IDEC Chip Design Contest

MS180-1805

A Low-Complexity Heartbeat Indicator using R-R Interval for Wearable ECG Devices

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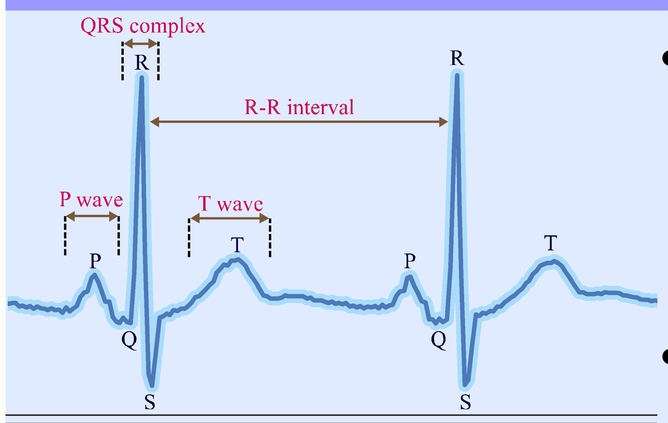
MOTIVATIONS:

- **C**ardiac arrhythmia can cause sudden cardiac death and a wearable ECG device that provides a warning about the cardiac status can aid the user to get the timely treatment.
- **I**n this work, we designed a low-complexity R-R interval (RRI) based heartbeat indicator to detect the cardiac arrhythmia. The database of the ECG signal recording taken from MIT/BIHT dataset is used to evaluate the proposed design.

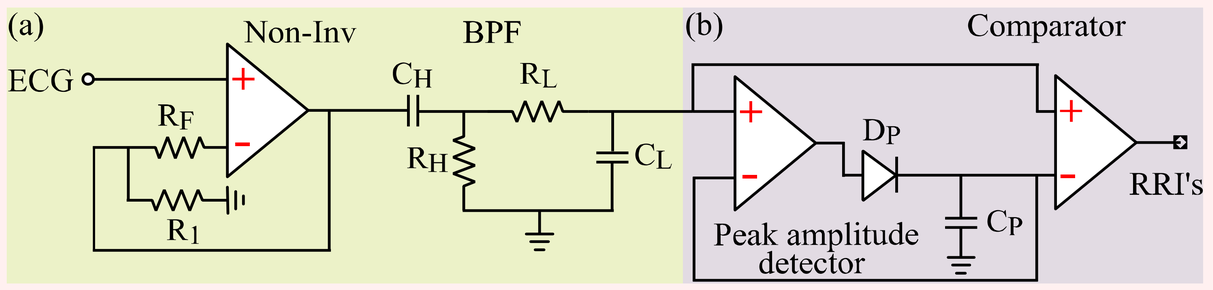
Components of ECG Wave



Component	Amplitude (mV)	Duration (ms)
P wave	0.1-0.2	60-80
QRS complex	1	80-120
T wave	0.1-0.3	120-160

- The components of ECG has the key features to find the heart rate (HR) and to analyze the cardiac condition of a person.
- Therefore, a large amount of research is focused on extracting the features from the components of ECG.
- The typical ECG will have components of P, QRS complex, and T.
- Under normal conditions, all the components of an ECG signal will have amplitudes and durations in the ranges as shown above.
- Amongst all the components of the ECG, features from the QRS complex are best suited to find the heart rate.

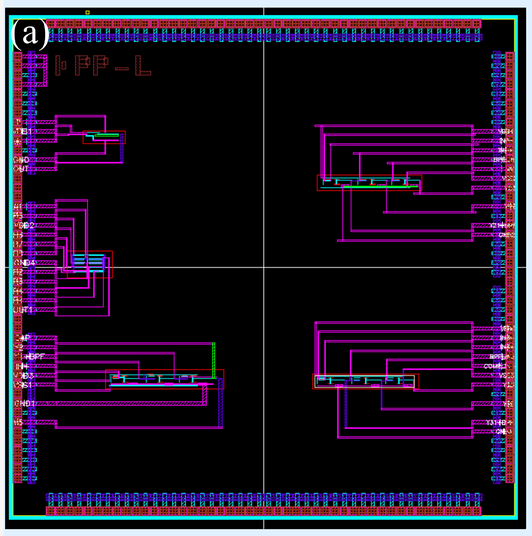
R-R Interval Detection Circuit



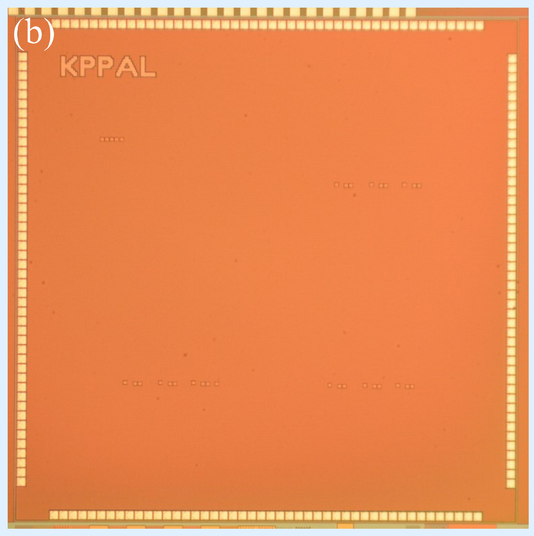
(a) ECG preprocessing block. (b) R-R interval detection block.

- Different ECG records consisting of fast, slow, and normal sinus rhythms are taken from the MIT/BIH database to evaluate the reliability of the proposed design.
- The preprocessing of the ECG signal is critical as it directly affects the features that are crucial in displaying the HR.
- As shown in above, the comparator is used to detect the RRI's. In design of comparator, an active peak amplitude detector (APAD) is used at inverting terminal. Both APAD and the non-inverting terminal of comparator has the preprocessed ECG as input.

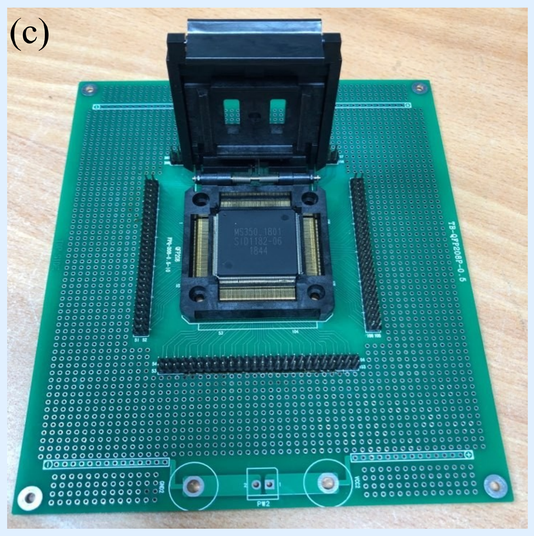
Chip Implementation and Results



(a) Package.

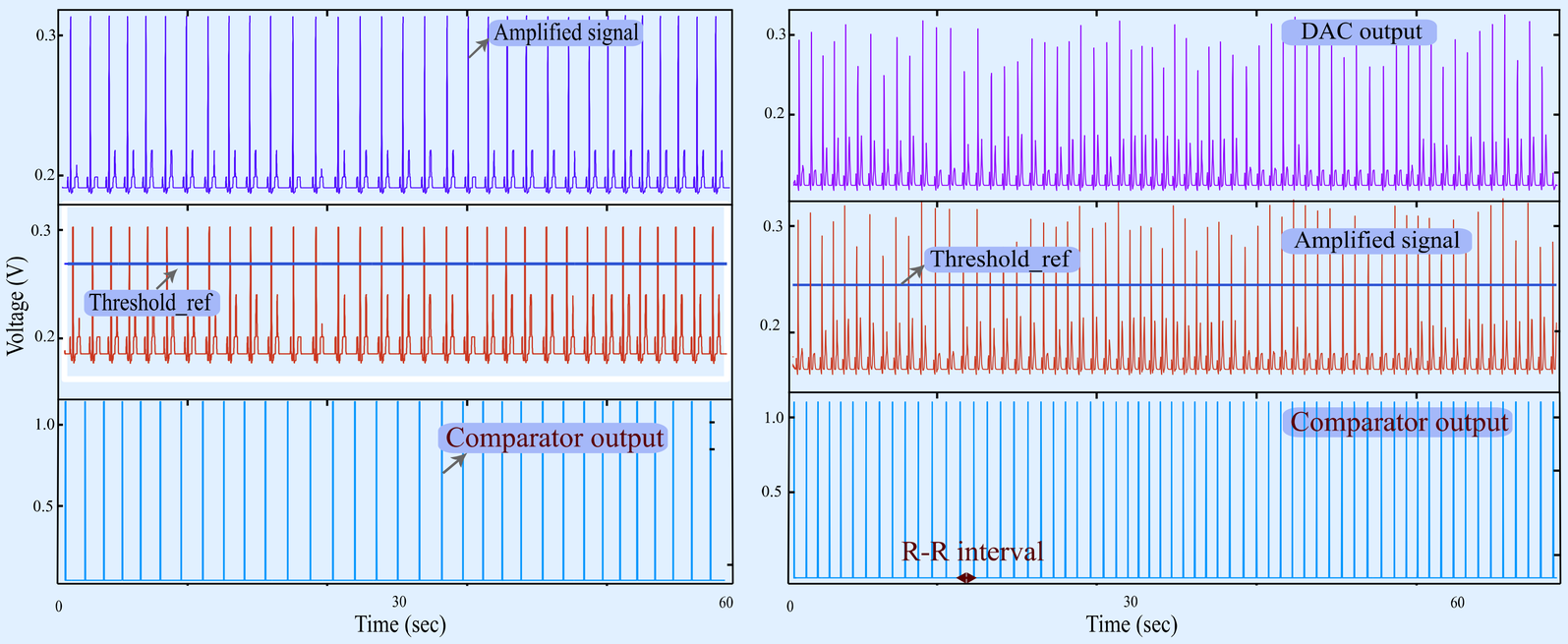


(b) Die micrograph.



(c) Fabricated chip.

- In ECG preprocessing stage, the ECG signal is amplified and passed through BPF. To amplify the ECG signal, we have designed a non-inverting op-amp with a gain of 75 dB. To remove the artifacts and gets noise-free ECG, we have designed BPF of frequency range (0.05 - 100) Hz.
- Using the APAD in design of comparator, we set threshold level to ~50% of the ECG peak amplitude and this threshold level can well detect every RRI.



R-R interval detection with two selected ECG records.

Conclusion

In this work, we have designed a simple circuit to detect the heartbeat in real-time and is suitable for ECG wearable devices.

References

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