# FLYBACK CONVERTER BASED CAPACITOR CHARGER WITH ASSURED DISCONTINUOUS CONDUCTION

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*Abstract*

A simple and reliable control scheme for a capacitor charging power supply using a fly-back converter has been presented. To charge a capacitor by a constant average current, time period of the flyback switches has to be varied in a non linear fashion. Developed charging scheme implements a piecewise linearised model of a non linear characteristic to vary the time period of flyback switches such that zero current in secondary of flyback transformer is guaranteed at the time of turn on of flyback switches. Earlier it has been achieved by sensing the secondary current [1]. For this to happen, this scheme implements a calculated characteristic as a function of charging capacitor voltage, using few op-amps. The scheme does not require secondary current-sensing to ensure zero current switch-on of flyback switches. Moreover, this scheme uses the charging time very effectively and thus has kept the switch peak currents to a minimum for available charging time. The turn-on and turn-off of the switches have been controlled by using low cost, simple and general purpose IC's like op-amps, timers, comparators etc.. The scheme has been used to charge a capacitor of 3mF up to 300V at 1Hz repetition rate from initially uncharged state.

## INTRODUCTION

In pulse power circuits, energy storage capacitor should be charged to its desired voltage before the next switching occurs. It is discharged within a small time, delivering large pulse power. Energy storage capacitor is charged with unidirectional current over a long period in milliseconds and discharged in a comparatively shorter period of time. A large numbers of capacitor charging schemes are available for this type of applications. The CCPS is specially designed for charging capacitor, which is a dynamic load [2]. It is different in many aspects from a conventional dc power supply. The charge-discharge cycle of a CCPS and different modes of operation are shown in figure-1.

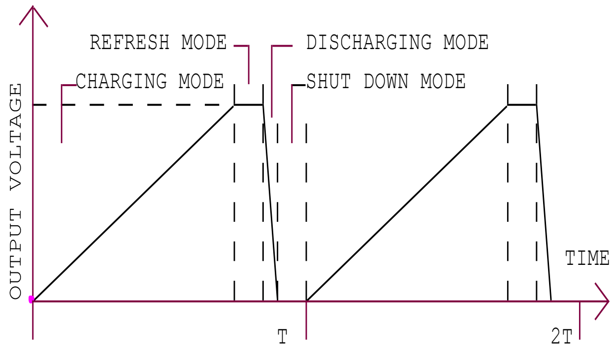


Fig 1: Charge discharge cycles of a capacitor charging PS

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In charging mode initially the capacitor is discharged so CCPS practically feeds to a short circuit. As capacitor voltage reaches to desired voltage and waits for a trigger, it replenishes a small amount of charge that has been lost to leakage and in the bleeder resistor to maintain good voltage stability. It remains off during discharge period. This is repeated. A fly back PS is designed to charge a capacitor bank of 3mF up to 300V at 1 Hz repetition.

## PROPOSED SCHEME

Fly-back converter topology is suitable for capacitor charging power supplies because this converter is one of the most attractive isolated switch mode converter in small power applications. Moreover this converter delivers the characteristics of current source which is specially suitable for capacitor charging applications. The fly-back transformer serves as a step-up/down to the input voltage. Reverse output voltage polarity provides electrical isolation, and provides energy storage during the operation. During the turn-on period of switches, energy is stored in the magnetic inductor and transferred to the secondary side during the turn-off period hence current will not flow in both the windings at the same time. Thus this converter is short circuit proof. This feature of the converter is particularly suitable to start the charging of capacitors from fully discharged state. When the switches are turned on, primary voltage becomes equal to the source voltage, and the diode is turned off by negative polarity. The magnetizing inductance starts charging linearly with slope Vin/Lm. Current increases to its maximum value and energy is stored in the transformer core but current does not flow in the secondary winding.

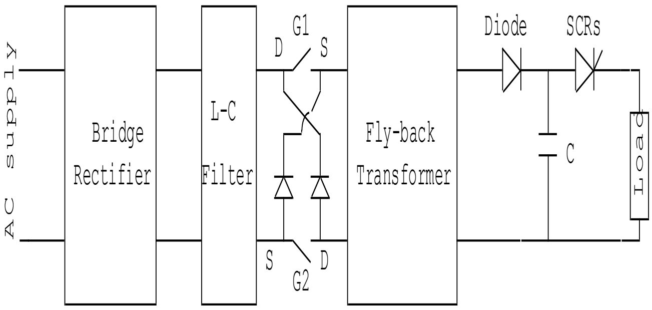


Figure 2 : Two switch topology based fly-back converter circuit

When switches are turned off, the diode is forced to carry the magnetizing inductor current, which decreases to zero value in the process of charging the capacitor C and energy stored in the transformer core is delivered to the capacitor C. This process occurs repeatedly to charge the capacitor C to a required final value.

For above circuit, we can write few relations as
$I_p = (V_{dc}/L_m)\,T_{on}$, $I_p/N = (V_c/N^2 L_m)\,T_{off}$
Time Period T = Ton + Toff where Transformer turn ratio = 1:N, Lm = Transformer magnetising inductance as seen in primary, Vdc = D.C. bus voltage, Ton= On time of Switches (G1,G2) , Toff = off time of switches, Ip=Peak primary current, Vc=Capacitor voltage. From the above equations we see that Vc*Toff= constt. when all other perameters are fixed. For this to hapen each value of capacitor voltage in the charging cycle corresponds to a fixed Toff and thus a curve showing T Vs Vc can be plotted for a fixed value of Ton. In this scheme Vc was sensed and T was varied as a non linear function of Vc such that realised T vs Vc curve lies above calculated T vs Vc curve giving an assured discontinuous conduction. Realisation of this non linear curve was achieved as peicevise linearised curve with the help of few op amps and IC 555 timer.

## EXPERIMENTAL RESULTS

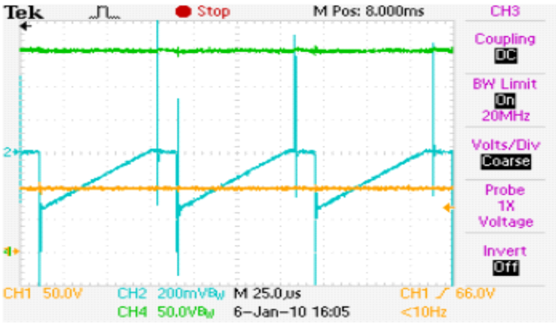


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Fig 3:Capacitor charging current : Blue, Charging capacitor voltage: Yellow, D.C.Bus voltage:Green

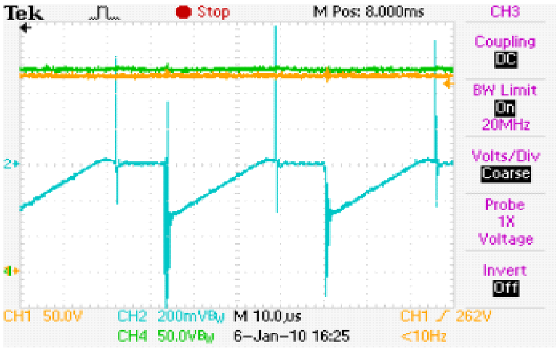


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Fig 4:Capacitor charging current : Blue, Charging capacitor voltage: Yellow, D.C.Bus voltage:Green

Figures 3 and 4 above shows various waveforms during capacitor charging at two different points of charging cycle. Capacitor charging current at channel 2 in the above figures confirms our assertion that it has reached zero before next turn on. Charging capacitor voltage Vs time in figure 5 shows a near straight line variation of capacitor voltage with time over full charging cycle. It establishes nearly constant current charging of capacitor over full charging cycle.

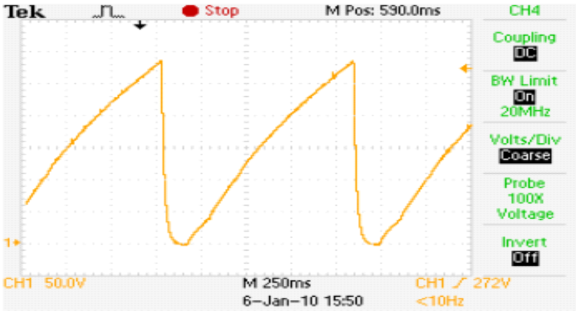


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Fig 5: Charging capacitor voltage Vs Time

## CONCLUSION

Fly-back converter is the best selection for charging a capacitor. It behaves as a constant current source and provides the isolation between input and output. It is suitable for low and medium power level charger. A fly-back based capacitor charging power supply has been designed to charge a capacitor bank, which is discharged repetitively. Full discharge of stored magnetic energy before next turn on of MOSFET switches has been assured over full charging cycle by way of sensing capacitor voltage only. Scheme has been used to charge capacitor bank of 3mF up to 300V within 900ms. In this scheme, two series connected switches reduce the voltage rating of switches to half of a equivalent single switch converter and cross connected diode recover the energy stored in the leakage inductance of fly-back transformer and therefore it reduces the voltage stress on the switches also. In this scheme, secondary current of fly-back transformer are operated in discontinuous mode and better utilization of time over charging cycle.

## ACKNOWLEDGEMENT

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