Wireless Sensor Network for Aircraft Health Monitoring

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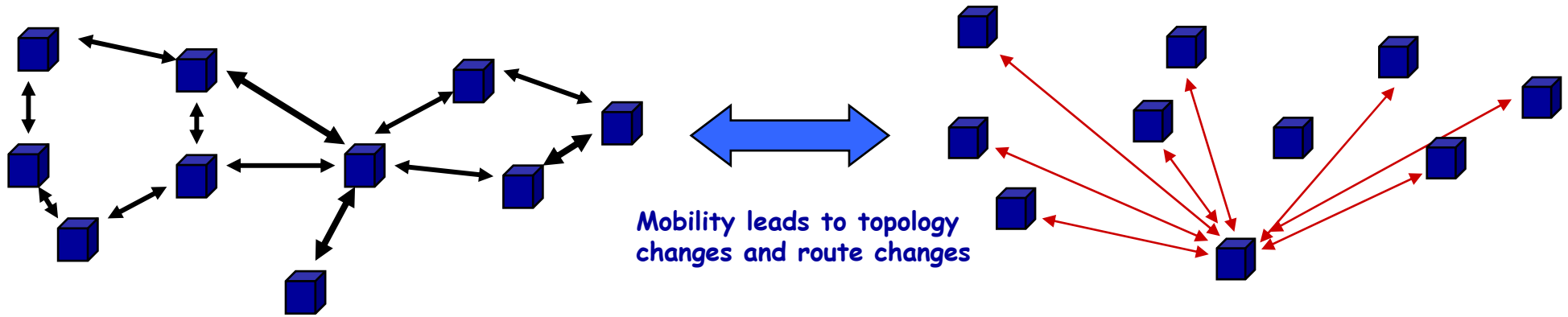Email: haowei.bai@honeywell.com

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Ad-Hoc Sensor Network

**Mobility leads to topology changes and route changes**

Characteristics

- Each node generates independent data.

- Power is the driving constraint.

- Source-destination pairs are chosen randomly.

- Topology is dynamic.

- Routing could be multihop.

- Need to allocate resource dynamically (rate, power, bandwidth, routes, etc).

Design Challenges

- Limitations of the Wireless Network
  - packet loss due to transmission errors
  - frequent disconnections/partitions
  - limited communication bandwidth
  - Broadcast nature of the communications
- Limitations Imposed by Mobility
  - dynamically changing topologies/routes
  - lack of mobility awareness by system/applications
- Limitations of the Mobile Computer
  - short battery lifetime

Our Proposed Solutions

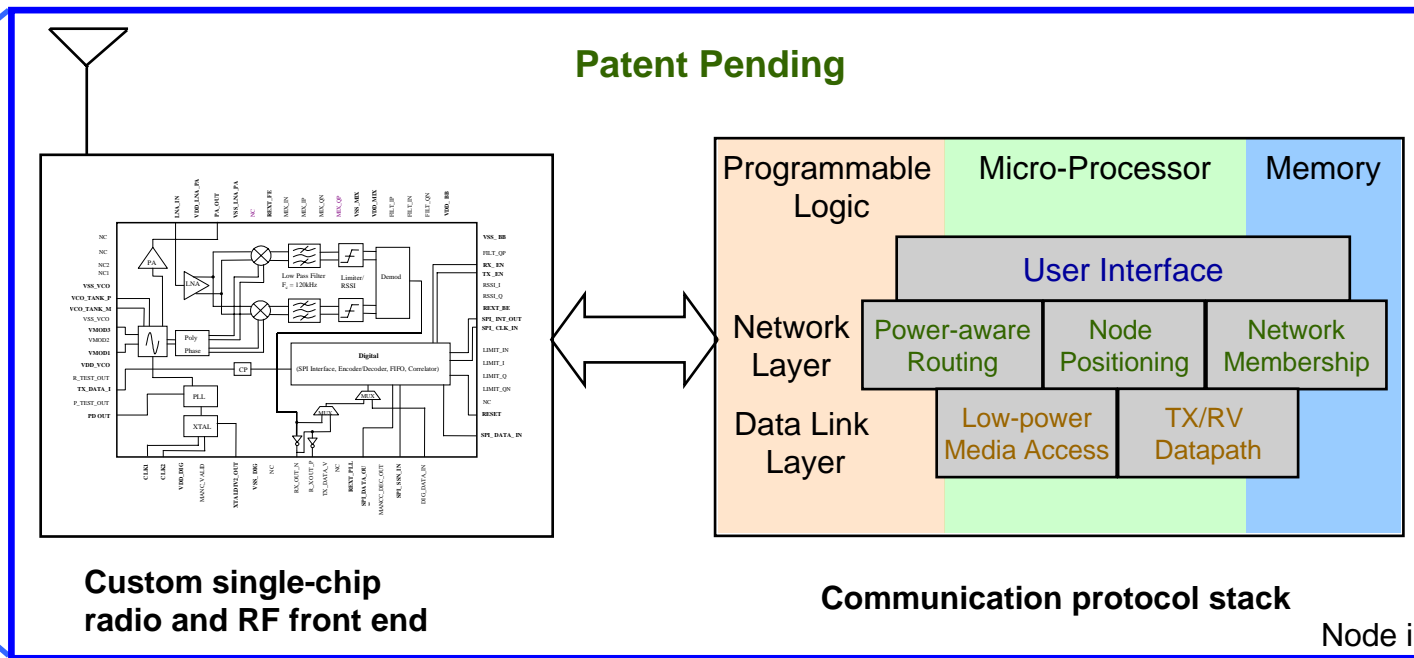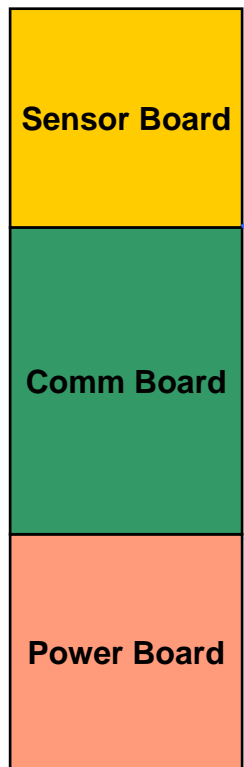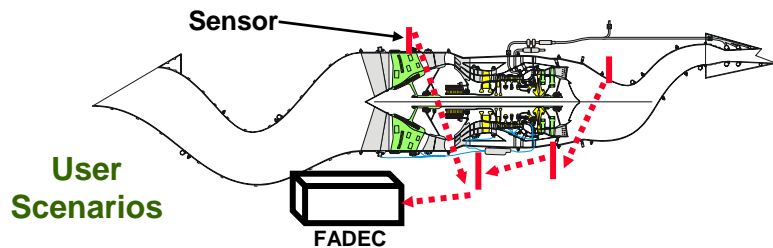|	Issues	Proposed Solutions
Limitations of the Wireless Network	Packet loss due to transmission errors	Error control and anti-interference (FHSS, OFDM)
	Limited communication bandwidth	Using high data rate RF technology, e.g., IEEE 802.11a/b
	Broadcast nature of the communications	MAC protocol in Ad Hoc Networks
Limitations Imposed by Mobility	Dynamically changing topologies/routes	Ad Hoc routing
	Frequent disconnections/partitions	MAC, Network addressing/membership for Ad Hoc network
	Lack of mobility awareness by system/applications	Node positioning
Limitations of the Mobile Computer	Short battery lifetime	Power-aware algorithms (power-aware routing, low-power MAC)
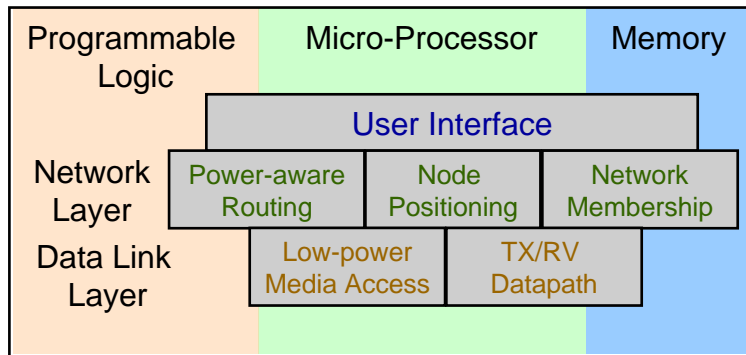
Communication protocol stack

- **Power-aware routing for Ad Hoc**: Reactive routing protocol, which starts to create routes when requested.

- **Low-power MAC**: sleep and wake-up scheme, which allows a node power itself down when it is neither sending nor receiving.

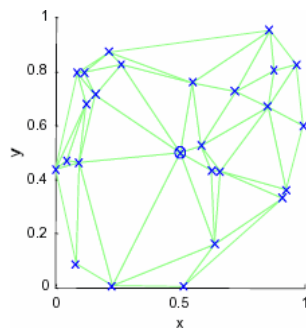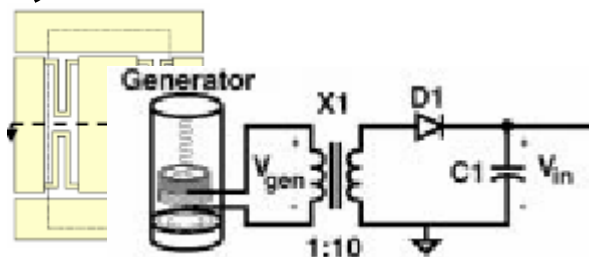- **Node positioning**: put node's location (coordinates) as part of its address.

Technologies presented here are patent pending. For more details, please send emails to haowei.bai@honeywell.com

Node Architecture of Ad Hoc Sensor Networks

- ## Concept Description

Standard Power & Communications Module

Sensor

User Scenarios

FADEC

Sensor Board

Comm Board

Power Board

Patent Pending

Node i

Custom single-chip radio and RF front end

Programmable Logic	Micro-Processor	Memory
	User Interface	
Network Layer	Power-aware Routing	Node Positioning	Network Membership
Data Link Layer	Low-power Media Access	TX/RV Datapath	

Communication protocol stack

Vibration-Powered Using MEMS Generator

Generator X1 D1

V_{gen} C1 V_{in}

1:10

Positioning

Source

Dest
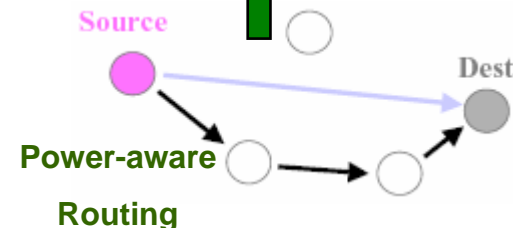
Power-aware Routing

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Honeywell Wireless Sensor Network in Harsh Env.

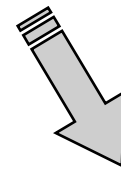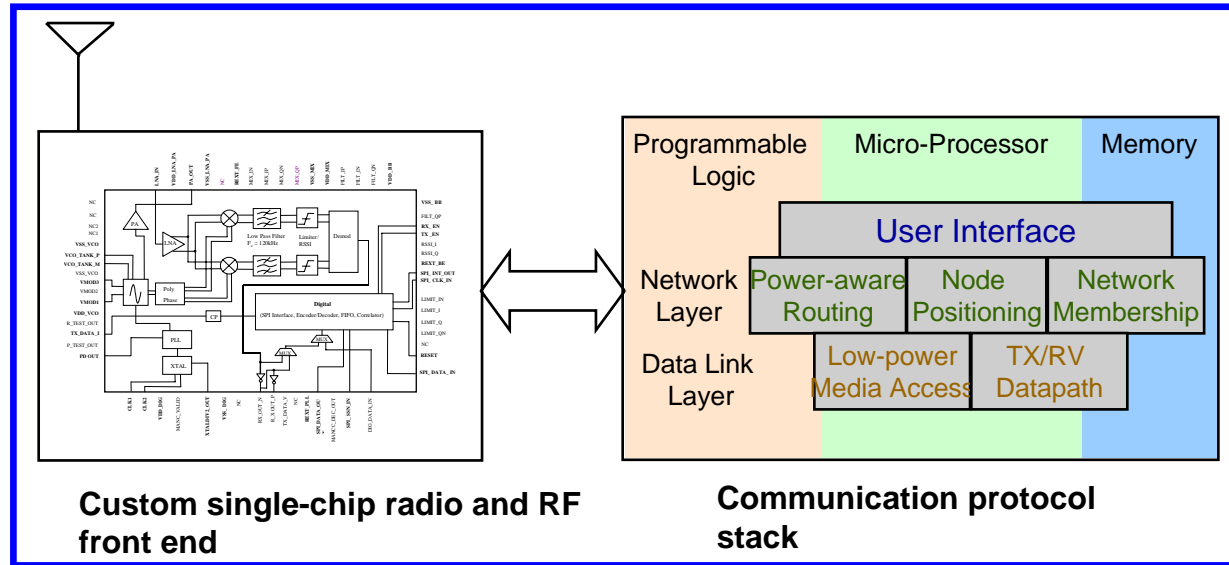Multi-chip/board wireless sensor node in our lab for industrial sensing

Multi-chip system integration

Custom single-chip radio and RF front end

Communication protocol stack

Voice of the Customer

- **High temperature capability.**
- **Less weight, improved reliability by eliminating wiring and wiring harnesses issues.**
- **More sensors onboard for predictive monitoring:**
  - **Installation cost savings (wiring costs)**
  - **Wireless sensors in places where wires are impossible (e.g., rotating shaft)**
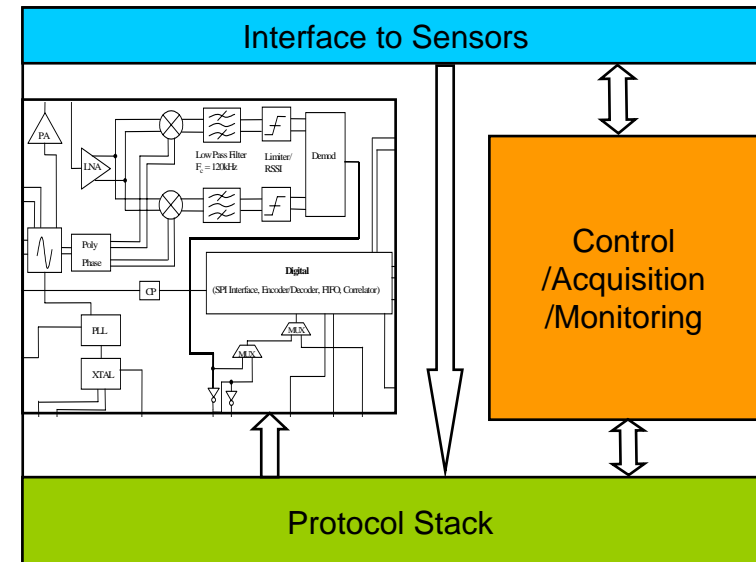 - **Network easily upgraded / modified**

Honeywell Technologies

- **SOI chip for up to 250C temperature capability.**
- **Single-chip wireless sensor node.**
- **Robust FHSS communication.**
- **Self-powered wireless sensor.**
- **Power-aware communication protocols.**
- **Node positioning capability and protocol.**
- **Node ID and authentication for comm security.**
- **Sensor network for harsh environment.**

Single-Chip Node

Technologies presented here are patent pending. For more details, please send emails to haowei.bai@honeywell.com

Custom Single-chip Radio

- **Honeywell Low Cost Single-chip RF Transceiver (GROW Chip)**

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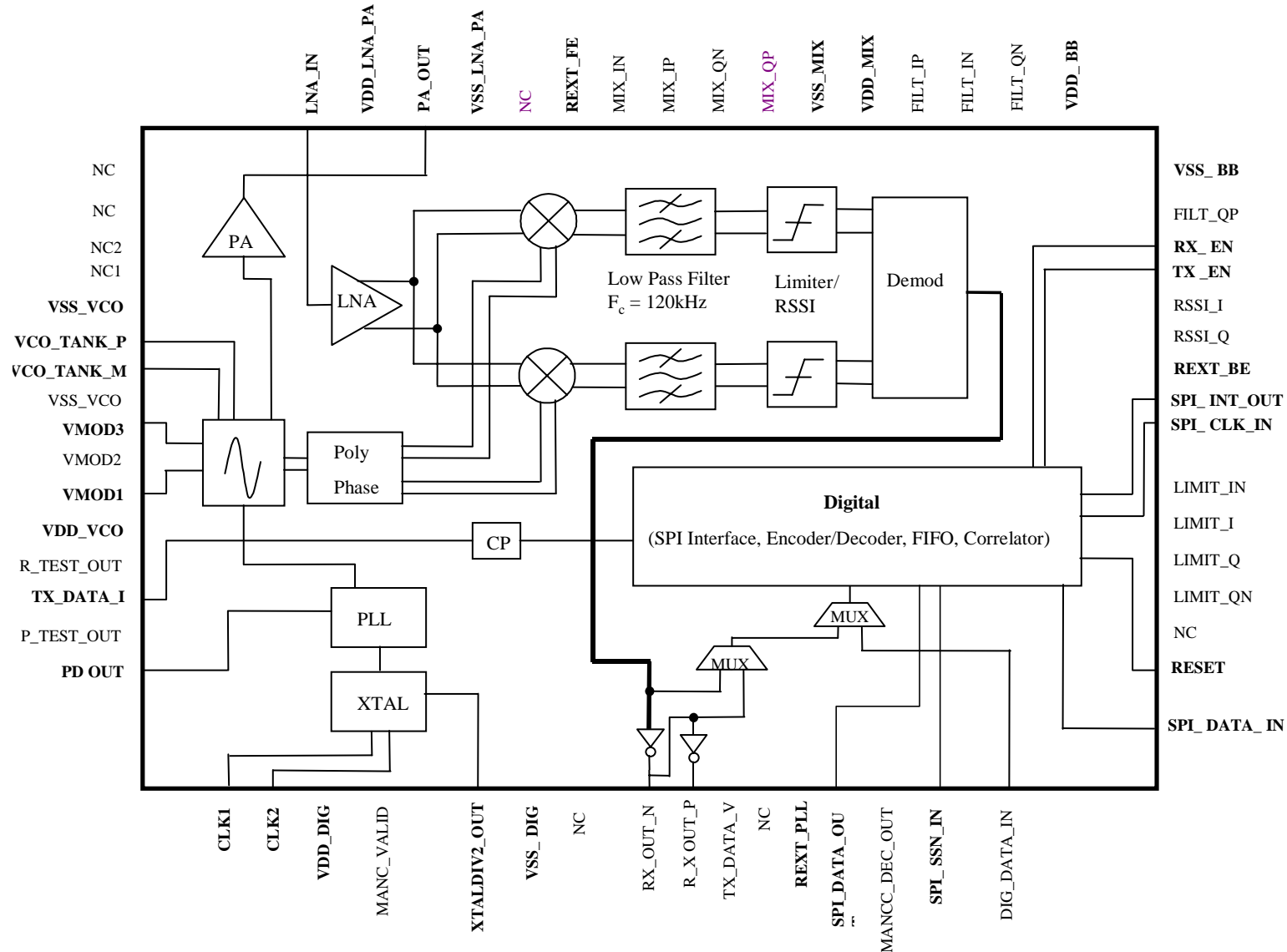
ASIC Details

Chip Size: 4.5mm x 4.5mm

PA (Power Amp)

DIFFERENTIAL BASEBAND FILTER

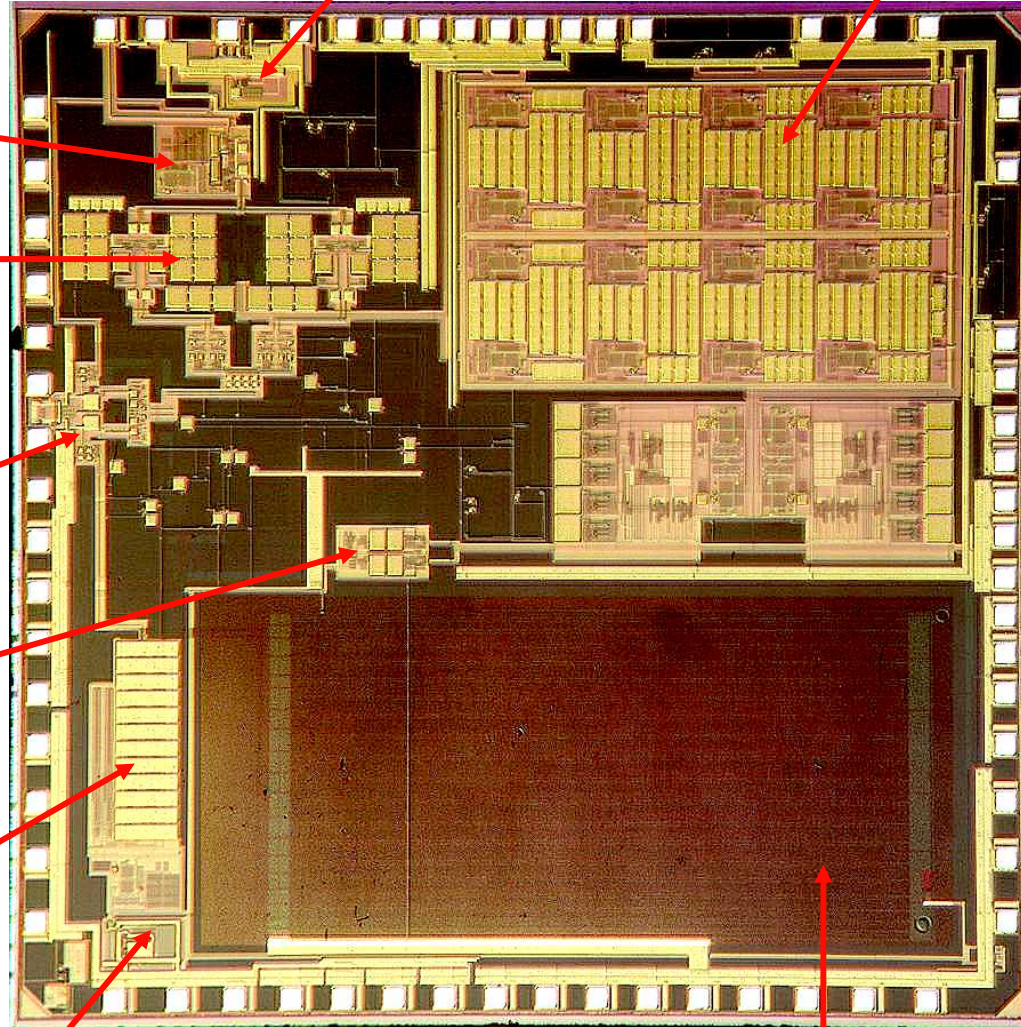LNA (Low Noise Amp)

I/Q MIXERS

VCO

DEMOD

PLL

CRYSTAL OSC

DIGITAL AND SPI

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Honeywell Single-chip Radio Main Features

RF System

- Fully integrated 418-928 MHz transceiver.

- Binary FSK Modulation.

- Lowest cost fully integrated RF solution requiring minimal external components.

- Programmable data rates up to 56 kbps.

- Programmable modulation frequency up to 2MHz.

- Adjustable Tx power levels from –20dBm up to +4dBm.

- Adjustable on-chip filters.

- Integrated PLL/VCO capable of 2kHz programmable increments.

- Integrated direct conversion receiver with –100dBm sensitivity.

- Low noise figure of Rx path ($NF_{RxSYS} < 10dB$).

- Capable of frequency agile communications.

- Received Strength Signal Indicator (RSSI) output for link quality indicator.

- Compatible with North American FCC Title 47 Part 15.

- Compatible with European ETS-300-220

- Compatible with United Kingdom MPT 1329/1340

Digital Interface and Functions

- Serial Peripheral Interface for configuration, Tx/Rx data transfer, program Tx power level, and PLL frequency.

- Digital Tx and Rx section with 64 byte FIFO

- 64 bit correlator in Rx

- Encoder and Decoder

CMOS Technology

- Low-power consumption (25 ma)

- $< 1.5\ \mu A$ standby current

- Single supply operation (3.3 - 2.4 volts).

- Mature $0.35\mu m$ CMOS fabrication geometry.

Cost Target

- Changed RF architectures to meet $5 final assembled Xcvr cost goal.
- Plastic Quad Flat Pack is initial package

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Honeywell's Position

◆ Honeywell already produces RF on a chip.

◆ Honeywell already produces secure communications.

◆ SOI is mature and proven, with additional functions and components being added from the DeepTrek DOE program.

◆ Wireless networks will allow easy addition of sensors for vehicle health management.

◆ Reduced weight by eliminating electrical harness.

Can bring Honeywell expertise in industrial wireless, mil communications and high temperature / high reliability electronics to bear on wireless sensors.

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