Wireless MEMS Sensor Platform Compatible with Cell Phones and Laptops

Doug Sparks

Integrated Sensing Systems Inc. (ISSYS)

391 Airport Industrial Dr Ypsilanti, MI 48198 USA 734-547-9896 ext 119 <u>www.mems-issys.com</u> <u>dsparks@mems-issys.com</u>



Outline

1. Traditional Wireless Sensors

- 2. New Wireless Sensing System
- 3. Examples at ISSYS
- 4. Other Applications

5. Summary



Traditional Wireless Sensors

Historically wireless sensor networks and systems often are customized sensors and electronics, some with low powered ASICs for the electronics



ISSYS' Wireless Pressure Sensing System

Two system components:

- Implantable pressure sensor(s)
- External handheld readout unit



Bio-pressure measured by the implant is read with handheld tester using RF telemetry





System Overview



Sensor Placed in Left Ventricle

ISSYS vs Millar Catheter Comparison 56 Days Implant Left Ventricle Apex



Time (sec)





Potential Implant Applications

Human body is considered by many medical experts simply as an advanced biological pluming system. As a result, knowing the pressure and flow in many places in the body is of significant medical value



Traditional Wireless Sensors

While traditional wireless sensor networks and system fill useful niches, the customized nature of the system slow wide spread use of this technology



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4 Elements of the New Wireless Sensor Network

- 1. Sensor Element in a relatively simple, low cost package
- Communication Portal standard laptop or cell phone
 Provides wireless antenna, display, power, keypad
- 3. Interface Software App, CD or downloaded software for a laptop
- 4. Conventional, existing wireless & wired networks



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Multiple Communication Nodes and Data Transmission Paths





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Implementing the New Network



- 1. Existing sensors with USB data output and power
- 2. Custom sensors designed around the new concept





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ISSYS' First Application: Density & Chemical Concentration Sensor

Density sensors are being used for monitoring the quality of jet fuel, petrochemicals, beverages



MEMS sensors offer a small, light-weight option for density sensing and chemical concentration. They are used in methanol fuel cells.





Resonant Silicon Microtube Technology

Silicon tubes are formed using micromachining processes such as wafer bonding, wet and plasma etching.



Density Sensing Principle: The resonant frequency of the tube is monitored, when fluid is injected into the tube, the mass and hence resonant frequency changes.



Fuel Type & Quality Monitoring **Using Density**

Fuel / Fluid	Density Range (gm/cc)]
Air	0.00122	
Gasoline	0.725-0.775	
E85	0.775-0.782	
Ethanol	0.7856]
Butanol	0.8095	
Fisher Tropsch		
"diesel"	0.784-0.801	
Diesel	0.822-0.860	
Biodiesel	0.860-0.900	
Water	0.99904	

Density ranges of various liquid fuels and fluids.



Can detect water, air bubbles and the incorrect fuel type and be used for fuel blending

ISSYS FuelSense[™] Application: Fuel Custody Transfer



Aviation Fuel Truck & Tank Farm

Density sensors are being used for monitoring the quality of fuels, fuel type and for blending. Portability to monitor gasoline/fuel tanks and stations was a driving force for this wireless sensing approach



Measuring Chemical Concentration With a Density Sensor



Methanol – Water over Temperature







"Conventional" USB Powered Sensors



These somewhat traditional sensors can be put on the new wireless sensing network.

Many conventional sensors now have USB outputs and can even be powered by the USB alone. However they still carry the bulk and cost of the traditional display, buttons, keypad human interface.





Pressure & Temperature Add-Ons





External temperature sensor allows the process chemical temperature to be monitored in the center of large diameter pipes. External pressure sensors enable the technology to be used with gases for density and concentration measurements. These can still be USB powered. This expands what sensor data can be wirelessly transmitted or downloaded for later retrieval and transmission



Light Gas Sensing – Hydrogen, Methane



Sensors Expo 2011, Chicago, IL, June 6-8th, 2011 Low Pressure Hydrogen





This is unique sensing technology at these low pressures with hydrogen fuel and hydrogen fuel cell applications.

Heavy Gas Sensing – SF₆





Use to monitor gas insulated, high voltage switches/transformers

Light Gas Concentration Sensing





Used in air-fed, hydrogen fuel cells

Existing Sensors on a Network

A subset of existing sensors can be added to the new wireless network. However there is a cost and size penalty associated with the sensor housing and interface.





Putting a Minimized Density Sensors onto the New Wireless Network





Changed the small embedded density sensor into a simple USB powered device that replies on the laptop for power, the human interface and communication



USB Powered - Laptop Interface Sensor

First ISSYS mobile application – fuel quality monitoring

The sensor has been stripped down to the bear minimum to save cost and size. The PC provides all of interface capabilities.

Data can be sent wirelessly or over landlines. It is also stored and processed on the laptop.







Sensors Expo 2011, Chicago, IL, June 6-8th, 2011 **External User Interface**



Key Board /Screen–User interface can also be taken off of the sensing unit. It is part of the laptop / cell phone

Display offers a richer user interface environment that an on-sensor LCD display can provide



USB Powered Density, Viscosity, Concentration, Temperature Meter



Need a 2 tiered interface: 1. Engineer/Scientist 2. Technician

Data Storage on Laptop / Cell Phone





Memory – data storage can also be taken off of the sensing unit. It is now stored on the laptop / cell phone



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Cell Phone Implementation

Cell phone already have embedded accelerometers, cameras and gyroscopes. Chemical sensors and microfluidic devices require an external device.

Cell phones can be used like laptops to perform the wireless communication platform for the density or other sensing element(s).





Mini-USB Connectors

Cable interface for liquids



Sensors Expo 2011, Chicago, IL, June 6-8th, 2011 Laptop to Smart Phone Transition

Must simplify the display detail and user interface when converting from the laptop environment to the smart phone display and interface environment.



App options and operating systems are more diverse than what is needed for laptops: Apple OS, RIM, Symbian...











This opens up the technology to a wide variety of applications

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Other Wireless Sensor Applications

ISSYS has traditionally serviced microfluidic markets, but this concept can apply to a variety of monitoring and sensing application, including but certainly not limited to:

- <u>Medical Conditions</u> testing blood, urine, (for exampleglucose in blood or urine, white and red blood cell count, cytometry) saliva, breath, bodily fluids, antigens, pathogens, cells, genetic testing -DNA, RNA
- <u>Homeland Security / DoD</u> biohazards, explosives, radiation – Geiger counter, chemical toxins, pathogens. Leverage the wide area coverage of existing cell phone used by first responders and others.

The detection systems required will not be incorporated onto a cell phone PCB, but can integrated externally with this type of approach.



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Long-Term Remote Wireless Monitoring

Batteries can provide power but for long-term wireless monitoring, a modified AC adapter can provide power. This is key for chemical, bio-agent, seismic and radiation sensors.





Smart Phone Considerations

App availability – Keep the App proprietary to customers only (high price instrumentation markets)? or offer them in an open App Store format (pervasive personal sensors – blood glucose, blood alcohol, urology, pathogen detection, etc.)?

OS support & development – many cell phone platforms use different operating systems. They may have some shared core software but will require some custom software work.

Small display versus laptop – just like laptop software requires a service engineer versus simple user interface, a smart phone's screen size and resolution needs to be taken into account.

Integration with GPS, motion sensors and cameras already in cell phones for expanded sensing and tracking capabilities. Example: GPS assisted tracking of dispersed pathogens







Sensors Expo 2011, Chicago, IL, June 6-8th, 2011 Summary- MEMS Sensing Elements: Ideal for Ubiquitous Sensing Networks

Microfluidic sensors, optical & IR sensors, capacitive piezoresistive and piezoelectric sensors elements, SAW sensors, gas chromatography sensors, massbased resonating systems, magnetic and radiation detectors all lend themselves to this wireless sensing approach.





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