Wearable Solutions For Improving Heart Health and Wellness

PPG vs. ECG-based Biosensors: The Pros and Cons

NeuroSky®

Body and Mind. Quantified.

Introduction

Recent advances in mobile, wireless, signal-processing, and semiconductor technologies are enabling the development of wearable devices that can capture, process, and analyze complex cardiovascular bio-signals in ways never before possible or practical. The biosensor chips that power such devices play a critical role in the mobile health (mHealth) and wellness revolution that is taking place today. By driving the creation of wearables with significant processing capability and complementary online tracking services, today's powerful biosensors provide deep insights into health and wellness, giving consumers innovative new ways to understand their personal wellbeing. And by extending the value of tracking services into large groups of users, they are creating profitable opportunities in the fast-growing market for B2C and B2B mHealth solutions.

This paper compares the principal technologies used to measure and analyze heart-health metrics: ECG-based vs. PPG-based biosensors. The two technologies differ in several ways, and each offers different potentialities for wearables that can provide insight into personal health and wellness.

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Key Metrics for Cardiovascular Health and Wellness

Heart Rate (HR) and Heart Rate Variability (HRV) are critical metrics reflecting a person's overall health. HR is a static measurement of beats-per-minute that varies by activity level. The baseline HR is the rate measured when a person is in a resting position. While having some merits, a resting heart rate itself is currently not considered a leading overall indicator of heart health.

In contrast, HRV is a measure of beat-to-beat variation over a period of time — e.g., the heart's ability to accelerate and decelerate quickly and efficiently to meet the body's immediate needs. While individual HRV readings can vary due to a variety of factors, a higher average HRV over time is generally seen as "more fit" than a lower average. It's also been widely demonstrated that routine aerobic exercise improves HRV over time. In addition to being a more insightful heart-health metric, HRV, in tandem with ECG-based technologies, can also be used to derive other important parameters like stress level, mood, fatigue, body recovery from overly strenuous exertion, and more.

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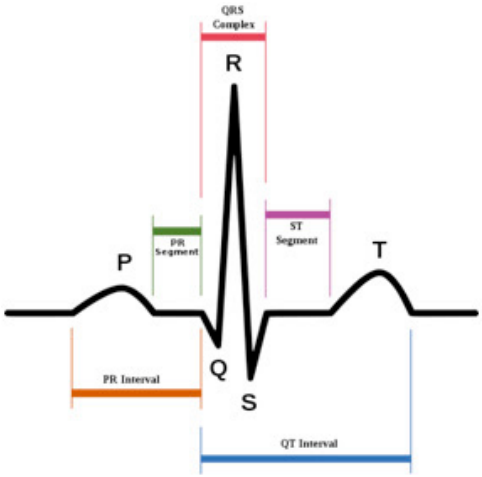
Two Primary Technologies for Measuring Heart Rate Metrics

1) ECG (electrocardiography) measures the bio-potential generated by electrical signals that control the expansion and contraction of heart chambers. Measurements can be taken via electrodes attached to the body or, in the case of today's ECG-based wearables, through electrical biosensors in devices often worn on the wrist.



Components of ECG Signal

The "R Peak" shown above in ECG waveform is used to mark the heartbeat. Because of its steep incline, algorithms that precisely extract the interval between successive R Peaks can be created. This is essential for calculating HRV accurately with shorter duration samples. Note that, since the ECG signal-frequency range overlaps with AC power-line frequencies, a main challenge for ECG-based solutions is being able to extract a clean electrical signal in the presence of noise. This is addressed by using a low-noise differential amplifier with high Common Mode Rejection, so only the differential ECG signal gets amplified.

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2) PPG (photoplethysmography) is a light-based technology that senses the rate of blood flow as controlled by the heart's pumping action. The volume of blood flowing in an artery increases at each heartbeat and decreases as blood flows back to the heart through the veins. PPG works on the principle that hemoglobin absorbs light both in transmission and in reflectance mode. Shining light on the skin and measuring the reflected light allows for gauging the change in blood flow in each cardiac cycle. The change in light absorption in turn generates the PPG waveform, and HR can be extracted by measuring the time interval between the waveform's successive peaks. However, the waveform's shape makes it difficult to precisely mark the peaks, which can lead to errors in HR calculation — especially with shorter duration samples. And, since HRV is based on the standard deviation of peak-to-peak intervals, uncertainty in locating the peaks with precision can introduce even more significant errors in HRV calculation.

The key challenges with PPG technology are cancelling the effects of ambient light, accommodating different skin conditions and colors, and dealing with physical motion artifacts. PPG should be used on parts of the body that have a high concentration of blood vessels; it can be difficult to get a good PPG signal from the wrist.

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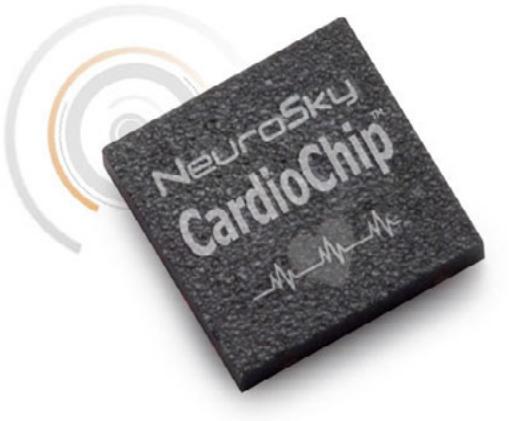
NeuroSky ECG-based Solution

NeuroSky BMD101 is a single-chip, integrated electrical biosensor specifically developed for wearable and mobile devices. The ECG-based solution includes an advanced Analog Front End for acquiring ECG signals using dry contact electrodes from the fingers and/or wrist and also includes a Digital Signal Processing capability providing noise filtering and signal conditioning as well as UART for serial interface to other devices.

By integrating all the functional blocks required for ECG signal processing as well as a voltage regulator and RC oscillator on a single chip, the BMD101 eliminates the need for other external devices and components, making it ideal for small footprint wearable devices.

The Age of Advanced Biometrics Is Here



Until recently, ECG-based electrical biosensors like the NeuroSky BMD101 were found only in expensive, high-end medical equipment. Now they have become practical for use in consumer wearable and mobile device applications and, along with biometric algorithms, can enable a variety of easy-to-understand health and wellness metrics. Today's electrical biosensors deliver compelling solutions that provide consumers with more insights into their personal wellbeing — without venturing into regulated medical uses that high-volume consumer solution providers typically seek to avoid.

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In contrast to PPG, ECG biosensors provide solutions capable of delivering the widest range of health metrics. That's because ECG-based solutions capture more comprehensive signals of overall heart performance. This enables a more accurate tracking of heart rate variability, which in turn allows for the extrapolation of validated, personalized heart-health trends.

Wearable devices are playing an increasingly important role in collecting personal wellness data. The ability to acquire ECG data by means of wearable devices along with applications running on smartphones and tablets have enabled the monitoring of heart rate metrics that correlate very well with overall health trends and provide actionable information to users. NeuroSky BMD101 provides a low-power small footprint ECG-based solution that can be very easily deployed by wearable health and wellness device makers.

About NeuroSky: Body and Mind. Quantified.

NeuroSky biosensors, biometric algorithms, and consulting services deliver intelligence and innovation to enable breakthrough wearable technologies. Our full solution technology platform enables device manufacturers and enterprise service providers to create best-of-breed solutions that can capture, monitor, quantify, and optimize personal physical and mental performance with detailed metrics for body and mind. **To learn more visit neurosky.com**.

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