THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Implementation of Wireless Sensor Network (WSN) in Engines in the Ship to Improve Integrated Machines and Engines Operation Control

Alexander Victor Bukit
Lecturer, Department of Electronics Study Program,
Indonesia Naval Technology College, STTAL Surabaya, Indonesia
Avando Bastari
Commander, Department of Indonesia Naval Technology College,
STTAL Surabaya, Indonesia
Joko Iswahyudi
Lecturer, Department of Electronics Study Program, Indonesia Naval Technology College STTAL Surabaya, Indonesia

Abstract:
The development of the current monitoring system technology has undergone very rapid development so that the better monitoring function can help humans to better guarantee the performance of a system that will be observed / monitored. With the existence of monitoring technology it is expected to reduce the damage factor of the tool which of course will require very large costs, increase the effectiveness and efficiency of the system by giving feedback in real time to the system.In this study will discuss the use of the Wireless Sensor Network (WSN) system on Vessels to Improve Engine Performance and Integrated Engine Operation Control. This refers to the conditions of the engines on a warship that have various systems equipped with their respective sensors which will then provide a value as input to the WSN system, and overall these inputs will be processed according to the specifications contained in each engine , to get the output decision that will be given as feedback to the engines to be able to increase effectiveness and efficiency and avoid damage that can occur suddenly without warning if it is not equipped with the monitoring system. The research results show that the Implementation of Wireless Sensor Network (WSN) on Vessel Engines to Improve Engine Performance and Engine Operation Control can be relied on reliably in combat operations so that the crew ship products can be applied in various military operations.

Keywords: *WSN, ship engine, performance, sensor*

1. Introduction

Each engine on the ship has a specific function that works to support each other so that optimal performance can be obtained from the operation of a ship. If one or several engine systems are interrupted, it will affect the performance of other engines or the entire system of the ship's operation, and in the end it can damage other machines as well. Supervision and checking of ship engines is an attempt to find out the existing conditions in the form of a state of temperature, pressure, RPM and other conditions to avoid the danger of sudden damage. Thus the temperature, pressure or RPM on existing machines may not exceed the specified maximum limit. If the temperature, pressure or RPM is allowed to exceed the predetermined limit, it is likely to cause damage to the equipment and disrupt the system as a whole. Routine checks are carried out to carry out patrols around the machines by looking directly at the conditions of the engines. Checking is done from one machine to another. Of course, there are still many gaps for things that are not desirable. Because checking is done on the machine not continuously and simultaneously. As a result, if a damage occurs, rational action cannot be taken quickly.

To overcome these problems it is necessary to make a remote monitoring system based on Wireless Sensor Network (WSN) which can monitor conditions on the machines continuously. By using this monitoring system parameter data can be taken in actual and real time using sensors so that the parameter data can be monitored in the monitoring room. The WSN-based machine monitoring system is a complex system consisting of data acquisition subsystems, data analysis and display subsystems. The data acquisition system is responsible for collecting sensor data towards the database server. The data analysis system is in charge of analyzing data from the database server. While the data display system is tasked with displaying data from the analysis via the web.

2. Material and Methods

2.1. Wireless Sensor Network (WSN)

Wireless Sensor Network (WSN) is a collection of a number of smart sensor nodes arranged in a network, where each sensor point has the ability to sense, process and communicate, but when developed in terms of number or connected to each other into a network, it will be able to perform the monitoring function of a physical state of the earth collectively. Initially the application of the wireless sensor network (WSN), as if only existed in imagination. But along with the many challenges that come, and erratic natural behavior causes this technology to develop wide and deep, starting from the network protocol used, power provisioning, to programming models.

As explained above, WSN is composed of many miniature sensors, each of which has the ability to feel and interact with nature, process data that has been collected, and can communicate vertically (fellow sensor nodes), or horizontally (with base stations) without going through a cable. and wireless communication, also provides added value to this technology, because the transmitted data can be distributed with intelligent algorithms, so that this network can self-organize.

The sensor points that are held have limited power, computing and communication. The main task of the sensor is to monitor the physical condition of an environment and communicate the results to the base station or fusion center.

The use of wireless sensor network (WSN) technology for the interests of industry, environment and health has shown very high development, this has become the idea of the need for the use of WSN technology for defense purposes. The WSN is able to provide a means for autonomous monitoring of physical events in areas where human existence is undesirable or impossible, several applications:

- Disaster relief
- Environmental control
- Military application
- Border security

The most important limitation on the use of WSN technology now is the availability of power, to supply power to the WSN node is currently obtained from the battery, but the battery has weaknesses such as not being able to support the operation of WSN nodes for a long time, now developed Maximum Power Point Tracker (MPPT) technology as a solution to the design philosophy requires the development of adaptive systems to transfer the energy produced by solar cells into storage media, such as batteries or super capacitors, while maintaining the cell's working point.

In WSN, sensor nodes are spread with the aim of capturing the symptoms or phenomena to be investigated. The number of nodes that are spread can be determined as needed and depend on several factors such as area, sensing node capability, and so on. Each node has the ability to collect data and route it back to the Base Station. Sensor nodes can collect large amounts of data from symptoms arising from the surrounding environment.

Today the development of sensor nodes follows the trend of nanotechnology, where the size of sensor nodes becomes smaller from year to year

Small sensor nodes are spread out in a sensor area. The sensor node has the ability to route data collected to other adjacent nodes. Data sent via radio transmission will be forwarded to the BS (Base Station) which is a link between the sensor and user. This information can be accessed through various platforms such as internet or satellite connections, allowing users to be able to access real-time via a remote server.

WSN can be divided into 5 parts, as:

2.1.1. Transceiver

This transceiver function is to receive / send data using the IEEE 802.15.4 or IEEE 802.11b/g protocol to other devices such as concentrators, Wifi modems and RF modems.

2.1.2. Microcontroller

Microcontroller functions is to perform calculation functions, control and process devices connected to the microcontroller.

2.1.3. Power Source

Power Source supplies the energy source for the entire Wireless Sensor system.

2.1.4. External Memory

External Memory functions as an additional memory for the Wireless Sensor system, basically a microcontroller unit has its own memory unit.

2.1.5. Sensor

Sensors are used to sensing the physical quantities to be measured. The sensor is a device capable of converting a form of energy into another form of energy, in this case is changing from the amount of energy measured into electrical energy which is then converted by the ADC into a sequence of quantized pulses which can then be read by the microcontroller. Wireless Sensors use 2 wireless communication standards:

- IEEE 802.15.4.

This IEEE 802.15.4 protocol is one of the kinds of protocols on WPAN (Wireless Personal Area Networks), one example of another WPAN is Bluetooth. This IEEE 802.15.4 protocol is the standard for radio waves (RF). This protocol works at a low data rate so that the battery can be durable, and simple. A device that uses this protocol, can be connected properly at a maximum radius of 10 m and with a maximum data rate of 250 Kbit / s with other devices. This protocol uses 3 frequency bands for operational purposes, such as:

- 868–868.8 MHz for European regions.
- 902-928 MHz for North America.
- 2400–2483.5 MHz for other regions throughout the world.

Zig Bee is one of the vendors who developed layers above the layer for IEEE 802.15.4 this. In its current development, this protocol already supports the use of Ipv6, with the marked birth of RFC 4919 (Request for Comments 4919) and RFC 4944 (Request for Comments 4844).

- IEEE 802.11

This protocol consists of several other types of standards for WLAN (Wireless Local Area Networks), currently the most popular are IEEE 802.11g and 802.11b. The Wireless Sensor Network uses the IEEE 802.11b / g protocol. This IEEE 802.11 protocol has several different frequency channels, so that there is no interference between IEEE 802.11 devices, frequency sharing for each channel is governed by each country's policies.

The IEEE 802.11b protocol used in Wireless Sensors has a maximum data rate of 11 Mbit / s. In fact, this protocol is only capable of having a maximum data rate of 5.9 Mbit / s with TCP, and 7.1 Mbit / s for UDP (User Datagram Protocol). This is because of the overhead on CSMA. The IEEE 802.11b protocol is capable of operating at a radius of 38 m from other devices, and has an operating frequency of 2.4 GHz.

2.2. Arduino

Arduino is an open-source single-board microcontroller, which is produced by the wiring platform, designed to facilitate the use and design of electronic devices in various fields. The hardware used uses an Atmel AVR processor and has software with its own programming language.

Arduino Uno is a microcontroller device that uses ATmega328. ArduinoUno has 14 digital input / output pins (where 6 pins can be used as PWM output), 6 analog inputs, 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button.

In this research the microcontroller used is Arduino Nano because this type of Arduino has a small size. As it is known that component size is something that must be considered because of the limited dimensions of WSN. Arduino Nano also has several advantages, it is supported by Arduino IDE with a library of programming languages that are quite complete.

The Arduino (sketch) software used as an Arduino IDE is also equipped with a serial monitor that allows programmers to display simple serial data that can be sent or received from the Arduino Nano board. The RX and TX LEDs installed on the Arduino Nano board will blink in the event of serial data communication between the PC and Arduino Nano.

2.3. Raspberry Pi

The Raspberry Pi is a single-board computer or SBC-sized credit card. Indeed, the Raspberry Pi is equipped with all functions like a complete computer, using ARM SoC (System-on-a-chip) which is packaged and integrated above PCB (circuit board) with dimensions of 5.5cm x 8.5cm and a height of 2cm. CMPS10 is a module that is equipped with a 2-axis accelerometer and magnetometer, uses a 16-bit processor, and is designed to eliminate errors caused by tilt of the PCB. The output of the sensor measures the direction of the magnetic field, as well as the pitch and roll of the accelerometer sensor. CMPS10 requires a 3.6 - 5v power supply with 25mA current. This module has several ways to access data, namely using serial interfaces, I2C interfaces, and PWM output.

2.4. RS-232 Serial Communication

Serial RS-232 as serial communication has 9 pins that have their respective functions. RS-232 communication was introduced in 1962 and in 1997. RS-232 is the most commonly used interface for serial communication, but has certain limits. RS-232 (single ended) data transmission specifications from TX to RX on average slow (20Kbit / s) and short distances (50 feet with maximum data average). Below is a Figure 1. RS-232 Standard Configuration:

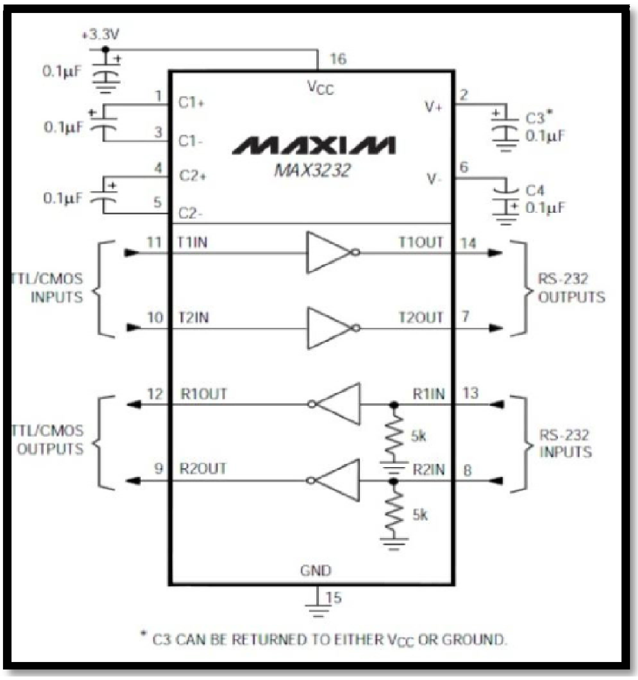

Figure 1: RS-232 Standard Configuration

The RS-232 signal is represented by a common system voltage that has many handshaking paths and also specifies a communication protocol. This type of signal works well in point-to-point communications at low data transmission averages. An interface can use ports on a computer, or need additional ports or adapters. The RS-232 port on a PC is a single device. RS 232 signal requires ground between the PC and the connected equipment. Cable distance must be limited to 1 to 200 feet on Asynchronous data and around 50 feet with synchronous data.

Synchronous data has a transmite and receive clock which limits the maximum distance when using a synchronous data path. RS-232 determines the meaning of the different serial signals and assignment pins on standard 25 pins (DB-25). Because RS-232 determines signals that are not used for most standard communications, sometimes the DB-25 connector loses unneeded pins. In short, the RS-232 port is designed to communicate with local equipment and will support 1 driver and 1 receiver.

2.5. Sensors

The sensor is a type of transducer that is used to change mechanical, magnetic, heat, light, and chemical quantities into electrical voltages and currents. Sensors are often used for detection when making measurements or controls. Some types of sensors used in machine monitoring systems include temperature sensors, pressure, and RPM.

<u>2.5.1. Limit Switch</u>

The limiting sensor, in the sense of detecting the motion of a machine so that it can control it or stop the movement of the machine so that it can limit the movement of the engine and not to exceed, the user is very common and many. Examples of using limit switches:

- Sensor door open / close.
- Sensor cylinder up / down.
- Sensor Safety equipment (emergency stop).
- Sensor position.:

<u>2.5.2. Induktive Sensor</u>

An inductive proximity sensor is a device that senses the presence of a metal object. This sensor works with an electromagnetic coil to detect the presence of a metal object. This sensor has four main elements namely coil, oscillator, trigger circuit, and an output. The oscillator functions to produce radio frequency. The electromagnetic field produced by the oscillator will be emitted by the coil through the sensor surface, this circuit will get feedback from the detected field to keep the oscilator working.

<u>2.5.3. Capasitive Sensor</u>

The capacitive sensor is an electronic sensor that works based on the capacitive concept. This sensor works based on changes in the charge of electrical energy that can be stored by the sensor due to changes in plate distance, changes in cross-sectional area and changes in the volume of the dielectric of the capacitive sensor. The concept of capacitors used in capacitive sensors is the process of storing and releasing electrical energy in the form of electric charges on capacitors which are influenced by surface area, distance and dielectric material.

The capacitive sensor is the same as the inductive sensor discussed earlier. The difference between a capacitive sensor and an inductive sensor is:

- Capacitive sensors produce electrostatic fields not electromagnetic fields as in inductive sensors.
- Capacitive sensors can detect materials made of metal or non-metals such as glass, liquid, or clothes..

Capacitive sensors can sense various things directly, such as: movement, chemical composition and electric field. Capacitive sensors can also sense various variables that are converted first into motion or dielectric constants, such as: pressure, acceleration, height and fluid composition. The capacitive sensor uses a conductive electrode with a dielectric. The detector circuit only requires a 5 Volt voltage (electricity) which will change the variation of capacitance into variations in voltage, frequency or pulse width..

2.5.4. Photoelectric Sensor

Photoelectric sensors are devices that convert signals generated by light emission into electrical signals. Rays can vary depending on the wavelength. Photoelectric sensors have 2 main components, namely the transmitter and receiveras follows:

2.5.4.1. Transmitter

- Luminescent Diode, also known as Light Emiting Diode (LED)
- Laser Diodes

2.5.4.2. Receiver

- Photodioda
- Phototransistor

2.5.5. Ultrasonic Sensor

Ultrasonic waves are waves with a frequency above the frequency of sound waves which is more than 20 KHz. As already mentioned, the ultrasonic sensor consists of an ultrasonic transmitter circuit called a transmitter and an ultrasonic receiver circuit called a receiver. The ultrasonic signal generated will be emitted from the ultrasonic transmitter. When a signal hits a barrier object, this signal is reflected, and is received by receiver ultrasonic. The signal received by the receiver circuit is sent to the microcontroller circuit to be processed to calculate the distance to the object in front of it (reflected field).

The signal is emitted by an ultrasonic transmitter. The signal has a frequency above 20kHz, usually used to measure the distance of objects is 40kHz. The signal is generated by an ultrasonic transmitter circuit.
The emitted signal will then propagate as a signal/sound wave with a sound speed that ranges from 340 m/s. The signal will then be reflected and will be received again by the Ultrasonic receiver.
After the signal reaches the ultrasonic receiver, then the signal will be processed to calculate the distance. Distance is calculated based on the formula :
$S = 340.t/2$

Symbol S is the distance between the ultrasonic sensor and the reflected field, and t is the time difference between the transmissions of ultrasonic waves until they are received back by the ultrasonic receiver.

2.6. Filter

In signal processing, filters also mean filtering. In this case the Filter is a tool or process to filter out an unwanted component or feature of a signal by removing the unwanted component. So, the filter captures the required frequency and discards the frequency that is not needed. The goal is to reduce noise. There are 4 types of filters commonly used including:

2.6.1. Low Pass Filter (LPF)

LPF is a type of filter that passes low frequencies and absorbs high frequencies, in the form of a response as shown in the picture. From Figure 2 it can be seen that when the frequency is low the transfer function value is maximum, and vice versa when the frequency has passed the cut-off frequency the transfer function drops to 0. This indicates that this filter passes frequencies below the cut-frequency off.

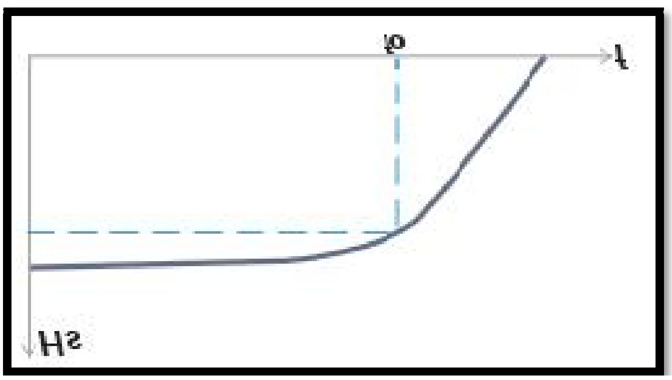

Figure 2: Low Pass Filter Response

2.6.2. High Pass Filter (HPF)

HPF is a type of filter that passes low frequencies and absorbs high frequencies, in the form of a response as shown in the picture. From Figure 3 it can be seen that when the frequency is low the transfer function value is maximum, and vice versa when the frequency has passed the cut-off frequency the transfer function rises to its maximum point. This shows that this filter passes frequencies that are above the cut-off frequency.

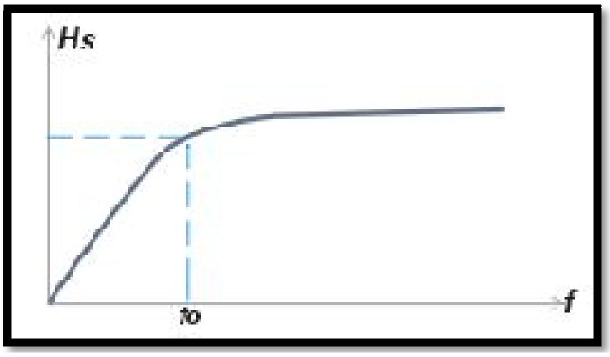

Figure 3: High Pass Filter Response

2.6.3. Band Pass Filter

Filter that passes a frequency range. In design, the Q value (quality factor) is calculated, with:

- Q = quality factor
- fo = cut-off frequency
- B = frequency band

Figure 4 shows that this filter passes a frequency that is above the Low cut-off frequency and below the High cut-off frequency. So that the frequency outside is muted..

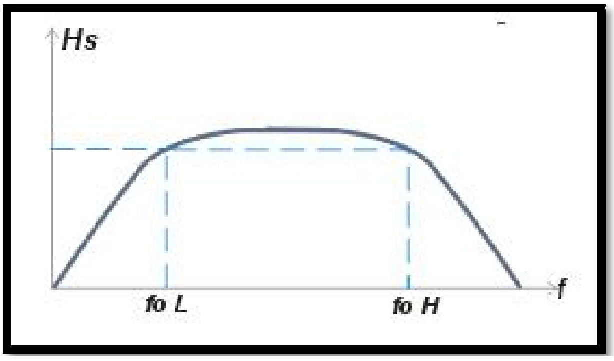

Figure 4: Band Pass Filter Response

2.6.4. Band Reject Filter

Filter that processes a frequency range. Just like bandpass filters, reject bands also take into account quality factors. From Figure 5 this circuit shows the inverse of the Band Pass Filter, which is to pass the frequency above the cut-off High and below the Low cut-off frequency..

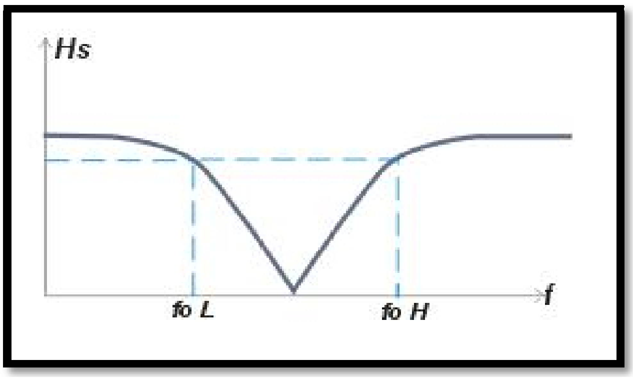

Figure 5: Band Reject Filter

3. Result and Discussion

The design of this system consists of designing hardware (hardware) and designing software (software). The figure below is a diagram block of the Wireless Sensor Network (WSN) Implementation System on Vessels on Boats to Improve

Machine Performance and Integrated Machine Operation Control. The research will be carried out through stages that are in accordance with the research steps shown in the flow diagram that can be seen in Figure 6.

The design of a monitoring system on machines on a wireless sensor network based ship consists of 2 large Subsystems namely the Data Acquisition Subsystem and the Embedded Server Subsystem with the configuration of 3 Nodes and 1 Data gathering that will be connected to the LAN. In the Data Acquisition Subsystem, each sensor node is equipped with a microcontroller, sensors and data network.

Sensors installed on machines will provide data responses based on conditions, situations in each machine. Each sensor node monitors the conditions in each machine, then the measurement results of the sensors enter the microcontroller. In the analog data microcontroller is processed with Analog to Digital Converter (ADC) and the output of the microcontroller is then sent to the Wireless Node Server. On the server side consists of xbee which is used as a receiver and Mini Personal Computer (PC) to display the results of monitoring and data base. The three nodes on the Block diagram monitoring system are subsystems of data acquisition as sensor data input to embedded subsystems. When the monitoring system works the sensor nodes on each machine will provide data continuously so that the development of the condition of the machines can be known.

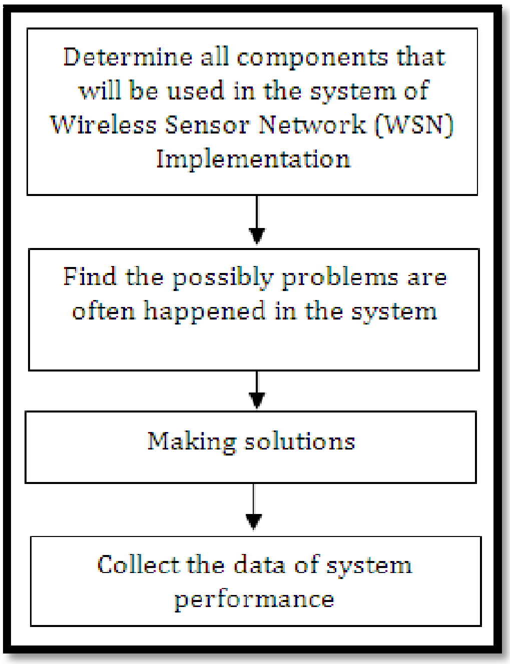

Figure 6: System Block Diagram

3.1. Hardware Design

Arduino microcontrollers is used for the data acquisition subsystem on the machine monitoring system based on the wireless sensor network consists of Node Sensors, IEEE 802.15.4/Zigbee wireless devices, temperature, pressure sensors and engine RPM, server subsystems consisting of data communication terminals transceiver. The design of sensor nodes using Arduino Uno R3 microcontroller based on Atmega 328. Arduino uno R3 microcontroller as data processing and features a digital I/O Pins 14, 6: provides PWM output, 6: analog inputs, 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button.

Data communication terminals are used to be connected via radio communication. Radio communication using zigbee types(IEEE 802.15.4), in this research with xbee pro devices because xbee-pro has advantages of low power consumption but has enough power in this research.

The working frequency of the module is 2.4 GHz, using the RS232 interface. Data rate capability of 250 kbps. For the sensitivity of this module it is quite good at -100 dBm. These modules use DSSS modulation (Direct sequence spread spectrum). The power supply needed is 2.8 - 5 V / 55 mA DC.

The server node on the machine monitoring system on the WSN-based ship is in the form of xbee pro, which is connected to both personal computers and laptops. From a PC or laptop use the UART communication connector to connect the xbee pro with a mini PC or laptop.

Data sensing from the sensor must be converted into digital data which is converted through the Analog Digital Converter microcontroller (ADC) port which has a resolution of 16 bits for each sensor. Arduino microcontrollers have ADC resolution that can be changed according to their needs, for 16 bit digital range values from 0 - 65535. Determination of this resolution is adjusted to the need for accuracy and accuracy where if the resolution is higher it will increase resolution and accuracy but conversely will decrease throughput process speed because the process is widely used to convert large data sizes. The highest resolution is 16 bits or 65535.

3.2. Software Design

The IEEE technology standard uses PAN/LAN/MAN standard (generally LAN) to connect the wireless sensor network. The wireless network protocol in the system designed determines the encoding process of the transmission signal using the data link layer. The wireless protocol used in this study also uses these specifications for the distribution of canals and handling procedures for each inputted data and event. The IEEE 802.15.4 / Zigbee standard protocol was used in this study which was linked through Xbee pro. The initial configuration parameters of the Xbee pro module are used in accordance with the software from the Xbee Pro factory, XCTU. Network devices that will send data frames using the CSMA/CA mechanism to PAN coordinator and on these devices will be provided with x bee pro device devices. XBee Pro has several addressing modes for the communication process. The addressing mode used in this study is short 16 bits. Using the short 16 bit addressing mode is used to address each of the wireless RF modules, so each wireless RF has a specific address so that all other wireless RF modules can communicate, and to avoid other RF wireless modules that cannot communicate. To be able to set the system can be done by changing through changing parameters in the wireless RF module using AT Command. In this research the data package used is the type API TX frame mode (transmit) and RX (receive) 16 bit address. In API frame will be given a data frame. Data frames are useful for facilitating the transmission of data. Each frame delivery can be distinguished through the API identifier. If the sensor node has sent a data packet, the frame will contain the sensor condition data that has been set before. Point to multipoint Xbee Pro Series 1 communication is linked to the star topology. After communication that connects the Xbee sensor node with the Xbee node server, the sensor readings on the Arduino node sensor pin are then sent to the server node in the form of data packets which will then be processed to be displayed and used in decision making. Flow chart of sending sensor data packets as shown in Figure 7.

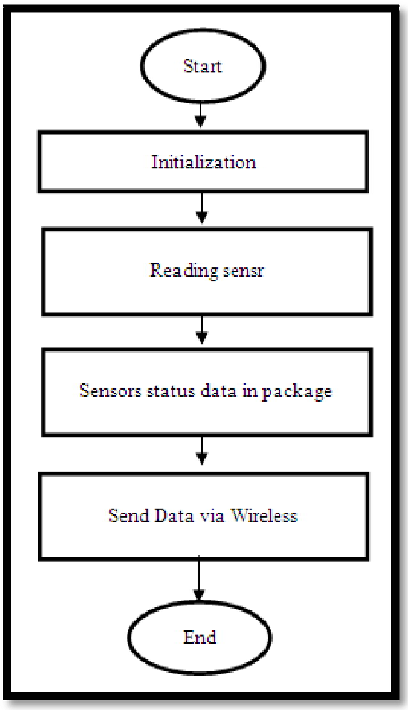

Figure 7: Flowchart of Data Package Communication

The data received at the server node is then stored on a PC or laptop, and then the data package will be arranged in a database to facilitate further processing. When carry out data, it will add a time stamp field as the data marker and will be sorted according to the time of data packet entry from all engine sensors. Data appearance can be shown in the form of tables or graphs according to operator requirements.

Throughput (message / second) is the total number of data packets sent divided by time duration. Formulation written in the equation:

$\eta = N / \tau x\, 8$ (bps)

withN = Data package,

η = Troughput,

τ = Total waktu untuk transmisi

End-to-end delay is the amount of time used by a packet when sent by a node and received at the destination node mathematically written in the equation::

$\Delta t = t_t - t_0$

withΔt= End-to-end delay,

t_t= Receive time,

t_0= Send time.

3.3. Testing of Sensors and Analog Digital Converter

When the device is first turned on, initialization will be carried out as needed. Determined the initial value needed for each sensor so that changes in the existing value can be adjusted to the system server requirements. Data from each sensor is still an analog value in the form of a voltage value with a scale of 0 volts up to the maximum value that is determined in this design is 5 volts as the maximum temperature, pressure and RPM.

Furthermore, to be able to be processed by the server system, the analog data must be converted into digital form by 16-bit analog to digital converter (ADC) as explained in the previous ADC design. The 16 bit ADC is implemented on each sensor. Analaog Digital Converter testing aims to see whether the process of changing the data format is as expected and the reading results go well. The results of measurements are shown in Table 1.

Tegangan Analog Sensor (pin A0)	Pembacaan ADC (16 bit)	Tegangan DAC	Selisih
2.4 Volt	31131	2.375 Volt	0.025 Volt
0.79 Volt	9926	0.787 Volt	0.003 Volt
2.05 Volt	26530	2.024 Volt	0.026 Volt
1.55 Volt	19749	1.556 Volt	0.004 Volt
1.79 Volt	22519	1.78 Volt	0.010 Volt
0.78 Volt	9922	0.757 Volt	0.023 Volt

Table 1: Delay Test of System

Table 1 is the result of a comparison of the readings between the analog voltage of the sensor output and the ADC output data and then the data is converted back to the DAC to compare the data and ensure that the system is running as expected. The analog voltage of the sensor is measured using a digital voltmeter while the ADC reading is read on a PC via an RS 232 serial cable in the monitor serial IDE and the DAC data is measured by a digital voltmeter. In Table 1 shows a comparison of the analog sensor voltage readings and the ADC reading results can run with the expected conditions and the error is still quite small in the desired tolerance below 10%.

Output calibration of each sensor is set at a scale of 0 volts which is when the engine is not yet operational or when off, then the maximum half scale is 2.5 volts which is when the engine operates optimally according to the manufacturing conditions, and the maximum scale is 5 volts when the engine enters the area operations that can damage the machine, both temperature, pressure and RPM.

4. Conclusion

After conducting the process of testing and analysis of the system that has been made, it can be concluded that:

- Delay obtained from the system to achieve balance, with 100ms delay tolerance.
- The error value of the weapon slope that appears on the system equates to a maximum error tolerance of 0.5% of the reference.
- To correct the delay obtained from the system can be done by recalculating the incoming data and data that goes to the microcontroller and microcomputer.
- Implementation of this system is also expected to be used on other engine systems.

5. Acknowledgement

The authors greatly acknowledge the support from Indonesian Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

6. References

i. Agustina, Irmalisa and Juwita Maria Pakpahan. 2016. Stereo Display Image and Position Detection For HMD. Jakarta: Gunadarma University.
ii. ATmega16 AVR Microcontroller Practicum Guide Issued by Elex Media Komutindo, January 2008
iii. Graham C. Goodwin, Stefan F. Graebe, E. Mario Salgado, Classical PID Control, Control System Design, Prentice Hall PTR.
iv. http://www.tandef.com, Discussing the Universal Role of the Navy, accessed on June 6, 2011.
v. http://wikipedia.com, Story GPMG 7.72 mm, accessed on June 6, 2011
vi. Ilbert Paul Malvino, PhD. 2004. Principle - Principles of Electronics, Erlanga, third edition of Surabaya.
vii. http: // www.datasheetcatalog.com/atmega16, accessed on June 8, 2011.
viii. http: // www.selenoid. com /, accessed on June 12, 2011.
ix. Parakevopoulos, P.N., 1996. Digital Control System. Printice Hall Europe. London