I. INTRODUCTION

1.1. Background

CVDs or Cardiovascular Diseases are one of the chronic diseases and one of the leading causes of death. According to WHO (2019), 17.9 million people died in 2019 due to CVDs which contributed to 32% of the global deaths. Around 37% of premature deaths under the age of 70 are also caused by CVDs. Therefore, it is very important to detect CVDs early, so that the counseling and medications can be initiated (WHO, 2019).

Heart failure (HF) is one of the CVDs, a condition when the heart is not able to pump enough blood to meet the body's needs. It is a global pandemic affecting at least 25 million people worldwide. HF is more detected in an aging population. Due to poor life quality, the mortality and morbidity of HF are still high despite the significant advances in therapies and prevention (Irina Alina & Mariana Carmen, 2018).

In Indonesia, heart failure (HF) has been a common health problem among people, with increasing incidence and prevalence (Rizki & Siswanto, 2014). There are many studies that state that there are HF patients that are not diagnosed or not treated accordingly (Rizki & Siswanto, 2014). Limited amount of facilities, whether to treat or diagnose patients have always been a problem for Indonesia (Rizki & Siswanto, 2014).

Electrocardiography (ECG) is still used as a tool for diagnosing any abnormalities in the cardiovascular system, more precisely in heart's activity (Saclova et al., 2022; Maršánová, Němcová, Smíšek, Vítek & Smital, 2019). ECG reflects electrical activity of the heart and provides information for cardiologists to evaluate heart functions (Saclova et al., 2022; Maršánová, Němcová, Smíšek, Vítek & Smital, 2019). ECG analysis can help in detecting abnormalities in HF, such arrhythmias, or even the long-term diagnostic tools for better treatment.

ECG record analysis is usually done by doctors, as technologies grow ECG records also have been evaluated by algorithms (Borodin et al., 2013; Saclova et al., 2022). However, none of these software or algorithms can evaluate a patient's heart functionality without being checked by the cardiologist, therefore algorithms and solutions are kept being developed, to be more accurate in processing and analyzing ECG records to replace ECG manual evaluation by the experts (Saclova et al., 2022; Maršánová, Němcová, Smíšek, Vítek & Smital, 2019).

Portable ECG has been used for health monitoring in non-clinical environments, it helps people in remote areas to continue monitoring their heart activity during their cardiac rehabilitation, and also in order to detect high risk situations. Using this portable ECG and arrhythmias algorithms detection, using wifi/internet, data will be continuously sent to the database, and do a real-time analysis with a certain delay (Lucani et al., 2022).

Fundamental parameters towards evaluating ECG signals are detection of P-, QRS- , and T- waves which are usually derived from Lead II (Saclova et al., 2022; Bae & Kwon, 2021). These 5 waves represent the order of activity that is happening when our hearts beat. Understanding and detecting these waves will be the main pillar and crucial for heart activity evaluation, including other abnormalities in the heart such as arrhythmia, hence good algorithm accuracy for detecting these waves is very important (Bae & Kwon, 2021; Maršánová, Němcová, Smíšek, Vítek & Smital, 2019).

Problems that can be included in the ECG records are noises and fluctuation that can come from contraction of muscle, power line interference, baseline drift because of respiration and motion artifacts. Hence filtering is needed to reduce noises (Bae & Kwon, 2021). Band pass filters usually are used which consist of low pass filter and high pass filter. High pass filters can reduce the high frequency noises, and low-pass filters can reduce the data fluctuations (Bae & Kwon, 2021).

P-wave represents atrial activity (atrial depolarization) which is the activation or starting point of heart's activity (Saclova et al., 2022). It is also associated with sinoatrial node (SAN) which produces the electrical activity automatically to initiate heartbeat, and atrioventricular node (AVN) which connects the impulse given by SAN from the atria to the ventricle (Heaton & Goyal, 2021; Choudhury, Boyett & Morris, 2015).

Unlike other waves, P-waves are considered as the most difficult to detect than other ECG components (Saclova et al., 2022). QRS detection, especially R-peaks, are preliminary steps to other algorithms, and will be used in other algorithms like rhythm, heartbeat, abnormalities, and even other wave detection. Hence the accuracy of QRS detection is also very important in ECG analysis (Bae & Kwon, 2021). There are many QRS detection solutions or algorithms that have been published , however for P- and T-waves studies or algorithms have not been studied as often as the QRS Complex (Bae & Kwon, 2021) .

P-waves are considered to be difficult to detect due to their low voltage, which results in low Signal-to-noise ratio (SNR), wide variability in range time, frequency, and morphology among patients (Saclova et al., 2022; Bae & Kwon, 2021; Maršánová, Němcová, Smíšek, Vítek & Smital, 2019). P waves also have been detected missing in several abnormalities, like tachycardia, Afib, AFlutter, P-waves can be

absent and also can be replaced by small repetition of waves called F-waves (Saclova et al., 2022; Bae & Kwon, 2021).

P-waves detection and information are very important to diagnose many types of arrhythmias (Saclova et al., 2022). P-waves positions can be used to diagnose AV block, also can be used for differentiation between supraventricular and ventricular tachycardias and also for identification of junctional and ventricular ectopic beat or rhythm, atrial fibrillation and flutter (Saclova et al., 2022).

P-wave morphology also can indicate several pathologies. For instance, atrial hypertrophy (atrial enlargement) is also possible to have connection with conductivity from AV node to atria (Saclova et al., 2022). Early detection of these abnormalities in P-waves morphology can give enough information for cardiologists to diagnose and treat the illness which results in decreasing the mortality risk of the patients (Saclova et al., 2022).

1.2. Research Objective

In this research, Methods for detecting and locating P-waves in physiological or normal conditions will be developed, which can act as a starting point for other algorithms. Proposed method consists of band-pass filtering and adaptive searching area for P wave detection and also additional rules that are added in case of pathological signals like Premature Ventricular Contraction (PVC) and Atrial Fibrillation (Afib). The objective of this research was to develop a high accuracy and reliable algorithm for detecting and marking P-waves and integrating it into the portable ECG prototype for real-time analysis.

1.3. Research Scopes

Algorithms are tested on 12 data from MIT-BIH arrhythmia database(MITDB) using the P waves annotations database, that is manually annotated by the experts (Saclova et al., 2022). Containing 3 types of pathological records, PVC, Second Degree AV block, A Fibrillation.

Algorithms are validated using the annotations that have been manually annotated by experts, from MITDB, R peaks detection performance will be tested prior to the P-waves detection performance.