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Model of DC – AC Micro-Grid with Fault Detection and Overload Tripping System using IoT

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ABSTRACT

Any small-scale, localized power station that has its own generation and storageresources and restricted boundaries can be considered as micro grid. The usableenergy derived from solar power source using PV panels and supplied through shortlength grid is known as DC – AC micro-grid or DC micro-grid. This type of power grids are known as localized power supply grids. Usually Micro-grid means, anysmall-scale, localized power station that has its own generation and storage resources and restricted boundaries can be considered as micro grid. For example; an isolated small island (a piece of land surrounded by water) or rural village where availability of conventional power source is not possible there we can implement this type of environmental friendly power source known as green energy.

For demo purpose, a mini model of micro-grid will be constructed with mini power system that generates 0.25 amp current at 220V AC from 12V DC source. Small Ac lamp loads are used to prove the concept practically. To do so, PWM technology is used and its output is driven through power Mosfets, inverter transformer,etc. The demo model will be constructed using a little length of power grid and at theend lamp loads are used to simulate normal load and over load. Regarding the part offault detection, 3 important parameters related DC micro-grid like monitoring the over load condition, monitoring the power system temperature and monitoring the input source voltage are implemented. For monitoring load current, CT is used and its output is converted in to digital using Arduino board.

Similarly temperature sensor is used to monitor the power system drive stage and at the same time battery terminalvoltage is also monitored. All these three parameter values are displayed through an LCD and the same data is transmitted to the concern mobile phone through Wi-Fi module interfaced with Arduino. If the system is over loaded, or if the power systemtemperature is raised to more than 50^0 C, or if the input battery voltage is less than 9V, automatically alarm will be energized and fault condition information will be transmittedto the same smart phone. Since it is a prototype model, the data will be transmitteddirectly to the smart phone whose number is stored in main processor. 12v – 10Watts solar panel is used and its output is fed to a high power rechargeable battery and for this purpose, 12v – 7.5 Ah battery is used.

Major Building blocks: Construction of solar power inverter, 10Watts Solar Panel, Rechargeable battery, Z44 Mosfets, inverter circuit built with IC 3524, Main output inverter transformer, Lamp loads, main processing unit built with Arduino Uno board, CT, LM35 is used as temperature sensor, LCD, ESP8266 WiFi module, alarm,voltage regulators, etc.

1. INTRODUCTION

The micro power grid solar power system supplies rural regions with low-power single-phase electricity. The goal of this project is to construct a solar-powered DC-AC microgrid. If the power system fails, an LCD will show the information and a WiFi module will send it to the mobile phone. Solar-based single-phase micro power networks may offer 1 megawatt of electricity to remote settlements. As a prototype module, a 50-watt system is created for demonstration.Project goal is to modernise microgrid technology with new features[10]. The Arduino Uno-based embedded system monitors power grid metrics such load current, temperature, and input source voltage. These metrics are continually monitored and shown on an Arduino-interfaced LCD. The technology also sends data to the processor-stored mobile phone number.

At low battery voltage, the power system activates alarm and displays fault state. If power system drive stage temperature surpasses 500 C, alarm and fault condition will be activated again. The system continually checks load current and generates alarms if it exceeds, displaying fault conditions such “over load”[4]. These faults are sent to the cell phone. Since the operations outlined above cannot be done without a microcontroller-based CPU, this device is called the heart of the project. Today, no power system operates without one. Thus, microcontrollers are increasingly employed to construct power systems for diverse purposes. Understanding microcontroller-based systems is crucial.

2. LITERATURE SURVEY

A stand-alone solar microgrid system that is based on design and simulation intended for use in island areasIn the present day, photovoltaic (PV)-based power production is increasing at a rapid pace as a source of electrical energy that is environmentally friendly[1,8]. This research aims to provide a blueprint for an intelligent distributed, standalone solar micro-grid system well-suited to island settings.This is because the traditional power system is extremely difficult and expensive to deliver energy in island areas. The proposed method may lead to enhanced efficiency and system dependability for the autonomous solar micro-grid. The components that make up this micro-grid are circulation load, generation and energy storage devices that are integrated together in the region to one another[9]. The simulation of each of these microgrid system models is carried out with the help of MATLAB/Simulink. For the purpose of analysing the standalone solar micro-grid, the following tools were utilised: single-phase full bridge DC to AC inverters, DC to DC Boost converters, battery discharge conditions, and backup conditions.In conclusion, this work presents a simulation that analyses various scenarios of this approach. The findings of this simulation satisfactorily verify the correctness of the models.

3. GENERAL DESCRIPTION OF AN INTEGRATED PWM CONTROLLER

Several integrated circuits have been created in recent years that incorporate all the functionalities needed to produce a PWM switching power supply in a single package with minimal extra components[2]. Simple PWM controller components and waveforms are illustrated below.

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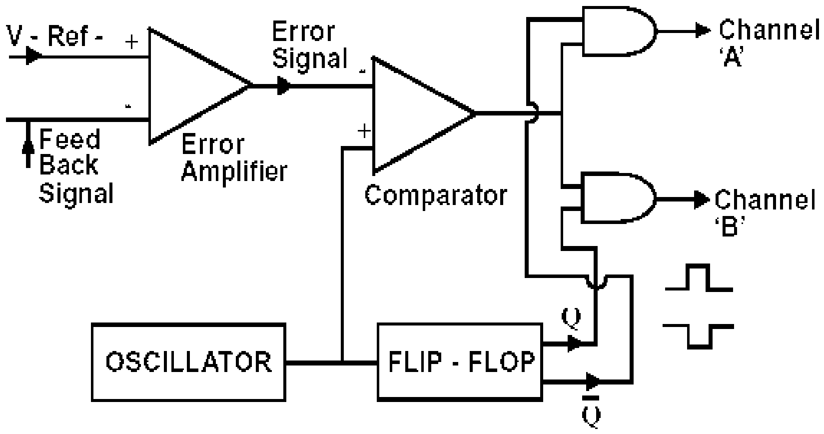

Figure 1. PWM controller

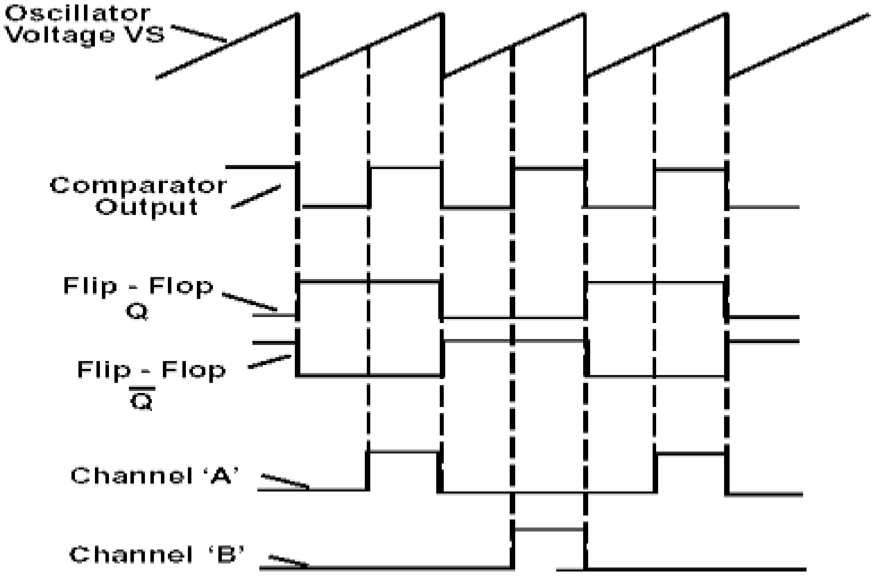

Figure 2. saw-tooth waveform with a linear slope

An op-amp compares the power supply output feedback signal to a preset reference voltage (V-ref). A comparator's inverting input receives an enhanced error signal. A fixed frequency oscillator generates a linear saw-tooth waveform for the comparator's non-inverting input. The oscillator output may be used to toggle a flip-flop to create the square wave outputs Q and Q. When both inputs are high, the Flip-Flop and comparator square wave outputs drive AND gates, activating each output. Channels "A" and "B" experience a pulse train with a variable duty cycle. The output pulse width fluctuates as the error signal amplitude varies, as shown by the dotted lines[5]. Primary power switching MOSFETS are often driven by externally buffered PWM controller outputs. This circuit may power one MOSFET or two transistors. Programmable fixed frequency oscillators, linear PWM sections with duty cycles ranging from 0% to 100%, configurable dead time to avoid output transistor or MOSFET simultaneous conduction, simplicity, dependability, and affordability are just a

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few of the numerous benefits of PWM controllers. The IC 3524 PWM control circuit was created to become the industry standard. These PWM controllers, which function effectively in single-ended or dual-channel applications, are the central component of the switching power supply design. When the feedback voltage varies between 0.5V and 3.5V, the error amplifier may use the PWM comparator to change the output pulse width from the maximum percent on time of the dead-time control input to zero. outputs of an active high error amplifier.

This design gives loop control to the amplifier that requires minimal output on time. The fundamental idea of pulse width modulation is: Due to their high gain, op-amps in open loop design generate +V sat or –V sat. When the inverting input voltage is marginally greater than the non-inverting input voltage, the output is expressed in –V sat. As a result, output is –V sat instantaneously if inverting input exceeds non-inverting input[3,8]. V ± 1.5V will be the SAT voltage. The output voltage is +V sat if the non-inverting voltage is marginally greater than the inverting input voltage. As a result, the output is simply either +V sat or -V sat. To investigate the variations in the output voltage, we will provide a saw-tooth or RAMP voltage to the non-inverting input and a variable DC voltage or feedback to the inverting input.

Feedback voltage determines output pulse width modulation. These are best explained by the waveforms below.

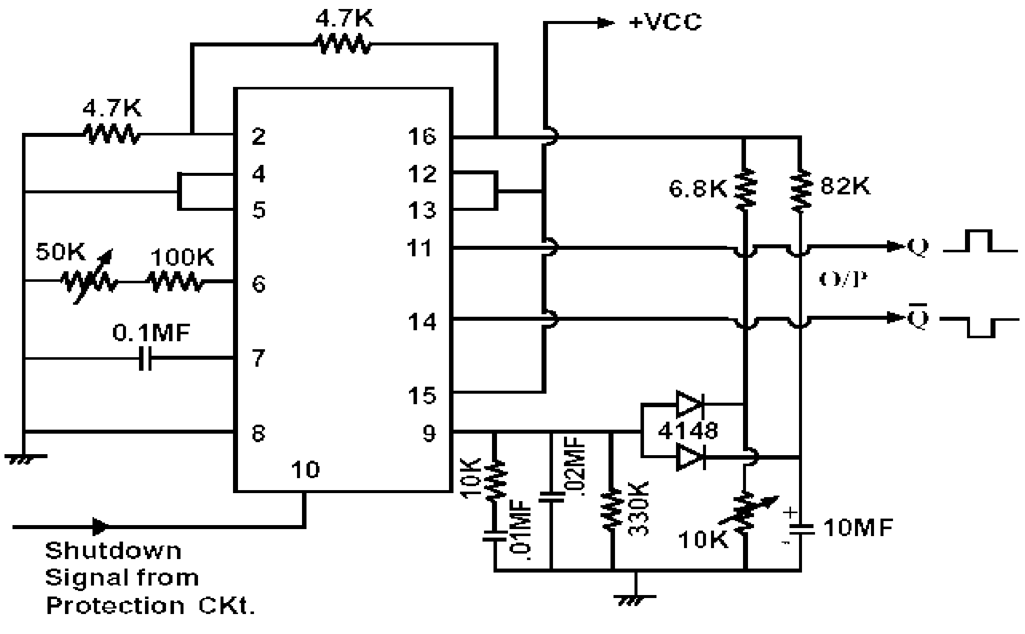

Figure 3. PWM Oscillator

The built-in 5V regulator, V ref, provides power to the inverting input of Pin No. 2 of the error amplifier using a voltage divider consisting of two 4.7K resistors. The regulator on the IC is +5V. 2.5V is present on Pin No. 2 (5V x 4.7K / 4.7K + 4.7K). Since it is not in use, the current limit amplifier is grounded.RT and CT modify internal oscillator frequency. Ramp generator and pulse width modulator are internal IC connections. Chapter Hardware information included IC internals[1]. In order to shut down the IC and save the inverter from overloading, the high signal to shutdown pin stops the PWM output. Internal NOR gates that are timed by the oscillator facilitate the passage of the Flip-Flop's "Q" and "Q" output, as well as the built-in PWM generator. These 50Hz PWM outputs are boosted by class ‘B’ push-pull stages. Soft start circuit uses Pin.9 compensating input. This slows the PWM regulator's output when the device is turned on, preventing spurious protection circuit activation. The RC time constant is 820m sec (82K x 10MF)[3]. A voltage divider of 6.8K and 10K potentiometers reduces this delay. Adjusting the voltage at Pin 9 modifies the output duty cycle. Between Pin 9 and ground, a 10K Pot (variable resistor) is positioned. It is possible to alter the resistance reference voltage at the compensation pin linearly. Output voltage is controlled by duty cycle changes.

4. DESCRIPTION ABOUT DRIVE STAGE

According to earlier chapters, the driving stage is a push-pull amplifier. The amplifier's primary function is to boost voltage and current to drive a 60Watts load, which may use 300ma at 220V ac. This amplifier generates 350ma maximum for safety. The output voltage of a voltage amplifier is several times the input voltage. Similarly, current is magnified[9]. Amplifier components are used to increase gain (output voltage to input voltage). The oscillator's low-voltage, low-current ac signal is too tiny to operate the motor without amplification. Power amplifiers have voltage gain, but power output—What matters more is the product of voltage and current.Two identical output circuitry stages with power Mosfets drive the main transformer in a class "B" push-pull amplifier. These Mosfets are stimulated by input signal voltages that are equal but 180 degrees out of phase.

In this configuration, one Mosfet amplifies the signal voltage's positive half cycles and the other the negative half cycles. The output transformer amplifies the input voltage and current by combining the amplified half cycles[8]. In reality, the oscillator's biassing signals flip the two Mosfets in order. Crossover distortion is avoided. The oscillator's frequency determines the duration between the Mosfets' turns on and off, which clips the output voltage. This circumstance causes crossover distortion in output.

BC 557 general-purpose PNP switching transistors drive Power MOSFETS in the circuit above. To drive the load, regulator PWM outputs from A and B transistor emitters (supplied within IC) are amplified. For this, pre-driver and driver phases employ class ‘B’ push-pull stages. Thus, push-pull design may minimise most of the distortion caused by dynamic transfer characteristic non-linearity. A MOSFET is positive when one of them is and the other is negative by the same amount. Even harmonics are reduced by push-pull amplifiers[4, 7]. In addition to zero axis symmetry, the push-pull exhibits "half wave" or "mirror" symmetry since the output current lacks any even harmonic terms.

Push-pull amplifiers provide higher output per active component for a given distortion since their outputs have no even harmonics. The push-pull configuration reduces distortion per MOSFET power output for the same reason. Another benefit of push-pull arrangement is that the transformer core's DC collector current components magnetically oppose each other. This reduces transformer magnetization curve curvature-induced core saturation and non-linear distortion. Other benefits include balancing power supply ripple voltages caused by poor filtering.Due to their input high impedance, power MOSFETS outperform bipolar power transistors. No-load current may be lowered and efficiency enhanced.

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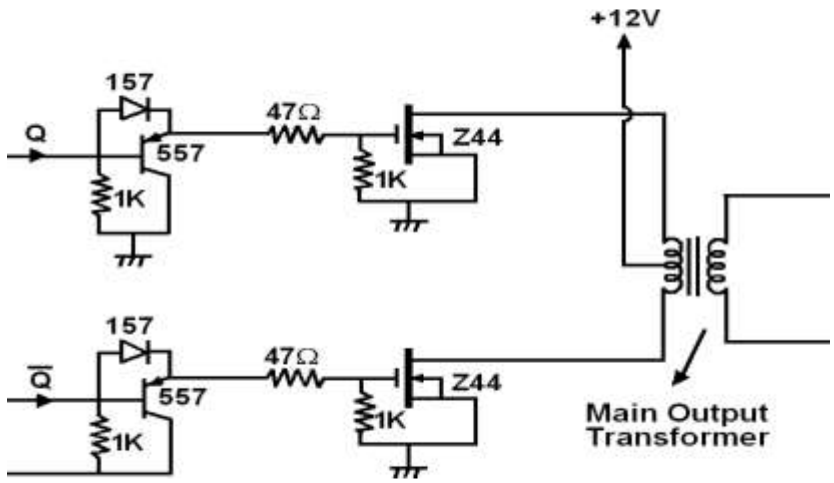

Figure 4. the circuit diagram of driver stage.

5. DESCRIPTION OF FAULT DETECTION CIRCUIT

This Arduino Uno processor board-based fault detection circuit monitors three important micro-power grid parameters: load current, power system drive stage temperature, and input source voltage (battery voltage). CT, LM35, and potential difference network are used to monitor load current, temperature, and input voltage. Arduino's inbuilt ADC digitises these three parameters' outputs[2]. The primary CPU reads and displays parameter values digitally via Arduino-interfaced LCD. The CPU also sends data to the cell phone. Any parameter value that exceeds its predetermined value activates the buzzer and sends a problem signal to the same mobile phone. Individual circuits are described here.

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A) LOAD MONITORING CIRCUIT

Current transformers monitor inverter transformer secondary loads. The current transformer's The main current of the primary winding is governed by the load on the system because it is linked in series with the load that is carrying the current to be measured.
not the secondary winding's load. There is no voltage loss across the main winding since it has few turns[4]. The current transformer's secondary winding has more turns, defined by the turn ratio.CT output is corrected, filtered, and sent to Arduino's ADC pin. The CT main current is proportional to the CT secondary voltage. The CT secondary output proportional to load current is regulated using a variable resistor (preset) and sent to the A/D converter pin. The microcontroller chip receives digital data from the A/D converter and displays load current in amps. When the load current exceeds the specified value (programmable based on transformer capacity), the controller activates the alarm and displays information.

The main current of this project's current transformer is limited to 3Amps. In practice, a higher-rated transformer may be employed based on the distribution transformer's power[5The majority of industrial CTs can produce high voltage without a load resistor and have current outputs between 5 and 10 amps. In this project, a step-up transformer (CT) is used. Because of the 1:50 ratio of this transformer, the secondary voltage is 50 times that of the primary voltage. Load current and primary voltage are proportionate. The secondary winding of the CT should always be connected to a burden resistor because of the step-up ratio; otherwise, the voltage between the open terminals might be quite high when the circuit is open circuited. The secondary AC signal is proportionate to the primary current because of transformer operation. It is rectified (half wave rectification) by a diode and filtered (filter capacitor).The load current affects this variable DC voltage[10]. Analogue to digital converter pins receive variable voltage from CT secondarys to convert analogue data to digital. For measuring CT primary current, the Arduino Uno board output has a digital display. The load sensing circuit diagram follows.

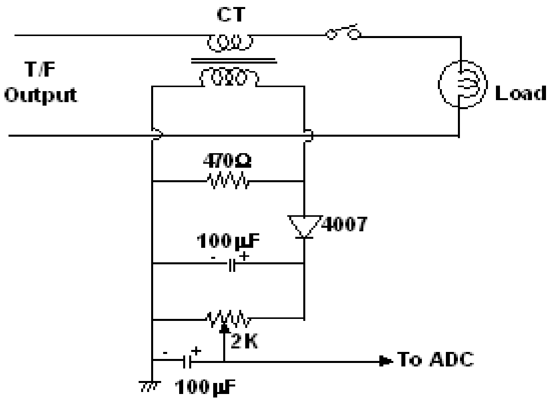

Figure 5. Load Monitoring Circuit

In the aforementioned design, a 470ohm resistor across the CT secondary suppresses ripple and gives the CT output true value. To modify this voltage, a 2K variable resistor is utilised and the output is obtained from the midway of the preset. For demonstration, a 50-watt inverter transformer is utilised to power the prototype module's low power inverter[9]. This secondary drives the light load via the current transformer primary. Different light loads may be used to compare load currents.

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B) TEMPERATURE SENSING CIRCUIT

This LM 35 circuit measures body temperature. The LM35, a temperature sensor, produces proportional voltage from its output pin based on sensor heat. LM35 precision integrated-circuit temperature devices provide a linearly-proportional output voltage to Centigrade temperature[8].[The LM35 device's linear output, low output impedance, and flawless inherent calibration make it easy to read or control circuitry interface.The third pin of the LM35 temperature sensor generates an analogue signal and requires VCC and GND. The Arduino ADC pin receives this output, which is used to convert analogue to digital. Precision integrated-circuit temperature sensors, or LM35 series, have an output voltage that is precisely proportional to Celsius (Centigrade).
However, the programme must be prepared to convert this data to Fahrenheit.

LM35's datasheet says it adjusts output voltage by 10mV every 1°C change. Finding a method to determine temperature using ADC digital numbers is the entire idea. LM35 is an integrated circuit sensor that measures temperature and outputs a proportional electrical signal. It measures temperature better than a thermister. Sensor circuitry is enclosed and oxidation-free. The LM35 may not need amplification since it produces a greater output voltage than thermocouples[7]. LM35 output voltage is proportional to Celsius temperature. .01V/°C scale factor. The LM35 requires no external calibration or trimming and has an accuracy of +/-0.4°C at ambient temperature and +/-0.8°C from 0°C to +100°C. Also, the LM35 uses just 60 micro amps from its supply and has minimal self-heating.

C) INTERNAL A TO D CONVERTER OF ARDUINO

Arduino processor's A/D converter receives temperature sensor data. Arduino has 6 analogue input channels, and channel selection relies on the address selected by the Micro-controller in the Arduino processor. One address input selects one of six internal ADC channels.Arduino features a 10-bit ADC that can detect 1,024 (2^10) discrete analogue values. Sensor output is often analogue when interfaced to a microcontroller. The microcontroller processes digital impulses. We employ ADC between sensor and microcontroller[5]. Analogue signals are converted to digital and sent to the microcontroller. ADC is used in biometrics, environmental monitoring, gas leak detection, and more.Six on-board ADC channels on Arduino Uno can read 0-5V analogue signals. Its 10-bit ADC provides digital values from 0 to 1023 (2^10). The amount of discrete values it can create over analogue values is termed resolution. Calculating digital output value ADC Resolution = Vref / (2^n - 1) Digital Output=Vin/ResolutionThe reference voltage is the ADC's maximum conversion value. To simplify, let Vref be 5V. For 0 Vin, digital o/p value = 0, for 5 Vin, 1023 (10-bit), and for 2.5 Vin, 512.

D) DISPLAY SECTION

The LCD display shows grid parameter values. This LCD has two rows with 16 characters each, depending on LCD panel availability. Use 3 or 4 line panels to present more information concurrently[4]. LED displays can only show numbers, while LCD screens can display alphabets, numbers, and special symbols, thus they dominate. These LCD screens are important for user communication and information. LCD screens come in several sizes. Two lines of 16 alphanumeric characters are most typical. Other formats include 3x16, 2x40, 3x40, etc.

E) WORKING PRINCIPLE OF LM35

The drawing centres on two transistors. A has 10 times the emitter area of another. Since both transistors carry the same current, it has one eighth the current densityOver the range, the voltage across resistor R1 is roughly linear and proportional to the absolute temperature[6]. By eliminating the "almost" component, a certain circuit straightens the voltage versus temperature graph that is somewhat bent. The amplifier at the top ensures that the voltage at the base of the left transistor (Q1) is proportionate to absolute temperature (PTAT) by comparing the output of the two transistors. Depending on the component (LM34 or LM35), the amplifier on the right converts Kelvin temperature to either Celsius or Fahrenheit.A circuit with a constant current source is the "i" circle.

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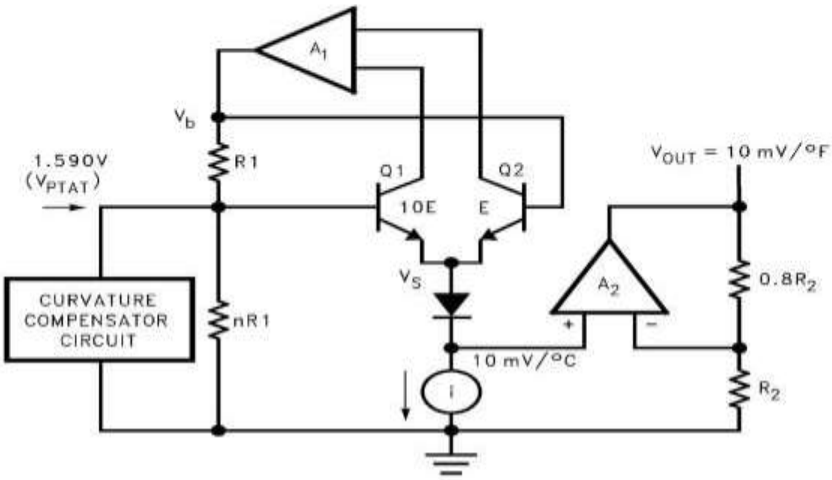

Figure 6. LM35

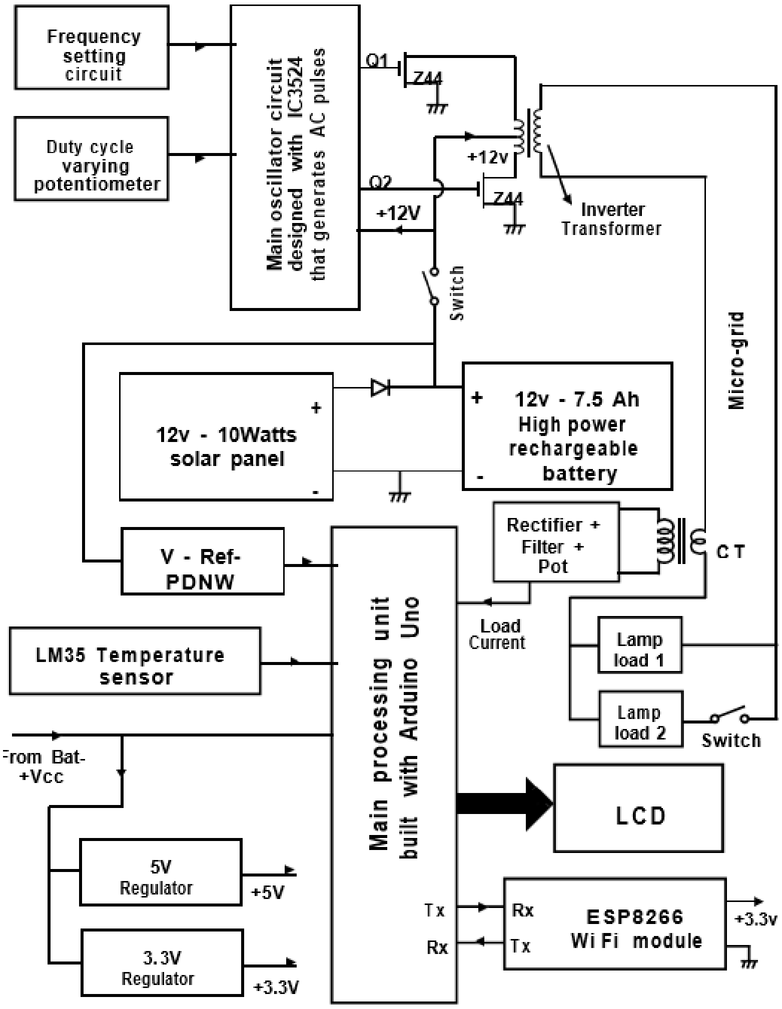

Figure 7. Model of DC – AC micro-grid with fault detection using IOT

To create an accurate temperature sensor, the manufacturer calibrates the two resistors[3]. Two transistors are located in the middle of the integrated circuit, along with other transistors in each amplifier, the curvature correction circuit, the constant current source, and other locations. Everything is included in the little three-lead package.Three pins make up the LM35 IC: two power sources

and 1 analogue output. Low-voltage ICs need around +5VDC. The output pin outputs a linearly proportional analogue voltage to Celsius. Pin 2 outputs 1 mV/0.1°C. Simply divide the voltage output by 10 to obtain the Celsius degree value.

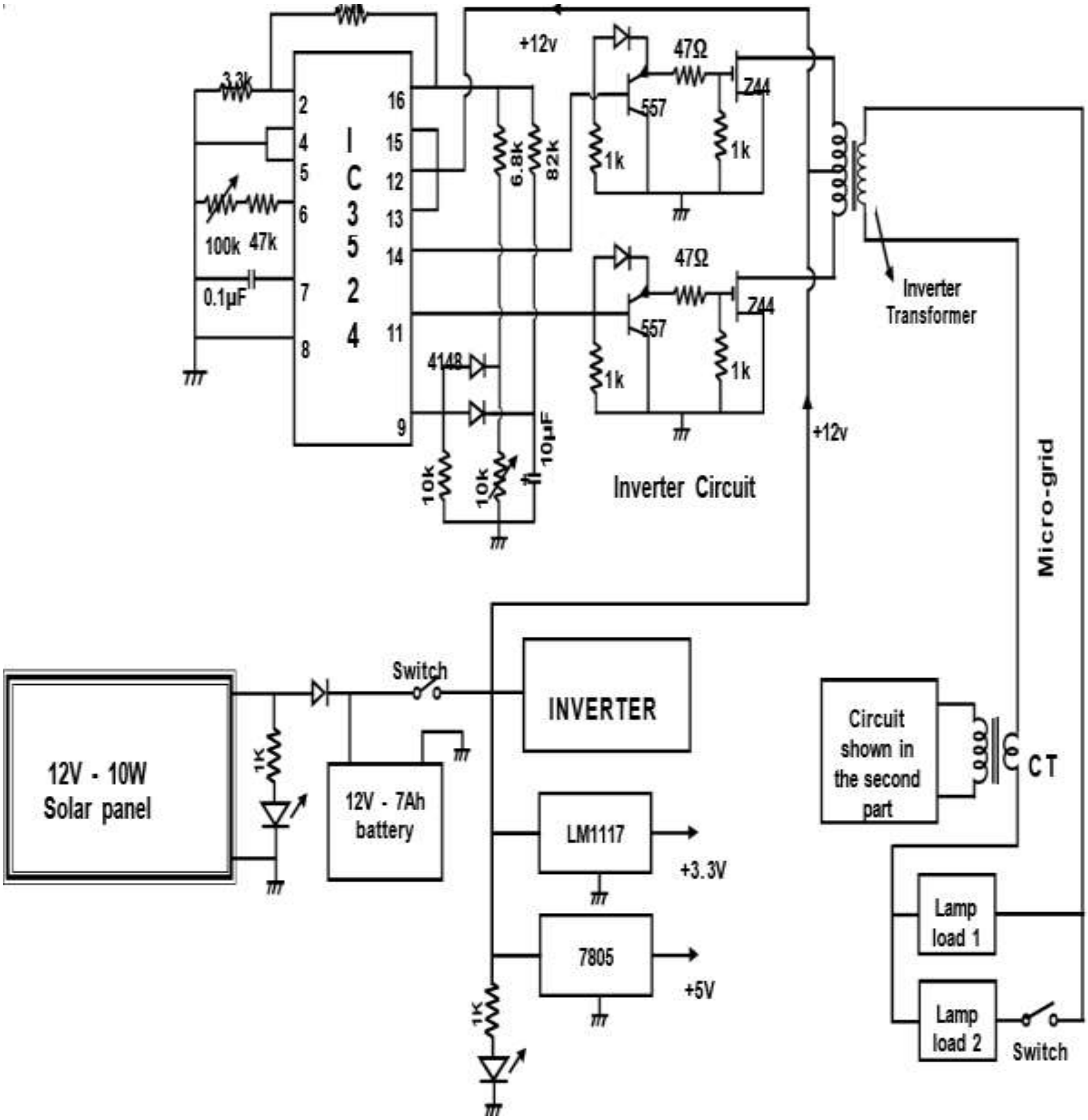

Figure 8. Model of DC – AC micro-grid with fault detection using IOT - PART 1

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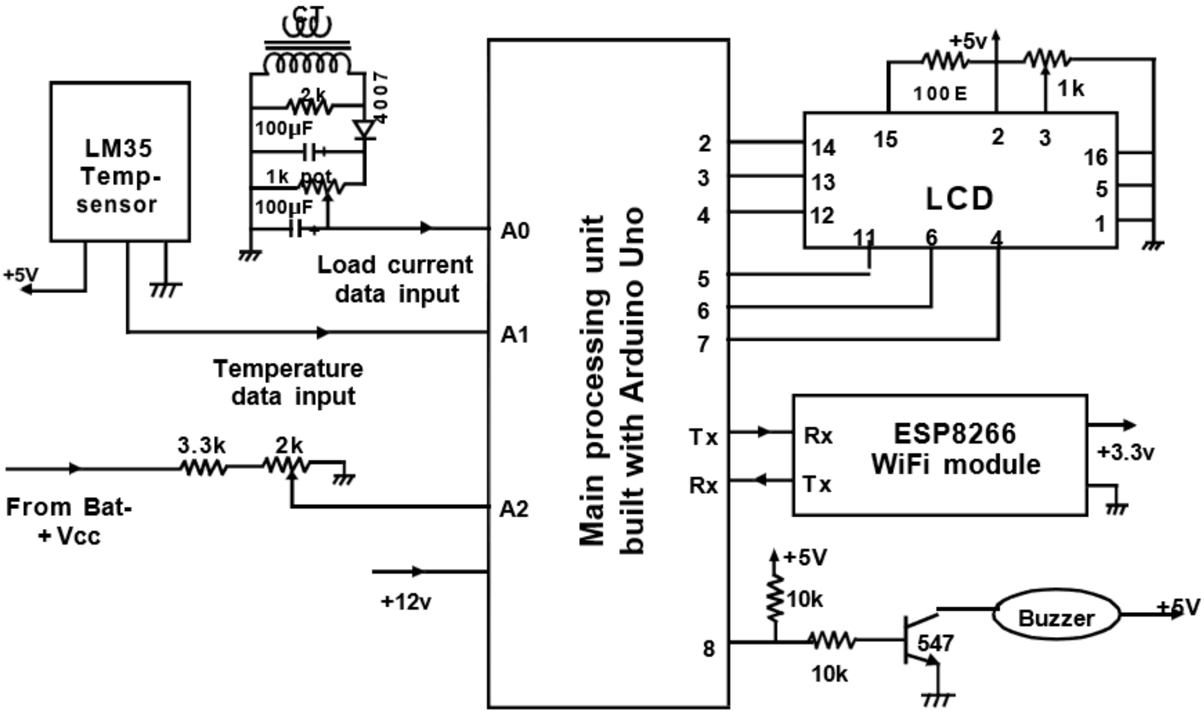

Figure 9. Model of DC – AC micro-grid with fault detection using IOT - PART 2

6. RESULTS

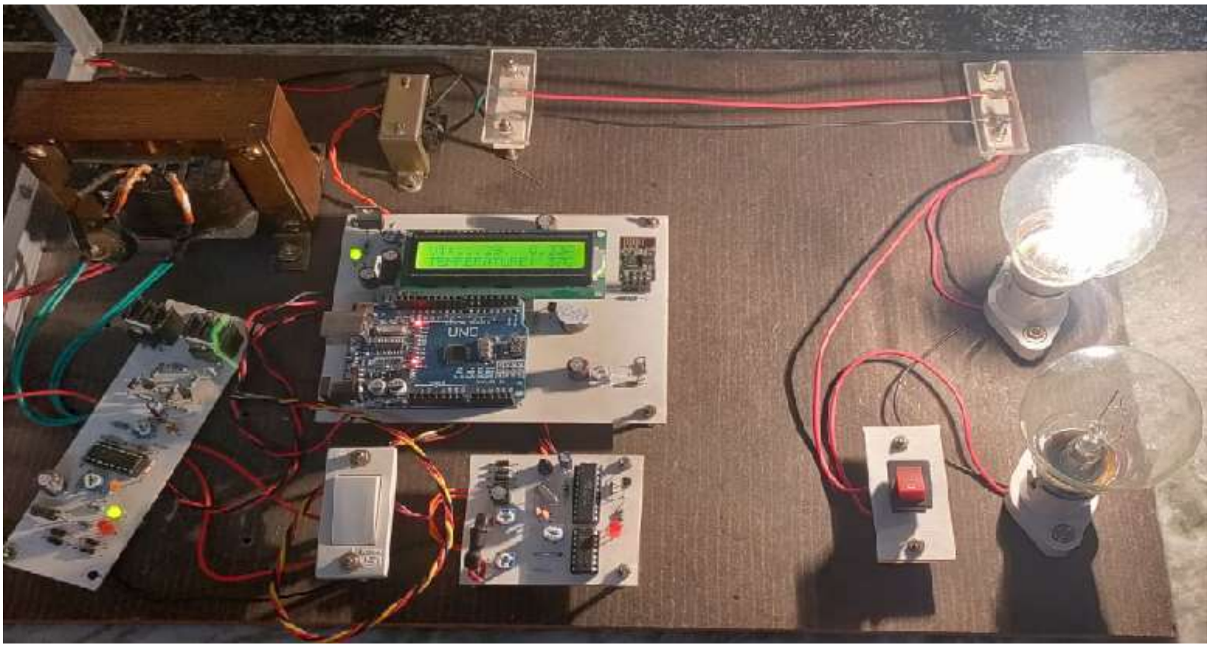

Figure 10. Hardware Model of DC – AC micro-grid with fault detection using IOT

CONCLUSIONS

The "Model of DC – AC micro-grid with fault detection using IOT" project was conceived, tested, and built[1]. As a demonstration unit, a little solar-based micro-grid has a low-power inverter that can supply 250 milliamps at 220V at the system output. For practical

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uses, a higher-rated inverter can provide higher-wattage electricity for isolated settlements. Since it's a power system-based micro-grid, protection circuits are necessary, so fault detection circuits are included. If a fault occurs in the grid, LCD will display the information and send it to the responsible mobile phone so the authority can act immediately. Since the system relies on solar power, it may not produce energy if there isn't enough sun. In such cases, we need a similar stand-by power source so that if the existing power system fails, the load can be automatically shifted. This is needed for real-time apps. Future development will focus on this feature.

This project uses solar energy to charge the battery, a non-conventional power producing approach. Energy comes from the sun, which radiates electromagnetic waves. Windmills generate electricity from natural breezes. These generators can charge batteries. The foregoing two approaches create abundant, unlimited, non-polluting, operator-free, and maintenance-free energy in non-conventional energy resources.

REFERENCES

[1] "A course in power systems", by J.B. Gupta, S K Kataria and .Sons publishers.

[2] "Solar energy utilization", by G.D. Rai, Khanna publishers.

[3] "Power from the sun – A practical guide to solar electricity", by Dan Chiras, New Society Publishers.

[4] "Wind and solar power systems", by Mukund R. Patil, CRC press.

[5] "Solar electricity handbook", by Michael Boxwell, Greenstream publishing.

[6] "Power Electronics", by P.C. Sen, McGraw Hill Education publication.

[7] "Beginning Arduino", by Michael Mc Roberts, APress Publisher.

[8] "Getting started with Arduino", by Massimo Banzi & Michael Shiloh, 3rd Edition, Maker Media Publication.

[9] "Reference Architectures for the Internet of Things", IEEE Transactions on Software, Volume: 33, Issue: 1, Jan.-Feb. 2016, Pages 112 – 116.