SWITCH MODE VARIABLE DC POWER SUPPLY WITH OUTPUT VOLTAGE REGULATION

By L.W.C. Gunarathne , U. A. R. Fernando, B. N. R. Fernando, A. C. Divitotawela

Supervised by Dr. J. P. Karunaradasa

1. Introduction:

One of the important devices in any Electrical / Electronic lab would be a Variable DC Power Supply. Most of the power supplies are implemented using transformers and for high ratings the power supply would be bulky. Further regulation of output voltage is restricted to small range.

These disadvantages can be overcome using the switch mode operation. Switch mode power supplies are much lighter than that of transformer power supplies which has the same rating. Further output power regulation is spread along a wide range. It is possible to keep the output voltage at constant value given that the input supply voltage is higher than the required output voltage.

2. Product Specifications:

Output Voltage :	0~100V DC
Input Voltage :	220V AC 50Hz
Max. Output Current:	5A max.
Output Voltage Resolution:	27mV per Degree
Voltage Display:	0~100V DC
Current Display:	0~6A DC
Height:	100 mm
Width:	120 mm
Length::	150 mm
Weight:	1500 g approx.

3. Switch Mode Operation:

If a DC voltage is switched at a given intervals, a voltage below or above can be obtained depending on the converter topology.

Variable voltage power supply is based on the step down process which uses the buck converter topology. Switching is carried out at high frequency in order to obtain the smooth DC output.

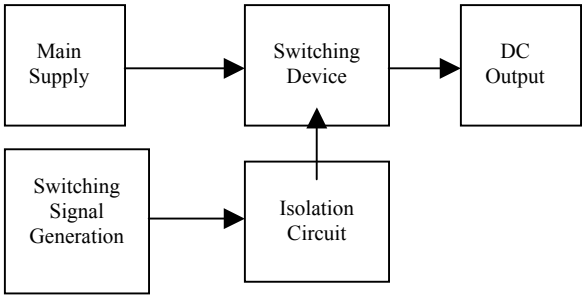

Fig 1. Block Diagram of Device

4. Control Circuit:

4.1 Operation:

This produces the switching signals with required duty factor. Voltage regulation is achieved via one of the two error amplifiers. Control circuit changes its duty cycle if it receives any error in inverting & non inverting inputs.

Output feedback is obtained via a potential divider which gives the maximum of 5V feedback for respective maximum output voltage of 200V. This feedback is fed into the non-inverting input and inverting input is adjusted using a variable resistor which determines the required output voltage.

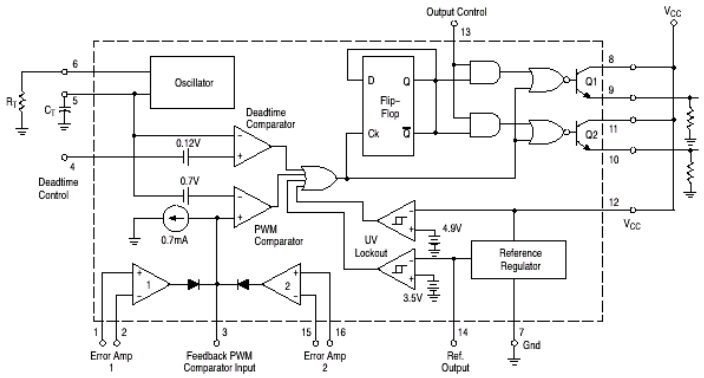

Fig 2. Control IC Internal Arrangement

4.2 Voltage Regulation:

Power supply is capable of supplying constant output voltage, for varying input voltage provided output voltage is lesser than the input supply voltage.

With the change of voltage, voltage error amplifier inputs sense a error and the duty cycle is changed accordingly in order to maintain the set output voltage.

When the output load vary, voltage error amp sense a error in its input and duty factor will be changed by the control circuit in order to maintain the constant output voltage.

5. Power Circuit Implementation:

Selecting the devices in power section mostly depend on the frequency at which circuit is intended to operate. Switching frequency is restricted by capacity of switching generation circuit as well as other devices such as opto-isolator, IGBT and Transistors. Operating at high frequency is desirable to reduce the inductor and capacitor size. It is the strike a balance between these gives the final frequency which circuit operates.

Main factor in selecting the frequency in this circuit was the inductor. Since all the other components are capable of operating at high frequency it was decided to select 24.5 KHz as the operating frequency.

Simple bridge diode is used in the initial step of the converter. Two electrolytic capacitors are used in input stage in order to obtain the smooth DC input. It was required to use four 330µf 400V in parallel in order to smooth the DC output. Four capacitors were used due to unavailability of the high voltage, high valued capacitors. Still it was not possible to reduce the ripple below 20%. This is not considered deeply since the circuit operates at fairly high frequency.

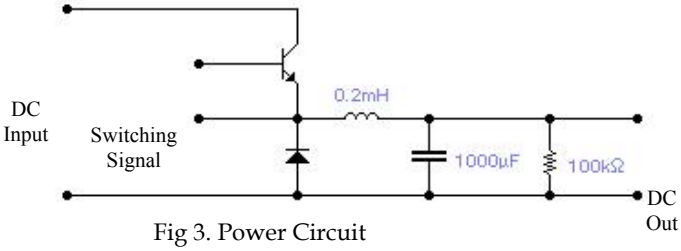

Fig 3. Power Circuit

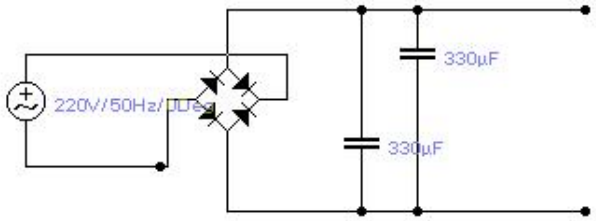

Fig 4. Bridge Circuit

A resistor is connected in parallel to the output of the power supply to make sure that circuit is not operate in discontinues mode. Resistor of 100KΩ is used so that current consumes is very small.

6. Isolation of Power Circuit:

In order to drive the IGBT, it should be given the signals to gate with reference to collector. Further feedback need to be derived from the output and it also provided to switching circuit. These connections make the input virtually short circuit when the IGBT is ON state. This was the main factor which a isolation made necessary.

A high frequency opto-isolator would be an ideal solution to the problem. Opto-isolator lonely was unable to provide the solution to the problem due capacitance exist between the gate & collector. This stray capacitance distorts the switching square waveform.

This results in reducing the maximum output obtainable from the power supply. A high frequency transistor is used after the opto-isolator in driving the IGBT. Output of the transistor is connected to the IGBT via a resistor.

In isolating the circuits a step down transformer with two windings is used to power the switching circuit and the opto-isolator. Opto-isolator operates between 0~10mA and 1k & 1.5k resistors are connected to obtain the required current level. Resistors 580Ω & 470Ω are used to bias the transistor.

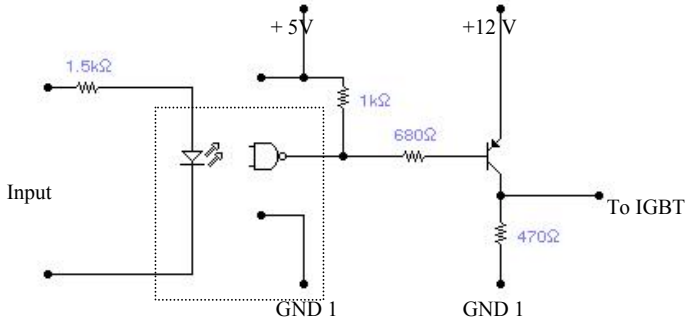

Fig 5. Isolation Circuit

7. Conclusion:

Almost every laboratory DC power supplies use power transformers to step down the voltage which are very heavy and bulkier. By using transformer it is very difficult to have good output regulation at variable input voltage and at large output currents.

By using switch-mode principle we could overcome these two major drawbacks.

We could have an outstanding output regulation from zero to full load current. We could also have same regulation from nominal input voltage to a very low value which is slightly higher than required output voltage. (I.e. at 12V output voltage we can achieve output regulation from about 20V to 250V of input voltage.)

Inherent disadvantage of the power switching circuits are that, it introduces reactive power to the supply system which reduce the quality of the power system. This is the main disadvantage when compared to the transformer power supplies.

One main shortcoming of this device is that, no isolation transformer is used to isolate the output. This would result in possible electric shock when the system is not properly earthed.

Efficiency of the switch-mode power supply is little less than that of the transformer power supply due to high heat dissipation. These errors are inheriting to the systems which cannot be removed with improving design.

References::

- RS International Product Catalogue
- www.onsemi.com
- www.national.com