Compact antennas for digital TV reception on mobile terminals

R. Gaffoglio[1], A. De Vita[2], B. Sacco[2], G. Giordanengo[1], M. Zucchi[3], G. Vecchi[3]

1. Advanced Computing and Applications, Fondazione LINKS, Torino, Italy
2. Centre for Research, Technology Innovation and Experimentation, RAI Radiotelevisione Italiana, Torino, Italy
3. Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy

INTRODUCTION: The only possibility found so far to design compact broadband antennas for digital TV reception on mobile terminals (3GPP, Rel. 14 [1]) relies on the excitation of the metal structure of the device (*chassis*). This is done by means of a Capacitive Coupling Element (CCE) able to efficiently excite the characteristic modes of the chassis [2]. Its resonance can be tuned across the entire digital terrestrial television (DTT) band with a proper matching circuit.

CCE ANALYSIS: The fundamental mode is excited by placing the CCE on the short edge (Fig. 1), while the second characteristic mode requires the CCE to be placed on the long edge (Fig. 2) [3].

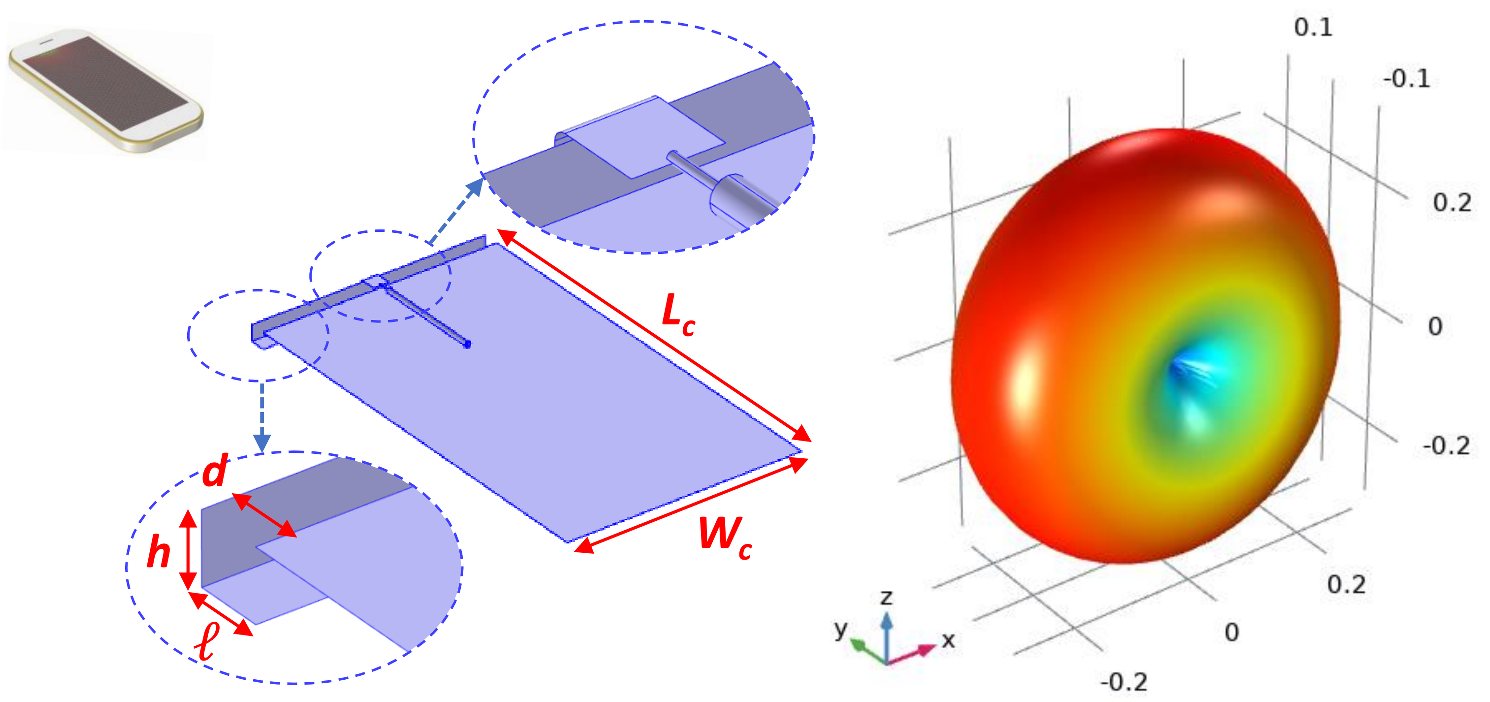

Figure 1. Coupling element-based antenna with the CE on the short edge (SE) with the Far-field norm pattern computed with COMSOL Multiphysics.

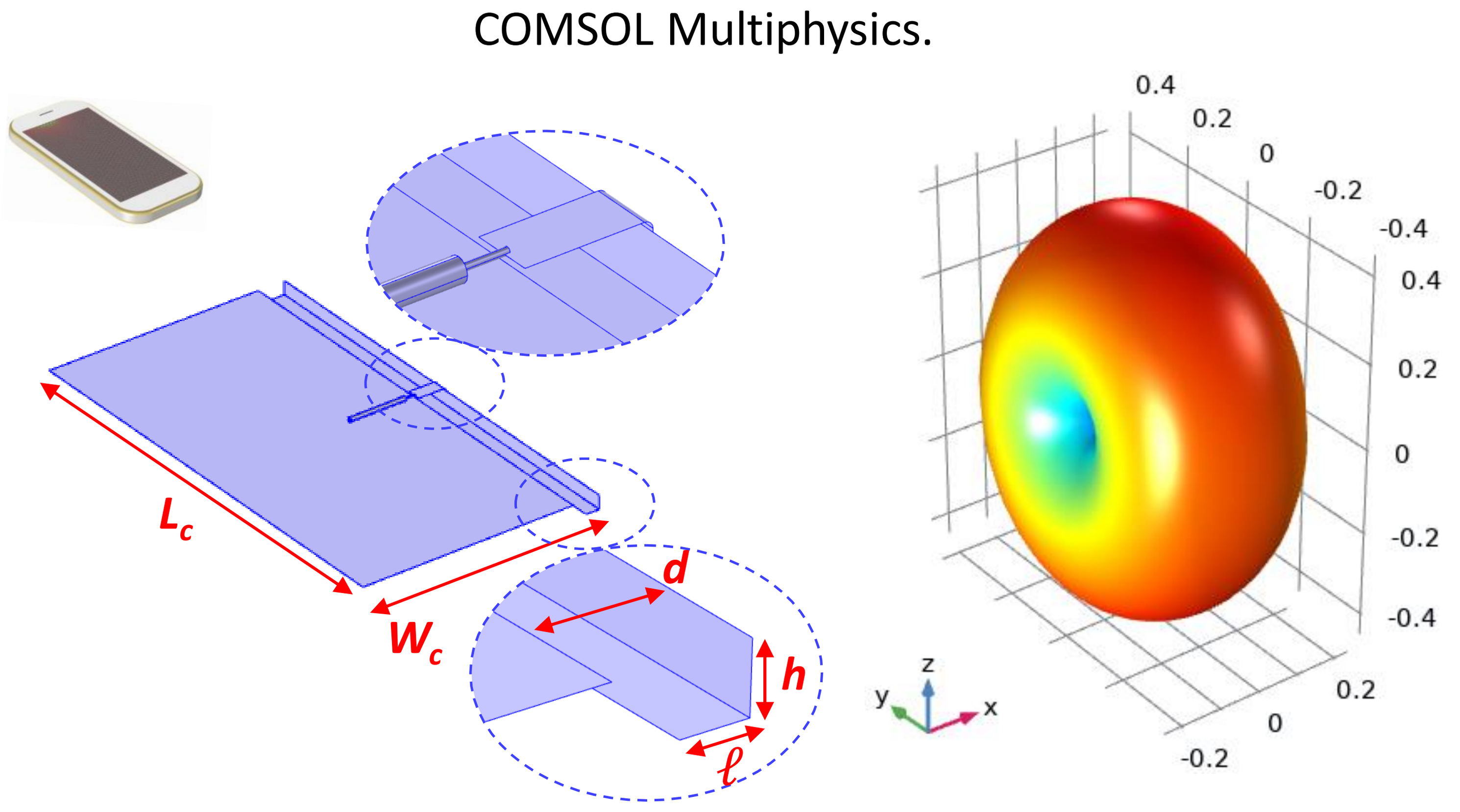

Figure 2. Coupling element-based antenna with the CE on the long edge (LE) with the Far-field norm pattern computed with COMSOL Multiphysics.

Both configurations were simulated in COMSOL Multiphysics. The chassis is simply modeled as an infinitely thin rectangular PEC layer, while the CCE is modeled as a folded PEC sheet with zero thickness.
The antenna is placed in a spherical air domain, surrounded by a PML layer.

CCE	L_C	W_C	h	d	ℓ
SE	135	75	5	5	5
LE	160	90	5	10	5

Table 1. Geometrical sizes in mm for the two configurations.

The total antenna efficiency and the directivity are obtained from the results of COMSOL simulations:

$$D(\theta,\phi,f) = \frac{G_{COMSOL}(\theta,\phi,f)}{\eta_{rad}(f)}$$

RESULTS: Both configurations were simulated, then prototyped and measured with a portable scanner. The input reflection coefficient (Fig. 3) and directivity (Fig. 4) are shown.

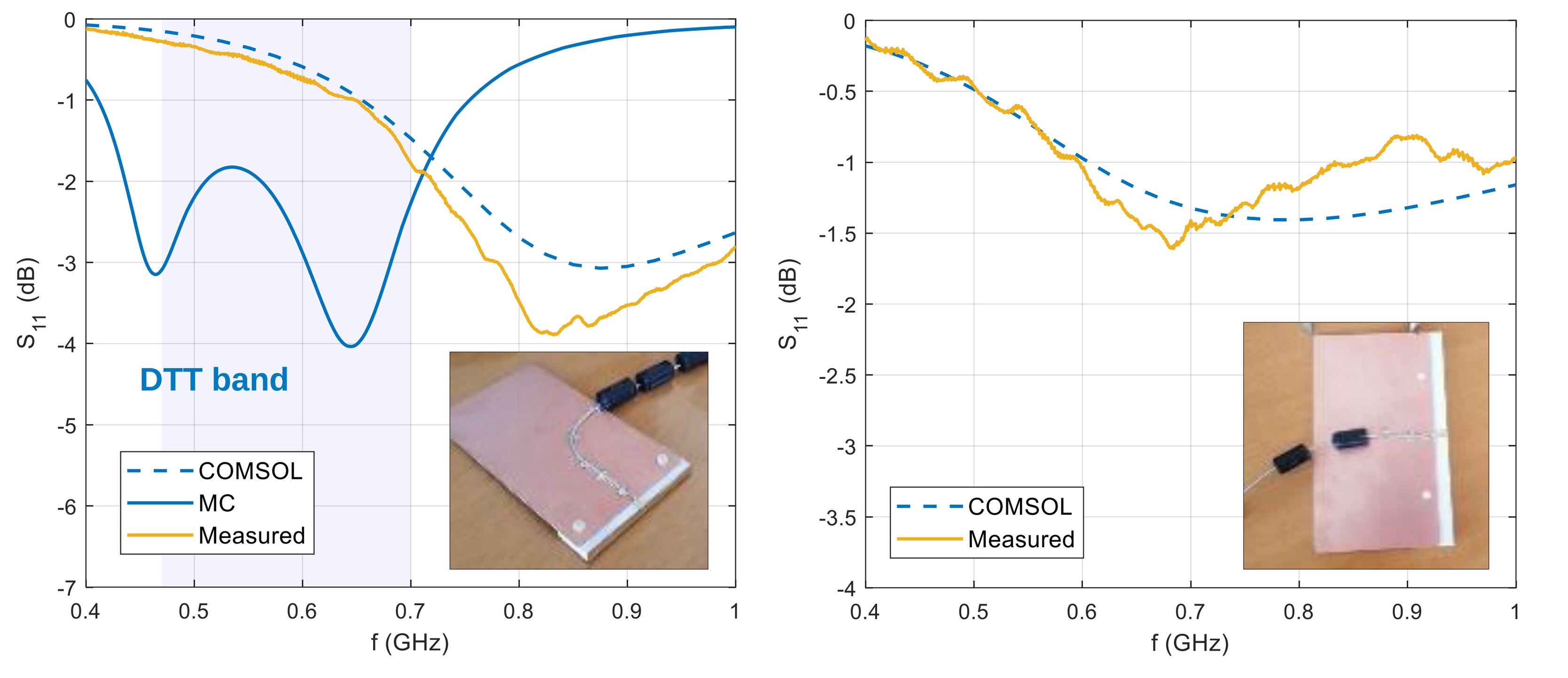

Figure 3. Input reflection coefficient for the SE (*left*) and LE (*right*) configurations. For the SE, it is also reported the resulting S11 after the introduction of a suitable matching circuit (MC), showing values lower than -1.5 dB (DVB-H specifications [4]) in the whole DTT band.

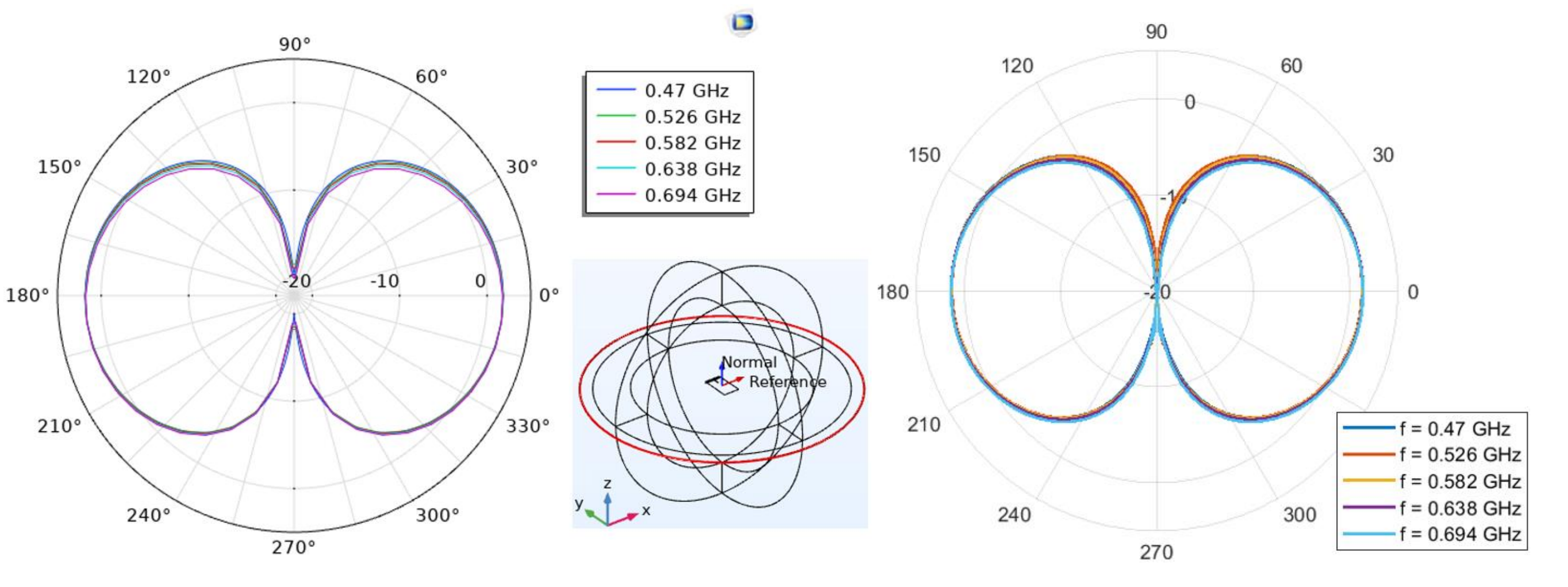

Figure 4. Directivity patterns on the *xy* plane for the SE configuration: evaluated with COMSOL Multiphysics (*left*) and measured with a compact bench-top electromagnetic scanner (EM-Scan RFX) (*right*).

f (MHz)	η_{rad} (-) (COMSOL)	D_{max} (dBi) (COMSOL)	D_{max} (dBi) (EM-Scan)
470	0.8969	1.96	2.23
526	0.9382	2.02	2.19
582	0.9586	2.10	2.21
638	0.9691	2.19	2.23
694	0.9747	2.29	2.29

Table 2. Radiation efficiency and maximum directivity for the SE configuration.

Figure 5. EM-Scan RFX compact scanner.

CONCLUSIONS: Two different configurations for the coupling element position were simulated, then prototyped and measured. The good agreement between simulations and measurements suggests how COMSOL can be used to study and optimize the geometry of the CCE element in order to maximize the excitation of the chassis eigen-currents.

REFERENCES:

1. 3rd Generation Partnership Project (Release 14), 3GPP TR 38.913 V0.4.0, 2016.
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3. R. Gaffoglio, M. Zucchi, G. Vecchi, and B. Sacco, "A Numerical Analysis of Compact/ Wideband Antenna Performance for DTT Reception on Mobile Terminals", *13th European Conference on Antennas and Propagation (EuCAP)*, 2019.
4. DVB-H Implementation Guidelines, ETSI TR 102 377, version 1.4.1, 2009.