The Effective Transmission of Acquired Sensor data with FFT, DWT and DTCWT in Different Channel Environment

Naveen H, Chetan H, Bhimsen Kulkarni, Sudatta Mohanty, Druva Kumar S, Sreerama Reddy G M

Abstract*: The paper describes the analysis of FFT, DWT and DTCDWT for effective transmission of acquired underwater sensor data in AWGN and Acoustic channel. The underwater temperature is acquired using a temperature sensor, pH value is acquired using pH sensor, and Depth of water is acquired using ultrasonic sensor. The sensor data is acquired using ARM Cortex M4 Microcontroller and the same data is processed using FFT, DWT and DTCDWT in AWGN channel and Acoustic channel for comparative analysis. Number of Samples is limited to 64 samples and SNR values ranging from 0 to 50 are considered for analysis. Graphical user interface is designed using MATLAB and the simulation results shows that number of errors after transmission in FFT is more compared to DWT and also number of errors is decreased in the case of DTCDWT.

Index Terms: Acoustic Channel, DWT, DTCDWT, FFT

I. INTRODUCTION

The underwater data acquisition system and effective transmission of the acquired data is essential nowadays. The information gathered from the underwater are mineral exploration, temperature measurement, marine life exploration, assessing quality of water and underwater depth. Typically, underwater sensors will be placed inside an remotely operated vehicle which consumes very less power. The sensors data will be collected from ROV will be sent to the Central Data Acquisition unit located on the ground. The central data acquisition unit is also used to transmit the acquired data to remote unit efficiently.

Contamination of underwater can impact marine life and also human life. Clean up of contaminated groundwater tends to be very costly. Effective remediation of underwater is generally very difficult [1]. Determining the water level of a water reservoir is not an easy job to do as the water runs around 90m - 450m. below the surface. Also the traditional methods involved in measuring water level like using a scale and chalk provides very inaccurate reading of the level or just a rough estimate of the water level. One of the major concern is also that a person has to be at the water reservoir site in order to perform the level and contamination measurement which is very time and cost consuming and quite impractical method.

II. DETAILED DESIGN

The purpose of detailed design is to divide the top module into small module as per the behavior of the system. The detailed design which is presented includes data flow diagram, system architecture, design consideration.

A. *Design Consideration*

System design identifies the modules that should be in the system, As per the requirements of this project, it is essential to identify water sensors that can provide real-time reading of water level and its contamination. Since the sensors will be installed on ROV it will be very difficult to transmit the data at very high speed to the base station directly therefore methods like efficient OFDM with good modulation technique are required to transmit data to the surface before transmitting to the base station. The OFDM technique uses FFT block which produces more errors. Hence more efficient techniques like DWT and DTCDWT block is replaced in OFDM block for efficient transmission of acquired underwater sensor data.

B. *Development Methods*

The figure below shows the top level block diagram of sensor data processing system wherein the temperature data, pH sensor data and depth information which is acquired will be processed using FFT, DWT and DTCDWT and sent into AWGN channel and Acoustic channel for comparative analysis.

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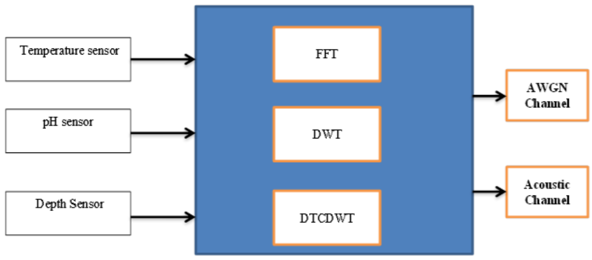


Fig. 1. Top level Block Diagram of Sensor Data Processing System

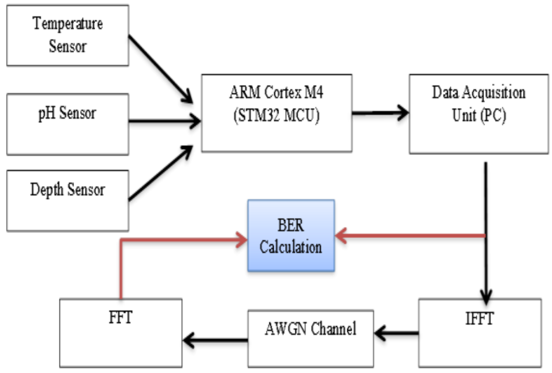


Figure.2. FFT based Sensor Data Processing system in AWGN Channel

III. IMPLEMENTATION

The large system consists of Sensor data Acquisition unit, Sensor data transmission unit and two Channel environments (AWGN and Acoustic Channel). The proposed architecture was implemented using PSOC 5LP board [2], it was little costlier for the complete project implementation. The same architecture is implemented using ARM Cortex M4 (STM 32 board). The system architecture includes Sensor data acquisition unit, sensor data transmission unit, channel and BER calculation. The Figure 2 and figure 3 shows the sensor data transmission unit, FFT/IFFT based Sensor data transmission unit in AWGN and Acoustic channel.

The Temperature sensor data, pH sensor data and Depth sensor data for one hour duration is acquired using STM32 board (ARM Cortex M4 Board) which is recorded in the table below.

Table 1. Sensor Data Acquired by ARM Cortex M4

Sl No	Temperature Sensor Data	pH Sensor Data	Depth sensor Data
1	28.30000000	7	0.60000000000
2	28.20000000	7.10000000000000	0.50000000000
3	28.30000000	7	0.90000000000
4	28.30000000	6.90000000000000	1
5	28.30000000	7.10000000000000	1.20000000000
6	28.40000000	7.10000000000000	1.60000000000
7	28.40000000	7.20000000000000	1.40000000000
8	28.40000000	7.20000000000000	1.20000000000
9	28.40000000	7.20000000000000	1.10000000000
10	28.40000000	7.10000000000000	1.70000000000
11	28.40000000	7.20000000000000	1.80000000000
12	28.30000000	7.20000000000000	1.90000000000
13	27.90000000	7.20000000000000	1.10000000000
14	27.90000000	7.30000000000000	0.70000000000
15	27.90000000	7.30000000000000	0.60000000000

The number of errors when the acquired temperature data,ph data and depth data is passed through FFT ,DWT and DTCDWT in AWGN and Acoustic noise is tabulated in the table 2,table 3 and table 4 for SNR from 0 to 50.

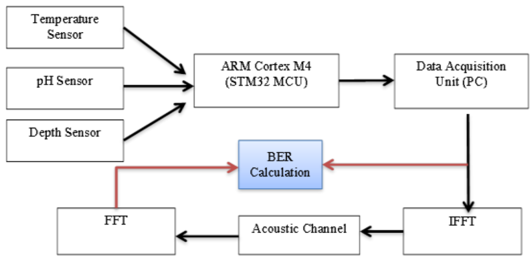


Figure.3. FFT based Sensor Data Processing system in Acoustic Channel

The Figure 4 and figure 5 shows the sensor data transmission unit , DWT/IDWT based Sensor data transmission unit in AWGN and Acoustic channel.

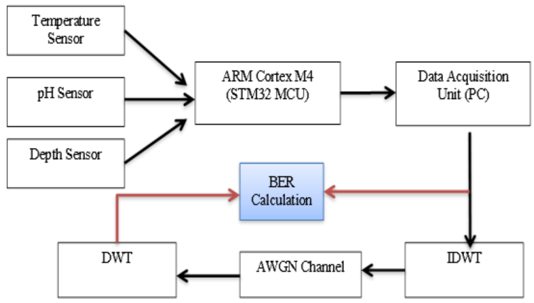


Figure.4. DWT based Sensor Data Processing system in AWGN Channel

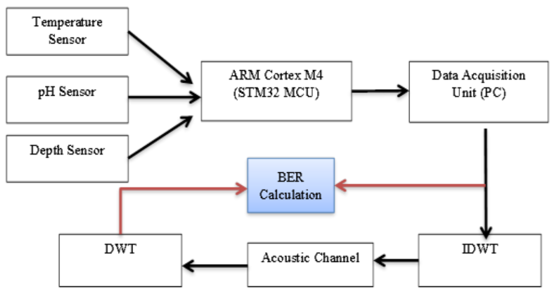


Figure.5. DWT based Sensor Data Processing system in Acoustic Channel

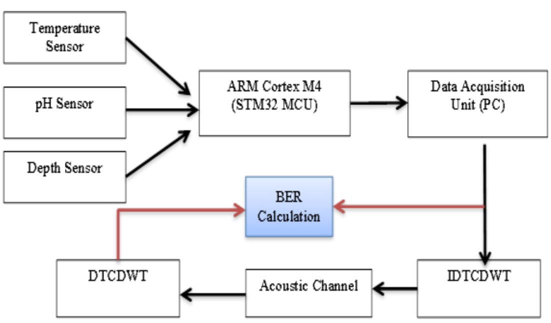
The Figure 6 and figure 7 shows the sensor data transmission unit , DTCDWT/IDTCDWT based Sensor data transmission unit **Figure.6. DTCDWT based Sensor Data Processing**

Parameter = Temperature : 26-30 C			Number of Acquired Sensor Data = 64				
Sl No	**SNR**	**Number of Errors in FFT with AWGN**	**Number of Errors in FFT with AWGN and Acoustic Noise**	**Number of Errors in DWT with AWGN**	**Number of Errors in DWT AWGN and Acoustic Noise**	**Number of Errors in DTCDWT with AWGN**	**Number of Errors in DTCDWT with AWGN + Acoustic Noise**
1	0	71.55	482509.83	59.382	46142.761	0.852	11457.95
2	10	17.93	198942	14.53	17463.63	0.82	11371.78
3	20	5.1894	57382.9	3.867	6481.76	0.8294	11520
4	30	2.27	23997.32	1.35	2385.53	0.8279	11434.99
5	40	0.70	22799.19	0.54	989.81	0.829	11451.98
6	50	0.17678	20319.3	0.171	606.07	0.83	11461.65

in AWGN and Acoustic channel. **system in Acoustic Channel**

Parameter = Ph 6.0-8.0 ppm			Number of Acquired Sensor Data = 64				
Sl No	**SNR**	**Number of Errors in FFT with AWGN**	**Number of Errors in FFT with AWGN and Acoustic Noise**	**Number of Errors in DWT with AWGN**	**Number of Errors in DWT AWGN and Acoustic Noise**	**Number of Errors in DTCDWT with AWGN**	**Number of Errors in DTCDWT with AWGN + Acoustic Noise**
1	0	15.057	163280.83	13.63	13983.85	0.237	5620.73
2	10	4.8806	55112.27	3.8953	3727.042	0.230	5295.94
3	20	1.755	22834.24	1.5865	1759.00	0.215	5282.17
4	30	0.490	21666.38	0.43	782.02	0.217	5317.22
5	40	0.1739	20386.0	0.1276	555.154	0.216	5316.0
6	50	0.044952	20229.052	0.0422	495.72	0.210	5320.60

Parameter = Water Depth (0-4m)			Number of Acquired Sensor Data = 64				
Sl No	**SNR**	**Number of Errors in FFT with AWGN**	**Number of Errors in FFT with AWGN and Acoustic Noise**	**Number of Errors in DWT with AWGN**	**Number of Errors in DWT AWGN and Acoustic Noise**	**Number of Errors in DTCDWT with AWGN**	**Number of Errors in DTCDWT with AWGN + Acoustic Noise**
1	0	4.3077	423240.15	3.769	27973.92	0.17879	4626.65
2	10	1.092	168900.94	1.0626	14714.90	0.081997	3858.97
3	20	0.39322	21072.85	0.368	6247.86	0.0779	3806.66
4	30	0.1234	20703.96	0.0843	5414.56	0.0575	3754.77
5	40	0.0363	20423.42	0.03609	4768.56	0.0589	3745.89
6	50	0.011185	20262.60	0.00894	4566.24	0.0573	3743.05



IV. RESULT AND ANALYSIS

The GUI of sensor data acquisition and Processing unit with three sensor data such has temperature, pH and Depth processed using FFT,DWT and DTCDWT in AWGN and Acoustic Channel.

A. Temperature sensor data Processing

The Figure below shows the GUI for FFT,DWT and DTCDWT in AWGN channel and Acoustic channel for Acquired temperature data with number of sensor data considered are 64 and SNR of 0 and 50.

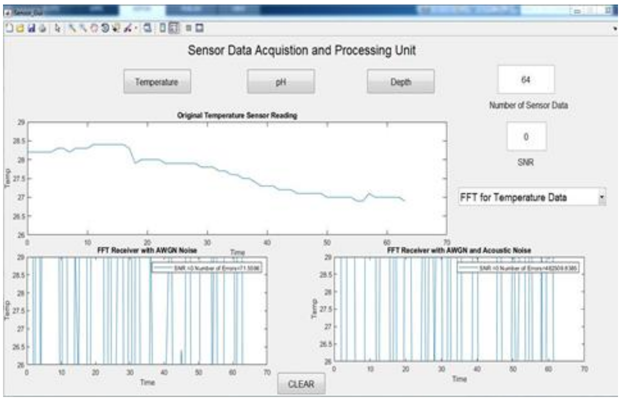


Figure.7. GUI for Temperature Sensor data in FFT with SNR=0

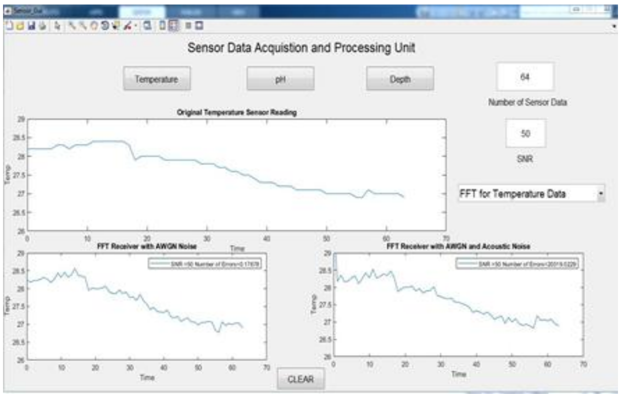


Figure.8. GUI for Temperature Sensor data in FFT with SNR=50

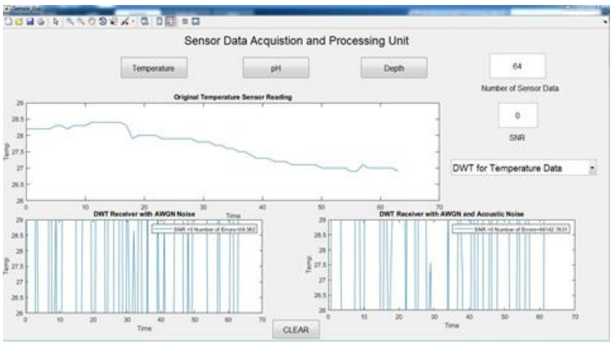


Figure.9. GUI for Temperature Sensor data in DWT with SNR=0

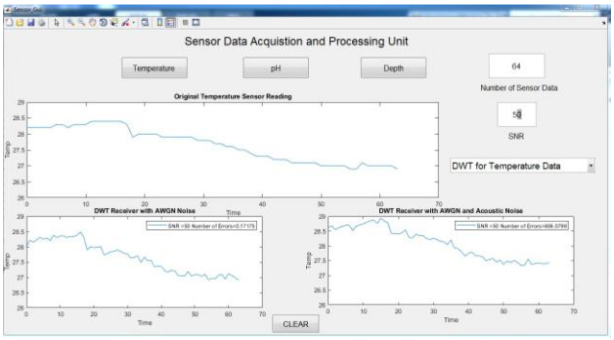


Figure.10. GUI for Temperature Sensor data in DWT with SNR=50

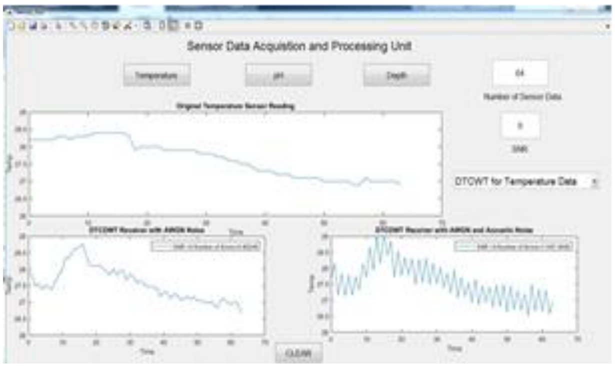


Figure.11. GUI for Temperature Sensor data in DTCDWT with SNR=0

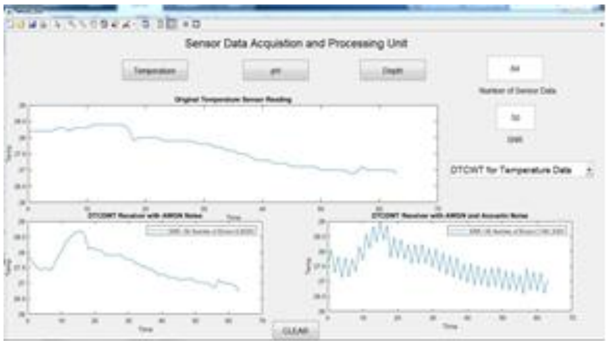


Figure.12. GUI for Temperature Sensor data in DTCDWT with SNR=50

B. pH sensor data Processing

The Figure below shows the GUI for FFT, DWT and DTCDWT in AWGN channel and Acoustic channel for Acquired pH data with number of sensor data considered are 64 and SNR of 0 and 50.

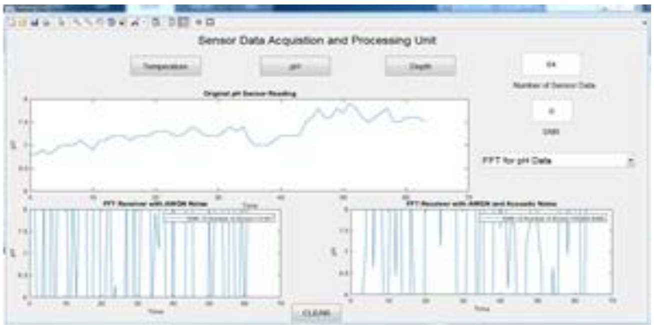


Figure.13. GUI for pH Sensor data in FFT with SNR=0

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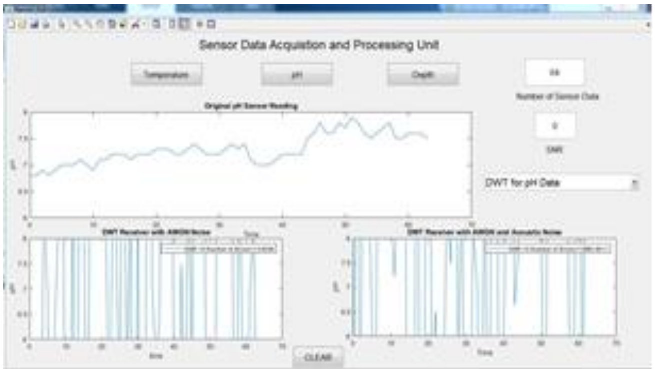


Figure.14. GUI for pH Sensor data in DWT with SNR=0

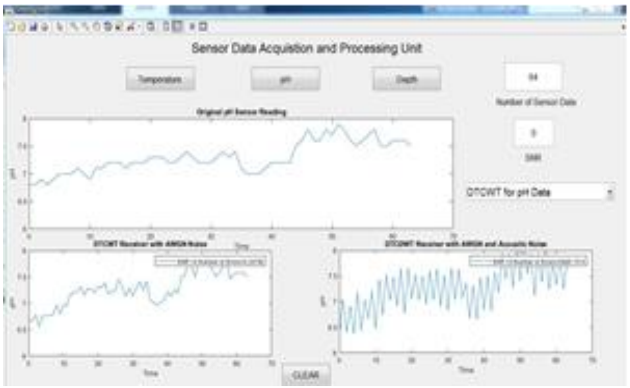


Figure.15. GUI for pH Sensor data in DTCDWT with SNR=0

C. Depth sensor data Processing

The Figure below shows the GUI for FFT,DWT and DTCDWT in AWGN channel and Acoustic channel for Acquired depth data with number of sensor data considered are 64 and SNR of 0 and 50.

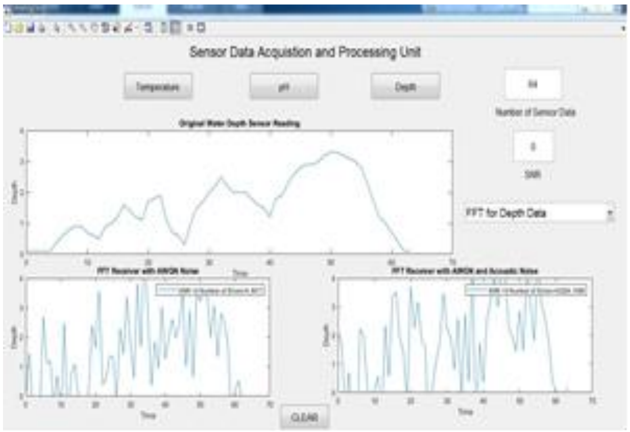


Figure.16. GUI for depth Sensor data in FFT with SNR=0

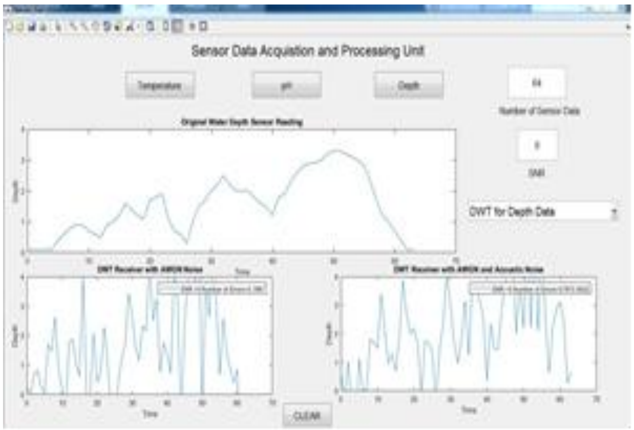


Figure.17. GUI for depth Sensor data in DWT with SNR=0

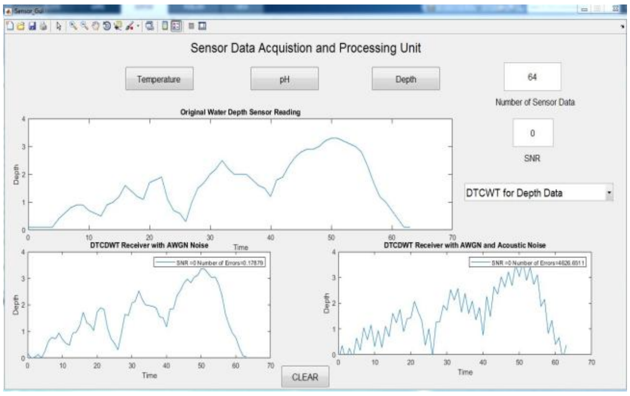


Figure.18. GUI for depth Sensor data in DTCDWT with SNR=0

The comparison of temperature sensor, depth sensor and pH sensor with different SNR ranging from 0 to 50 with 64 numbers of samples considered.

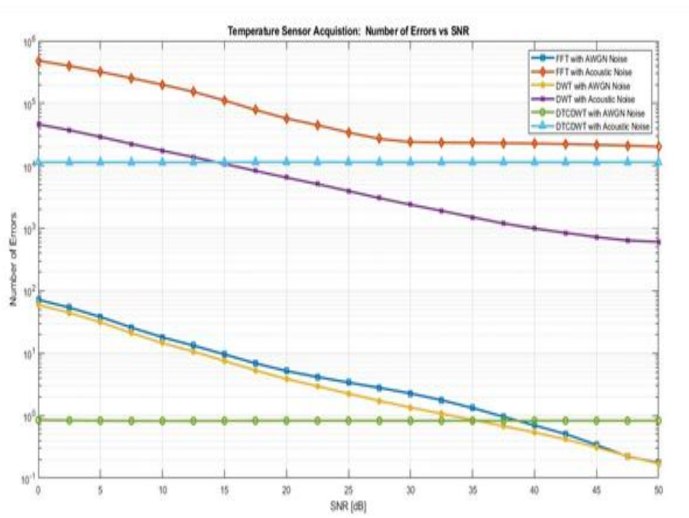
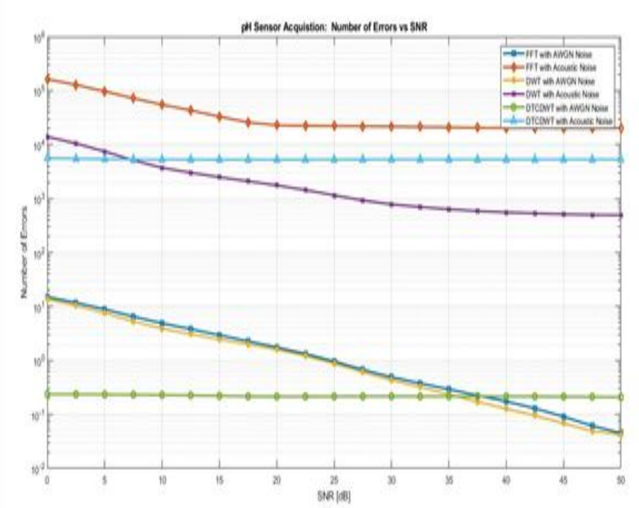


Figure.19. Comparison of Temperature Sensor Acquisition with AWGN and Acoustic Channel



AWGN and Acoustic Channel

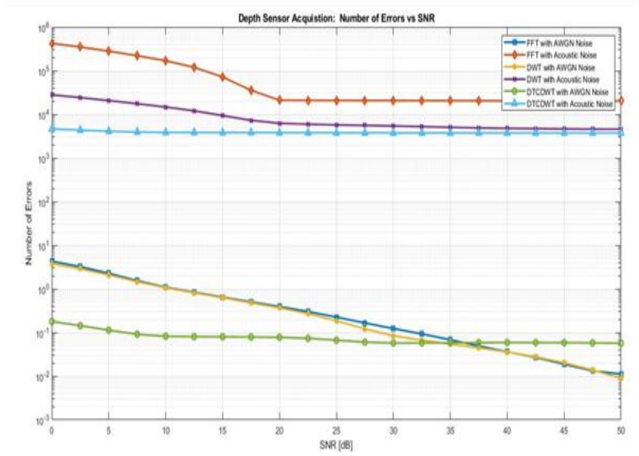


Figure.21. Comparison of depth Sensor Acquisition with AWGN and Acoustic Channel

Comparison results shows that the number of errors in the case of DTCDWT is less when compared to DWT and FFT in all the acquired sensor values and also we can notice that in acoustic channel number of errors are increased all the three cases and is slightly reduced in the case of DTCDWT.

V. CONCLUSION

The analysis of FFT, DWT and DTCDWT for efficient transmission of real time sensor data in different channel environment such as AWGN and Acoustic Channel has been achieved. The simulation results show that number of errors in the case of DTCDWT is less compared to DWT and FFT for all the acquired sensor values. The number of errors is more in acoustic channel because of thermal noise, shipping noise, wave noise and other additional noise factors. The real time underwater sensor data is acquired for one hour duration. The three sensor data like temperature sensor data, pH Sensor data, depth sensor data are acquired and processed using FFT, DWT and DTCDWT. The simulation is done using MATLAB GUI for the real sensor data which was acquired. Implementation of the same work was carried out using STM32 Microcontroller Boards.

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