DESIGNING OF SMPS USING FLY BACK TOPOLOGY WITH SHORT CIRCUIT PROTECTION AT THE OUTPUT

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ABSTRACT

SMPS are indispensable in industries to ensure flexible operation and reliability offers in the circuit. Most of the electronic circuits operate on low DC voltages converting AC input voltages available to the desired DC output levels. This paper describes the design of a SMPS using Fly Back topology as it is most popular amongst isolated topologies for low power application. One advantage of the fly back topology over other isolated topologies is no separate storage inductor is required in the design as is the case with other topologies in this category. This, coupled with the fact that the rest of the circuitry is simple, makes the fly back topology a cost effective and popular topology.

Some important problems associated with SMPS are over voltage & short circuiting at the output terminal that can damage the SMPS circuit. This Paper aims the design of SMPS with Short circuit protection at the output terminal.

Keywords: SMPS, Fly Back Topology, IC TPS92210 And Short Circuit Protection Circuit.

I. INTRODUCTION

A switched-mode power supply (SMPS) is an electronic power supply that incorporates a switching regulator to convert electrical input power efficiently. Like other power supplies, an SMP transfers power from the source or A switched-mode power supply (SMPS) is an electronic power supply that incorporates a switching regulator to convert electrical input power efficiently. Like other power supplies, an SMP transfers power from the source or mains to a load, e.g. personal computer. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes dissipation of energy. Ideally, a SMPS dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. The high power conversion efficiency is an important advantage of a switched-mode power supply. Modern SMPS are substantially mini-size and lighter than the conventional linear supply due to the smaller transformer size and weight.

Switching regulators are fast replacing linear regulators due to higher efficiency, compact size and lighter weight. The circuitry of SMPs is, however, more complicated; their switching currents can cause electrical noise problems requiring noise suppression circuits and may even have a low power factor.

II. THEORY OF OPERATION

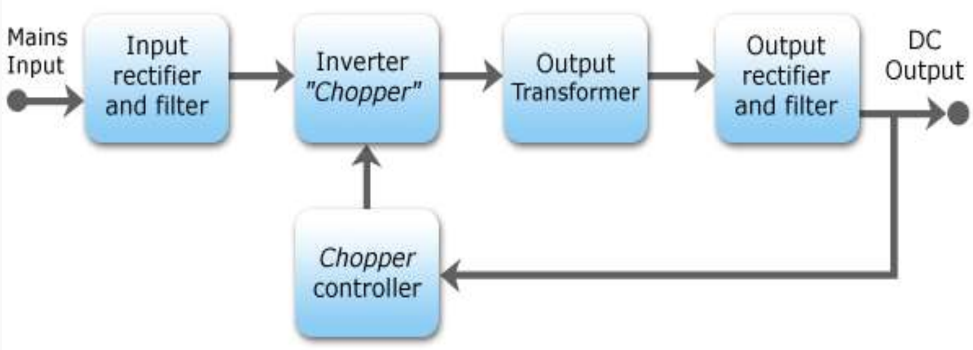

Fig-1 Block Diagram of a Mains Operated AC/DC SMPS With Output Voltage Regulation.

III. INPUT RECTIFICATION WAVEFORMS

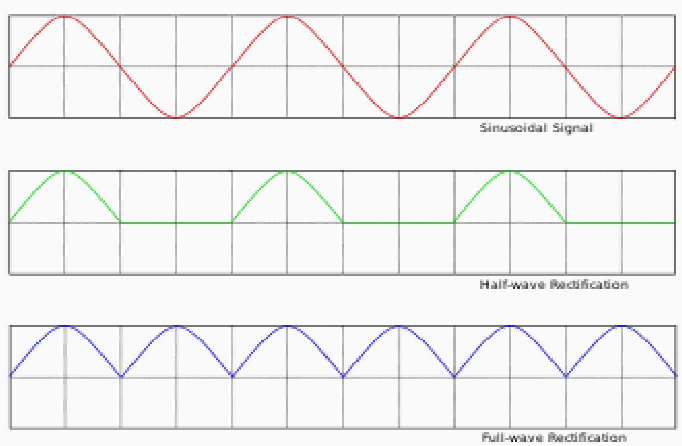

Fig-2 AC, Half-Wave and Full-Wave Rectified Waveforms

IV. WORKING PRINCIPLE OF SMPS

4.1 Input Rectifier stage

If the SMPS has an (AC input), then the first stage is to convert the input to DC through the rectification process. A SMPS with DC input does not require this stage. In some power supplies (mostly computer ATX power supplies), the rectifier circuit can be configured as a voltage doublers by the addition of a switch operated either manually or automatically. This feature permits operation from power sources that are normally at 115 V or at 230 V. The rectifier produces an unregulated DC voltage which is passed on to a large filter capacitor. The current drawn from the mains supply by the rectifier circuit occurs in short pulses around the AC voltage peaks.

4.2 Inverter Stage

The inverter stage in Fig 1 converts DC, either directly from the dc input or from the rectifier stage mentioned above into AC by running it through a power oscillator, whose output transformer is of miniature size with very few turns operated at high frequency in the range of kilohertz. The frequency chosen is usually 20 kHz, to make it inaudible. The switching is implemented in the multistages (to accomplish high gain) MOSFET amplifier. MOSFETs are used to offer low on-resistance and a high current-handling capacity to the design.

4.3 Voltage Convertor & Output Rectifier

If the output is required to be isolated from the input, as is usually the case in mains power supplies, the inverted AC is used to drive the primary winding of a high-frequency transformer. This converts the voltage up or down to the required output level in the secondary winding. The output transformer shown in the block diagram accomplishes this task.

To obtain DC at the output terminals, the AC output obtained at the transformer secondary is rectified. The rectified output is smoothed by a filter consisting of inductors and capacitors. For higher switching frequencies, components with lower capacitance and inductance are provided in the circuit.

4.4 Regulation

A feedback circuit monitors the output voltage and compares it with a reference, as shown in the block diagram serves. Depending on design/safety requirements, the controller may contain isolation mechanism (such as opto-coupler) to isolate it from the DC output. Switching supplies in computers, TVs and VCRs have opto-couplers to tightly control the output voltage.

V. FLY BACK CONVERTOR

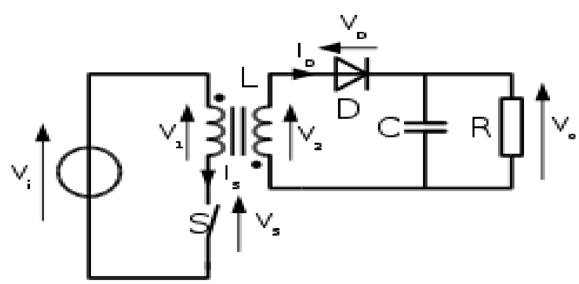

Fig-3. Fly Back Convertor.

The Fly back convertor belongs to the primary switched convertor family, which means there is isolation between in and output. Fly back convertors are used in nearly all mains supplied electronic equipment to ensure low power consumption.

STRUCTURE AND PRINCIPLE

The two states of a fly back converter exist: In the on-state, the energy is transferred from the input voltage source to the transformer (the output capacitor supplies energy to the output load). In the off-state, the energy is transferred from the transformer to the output load (and the output capacitor).

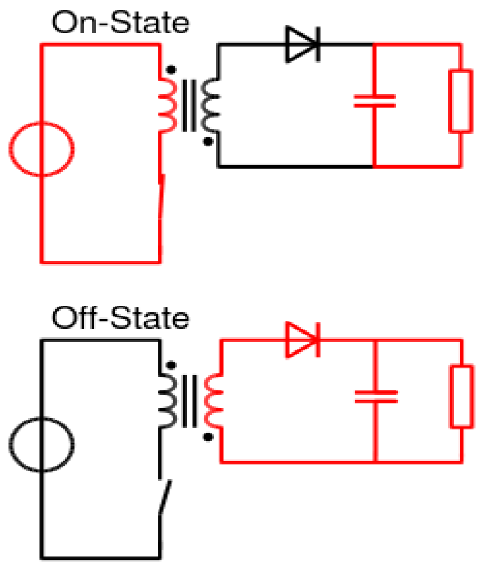

Fig-4(a) and (b): Operation of a Fly back Convertor

When the switch is closed (Fig. 4a), the primary of the transformer is directly connected to the input voltage source. The primary current and magnetic flux in the transformer increase, storing energy in the transformer. The voltage induced in the secondary winding is negative, so that the diode is reverse-biased (non conducting state). The output capacitor supplies energy to the output load.

When the switch is opened (bottom of Fig. 4b), the primary current and magnetic flux drops. The secondary voltage is positive, forward-biasing the diode, allowing current to flow from the transformer. The energy from the transformer core recharges the capacitor and supplies the load.

The operation of storing energy in the transformer before transferring to the output of the converter allows the topology to easily generate multiple outputs with little additional circuitry, although the output voltages must match each other through the turns ratio. Also there is a need for a controlling rail which has to be loaded before load is applied to the uncontrolled rails, this is to allow the PWM to open up and supply enough energy to the transformer.

VI. WAVE FORM OF FLY BACK CONVERTOR

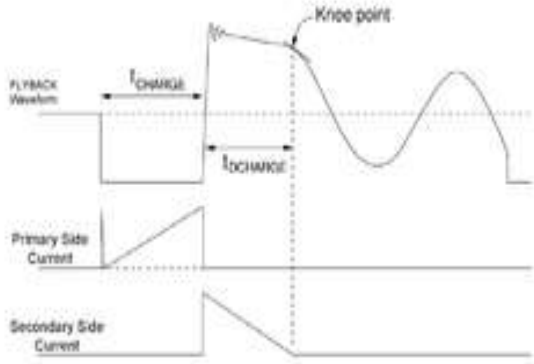

Fig. 5: Waveform - Using Primary Side Sensing Techniques - Showing the 'Knee Point'.

Advantages of Fly Back Convertor

1- Fly back convertors have a remarkably low number of components compared to other SMPS configurations; they also have the advantage of regulating several isolated output voltages can by a single control circuit.

2- In fly back convertor power is reused so that its efficiency is high.

3- Another advantage of fly back topology over the other isolated topologies is that many of the AC supply voltages can be obtained from separate storage inductor

VII. TYPICAL SPECIFICATIONS OF IC- TPS92210

- Flexible operation Modes.
- Cascaded MosFET configuration.
- Discontinuous Conduction Mode.
- Advanced overvoltage Protection.
- Output overvoltage Protection.
- Internal Over- Temperature Protection.
- Line Surge Protection.
- 8-pin SOIC Package

PIN CONFIGURATION OF TPS92210

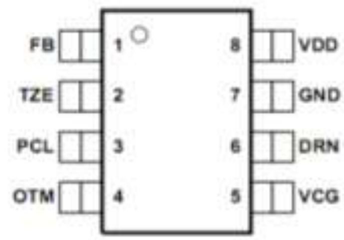

Fig-6:Pin Diagram TPS92210

VIII. SHORT CIRCUIT AND ITS CAUSES

A short circuit occurs when an electric current flows along a path is different from the intended one in the electric circuit. When this happens, there is an excessive electric current that may lead to circuit damage, fire, or explosion. In fact, short circuits are generally the major cause of electrical fires throughout the world.

Short circuits occur when the insulation of the wiring used breaks down. Can also occur due to the presence of an external conducting material (such as water) introduced accidently into the circuit. Electrical batteries can explode if they are subjected to a large current.

IX. SHORT CIRCUIT PROTECTION REMEDIES

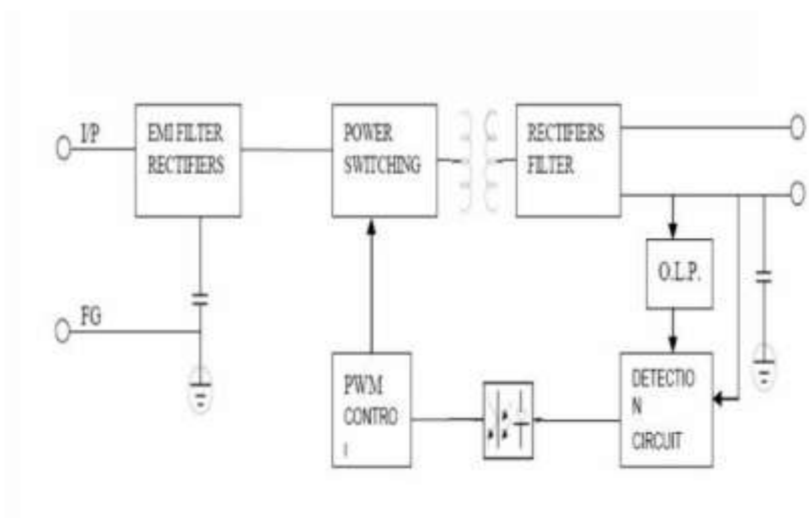

Fig-7 Block Diagram

At the time of short circuiting, ideally our controlling IC should be switched off but in practical cases the controlling IC is working and in this case total output power is converted in to current form. Short circuiting is happens due to overheating of load, Moisture & due to manual mistakes. During Short Circuiting our Switches, fuses, Diodes & sometimes our controlling IC become busted and our complete system becomes fail.

REMEDY-1:-

At the time of short circuiting a control IC is required. For this purpose we need to convert secondary auxiliary winding in to forward winding. When we convert secondary auxillary winding in to forward winding, there is some voltage present to operate the controlling IC. It will not allow flowing excess current in the output rectifier. In this way our system becomes safe.

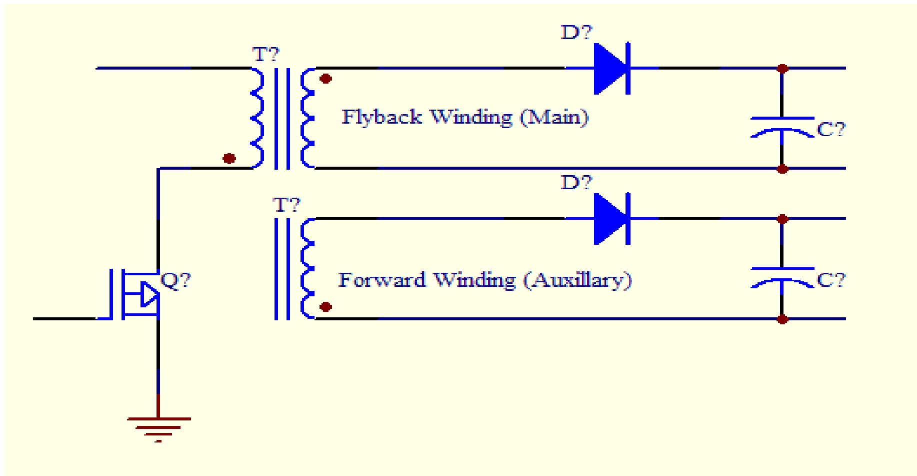

Fig-8: **Secondary Auxillary Winding Converted In To Forward Winding**

A major drawback of this method is that the efficiency of SMPS decreases. So this method is avoided in the design of SMPS as energy efficiency is one of the important considerations in the design.

REMEDY-2:-

In this Method we put a voltage divider and a MoSFET on the secondary side after the diode.

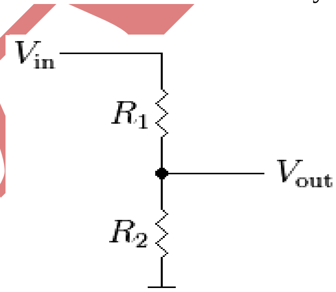

Fig-9 Voltage Divider

In normal running case (i.e without Short circuiting), MoSFET is in ON state and the circuit loop is completed..During short circuit , MoSFET will act as short circuit Protector . when short circuit occurs the voltage at point A becomes zero with respect to transformer and MOSFET is off and flow of current is blocked. This renders the SMPS safe for operational purpose.When MoSFET is off the system behaves like open circuit and a potential develops at point A and Mosfet starts to ON-OFF and no excess current will flow in the circuit.

This method can be used for heavy wattage SMPS but this leads to cost increase. Another disadvantage of this method is that we need to put some external resistance to protect the MOSFET which increase the complexity of system. so we avoid this metthod for practical uses.

Due to some drawbacks of above two methods we required an additional techinque to overcome these problems.

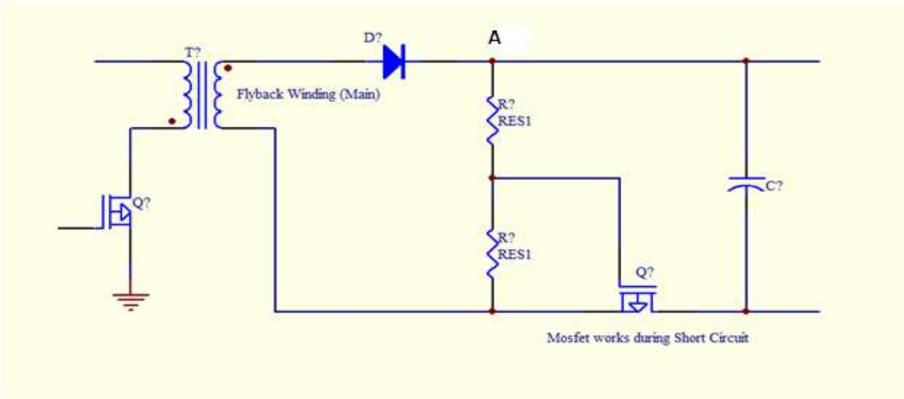

Fig-10 : MOSFET Configuration

REMEDY-3:-

Some how we need to detect the change during short circuit at primary side & try to switch off the switching IC i.e TPS92210.There is one observation is made during short circuit that primary auxillary Voltage (V_{CC}) falls up to 50%. So we were looking to work on this point.If we go through the IC(TPS92210) specification then we found that Pin no 4 i.e MOT pin is responsible for switching and if we pull down that particular pin the IC become automatically off & our SMPS becomes safe.Firstly we put a single NPN transistor for pull down MOT pin but it will not allow to switch on the IC & our system is not working in any case. Then we design a complete circuit for this purpose.

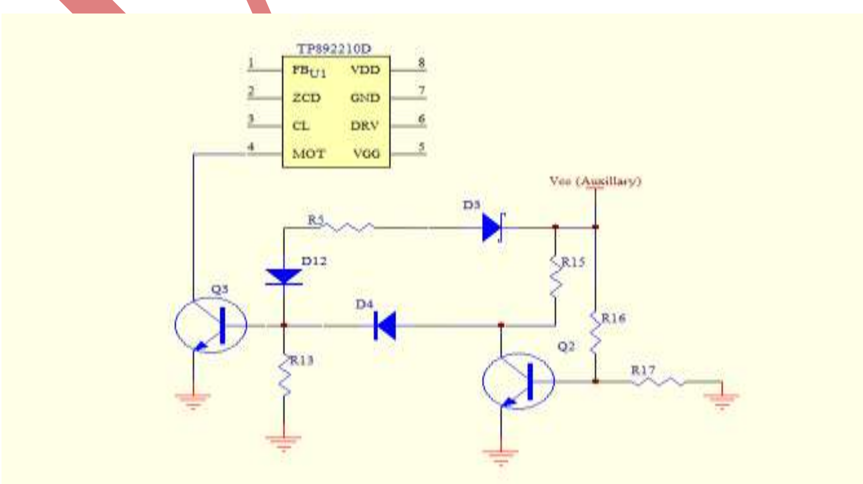

Fig-11 Short Circuit Protection

We make an arrangement of two Transistor which is shown in fig-11. Transistor Q_2 is used to switched off the transistor Q_3. In normal condition transistor Q_2 remains always ON & transistor Q_3 is off. During short circuit, transistor Q_2 becomes switched off due to voltage falls on V_{CC} and transistor Q_3 switched ON. When Q_3 is ON it will pull down the MOT pin & IC becomes switched off and our system is protected during short circuiting. We put some additional component in this given arrangement i.e Zener Diode D_3 & Diode D_{12} to protect our system from high voltage. Rating of zener diode is kept high in case of over voltage. Diode D_3 is conduction at the time of high voltage & it allow to switch ON the transistor Q_3 & it will switch off the switching IC and our SMPS is also protect from over voltages.

X. CONCLUSION

The design of the SMPS using fly back topology with short circuit protection has been validated by test result on LED drivers. The experimental results have revealed the improved performance of the proposed additional circuit at the output terminal. The over voltages protection feature has also been studied and implemented in this SMPS. The experiment results show that the input AC voltage is 220V, and the output terminal has been shorted for some time and after eliminating the short circuit the SMPS remains stable, which proves the method is correct and feasible.

XI. REFRERENCES

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