

Design and Development of a Bluetooth-based Continuous Blood Pressure Monitoring Device

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Abstract— Our lab aims to develop a 24-hour monitoring cuff-less blood pressure device based on pulse transit time. The device communicates to a smartphone via Bluetooth to display and store BP values. The device will be fabricated on Kapton to make it flexible to wear and hence requires a flexible BT antenna. This paper is an introductory work in designing rectangular inset fed antenna. First, a PCB based antenna is simulated, built and tested using MATLAB's Antenna Toolbox and Network analyzer. Using similar equations simulation is performed for a Kapton based antenna as well. Future work involves fabrication and testing of Kapton based antenna and evaluation of body movements on the antenna characteristics.

Index Terms—Bluetooth, Patch Antenna, Network Analyzer

I. INTRODUCTION

High blood pressure (BP) or hypertension (HTN) is a common condition which can lead to serious cardiovascular complications if left uncontrolled. HTN is marked by increased pressure in the arteries that can lead to stress on the heart, also known as hypertensive heart disease. 67 Million American adults (31%) are affected by hypertension, 47% of whom maintain normal blood pressure control [1]. In this work, we propose a home monitoring cuff-less and hassle-free blood pressure wrist-based device that can analytically derive BP from ECG and wrist pulse or photoplethysmography (PPG) signals after a simple calibration step. The entire system uses Bluetooth for real-time wireless communication with a smartphone. A user can wear this device as a watch/wristband/armband (**Fig.1a**) and the signals are transmitted to a mobile device or computer, possibly connected to a cloud for further analyses and computing.

A 2.4Ghz antenna is required to transmit the signal. The paper models a PCB based inset fed rectangular patch antenna. This step is more of a learning step for the student to understand the mathematics, described in section II behind the antenna dimensions and to use network analyzer to estimate S11 parameter. The antenna is fabricated in house using double sided copper PCB board, laser cutter and etching. In the next iteration, Kapton based antenna's dimensions are estimated and an antenna modelled using MATLAB. The dimensions

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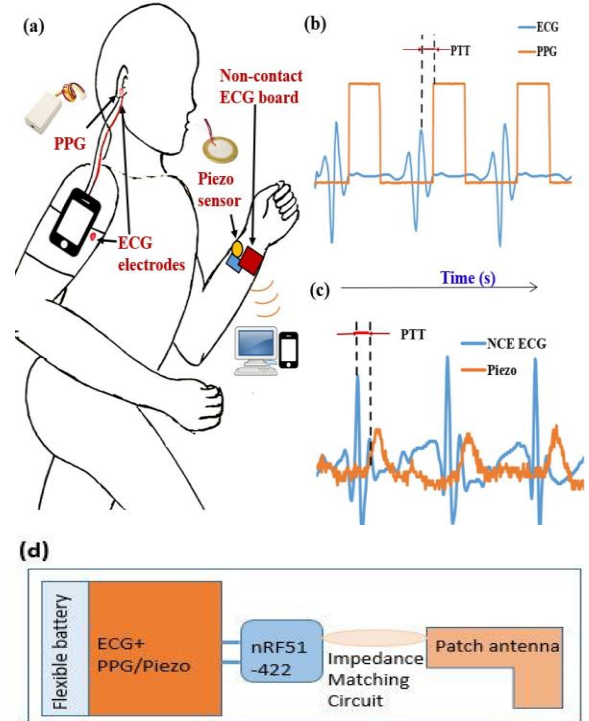


Fig. 1. (a) Conceptual designs of the two devices. (b) PTT from ECG and PPG. (c) PTT from NCE ECG and piezoelectric pressure sensor. (d) Kapton-based flexible device model with a patch antenna.

will be used to fabricate and test the flexible antenna by other undergraduate students in the lab.

II. MATHEMATICAL EQUATIONS

Following equations were used to calculate the length and width of antenna and ground plane where f_0 is frequency of operation, 2.4Ghz and ϵ_r is dielectric constant of antenna [2]. For PCB board, $\epsilon_r = 4.4$ and for Kapton, $\epsilon_r = 3.5$.

A. Width of the Antenna (W)

$$W = \frac{1}{2f_0\sqrt{(\mu_0\epsilon_0)}} \sqrt{\frac{2}{\epsilon_r + 1}}$$

B. Effective Dielectric (ϵ_{eff})

$$\epsilon_{\text{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \frac{1}{\sqrt{1 + \frac{12h}{W}}}$$

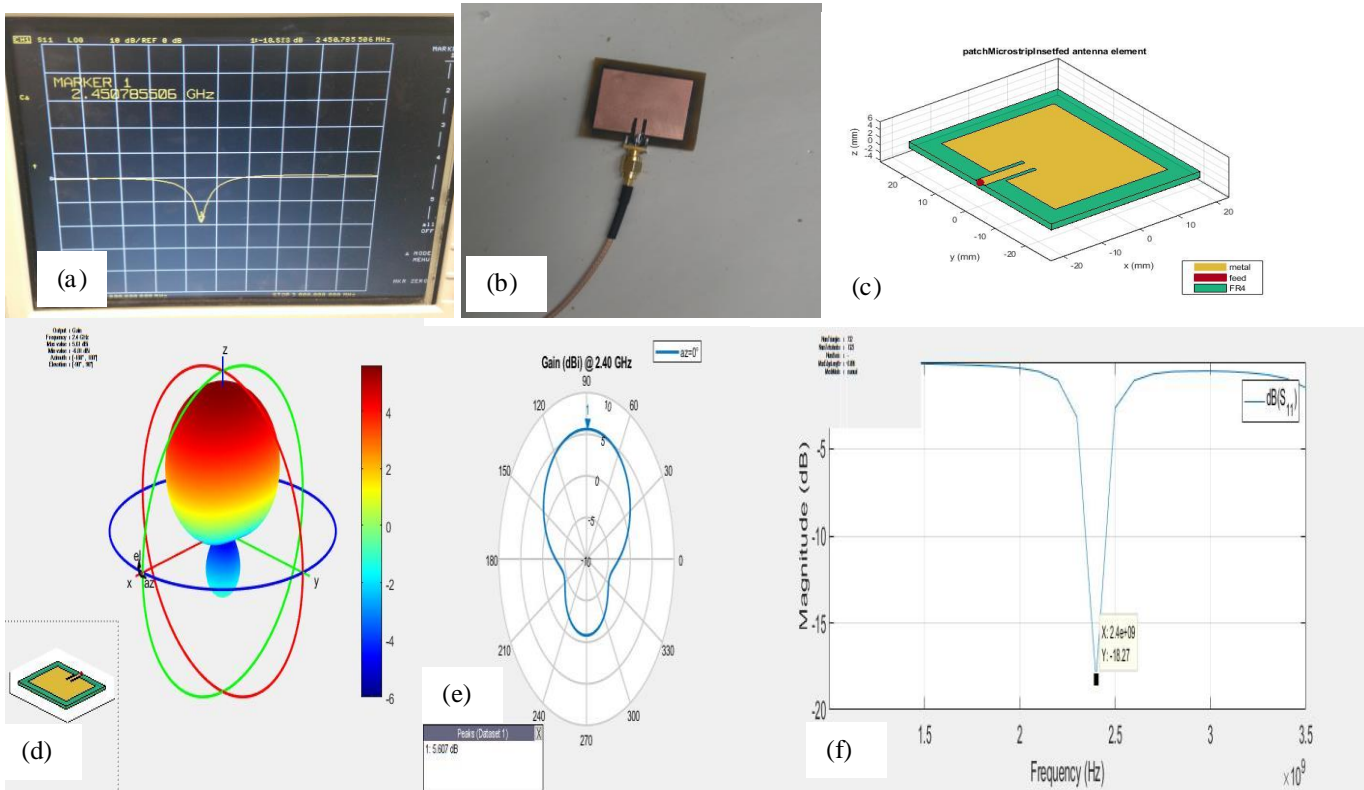


Fig 2. (a) S11 parameter using Network Analyzer, -16dB reflection coefficient is obtained at 2.45GHz. (b) PCB antenna (c) Simulation of PCB antenna using FR4 dielectric as 4.4 (d) Radiation pattern of simulated PCB antenna (e) Simulated S11 parameter. -18db at 2.4GHz.

C. Effective Length L_{eff}

$$L_{eff} = \frac{C}{2fr\sqrt{\epsilon_{eff}}}$$

D. Length Extension (ΔL)

$$\frac{\Delta L}{h} = \frac{0.412(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

E. Length of patch Antenna

$$L = L_{eff} - 2\Delta L$$

F. Ground Plane Dimension

i. Length of Ground plane

$$L_g = 6h + L$$

ii. Width of Ground plane

$$W_g = 6h + W$$

III. RESULT

Simulation and experimental result for PCB based antenna is summarized in Figure 2. For, the Kapton based antenna, S11 of -3dB could be obtained for a substrate thickness of 1mm. Since, Kapton is available in much thinner options, further simulations are required with better topology to get higher reflection coefficient.

IV. SCHOLARSHIP IMPACT

I am thankful to the MTT-S award committee for selecting me as one of the award recipients. This award motivated me to work in the RF field and study antenna theory. The travel award further helped me to learn the latest cutting-edge research in the field. Since, I am working in sensor field, I am sure the knowledge I gained will be helpful for my future research work. I am presently a first year Ph.D. student in Electrical Engineering Department at University of Washington, Seattle. My present work involves image processing and optical sensor system design. I aim to work in the research industry after finishing my degree.

V. ACKNOWLEDGEMENT

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