

# Circuit Modeling and Analysis of Cardiovascular System using Analog Circuit Analogy

Laty Shazana Ismail, Saiful A. Zulcifa, Nor Hisham Hamid  
 Department of Electrical and Electronics Engineering  
 Universiti Teknologi PETRONAS  
 32610 Seri Iskandar, Perak, Malaysia.

**Abstract**—Cardiovascular disease is one of major diseases that contribute to mortalities and morbidities in industrialized countries. Seeking an in-depth understanding of what happens in the human body involving cardiovascular disease leads to investigation of the system using cardiovascular model. The objective of this work is to develop and analyze a model of the human cardiovascular system capable of simulating normal cardiac operation based on circuit analogy. To simulate the entire cardiovascular system, the models are divided to into three sub-systems: pulmonary circuit, cardiac circuit (consisting of left and right heart circuits) and systemic circuit. Modeling hemodynamics of blood flow circulation uses an electric circuit analogy called the lumped parameter method. Parameters of the model have been extracted from existing literature. Based on a previous model, the present work analyzes pumping characteristics of the cardiovascular system with 1 and 3 AC sources. It also investigates contraction of arterial characteristics when added at the right and left atriums. Simulation results are found to be in good agreement with biological data.

**Keywords**—human cardiovascular system, cardiac output, circuit modeling, analog circuit analogy, lumped parameter.

## I. INTRODUCTION

To date, cardiovascular disease is considered one of the main diseases that contribute to mortalities and morbidities especially in industrial countries [1]. Cardiovascular system is also referred as circulatory systems. The function is delivering oxygen and nutrients to body cells. It also carries waste products to organs that are responsible to eliminate them. The cardiovascular system consists of the heart and blood vessels which are of two types: arteries which work to carry oxygenated blood from the heart to the rest of the human body, and veins which work to carry deoxygenated blood back to the heart.

The hemodynamics of cardiovascular flow can be divided into two models: cardiac model and blood vessel network. The latter can be further divided into pulmonary circuit and systemic circuit. The cardiac model includes the equivalent circuits of the atrium, and the left and right ventricles, which are responsible for pumping and contraction characteristics of the heart system [2]. The pulmonary model refers to the pulmonary circulation from heart to lung and back to the heart. The systemic model refers to the systemic circulation which starts from the heart with oxygenated blood, carried to the entire body and cells, and returns to the heart with deoxygenated blood [3]. This entire cycle of heart system is shown in Fig. 1.

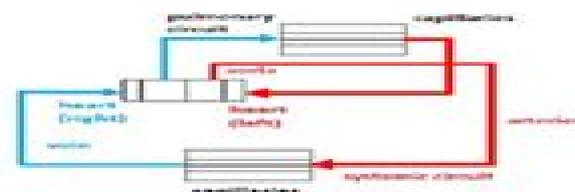


Figure 1. Cardiovascular system block diagram

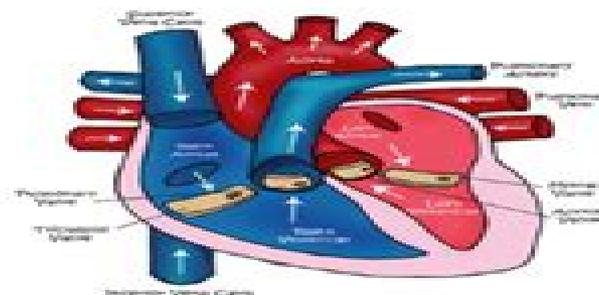


Figure 2. Biological heart circulation diagram (blue and red colors indicate deoxygenated and oxygenated blood respectively) [4]

In Fig. 2, it can be seen that the heart circulation cycle begins by collecting deoxygenated blood from the superior vena cava to the right atrium and into the right ventricle by passing through the pulmonary valve. Then blood is pump out from the right ventricle pumps through the tricuspid valve into the pulmonary artery which goes to the pulmonary circuit where the carbon dioxide is released from the blood. Fresh oxygen that is breathed in enters the blood from the pulmonary vein, into the left atrium and the left ventricle by passing through the mitral valve. Finally, the left ventricle pumps the blood to the aorta by passing through the aortic valve, delivering oxygenated blood to the entire body. This is the biological circulation structure of the heart system [5].

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