

Title :IoT Based Solar Powered Smart Indoor Vertical Farming System

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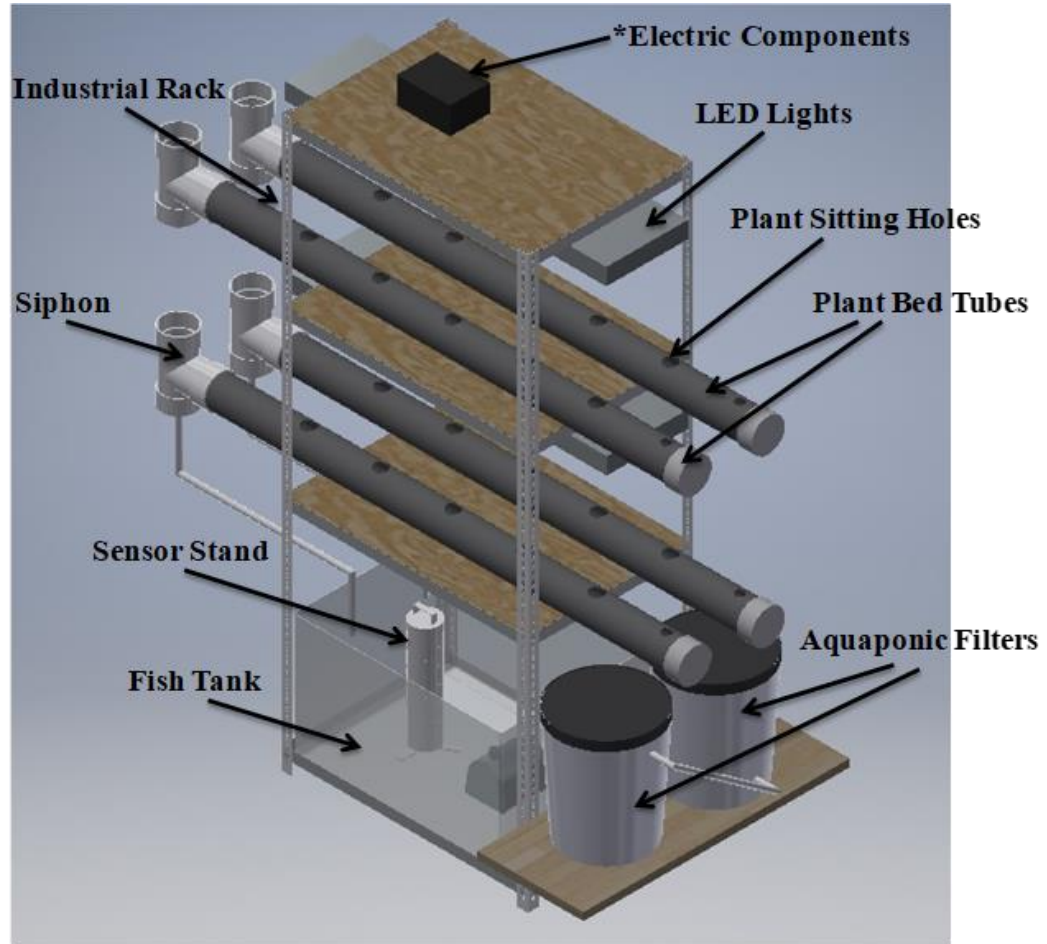
Background :

- Traditional farming on soil has its advantages and disadvantages where most of them are outdoors and require high input efforts and low efficiency.
- Most people still interpret farming is operated outdoors where farmers are exposed to strong heat and high effort work rate.
- Due to traditional outdoor farming, young generation are reluctant to contribute to agriculture in hot climate countries like Brunei and ASEAN countries.
- By implementing technology based indoor farming, it can solve the traditional farming problems whereby modern indoor farm can be in a compact space, multi-leveled, automated and IoT based intra and inter networking connected.

Targets:

- Build a system that can grow local/regional high demanding and popular plants/crops such as lettuce, orchids and paddy.
- Implement Industry 4.0 concept to a farming system-incorporation of Internet of Things (IoT) for monitoring, controlling, data collection and internetworking the systems using an Android app along with integration of a renewable energy sources.
- The farming system should be automated, self-sufficient while producing pesticide-free plants with minimal human intervention with continuous monitoring.
- Compare growth results for the tested plants by analyzing the LED power, LED type, light duration, LED distance to plant, growth rate to no. of fishes with plant ratio and water condition.
- Results from comparison aims to identify which parameters are best for growing while using less power and with better efficiency for consumer use or production use.

Self-Sufficient Solar Smart Modern Farming System is a system capable of **growing fishes** and **pesticide-free plants/crops** self-sufficiently with digitally controlled and modular monitoring technology through an LCD or remotely/internet/Wi-Fi services on a limited space with shorten growing time and less labor effort-Shortly **Smart Indoor Aquaponics System**.



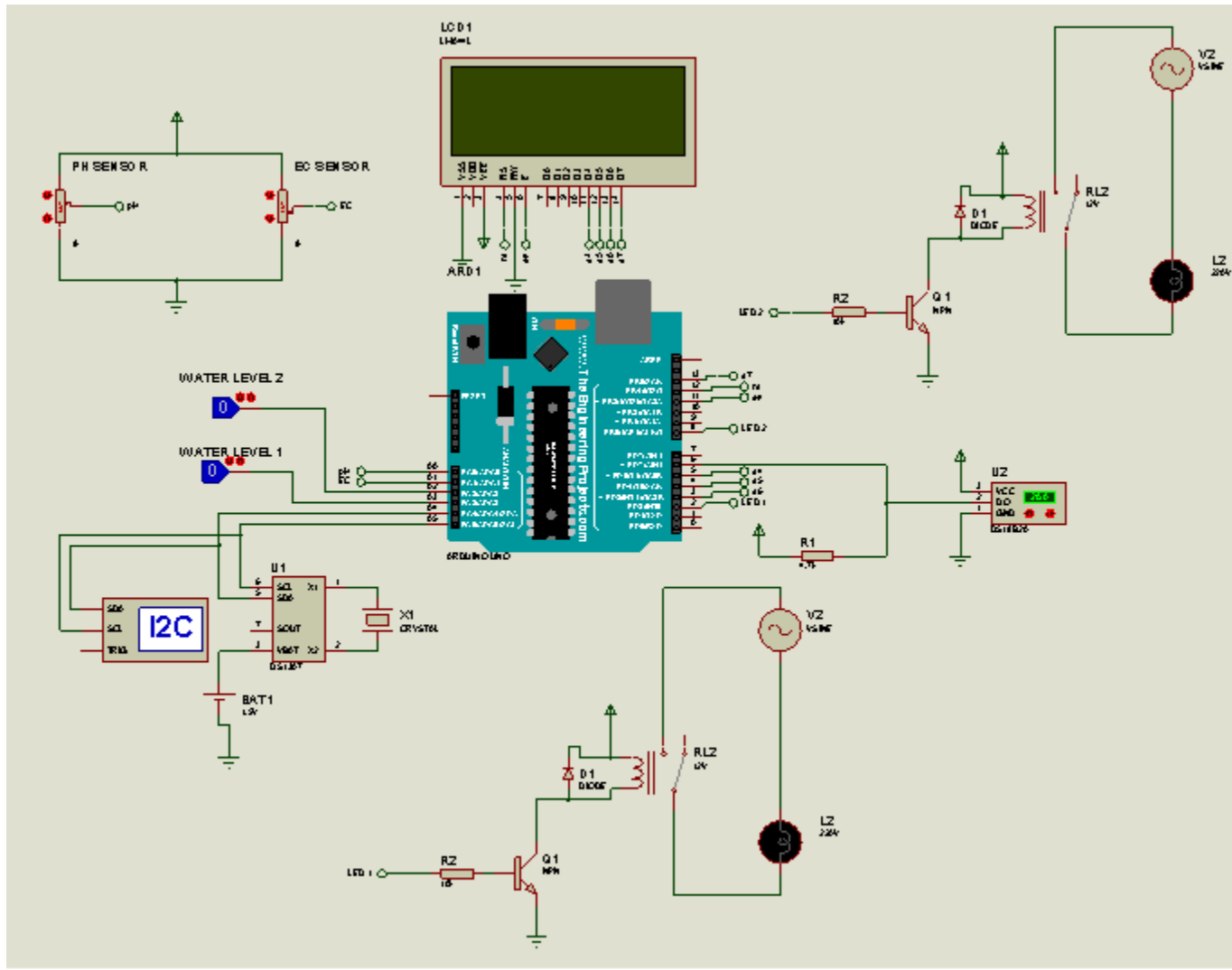
- The design of the Aquaponics system consists of a rack to hold the sitting beds for the plants to get water and nutrients from the fish tank.
- The Aquaponics system is capable of upgrading its levels depending on the room height.
- The reason why 2 levels Aquaponics system is chosen because two levels is the minimum number to test a multi-level plantation.
- Each level will have 2 sitting beds for the plants to grow and each sitting bed will grow 5 plants where each bed has a siphon at the end to automatically drain water.
- The fish tank is placed at the bottom level due to safety reasons and will require a pump to transport water to the top level.
- As for the solar power, a solar panel will be placed externally outdoors and connect to the integrated board through a cable indoors.
- This is to ensure that the solar receives plenty of sunlight while its electronics/IoT service devices remain indoors to avoid harsh weather condition which might damage the electronics.

- This system will be capable of functioning smartly either by solar power or conventional power.
- The sensors to monitor and act according to various parameters such as water flow rate, LED light intensity, LED on/off timing, temperature, water level and pH.
- The plant and fish growing method is a Nutrient Film Technique (NFT) 'Flood and Drain' (F&D) hybrid system with two levels to support two tube beds on each platform and the fish tank is underneath of the tube beds.
- The main microcontroller used to operate the whole system is an Arduino Mega 2260 Board while the solar panel system uses a solar controller where it can interlink with the existing Arduino Mega 2260.
- The main microcontroller will control the water flow rate, LED light intensity; LED on/off timing, temperature, water level, nutrients concentration and pH in real time. On the other hand, the solar controller is used to control the solar to battery functions and provide efficient charging for the battery depending on the specification from the manufacturer.

Proposed Method: 3/4

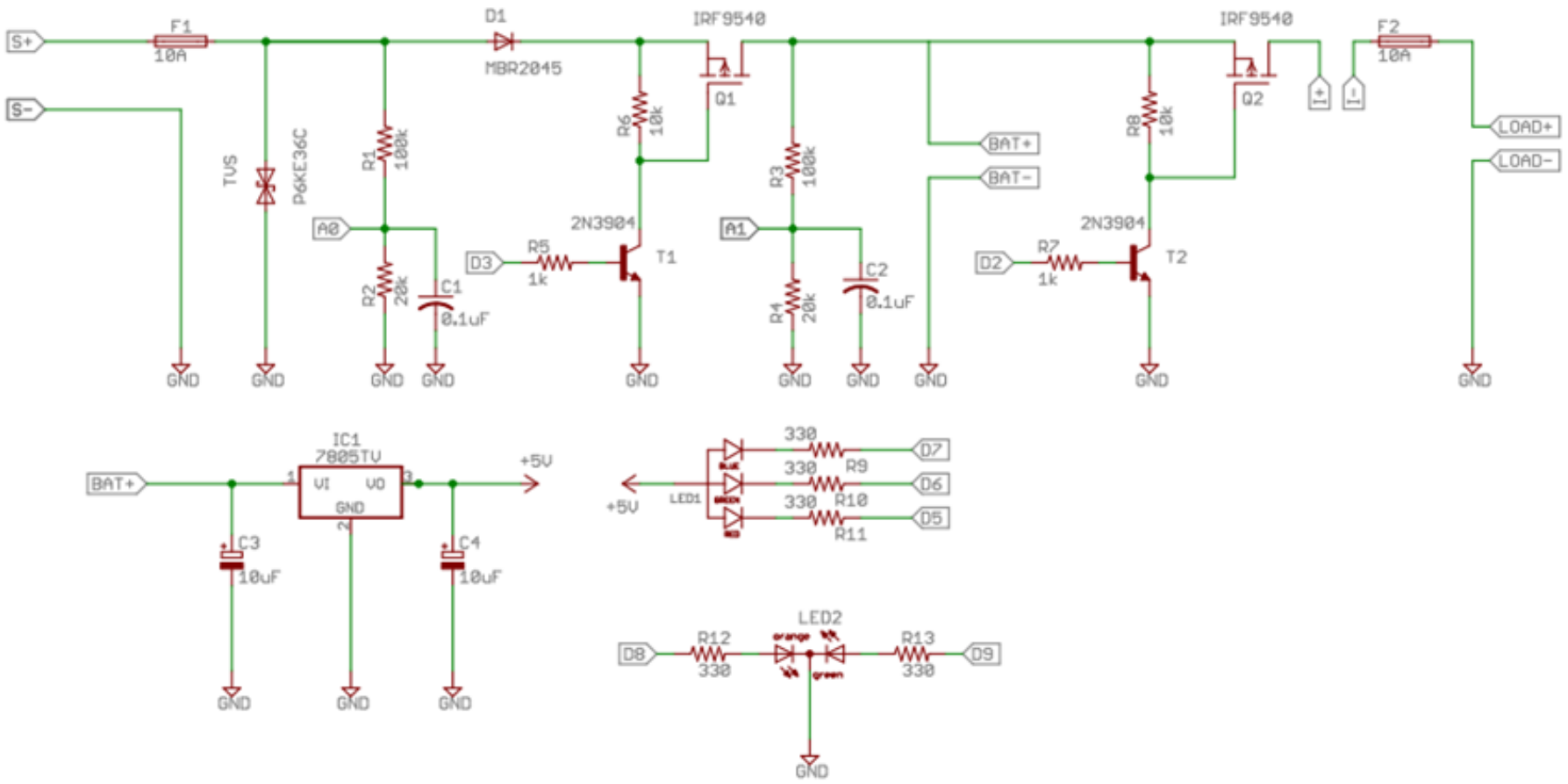
Main Microcontroller circuits Simulation:

All sensors monitoring, actuators, pumps, water flow, LED switching, intensity controlling.



Proposed Method: 3/5

Solar integration controller Circuits:
 Monitoring solar power status, Stabilizing required voltage,
 Automated switching between solar and conventional grid power



- The system is aimed to be able to be use any type of land space whether the land is outdoor, infertile, indoors, abandon buildings or unused space in the office.
- By incorporating devices to the system which includes a continuous monitoring system, Smart features, online access capabilities and solar power, this will highly reduce daily routine such as daily water testing for each parameter and by adding solar, power consumption.
- This will not only save energy but it will reduce electricity usage, hence reduce cost.
- As for online IoT features, this enables flexibility of location and time of operating/monotoring the system.
- The system will be able to operate at night where when a sensor triggers it is able to warn users for incoming hazards.

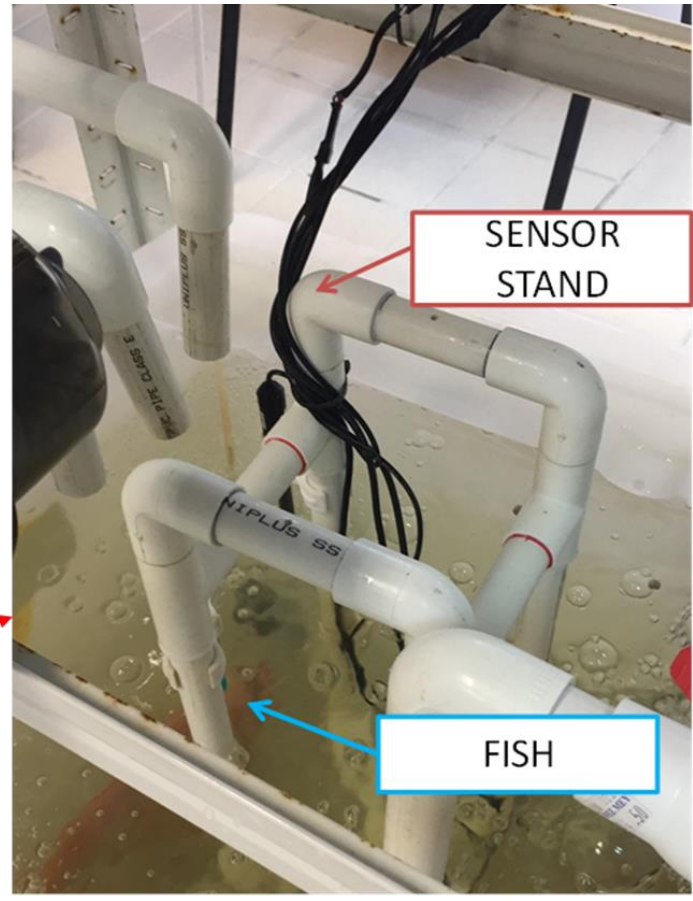
It is noted that the implementation of Industrial 4.0 including IoT into agriculture has not been made common in Brunei Darussalam and probably other ASEAN countries, as farming is still operated traditionally.

With the implementation of Industry 4.0 including IoT into agriculture, the concept of smart farming will be reality by our design.

This IoT based farming method can interconnect farmers in the country as well as in the ASEAN region to have the updated information and knowledge on the product, procedures and further improvement.



(a)



(b)

(a) Lettuce grown after 4 weeks, (b) Zoom in of the Fish Tank.

Our system is able to grow more plants in a square meter due to its multi-level vertical farming features, compared to typical outdoor Aquaponics system.

This system can provide both protein and vegetables for our daily meals.

Grow time requires less than a month (Lettuce grow) while the traditional grow requires around 8 weeks.

The system is fully automated and have the capability to externally monitor and control by IoT enabled devices and circuits.

The system uses renewable solar power.

It has dual function to automatically switch between solar and the national grid power when necessary.

The project was able to grow 20 plants during the growth testing cycle while growing two fishes.

By using the system, not only the growing process was done indoors, the growing time has also been reduced where lettuce grows mature within 21 days while growing traditionally will take 45-55 days.

The system is fully automated, indoor, vertically expansion flexible, require compact space.

It has IoT and IR4.0 integration (Mechanical, Electrical, Digital, Biological, IoT integration).

It uses the renewable energy (solar power) to operate. Additionally it has the function to switch between solar power and the traditional grid power if necessary.

The nutrient cycle method is the hybrid of “Nutrient-Filmed Technique (NFT) and Flood & Drain (F&D)”.

This project will not only leave a huge impact in raising the agriculture economy in Brunei Darussalam when it is developed into a larger scale project but with this innovation, the self-sufficiency in food production can be improved greatly in locally, regionally as well as globally.

The presented project was a prototype due to budget limit.

A lot of things to do in the future plan.

Project needs to use standard electrical/electronic/IoT components to make it commercially available. For student project, we use low cost items because it is just for prototype and short duration.

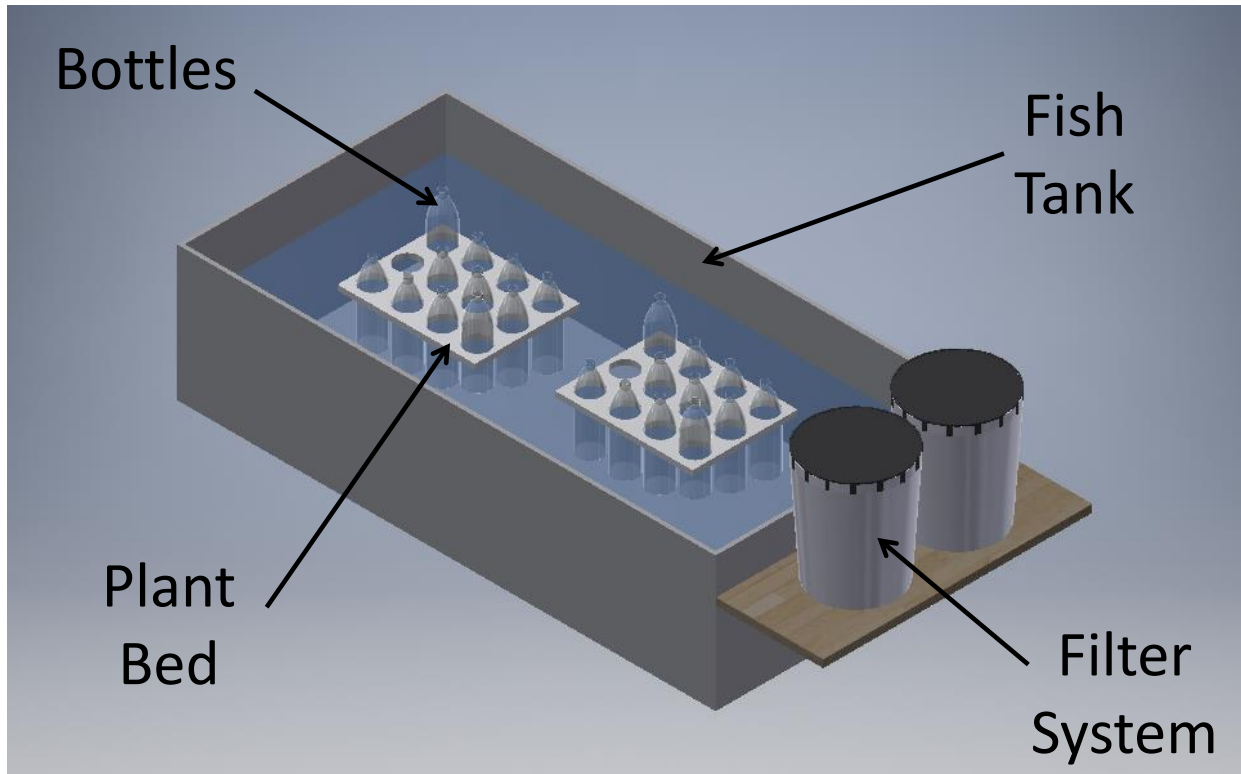
The project needs to expand to not only lettuce, to Orchids, indoor paddy farming and other plants and crops.

Need to study extensively the behavior of fishes in this indoor environment. So, require camera incorporation and image processing to observe the movement of the fishes.

Need to test and analyse number of fishes and the plants/crop grow ratio.

Need to analyse the intensity as well as spectrum of the LEDs and the relationship of the plants/crop growth.

Future research plan to grow paddy (indoor) using the same methods as lettuce grow including all the smart features.



THANKS

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