# MICROSTRIP COMPOSITE ANTENNA FOR MULTIPLE COMMUNICATION PROTOCOLS

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**Abstract** The receiver antenna represents an important part of any communication system. The antenna dimensions are inversely proportional to frequency. As the frequency increases the optimal antenna becomes smaller. When multiple communication protocols spread over distinct frequency bands are considered, using a single antenna becomes a challenging task. In this paper we present a new miniature micro strip composite antenna that allows the reception of various signals in different frequency bands with a single antenna. The new antenna is constructed from a classic micro strip dipole structure with a similar shorted antenna, called a booster, placed in the near field. This technique is applicable to communication protocols at multiple frequencies. As an example we designed an antenna that supports Digital Video Broadcasting (DVB), UMTS cellular, and WLAN frequency band reception. In this paper we describe our design technique and present measured antenna performance.

## 1. INTRODUCTION

The trend in the wireless mobile industry is to aggregate multiple communication protocols in a single device. With new Digital Signal Processors (DSPs) capable of executing over 10 billion operations per second, it is now possible to run multiple communication protocols on the same platform [1] [4] . In Software Defined Radios (SDR) the same processor is able to run different baseband communication protocols by changing dynamically the software that executes on the processor. A significant challenge is the antenna and the Radio Frequency (RF) front end design. Each communication protocol typically requires a different antenna and a different RF front end. This results in cost and size constraints inhibiting miniaturization efforts.

In this paper we present a solution that adds additional low frequency bands to a previously published multi-band antenna designed for the GSM, UMTS-3G and WLAN [3] . Our present design incorporates a DVB band in the 100 to 1000MHz frequency band for the Sandbridge Technologies DVB solution [2]

## 2. RELATED WORK

The effort to miniaturize cell phone antennas and add more frequency bands to an existing antenna design is complex. As the dielectric constant increases the antenna will concentrate more energy resulting in less bandwidth and lower efficiency. To add more frequency bands meta materials are used on the ground plane in a periodic structure as reported in [5] or, a combination of composite magneto-dielectric substrate is used to increase the bandwidth and efficiency as described in [6] .

## 3. ANTENNA DESCRIPTION

For our composite antenna we added a shorted antenna as a single reflective layer that has been placed in the near field of an active antenna.

The antenna was developed to augment the UMTS and WLAN printed dipole antenna described in [3] The result is a multilayer composite antenna meant to add more received frequency bands, especially at low frequencies ( 100 to 1000 MHz) to cover analog and digital TV channels. Using this technique the overall antenna gain is also increased.

The shorted antenna acts as a selective reflector in the near field of the active antenna thereby producing a composite antenna design. This is based on the properties of the Electromagnetic wave (EM) reflection on objects in free space [7] . Specifically, consider a dimensionless object as an ideal antenna. The antenna is assumed to have a specific gain in a specific frequency band $\Delta f$. When the electromagnetic wave of frequency $f_0$, (where $f_0$ belongs to $\Delta f$) interacts with the ideal antenna the reflected EM wave will exhibit the following characteristics: [7]

1. Zero energy when the antenna is connected to an open circuit. If we place a voltage probe in the vicinity of the antenna the measured voltage will be zero i.e. $\Delta U_{open} = 0$ and, does not depend on the probe position.
2. Progressive wave when the antenna is connected to a matched load. The antenna reflects as much as it absorbs, the detected voltage will be $\Delta U_{prog} = U$.

In lossy environment U decreases as the distance to the antenna increases.

3. Standing wave if the antenna is connected to a short circuit. The antenna reflects as much as it absorbs but the maximum voltage detected by a probe will be $\Delta U_{stand}=U^2$. The voltage detected by a probe will be a squared sinusoidal function with the distance to the antenna (Umax= $U^2$ and Umin =0). The maximum value is attained at a distance of $\lambda/4$ from the antenna, where $\lambda$ is the mid-band frequency ($\Delta f$) wavelength and

$$\Delta U = U_{\text{with antenna}} - U_{\text{without antenna}}$$

In the previous equation, $\Delta U$ has the significance of the voltage detected by a probe in free space with and without an antenna.

The cross section of the proposed antenna structure is illustrated in Fig 1

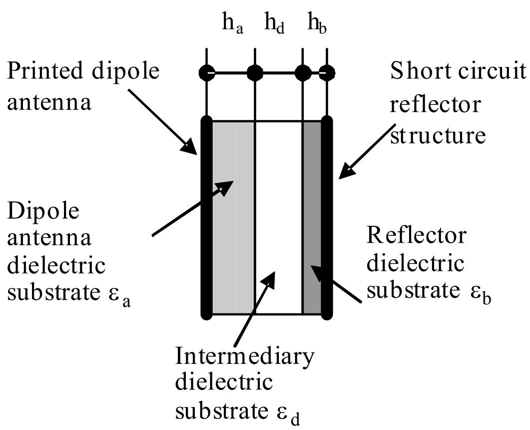


Fig 1. Antenna cross section

In our design, the dielectric substrate of the active dipole antenna has the same electrical proprieties as the one for the shorted antenna but the thickness will be different.

$$\epsilon_a = \epsilon_b \quad h_a < h_b \tag{1}$$

The intermediary dielectric substrate has the relative dielectric permittivity value $\epsilon_\delta$ between 1 and 2.5. The total height of the composite antenna must be less than the quarter wave length of the mid-lowest frequency band:

$$h_a + h_b + h_d < \lambda/4 \tag{2}$$

The active antenna printed dipole layout is depicted in Fig 2. The matching circuit, illustrated in Fig 3, from the line impedance $Z_0$ to the dipole impedance $Z_{dip}$ is placed in this layer. For convenience $C_1$ and $C_2$ are shown in Fig 4.

The shorted antenna has approximately the same geometric configuration as the active dipole, except that the excitation point is short circuited.

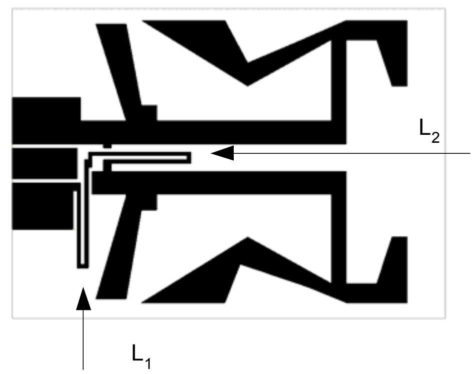


Fig 2. The layout of the active printed dipole.

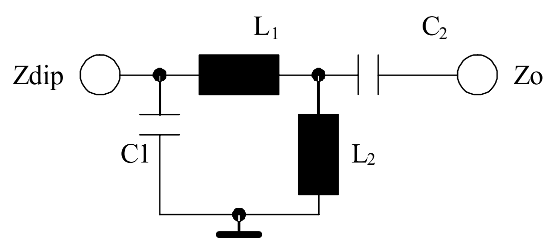


Fig 3. The antenna matching circuit

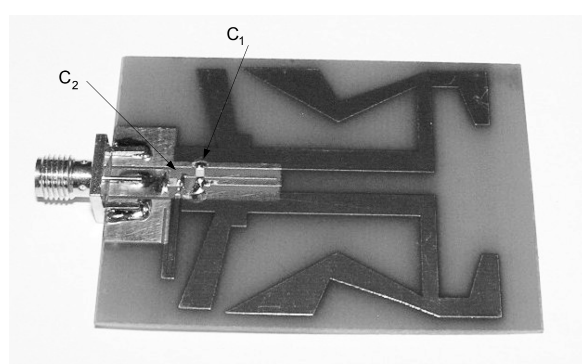


Fig 4. Active dipole picture

The shorted antenna is illustrated in Fig 5. It can be seen that the two halves are shorted at the point where the excitation should be. A 3D representation of the composite antenna is illustrated in Fig 6 while a picture of the back of the antenna is shown in Fig 7

The active antenna we described above represents the starting point for the entire structure.

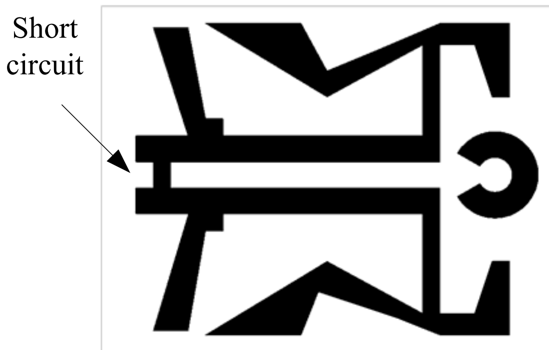


Fig 5. Reflective layer

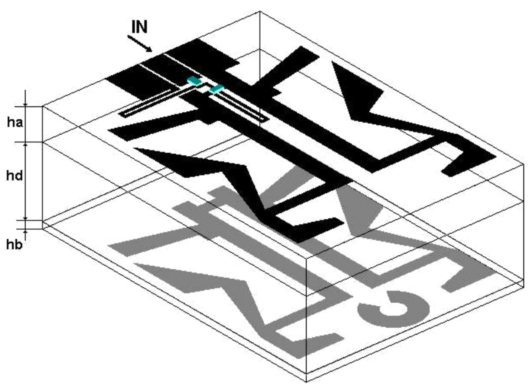


Fig 6. 3D representation of the composite antenna

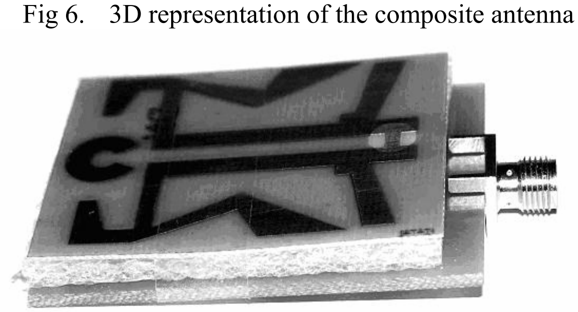

Fig 7. The back of the composite antenna

## 4. MEASUREMENTS

As a proof of concept we built and measured an antenna using the technique described above.

First we built and measured the active printed dipole. The $S_{11}$ parameter of the active dipole alone is illustrated in Fig 8. It can be seen that the antenna exhibits two frequency bands at 3 and close to 5 GHz.. As soon as we add the other layers required for the composite antenna, the results improved dramatically. Instead of having only two frequency bands, a variety of other bands appear centered at different frequencies. It can also be seen that the initial bands have moved from the initial position.

Combing the simulation and measurement techniques the additional bands can be tuned in such a way that they will be positioned at the desired frequencies for the specific communication systems.

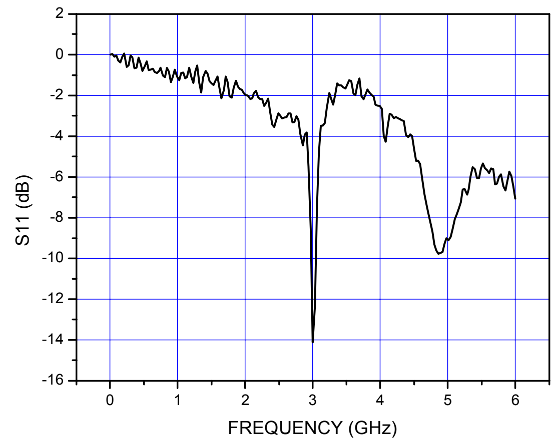


Fig 8. S11 for the active dipole

The composite antenna we designed has the following frequency bands at VSWR<2: 470-490 MHz, 1.16-1.175GHz, 2.1-2.6GHz, 3.64-3.7GHz and 4.78-4.91GHz. It also can be seen that there is a lower frequency band specific to the TV channels.

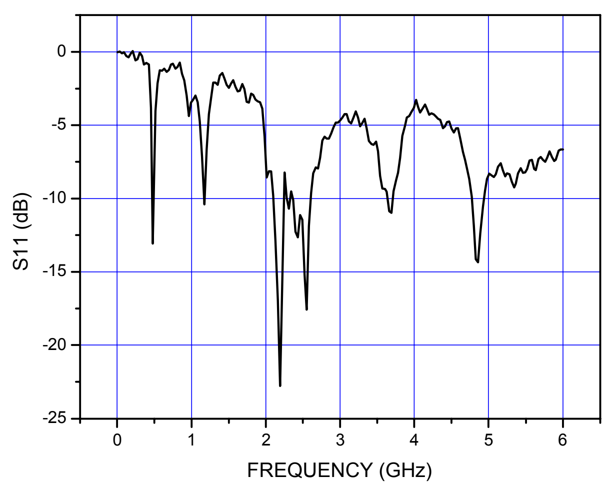


Fig 9. S11 for the composite antenna

## 5. CONCLUSIONS

We presented a new design method, to obtain a composite multi band antenna starting with a known printed dipole antenna. This method proves to be useful when there is a need to add more frequency bands to an exiting antenna. The method is inexpensive and can achieve the desired characteristics.

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