Design and Development of ARJUN MBT Tank Engine Control Junction Box using Micro Controller

P.K.Mani, R.Rajagopal, J.Shanmugapriyan, M.Vijayalakshmi

Abstract:This paper explains how we can replace the conventional power-consuming mechanical relay based Engine Control Junction Box of ARJUN MBT Tank using Micro Controller. The aim of this paper is to minimize the size of existing ECJB and to reduce the complexity of operation. The existing ECJB has 4 normal relays, 16 special type relays and 4 critical relays for smooth operation of the engine and is hardwired, thus making it difficult to operate and troubleshoot.

By using 8051 microcontroller we can overcome the existing problems of ECJB. It implements the following parameters and operation.

- ***Starting Sequence***
- ***Starter Interlock***
- ***Sequential switching of Dust Eject motors***
- ***Display the sensor information to the driver***
- ***Automatic shutdown***

The advantage is that it possesses inbuilt fault diagnostic function. The size has been reduced to 1/4th of the existing ECJB, only indigenized components and relays are used and imported items are totally eliminated.

Keywords:Engine Control Junction Box, Micro Controller, Dust EjectMotors.

I. INTRODUCTION

Existing ARJUN MBT Engine Control Junction Box is relay based. It consists of 4 critical relays, 16 special type of relays and 4 normal relays.

The equipment is fully depending up on the imported items and it is totally hard wired and so it is complex system for trouble shooting. Hence there is requirement to replace this system by microcontroller.

If there is fault occurrence in the inbuilt components of ECJB, the entire system must be examined which results in shutting down of the system. So ECJB must be upgraded such that it possess inbuilt problem diagnose.

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* Correspondence Author

Dr.P.K.Mani*, Dept of EEE,VEL TECH MULTI TECH Dr.RANGARAJAN Dr.SAKUNTHALA ENGINEERING COLLEGE, Chennai, India. Email: manipudhurkannan@gmail.com

Dr.R.Rajagopal, Dept of EEE, PSR ENGINEERING COLLEGE, Sivakasi, India.Email: r.rajagopal@yahoo.com

Dr.J.Shanmugapriyan,Dept of EEE, VEL TECH MULTI TECH Dr.RANGARAJAN Dr.SAKUNTHALA ENGINEERING COLLEGE, Chennai, India. Email:jspriyan@gmail.com

M.Vijayalakshmi, Dept of EEE, VEL TECH MULTI TECH Dr.RANGARAJAN Dr.SAKUNTHALA ENGINEERING COLLEGE, Chennai, India. Email: mvijayalakshmi22@gmail.com

TABLE–I: COMPARISON OF EXISTING AND PROPOSED ENGINE CONTROL UNIT

Existing Engine Control Unit	Proposed Engine Control Unit
Very high cost	Cost reduction
Huge in size	Size reduced to ¼ of its Original size
Imported components used	Mill grade components which is available in open market
Hard wired system and complex	Less space and has good reliability

II. DESIGN AND DEVELOPMENT

A) Development of the logic from the existing ECJB

The Existing Engine control junction box (ECJB) is intended to perform all control, sequencing, logical operations related to engine through suitable interlock and built – in safety mechanisms. These functions are effectively achieved by using electro -mechanical relays, rpm switches, start interlock and start repeat relays integrated onto these assembly. Analog signals are also routed through this assembly to the Instrument panels to give status-warning indications to the crew members.

B)Functions of existing ECJB

- To interface electrically the engine and transmission with the fighting compartment electrical assemblies
- To control the running of the Dust ejector blowers A & B through Engine speed sensitive switches 400 rpm / 700 rpm respectively.
- To control the functioning of the fuel pumps LP & HP through relays.
- To switch ON the engine by checking starting sequence and switch off the starter motor after successful start of the engine and to block the restarting sequence (while the engine is already running) through start interlock relay.
- To protect the starter solenoid /switch while starting motor pinion is improperly meshed with the engineering gear. The start repeat relay interrupts the starting procedure automatically and initiates a restart after some delay.
- To pre-heat the engine through glow plug banks
- All the engine related interfaces are routed through the ECJB for better fault diagnosis.

C) Design and Development of Micro Controller basedEngine Control Unit

Hardware setup:

Input Section:

1) Master Switch (MS-2): Master switch is the switch which allows the power supply flow to other components of ECJB when it is energized.

2) Pre-Glow 1 & Pre-Glow 2: Pre-glow 1 is energized to have proper initializing conditions for engine, so that pre-glow relay is made to switch on when this input is given. Pre-glow2 is made to energize the glow plug.

3) Regulated Feedback: Regulator feedback is to show battery status .

4) FBS: This input is to ensure the proper feedback condition from the parameters to be controlled.

5) Engine stop: This input is provided to have emergency shut down of the whole engine without any fault condition.

6) Deep Fording: For the proper running condition of the engine in the aquatic circumstance without responding to the error signals.

Fig .1.Input Section of Engine Control Unit

Output Section:

1) Starter Motor Relay:Starter motor relay is to activate starter motor for the cranking of engine.

2) Dust Eject Motor A &B Relay:These relays energize dust eject motors in different speed of the engine, at 400rpm DE-A and at 700rpm DE-B are energized.

3) Fuel Pump Relay:Fuel pump is energized through this relay. So that the fuel circulation is achieved.

4) Glow Plug:Glow Plug relay will pre-heat the engine to attain required temperature.

5)Shut Down Button:When this relay gets energized whole engine gets shut down.

6)Micro Controller:

The 8051 architecture provides many functions (CPU, RAM, ROM, I/O, interrupt logic, timer, etc.) in a single package

- 8-bit ALU, Accumulator and 8-bit Registers; hence it is an 8-bit microcontroller
- 8-bit data bus – It can access 8 bits of data in one operation
- 16-bit address bus – It can access 2^{16} memory locations – 64 KB (65536 locations) each of RAM and ROM
- On-chip RAM – 128 bytes (data memory)
- On-chip ROM – 4 kByte (program memory)
- Four byte bi-directional input/output port
- UART (serial port)
- Two 16-bit Counter/timers
- Two-level interrupt priority
- Power saving mode (on some derivatives)

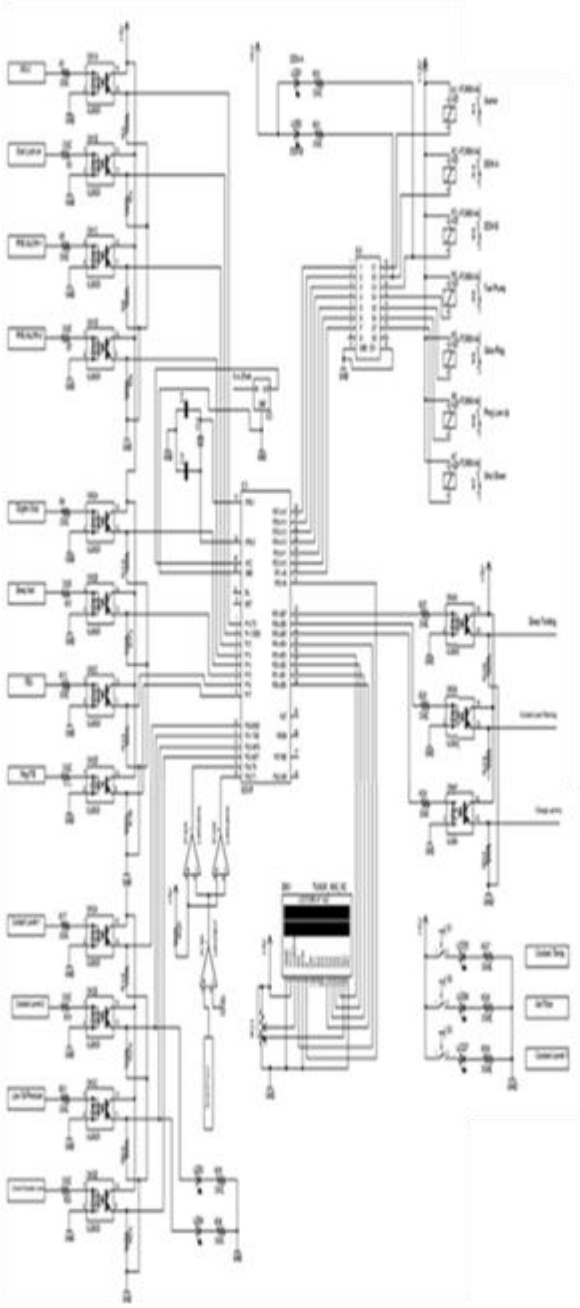

Fig .2.Ouput Section of Engine Control Unit

D) Development of experimental setup:

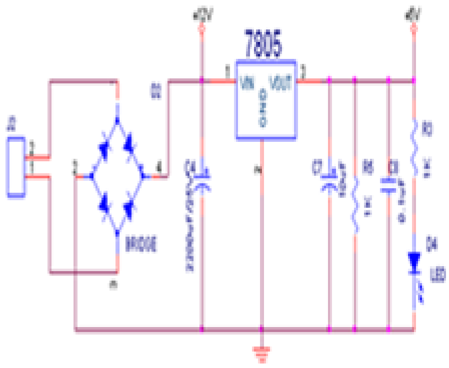

Fig .3.Power Supply Unit

Hardware used:

1) Photo Transistor Opto coupler (ILQ74): It maintains high degree of isolation between input and output. DC level can be transmitted by the device. Continuous forward current up to 60mA.

2) Operational Amplifier (LM324): It is used as comparator and it is low in cost. It requires very low supply current. The supply voltage is 3V to 32V and supply current is 3.4mA.

3) Frequency to Voltage Converter (LM2907): Frequency to voltage converter with high gain op-amp/ comparator designed to operate a relay/ lamp. The supply voltage is 28V and supply current is 25mA.

4) Driver (ULN2803) Darlington Transistor: It is an 8-pin NPN Darlington connected transistor with common emitter and integral suppression of diodes for inductive loads. Each Darlington features a peak load current rating of 600mA and can withstand at least 50V in off state. Input voltage of 30V and an output voltage of 50V

5) Linear Regulator (MAX1615): High power, low voltage linear regulator. The supply is always on. The input voltage is from 4V to 28V and supply current of 15microamps.Otput current of 30mA.

6) Relays: Relays are either normally open or normally closed. Notice the position of the switches in the two relays shown below. Normally open relays have a switch that remains open until energized (ON) while normally closed relays are closed until energized. Relays are always shown in the de-energized position (no current flowing through the control circuit- OFF).Normally open relays are the most common in vehicles; however either can be used in automotive application.

III. INTEGRATION

Integration deals with the connection of the hardware selected.

Here complete development of the proto type is explained in different blocks.

1) Input Block:

The prototype of the real time implementation of this paper is carried, so the inputs are given from switches assuming to be obtained from the sensors and error conditions from feedback circuit.

The inputs are:

1. Master Switch postion-2
2. Start lock transmission
3. Preglow1
4. Preglow2
5. Engine stop
6. Deep ford
7. Feed back
8. Regulator feedback
9. Coolant level1
10. Coolant level 2
11. Low oil pressure
12. Coolant circulation level

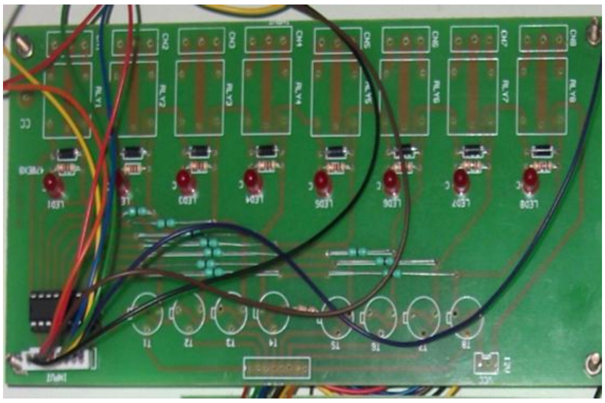

Fig .4.Input Block

These inputs are connected to controller AT89S52 along with opto isolators ILQ74.

In port1 from P10 to P17 pins are connected to first seven inputs as stated above. The rest of the inputs are connected to port3 from the pin P30 to P33.

Speed input is given in the form frequency to the frequency to voltage converter LM2907.Here two LM2907s can be used to have two direct inputs to the controller in accordance with the two speed condition (here its frequency),but here we use single LM2907 along with LM324 as comparator circuit. The outputs of the comparator circuit are given to pin number P34&P35 of port3.

2) Power Supply Unit:

Power Supply unit consists of MAX1615.This IC is preferred, since it is linear regulators that supply is always-on, keep-alive power and heat dissipation is low. The DC supply is provided using Bridge-rectifying circuit.

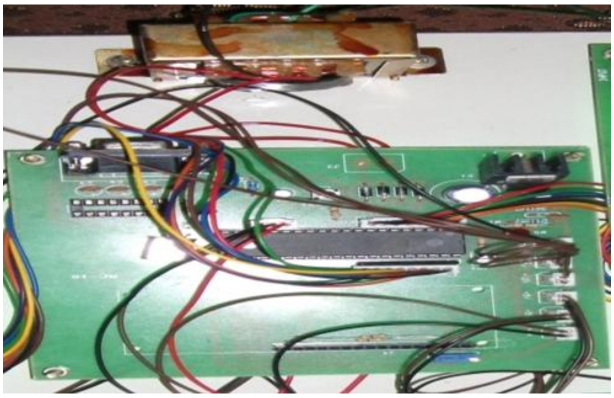

Fig .5.Power Supply Unit

3) Output Block:

The output block consists of seven relays, namely

1. Starter motor relay
2. Dust Eject Motor A relay (DEMA)

3. Dust Eject Motor B relay (DEMB)
4. Fuel Pump
5. Glow-Plug
6. Preglow
7. Shut Down

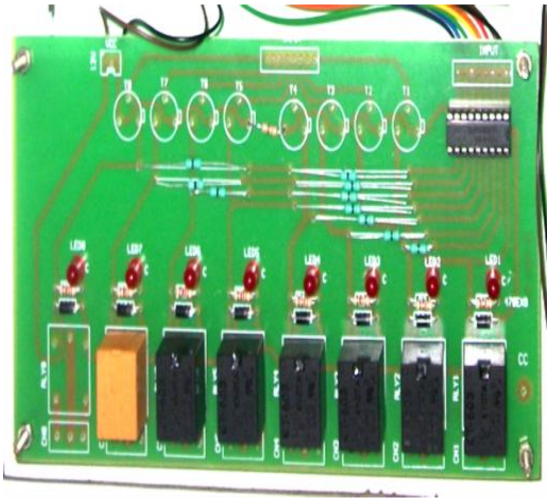

Fig .6.Output Block

4) Relays:

These relays are connected to AT89S52 through driver circuit ULN2803.The ULN2083 has its inputs from port2 of the controller. The pins used in this port are P21-P27.In accordance to the program the corresponding input from port2 energizes ULN2803 to activate respective output relay. The driver circuit is provided with the appropriate driving voltage to activate the highly rated relays. The driving voltage provided here is 28V.

5) Indicator Block:

There has been seven indicators fixed, namely

- DEMA indicator
- DEMB indicator
- Coolant level1 indicator
- Coolant level2 indicator
- Coolant circulation level indicator
- Deep Fording indicator
- Charge lamp indicator

The indicators are in the form of LEDs. The Coolant level 1&2 indicators are directly connected to the input so that as the error input is given LED is made to glow.

DEM A&B indicators connected in the reverse form to indicate the no operable condition of the respective Dust Eject Motors.

The last three indicators mentioned above is connected to the controller at port0 through opto coupler. Coolant circulation level indicator is to have coolant circulation warning i.e., to show whether coolant is circulating or not. This indicator is connected to port0 of pin P06.The charge lamp indicator is connected to controller at pin P05.The deep fording indicator is connected to the controller at pin P07.

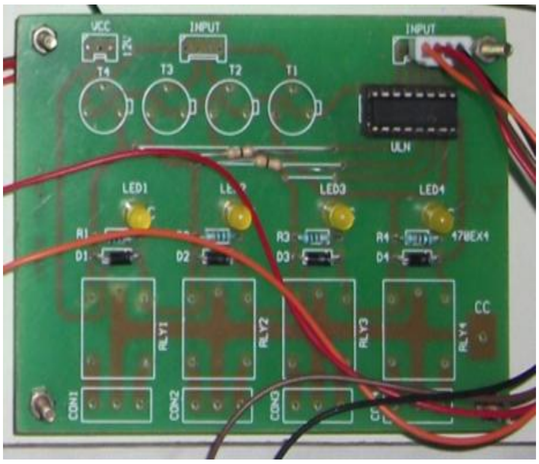

Fig .7.Indicator Block Unit I

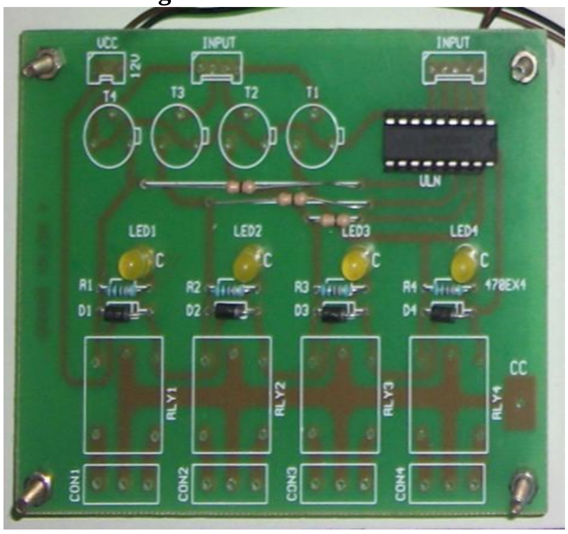

Fig .8.Indicator Block Unit II

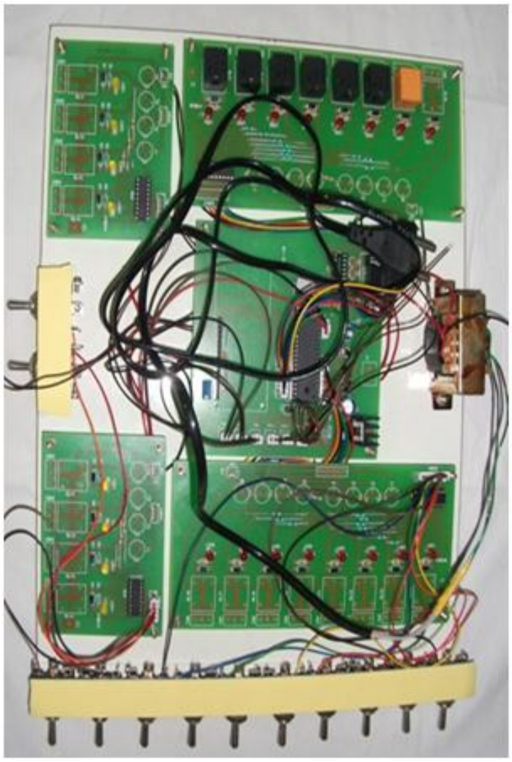

Fig .9.Total Hardware Setup

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IV. PROGRAMMING AND TESTING

A) Software Development

1) Introduction to Keil C:

Keil C is the best and effective compiler for the AT89S52 microcontroller. Keil C compilers, macro assemblers, real-time kernels, debuggers, simulator, integrated environments, evaluation boars and emulators for ARM7/ARM9/cortex-M3, XC16x/C16x/ST10, 251and 8051 MCU families keil also contains

☐IDE stimulator

☐Ansi debugger

☐Broad set of libraries and model prog

2) Details of Keil C Complier:

It combines all aspects of embedded project development including source code editing, project organization and management, revisioncontrol, make facility, target debugging, simulation, and flash programming. Microvision offers a significant advantage to developers who must get projects working quickly.

3) Keil C Compiler contains following Window:

Code Explorer

☐Code Editor

☐Code assistant

☐Watch Assistant

☐Project

☐Summary

V. ALGORITHM

A) Starting Sequence of an Engine:

Step1- When the inputs master switch-2 &start lock transmission is ON then the pre-glow relay will operate and this will be the input to the pre-glow1.

Step2- If the pre-glow1 toggle switch is pressed, then the glow plug relay is energized and at the same time all the warning signals will be indicated.

Step3- If the pre-glow2 is pressed, then the starter motor and fuel pump relay will be energized. At the same time it will also check the feed back signal from the starter.

Step4- If the feed back signal is positive and speed is 400 rpm, de-energize the starter motor and glow plug relay and keep energizing the fuel pump relay.

Step5- If the feed back signal is in ground then de-energizes the starter motor and fuel pump relay.

Step6- Once de-energizes these two relays again re-energize them after the delay around 100microseconds.

Step7- If the regulator feedback is ON then the charge lamp will be de-energized.

B) Monitoring:

Step1- When the speed is greater than the 400 rpm, energize the dust ejector motor A and if the speed is greater than 700 rpm, energize the dust ejector motor B.

Step2- If the coolant level1 is energized then it will energize the coolant level warning and if the coolant level2 is energized then the coolant level 2 is blinking.

Step3- Low oil pressure, coolant level 2 and coolant circulation level. Of these signals if any one of the signal is ON, then the shutdown relay will de-energize and also check whether speed is greater than 700 rpm and deep fording is OFF.

Step4- When the deep fording switch is ON, then the deep fording warning is enabled and at the same time, dust ejector motor A and B and shut down relay is disabled and there will also be a warning indication in the dust ejector A and B.

Step5- Engine stop button is used to shut down the system and energize the shutdown relay to shut down the system and all the relays will be de-energized.

VI. CONCLUSION

This paper presents a work aimed to achieve the microcontroller version of existing ECJB. Along with the existing ECJB functions, it will carry out engine shut down system activities also. The necessary logic sequence was derived from existing Master wiring diagram. Initial design was implemented in 8051 based platform. After due testing and verification it will be implemented using standalone FPGA based processor. Frequency to voltage converter IC is used to convert the available speed signal in to required error signal to activate the Dust Eject motor A and B. The logics are implemented by using Embedded C and validated using Keil assembler and the Hex files were generated. The Hex files are fused in to the processor using flash software. The entire hardware setup is designed using ORCAD software. Circuit routings also re arranged for better board design. Microcontroller 8051 based platform is chosen due to the Input/output port requirement, memory, and easy availability of hardware and cost effective.

Hardware setup is initially tested in bread board with necessary fine tuning on design parameter was carried out. Comparator is used in the output stage of the Frequency to voltage converter circuit. It will produce to error signal one at 400 rpm another at 700 rpm.

PCB was fabricated as per the schematic and extensive testing was carried out.

The sequence and control was tested by manual mode of testing and the board is performing as per design.

Extensive testing with various input condition is carried. The starting sequence and shut down system parameter was analyzed separately to ascertain the performance.

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AUTHORS PROFILE

Dr.P.K.Mani has completed his B.E. Electrical and Electronics Engineering and M.E. Power Systems Engineering at Anna University, Chennai .He has completed his Ph.D. in Electrical and Electronics Engineering at Vel Tech Rangarajan Dr.Sagunthal R&D Institute of Science and Technology. At present he is working as Associate Professor in Electrical and Electronics Engineering Dept,
Vel Tech MultiTech Dr.Rangarajan Dr.SakunthalaEngineering College, Chennai-600062. He has published 14 research papers from his research works in reputed International journals. He is a Life Member of ISTE and Member of IENAG. He has 19 years of teaching experience and 10 years of industrial experience. His fields of interest are Intelligent Techniques used for Power Quality Improvement, Renewable Energy Systems and Battery Management.
Email: manipudhurkannan@gmail.com

Dr.Rajagopal has completed his B.E. Electrical and Electronics Engineering and M.E. Applied at Anna University, Chennai .He has completed his Ph.D. in Image Processing at St.Peters University, Chennai. At present he is working as Associate Professor in Electrical and Electronics Engineering Dept,PSR Engineering College, Sivakasi. He has published his research works in reputed International journals. His fields of interest are Power Electronics, Image Processing
Email: r.rajagopal@yahoo.com

Dr. J. Shanmugapriyan is an Associate Professor in the department of EEE at Veltech MultiTech Dr.Rangarajan Dr.SakunthalaEngineering College, Chennai. His areas of interest are Power Electronics and Drives, and VLSI Design. He has published 10 papers in International and National journals.
Email:jspriyan@gmail.com

Mrs.M.Vijayalakshmi has completed her B.E. Electrical and Electronics Engineering and M.E. Power Electronics and Drives at Anna University, Chennai. At present she is working as Assistant Professor in Electrical and Electronics Engineering Dept, Vel Tech MultitTech Dr.Rangarajan Dr.SakunthalaEngineering College, Chennai-600062.Her fields of interest are, Renewable Energy Systems and Battery Management.
Email: mvijayalakshmi22@gmail.com