Micro-radar Wearable Respiration Monitor

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Motivation: Lack of Portable Breathing Rate Monitors

Portable respiration monitoring devices are required for **continuous breathing rate monitoring**, which is useful in evaluating breathing disorders symptoms.
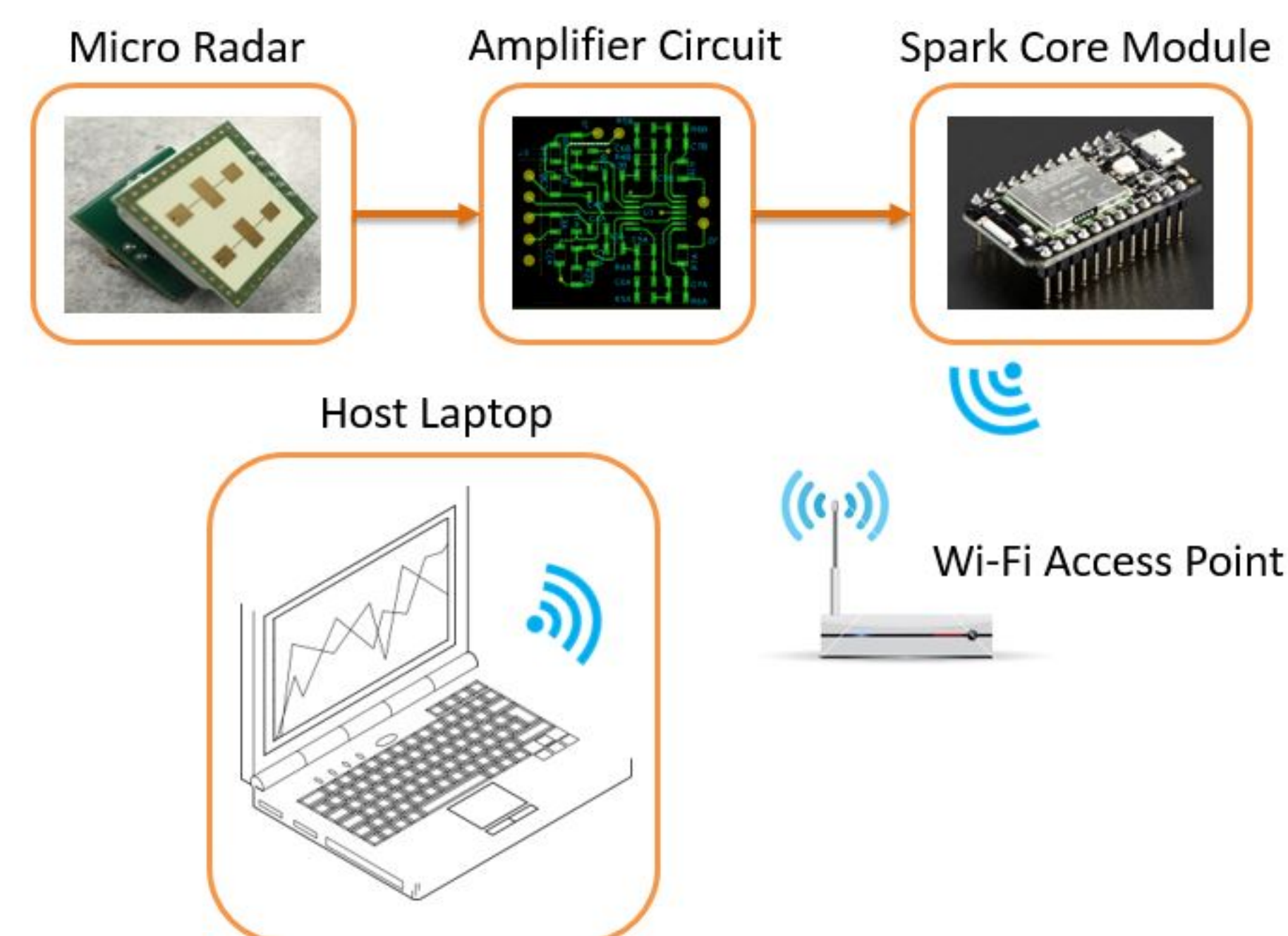
- Existing devices:
  - Nasal mask: uncomfortable and intrusive
  - Chest strap: hindering chest wall movement, might cause obstructive breathing problems
  - Radar deployed in room: interfered by environmental noise

Proposed Solution: A Radar-based Wearable System

- Micro radar
- Non-intrusive
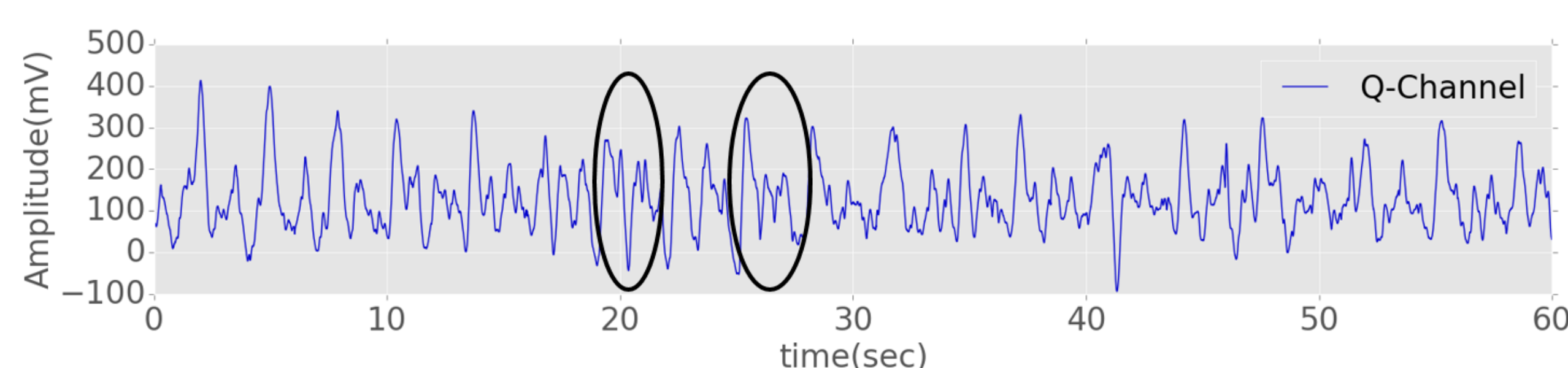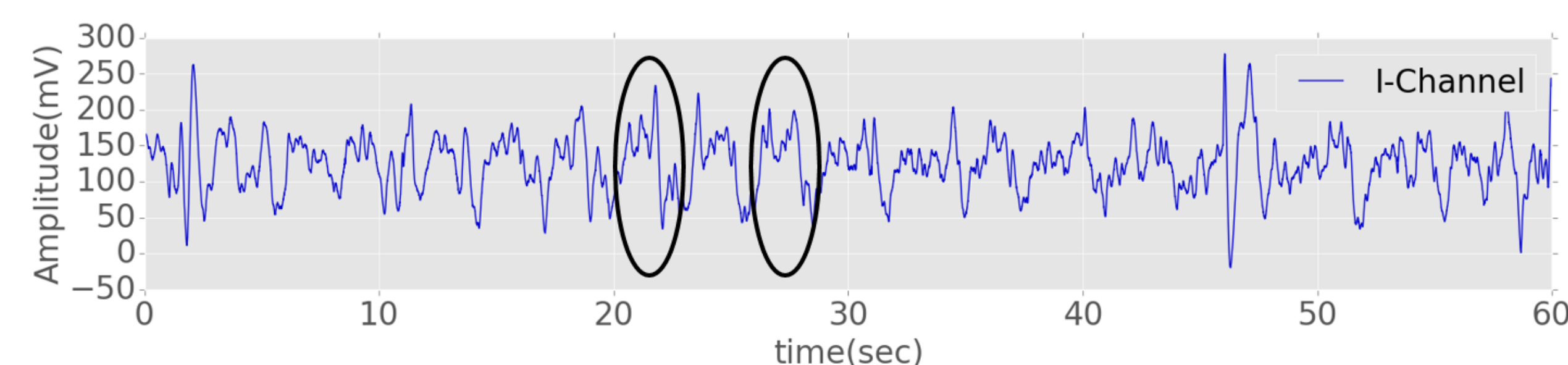- Wireless
- Wearable
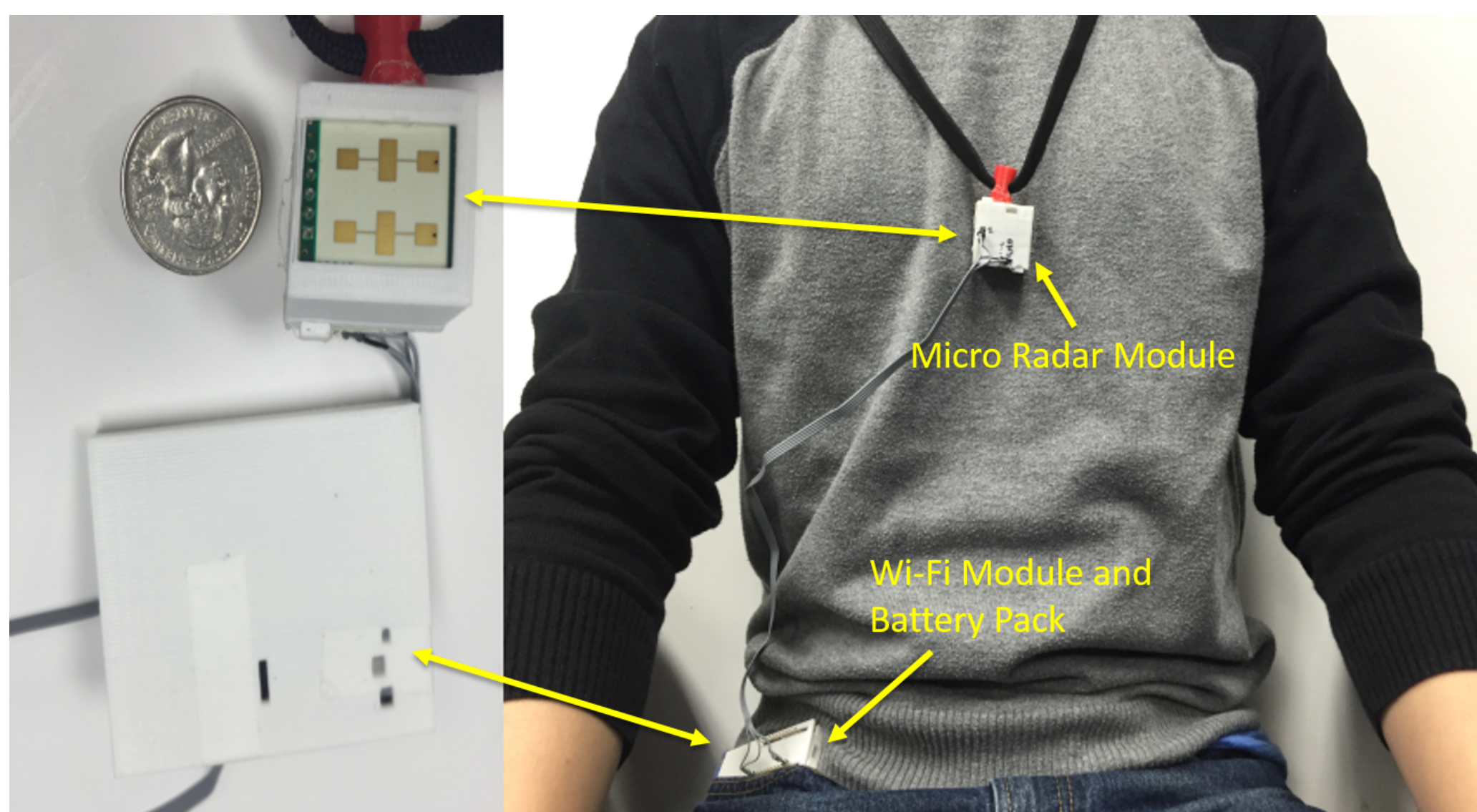
System Architecture

- 24 GHz contiuous wave Doppler radar sensor
  - Facing toward chest to minimize environmental interference
  - With I/Q channels to discriminate movement direction
- Custom active analog filter circuit
  - Targeted range: 0.2Hz - 0.6Hz (Doppler shift by extreme cheset movement)
  - Design: 2.5 Hz bandwidth with a net gain of 50 dB
- Spark Core module: ADC, micro-controller, WiFi

Signal Processing

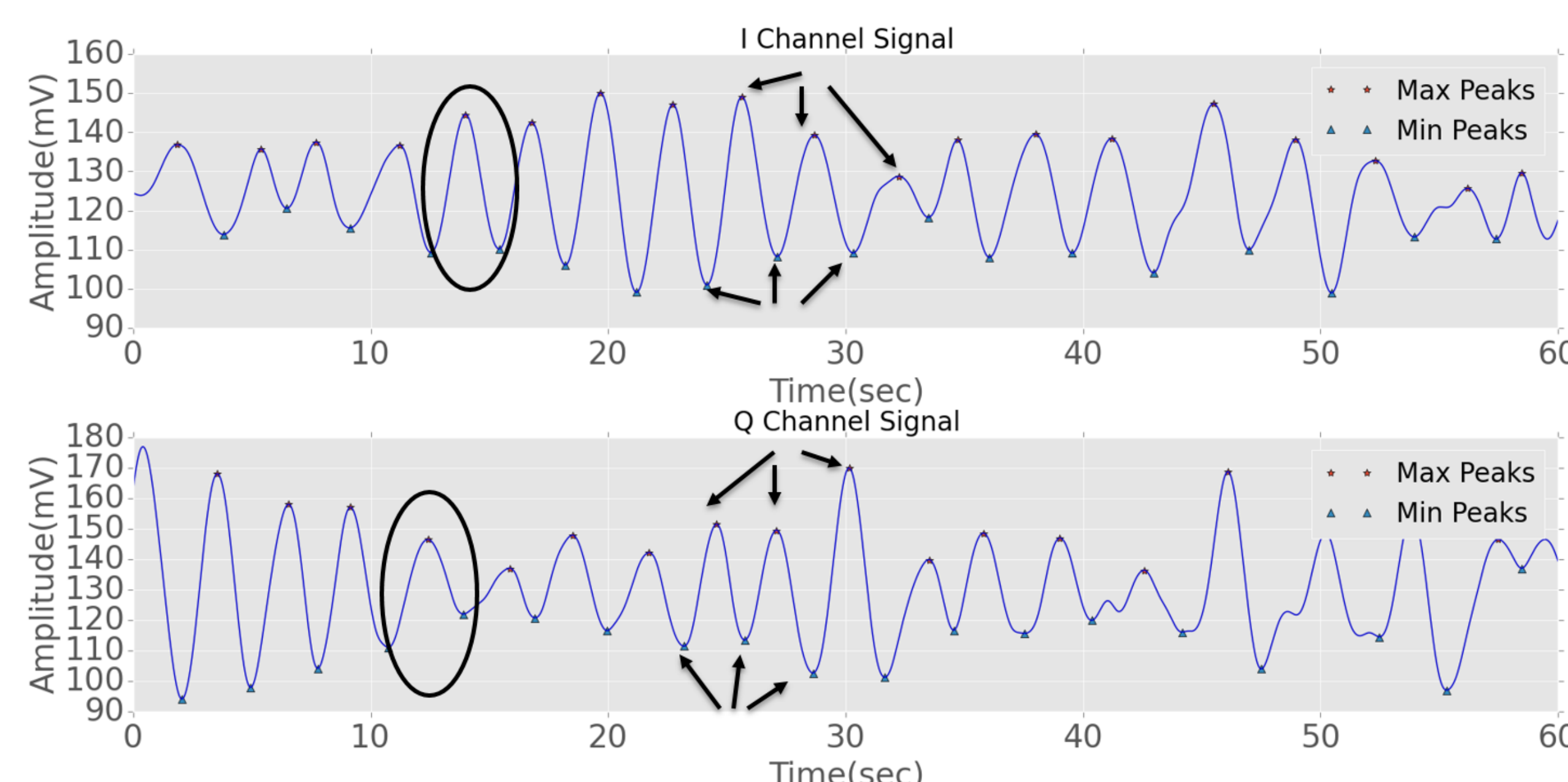Raw radar signals of respiration captured in our system:
- Noisy but periodic pattern is visible

Frequency analysis of the respiration signal:

Not accurate by looking at the maximum since breathing period vary over time, which might generate multiple peaks
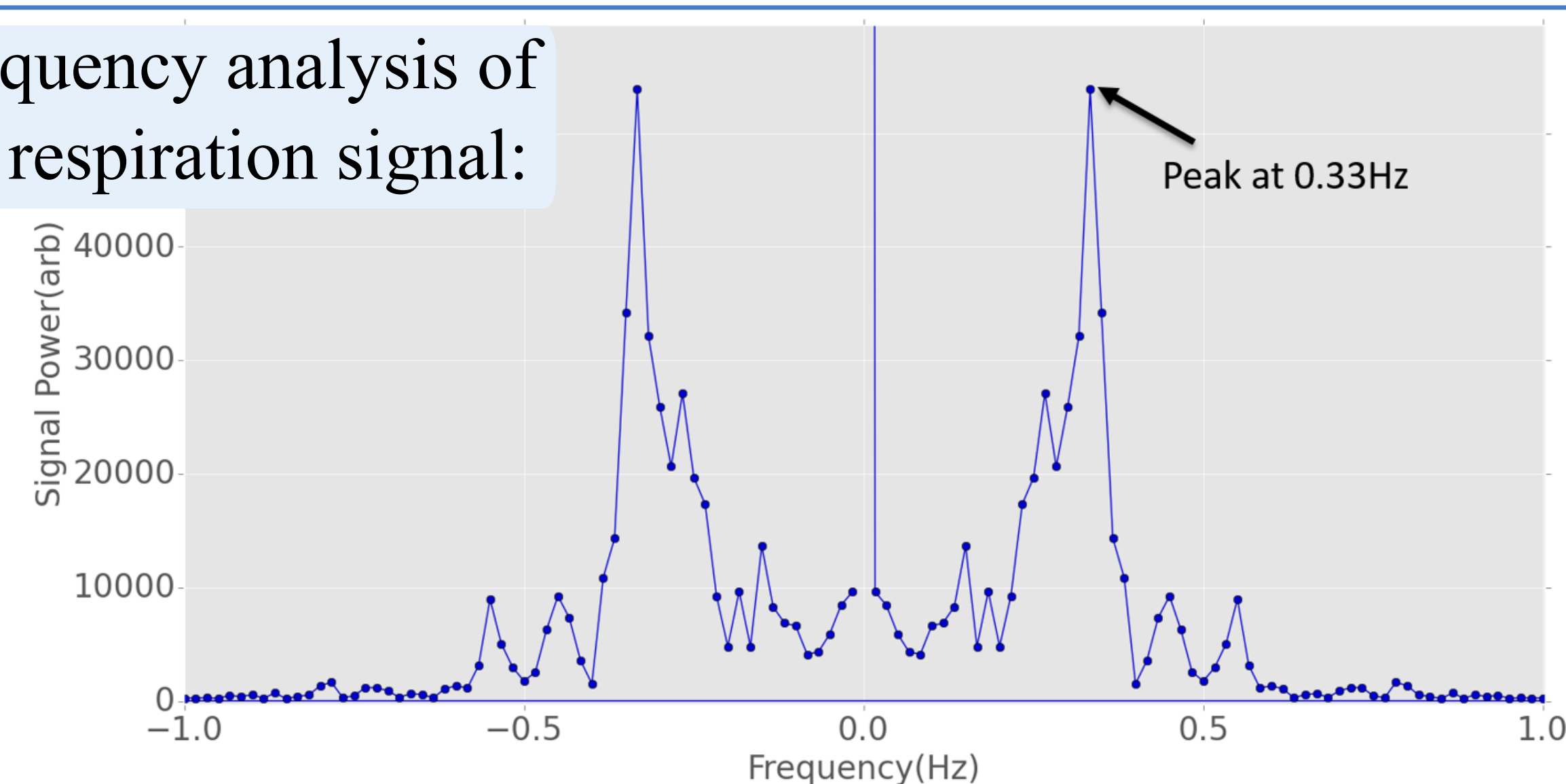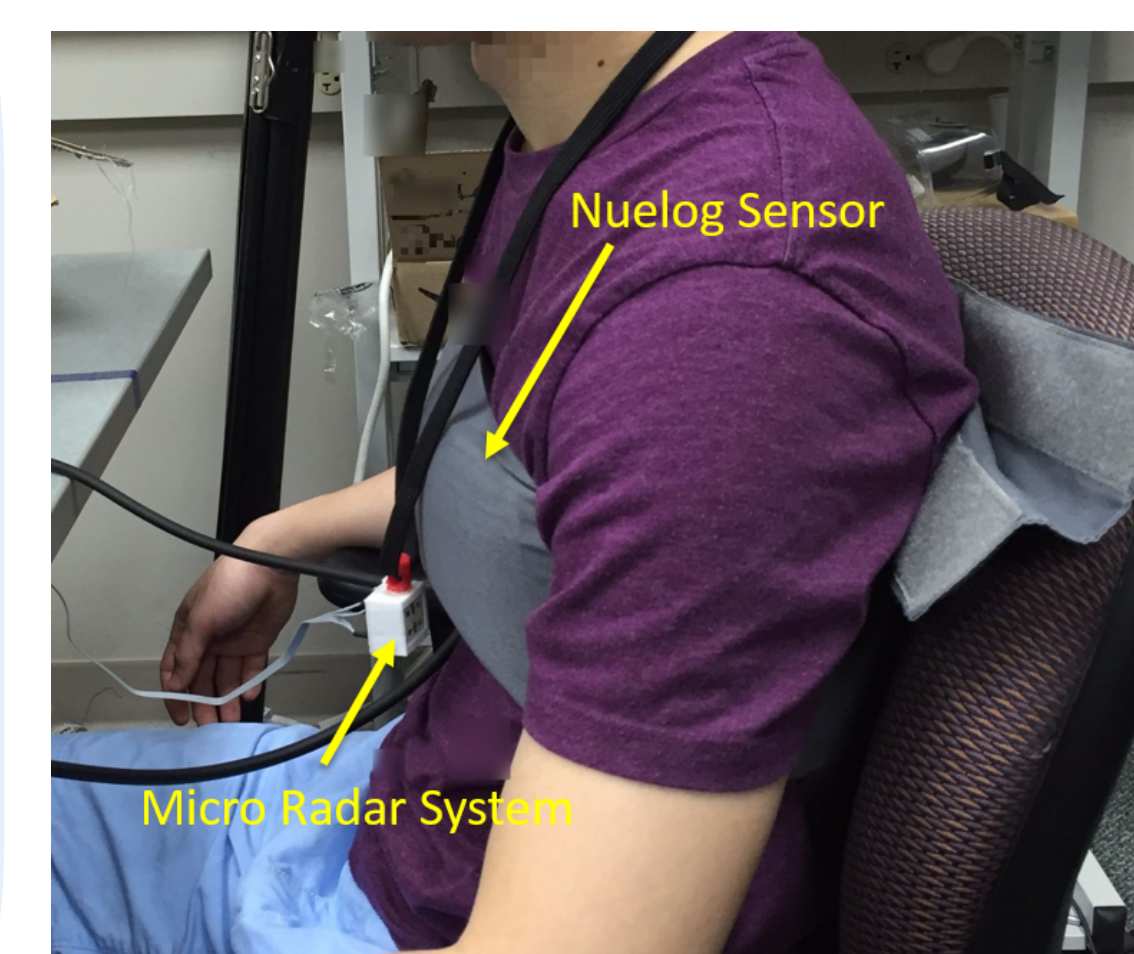
Using moving average filter:
- Window size is chosen to be less than or equal to half of desired signal, which typically ranges from 1.5 s to 3.5 s, to avoid loosing actual data.

Breathing rate estimation with peak detection:

System Evaluation

- Golden standard: Neulog chest band system
- 10 adult subjects
- Subjects are sitting stably in static environment

Breathing rate estimation

Subject ID	Frequency Based	Peak Analysis Based	Golden Standard
1	19.50	18	18
2	16.20	20	20
3	16.02	17	17
4	16.50	18	17
5	16.02	16.6	16
6	17.94	18	17
7	16.44	16	17
8	16.50	16	16
9	16.92	18	17
10	20.40	20	20