SWITCHING REGULATOR EXAMPLE

An example of general purpose regulator is Motorola's MC1723. It can be used in many different ways, for example, as a fixed positive or negative output voltage regulator, variable regulator or switching regulator because of its flexibility.

To minimize the power dissipation during switching, the external transistor used must be a switching power transistor.

To improve the efficiency of a regulator, the series pass transistor is used as a switch rather than as a variable resistor as in the linear mode.

- A regulator constructed to operate in this manner is called a series switching regulator. In such regulators the series pass transistor is switched between cut off & saturation at a high frequency which produces a pulse width modulated (PWM) square wave output.
- This output is filtered through a low pass LC filter to produce an average dc output voltage.
- Thus the output voltage is proportional to the pulse width and frequency.
- The efficiency of a series switching regulator is independent of the input & output differential & can approach 95%

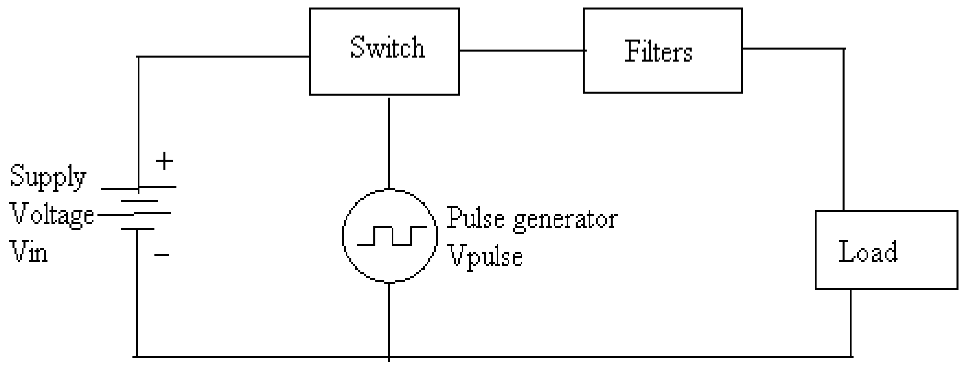

Fig : Basic Switching regulator

A basic switching regulator consists of 4 major components,

1. Voltage source Vin
2. Switch S1
3. Pulse generator Vpulse
4. Filter F1

1. Voltage Source Vin:

It may be any dc supply – a battery or an unregulated or a regulated voltage. The voltage source must satisfy the following requirements.

- It must supply the required output power & the losses associated with the switching regulator.
- It must be large enough to supply sufficient dynamic range for line & load regulations.
- It must be sufficiently high to meet the minimum requirement of the regulator system to be designed.

- It may be required to store energy for a specified amount of time during power failures.

2. Switch S1:

It is typically a transistor or thyristor connected as a power switch & is operated in the saturated mode. The pulse generator output alternately turns the switch ON & OFF

3. Pulse generator Vpulse:

It provides an asymmetrical square wave varying in either frequency or pulse width called frequency modulation or pulse width modulation respectively. The most effective frequency range for the pulse generator for optimum efficiency 20 KHz. This frequency is inaudible to the human ear & also well within the switching speeds of most inexpensive transistors & diodes.

- The duty cucly of the pulse wave form determines the relationship between the input & output voltages. The duty cycle is the ratio of the on time ton, to the period T of the pulse waveform.

$$\text{Duty cycle} = \frac{ton}{ton + toff}$$

$$= \frac{ton}{T} = \text{ton f.}$$

Where ton = On-time of the pulse waveform

toff=off-time of the pulse wave form

T = time period = ton + toff

= 1/frequency or

$T = 1/f$

- Typical operating frequencies of switching regulator range from 10 to 50khz.
- Lower operating frequency improve efficiency & reduce electrical noise, but require large filter components (inductors & capacitors).

4. Filter F1:

It converts the pulse waveform from the output of the switch into a dc voltage. Since this switching mechanism allows a conversion similar to transformers, the switching regulator is often referred to as a dc transformer.

The output voltage Vo of the switching regulator is a function of duty cycle & the input voltage Vin.

Vo is expressed as follows,

$$Vo = \frac{ton}{T}\ Vin$$

- This equation indicates that, if time period T is constant, Vo is directly proportional to the ON-time, ton for a given value of Vin. This method of changing the output voltage by varying ton is referred to as a pulse width modulation.
- Similarly, if ton is held constant, the output voltage Vo is inversely proportional to the period T or directly proportional to the frequency of the pulse waveform. This method of varying the output voltage is referred to as frequency modulation (FM).
- Switching regulator can operate in any of 3 modes

i) Step – Down
ii) Step – Up
iii) Polarity inverting