APPENDIX III - FREQUENCY RESPONSE OF THE CURRENT LOOP

- **CS/A** - Figure 22 shows the open-loop gain and phase response of the UC1834 CS/A. This is also a transconductance amplifier, having $g_M \approx 1/70\Omega = 14mS$. The voltage gain is analogous to that of the E/A. The E/A compensation impedance (Z_C or $Z_{F(E/A)}$) is also seen by the CS/A output. For purposes of small signal AC analysis, the CS/A will always see this impedance as being returned to $\overline{V_{IN}}$ (as shown in Figures 16c, d) when the E/A is compensated by either of the methods shown in Table 2.

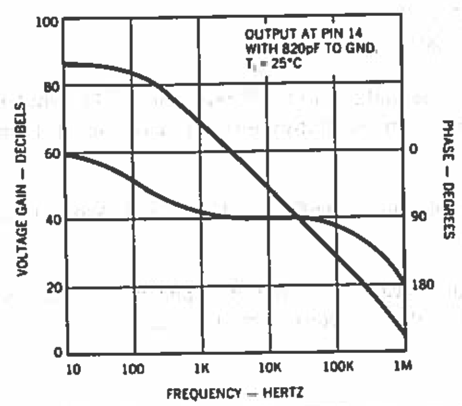

Figure 22. Current Sense Amplifier Gain and Phase Frequency Response

- **Pass Transistor** - Introduces current gain β to the loop transfer of both basic configurations (Figures 16c, d).Considerations outlined in Appendix I also apply here.

- **Sense Resistor** - Resistance value R_{SENSE} appears in transfer function for both configurations.

- **Drive Transistor** - In the circuit of Figure 16c, R_E allows operation of the driver as an emitter-follower. Effective conductance is $1/R_E$.

Closed-loop responses are given by the following:

for circuit of Figure 16c:

$$A_I = g_M \cdot Z_C \cdot \frac{1}{R_E} \cdot \beta \cdot R_{SENSE} \qquad \left(f < 500kHz,\ f < \frac{f_T}{\beta}\left(1 + \frac{\beta r_e}{R_{BE}}\right)\right)$$

for circuit of Figure 16d:

$$A_I = g_M \cdot \frac{Z_C}{Z_C + \beta Z_L} \cdot \beta \cdot R_{SENSE} \qquad \left(f < 500kHz,\ f < \frac{f_T}{\beta}\left(1 + \frac{\beta r_e}{R_{BE}}\right)\right)$$

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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.

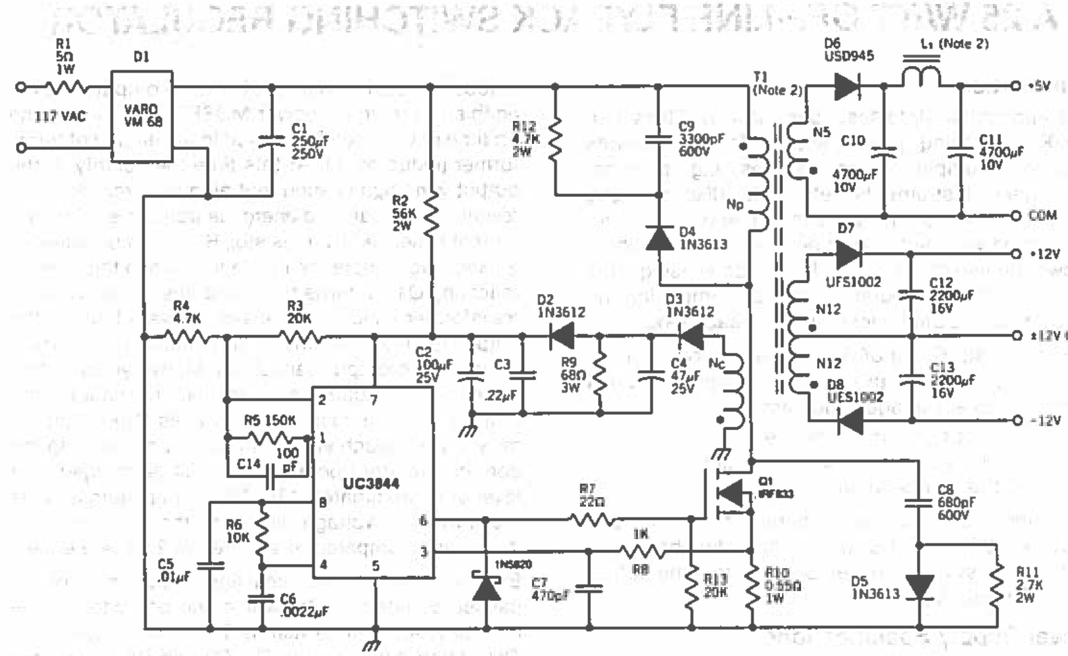
Energy stored in the leakage inductance of T1 causes a voltage spike which will be added to the normal reset voltage across T1 when Q1 turns off. The clamp consisting of D4, C9 and R12 limits this voltage excursion from exceeding the BVDSS rating of Q1. In addition, a turn-off snubber made up of D5, 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.

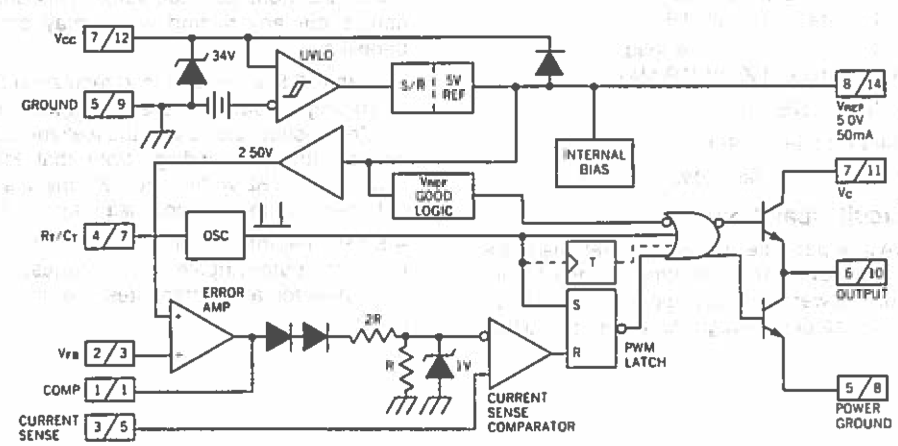
9

25W OFF-LINE FLYBACK REGULATOR



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

BLOCK DIAGRAM

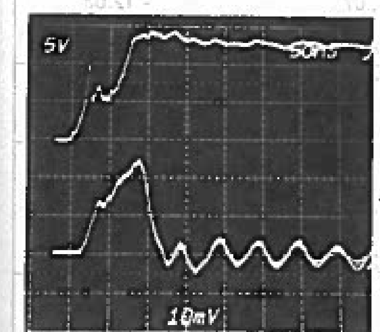


Note: 1 A/B A = DIL-8 Pin Number B = SO-14 Pin Number.
2 Toggle flip flop used only in 1844 and 1845

UC3842/3/4/5 CURRENT MODE PWM CONTROLLER

TYPICAL SWITCHING WAVEFORMS

T_{on} — Drive waveforms

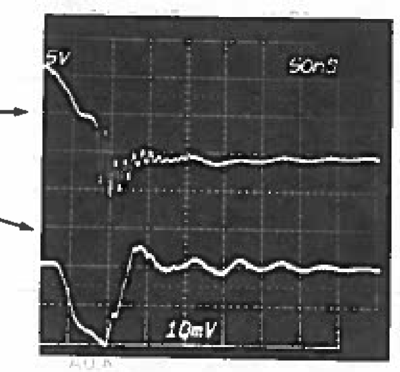


5V/DIV

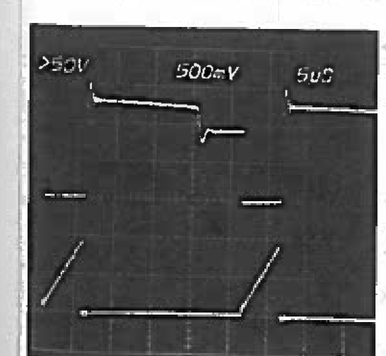
200mA/DIV

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

T_{off} — Drive waveforms



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



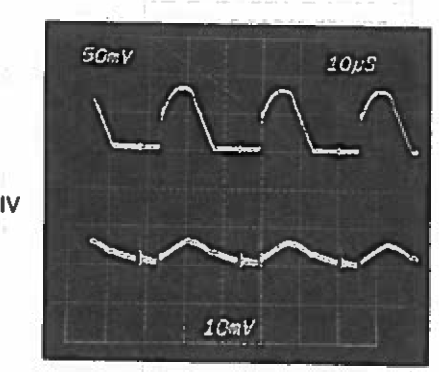
100V/DIV

0.5A/DIV

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

5A/DIV

50mV/DIV



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

9

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		**CAPACITORS**		C10, C11	4700μF, 10V	R7	22Ω
IC1	UC3844	C1	250μF, 250V	C12, C13	2200μF, 16V	R8	1K
POWER MOSFET		C2	100μF, 25V	C14	100pF, 25V	R9	68Ω, 3W
Q1	UFN833	C3	0.22μF, 25V	**RESISTORS**		R10	0.55Ω, 1W
RECTIFIERS		C4	47μF, 25V	R1	5Ω, 1W	R11	2.7K, 2W
D1	VM68 varo	C5	.01μF, 25V	R2	56K, 2W	R12	4.7K, 2W
D2, D3	1N3612	C6	.0047μF, 25V	R3	20K	R13	20K
D4, D5	1N3613	C7	470pF, 25V	R4	4.7K	**MAGNETICS**	
D6	USD945	C8	680pF, 600V	R5	150K	T_1	see appendix
D7, D8	UES1002	C9	3300pF, 600V	R6	10K	L_1	see appendix

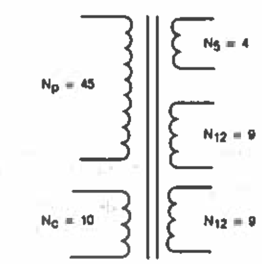
APPENDIX

POWER TRANSFORMER—T1

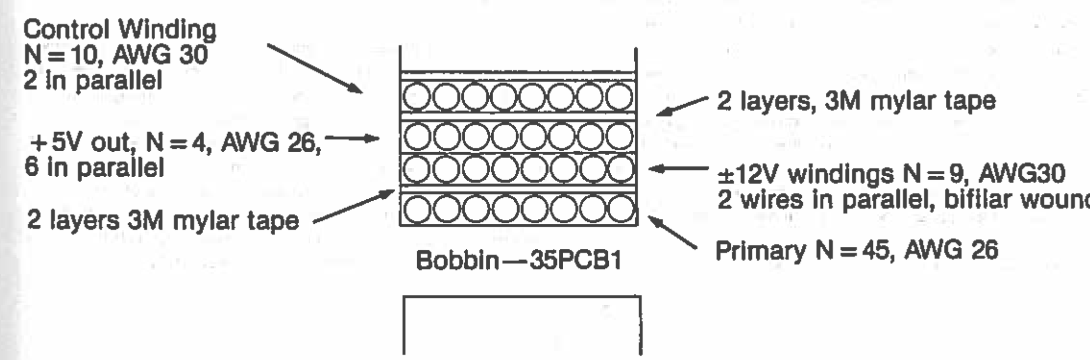
Core: Ferroxcube EC-35/3C8
Gap: 10 mil in each outer leg

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

Ferroxcube EC-35/3C8



TRANSFORMER CONSTRUCTION



5V OUTPUT INDUCTOR

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