Modeling and Simulation of a wireless sensor data acquisition system using PCM algorithms

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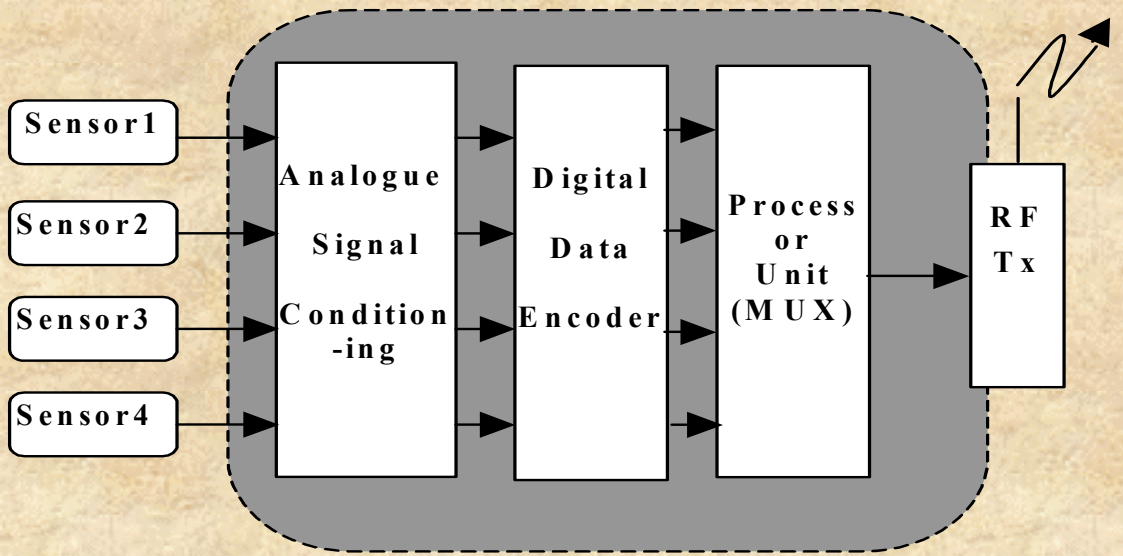
Motivation

- Motivation 1 → Recent advances in integrated sensors have made a realization of smart microsystems combining a large mixture of micro-sensors and signal processing circuitries
- Motivation 2 → Wireless communication is a viable and cost-effective method of transmitting data over long distances, through electrically noisy environments .
- Object → A novel data acquisition system to be developed, simulated and tested. Pressure and pH sensors signals are employed for system performance assessment as they have a significant role in environmental monitoring.



Block diagram of telemetry multisensor system

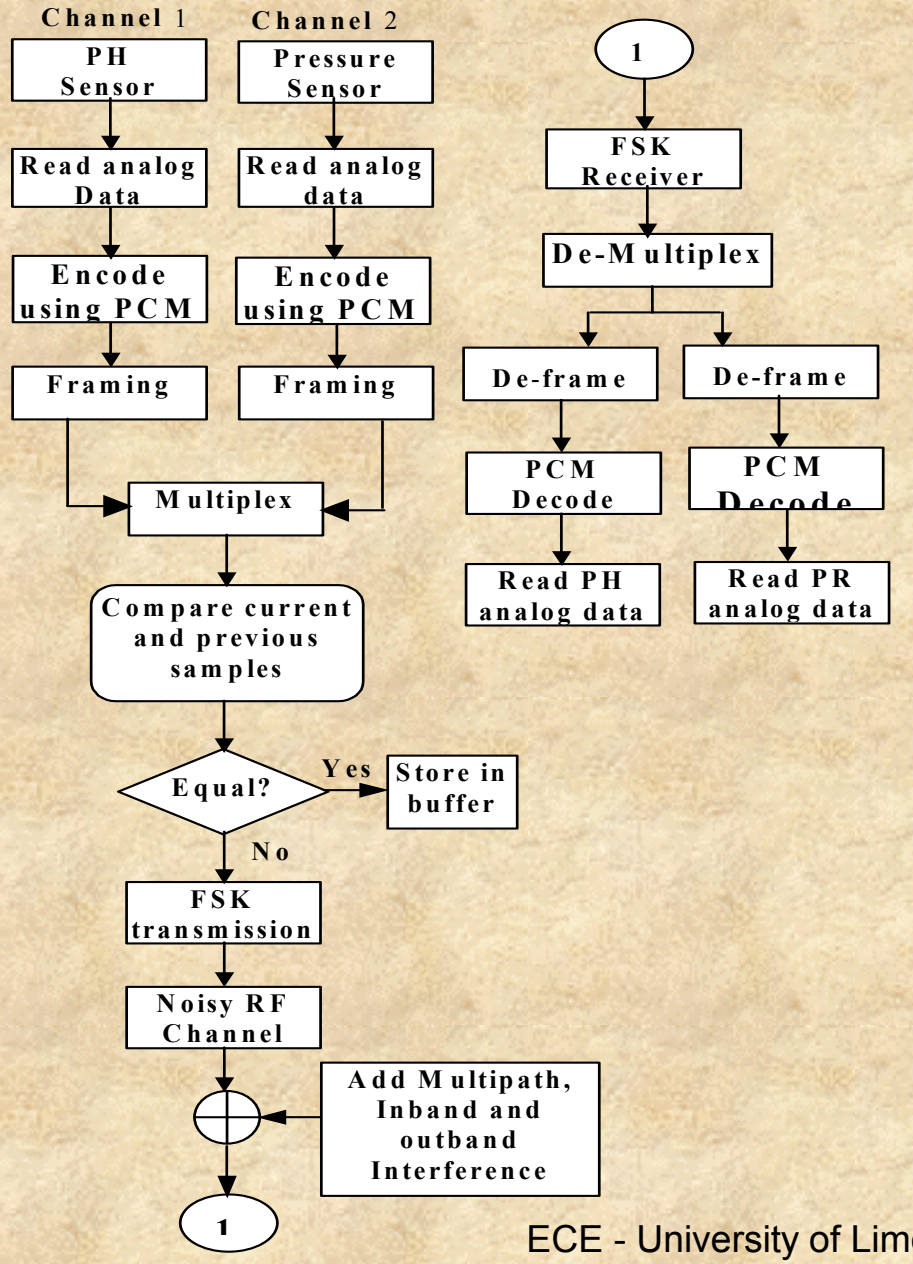
Abstract

This paper presents a novel simulated model for a wireless data acquisition system. The system will read analogue information provided by two sensors and can be used for medical purposes. Real data has been obtained and a simulation of the two signals coming from both pH and pressure sensors embedded in the system has been employed. The created model contains four main units simulated using SIMULINK. At the first unit, the output signal is encoded to digital signal based on adapting one of the Pulse Coding Modulation (PCM) algorithms. The second unit simulates the processor function that is responsible for framing, mixing and compressing the incoming bit streams from both sensors. The third unit, where the digital data is modulated and sent through different noisy channels, represents an efficient FSK transmitter/receiver model. At the receiver end, the signal is demodulated and processed inversely to extract the original analogue signal read by the two sensors.

In this work, the performance of the systems using different PCM methods will be studied comparatively in order to control the transmission and reduce the amount of data sent. This leads to a significant reduction in power consumption. In addition, efficiency of the RF channel in terms of Bit Error Rate (BER) and through different noisy conditions is investigated.

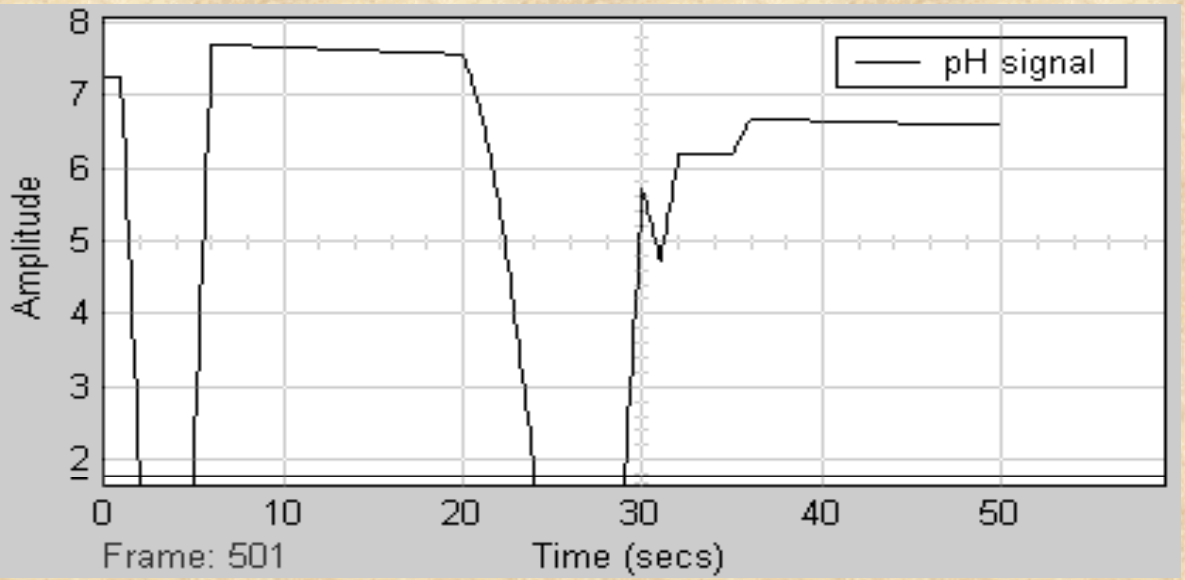
System Specifications

Figure below shows the main task and functions that should be implemented by the proposed system

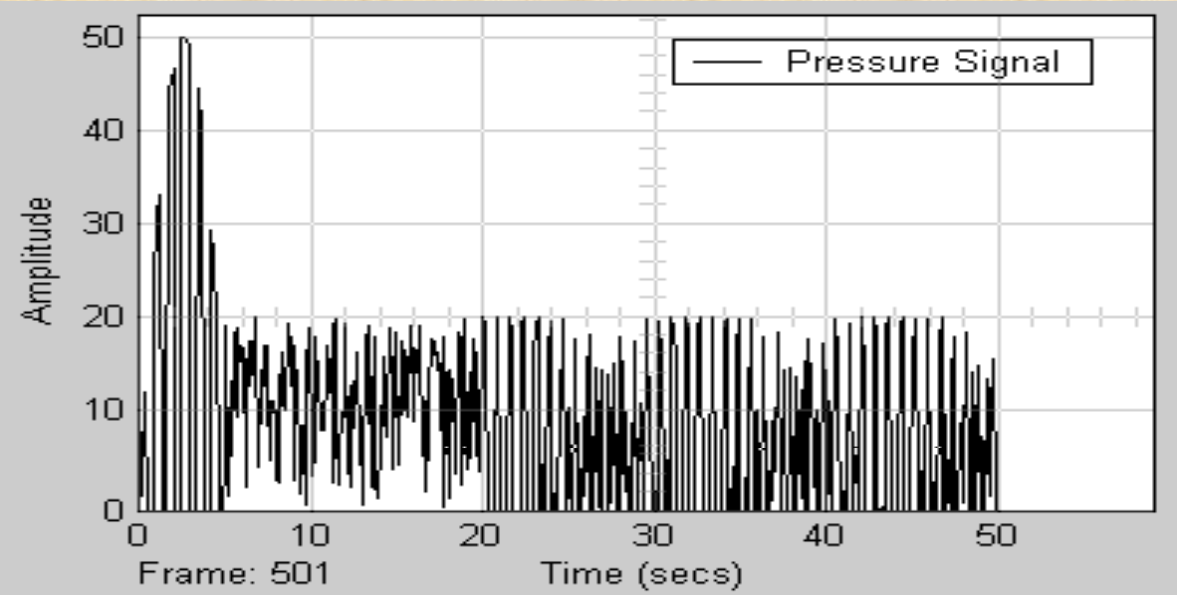


System Functions:

- The output of the first stage is a digital encoded bit stream using a PCM algorithm
- The two binary data streams coming from the two channels are processed by the controller unit
- The data coming from each channel is framed, multiplexed and compressed at this stage before it is sent to RF unit.
- the serial binary stream will be modulated using FSK and sent through a noisy RF channel to the receiver
- The data is then demodulated at the receiver side and inversely processed to recover the two analog signals



Simulated signal from a pH sensor

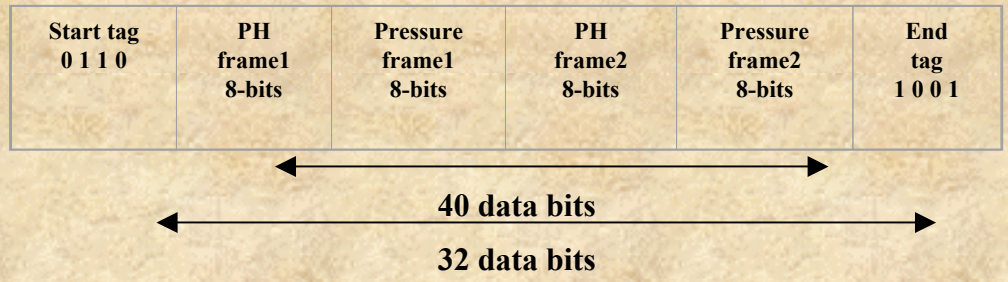


Simulated signal from a pressure sensor

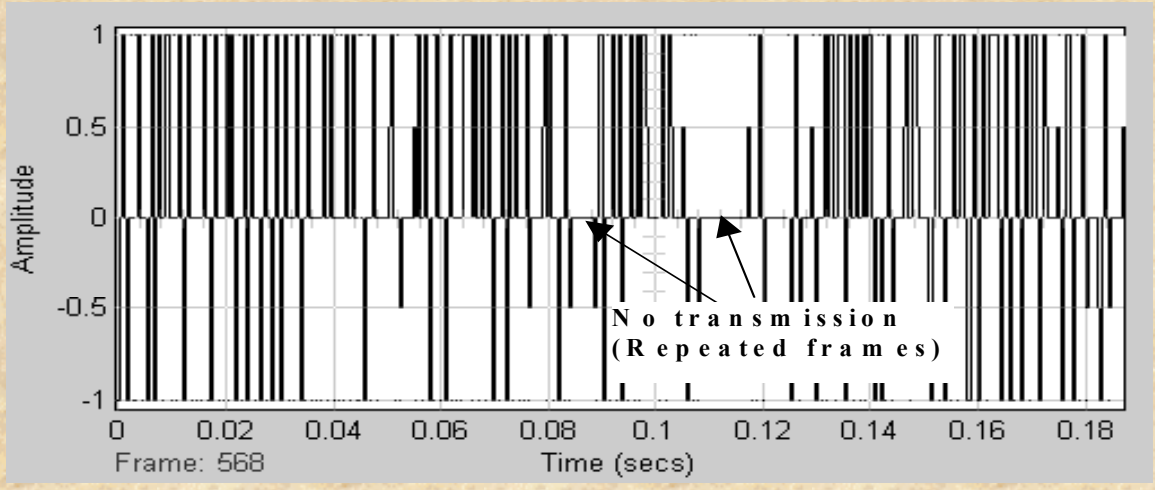
Simulation Of The Controller Unit

Unit Tasks :

- Framing the input coded bit streams coming from the PCM stage.
- Control the operation of the RF transmitter/receiver by compressing the amount of serial bits to be transmitted. A sample of data compressed is shown below.
- Multiplex the pH and pressure frames into a single frame with a start and end flag



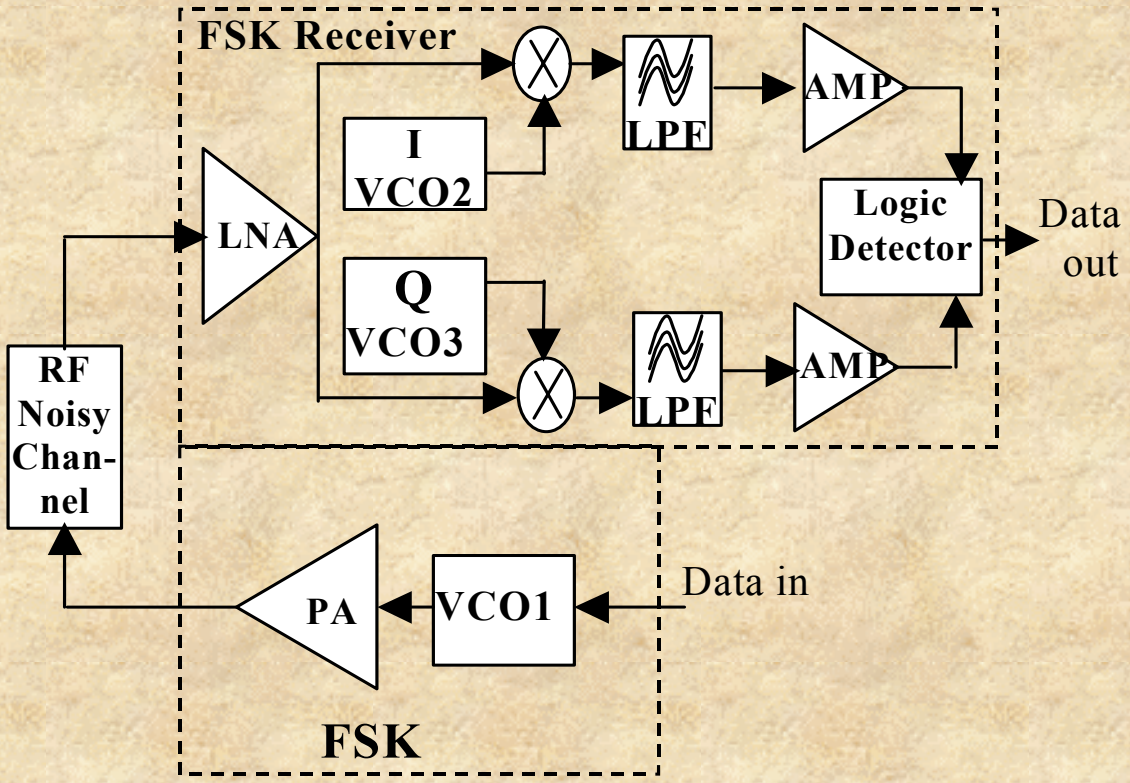
- Outputs a serial bit stream to the RF transmitter at a bit rate or 2.5 kbps



Sample of output data after compression

Simulation of the RF Transmitter/Receiver

- Voltage controlled oscillator (VCO) is employed in the transmitter side to modulate the incoming data.
- At the receiver, a two quadrature VCO's will be multiplexed with the modulated signal coming from the noisy RF channel and down convert its frequency using analog low pass filters
- A logic detector will be used to determine the demodulated bit whether 0 or 1.



Structure of the simulated FSK transmitter/receiver

Simulation Results

Testing PCM and compression mechanism

- The performance of the compression implemented by the controller was assessed in terms of the total number of repeated and unrepeated frames that have to be sent to the receiver side .

PCM Coding algorithm (8 bits for sample)	pH Frames Sent	pH Frames Not sent	Compression Ratio %
UPCM	437	4849	91.73
N PCM	662	4624	87.47
DPCM	2588	2698	51.04

Compression performance for pH signal

PCM Coding algorithm (8 bits for sample)	PR Frames Sent	PR Frames Not sent	Compression Ratio %
UPCM	3036	2250	42.56
NPCM	480	4806	90.10
DPCM	3321	1965	37.17

Compression performance for pressure signal

Performance Evaluation …. Sample Results

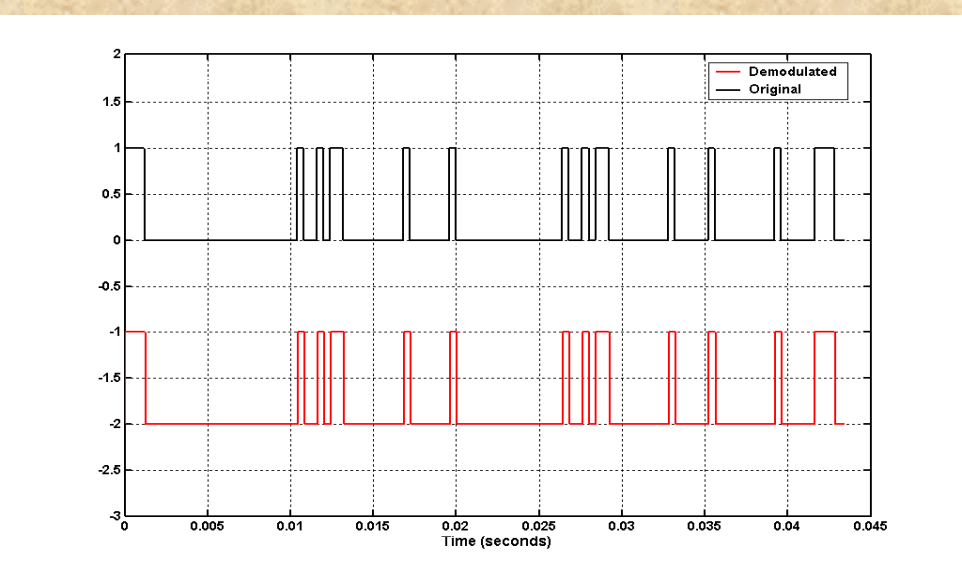
- The distortion has been measured between the original and recovered waveforms for both pH and pressure as given in the table below

PCM Coding algorithm	pH signal Distortion	Pressure signal Distortion
UPCM	0.0104	0.0327
NPCM	0.8143	0.1309
DPCM	0.0284	0.1214

Distortion measure of the system output signals using the PCM methods

Testing the performance of the RF FSK transmitter/receiver

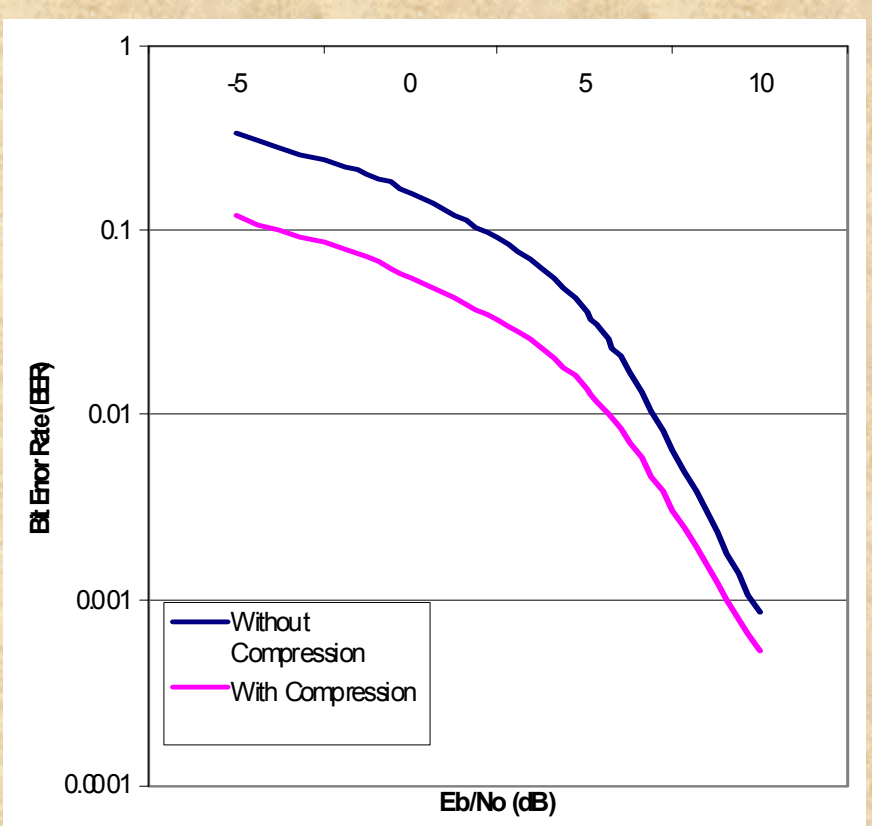
- Sample of unipolar modulated and demodulated signals at carrier frequency of 100MHz are shown in Figure



Original and demodulated using FSK receiver with a carrier frequency of 100MHz

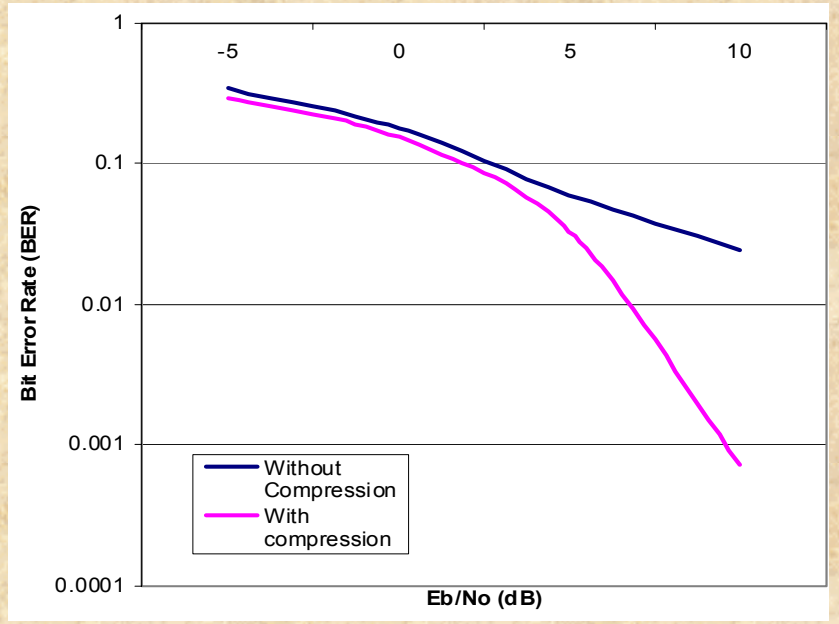
BER Performance Evaluation

- The performance of the model through RF channel with different noisy conditions was examined by estimating the average Bit Error Rate (BER) for the different PCM schemes.
- The effect of the compression mechanism implemented by the previous stage on the model was investigated.

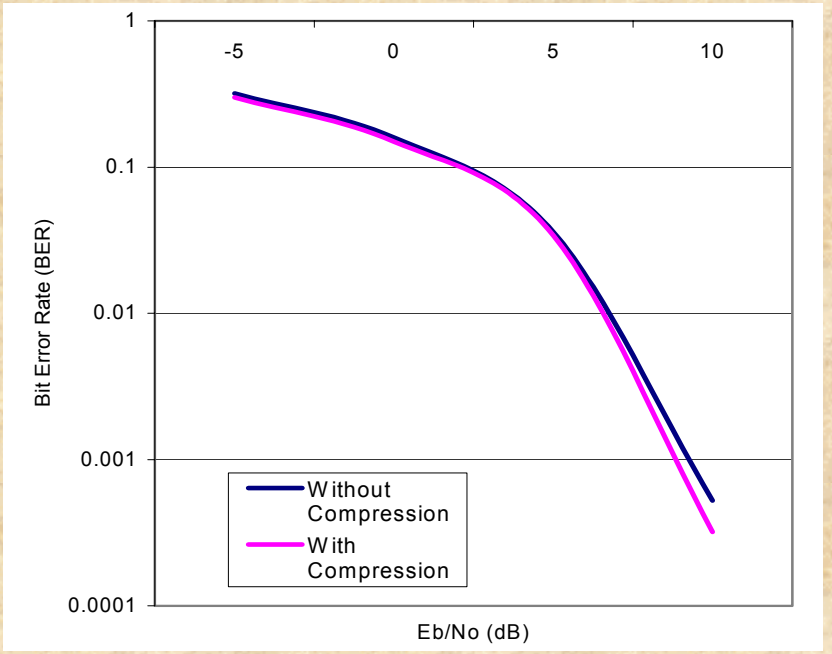


Simulated BER performance for FSK system using UPCM

BER Performance Evaluation …. Sample Results



Simulated BER performance for FSK system using NPCM



Simulated BER performance for FSK system using DPCM

Conclusions

- **A novel model for a wireless sensor data acquisition system based on PCM schemes has been presented.**
- **Four different PCM schemes have been considered in this model and a compression mechanism based on sending only the unrepeated frames has been developed.**
- **Minimum distortion in the recovered signals in both, pH and pressure sensors were obtained by using the UPCM and DPCM.**
- **The performance of the model has been improved for the two PCM methods (UPCM & NPCM) by introducing the compression mechanism**
- **It was found that when the NPCM and the compression mechanism are used in combination, a significant reduction in the amount of data transmitted through the channel is obtained.**
- **The BER for the NPCM after 5 dB was greatly reduced by the compression**
- **A slight improvement in BER is obtained when the DPCM is working in the compression mode.**

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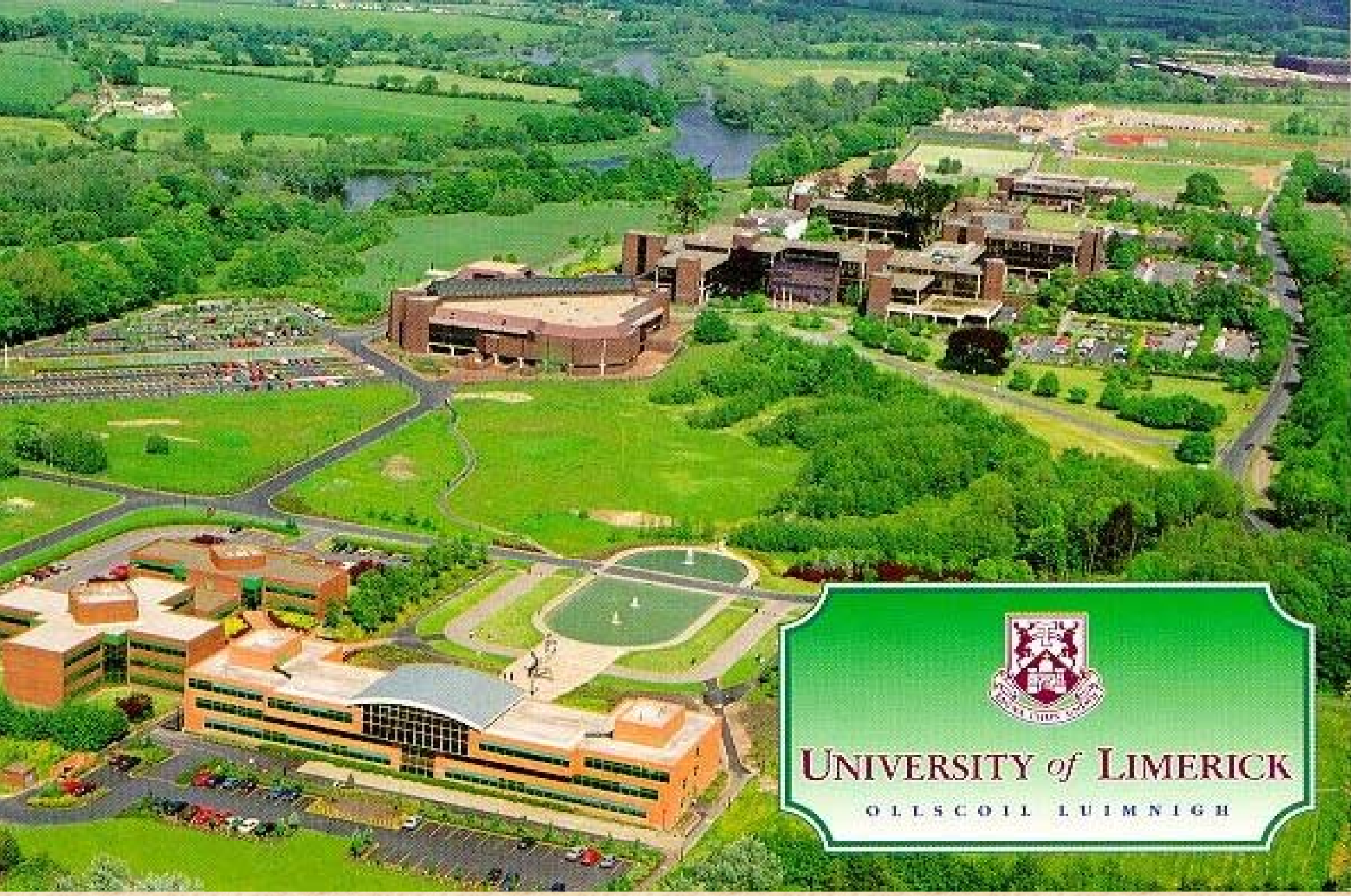

Thank you for your attention