonators is realized by a three-section impedance transformer: the first quarter-wavelength transmission line is implemented partially by a bi-wire line (corresponding to the feeding line of the dipole) while the remaining part is realized in coplanar stripline; the second section of the transformer, realized in microstrip line, is connected to the input ports of the rat-race;

the third stage of the transformer is then obtained from the first quarter-wavelength transmission line of the rat-race, in the differential-mode branches. The second resonator is realized adding a microstrip half-wavelength open-circuit stub. This stub is inserted just before the second quarter-wavelength transmission line of the hybrid-ring, which is used to implement the second impedance inverter. Finally, the third resonator of the filter is then realized by a slotline etched in the ground-plane of the rat-race. The output of the overall structure is provided by a microstrip line placed beneath the ground-plane and coupled with the rat-race through the slot. While the differential branches of the hybrid-ring perform part of the filtering function, the common-mode, if excited, is absorbed at the H-port. This port is impedance matched with the input ports of the rat-race through a quarter-wavelength transmission line.

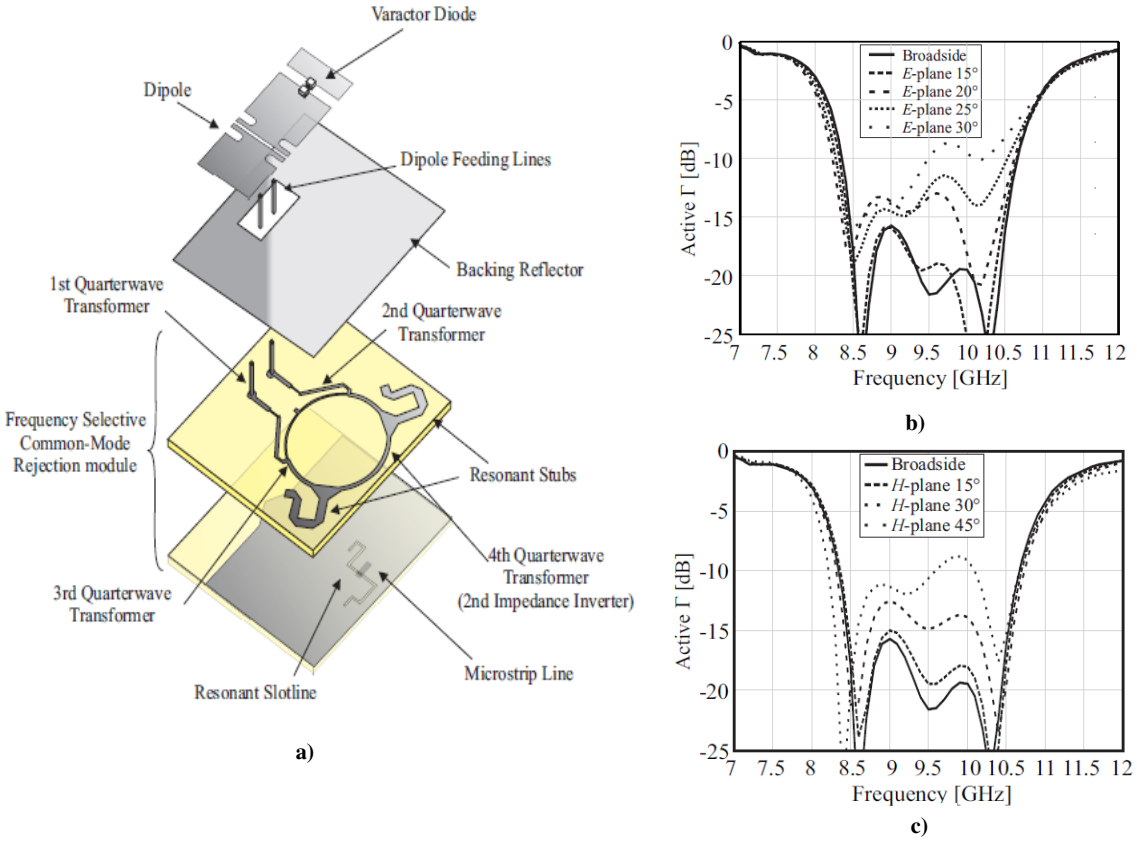

Figure 5. a) Exploded view of the entire filtenna structure. b) Active reflection coefficient of the filtenna structure for E-plane scan to 30°. c) Active reflection coefficient of the filtenna structure for H-plane scan to 45°.

Scanning performances for both main planes have been validated by electromagnetic simulations performed via the commercial tool Ansoft HFSS. As apparent from Figure 5b, the active reflection coefficient for *E*-plane scanning is resonance-free up to 30°. Active reflection coefficient curves for *H*-plane scanning are presented in Figure 5c: good matching levels can be achieved for scan up to 45°.

Being capable to obtain wide scanning angles mainly on one of the main planes, the present work is addressed to Synthetic Aperture Radar (SAR) applications based on purely planar printed technology. In addition to SAR, other applications can be envisaged: these includes radar with hybrid mechanical-electronical scanning, where the beam steering is performed electronically in one dimension, while mechanical motion is used for azimuthal scanning.

[1] D. Cavallo, S. Savoia, G. Gerini, A. Neto, and V. Galdi, *Design of a lowprofile printed array of loaded dipoles with inherent frequency selectivity properties*, 5th European Conf. Antennas and Propag., Rome, Italy, April 2011, pp. 807-811.

MAIN RESULTS OF THE STAY

1) L. Cifola, D. Cavallo, G. Gerini, S. Savoia, A. Morini, G. Venanzoni, *Common-Mode Rejection in a Connected Array of Dipoles with Inherent Frequency Selectivity Properties,* 6th European Conf. Antennas and Propag., Prague, Czech Republic, March 2012, accepted for publication
2) L. Cifola, D. Cavallo, G. Gerini, A. Morini, *Compact Design of a Planar Filtering Antenna Array including a Frequency Selective Common-Mode Rejection Module,* submitted to IEEE Antennas and Propag. Int. Symp., Chicago, IL, Jul. 2012.

Number of Publications: 2

Number of Documents/ Reports: _____

Number of Case Studies & Demonstrators: _____

Other(s):

(1)_____

(2)_____

(3)_____

* Attach all relevant documentation that specifies your results

FORECAST ACTIVITIES

Fixed-Term Employment Contract with TNO. The activity will be focused on the design of planar reconfigurable antennas.

In order to improve CARE's secondment program, please fill this short questionnaire. Use the space at the end to expand your answers, if needed. Our aim is to improve the general experience for secondees in future.

Disagree ⮜ ⮞ Agree

GENERAL				
My objectives were achieved.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
The research topics were relevant to my work.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I benefited from being part of a wider research culture.	**1** ☐	**2** ☐	**3** ☐	**4** ☒

HOST ORGANIZATION				
I am satisfied with the quality and quantity of supervision I received.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I had access to adequate resources to support my research.	**1** ☐	**2** ☐	**3** ☐	**4** ☒

SECONDMENT PROGRAM				
I would recommend this secondment programme to others.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I believe the skills I have learned will help me to improve my job/research.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
I would apply to another programme similar to CARE.	**1** ☐	**2** ☐	**3** ☐	**4** ☒
In general, how would you classify the CARE Secondment Programme?	**1** ☐	**2** ☐	**3** ☐	**4** ☒

Other questions/comments to be potentially considered: _____
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SIGNATURES

Candidate **Cifola Lorenzo** **Date**: 25/01/2012

Signature