Wideband Active Small Antenna Design Using the Dummy Antenna For T-DMB System

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Introduction

The frequency band for T-DMB (terrestrial digital multimedia broadcasting) system in Korea is assigned to the VHF channel 7~13 (174MHz~216MHz) and channel 8 and channel 12 are used in Seoul. The length of the $\lambda/4$ monopole with an infinite ground is about 38*cm* to make a resonance at 200MHz. Generally, meander line, high dielectric constant material and parasitic elements have been used to reduce the large size of a T-DMB antenna. But, as the effective size of an antenna is reduced, the bandwidth is getting narrower. So, these passive small antennas can not cover the wideband of T-DMB.

In this work, the wideband active small antenna is proposed. We integrated the $\lambda/32$ (4.75*cm*) short monopole with LNA (low noise amplifier) for the mobile application. To obtain the wideband characteristic, we used the dummy antenna, which is the 2-port equivalent circuit of real antenna.

Design of the wideband active small antenna

Fig.1(a) shows the $\lambda/32$ short monopole antenna with the enough ground and the input impedance of the short monopole is given as[2]

$$Z_{in\_monopole} = 0.5\cdot\left(20(kl)^2 - j120(kl)^{-1}(\ln 2l/a - 1)\right) \quad (1)$$

where, $k = 2\pi/\lambda$, l is height of monopole and a is the radius of cylindrical monopole. From eq.(1), as the height of antenna is decreased, the real term, which is radiation resistance, is getting smaller, but the imaginary term is getting larger. If $l = 4.75cm$, and $a = 0.25cm$, the input impedance is $0.386 - j806\Omega$ at 200 MHz. Fig. 1(b) shows the equivalent circuit model, which explains the process of the voltage signal transmission of a short monopole. The short monopole can be modeled with R_{ant} and C_{ant} by eq.(1) and the load impedance is modeled with R_{load} and L_{load}, which is the input impedance of LNA. The received voltage signal V_{ant} in proportion to the effective length h_{eff} is transmitted from antenna to load.

$$V_{load} = V_{ant} \times \frac{(R_{load} + j\omega L_{load})}{(R_{ant} - j/\omega C_{ant}) + (R_{load} + j\omega L_{load})} \quad (2)$$

For the maximum V_{load}, the voltage of L_{load} should be determined to cancel out C_{ant}. It is the dominant factor of the impedance mismatching of the short monopole. For a LNA and a short monopole co-design optimally, 1-port antenna should be transformed into the 2-port network. Fig. 2 shows the geometry of the proposed antenna and the equivalent 2-port network (which is called by the *dummy antenna* in this paper). The measured input impedance of the proposed monopole is about $5 - j260\Omega$ at 200MHz. From eq.(1), the 1-port short monople can be changed to the equivalent C_1 and C_2 as shown in Fig 2(b). The values of C_1 and C_2 are determined so that Z_{ant_1} is equal to Z_{ant_2}. Fig. 3(a) shows the antenna-LNA co-design method using dummy antenna. Fig.3 (b) shows the simulated and measured S_{21} of the proposed antenna. In the band of T-DMB, the S_{21} of LNA with the dummy antenna is about -3~2dB. It is said that the gain of LNA is about 7~12dB, because the dummy antenna has about -10dB insertion loss considering the impedance transformation.

Experiment Results

Fig. 4 shows the implemented antenna and the radiation patterns at 180MHz and 210MHz, which are omni-directional. Fig. 5 shows the measured gain and output noise of the proposed active small antenna. The antenna gain of the proposed active small antenna is -4~3dBi in the T-DMB and it also has the notch characteristic in the FM radio band. The output noise of the proposed active small antenna is about -150dBm/Hz. Fig. 6 shows the received signal of T-DMB in suburban area of Daejeon. The measured background noise level is about -147dBm/Hz, which is upper than the output noise of the proposed active antenna. So, the output noise of the proposed active antenna is not affected with the SNR of the T-DMB system at suburban or urban area.

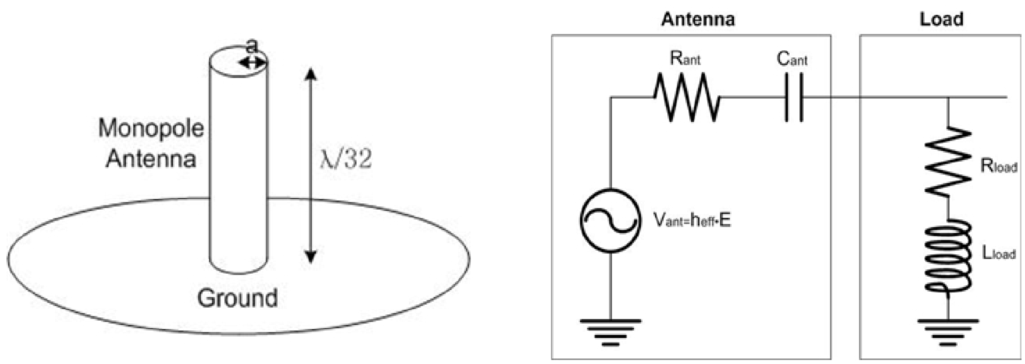
Conclusion

The $\lambda/32$ short monopole active antenna was designed using the dummy antenna in order to cover the wideband of T-DMB. The implemented antenna gain is about -4~3dBi and the noise output is about -150dBm/Hz and the pattern is omni-directional. The proposed active antenna was designed for the portable device. The receiving performance was verified by the field test in Seoul and Daejeon in Korea.

References:

[1] Andrey S. Andrenko, "Impedance matching in active integrated antenna receiver front end desing," *IEEE Microwave and Guided Wave Letters*, vol.10, no. 1, Jan. 2000.

[2] R.A.Burberry, "VHF and UHF Antennas", Peter Peregrinus Ltd. On behalf of the institution of Electrical Engeerers



(a) λ/32 Short Monopole Antenna

(b) Voltage Signal Transmission Modeling for Short Monopole Antenna

Fig. 1 The λ/32 short monopole and voltage transmission model

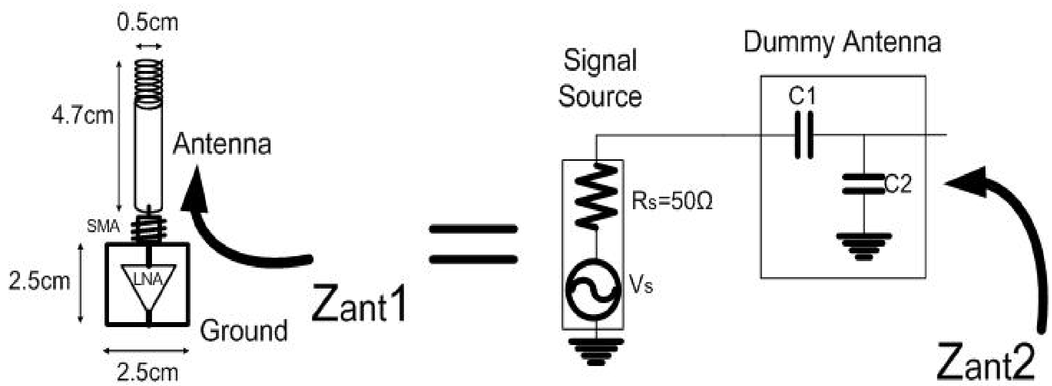
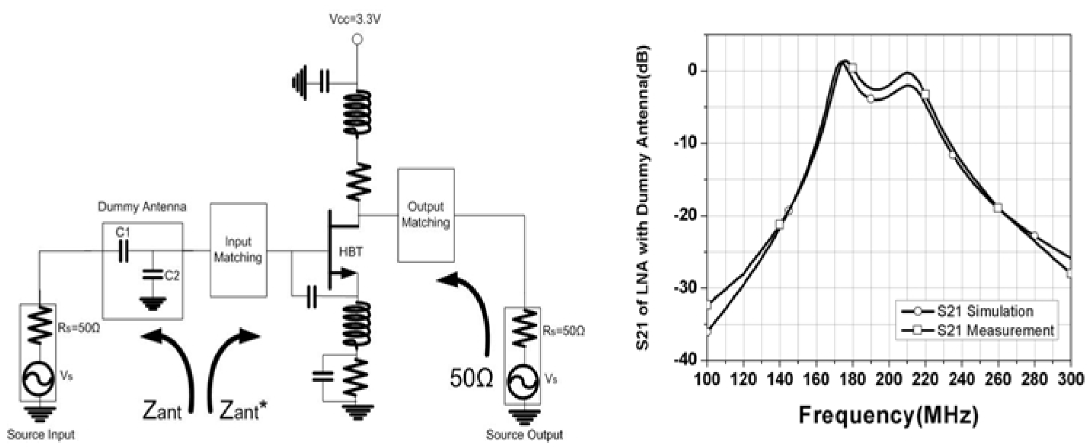


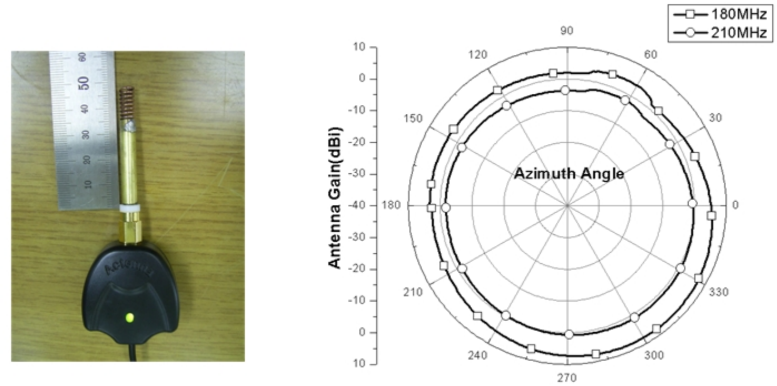
Fig. 2 Geometry of the proposed antenna and Equivalent 2-port network (dummy antenna)



(a) Block Diagram of LNA

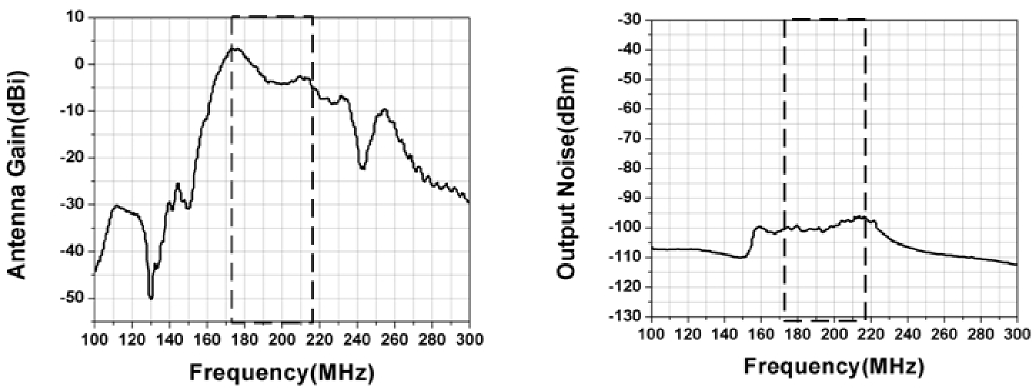
(b) S21 of LNA with Dummy Antenna

Fig. 3 2-port simulation (ADS) and measurement results using the dummy antenna



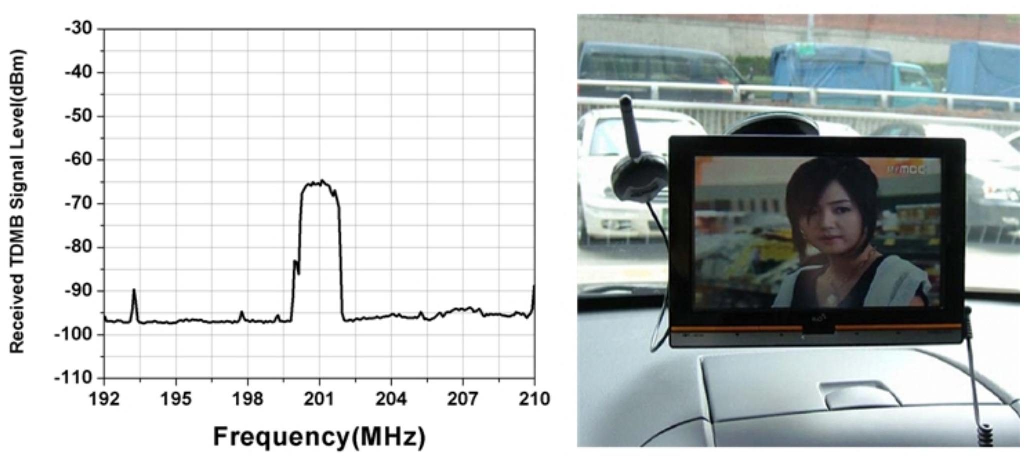
(a) Proposed Active Small Antenna (b) Radiation Pattern

Fig. 4 The proposed active small antenna and radiation pattern



(a) Antenna Gain (b) Output Noise in the Anechoic Chamber @ RBW100kHz

Fig. 5 Measured antenna gain and output noise power



(a) Received TDMB Signal and Noise Level Comparison in Deajeon (@ RBW 100kHz) (b) TDMB Screen Capture using Proposed Active Small Antenna

Fig. 6 Received TDMB signal and noise level in field test