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BORDER SECURITY USING WIRELESS INTEGRATED NETWORK SENSORS (WINS)

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ABSTRACT

Wireless Integrated Network Sensors (WINS) now provide a new monitoring and control capability for transportation, manufacturing, health care environmental monitoring, and safety and security. WINS combine sensing, signal processing, decision capability, and wireless networking capability in a compact, low power system. WINS systems combine micro sensor technology with low power sensor interface, signal processing, and RF communication circuits. The need for low cost presents engineering challenges for implementation of these systems in conventional digital CMOS technology. This paper describes micro-power data converter, digital signal processing systems, and weak inversion CMOS RF circuits. The digital signal processing system relies on a continuously operating spectrum analyser. Finally, the weak inversion CMOS RF systems are designed to exploit the properties of high-Q inductors to enable low power operation.

Keywords*: Remote Charging, development, power transmission*

1. INTRODUCTION

Wireless Integrated Network Sensors (WINS) combine sensing, signal processing, decision capability, and wireless networking capability in a compact, low power system. Compact geometry and low cost allow WINS to be embedded and distributed at a small fraction of the cost of conventional wire line sensor and actuator systems. On a local, wide-area scale, battlefield situational awareness will provide personnel health monitoring and enhance security and efficiency. Also, on a metropolitan scale, new traffic, security, emergency, and disaster recovery services will be enabled by WINS. On a local, enterprise scale, WINS will create a manufacturing information service for cost and quality control. The opportunities for WINS depend on the development of scalable, low cost, sensor network architecture. This requires that sensor information be conveyed to the user at low bit rate with low power transceivers. Continuous sensor signal processing must be provided to enable constant monitoring of events in an environment. Distributed signal processing and decision making enable events to be identified at the remote sensor. Thus, information in the form of decisions is conveyed in short message packets. Future applications of distributed embedded processors and sensors will require massive numbers of devices. In this paper we have concentrated in the most important applications, Border Security.

WINS Initiated in 1993 under Defense advance research project agency (DARPA) in US. LWIM (Low power wireless integrated micro sensor) program began in 1995 for further development of WINS sponsored by DARPA. In 1998, WINS NG introduced for wide variety of application. The LWIM project for multihop, self-assembled, wireless network algorithms for operating at micro power.

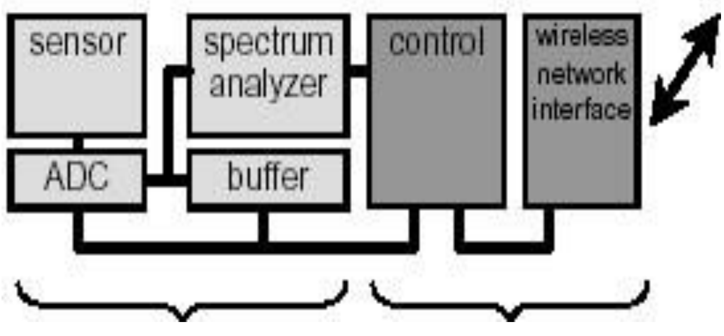

Figure 1. The wireless integrated network sensor (WINS) architecture includes sensor, data converter, signal processing, and control functions. Micropower RF communication provides bidirectional network access for low bit rate, short range communication. The micropower components operate continuously for event recognition, while the network interface operates at low duty cycle.

2. WIRELESS INTEGRATED NETWORK SENSOR (WINS) SYSTEM ARCHITECTURE

Conventional wireless networks are supported by complex protocols that are developed for voice and data transmission for handhelds and mobile terminals. These networks are also developed to support communication over long range (up to 1km or more) with link bit rate over 100kbps. In contrast to conventional wireless networks, the WINS network must support large numbers of sensors in a local area with short range and low average bit rate communication (less than 1kbps). The network design must consider the requirement to service dense sensor distributions with an emphasis on recovering environment information. Multihop communication yields large power and scalability advantages for WINS networks. Multihop communication, therefore, provides an immediate advance in capability for the WINS narrow Bandwidth devices. However, WINS Multihop Communication networks permit large power reduction and the implementation of dense node distribution.

3. WINS NODE ARCHITECTURE

The WINS node architecture is developed to enable continuous sensing, event detection, and event identification at low power. Since the event detection process must occur continuously, the sensor, data converter, data buffer, and spectrum analyzer must all operate at micro power levels. In the event that an event is detected, the spectrum analyzer output may trigger the microcontroller. The microcontroller may then issue commands for additional signal processing operations for identification of the event signal. Protocols or node operation then determine whether a remote user or neighboring WINS node should be alerted. The WINS node then supplies an attribute of the identified event, for example, the address of the event in an event look-up-table stored in all network nodes. Total average system supply currents must be less than 30A. Low power, reliable, and efficient network operation is obtained with intelligent sensor nodes that include sensor signal processing, control, and a wireless network interface.

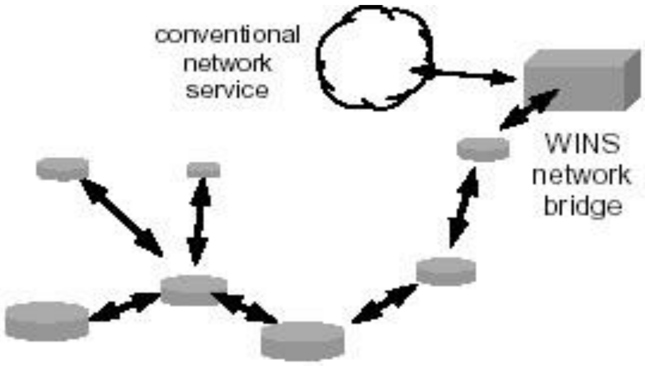

Figure 2. WINS nodes (shown as disks) are distributed at high density in an environment to be monitored. Multihop communication permits low power operation of dense WINS sensor networks. WINS node data is transferred over the asymmetric wireless link to an end user or to a conventional wireline or wireless (IP) network service through a WINS network bridge.

Distributed network sensor devices must continuously monitor multiple sensor systems, process sensor signals, and adapt to changing environments and user requirements, while completing decisions on measured signals.

For the particular applications of military security, the WINS sensor systems must operate at low power, sampling at low frequency and with environmental background limited sensitivity. The micro power interface circuits must sample at dc or low frequency where “1/f” noise in these CMOS interfaces is large.

The micro power signal processing system must be implemented at low power and with limited word length. In particular, WINS applications are generally tolerant to latency. The WINS node event recognition may be delayed by 10 – 100 msec, or longer.

4. WINS MICRO SENSORS

Source signals (seismic, infrared, acoustic and others) all decay in amplitude rapidly with radial distance from the source. To maximize detection range, sensor sensitivity must be optimized. In addition, due to the fundamental limits of background noise, a maximum detection range exists for any sensor. Thus, it is critical to obtain the greatest sensitivity and to develop compact sensors that may be widely distributed. Clearly, micro electromechanical systems (MEMS) technology provides an ideal path for implementation of these highly distributed systems. The sensor-substrate “Sensorstrate” is then a platform for support of interface, signal processing, and communication circuits. The detector is the thermal detector. It just captures the harmonic signals produced by the footsteps of the stranger entering the border. These signals are then converted into their PSD values and are then compared with the reference values set by the user.

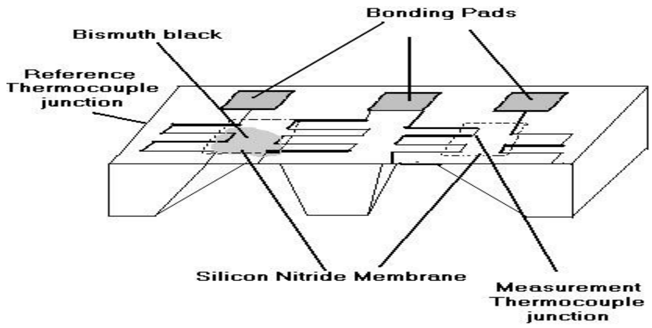

Figure 3. WINS microsensor example: a thermal infrared detector (based on a thin film supported array of Bi-Sb thermopile junctions) is shown with its structure in a micrograph of the thermopile junction array

5. ROUTING BETWEEN NODES

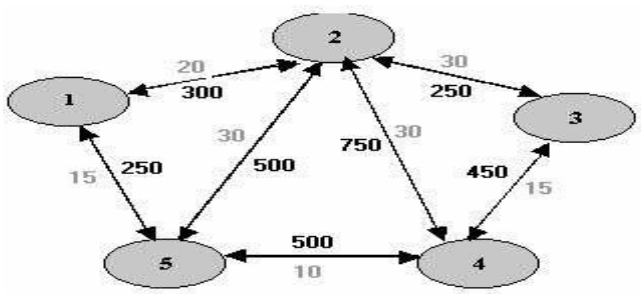

Figure 4. Nodal distance and Traffic

The sensed signals are then routed to the major node. This routing is done based on the shortest distance. That is the distance between the nodes is not considered, but the traffic between the nodes is considered. This has been depicted in the figure 4. In the figure, the distances between the nodes and the traffic between the nodes have been clearly shown. For example, if we want to route the signal from the node 2 to node 4, the shortest distance route will be from node 2 via node 3 to node 4. But the traffic through this path is higher than the path node 2 to node 4. Whereas this path is longer in distance.

6. WINS DIGITAL SIGNAL PROCESSING

If a stranger enters the border, his footsteps will generate harmonic signals. It can be detected as a characteristic feature in a signal power spectrum. Thus, a spectrum analyzer must be implemented in the WINS digital signal processing system. The spectrum analyzer resolves the WINS input data into a low-resolution power spectrum. Power spectral density (PSD) in each frequency "bins" is computed with adjustable band location and width. Bandwidth and position for each power spectrum bin is matched to the specific detection problem. The WINS spectrum analyzer must operate at W power level. So, the complete WINS system, containing controller and wireless network interface components, achieves low power operation by maintaining only the micropower components in continuous operation.

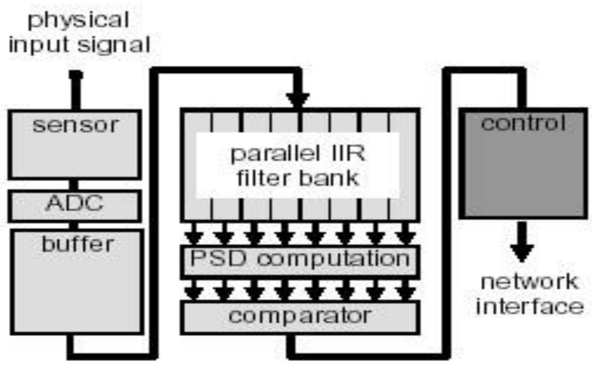

Figure 5. WINS micropower spectrum analyzer architecture. The sensor, ADC, buffer, filter bank, and decision systems operate continuously. Upon recognition of an event, microcontroller operation is initiated.

Each filter is assigned a coefficient set for PSD computation. Finally, PSD values are compared with background reference values in the event that the measured PSD spectrum values exceed that of the background reference values, the operation of a microcontroller is triggered. Thus, only if an event appears, the micro controller operates. Buffered data is stored during continuous computation of the PSD spectrum. If an event is detected, the input data time series, including that acquired prior to the event, are available to the micro controller. The micro controller sends a HIGH signal, if the difference is high. It sends a LOW signal, if the difference is low.

7. CHARACTERISTICS AND APPLICATIONS

Characteristics:

1. Support large numbers of sensor.
2. Dense sensor distributions.
3. These sensor are also developed to support short distance RF communication.
4. Internet access to sensors, controllers and processor.

Applications:

1. On a global scale, WINS will permit monitoring of land, water, and air resources for environmental monitoring.
2. On a national scale, transportation systems, and borders will be monitored for efficiency, safety, and security.
3. On a local, enterprise scale, WINS will create a manufacturing information service for cost and quality control.

8. DESIGN CONSIDERATION

Reliability: The system must be reliable so that the probability of failures and faulty operations must be very less.

Energy: There are four ways in which node consumes energy

- Sensing: Choosing right sensor for the job can improve the system performance and to consume less power.
- Computation: The sensor must be chosen so that the speed of computation can be very fast and less faults.
- Storing: The sensor must have sufficient storage to store the sensed data so that it can be communicated.

Communicating: The communicating between sensors is very important factor when it is used for border security. There must not be any faults during communicating the sensed data between various nodes and the gateway.

The sensor must be designed to minimize the likelihood of environment effect of wind, rain, snow etc. The enclosure is manufacture from clear acrylic material. Otherwise, the sensor may damage due to weather effects and may give fault results.

9. CONCLUSION

A series of interface, signal processing, and communication systems have been implemented in micro power CMOS circuits. A micro power spectrum analyser has been developed to enable low power operation of the entire WINS system. Thus, WINS require a Microwatt of power. But it is very cheaper when compared to other security systems such as RADAR under use. It is even used for short distance communication less than 1 Km. it produces a less amount of delay. Hence it is reasonably faster. On a global scale, WINS will permit monitoring of land, water, and air resources for environmental monitoring. On a national scale, transportation systems, and borders will be monitored for efficiency, safety, and security.

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