# A 25 WATT OFF-LINE FLYBACK SWITCHING REGULATOR

## Introduction

This Application Note describes a low cost (less than $10.00) switching power supply for applications requiring multiple output voltages, e.g. personal computers, instruments, etc...The discontinuous mode flyback regulator used in this application provides good voltage tracking between outputs, which allows the use of primary side voltage sensing. This sensing technique reduces costs by eliminating the need for an isolated secondary feedback loop.

The low cost, (8 pin) UC3844 current mode control chip employed in this power supply provides performance advantages such as:

1) Fast transient response
2) Pulse by pulse current limiting
3) Stable operation

To simplify drive circuit requirements, a TO-220 power MOSFET (UFN833) is utilized for the power switch. This switch is driven directly from the output of the control chip.

## Power Supply Specifications

1. Input voltage: 95VAC to 130VAC (50Hz/60Hz)
2. Output voltage:
   A. +5V, ±5%: 1A to 4A load
      Ripple voltage: 50mV P-P Max.
   B. +12V, ±3%: 0.1A to 0.3A load
      Ripple voltage: 100mV P-P Max.
   C. −12V, ±3%: 0.1A to 0.3A load
      Ripple voltage: 100mV P-P Max.
3. Line Isolation: 3750 Volts
4. Switching Frequency: 40KHz
5. Efficiency @ Full Load: 70%

## Basic Circuit Operation

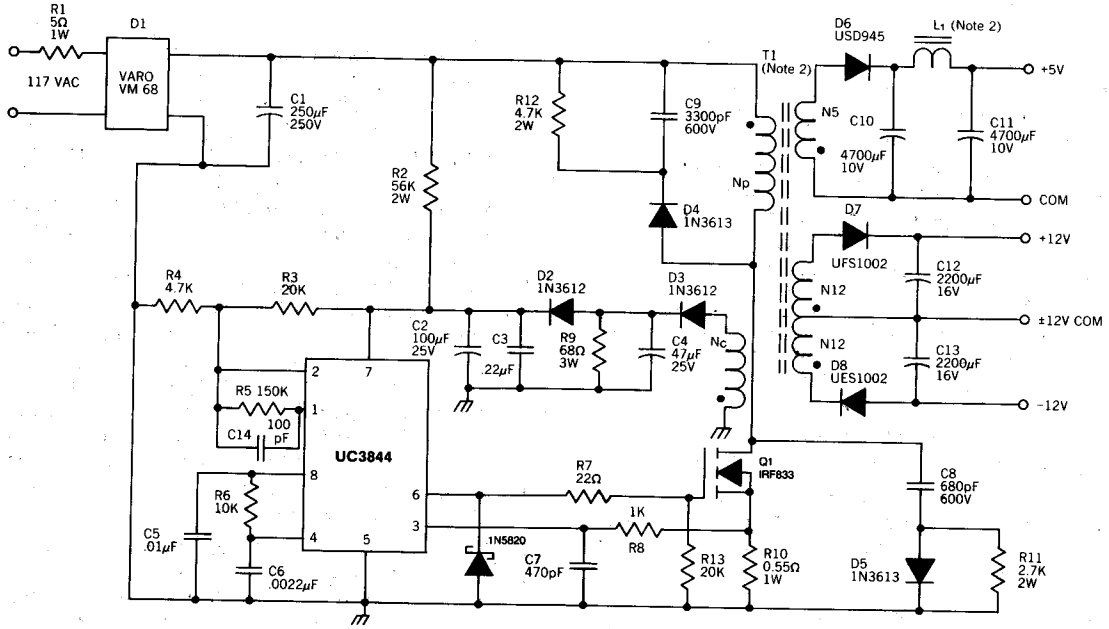
The 117VAC input line voltage is rectified and smoothed to provide DC operating voltage for the circuit. When power is initially applied to the circuit, capacitor C2 charges through R2. When the voltage across C2 reaches a level of 16V the output of IC1 is enabled, turning on power MOSFET Q1. During the on time of Q1, energy is stored in the air gap of transformer (inductor) T1. At this time the polarity of the output windings is such that all output rectifiers are reverse biased and no energy is transferred. Primary current is sensed by a resistor, R10, and compared to a fixed 1 volt reference inside IC1. When this level is reached, Q1 is turned off and the polarity of all transformer windings reverses, forward biasing the output rectifiers. All the energy stored is now transferred to the output capacitors. Many cycles of this store/release action are needed to charge the outputs to their respective voltages. Note that C2 must have enough energy stored initially to keep the control circuitry operating until C4 is charged to a level of approximately 13V. The voltage across C4 is fed through a voltage divider to the error amplifier (pin 2) and compared to an internal 2.5V reference.

Energy stored in the leakage inductance of T1 causes a voltage spike which will be added to the normal reset voltage across T1 when Q1 turns off. The clamp consisting of D4, C9 and R12 limits this voltage excursion from exceeding the BVDSS rating of Q1. In addition, a turn-off snubber made up of D5, C8 and R11 keeps power dissipation in Q1 low by delaying the voltage rise until drain current has decreased from its peak value. This snubber also damps out any ringing which may occur due to parasitics.

Less than 3.5% line and load regulation is achieved by loading the output of the control winding, Nc, with R9. This resistor dissipates the leakage energy associated with this winding. Note that R9 must be isolated from R2 with diode D2, otherwise C2 could not charge to the 16V necessary for initial start-up.

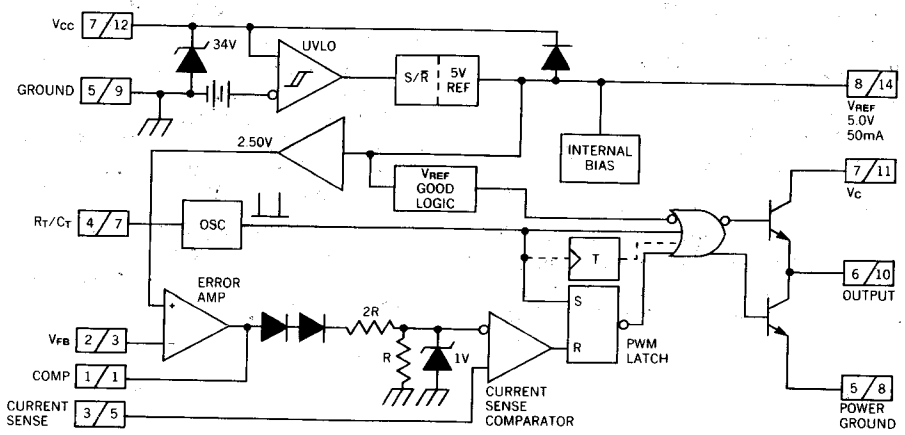
A small filter inductor in the 5V secondary is added to reduce output ripple voltage to less than 50mV. This inductor also attenuates any high frequency noise.

# 25W OFF-LINE FLYBACK REGULATOR




*Notes: 1. All resistors are ¼ watt unless noted*
*2. See Appendix for construction details*

## BLOCK DIAGRAM

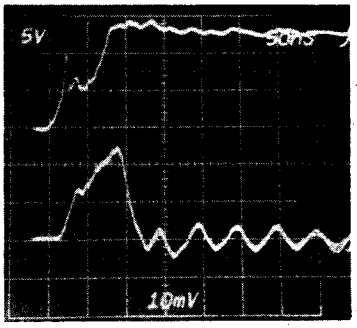



**Note:** 1. A/B A = DIL-8 Pin Number. B = SO-14 Pin Number.
2. Toggle flip flop used only in 1844 and 1845.

## UC3842/3/4/5 CURRENT MODE PWM CONTROLLER

# TYPICAL SWITCHING WAVEFORMS

$T_{on}$ — Drive waveforms

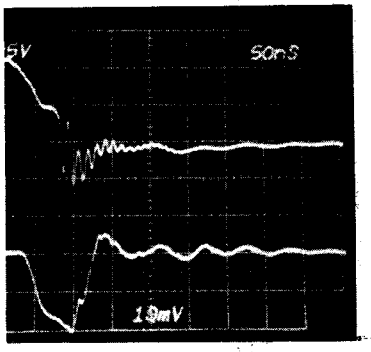



Upper trace: $Q_1$ — Gate to source voltage
Lower trace: $Q_1$ — Gate current

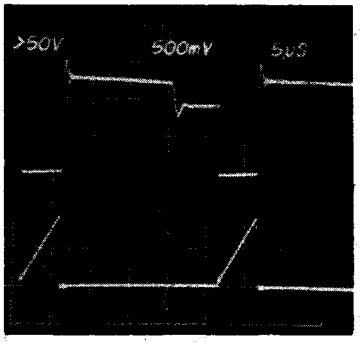
5V/DIV

200mA/DIV

$T_{off}$ — Drive waveforms




Upper trace: $Q_1$ — Gate to source voltage
Lower trace: $Q_1$ — Gate current



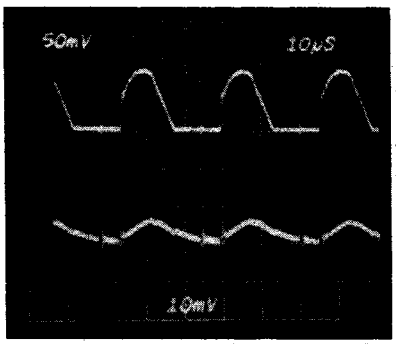

Upper trace: $Q_1$ — Drain to source voltage
Lower trace: Primary current — $I_D$

100V/DIV

0.5A/DIV

5A/DIV

50mV/DIV




Upper trace: +5V charging current
Lower trace: +5V output ripple voltage

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# PERFORMANCE DATA

| CONDITIONS | | 5V out | 12V out | −12V out |
|---|---|---|---|---|
| **Low Line (95VAC)** | | | | |
| ± 12 @ 100mA | +5V @ 1.0A | 5.211 | 12.05 | −12.01 |
| | 4.0A | 4.854 | 12.19 | −12.14 |
| ± 12 @ 300mA | +5V @ 1.0A | 5.199 | 11.73 | −11.69 |
| | 4.0A | 4.950 | 11.68 | −11.63 |
| **Nominal Line (120VAC)** | | | | |
| ± 12 @ 100mA | +5V @ 1.0A | 5.220 | 12.07 | −12.03 |
| | 4.0A | 4.875 | 12.23 | −12.18 |
| ± 12 @ 300mA | +5V @ 1.0A | 5.208 | 11.73 | −11.68 |
| | 4.0A | 4.906 | 11.67 | −11.62 |
| **High Line (130VAC)** | | | | |
| ± 12 @ 100mA | +5V @ 1.0A | 5.207 | 12.06 | −12.02 |
| | 4.0A | 4.855 | 12.21 | −12.15 |
| ± 12V @ 300mA | +5V @ 1.0A | 5.200 | 11.71 | −11.67 |
| | 4.0A | 4.902 | 11.66 | 11.61 |
| **Overall Line and Load Regulation** | | ±3.5% | ±2.3% | ±2.4% |

# PARTS LIST

| IC's | |
|---|---|
| IC1 | UC3844 |
| **POWER MOSFET** | |
| Q1 | UFN833 |
| **RECTIFIERS** | |
| D1 | VM68 varo |
| D2, D3 | 1N3612 |
| D4, D5 | 1N3613 |
| D6 | USD945 |
| D7, D8 | UES1002 |

| CAPACITORS | |
|---|---|
| C1 | 250μF, 250V |
| C2 | 100μF, 25V |
| C3 | 0.22μF, 25V |
| C4 | 47μF, 25V |
| C5 | .01μF, 25V |
| C6 | .0047μF, 25V |
| C7 | 470pF, 25V |
| C8 | 680pF, 600V |
| C9 | 3300pF, 600V |

| | |
|---|---|
| C10, C11 | 4700μF, 10V |
| C12, C13 | 2200μF, 16V |
| C14 | 100pF, 25V |
| **RESISTORS** | |
| R1 | 5Ω, 1W |
| R2 | 56K, 2W |
| R3 | 20K |
| R4 | 4.7K |
| R5 | 150K |
| R6 | 10K |

| | |
|---|---|
| R7 | 22Ω |
| R8 | 1K |
| R9 | 68Ω, 3W |
| R10 | 0.55Ω, 1W |
| R11 | 2.7K, 2W |
| R12 | 4.7K, 2W |
| R13 | 20K |
| **MAGNETICS** | |
| $T_1$ | see appendix |
| $L_1$ | see appendix |

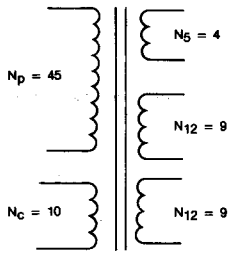
# APPENDIX

## POWER TRANSFORMER—T1

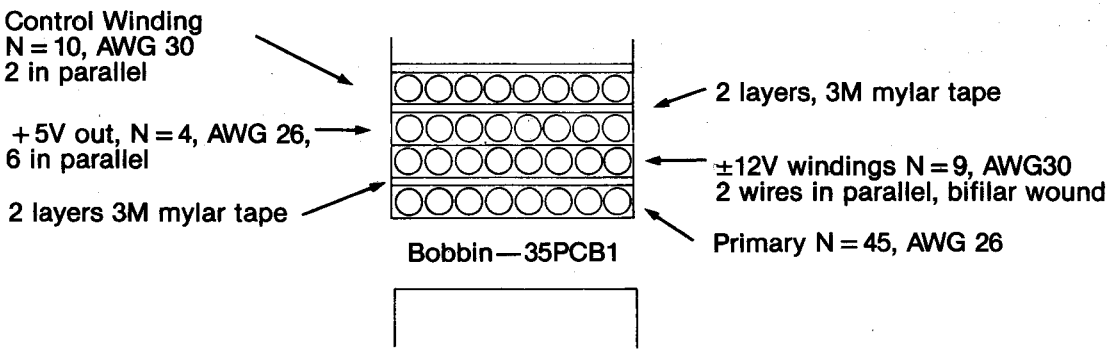
Core: Ferroxcube EC-35/3C8
Gap: 10 mil in each outer leg

*NOTE: For reduced EMI put gap in center leg only. Use 20 mil.*

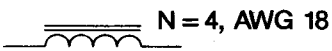
Ferroxcube
EC-35/3C8




## TRANSFORMER CONSTRUCTION




## 5V OUTPUT INDUCTOR




Ferroxcube
204 T 250 — 3C8 (toroid)

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