ECGR-6185
Advanced Embedded Systems

Wireless Sensor Network for pH Sensing

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Sensor Network for pH Sensing

- Introduction.
- Architecture.
- Working.
- Application.

Introduction

- An aqueous sensor network is described consisting of an array of sensor nodes that can be randomly distributed throughout a lake or drinking water reservoir.

- The data of an individual node is transmitted to the host node via acoustic waves using intermediate nodes as relays.

- Each node of the sensor network is a data router, and contains sensors capable of measuring environmental parameters of interest.

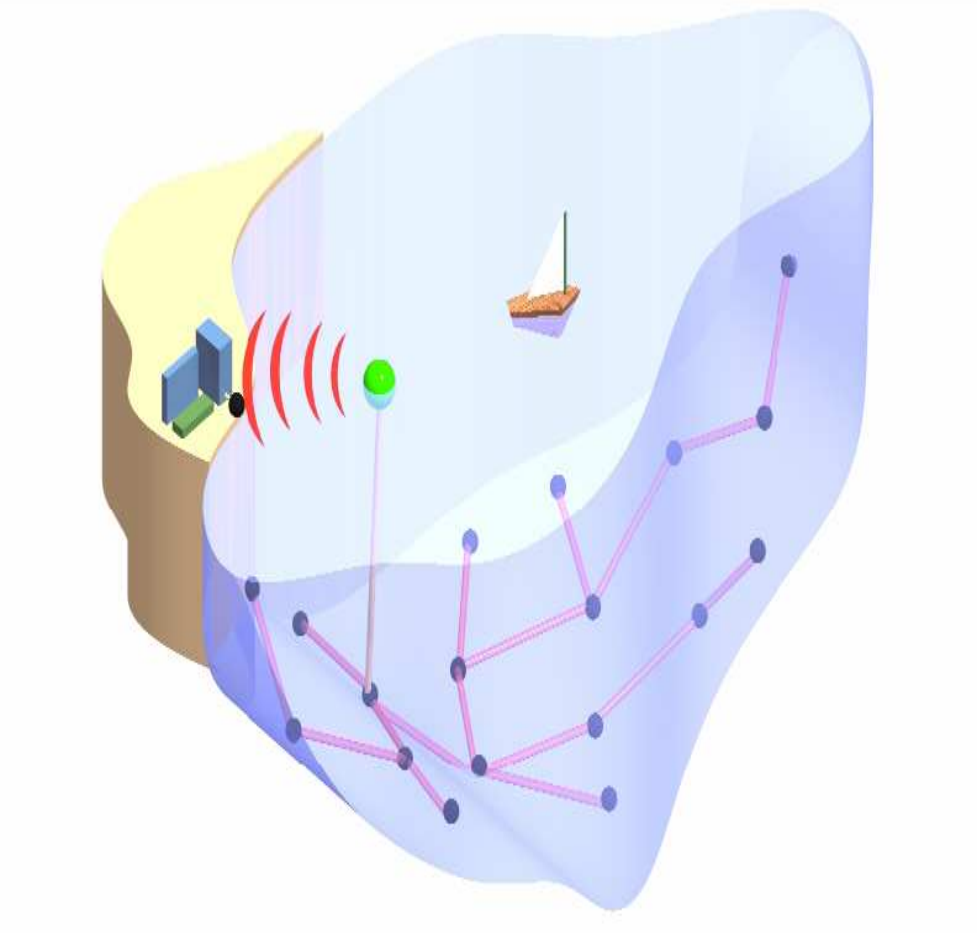
Introduction

Three types of nodes:-

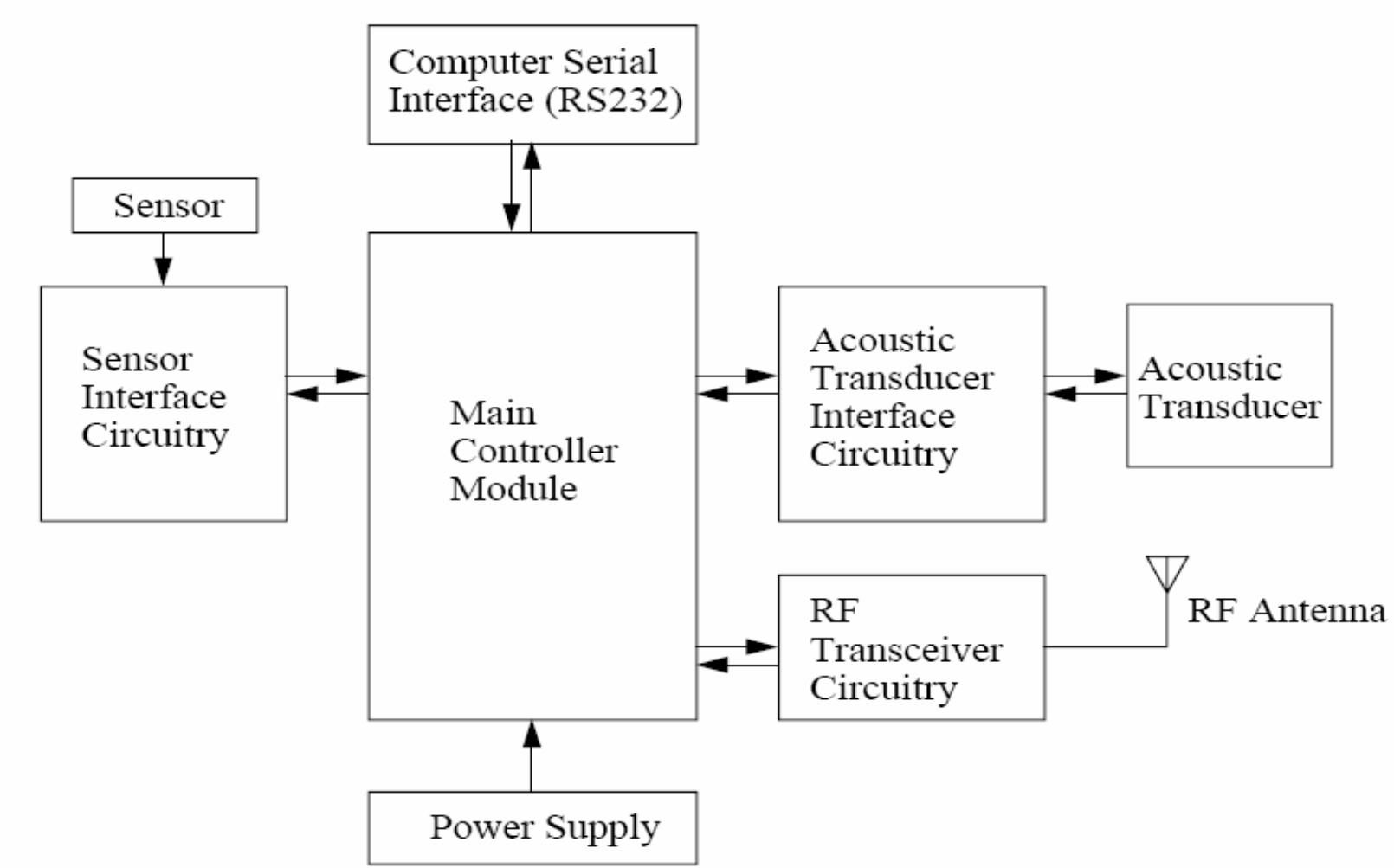
- General nodes: They are simply dispersed in water.
- Host node: It is placed on land & physically connected to a computer and uses a RF transceiver for wireless communication.
- Uplink node: The uplink node (floating green sphere) transfers information across the water/air boundary, using a RF transceiver to communicate with the host node, and acoustic transducer to communicate with the submerged nodes.

Introduction

- The nodes (blue spheres) are scattered throughout the lake and communicate acoustically (red lines).
- The uplink node (green sphere) contains both an acoustic transducer, and a RF transceiver through which it communicates to the host node (black sphere) that is directly attached to a computer.



Block Diagram



Explanation of Block Diagram

- The critical components are the main controller module that oversees the sensor node operation.
- The acoustic transducer interface circuitry that amplifies and modulates the output and input signal to/from the transducer.
- The sensor interface circuitry that converts the raw sensor signals to digital information, and the power supply.

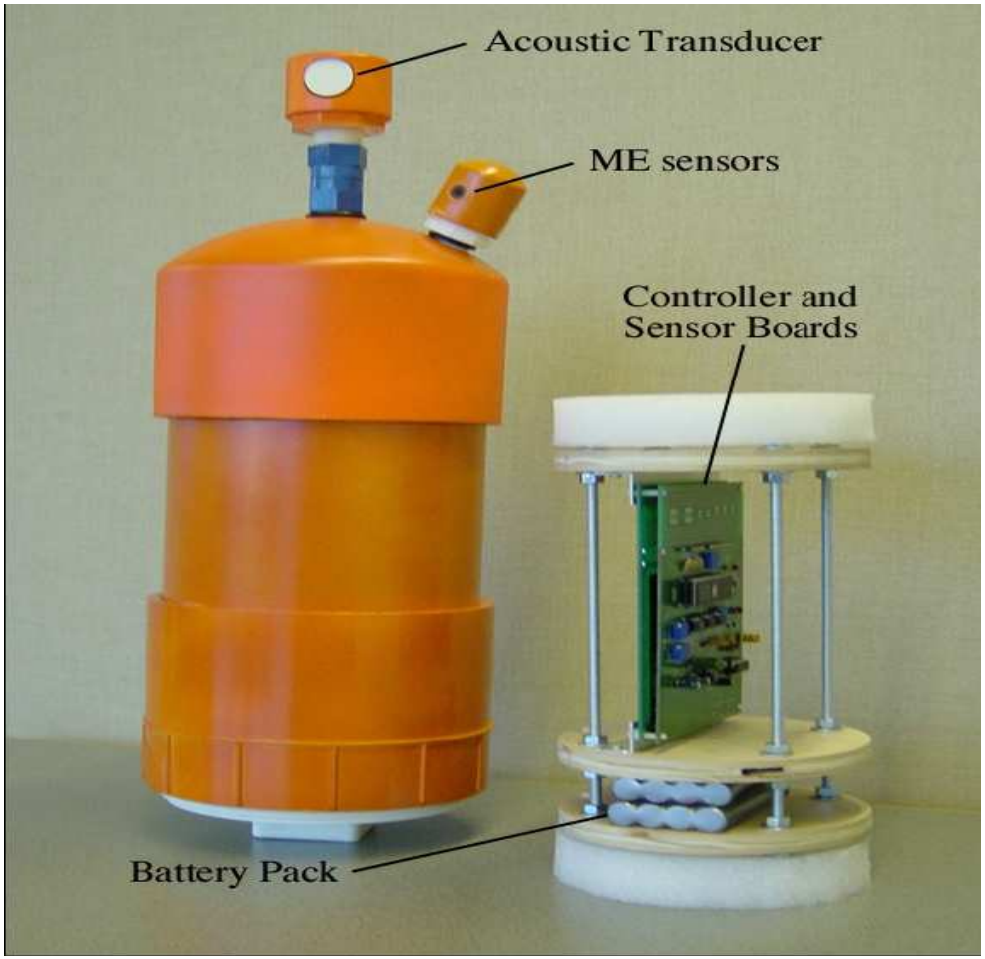
Explanation of Block Diagram

- Although the nodes can be equipped with different types of sensors in this work they are equipped with magnetoelastic sensor arrays to monitor ambient pH.

- The host node contains only a RF transceiver, and communicates with the computer via RS232 protocol.

- The uplink node contains both RF and acoustic transducers, while the rest of the nodes contain only acoustic transducers.

The Sensor Node

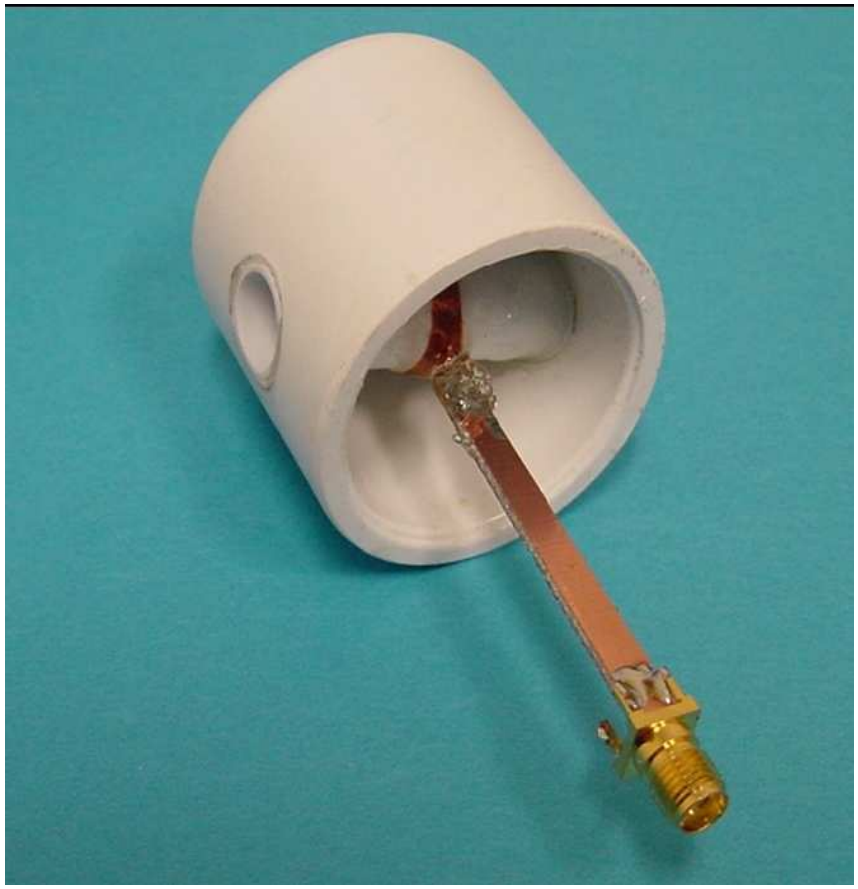


The Sensor Node

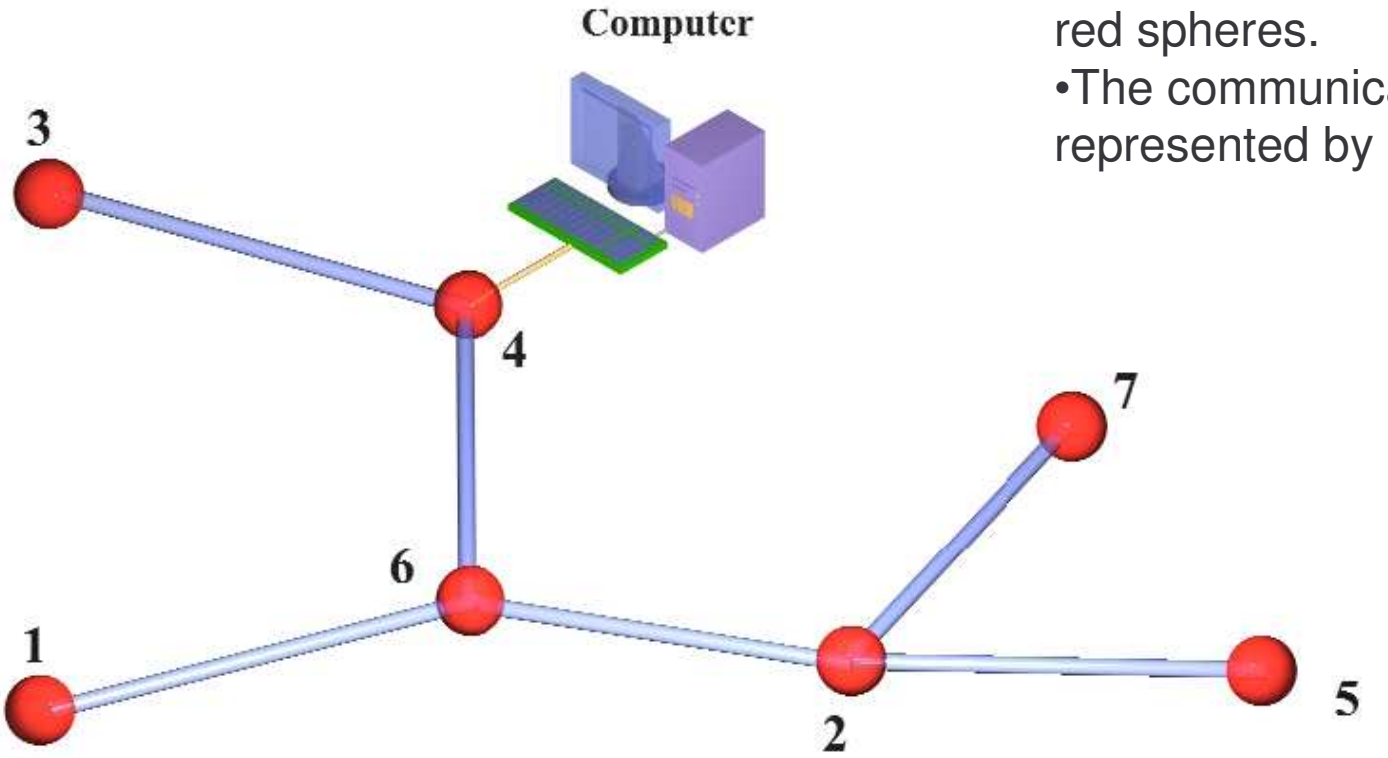
- The circuit modules and batteries are mounted on a frame that slides into the protective frame made of PVC pipe.
- Before deploying the sensor node is sealed and connected to a concrete block acting as an anchor.
- The acoustic transducer is mounted inside a PVC cap, with its front end exposed to water.

The Sensor Node

- The magnetoelastic sensor array is mounted within an open pipe, fitted through a 3 cm in diameter PVC cap, through which water flows.
- A 100-turn loop of 40 gauge wire is wrapped around this open pipe, creating in effect a solenoid, which is used to transduce sensor information.



Aqueous Sensor Network Design



- The nodes are represented by red spheres.
- The communication links represented by blue lines.

Aqueous Sensor Network Design

- To establish a network, the host node first sends out a broadcast signal containing its identity, which is 4.
- The signal is modulated using on-off modulation scheme.
- The data is encoded with one-byte-to-twelve-bits conversion before transmission.

Aqueous Sensor Network Design

- The broadcast signal format is:

Preamble	Start	Length	To	From	Command	Level	Checksum
CC	C0	06	00	Node ID	01	01	XX

Aqueous Sensor Network Design

- The first byte of the broadcast signal is *Preamble*, which is always CC in hex decimal. It is used for the receiver to synchronize (lock) to the frequency of the signal.

- The preamble is followed by *Start*, which is always C0, to indicate the beginning of the actual data.

- the *Length* field shows the length of the data.

- Since the host does not know the specific target of its initial broadcast transmission, the *To* field of the data is set to zero.

Aqueous Sensor Network Design

- The identity of the node is stored in the *From* field.
- The *Command* field is set to 01 indicating this is a broadcast signal.
- The *Level* field indicates the number of nodes this broadcast signal has passed through, with the host node starts at 1.
- The *Checksum* field is used for error detection.

Aqueous Sensor Network Design

An acknowledgement signal back to the host to indicate that the node has received the host's broadcast signal:

Preamble	Start	Length	To	From	Command	Checksum
CC	C0	05	Sender ID	Node ID	X3	XX

Aqueous Sensor Network Design

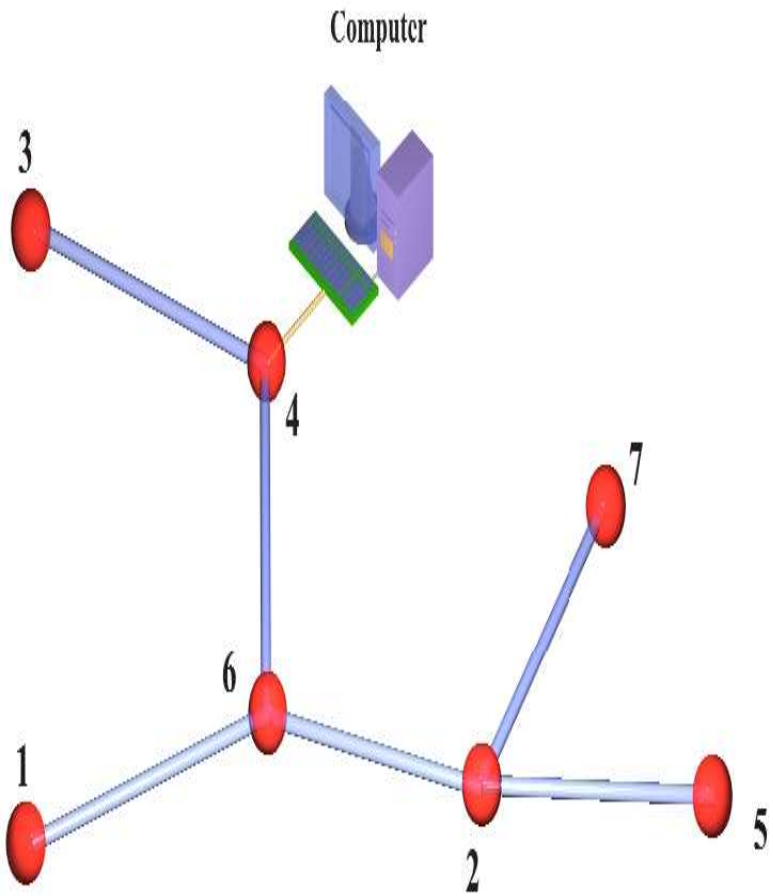
- The *Preamble*, *Start*, *Length*, *From*, *To*, and *Checksum* fields are identical to the broadcast signal.

- In the *Command* field, ‘3’ indicates this is an acknowledgement signal and the X in *Command* field is the sequence number, which is toggled between 1 and 0 per each successive transmission.

- The sequence number is important for the node to know if its acknowledgement signal is received correctly by its parent node.

Aqueous Sensor Network Design

- Note that when Node 6 sends out a broadcast signal, Node 3, which is at the same hierarchical level as Node 6, will also receive it.
- To avoid confusion each node is programmed to accept only signals from a node of higher level.
- Hence, the broadcast from Node 6 will be ignored by Node 3 and the host node.



Aqueous Sensor Network Design

- After all nodes know the identity of their parent nodes, they will acquire sensor data and transmit it at a predetermined time interval. The relayed sensor data has the form of:

Preamble	Start	Length	To	From	Command	Data	Checksum
CC	C0	XX	XX	XX	X2	XX....	XX

Aqueous Sensor Network Design

- The *Preamble*, *Start*, *Length*, *To*, *From*, and *Checksum* are identical to the broadcast signal.
- The '2' in *Command* field indicates this transmission contains sensor data.
- To know the origin of this sensor data, The *Data* field starts with the identities of the nodes that relay the data, followed by a byte of zero, and then the actual sensor data.
- For example, when Node 6 relays Node 7 data to Node 4, the
- *Data* field is:

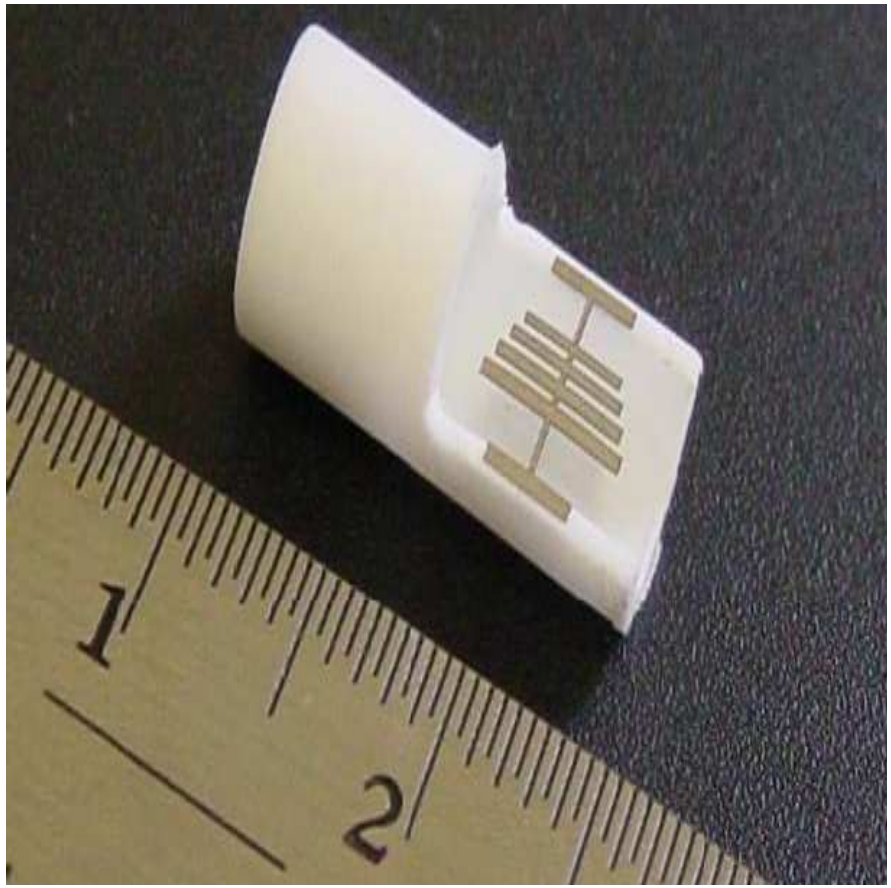
Data				
07	02	06	00	Sensor Data

pH Sensing

- To measure pH independently of background salt concentrations, one sensor element is coated with poly(3-sulfopropyl methacrylate-co-isooctylacrylate), abbreviated pSPMA-IOA, a strong polyelectrolyte gel the swelling/shrinking of which is dependent on solution salt concentration and independent of pH.

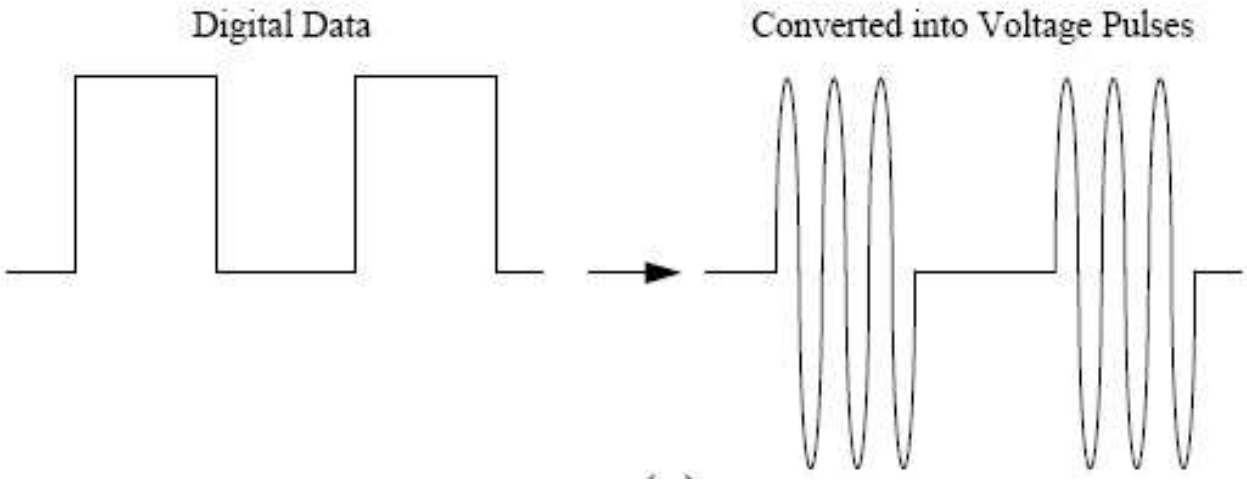
- Another magnetoelastic element is coated with poly(acrylic acid -coisooctylacrylate), abbreviated pAA-IOA, a pH responsive polymer described earlier that also responds to ambient salt concentration levels.

- Cross correlation between the frequency responses of the polymer coated magnetoelastic elements enables an absolute determination of pH.



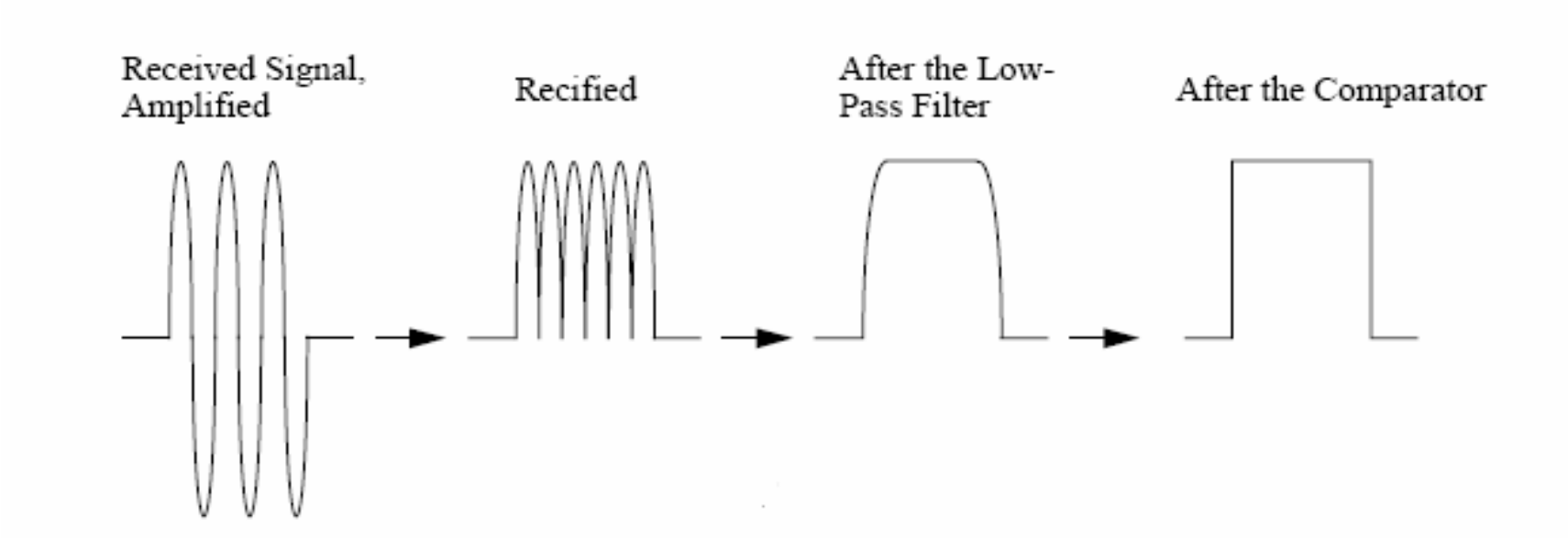
pH Sensing

- A sensor interface circuit is used to convert the measured resonant frequency of a magnetoelastic sensor, the parameter of interest, to a digital signal compatible with the hardware of the aqueous sensor node.



pH Sensing

- The received signal is first amplified and rectified.
- Then high-frequency component of the rectified signal is filtered, and the digital state carried by the signal is extracted by passing through a comparator.



Applications

- Beyond ensuring drinking water safety, possible applications for the aqueous sensor network include:
- Advanced industrial process control.
- Monitoring of aquatic biological communities.
- Monitoring of waste-stream effluents.
- Moreover it is tremendous tool for biologists seeking to monitor the temperature, flow characteristics, and chemical environment of aquatic communities.

References

- **Design of a Wireless Sensor Network for Long-term, *In-Situ* Monitoring of an Aqueous Environment.**
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- **A wireless micro-sensor for simultaneous measurement of pH, temperature, and pressure.**
  http://www.ee.psu.edu/grimes/publications/pH-usensor.pdf

- **Magneto elastic sensors.**
  http://www.iop.org/EJ/abstract/0964-1726/10/2/322

Any Questions?

Thank You