Radio Wave propagation in industrial environments
Stanford 30/10-2001

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Outline

- Brief introduction to ABB
- The wireless revolution; a new paradigm!
- Why wireless in industry?
- Radio wave propagation in industrial environments
  - What is industry like?
  - Measurements/test results
  - Simulations
  - Noise
- Wireless power
- Application examples
- Summary, research challenges
ABB

- Global company
- 160,000 employees
- Head quarters in Zurich
- Industrial IT
- Worlds largest automation company
- Transmission and distribution
- Robotics
- Manufacturing
- Process industries
- Oil and Gas
ABB Corporate Research

- 800 Scientists
- Located in: US, Finland, Sweden, Norway, Germany, Switzerland, Italy, India, Singapore, China
- Research areas
  - SW architecture
  - Control and optimisation
  - Communication
  - Mechatronics
  - Manufacturing
  - Oil and Gas
  - Power technologies
- Wireless program
  - 50 Scientist
  - Norway, Sweden, Germany, Switzerland
  - Wireless communication
  - Wireless internet
  - Industrial ethernet
  - Safety, security
  - Communication solutions for Automation
  - Communication solutions for performance building
The Wireless revolution; a new paradigm!

“All machines and parts in industry will communicate”
“People will be the distinct minority on the Net”
“Our great grandchildren will be as familiar with RJ11 jacks as we are with horse shoes”

Professor Nicholas Negroponte, Director MIT Media Lab

“Wireless technology is expected to have a major impact on the manufacturing industries in the next five years”
“A Maze of copper wiring needed to connect sensors and actuators systems is expensive to design, install, test, commission, and maintain”

ARC Strategies May 2001
The Wireless revolution; a new paradigm!

The last few years have seen a wireless revolution, offering;
- advanced communication solutions
- at a low cost

This is due to the high volumes in the consumer and office automation market.

Global co-operation for a world standard for wireless links.
- Shortrange communication (Bluetooth, 802.11, HiperLAN )
- Long range communication (GPRS, 3G/UMTS etc.)

“wireless connections everywhere “!
Why wireless in industry; Business drivers

- Wireless reduce;
  - installation cost
  - engineering cost
  - material cost

- Wireless offer;
  - mobility
  - flexibility
  - wireless network access

- Wireless allow new services like
  - portable clients
  - wireless operator terminals
  - wireless face plates
  - remote diagnostics
  - wireless internet
Why wireless in industry; Technology Drivers

- Wireless communication
  - Shortrange
  - Bluetooth,
  - 802.11
  - HiperLAN)

- Wireless internet
  - Long range
  - GPRS
  - 3G

- Safety and reliability issues in industrial communications.
- Speech recognition and synthesis
Radio wave propagation industry
Radio wave propagation industry

- Industrial requirements
  - Short messages
  - Swift response
  - Reliability
  - Harsh environments

- Main requirements
  - Reliability
  - Transparent data packets
  - Possibility of time stamping
  - Power consumption
  - Increased temperature range

Important to understand industrial requirements!
Radio wave propagation industry

- Industrial plants, power plants, productions facilities
  - Harsh environments
  - Extreme temperature
  - Vibration
  - Steel constructions
  - Obstructions
  - Possible EMC

Results
- Heavy multipath fading
- Fast/slow fading
- Good coverage
- Local variations in received power
Radio wave propagation industry

Received power versus logarithmic distance between TX and RX

- Measured
- Regression
- \(-m = 2\)
Radio wave propagation industry

Received power versus time (distance)
Radio wave propagation industry

Simulations of radiowave propagation in a nuclear power plant
Radio wave propagation industry

Simulations of radiowave propagation in a nuclear power plant
Radio wave propagation industry

“RMS delay spread

RMS delay spread : 76.78 ns
Coh. BW : 2287.62 kHz
K-Fact : 1 dB
Radio wave propagation industry

- RMS delay spread for Rx at centre 2400MHz
Radio wave propagation industry

- K-factor grid for Tx at edge, 2400MHz
Noise in 2.4GHz range, NEFI high voltage lab

Measure spectrum in vicinity of arc:
- arc length 10cm, distance 2m
- arc current 16kA
- duration 1.0 sec
- 3dBi omnidirectional antenna
Noise in the 2.4GHz ISM band

2.4 - 2.5GHz, max hold
No measurable effect in this band!

Baseline plot

Arc plot
Bluetooth test at Sauda smelting plant

- Strong electromagnetic fields, 25MW at 110V three phase
- Typical industrial environment (heat, dust, metal obj.,)
Bluetooth performance

Proximity to oven does not affect performance!

Measured BER vs. Separation distance between the Bluetooth radio modules (m)

- 10m from the oven
- 5m from the oven
- 2m from the oven
- Office plan area
Applications

- ABB Wireless client (portable operator terminal);
- Wireless set-up and configuration
- Wireless data collection
- Wireless handheld terminal
- Seamless integration with office and telecom equipment
- Remote diagnostics
Applications; Examples
Applications (2); Stop the Press

Wireless S800 i/o

✈️ The world's first wireless i/o for process control!

✈️ ABB's first wireless i/o modules is currently being presented at the Interkama fair in September 2001
Research Challenges

- Network architecture
  - congestion control
  - scaleable networks
- Optical networks
- Time stamping/time distribution
- COTS in industry
  - adaptations
  - new protocol layers
  - time stamping
- Reliability
- Safety security/encryption
- Protocol

- QoS
  - priority scheme
  - emergency communication
  - fall back
  - adaptive applications/protocols
- Power consumption
  - Startup time
  - Low power design
  - Efficient protocols
- Noise measurements/ channel characterization
- Co existence
In summary

- Numerous ABB products will contain wireless solutions in the future, for seamless connection with office automation equipment.
- Mobility possible in ABB products with wireless solutions.
- Bluetooth/802.11 will allow industrial applications interoperability with portable computers, mobile phones, etc.
- Industrial applications have different requirements to wireless (power consumption, transparent data, time stamping, reliability).
- Heavy multipath fading in industrial environments, but good coverage.