

# IOT based Buck-Boost Voltage Stabilizer for Industrial and Residential Load

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**Abstract** - The effects of overvoltage are more severe and destructive. It may cause the electrical equipment to fail, due to overheating caused by high voltage. Also electronic and other sensitive equipment are prone to malfunction. Overvoltage can occur due to single line to ground fault, which in turn will raise the voltage of the other phases. It can also cause due to disconnection of heavy industrial loads or switching on the capacitor banks. When it comes to overcome the problem of over voltage and under voltage the circuit is been triped for safety. But this project is done with an intention to carry on the working of the circuit with a single phase motor as load with the help of 5 tapping transformer. Automation circuit with IOT based connection helps it to restart the circuit when voltage reaches the range above the limit of stabilizer.

**Keywords:** -overvoltage and under voltage protection, voltage comparator circuitry, tripping mechanism of relay.

## 1. INTRODUCTION

A Voltage Stabilizer is an electrical device which is used to provide a constant voltage output to a load at its output terminals irrespective of any change/ fluctuation in the input i.e. incoming supply.

The basic purpose of a Voltage Stabilizer is to protect the electrical/ electronic gadgets (for example - Air conditioning Unit, Refrigerator, TV, etc.) from the probable damage due to Voltage Surge/ fluctuations, Over Voltage and Under Voltage conditions.

Voltage Stabilizer is also known as AVR (Automatic Voltage Regulator). The use of Voltage Stabilizer is not only limited to house/ office equipment which are being fed power supply from outside. Even the ships, who have their own internal power supply arrangement in form of Diesel Alternators, are heavily dependent on these AVRs for safety of their equipment.

We can see different types of Voltage Stabilizers available in the market. Both analog and digital automatic Voltage Stabilizers are available from so many manufactures. Thanks to the rising competition and increasing awareness for the safety devices. These Voltage Stabilizers may be single phase (Output of 220-230 volt) or three phase (Output of 380/400 volt) as required by the type of application. The regulation of desired stabilized output is

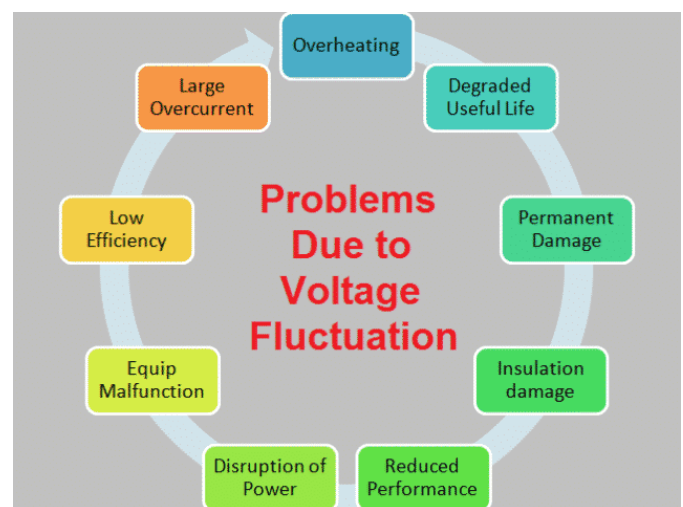
done by buck and boost method as performed by its internal circuitry. Three phase Voltage stabilizers are available in two different models i.e. Balanced load models and Unbalanced load models.

They are available in different KVA rating and ranges too. A normal range Voltage Stabilizer can ensure a stabilized output voltage of 200-240 volt with 20-35 volt boost-buck from an input voltage feed ranging from 180 volt to 270 volt. Whereas, A wide range Voltage Stabilizer can ensure a stabilized out voltage of 190-240 volt with a 50-55 volt boost buck from an input voltage ranging from 140 volt to 300 volt.

Why do we need Voltage Stabilizers? - Its Importance

All electrical/ electronic devices are designed and manufactured to operate at maximum efficiency with a typical voltage supply which is known as the nominal operating voltage. Depending on the designed safe operating limit, the working range (with optimum efficiency) of an electrical/ electronic device may be limited to  $\pm 5\%$ ,  $\pm 10\%$  or more.

Owing to many issues, the input voltage supply which we get always tends to fluctuate resulting to a constantly varying input voltage supply. This varying voltage is a major contributing factor for reduction of a device's efficiency as well increase in its failure rate.



A correct and stabilized voltage supply is very much required for the device to perform its intended function in the most optimized way. It is the Voltage stabilizer which ensures that the device get the desired and stabilized voltage no matter how much the fluctuation is. Therefore, Voltage stabilizer is a very efficient solution for anyone who desire to get an optimum performance and protect their devices against these unpredictable voltage fluctuations, surge and noise present in the supply.

Like UPS, voltage stabilizers are also an asset to the protection of electrical and electronic equipment. The voltage fluctuations are very common irrespective of where ever you live. There may be various reasons for the voltage fluctuation such as electrical faults, faulty wiring, lightning, short circuits, etc. These fluctuations may be in the form of Over voltage or Under voltage.

## 2. POWER QUALITY ISSUES:

### 2.1 OVERVOLTAGE

An overvoltage is an increase in the rms value of ac voltage greater than 110 percent or 0.11pu at the power frequency for a duration longer than 1 min. over voltages are usually the result of load switching (e.g., switching off a large load or energizing a capacitor bank). The over voltages result because either the system is too weak for the desired voltage regulation or voltage controls are inadequate. Incorrect tap settings on transformers can also result in system over voltages.

#### 2.1.1 Causes of over voltages:

- It may cause permanent damage to the connected device.
- It may cause damage to the winding insulation.
- It may lead to unnecessary disruption in the load
- It may lead to over-heating of the cable or device.
- It may degrade useful life of the device

### 2.2 Under voltage:

An under voltage is a decrease in the RMS value ac voltage to less than 90 percent or 0.90pu at the power frequency for a time period longer than 1 min. Under voltages are the result of switching events that are the opposite of the events that cause over voltage.

Under voltages are the most common power disturbance whose effect is quite severe especially in industrial and large commercial customers such as the damage of the sensitivity equipment's and loss of daily productions and finances. The examples of the sensitive equipment's are Programmable Logic Controller (PLC), Adjustable Speed Drive (ASD) and Chiller control. Under voltage at the equipment terminal can be due to a short circuit fault hundreds of kilometers away in the transmission system.

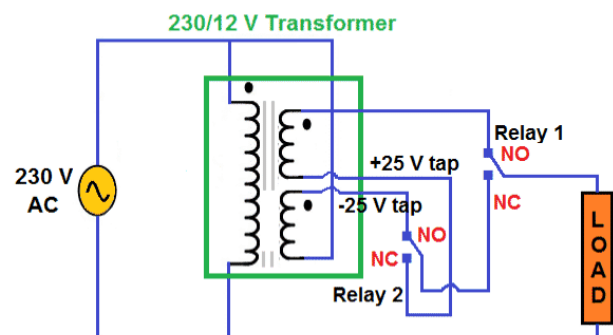
### 2.2.1 Causes of under voltages:

- Closing and Opening of Circuit Breakers
- Due to Fault
- Due to Motor Starting
- Due to Transformer Energizing
- Equipment Failure
- Bad Weather and Pollution (Lightning strikes, Flash over, etc.)
- Construction Activity (damage to underground
- Cables

### 3. Equipment used in Circuit:

- IOT-MicrocontrollerESp8266
- Stabilizer-5 tapping transformer
- AC motor
- Auto Transformer
- Potential transformer
- LCD
- Relays
- Resistors
- Bridge rectifiers
- Capacitors
- 7805 voltage regulator
- Connectors

### Automatic Buck and Boost function in a Voltage Stabilizer



In the Circuit diagram of 02 stage Voltage Stabilizer (depicted above), Relay 1 and Relay 2 are used to provide Buck and Boost configurations during the different Voltage fluctuation circumstances i.e. Over Voltage and Under Voltage. For example – Suppose the ac input is 230 volt AC and output required is also constant 230 volt AC. Now if you have +/- 25 Volt Buck & Boost stabilization, that it means that your Voltage Stabilizer can provide you constant desired voltage (230 volt) in between 205 volt (Under Voltage) and 255 Volt (Over Voltage) of input AC supply.

In Voltage Stabilizers that use tapped Transformers, the tap points are selected on the basis of required amount of voltage to be Bucked or Boosted. In this case, we have different voltage ranges to select for. Whereas, in Voltage Stabilizers that use auto transformers, Servo motors along with sliding contacts are used for obtaining required amount of voltage to be Bucked or Boosted. Sliding contact is necessary as auto transformers have only a single winding.

### Different Types of Voltage Stabilizers

Initially manually operated/ selector switch operated Voltage Stabilizers came in the market. These type of stabilizers used electro-mechanical relays for selection of desired voltage. With advancement of technology, added electronic circuits came into existence and the Voltage Stabilizers became automatic. Then came the Servo based Voltage Stabilizer which is capable of stabilizing the voltage continuously, without any manual intervention. Now, IC/ Micro controller based Voltage Stabilizers are also available which can perform additional functions too.

The Voltage Stabilizers can be broadly categorized into three types. They are:

- Relay Type Voltage Stabilizers
- Servo based Voltage Stabilizers
- Static Voltage Stabilizers

#### Relay Type Voltage Stabilizers

In Relay type Voltage Stabilizers, the voltage is regulated by switching relays. The relays are used to connect the secondary transformer(s) in different configurations to achieve Buck & Boost function.

#### Uses/ Advantages of Relay type Voltage Stabilizers

This stabilizer is mostly used for low power rating appliances/ equipment in Residential/Commercial/Industrial use.

- They cost less.
- They are compact in size.

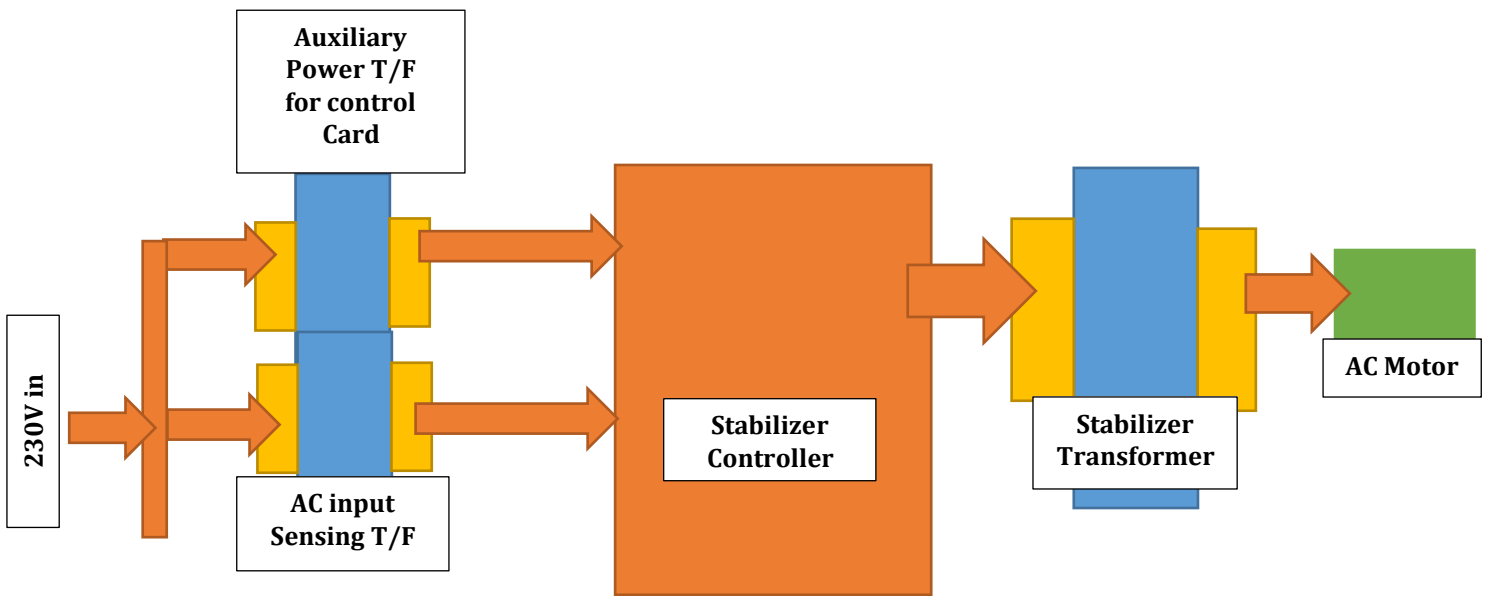
### Limitations of Relay type Voltage Stabilizers

- Their response to voltage fluctuation is a bit slow if compared to other type of Voltage Stabilizers
- They are less durable
- They are less reliable
- They are not able to withstand high voltage surges as their fluctuation tolerance limit is less.
- While stabilization of voltage, transition of power supply path may provide minor interruption in power supply.
- **IoT based Buck-Boost Voltage Stabilizer**

IoT based voltage stabilizer is a stabilizer which constantly monitors the AC Mains voltage and controls variations in the input voltage by Auto-transformer tap changing. In other words, it automatically regulates the voltage. This tap-changing auto transformer decides the output voltage on the transformer. It is considered to be a cheap and good voltage stabilizer. This is a perfect solution to protect the appliances from voltage fluctuations. This is a smart internet connected voltage stabilizer. IoT platform enables us to turn on- turn off and monitor the voltage levels of the output load. Here output load will be AC motor.

A stabilizer is highly important for an optimum performance of any electrical or electronic equipment that maintains input mains voltage stability. A fluctuation, be it a high voltage or low voltage can prove harmful on the voltage sensitive devices. Hence, a solution has been identified by smart IoT based Tap-changing stabilizer that will guarantee that the voltage will be under the safety limits i.e. 220V-240V. The stabilizer ensures that the load is operated within safety limits and machines operate at a better efficiency avoiding losses.

IoT enabled android app is made so as to have interface with the stabilizer. Embedded-C language is used to program the controller. Blynk platform was used for IoT integration with the hardware. The voltage stabilizer was made on ESP32 controller embedded with Wifi enabled function. This wifi function provides an IP address to the voltage stabilizer, so that it can be controlled remotely over mobile or desktop application. Fig below shows basic block diagram of implemented voltage stabilizer hardware.



Basic Block Diagram for IoT Based Voltage Stabilizer

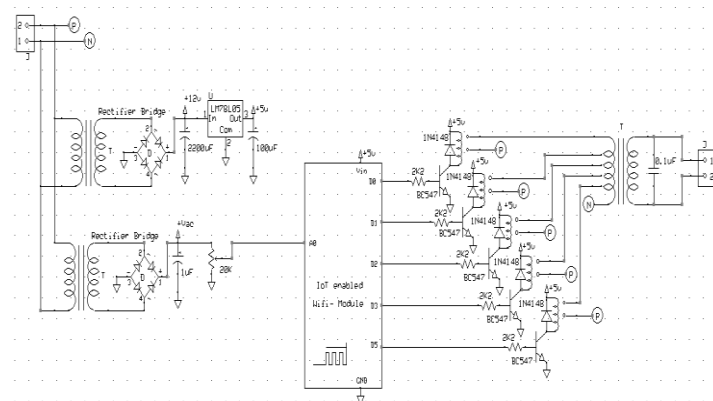
#### 4. WORKING

##### Block diagram working:

230VAC unregulated is given at the input of the system. This is stepped down and given to the stabilizer control card for powering up the microcontroller and other supporting components. A small part of this 230VAC is stepped down and given for sensing the voltage of  $V_{in}$ , this is also called as potential transformer (PT). This PT converts 230V to a lower value say 1.8V-2V for proper functioning of the microcontroller circuit.

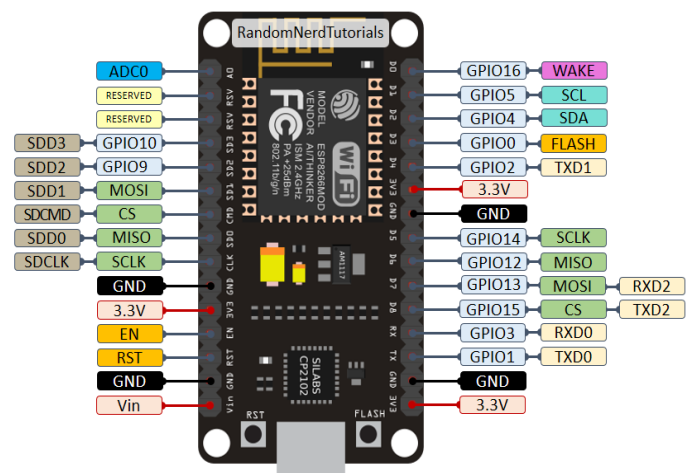
The Stabilizer control card contains the main microcontroller ESP8266 based WiFi module that help communicate to the mobile app for iot monitoring and control. This card also has 5 relays that does the tap changing depending upon the input supply voltage.

The tap changing transformer is special transformer with 5 winding at the input primary side. If more than 240V appears at the input then the controller switches the respective relay to stabilize the output voltage on the motor. AC motor is connected at the output.



#### 5. PIN DIAGRAM:

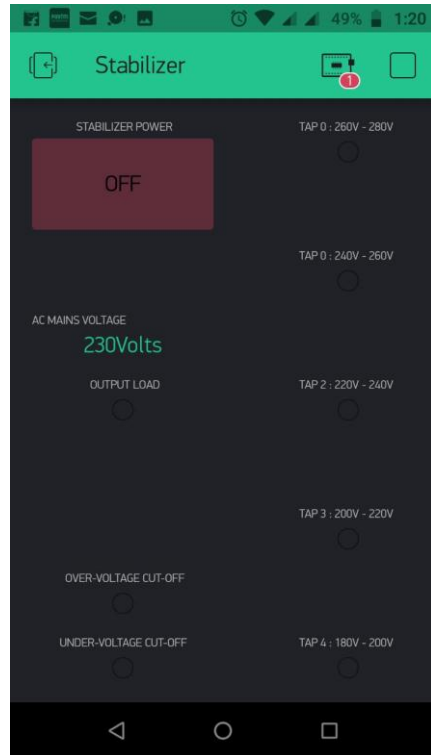
Fig. ESP8266



The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability, produced by Espressif Systems in Shanghai, China.



- HIGH DURABILITY: ESP8266 is capable of functioning consistently in industrial environments, due to its wide operating temperature range.
- COMPACTNESS: ESP8266EX is integrated with a 32-bit Tensilica processor, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules.
- 32 bit tensilica processor: The ESP8266EX microcontroller integrates a Tensilica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160 MHz.



### 8. LM78L05 Regulator Features:

- 5V Positive Voltage Regulator
- Output Current upto 100mA
- Maximum Input Voltage is 30V
- Operating current(IQ) is 5mA
- Internal Thermal Overload and Short circuit current limiting protection is available.
- Available in TO-92,SO-8 and SOT-89 package

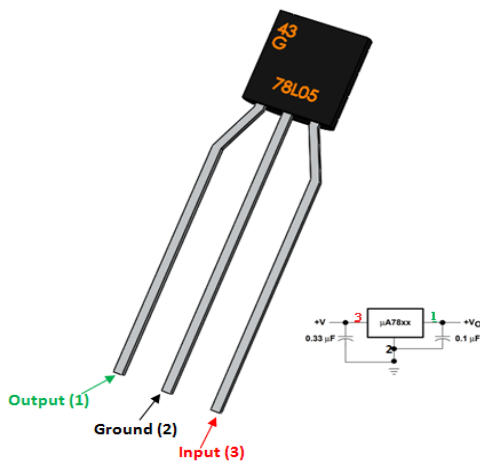


Fig.LM78L05 voltage regulator

### Experiment Result

input	transistor ON	output
175V	None	0V
OFF	D5	227V
185V	D5	235V
OFF	D3	226V
205V	D3	235V
OFF	D2	224V
225V	D2	237V
OFF	D1	225V
245V	D1	237V
OFF	D0	228V
265V	D0	237V
OFF	None	0V
275V	None	0V
OFF	None	0V
285V	None	0V
OFF	None	0V

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 From vivo Notes

## 9. Conclusion

From above discussion it has cleared that of under voltage and overvoltage problem are very common and can create problem for consumer good and industrial application. So system should be protected by certain protection scheme. So here system modeled using relay to disconnect or regulate supply as per the requirement of rating of load motor when any overvoltage and under voltage problem occurs.

## 10. REFERENCES

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