DC – DC Voltage Booster Using Op Amp

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Abstract- *Voltage boosters are designed using large inductors and capacitors (Buck – Boost converter). In place of large inductors using dual op amp 741, a booster circuit is designed. It consists of regulator circuit, dual op amp circuit, relay, controller, and LM35 sensor. Temperature sensor is used to detect the temperature of op amp 741. In abnormal conditions controller operate the relay to supply the load using only the rectifier circuit. It also provides variable voltage by adjusting the 10 K Ω potentiometer connected as feedback on op amp. It also acts as a voltage regulator. The dual op amp circuit is based on the voltage between two nodes. So, that each op amp operates in different operating modes.*

Keywords- Controller – LM35 – Relay – Op amp 741 – Regulator circuit.

I. INTRODUCTION

A Voltage boost converter is sometimes called as step-up converter because the booster circuit steps up the input source voltage.It consists of at least two semiconductors and one energy storage element like capacitor, inductor, or used both together. To reduce the voltage ripple filters circuit is used. Filter circuit generally consists of capacitors are normally added to such a converter's output and input. The booster converter generates an output voltage greater than the input voltage.

Since power must be conserved, the output current is lower than the source current. A DC – DC boost converter is designed using dual op amp 741 in addition to that a temperature sensor is added to monitor the op amp temperature.

The sensor output is fed to an Arduino UNO to operate the relay based on input. Depending upon sensor input Arduino UNO connect the load either to booster circuit or to the voltage regulator circuit. A potentiometer is connected to obtain variable voltage. Chapter 2 explains the conventional booster circuit. Chapter 3 explains its disadvantages through simulation results. Chapter 4 explains the proposed system methodology with a circuit diagram. Chapter 5 describes the description of components used in booster circuit. Chapter 6 represent the comparative results. Chapter 7 shows the simulation results. Chapter 8 shows the real time hardware results.

II. EXISTING SYSTEMS

Conventional Boost converter

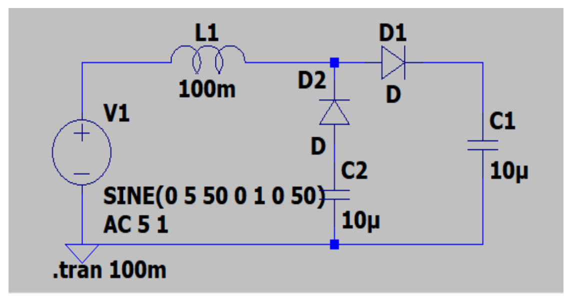

Fig. 1 Conventional boost converter

A Buck - Boost converter transforms a positive DC voltage at the input to a negative DC voltage at the output. A boost converter circuit designed using inductors and capacitors is shown in Fig.1. The circuit operation depends on the conduction state of the MOSFET: On-state: The current through the inductor increases and the diode is in blocking state.Off-state: Since the current through the inductor cannot abruptly change the diode must carry the current so it commutates and begins conducting. If 5V is given as input maximum of 6.7-7V is obtained from this booster circuit.

III. SIMULATION RESULTS AND ANALYSIS

The conventional boost converter is designed and simulated using LT Spice, an open source software design tool.Fig.2 shows the time response of the boost converter. The following observations are made from the results

a) Slower response

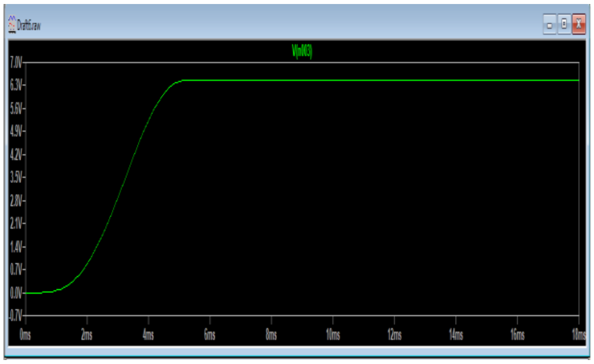
Fig. 2 Time response of conventional boost converter

b)Distortion in the output voltage
c)The output voltage is very sensitive to the changes in DC (duty cycle).
d)Large inductor and capacitor is required to provide ripple free output.

IV. PROPOSED SYSTEM

Booster circuit using op amp

A novel DC- DC voltage booster converter is designed using op – amp IC 741 and the proposed circuit diagram is shown in Fig.3.

a) Circuit diagram

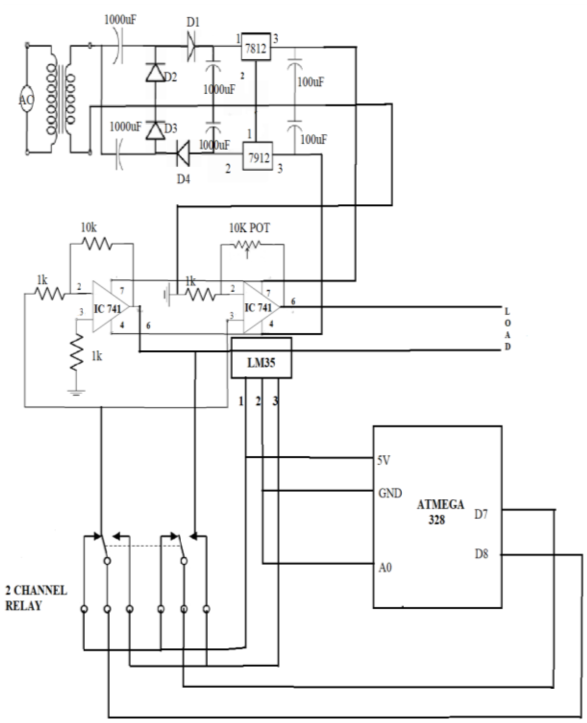

Fig.3 Voltage booster using op amp 741

The voltage regulator consists of a rectifier circuit. The Rectifier circuit present in regulator circuit is used to convert the input AC supply to a DC supply. The voltage regulator circuit is used to supply the +Vcc and –Vcc for op amp. The op amp circuit consists of two op amp 741, three 1k Ω resistor, 10k Ω resistor and 10k Ω pot resistor. The op amp circuit is the booster circuit which takes 5V as input and gives a maximum of 20V as output. LM35 sensor is used to detect the temperature of the op amp 741. The Arduino UNO takes the sensor output as input and operate the relay accordingly. It connects the load with booster circuit under normal conditions and connects the regulator circuit alone under abnormal conditions. It also able to obtain the desired voltage by adjusting the 10k Ω potentiometer.

The output of booster circuit is theoretically derived as Output voltage = $(Vin/2)*((R2/R1)+(1+(R4/R3)))$.

The maximum voltage achieved is calculated as follows
Maximum output voltage = $2*Vcc*0.9$.

V. DESCRIPTION

a) Potential Transformer

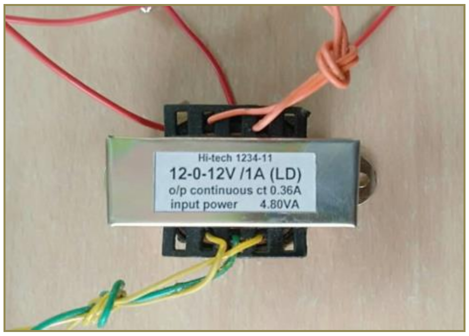

Fig. 4.1 12 – 0 – 12 Potential transformer

Voltage transformers, also called potential transformers, are a parallel connected type of instrument transformer. A normal 12 – 0 – 12 transformer is shown in Fig 4.1.It is having an accurate voltage ratio. Phase relationship that enable the accurate secondary connected metering. This voltage transformer is used as primary supply to the voltage regulator circuit.

Range = 12-0-12 V.

b) Voltage regulator circuit

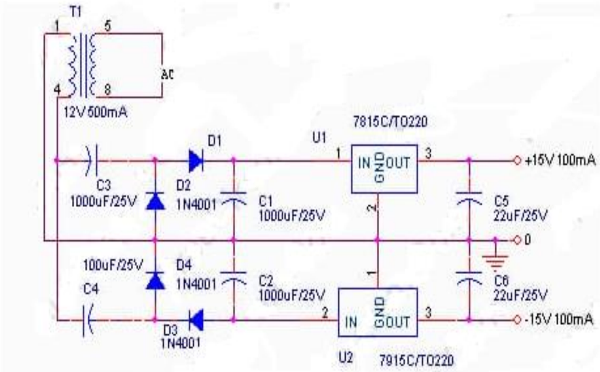

Fig. 4.2 Voltage regulator circuit

Regulator circuitis used to convert the AC supply into DC supply. The voltage regulator circuit is to make that perfect(regulate) DC. The designed circuit is to convert the 230V AC to +12V, 0V, -12V. A voltage regulator circuit consist of rectifier circuit, IC 7812 and IC 7912 is shown in Fig 4.2. This is used to power the IC. In other terms it is used as +Vcc and –Vcc for both the op – amp.

c) Relay

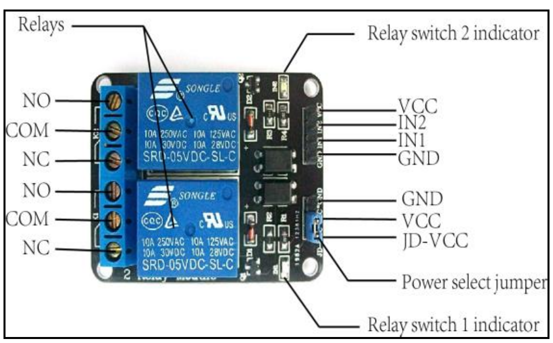

Fig. 4.32-Channel5VRelay Module.

Relay has two modes NO and NC(Normally closed and Normally open). It takes 5V as input. It is interface with Arduino UNO. Relay connect the load with booster circuit under normal conditions. The load is connected with regulator circuit alone under abnormal conditions. An Arduino UNO is used to operate the relay between these modes.

d) LM35 temperature sensor

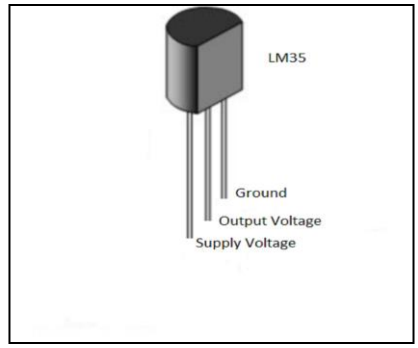

Fig. 4.4 LM35 temperature sensor

LM35 temperature sensor is used to detect the temperature of op amp 741used in booster circuit continuously until it is turned off. The output of LM35 is given to an Arduino UNO. Based on the input from LM35 Arduino operate the relay accordingly.A LM35 temperature sensor is shown in Fig. 4.4.

e) Arduino UNO

Fig. 4.5Arduino UNO ATMEGA 328

Arduino UNO is a board that has 14 digital pins and 6 analog pins. It also has PWM pins. It is Programmed using Arduino UNO IDE. Flash Memory: 32 KB of which 0.5 KB used by bootloader, SRAM - 2 KB, EEPROM - 1 KB, Clock Speed - 16 MHz and Arduino UNO acts as an input supply for relay and op amp. Mainly it is used to operate the relay based on the input from temperature sensor.An Arduino UNO ATMEGA 328 is shown in Fig. 4.5.

f) Potentiometer

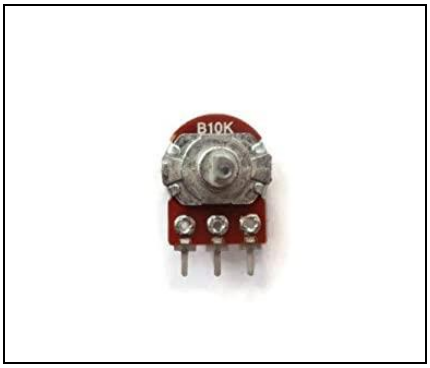

Fig.4.6 10kΩ pot resistor

Pot resistor is nothing but a resistor with one variable end. The 10k Ωpotentiometer has three terminals. It is connected across op amp as a feedback resistor. Either it is able to obtain both 10Ω and variable resistance by adjusting the nob. A 10kΩ potentiometer with three terminals is shown in Fig. 4.6. Using this potentiometer desired voltage is obtained.

g) Op amp circuit:

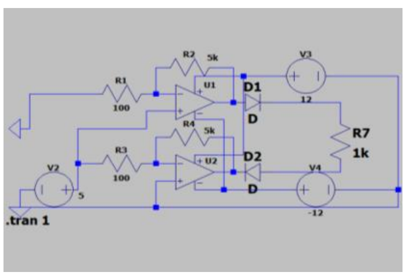

Fig. 4.7 Booster circuit using op amp

The operational amplifier is used to boost the voltage depending upon the gain and polarity that is required.The Op amp booster circuit designed in LT spice is shown in Fig. 4.7. The maximum voltage that can be achieved is directly proportional to the Vcc supply. By dual op amp setup, the voltage can be doubled than the single output voltage of the normal op amp circuit. One of the op amp is connected in inverting mode and another in non-inverting mode. When both are connected across the load the voltage get summed up and gives double times the voltage. The variable voltage can be achieved by controlling the feedback resistor through pot resistor. Each op amp operates in different mode because voltage between two nodes is given with voltage at one end subtracted from other end. So, only the op amp operates in different mode.

VI. COMPARATIVE ANALYSIS

CIRCUIT NAME	VOLTAGE (V)	TIME TAKEN TO REACH MAXIMUM (ms)
Normal	5	-
SingleOp amp	11.6	0
Boost converter	6.7	5
Dual Op amp	21.6	0

Fig. 5 Comparative table

This is the comparative analysis among boost converter, single op amp and dual op amp circuits. This clearly shows that boost converter takes 5 ms as time response. Where dual op amp booster takes time less than 0 ms. The dual op amp booster gives a maximum voltage 20v with just 5v as input. Time response tabulation is shown in Fig. 5.

VII. SIMULATION RESULTS

Fig. 6 Simulation results

The dual op amp circuit is simulated using LT spice software. It takes 5v as input and boost it up to maximum of 21v. The simulation result is shown in Fig. 6.

VIII. PRACTICAL RESULTS

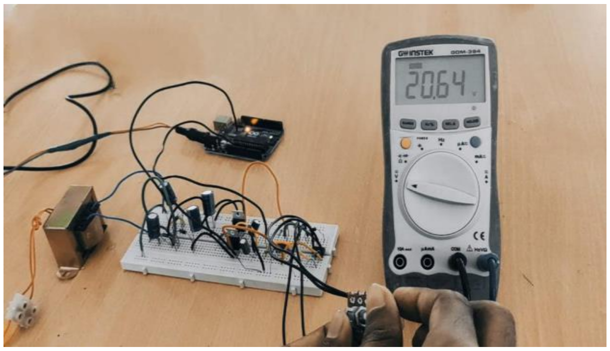

Fig.7.1 Maximum output voltage

The booster circuit as shown in Fig.7 which takes 5v as input Gives 20v as output. Where the output of the booster circuit is shown in multimeter.

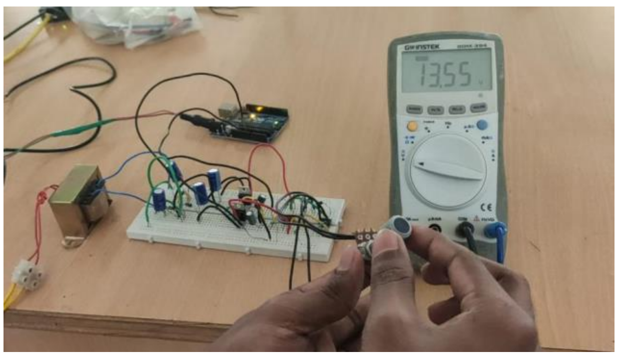

Fig.7.2 Variable voltage

Here the variable voltage is obtained by adjusting the 10k Ω pot resistor as shown in Fig.7.2.

IX. CONCLUSION

In place of buck boost converters, we can use this op-amp booster so that we can cut-off half the cost.Faster response makes sure that always readily available for use. Desired voltage is obtained by varying potentiometer across op amp. In case booster circuit falls under abnormal conditions using temperature sensor it is detected and automatically cut – off booster circuit and connect regulator circuit through relay. So that the devices prevented from high voltage. It also acts as a voltage regulator. It is a low cost option comparable to other boost converters.The booster circuit through op amp is having a speed response. So, the booster can be used in battery operated circuit, where there is need to boost the voltage and needed variable voltage. This circuit can be used in place of boost converter, where there is need of variable voltage. This circuit can be used in solar charger

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