# CONTINUOUS MONITORING OF AQUACULTURE POND WITH OPTICAL BASED SYSTEM

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*Abstract* ***–The objective of this project is to design a continuous monitoring equipped system for aquaculture pond with optical fiber sensors. The scope of this project is to develop a micro-controller based control system with the use of optical fiber signal as input to measurement equipment and software for decision making. The project focusing on data acquisition and instrument interfacing between wavelength meter (HP86120C) and Agilent Vee as well as microcontroller for automated response. The aquaculture pond is equipped with a fiber optic sensing network to monitors water level and multipoint temperature sensor. The data for water level wirelessly transmits to control water pump that acts upon trigger. The fiber optic network is also used as a means of communication between external sensors and the main monitoring sensors. Three different voltage levels from an external sensor can be interfaced to a microcontroller that controls three level of aeration pump speed.***

## I. INTRODUCTION

Aquaculture can be defined as rearing aquatic animals or cultivating aquatic plants such as crustaceans, shellfish or other saltwater organisms [1]. In Malaysia, the aquaculture industries have grown rapidly from time to time. Some of the aquaculture ponds farming can have more than 50 ponds in one farm. So it demands high labor intensity to monitor every pond at certain time. There are parameter needs to monitor and control such as dissolved oxygen, pH value, ammonia, temperature, water level and other important environmental factor to ensure the health and growth of aquatic animal is stable[2]. Therefore, to carry out aquaculture monitoring and control system of the digital key technology research and application work to promote efficient health of aquatic products breeding and sustainable development, the establishment of aquaculture environment for the automatic monitoring system, environmental control culture in the best condition for efficient breeding , will certainly be the future industrialization of farming trends[3].

The focus of this project is to monitor and control the level of water and dissolved oxygen. The level of water is monitored by using Agilent Vee tool. Agilent Vee is a graphical programming language optimized for building test and measurement applications, and programs with operator interfaces. The data from these 2 parameters are carrying by the signal of optical fiber. The optical fiber is connected to wavelength meter (HP86120C) which is interface with PC where the Agilent Vee is located. Agilent Vee processes the signal and display the level of water. Microcontroller transmits the data from Agilent Vee and dissolved oxygen wirelessly to receiver microcontroller. There are three level of water which is safe, mid-range and danger. Water pump is triggered when the level of water at danger position. For dissolved oxygen, aeration system will run at three different speeds correspond to three levels of dissolved oxygen.

## II. METHODOLOGY

*Part 1: System Design*

This section will discuss about the overall system design. The system composed of the usage of computer as a monitoring medium to detect the level of water and temperature at the pond. It also includes the usage of microcontroller for wirelessly transmit the data of water level and dissolved oxygen for controlling purpose. A model schematic of the system in application is shown in figure 1.

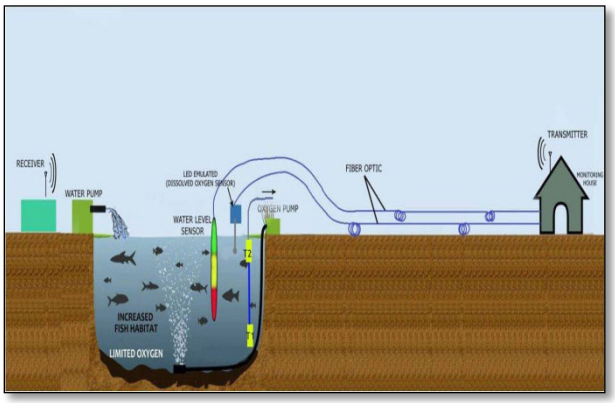


Figure 1: System application

It shows;

- An aquaculture pond with continuous monitoring system.
- Connection from the pond to the monitoring system using optical fiber.
- Communication between the monitoring station and controller of the water pump and aeration system wirelessly.

The system can handle three different kinds of sensors:

- FBG sensing water level
- FBG sensing temperature based
- Intensity based – emulation

### A. Fiber Bragg Sensing – Water Level

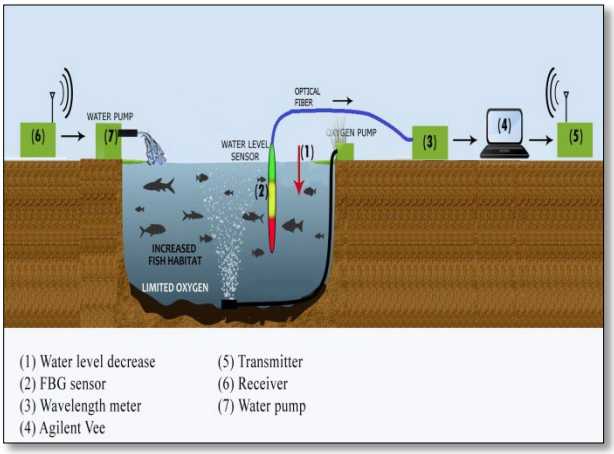


Figure 2: Project framework for Water Level

Figure above show the project framework for water level starting from detection of the signal until controlling the water pump. There are three levels of water which is safe, mid-range and danger. The level of water is detected by Fiber Bragg Grating (FBG) sensor where the sensor is mounted on the cantilever. Wavelength meter (HP86120C) is used to measure wavelength of optical fiber over a specified wavelength range. When the level of water is safe, it will remain at center wavelength value of optical fiber. If the water drop the wavelength would change and this shows that the level of water will be at mid-range or danger depends on the wavelength value.

The wavelength then processed by computer where Agilent Vee is located for monitoring purpose. Wavelength meter is interfaced with computer by using General Purpose Interfacing Bus (GPIB) cable. Agilent Vee would monitor the level of water and send the data to transmitter microcontroller which is also interfaced with Agilent Vee. The data then wirelessly transmit to receiver microcontroller to control the water pump. If the level of water is danger, microcontroller will trigger the water pump to pumping water back into the pond.

B. Fiber Bragg Sensing – Temperature Based

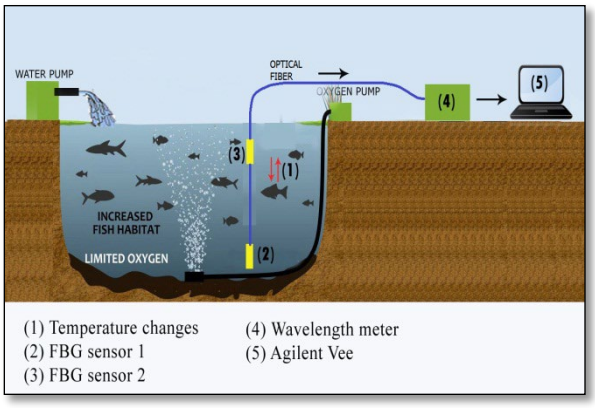


Figure 3: Project framework for Temperature Based

Figure above show the project framework for temperature. For this parameter, the sensing system is do in multipoint sensor which is in one line of fiber there are two temperature sensors to detect the temperature at bottom and near the surface of the pond. Every sensor has different center wavelength. Wavelength meter will show two different wavelength values which it is mean that there are two sensors in optical fiber line. Wavelength value will increase or decrease depends on the environment and temperature at the pond.

Wavelength meter meter will interfaced with computer (Agilent Vee) for monitoring purpose. Temperature will increase or decrease based on wavelength range that has been set in Agilent Vee. For example 1.550235 um – 1.550245 um is approximate to 27.5 ºC.

C. Intensity Based – Emulation

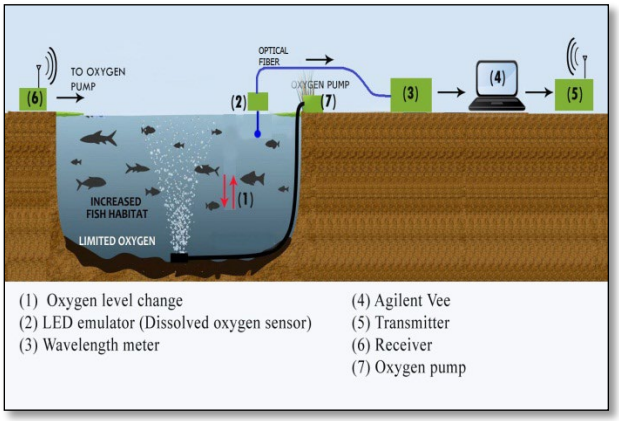


Figure 4: Project framework for Intensity Based - Emulation

Figure above show the project framework for Intensity based which is the LED emulated circuit for dissolved oxygen. There are three level of dissolved oxygen which is safe, normal and danger. LED driver will send three different intensity that correspond to the level of dissolved oxygen. Optical fiber carries the signal to optical receiver where it is interfaced with transmitter microcontroller. Some algorithm or formula needs to be done to convert the intensity to voltage or current value. The purpose is to get the accurate ranges of every level. The data then wirelessly transmit to receiver microcontroller to control the speed of aeration system.

*Part 2: Data Interfacing and Monitoring*

In Agilent Vee, the Vee workspace is where the Vee program is constructed. For monitoring purpose, Agilent Vee is interfaced with wavelength meter. There are two parameters need to monitor which is water level and temperature.

A. Water Level

Water level monitoring system can be dividing into two sections which is monitoring and interfacing. For monitoring part, it covers from wavelength meter direct input output (DIO) until tank that will display the level of water. Interfacing part is where Agilent Vee is interfaced with microcontroller and sends the data to trigger the water pump.

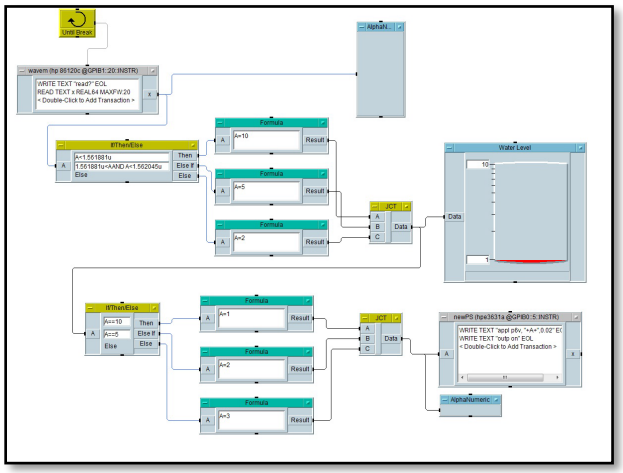

Figure 5: Agilent Vee workspace with objects for water level monitoring

Vee program description:

- Wavelength meter (HP86120C) DIO Command: “read?” – Measures and queries wavelength from wavelength meter.

- Power supply (hpe3631a) DIO
  Command: “appl p6v “+A+”,0.002” – apply +6v ouput, voltage depends on the value of input A, current 0.002A.
  “outp on” – enables the ouput.

B. Temperature

Agilent Vee will monitor multipoint sensing for temperature where it has different command with water level monitoring. Because of it is multipoint, Agilent Vee need to read it in array form.

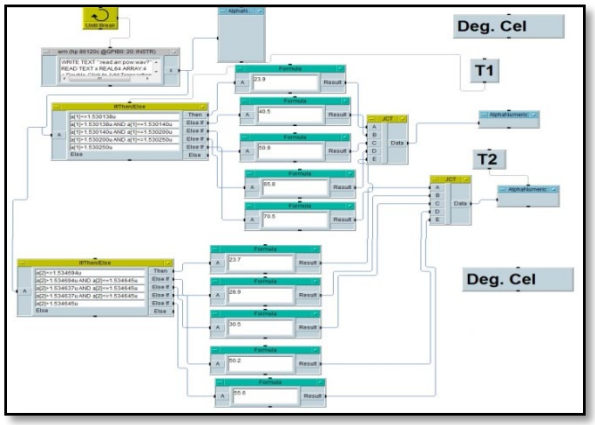


Figure 6: Agilent Vee workspace with objects for temperature

Vee program description:

- Wavelength meter (HP86120C) DIO
  Command: “:read:arr:pow:wav?” -
  Measures and queries wavelength and power from wavelength meter in array form.

## III. RESULT AND DISCUSSION

### A. Water Level Monitoring

The water level is monitored and processed by computer (Agilent Vee). Agilent Vee successful and able to detect the wavelength meter and process the signal. The water level is being monitored continuously and it is displayed at the tank which is representing the water level. After processed, the information is sent to microcontroller to take an action.

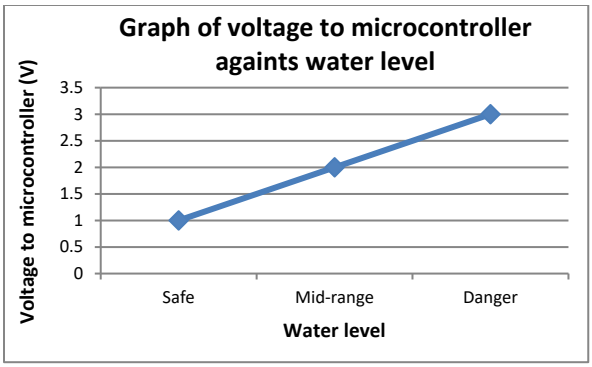


Figure 7: Voltage send to microcontroller correspond to the water level

Some calibration need to do because of the FBG is very sensitive with environment. The wavelength will change due to some causes.The FBG need to calibrate certain time to get accurate range of water level. Three calibrations were made for this parameter.

| Water level / cm | Wavelength / nm |
|---|---|
| 19 | 1550.184 |
| 18 | 1550.202 |
| 17 | 1550.204 |
| 16 | 1550.238 |
| 15 | 1550.328 |
| 14 | 1550.437 |
| 13 | 1550.521 |
| 12 | 1550.614 |

Table 1: Tabulated data Bragg wavelength to the changing of water level for first calibration

| Water level / cm | Wavelength / nm |
|---|---|
| 19 | 1550.184 |
| 18 | 1550.202 |
| 17 | 1550.203 |
| 16 | 1550.238 |
| 15 | 1550.327 |
| 14 | 1550.439 |
| 13 | 1550.521 |
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Table 2: Tabulated data Bragg wavelength to the changing of water level for second calibration

| Water level / cm | Wavelength / nm |
|---|---|
| 19 | 1550.184 |
| 18 | 1550.202 |
| 17 | 1550.204 |
| 16 | 1550.239 |
| 15 | 1550.329 |
| 14 | 1550.438 |
| 13 | 1550.530 |
| 12 | 1550.619 |

Table 3: Tabulated data Bragg wavelength to the changing of water level for third calibration

- Water level is safe

When there is no shifting of wavelength which means the peak of the wavelength is located at actual value which is 1.55020 um, level of water is safe. At the Vee program, maximum value of the tank has been set to 10. When the level of water is safe, the tank is displayed green color with the value of 10.

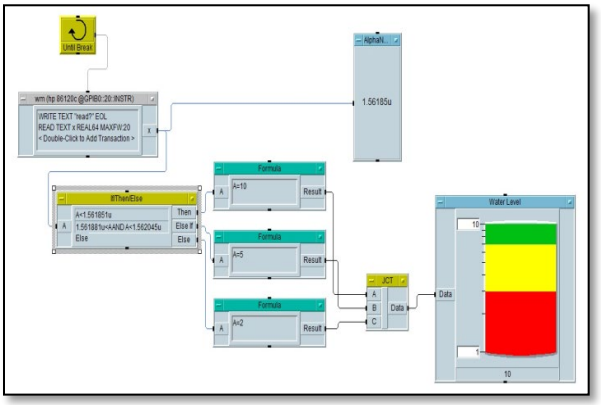

Figure 8: The tank shows that the level of water is safe

- Water level is mid-range

When the FBG detects a changing of water level, wavelength value is increased. Level of water is at the mid-range if the value of wavelength is between 1.55020 um - 1.550521 um. Tank is displayed yellow color with the value of 5.

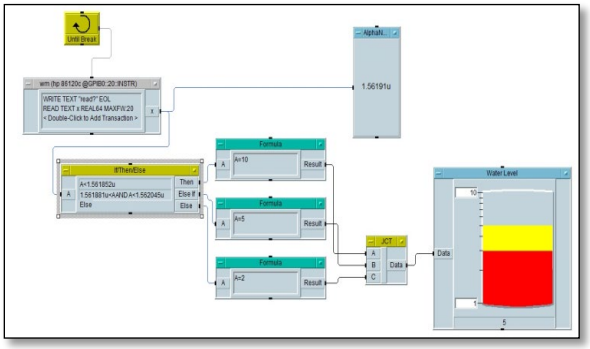

Figure 9: The tank shows that the level of water is mid-range

- Water level is danger

When the wavelength is above than 1.55021 um, the water level has drop to the danger level. The tank is displayed red color. At this point, microcontroller transmits a signal to trigger the water pump.

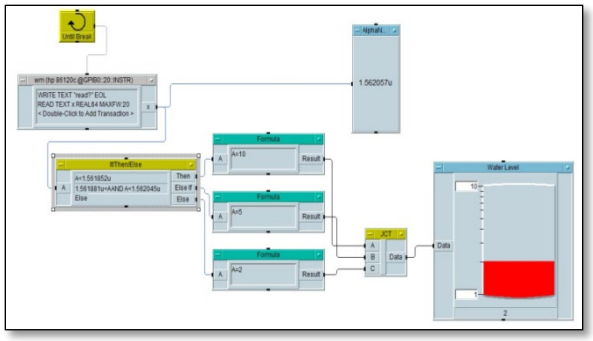

Figure 10: The tank shows that the level of water is danger

B. Temperature.

The temperature monitored continuously and processed by computer (Agilent Vee). Agilent Vee successful and able to detect the wavelength meter and process the signal.

Wavelength will shift to the left or right due to the water temperature. By using thermometer, the temperature of water is measured and record the wavelength. There are two temperatures that has recorded:

- Temperature at bottom (T1)
- Temperature at near of the surface (T2)

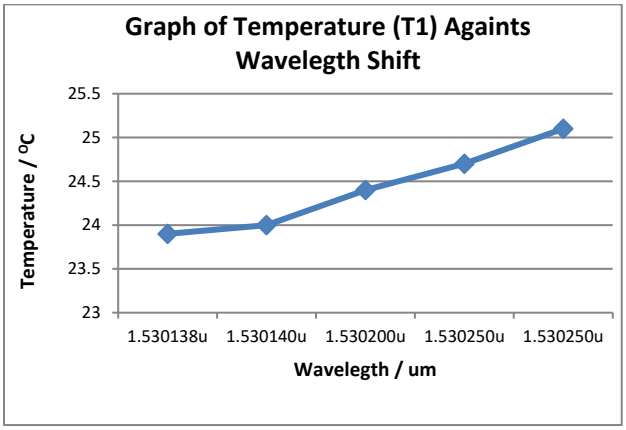


Figure 11: Temperature (T1) recorded correspond to the wavelength shift

Figure 11 shows that the maximum temperature at the bottom is 25.1°C with wavelength of 1.530250 um and the lowest temperature is 23.9°C with wavelength of 1.530138 um.

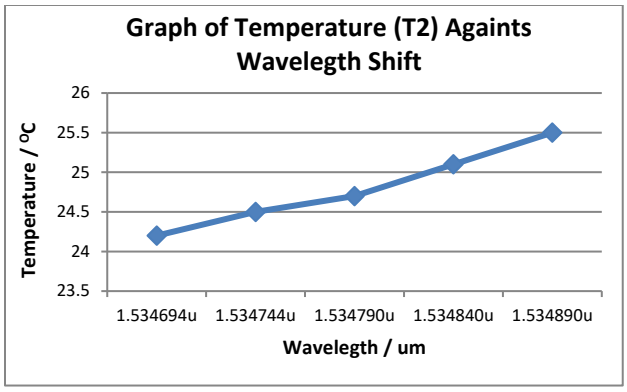


Figure 12: Temperature (T2) recorded correspond to the wavelength shift

Figure 12 shows that the maximum temperature at near the surface is 25.5°C with wavelength of 1.534890 um and the lowest temperature is 24.2°C with wavelength of 1.534694 um.

C. Dissolved Oxygen

The data for dissolved oxygen come from the LED emulator circuit which has different intensity that corresponds to different level. The signal form LED driver is carry by optical fiber to optical receiver. To control the aeration system, these three levels of intensity is fed to the input of transmitter microcontroller and wirelessly transmit the data.

| Voltage Range Input ( V ) | Oxygen Level (ppm) |
|---|---|
| < 2.0 | 9.0 – 10.0 (safe) |
| > 2.0 - < 4.0 | 4.0 – 8.9 (normal) |
| > 4.0 | 0.0 – 3.9 (danger) |

Table 4: Table show the three levels of voltage representing three levels of oxygen

The aeration system will respond as follow:

- When microcontroller receiving 2V, which is corresponding to level of oxygen, is safe, the aeration system is off.
- Upon receiving between 2V – 4V which correspond to normal, aeration system operates at medium speed.
- Upon receiving greater than 4V which is correspond to danger, the aeration system operates at maximum speed.

## IV. CONCLUSION

The system develop is able to continuously monitor water levels and temperature. The water pump and aeration system is operates when it is required. Power consumption was reduced because of the aeration only function with different speed when the level of oxygen is drop. The overall system function without human interference, thus labor intensity is reduced.

## V. REFERENCES

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