LECTURE 4: HOW DO SENSORS & SENSOR SYSTEMS WORK

ADVANCED GIS: TRANSPORTATION - SENSORS - AND THE SMART CITY

Geog 491/591 Spring 2015

WELCOME | SYLLABUS | LECTURES | ASSIGNMENTS | LABS | NEWS & EVENTS

NEWS & EVENTS

EVENT OF INTEREST

HOPES Conference is this week – April 9,10,11. "Catalyst: 21st Century Systems" – here on our campus – in Lawrence Hall. There are some great, Smart City flavored, talks on the agenda. I've posted two below that I'm going to try to attend (dad duties permitting…) that involve Carlo Ratti – the Director of MIT's Senseable Cities Lab. You've seen his work referenced in several of our readings and I've shown a few of their projects in lecture. *Ken*

TOPIC

EVENTS AND NEWS

DATE **4-8-15**

LECTURE **#4 - SENSOR SYSTEMS**

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SENSEABLE CITIES
WITH CARLO RATTI
LAWRENCE 115 10:30 AM – 11:30 AM

TRANSIT AND THE CITY: SYSTEMS THAT INSPIRE
WITH ANDREW HEUMANN, JENNIFER WIELAND, CHRIS BELL, CARLO RATTI, RAB ZAKO, AND PHILIP SPERANZA
LAWRENCE 206 1:00 PM – 2:00 PM

TOPIC

EVENTS AND NEWS

DATE 4-8-15

LECTURE #4 - SENSOR SYSTEMS

EVENT OF INTEREST

Computer and Information Science (CIS) has an entrepreneurship-focused departmental colloquium this week. Embedded systems are right up the alley of Smart Cities – this looks like a good talk. *Ken*

Thursday April 9th from 3:30pm to 5:00pm in 220 Deschutes Hall.

Abstract of Talk:
This talk will introduce basic embedded systems and bridge general-purpose computing software to the application of programming small simple microprocessors, which can then directly interact with any example of circuitry. Basic prototyping methods and tools will be discussed including specific examples and tools that will be of immediate use to anyone with an idea for an embedded system. Finally, the business startup aspect will be discussed including team building and funding with an emphasis on crowdfunding via platforms such as Kickstarter.

Biography:
Kevin King is a self taught electrical engineer. He invented a radio control system for photographic lighting in 2007 and learned electronics as a necessity to bring the product to market. In February 2015 he founded Plum Geek LLC as a new endeavor aimed at open source hardware and robotics. The intention is to build a sustainable business based on developing open hardware that can be used for pure entertainment as well as education. The Ringo robot is the first product offered by Plum Geek, and recently raised over $85,000 on Kickstarter toward an initial goal of $12,000.

TOPIC

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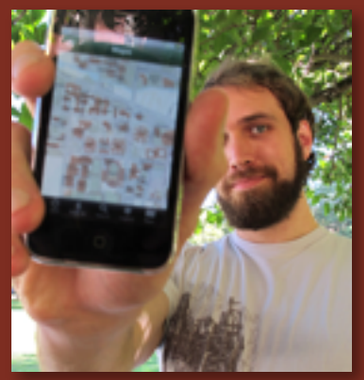
LECTURE #4 - SENSOR SYSTEMS

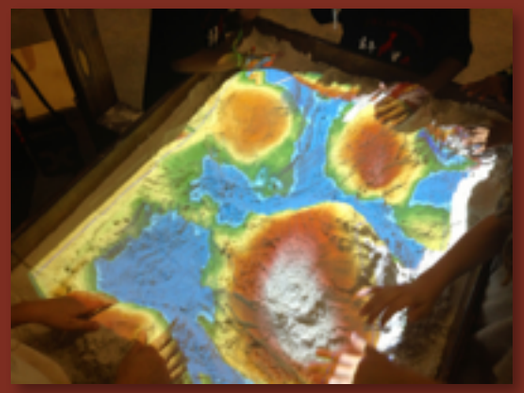
Explore Geography!



Thursday, April 16th, 3:30-5:30pm, First Floor of Condon Hall

Come for the food, door prizes, and swag…

… Stay to witness the opportunities that our classes and department provide!



And see some neat geography gadgets, including the augmented reality stream table, Inflate-o-globe 2.0 and the newest addition to our river fleet!

Take tours of out department, our research labs, including InfoGraphics and the Spatial Computation, Cognition and Complexity (S3C) Labs

Discover the world open to you with a degree in Geography!

Sponsored by UO Department of Geography and the Geography Club

LECTURE 4: HOW DO SENSORS & SENSOR SYSTEMS WORK

Reading #1 Takeaways

- The idea of sensor networks is not new
- Sensors are now small enough, low power enough to make networks doable
- Hardware platform is more than just the sensor
- Network topology matters
- Multiple communication protocols
- Each has advantages and disadvantages
- Multiple security threats
- Countermeasures must be utilized

Reading #2 Takeaways

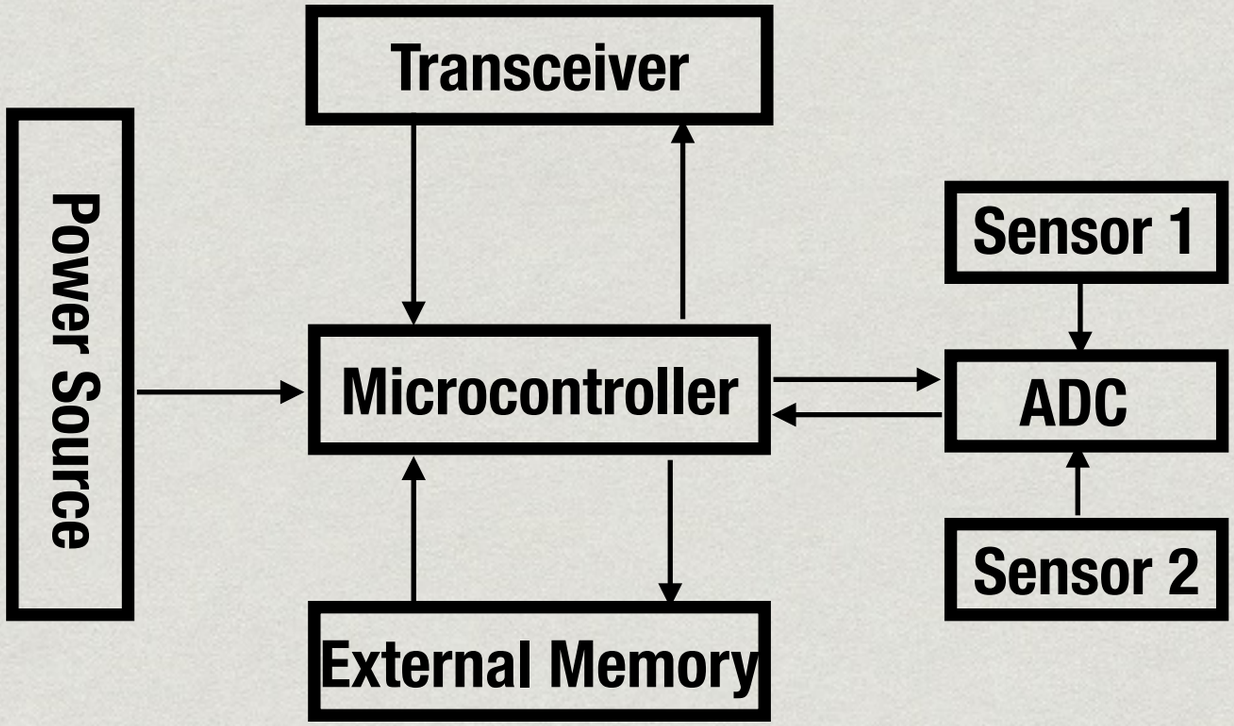
- In practice, actual setups are very complex
- Separate networks for different systems, connected by access points
- Nodes, repeaters, access points
- Ability to experiment important but best if run in parallel to main system
- Ability to communicate in a centralized manner with equipment important for updates
- Access control and authentication

What is a sensor?

- A sensor is a transducer whose purpose is to sense (that is, to detect) some characteristic of its environs. It detects events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal; for example, a thermocouple converts temperature to an output voltage.

Sensor system / sensor node

- Microcontroller
- Power
- Memory
- Transceiver
- Sensor(s)
- ADC



Open vs Closed

- Closed Hardware examples:
  - Traditional smoke detecter
  - Oven
- Manually open
  - Sensors that store data locally but allow physical download
  - Traditional GPS
  - Traffic Counter
- Open Hardware examples:
  - Basically any sensor system that sends its data out over a communication type.
  - Sensor Tag
  - Smartphone

Networking Terms

- Ad Hoc Network:
  - An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range
- Infrastructure mode Network:
  - A network where all devices communicate through a single access point, which is generally the wireless router. An infrastructure mode network requires a central access point that all devices connect to.
- Local Area Network (LAN)
  - A local area network (LAN) is a computer network that interconnects computers within a limited area such as a home, school, computer laboratory, or office building, using network media.
- Wide Area Network (WAN)
  - A wide area network (WAN) is a network that covers a broad area (i.e., any telecommunications network that links across metropolitan, regional, national or international boundaries) using leased telecommunication lines.
- Personal Area Network (PAN)
  - A personal area network (PAN) is a computer network used for data transmission among devices such as computers, telephones and personal digital assistants.

Sensor Network Components

- Node - The sensor board itself
- Repeater - Component that receives data from multiple nodes and repeats it forward
- Access Point / Sink - Component that receives data from multiple nodes and repeaters and is connected to a LAN or WAN.

Communication Types

- Wireless Connections
  - Cellular (2G/3G/4G/LTE)
  - WIFI 802.11 (a/b/g/n)
  - Bluetooth (802.15.1)
  - WPAN (802.15.3 / 802.15.4)
  - Others - BAN (802.15.6)
- Wired Connections
  - Ethernet
  - Serial
  - USB

Cellular

- Advantages
  - Ubiquitous coverage
  - Throughput
- Disadvantages
  - Expensive (although slower, less costly options exist)
  - Proprietary
  - Power Consumption

WIFI (802.11)

- Advantages
  - Ubiquitous coverage
  - Throughput
  - Range
- Disadvantages
  - Power consumption
  - Complex

Bluetooth

- Advantages
  - Low power
  - Throughput
  - Bluetooth Low Energy
- Disadvantages
  - Limited range
  - Complex
  - Limited nodes

LR-WPAN (802.15.4)

- Advantages
  - Low power
  - Designed for large amount of devices
- Disadvantages
  - Limited range
  - Limited throughput

Traffic / Bike Counter

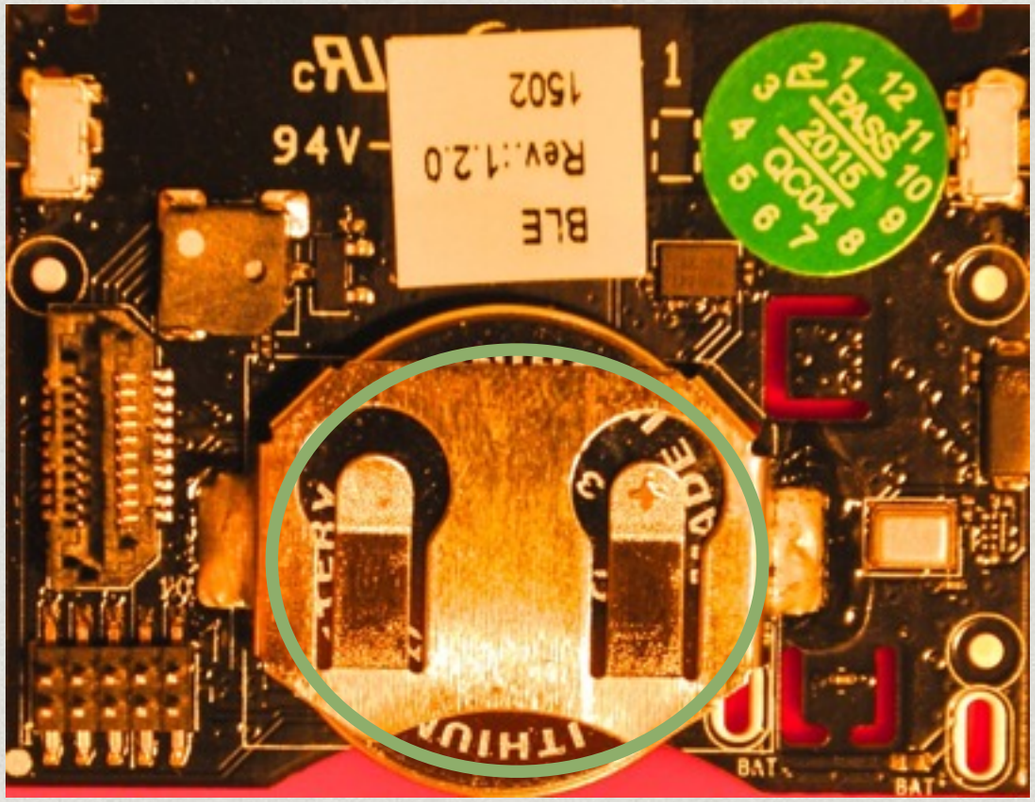
- Serial Port Connection
- Connects to network through serial server

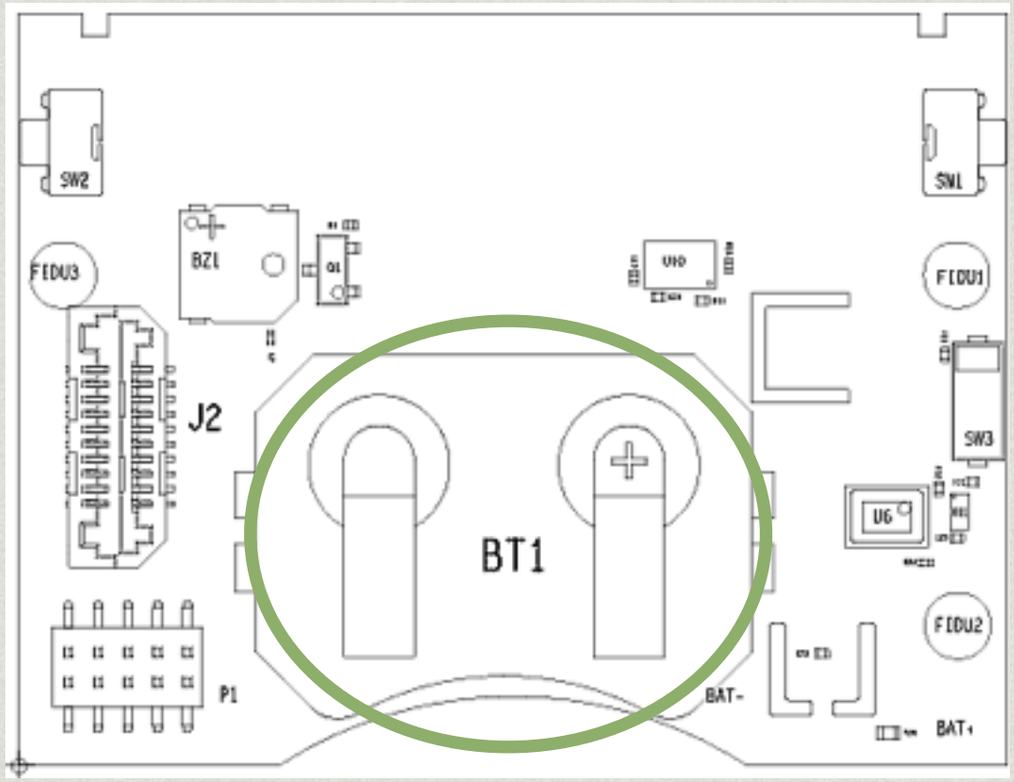
Example SensorTag

- 10 low-power MEMS sensors
- Bluetooth Smart
- ZigBee and 6LoWPAN supported
- Low power (coin battery)

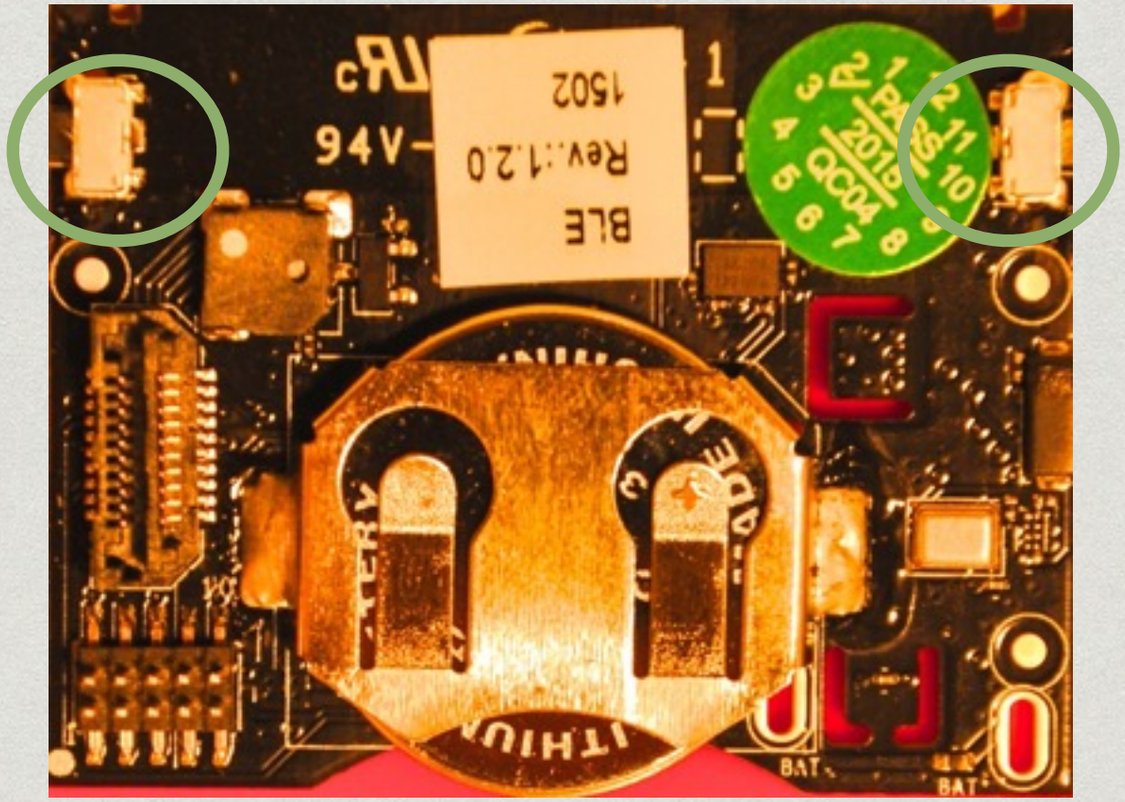
Sensor Tag examined

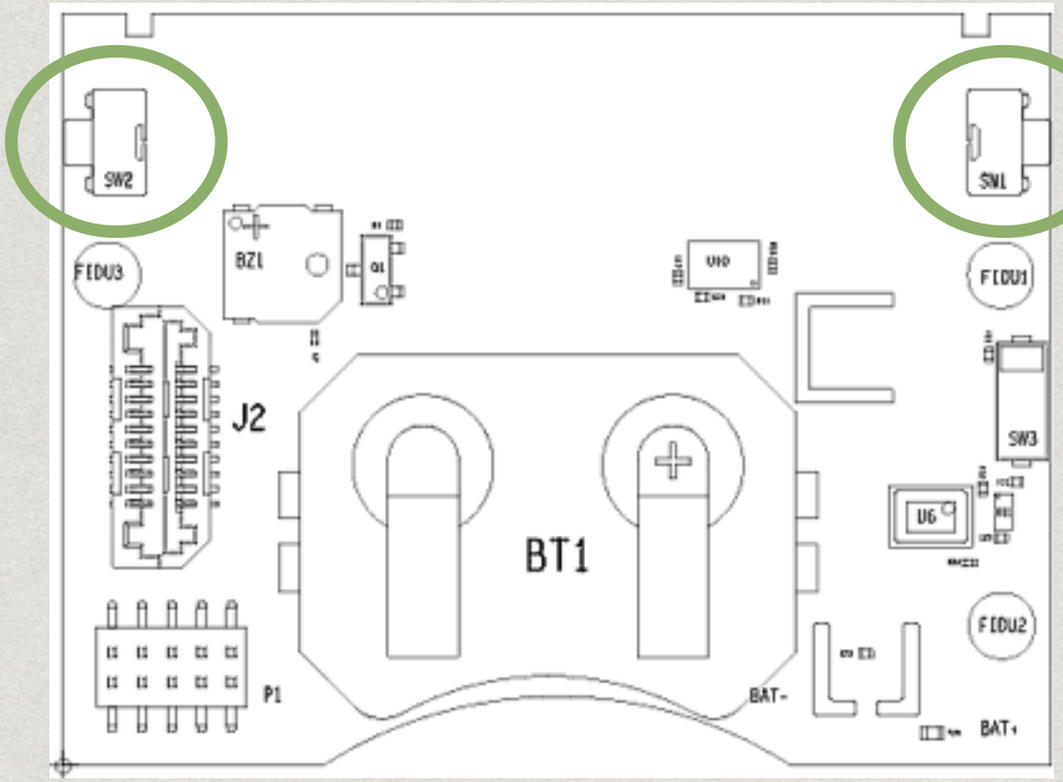
- Let’s look at the layout of the sensor tag board
- What do selected components look like?
- Cost for chips?



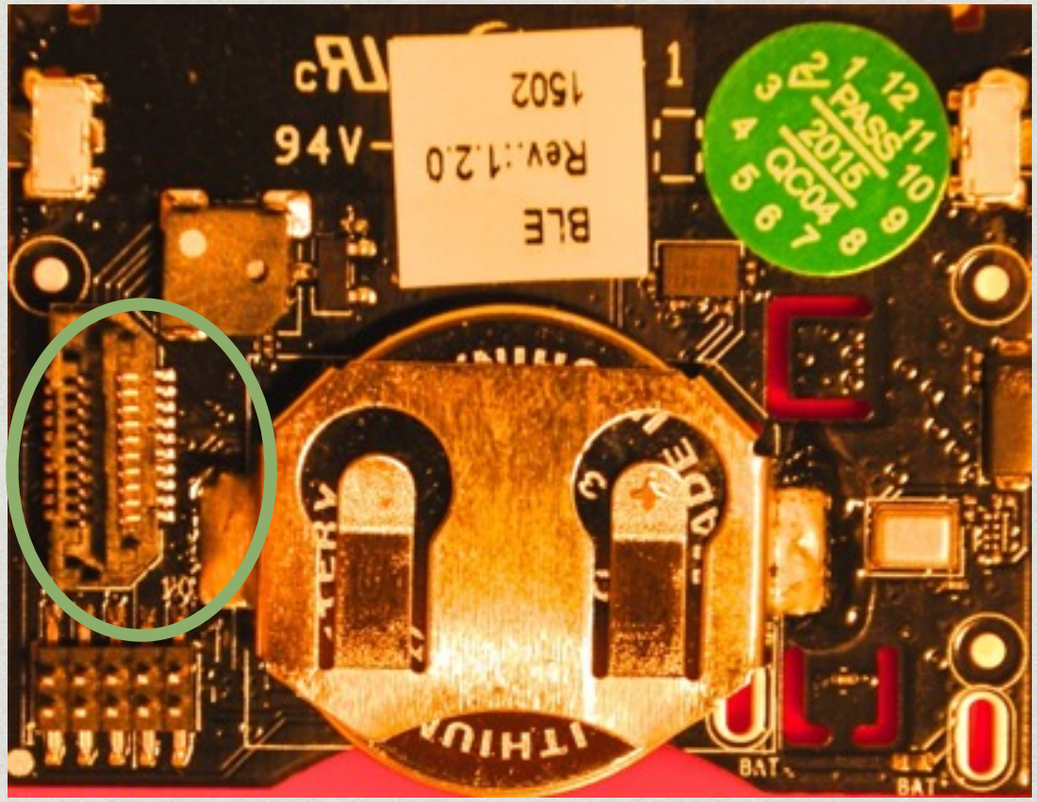


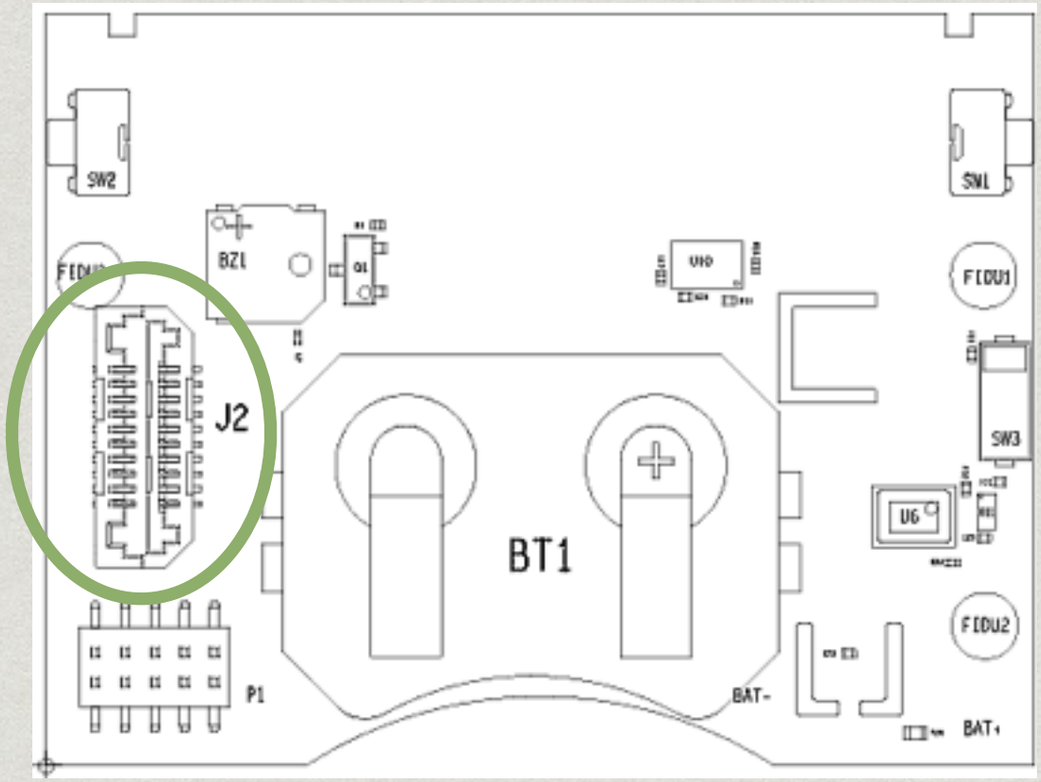
POWER:
Battery Holder
LINX BAT-HLD-001
1: $0.28
100: $0.233
500: $0.215





SENSOR / INPUT:
TACTILE SWITCH
DIPTRONICS MTA2
100: $0.233
500: $0.215





INPUT/OUTPUT:

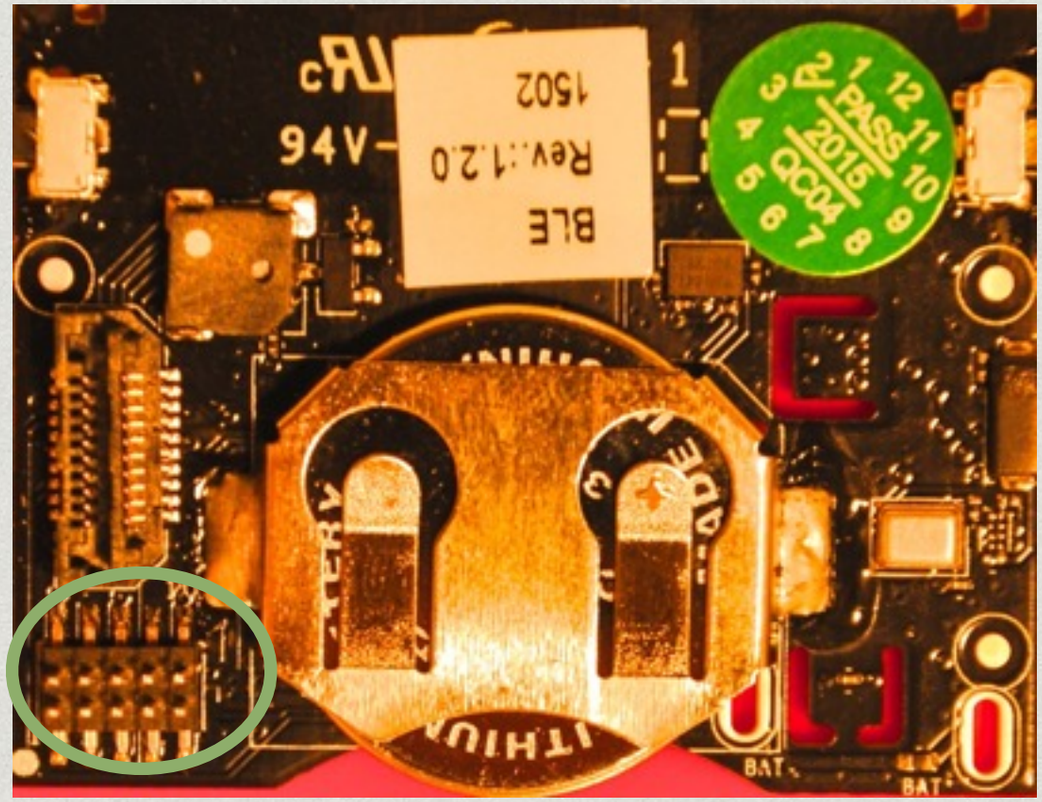
20 PINS, HI-SPEED SOCKET

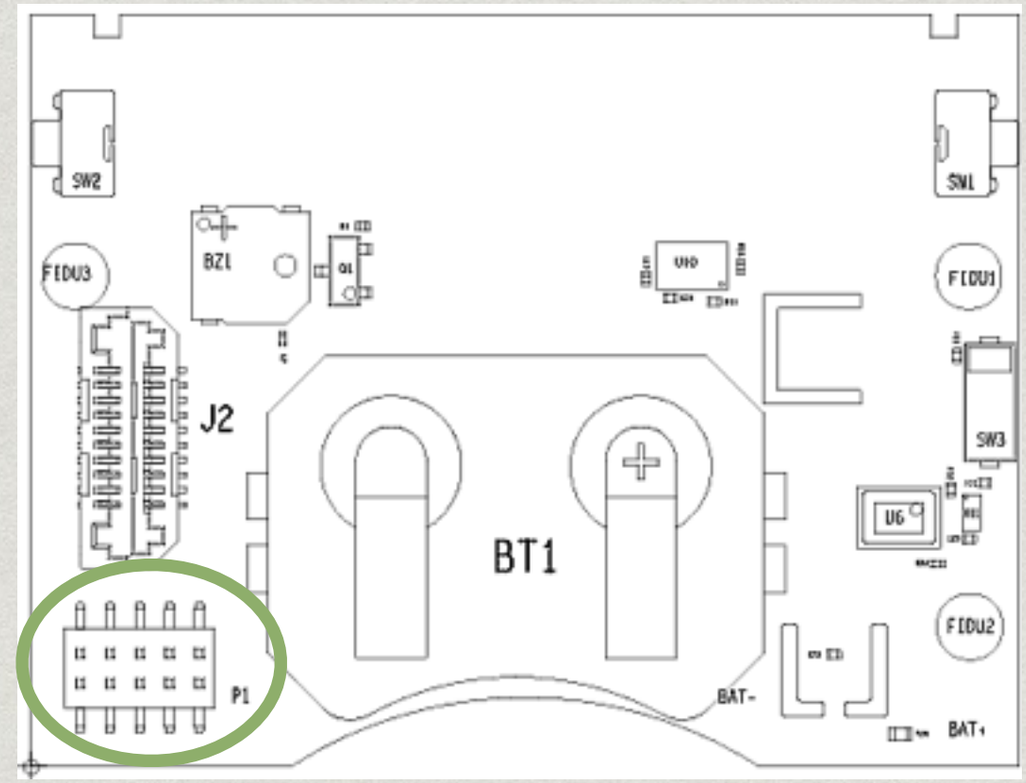
SAMTEC LSS-110-01-F-DV-A-TR

1: $1.83

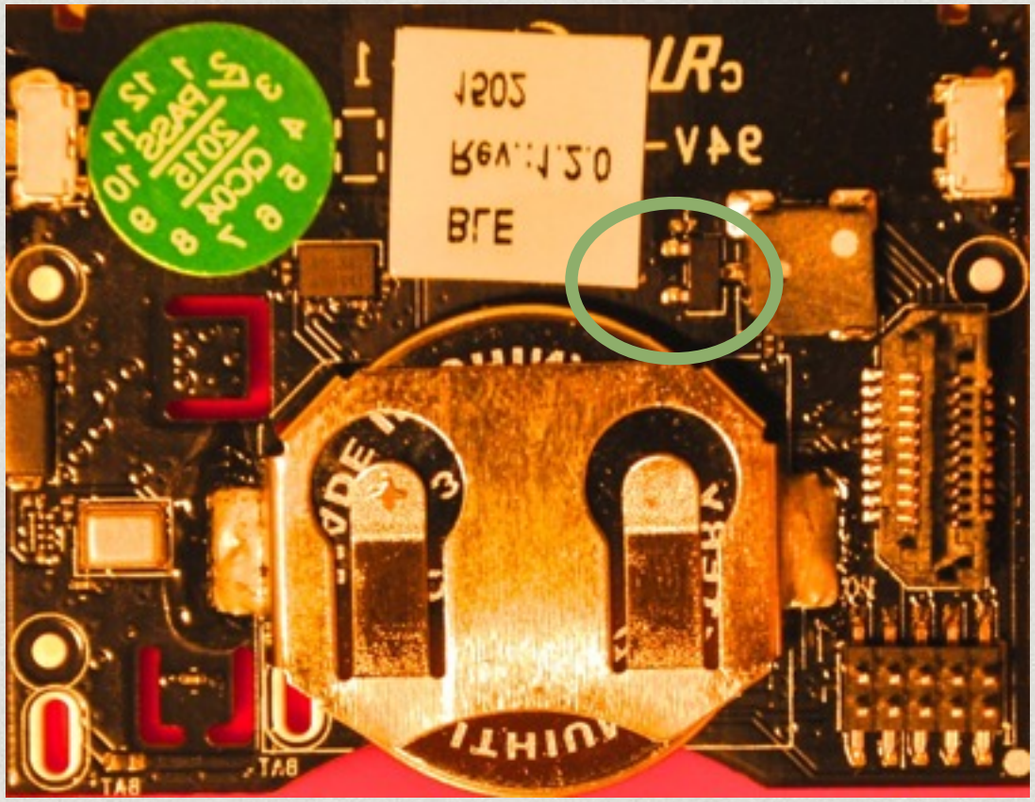
100: $1.59

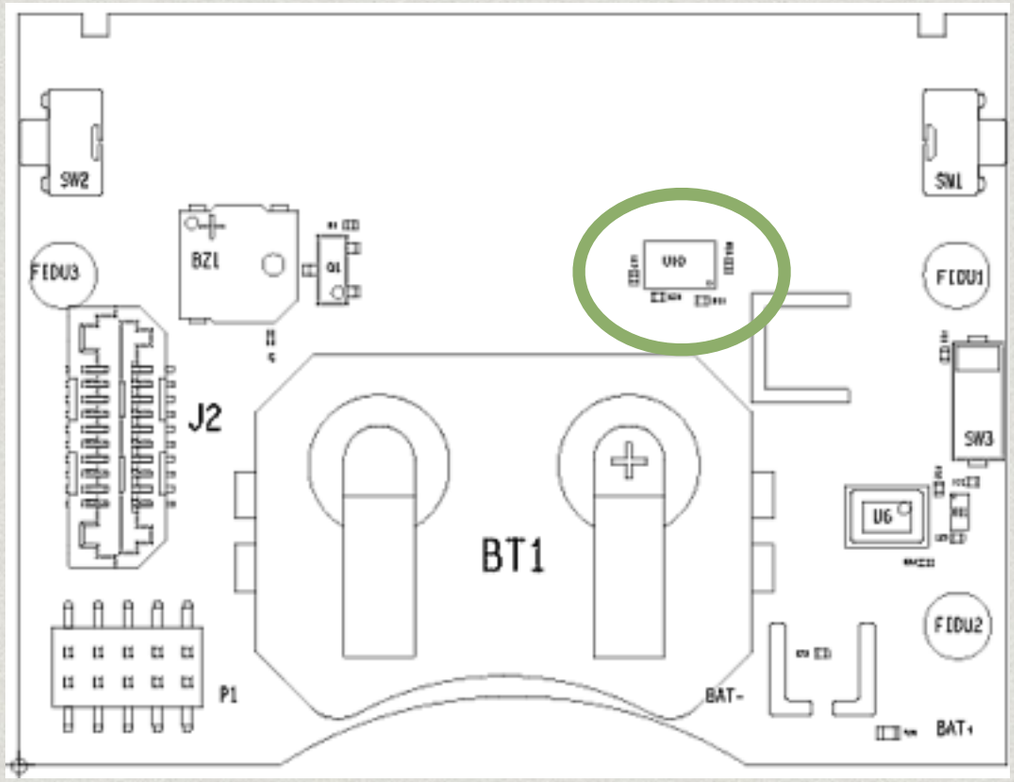
500: $1.39



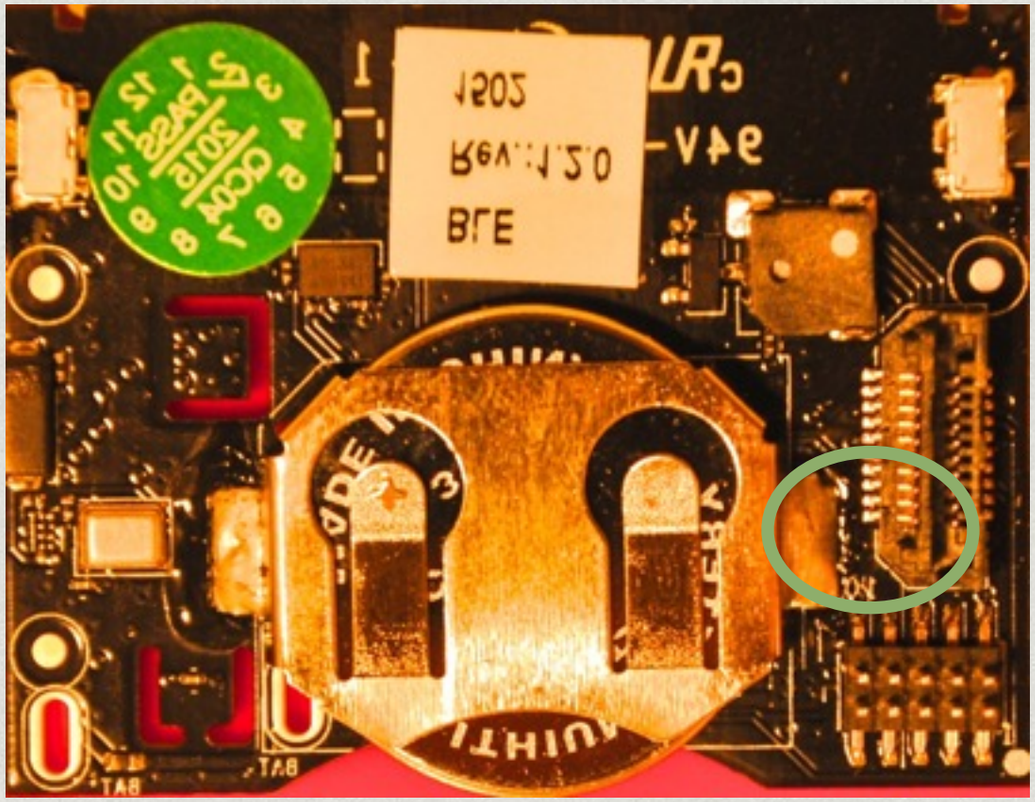


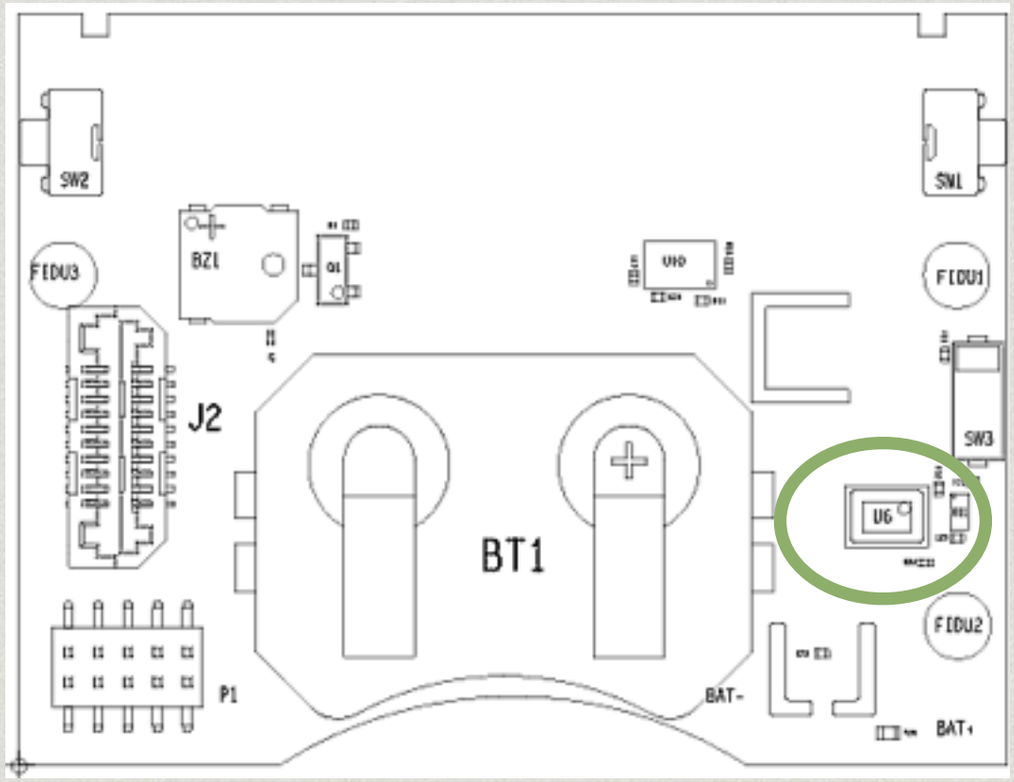
INPUT/OUTPUT:
2 ROW, 10 PIN CONNECTOR HEADER
GRADCONN BB02-BS101-KA8-025B00
Unknown pricing



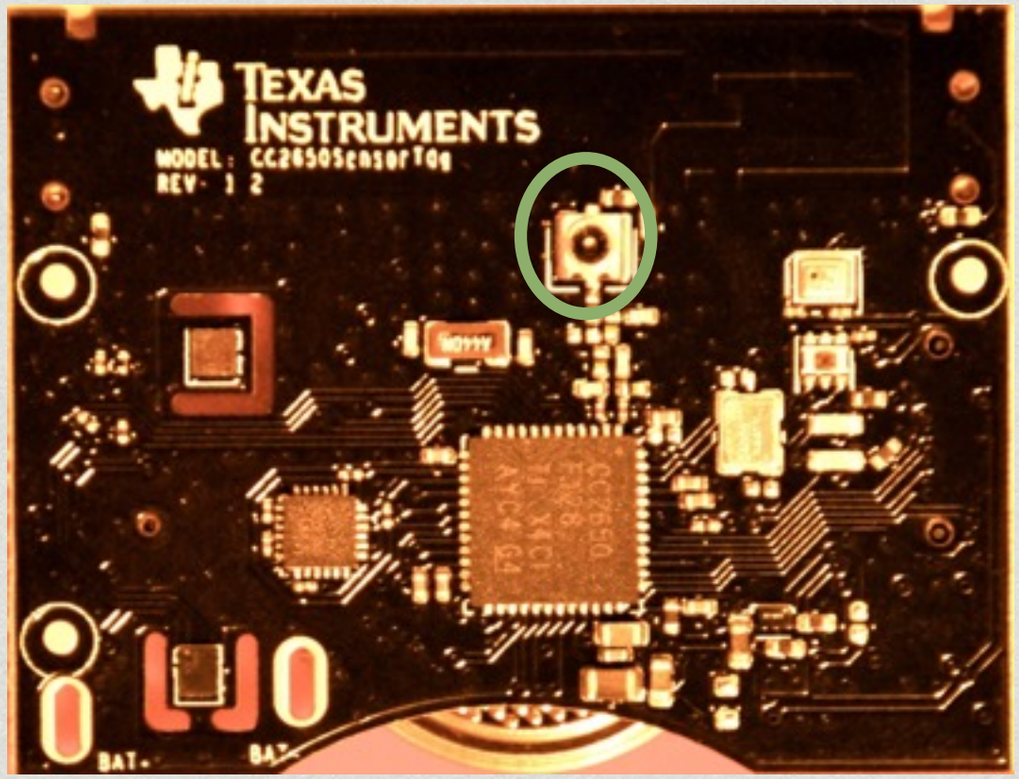


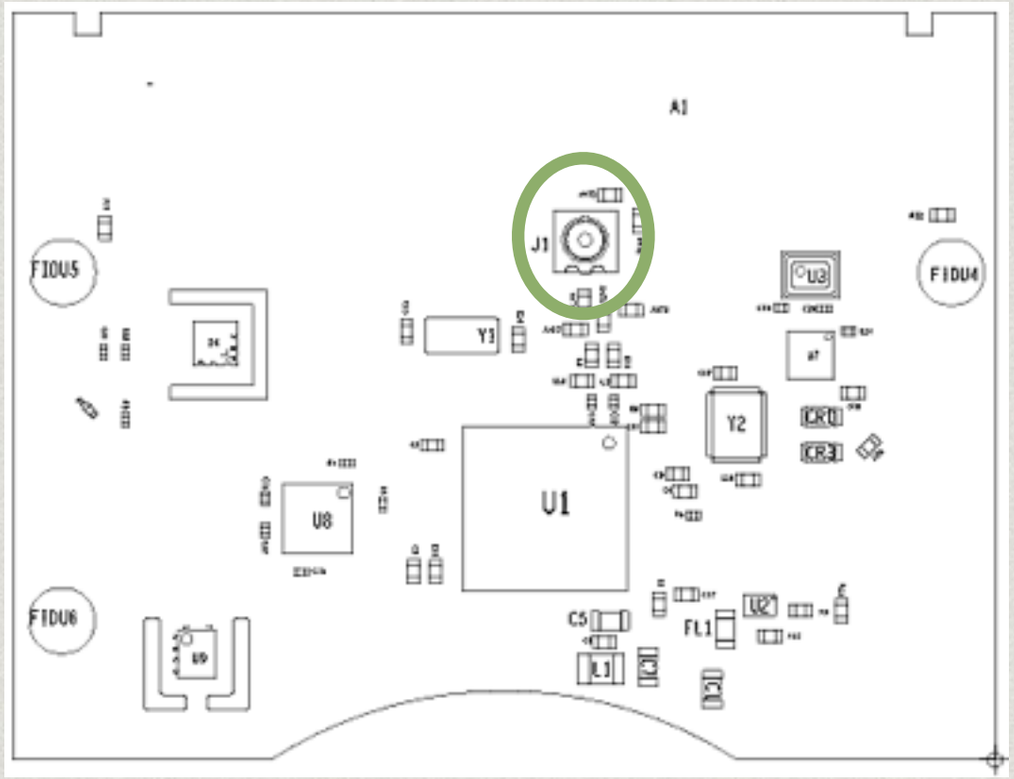
MEMORY:
4MB SERIAL FLASH MEMORY
WINBOND W25X40CLUXIG
4,000 $0.33202



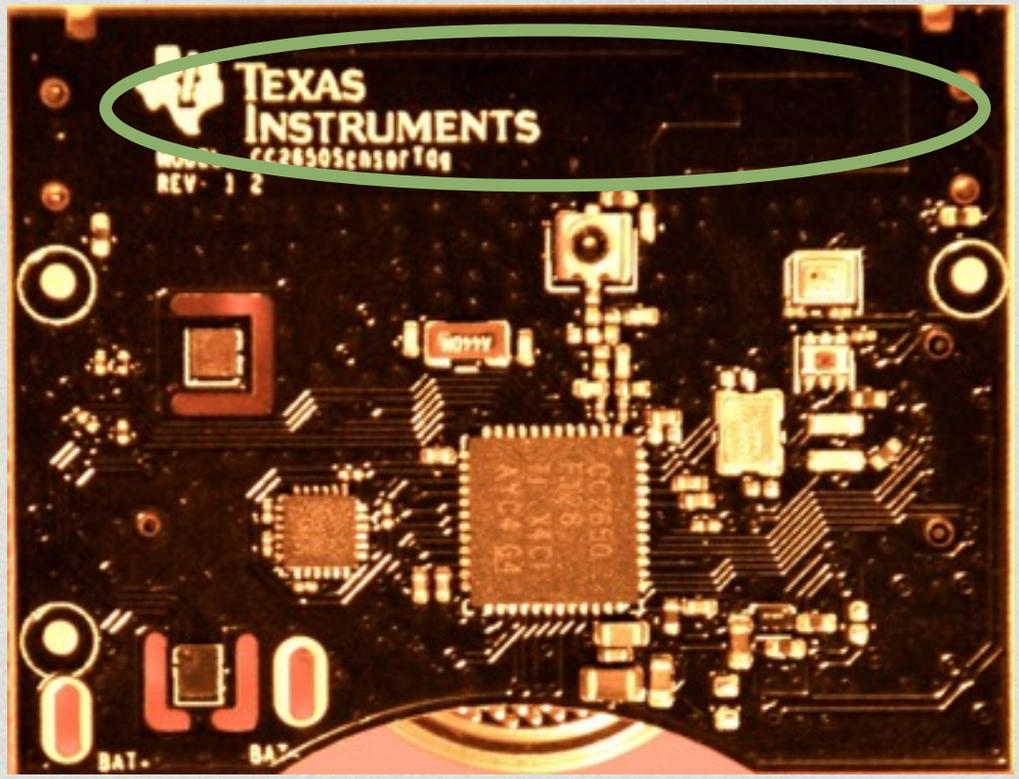


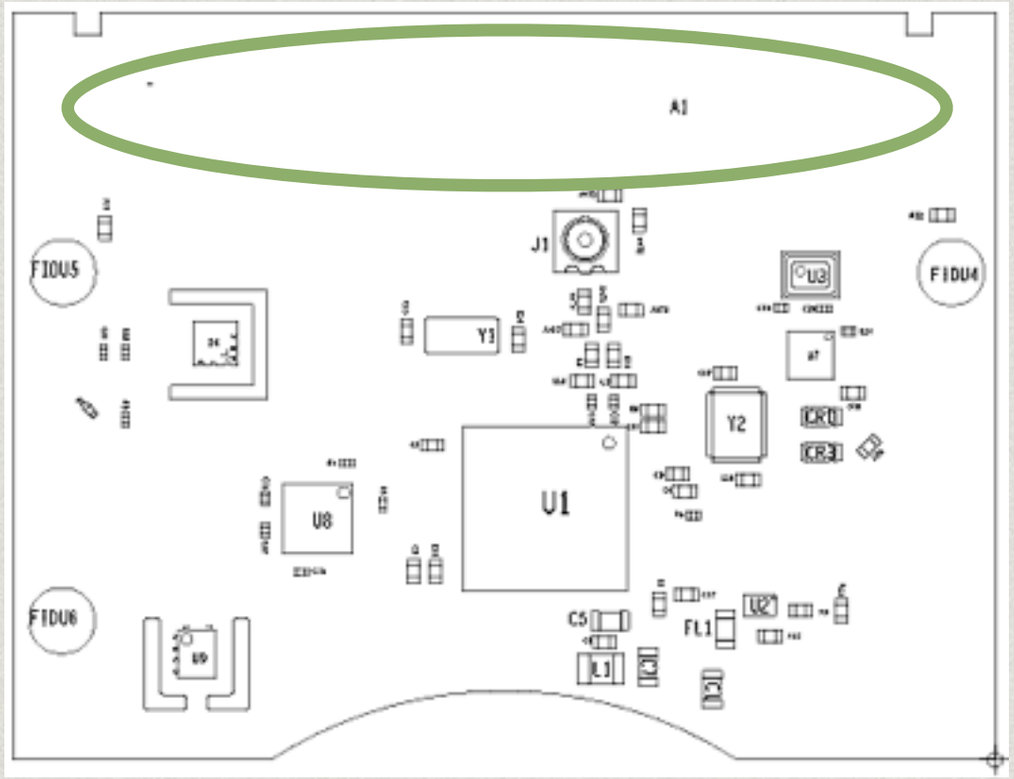
SENSOR:
MICROPHONE
KNOWLES SPH0641LU4H
1: $2.44
100: $1.34
500: $1.26



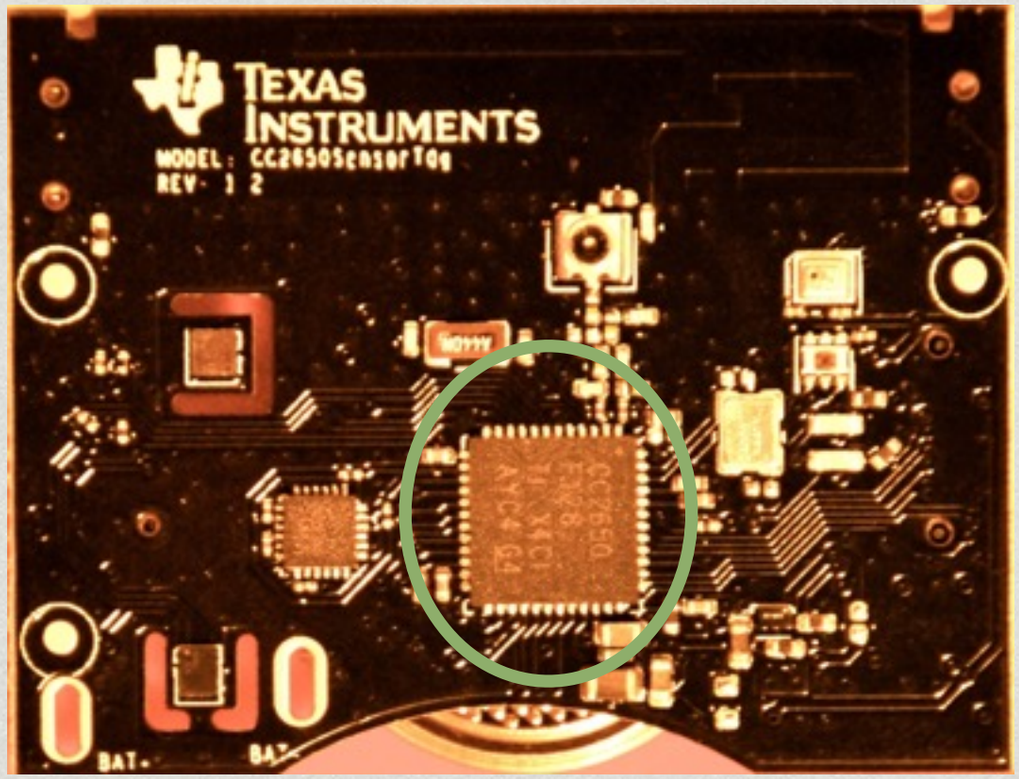


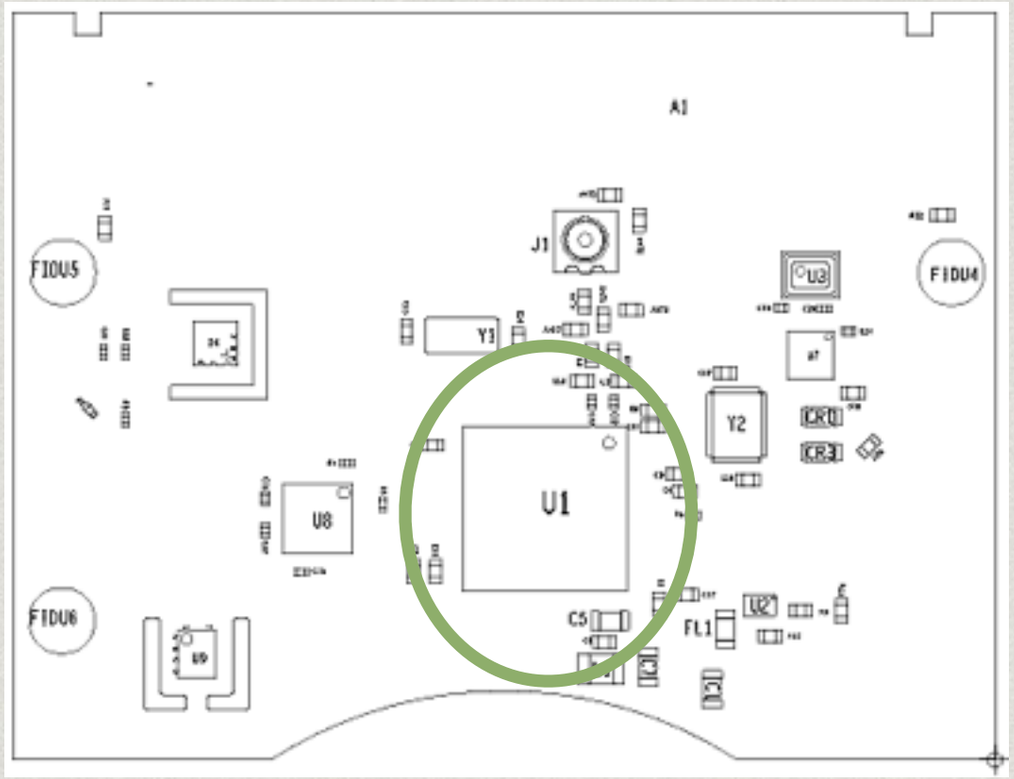
INPUT / OUTPUT:
CONNECTOR COAX RF
HIROSE MS-156HF
1: $0.76
100: $0.504
500: $0.48



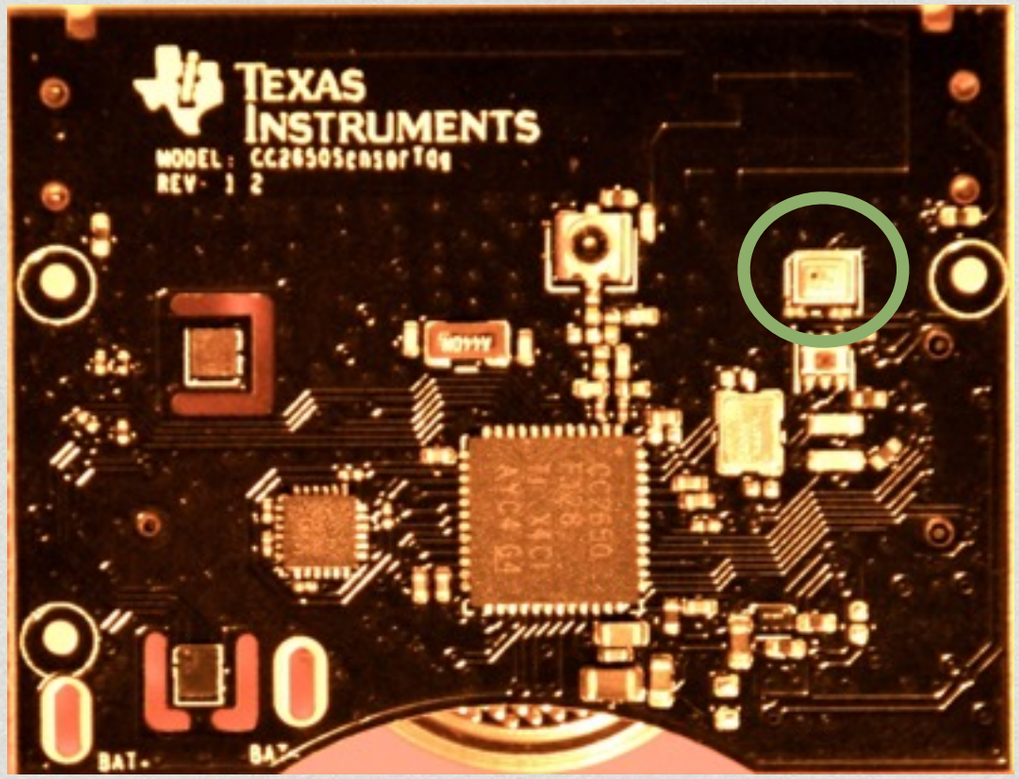


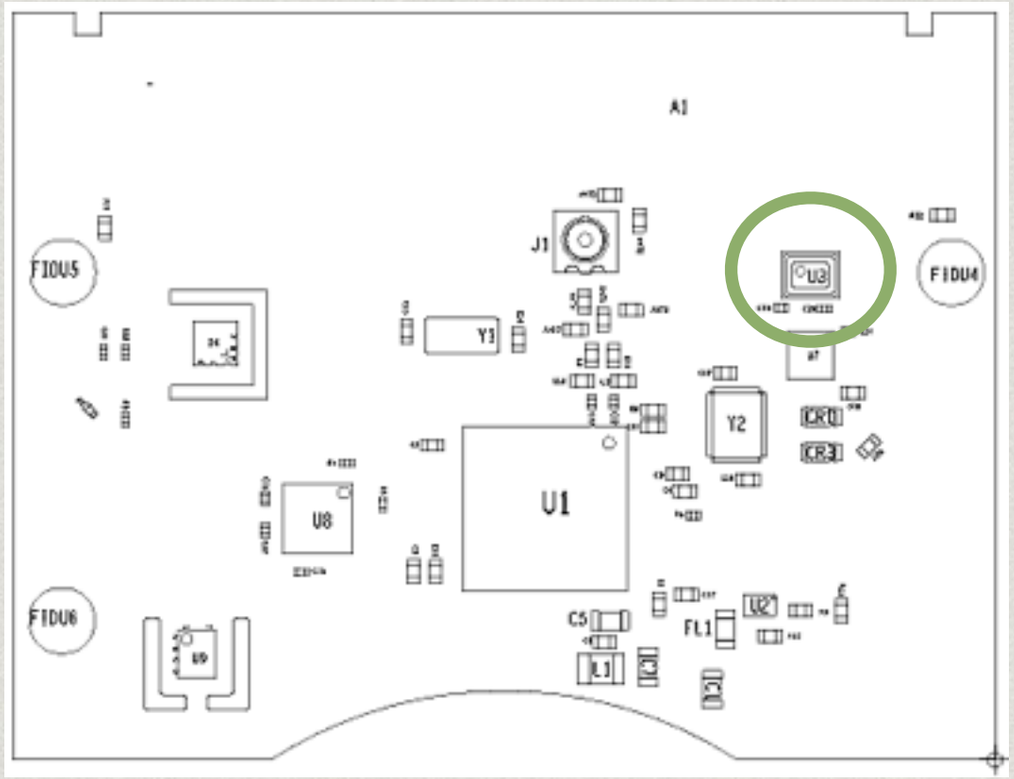
TRANSCEIVER:
2.4GHz INVERTED F ANTENNA
TEXAS INSTRUMENTS DN007
Unknown pricing



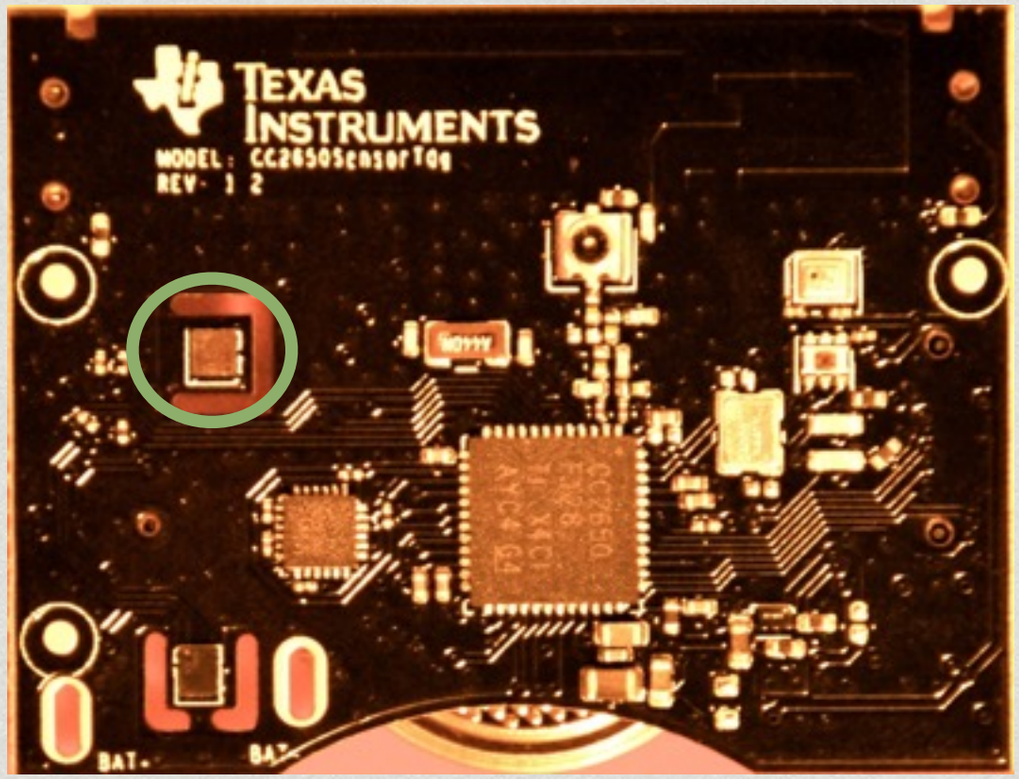


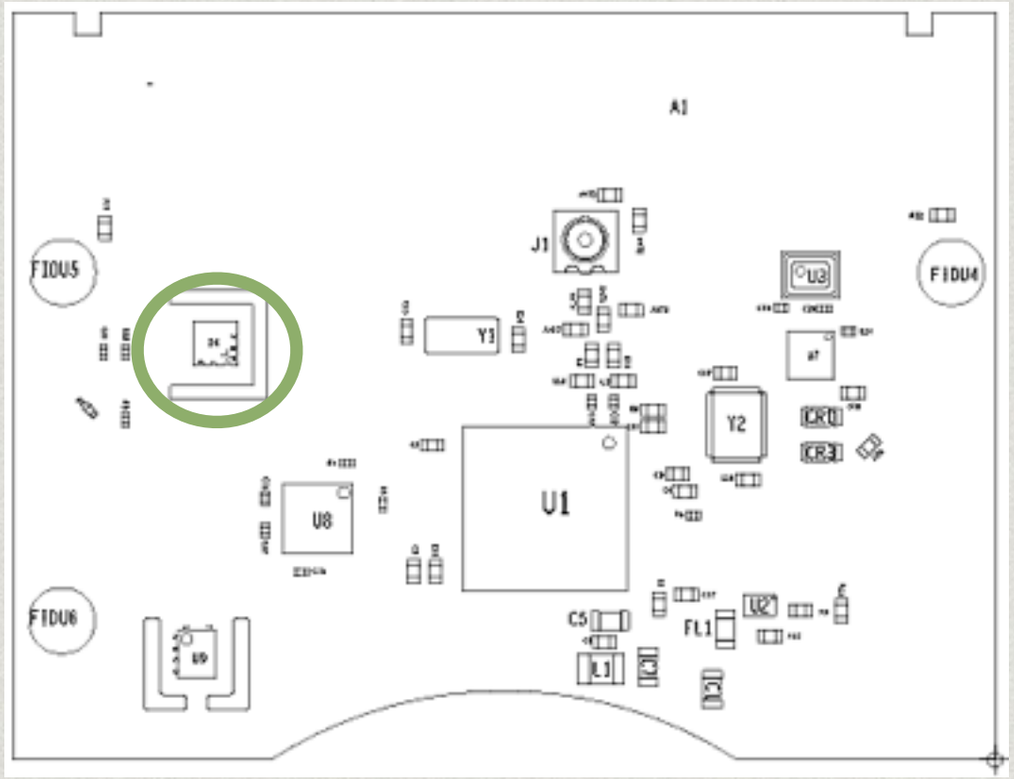
MICROCONTROLLER:
ARM CORTEX M3
TEXAS INSTRUMENTS CC26xx_7x7_QFN48
1:$16.68
100:$12.90



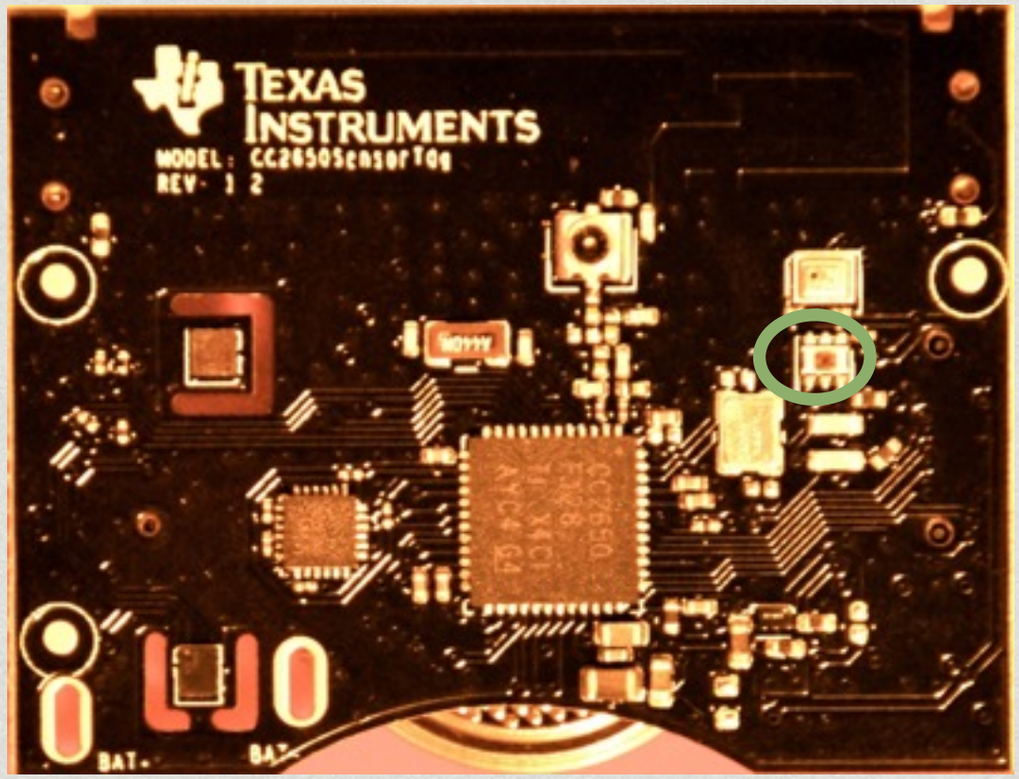


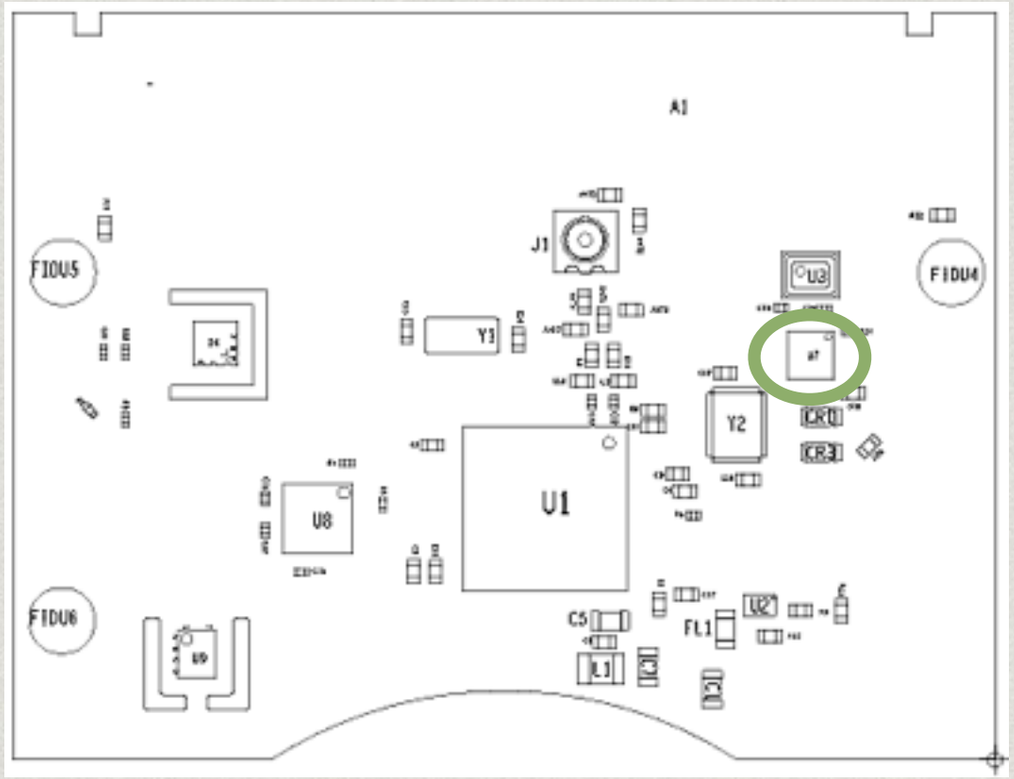
SENSOR:
TRANSDUCER PRESSURE
BOSCH BMP280
1:$2.83
100:$2.19
500:$1.87





SENSOR:
INFRARED THERMOPILE
TEXAS INSTRUMENTS TMP007AIYZFR
1: $6.40
100: $3.47
500: $2.91





SENSOR:

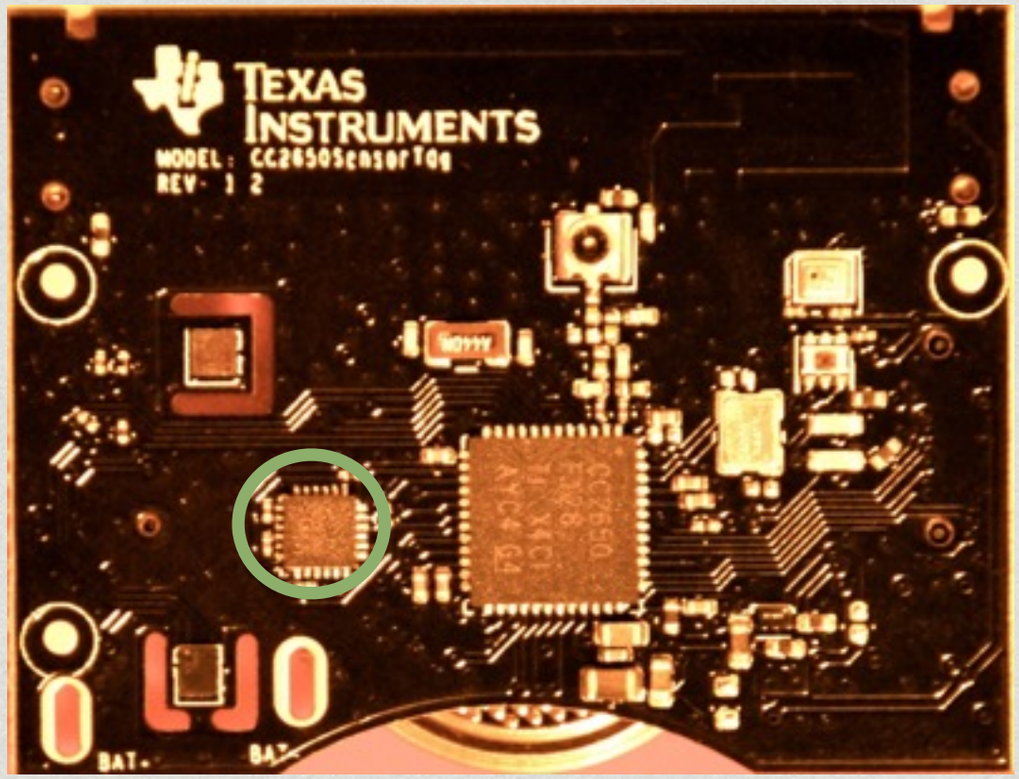
LIGHT SENSOR

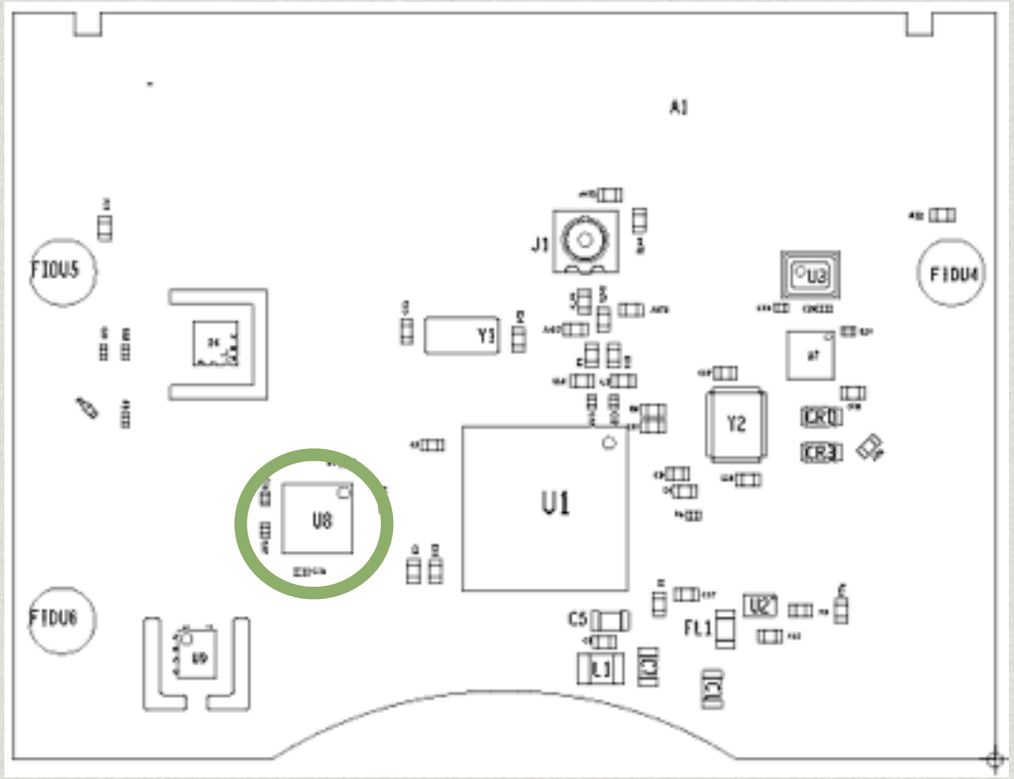
TEXAS INSTRUMENTS OPT3001

1: $3.43

100: $1.86

500: $1.56





SENSOR:

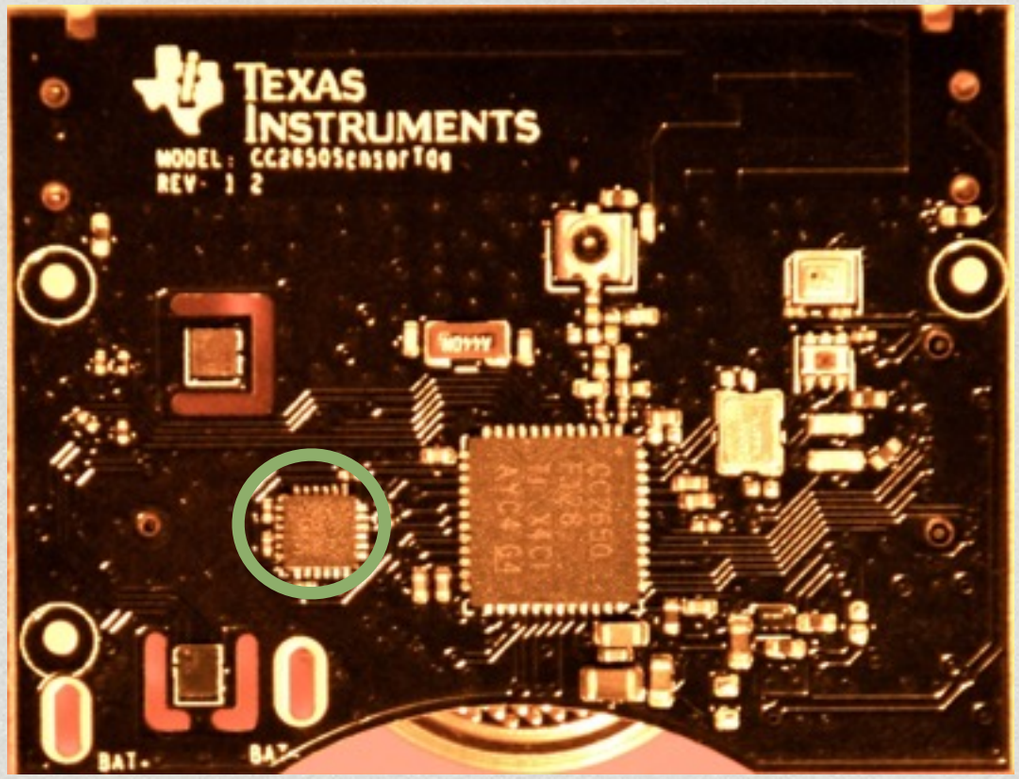
GYRO + ACCELEROMETER + COMPASS

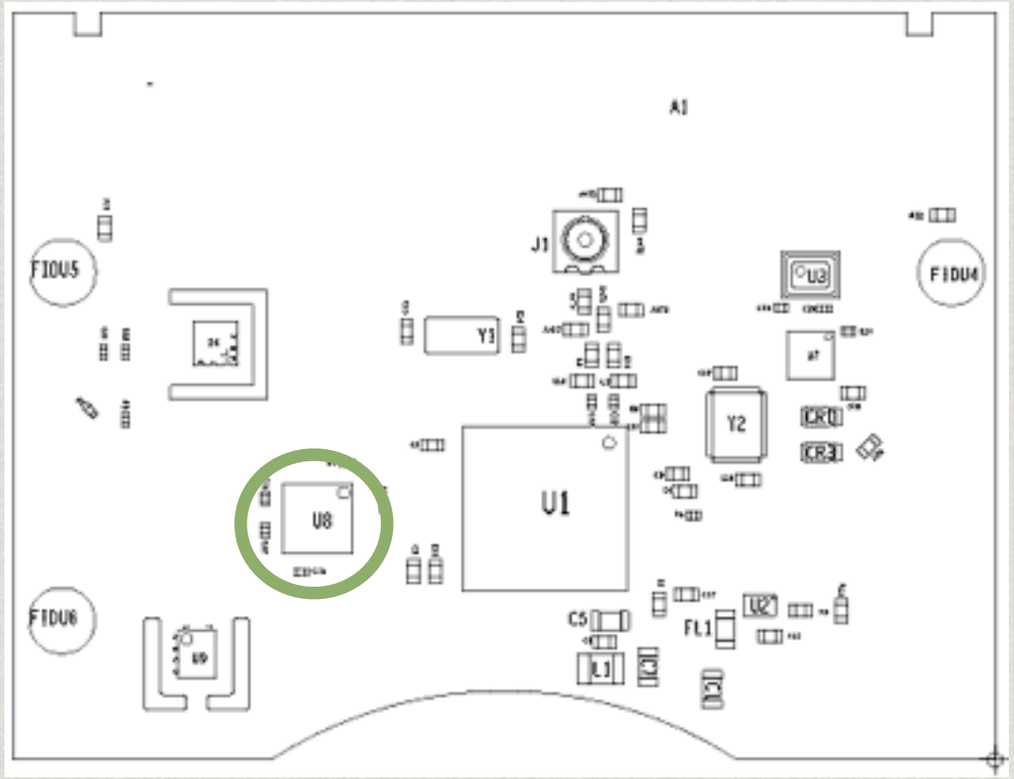
INVENSENSE MPU-9250

1: $12.82

100: $7.19

500: $6.74





SENSOR:
HUMIDITY AND TEMPERATURE
TEXAS INSTRUMENTS HDC1000YPAR
1: $5.25
100: $3.85
1000: $2.48

Hands-on with the Sensor Tags

The Id is the number on the sensor tag and the UUID is the unique identifier of the device.

Id	UUID
2	55415FFD-
3	1E15A87F-
4	131DF018-
5	ACA88192-
6	4291AFD6-
7	355BA112-
8	DB4A28DD-
9	D4BB6653-
10	3DB136E5-