PAPER ID – MTRX03

PLC (ARDUINO) BASED SELF-SUSTAINING HYDROPONIC FODDER SYSTEM

Sandip Jagdale
Student, BE Mechanical Engg., ICEM, Pune, INDIA
Roshan Singh
Student, BE Mechanical Engg., ICEM, Pune, INDIA
Rohit More
Student, BE Mechanical Engg., ICEM, Pune, INDIA
Rohit Muluk
Student, BE Mechanical Engg., ICEM, Pune, INDIA
Amit Narwade
Asst. Prof. Mechanical Engg. Department, ICEM, Pune, INDIA

***Abstract*—In India only 4.9 % of cropped land area is utilized for cultivating fodder. India faces a deficit of 35.6% green fodder, 26% of dry fodder and 41% of concentrate feed ingredients.So our goal in this project is to develop a self-sustaining fodder system using basic PLC circuits and to operate it on renewable energy. Which in result will reduce the energy requirement, cost of production per kg, water and land requirements to operate the system along with the ready availability of green fodder and negligible human interference.**

Keywords—hydroponics; PLC; Arduino; automation; fodder system; solar; renewable energy.

I. INTRODUCTION

In total of 328.7 million hectares of India's geographical area only 8.3 million hectares is utilized for the fodder crops which are targeted to fulfill the needs of dairy cattle and livestock. Since the production doesn't meet the daily requirement, India faces green fodder deficit of 60-65% Water conserving hydroponic technology is a state of the art technology that has revolutionised the fodder production system during the past decades across the globe. There is no doubt that it will play a major role in reducing the green fodder demand and supply gap in our country as well as state.[1]

II. ARDUINO AS PLC

A. Arduino Specifications

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller

B. Using Arduino

The controller itself controls lights, a water pump and a fan to aid in the growing of fodder. The use of appropriate lighting would make it possible for people living in conditions of little light, to grow fresh fodder all year round. Also the increased photosynthesis time results in faster growth of fodder and more production in weight for predefined time. This would be especially useful now that fodder prices are increasing.[2]

III. RELATED RESEARCH

For the supplementary lights in hydroponics system, there are options available such as sodium vapor lamp and fluorescent lamps but these consume more power and the Correlate color temperature (CCT) produced by these lights ranges between 2500k to 5000k which differs from the actual cold white sunlight. This is the reason we decided to go with the LED modules SMT5630 which consume 0.63w per module and produces 5700k to 6500k CCT this lighting conditions are much closer to daylight conditions (5800k-6500k). This helps fodder to grow faster.[3]

According to the research results revealed that, in general terms, the lighting operating hours of about 12-16 hours is the most suitable for fodder production. [4]

Growth of hydroponics fodder depends on the temperature and humidity of system. The best conditions for the fastest growth are temperature (15º - 32 ºC) and humidity (70 -80 %) range without fungal growth. [5]

IV. SENSORS AND HARDWARES

Table 1: Sensors and Hardware Specification

Sensor/hardware	Specifications
Light sensor	400 ohm- 9k ohm
Temp. & Humidity sensor	20-90% RH 0-50 ℃
RTC	-0.5V to +7.0V
Solar panel	12V, 20W
Rechargeable battery	12V, 12Ah
Cooling and exhaust fans	12V 0.20A. Speed: 3000 RPM
Diaphragm pump	12V, 2.8A, 5.0LPM, 100psi cutoff

V. WORKING

To achieve the desired automation the goal is to program the Arduino in such a way that whenever a parameter which needs controlling goes beyond the predefined limits then according to the logic Arduino should take the action which in turn will activate the output device to compensate the change.

A. Temperature

The desired temperature range for hydroponic fodder system is 15º - 32 ºC. When the temperature goes beyond this range the DTH11 temperature sensor senses the input and Arduino activates the foggers which are mounted above the trays. The fine mist produced will lower the temperature by the effect of vaporization.

B. Humidity

The desired range for humidity is 70-80%. This problem where there is a constant need of higher humidity can be solved by using Misting water supply. This mist from fogger tends to increase humidity of air by evaporation. Hence there is no need of using humidifiers such as in Nutrient film technique where water supply is by thin film of nutrient water solution which can be supplied directly to the roots of growing fodder.

Increased humidity is good for the growing fodder but till a limit of 80% when it exceeds that value the suppressed fungus on the roots of fodder starts growing rapidly. To avoid this Arduino turns on the fans which will be mounted on the opposite walls of enclosure to ensure the better aeriation. The fresh air from surrounding will drop down the humidity in the limited range only then Arduino will turn off the fans.

C. Light Conditions

Photosynthesis process is at its best during the natural daylight. The correlated color temperature (CCT) at this time ranges from 5800k to 6500k. There are artificial lights that can mimic the CCT of daylight but according to our research the best available option is to use the SMT 5630 LED modules which consume less energy. There have been some ongoing studies that includes using single spectrum or mixed spectrum lights but according to the reports available till date white light is the answer when concerned with the fodder.[3]

When the natural light conditions drop down below predefined CCT, the LDR changes its resistance causing Arduino to turn on the supplementary lights.

VI. CALCULATIONS

A. Battery Charge Time

Battery capacity - 12v, 12Ah
Solar Ratings - 12v, 20W
Maximum Current – 1.13A
Maximum Voltage – 17.7V
After using charge controller circuit, Voltage is adjusted to 14 V maximum and current is increased to 1.5A

Charge Time = $\frac{Capacity\ of\ battery\ in\ Ah}{Maximum\ charging\ current}$

Charge time = $\frac{12\ Ah}{1.5A} = 8\ Hrs$

If battery efficiency is 60% then the charge time reduces to- 8×0.60=4.8Hrs

B. Discharging

To calculate discharge time (backup) we need to calculate the total power consumption by all output devices

1. Arduino Uno

For Arduino recommended Operating Voltage range for heavy loads is 7v to 12v but Arduino Uno on light loads can also operate on -0.5v to +5.5v i.e. 6v maximum operating current range for Arduino Uno is 500mA
Power consumption by Arduino = 6×0.500= 3 watt
This power consumption is during active time hence it can be much less during practice.

2. Diaphragm Pump

Specifications:
Voltage - 12V nominal (9-14V)
Current – 2.8A
Power consumption = 12×2.8=33.6 watts
To achieve the desired pressure range for misting nozzles we will use two diaphragm pumps connected serially.
Hence total power consumption = 2×33.6=67.2 watts

3. Supplementary Lights

Power consumption by SMT 5630 LED module is 0.612W
We will require one module for two tray. Hence for 8 tray system 4 modules will be required.
Total power consumption= 4×0.612=2.448 watt

4. Fans

For aeriation purpose we will use set of two fans opposite to each other.
Specifications-
Voltage – 12v
Current – 0.20A
Hence total power consumption = 12v×0.2A×4Nos=9.6 watt

5. Sensors

Since the operating voltage and current required for sensors is very low we can neglect power consumption by sensors.

6. Total power consumption by system

It is the addition of power consumed by each part of the system.
Hence total power requirement of system
=67.2w+2.448w+9.6w
=82.24w
When battery is fully charged backup time is-

$$\frac{12V \times 12Ah}{85W} = 1.69\ Hrs$$

For battery with 60% efficiency backup time is 1.69×0.60=1Hrs
But in Practical use Diaphragm pump uses the largest part power and will only use this power for about 2 minutes for each hour. Hence the actual power consumed will be even less and battery backup will be higher than calculated. This will be useful during low light seasons.

ABBREVIATIONS ANDACRONYMS

PLC – Programmable logic controller
LDR – Light dependent resistance
SMT – surface mounted technology
RTC – Real time clock
CCT – Correlated color temperature

VII. COSTING

Table 2: Project Costing

Sensor/hardware	Nos.	Cost/unit (INR)	Total (INR)
Light sensor	1	50	50
Temp. & Humidity sensor	1	200	200
RTC	1	200	200
Solar panel	1	1500	1500
Rechargeable battery	1	1550	1550
Cooling and exhaust fans	4	100	400
Diaphragm pump	2	550	1100
SMT5630 LED	4	60	240
Arduino Uno	1	550	550

4 channel Relay board	1	320	320
Fogger Nozzles and Connectors	8	40	320
Feeder Line	1	300	300
Solar Charge Controller Circuit	1	500	500
Battery Eliminator Circuit	1	500	500
Rack	1	4000	4000
Trays	8	300	2400
Shade net	1	200	200
Unaccounted	-	-	1000
		Total	15330/-

VIII. CONCLUSION

As discussed earlier in this paper the Arduino is capable to create the ideal environment for growing fodder. The cost of sensors and other components used in this project is much lesser than the commercial models available in the market. The major advantage in this system design is the use of renewable energy as power source. This ensures the uninterrupted running of system.

IX. ACKNOWLEDGEMENT

We would like to express our sincere gratitude to Prof. Amit Narwade for providing their invaluable guidance, comments and suggestions throughout the project.

REFERENCES

Dr. Rachel Jemimah, Dr. P. Tensingh Gnanaraj, "Hydroponic Green Fodder Production," Chennai, 2015

M. Griffiths, "THE DESIGN AND IMPLEMENTATION OF A HYDROPONICS CONTROL," 2014.

Gioia D. Massa, Hyeon-Hye Kim and Raymond M. Wheeler, "Plant Productivity in Response to LED Lighting," *HORTSCIENCE*, vol. VOL. 43(7), 2008.

M. M. E.-D. e. al., "ENGINEERING FACTORS AFFECTING HYDROPONICS GRASS- FODDER PRODUCTION," in *Misr Society of Ag. Eng*, 2009.

M. M. E.-D. e. al., "ENGINEERING FACTORS AFFECTING HYDROPONICS GRASS- FODDER PRODUCTION," in *Misr Society of Ag. Eng*, 2009.