IDEC Chip Design Contest

KNU

MS180-1902

SEE School of Electronics Engineering

Design of Cardiac Status Indicator and R-R Interval Adjustment Circuits

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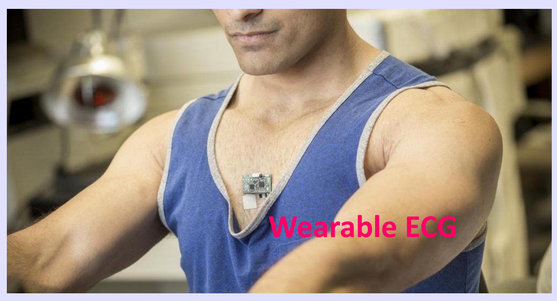
MOTIVATIONS:

- Despite great advancements in medical field, millions of people suffered from cardiac arrhythmia. The solutions for the arrhythmia rely largely on early diagnosis and recognition. Therefore, in this work, we have designed a Cardiac Status Indicator to continuously indicate the status of heart.
- Every year, over one million pacemaker implants are used as a therapeutic tool to minimize the deaths caused due to cardiac arrhythmia. In this work, we have designed a low complexity beat-beat adjustment circuit which interprets and alters the detected ECG on the basis of normal ECG rhythm.

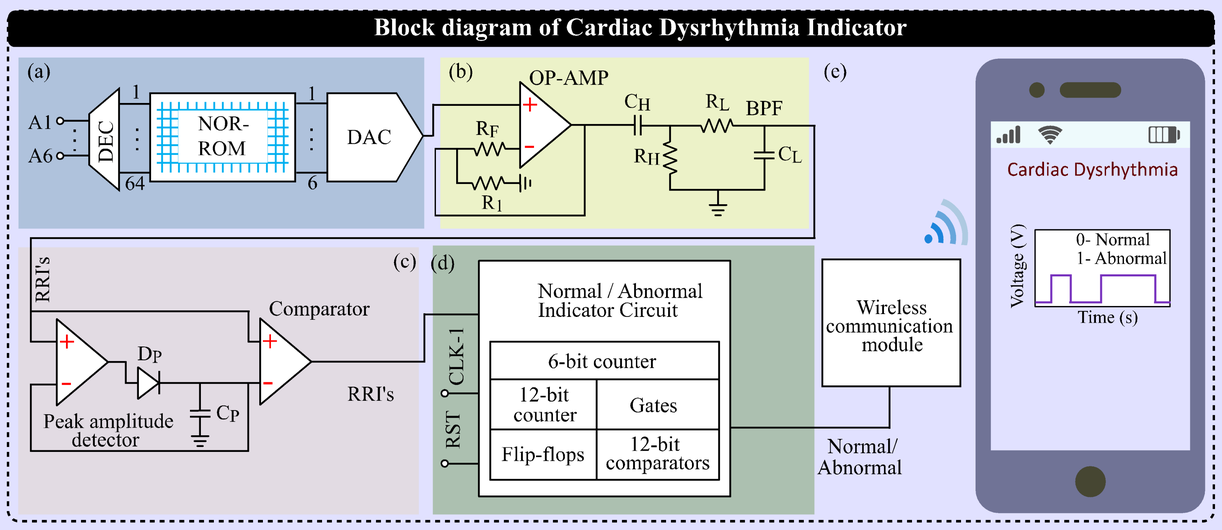
CARDIAC STATUS INDICATOR



ECG monitoring techniques:

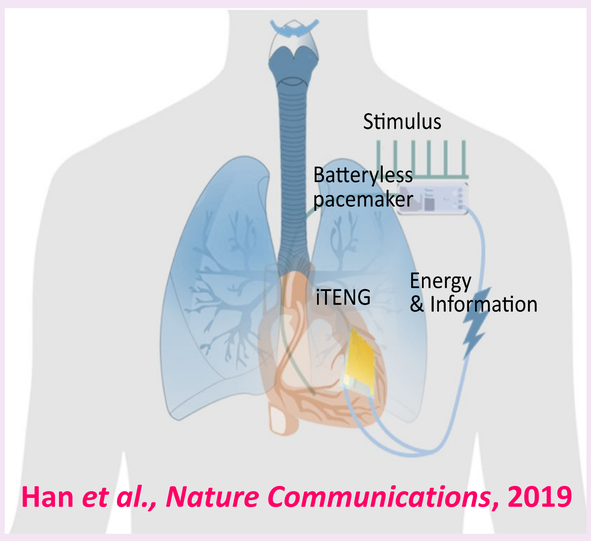
1. Patch-based technique
2. Holter-based technique
3. Smart T-shirt-based technique

- The function of the CSI is to continuously indicate status of heart.
- CSI is divided into five stages, which are ECG data, preprocessing, R-R interval detection, Normal-Abnormal Indication, and user display module.



(a) ECG data. (b) Preprocessing. (c) R-R interval detection. (d) Normal-Abnormal Indication. (e) User display module.

BEAT-BEAT SENSING AND ADJUSTMENT

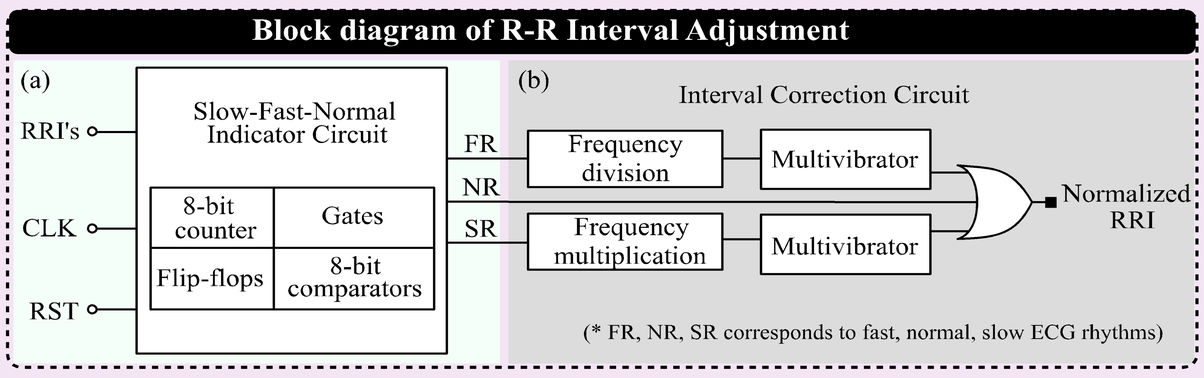


Han *et al., Nature Communications*, 2019

Pacemaker types:

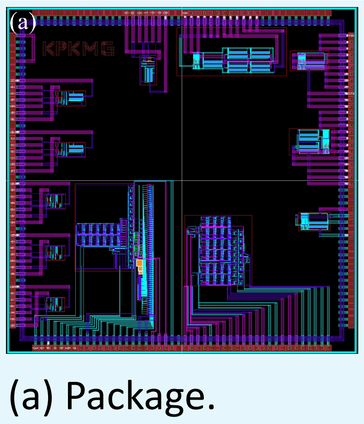
1. Fixed-rate pacemaker generates pulses at a steady predefined rate.
2. Pacemaker "on demand" first senses the heart rhythm and produces pulses if the heart beat misses/slow.
3. Rate-responsive pacemaker senses and based on rhythm it speeds up/slow down the pulses.

- Slow-Fast-Normal Indication Circuit classifies each beat into slow, fast and normal and Interval Correction Circuit is to generate an anti-waveform again the abnormal waveform.



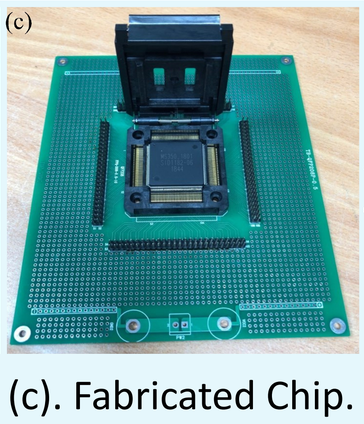
(a) Slow-Fast-Normal Indicator. (b) Interval Correction Circuit.

CHIP IMPLEMENTATION AND RESULTS

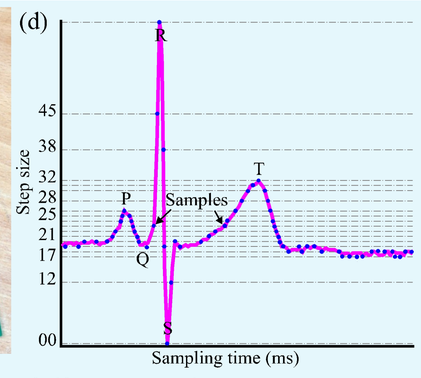


(a) Package.

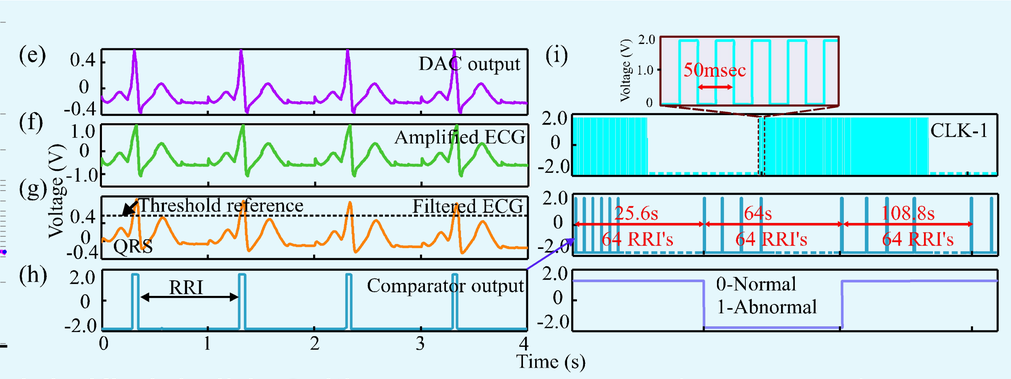
(b) Die micrograph.



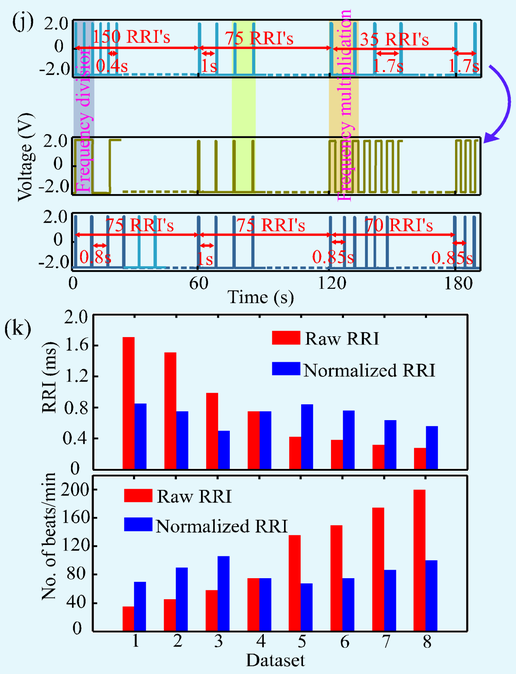
(c). Fabricated Chip.



(d). ECG data.



(e), (f), (g), (h), & (i) Preprocessing and status indication.



(j) Beat adjustment output. (i) Adjusted beats of different heartbeats.

- To test the proposed design, inputs of various ECG rhythms are generated based on predefined ECG data.
- CSI: A 6-bit counter is used to count 64 RRI's and a 12-bit counter with a clock frequency 20 Hz is used to calculate the time for every 64 RRI's.
- RRIA: A 8-bit counter with a clock frequency of 100 Hz was chosen to calculate the time for every RRI.

CONCLUSION

The proposed CSI and RRI adjustment circuits accurately detect and adjusts RRI respectively. For future work, we intend to integrate the wireless communication module with CSI.

REFERENCES

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[2] C. J. Deepu, *et al.*, "IEEE TCAS II", 2016.

[3] S. Surendarraj, et al., "IEEE ISOCC", 2019.

[4] J. Kim, *et al.*, "Nature Biotechnology", 2019.

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