

ON-BOARD WIRELESS DATA ACQUISITION SYSTEM AND TELEMETRY

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ABSTRACT

Most of today's aircraft used for the commercial transport of passengers or military aircraft still rely on simple technology such as cables, connectors and sensors to provide power, avionics data, control system, aircraft instrumentation etc. throughout the vehicle's life-cycle for flight monitoring and fault diagnosis.

Despite a marked improvement in the quality and reliability of these components, they continue to be the main cause of failures due to corrosion, misuse, improper installation, etc, using-up endless man-hours to troubleshoot, repair and upgrade them. Wireless monitoring by telemetry of some of the critical systems has been in use for some time as a point to point data link designed to provide vital information, potentially improving the safety and efficiency of any flight. Aircraft manufacturers are now looking at the use of wireless networks to replace current data buses used for the transfer of data between avionics systems and their sensors as well as for the control of some of the surface actuators. Wireless networks used in this way could reduce the amount of cabling and its associated weight as well as simplify the re-routing of connections making upgradation less expensive and quicker, again a benefit to airlines.

Despite many benefits there is a potentially serious security issue by means of an introduction of a backdoor into the system, meaning that before aircrafts become network-enabled, all the security issues must be identified in full and dealt with.

KEY WORDS

Data Acquisition, Sensors, Bluetooth

INTRODUCTION

With the advent of the new low-cost wireless technologies, the functionality of data acquisition systems can be enhanced eliminating the burden of cabled connection between the system itself and the data processing unit. Especially in the industrial environment, where every supplementary plug implies design and financial efforts, a wireless link between a data acquisition module (sensor with signal conditioning and digital conversion) and a data processing unit (PC, Laptop or PDA) brings flexibility and robustness to the entire design. The goal of this work was to investigate the possibility to build a small-sized, low-cost wireless data acquisition system with improved computational capabilities. The aimed computational platform was a basic microcontroller AT89C51 while the chosen wireless communication standard was Bluetooth.

SYSTEM DESIGN

Wireless Communication

The aim to build a wireless low-cost communication system implies using wireless communication standards already since a certain time on the market, offering low-cost hardware and good performances. The two suitable standards for the current research topic were WLAN (IEEE 802.11) and Bluetooth (IEEE 802.15.1). Using both operate at the same frequency band, the standards differ mainly in terms of through output, power consumption and network architecture. WLAN (802.11b version) offers in the a maximum transmission rate of 11 Mbps, more than ten times higher then Bluetooth transmission rate of 1 Mbps. This advantage is eclipsed by the high power consumption of the WLAN hardware which offers power saving modes only in the infrastructure mode, implying the existence of an access point. Bluetooth was designed from the beginning as peer-to-peer low power communication standard, offering various power saving modes without additional hardware such as access points. Based on this main advantage and taking into consideration also the simple interfaces offered (serial connection), Bluetooth was preferred as wireless communication standard.

Bluetooth

Commercial Bluetooth hardware is available in the form of transceiver modules which are small shielded subsystems designed to be used as add-on peripherals. They feature an embedded CPU, around 1 Kbyte of memory and the baseband and radio circuits. Depending on the product, one or more upper layers of the Bluetooth Protocol Stack are also implemented, like Link Controller and Manager, Host Controller Interface, Logical Link and RFCOMM. Modules that have implemented also the RFCOMM layer are called Cable

Replacement modules and are emulating one or more serial connection (RS 232) based on the ETSI TS 07.10 standard. The RFCOMM layer offers to the upper application layers a Serial Port Profile (SPP), which is a virtual serial interface. The maximum baud rates for the Cable Replacement modules vary from 115 kbps to 960 kbps and the featured transmission range varies from 10 to 100 m. Both internal and external antennas are available. Successful serial communication up to 960 kbps has been tested for Bluetooth modules.

Microcontroller Architecture

The tasks of data acquisition, storage and communication have been implemented in a microcontroller architecture consisting of an Analog Devices Microcontroller with integrated A/D converter, integrated UART interface and an external non-volatile memory chip. The ADC0808 from Analog Devices is a versatile and powerful microcontroller having an integrated, self-calibrating A/D converter with a maximum sampling rate of 200 kHz and ½ LSB precision. The core is an 8 bit 8051 compatible core operating at frequencies up to 12MHz. A very useful feature of this microcontroller is the possibility to make continuous data acquisition via DMA (Direct Memory Access) into an external memory with a maximum capacity of 16 Mbytes. The access to external memory is done using two external latches. Communication with the external circuits is done by the integrated UART interface with two lines (Rx/Tx).

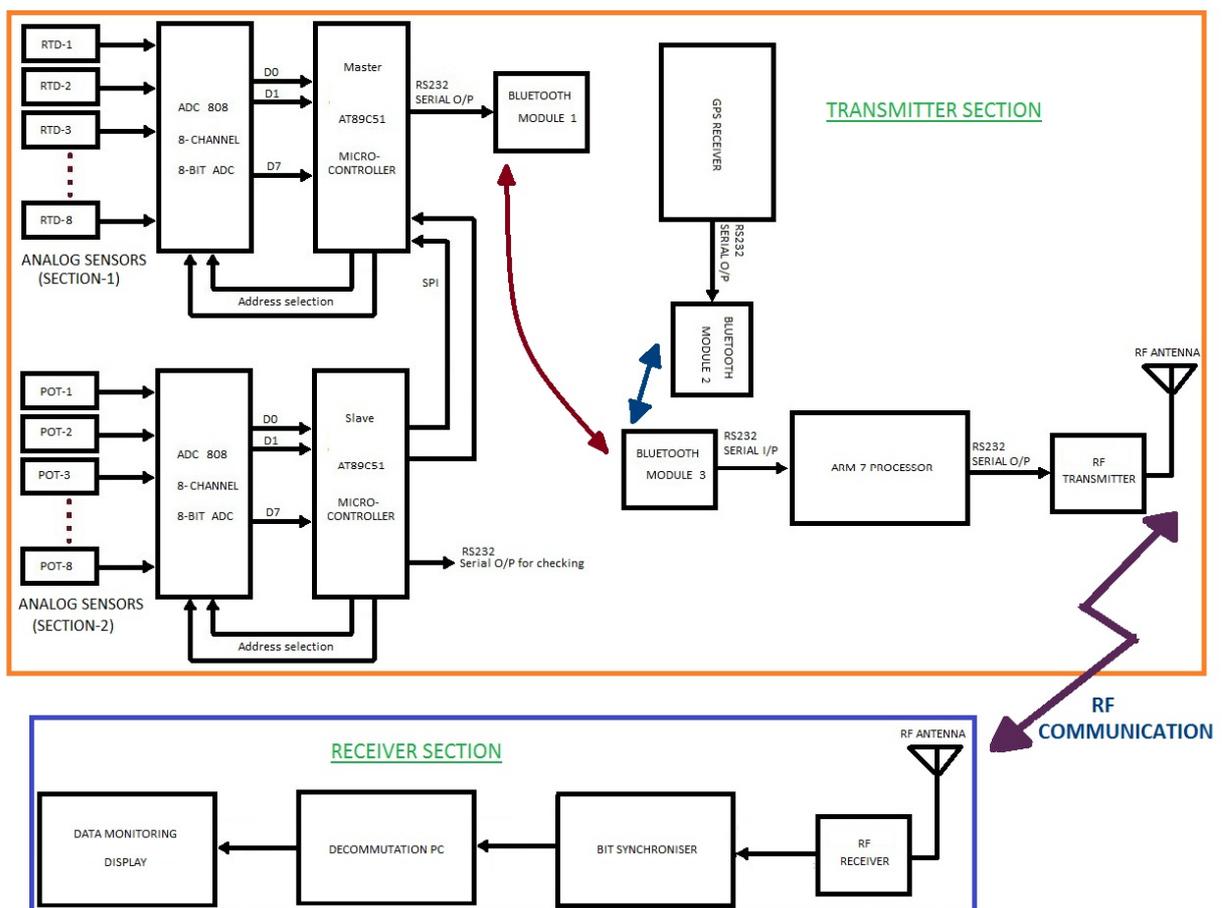


Figure 1: Data Acquisition Functional Block Diagram

TRANSMITTER SECTION FLOWCHART

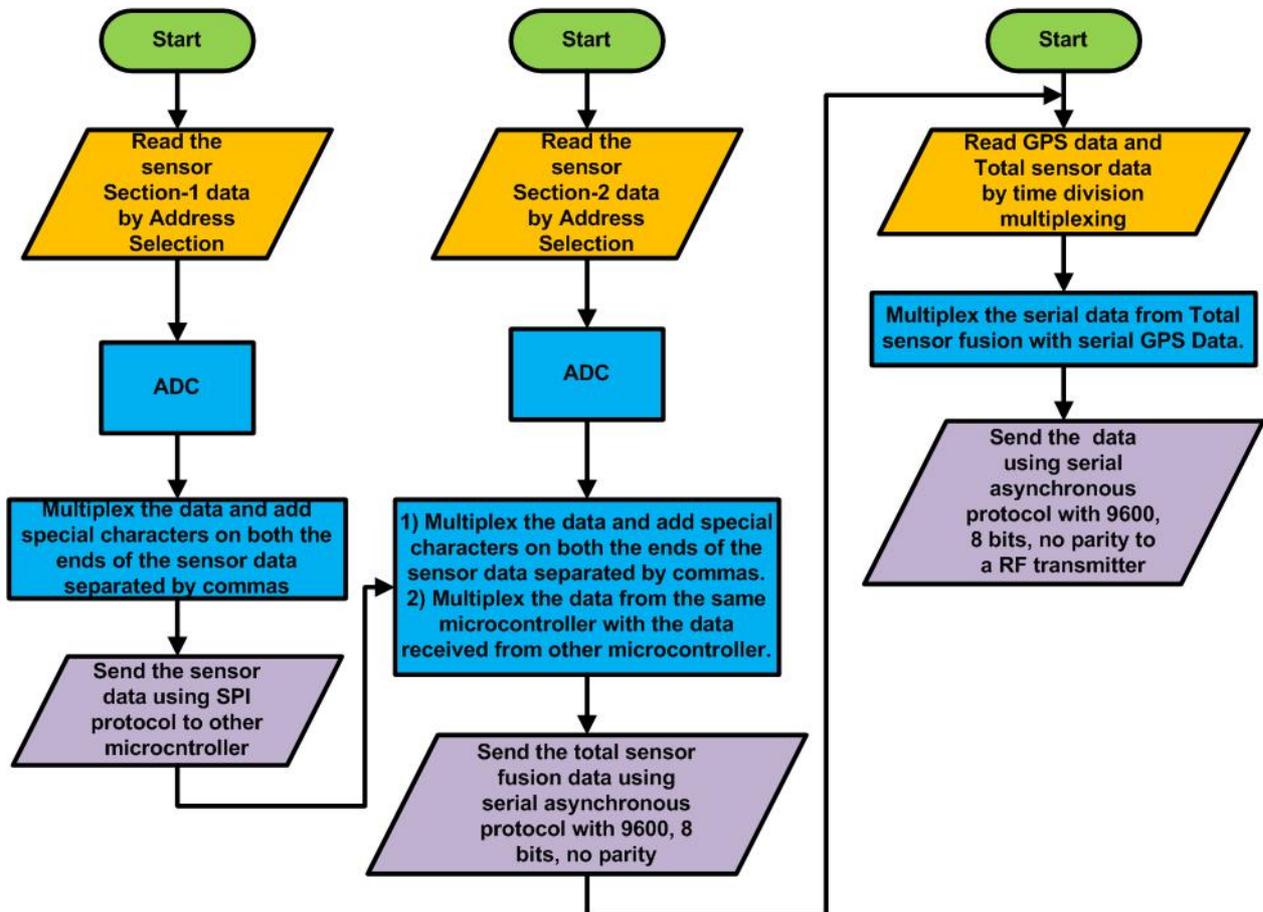


Figure 2: Transmitting Section Flow Chart

WORKING

Sensor Acquisition:

- ❖ The Data Sensed by the sensor is initially in the analog form. For the purpose of wireless communication the data has to be presented in the digital form. Data is more secure in Digital format, as compared to analog. Thus, Data is forwarded in Digital Form.
- ❖ For the Purpose of conversion, 8-bit Analog to Digital convertor (ADC 808) is used .The ADC converts the input analog voltage into Digital Binary format, which is represented through 8 output lines in the ADC.
- ❖ The Binary Data is then given to the 89C51 Microcontroller, which is initially programmed to sense the input parameters. The Programming Language used is c.

- ❖ Now the data is Present in parallel Form. This data is to be transmitted serially over the wireless channel. For this, MAX232 IC is used. The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits.
- ❖ The data is framed to identify with a specific pattern for de-commutation and also included with start and stop bits, no parity for the purpose of asynchronous transmission over Bluetooth Transceiver Module-1. The Baud Rate is set variably with preferred usage at 9600bps.
- ❖ GPS is a satellite-based global navigation system that enables users to accurately determine latitude, longitude, height and time. The GPS receiver that was selected is EM-408 due to its characteristics of low power and an inbuilt antenna on the receiver. The GPS receiver can output NMEA data on a serial port. The output of the receiver is given to a Bluetooth Transceiver Module-2.
- ❖ Bluetooth Transceiver Modules are used to Transmit/Receive. The Receiver is set as the Master Mode. The Transmitter is used in Slave Mode. The Master and Slave are configured with MAC source and Destination Addresses and initialized to recognize and authenticate each other.
- ❖ Data received through Bluetooth Transceiver-3 Module is then processed by the ARM7 Processor Module. The data from the Bluetooth Module-1 and Bluetooth Module-2 are mixed and sent to second serial port for RF transmission.
- ❖ The RF transmission used in the setup is a L-Band transmitter with 10W power output.
- ❖ The multiplexed data was received through a RF receiver, bit synchronised the data and given to a de-commutation system.
- ❖ The framed data pattern is identified with special characters that are encoded during transmission along with a Start and Stop bit. The special characters are then removed from the received data, which is then converted into required Engineering Value.
- ❖ The Processed data is then displayed on the on-board LCD screen, which can be simultaneously displayed on the computer screen.

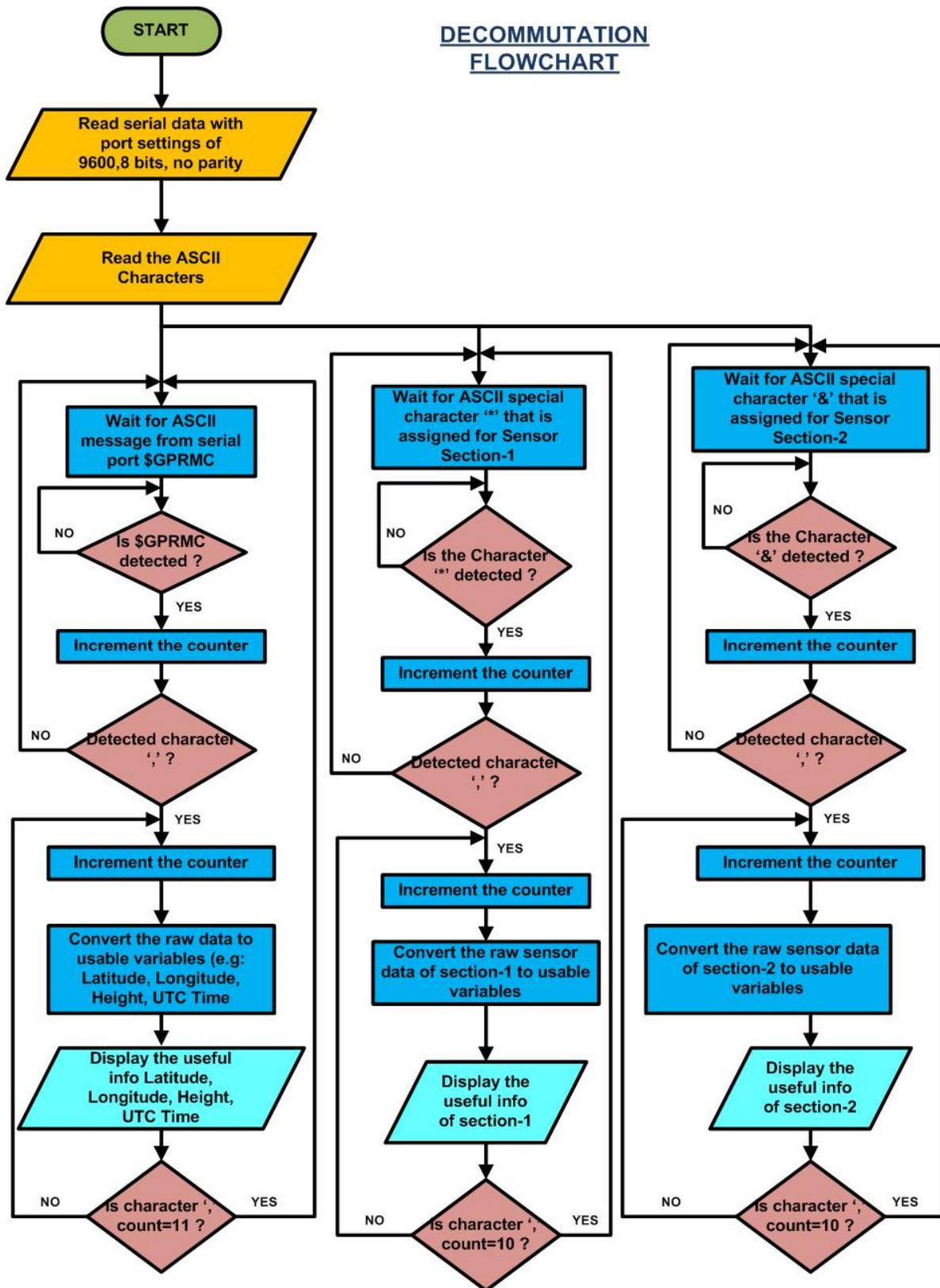


Figure 3: Decommutation Flow Chart

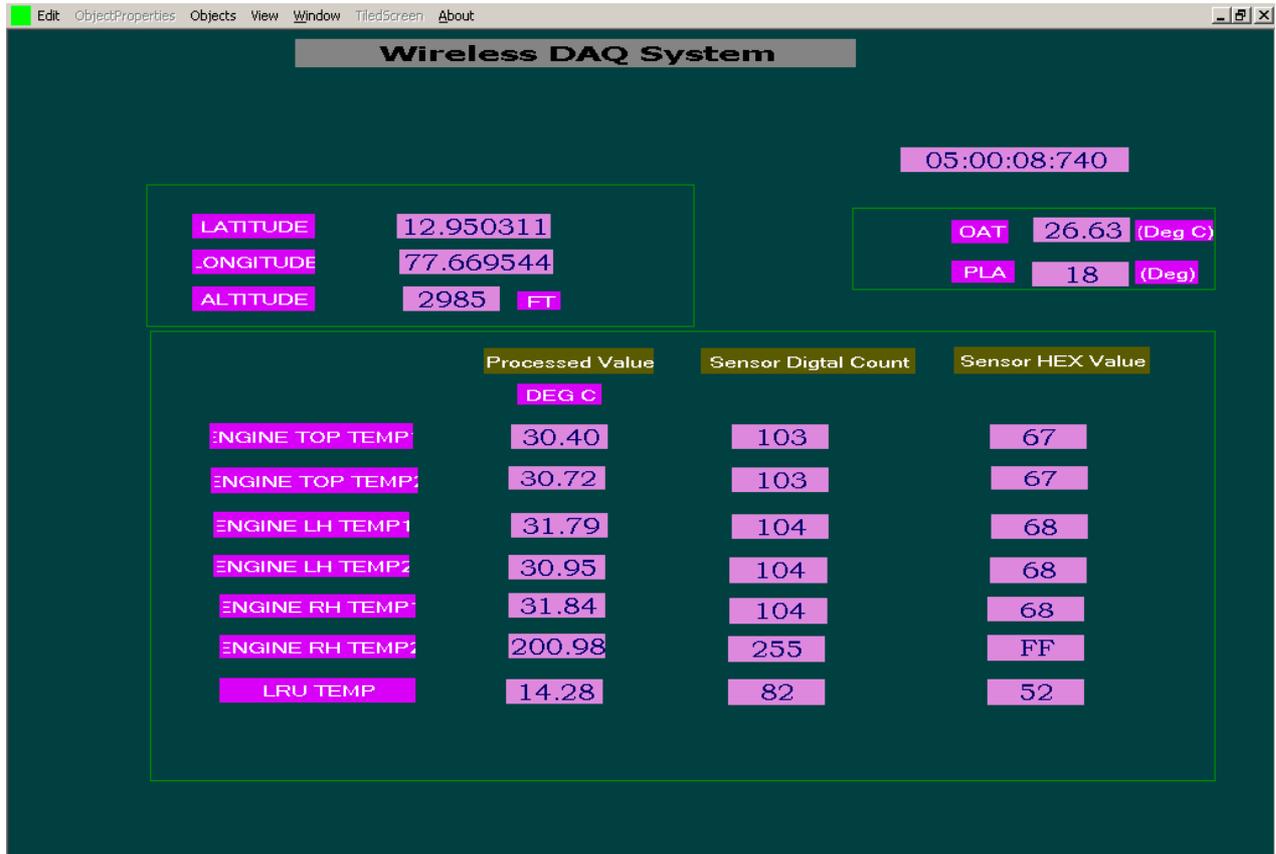


Figure 4: Simulated Output

ADVANTAGES

Sensor-level processing: Microcontroller at remote station enables real-time analysis.

Low power requirements: Smart power management scheme allows for increased life of battery-powered remote stations while reducing size, weight, and cost.

High reliability: System provides self-diagnosis of communications links and automatically reconfigures upon failure detection.

Guaranteed data integrity: Buffering at remote stations ensures data availability and integrity if temporary communications losses occur.

Scalability: Modular design facilitates any installation.

Low cost: Generic modules are common to remote and central stations.

Reduced wiring communication: Without wires, cost intensive wiring plans become obsolete. Labour-intensive cable installation costs will be dramatically reduced and there will be no more need for wiring maintenance tasks.

Reduced power cabling costs: The freedom to place wireless sensors anywhere in the factory plant or a building gets limited if those devices have still to be connected to a main power source. So further advances would be achieved by obviating the need of power cables. In the field of sensors, using low power semiconductor technologies, power cabling can be obviated if the sensors use internal batteries or harvest the energy from the environment.

APPLICATIONS

Industrial parameter monitoring: Different data parameters like temperature, pressure, humidity can be measured using this technology and transmitted wirelessly.

Lab instrumentation: Experimentation involving radiation cannot be monitored physically. This requires wireless Monitoring Facility.

Remote location data gathering: Hard-to-Access Conditions on Geographical areas could use this Technology to Monitor and read various Parameters.

Environmental monitoring.

Health care: Wireless monitoring equipment are already in use in Major Multi-speciality Hospitals round the world for monitoring Physiological Vitals of Large number of Patients on a single Monitor.

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