Chest-worn Transmitarray Lens for Monitoring Heart Rate Variability With a Remote Self-Injection-Locked Doppler Radar

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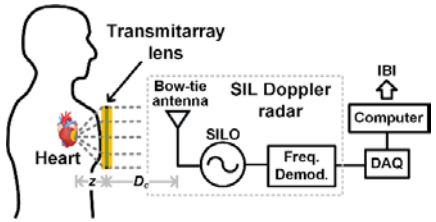
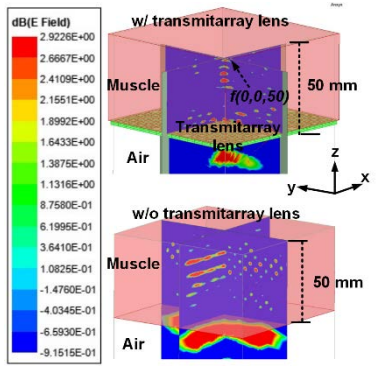
STATUS QUO

Proposed HRV monitoring system



- Remote Doppler radar: insufficient directivity
- Wearable active tag: high accuracy but with a battery life issue
- Wearable passive tag: no battery life issue but with a nonlinear design

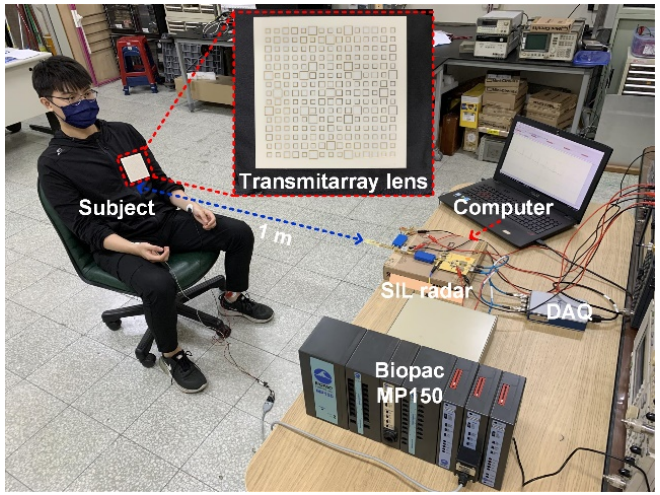
NEW INSIGHTS



The use of transmitarray lens can help

- ✓ Concentrate radar illumination
- ✓ Improve chest electric field penetration
- ✓ Reduce standing-wave ratio on chest surface

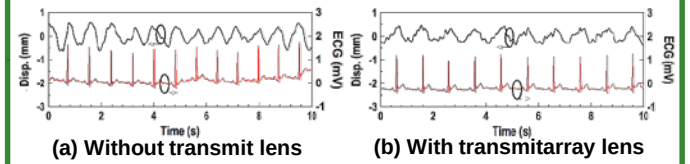
DESCRIPTION



The system comprises two parts:

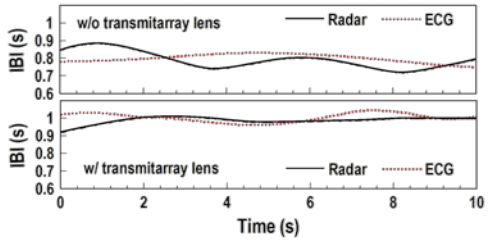
- ✓ **Chest-worn transmitarray lens**
  - A 15 × 15 array of metamaterial cells with different sizes
  - Conversion of a spherical phase front to a planar phase front
  - Made of three-layer Duroid RO4003 substrate
- ✓ **Self-injection-locked (SIL) Doppler radar**
  - Composed of a bow-tie antenna, a SILO, a frequency demodulator, a DAC, and a computer

QUANTITATIVE IMPACT



(a) Without transmit lens **(b) With transmitarray lens**

Comparison of detected displacement signal with reference ECG signal while holding breath



Improvement of interbeat interval (IBI) accuracy by more than 40%

PROPOSED CONCEPT GOALS

- ✓ A chest-worn transmitarray lens improves HRV monitoring with a SIL Doppler radar.
- ✓ The transmitarray lens focuses the radar beam for accurate heartbeat detection in a specific area of the heart.
- ✓ Experiments confirmed the transmitarray lens's favorable performance.
- ✓ Future work will implement the transmitarray lens using flexible materials and/or 3D printing techniques.