High Performance Current Mode Controllers

General Description

The UC3842B/3B/4B/5B, series are high performance fixed frequency current mode controllers. They are specifically designed for Off–Line and dc–to–dc converter applications offering the designer a cost–effective solution with minimal external components. These integrated circuits feature a trimmed oscillator for precise duty cycle control, a temperature compensated reference, high gain error amplifier, current sensing comparator, and a high current totem pole output ideally suited for driving a power MOSFET.

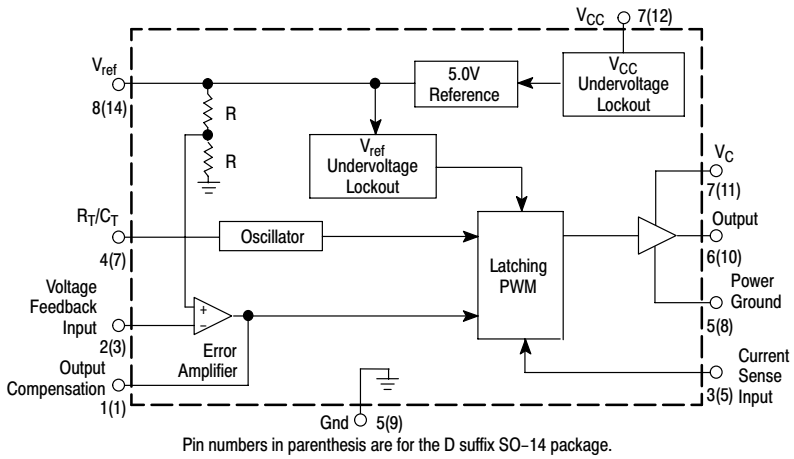
Also included are protective features consisting of input and reference undervoltage lockouts each with hysteresis, cycle–by–cycle current limiting, programmable output deadtime, and a latch for single pulse metering.

These devices are available in an 8–pin dual–in–line and surface mount (SO–8) plastic package as well as the 14–pin plastic surface mount (SO–14). The SO–14 package has separate power and ground pins for the totem pole output stage.

The UCX842B has UVLO thresholds of 16 V (on) and 10 V (off), ideally suited for off–line converters. The UCX843B is tailored for lower voltage applications having UVLO thresholds of 8.5 V (on) and 7.6 V (off).

Features

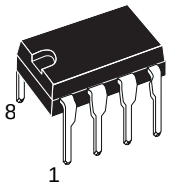
- Trimmed Oscillator for Precise Frequency Control
- Oscillator Frequency Guaranteed at 250 kHz
- Current Mode Operation to 500 kHz
- Automatic Feed Forward Compensation
- Latching PWM for Cycle–By–Cycle Current Limiting
- Internally Trimmed Reference with Undervoltage Lockout
- High Current Totem Pole Output
- Undervoltage Lockout with Hysteresis
- Low Startup and Operating Current



Pin numbers in parenthesis are for the D suffix SO–14 package.

Figure 1. Simplified Block Diagram

Package outline



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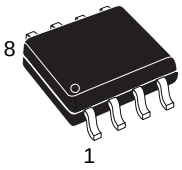
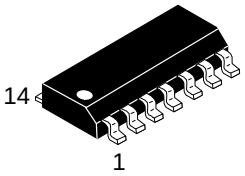
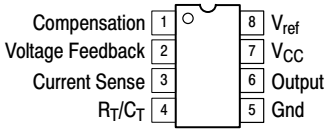


SOP-8

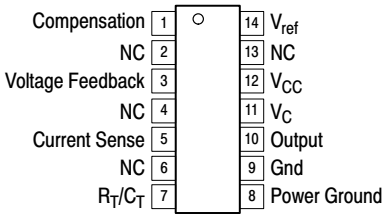


SOP-14

Pin Connections



(Top View)



(Top View)

Maximum Ratings

Rating	Symbol	Value	Unit
Bias and Driver Voltages (Zero Series Impedance, see also Total Device spec)	V_{CC}, V_C	30	V
Total Power Supply and Zener Current	(I_{CC} + I_Z)	30	mA
Output Current, Source or Sink (Note 1)	I_O	1.0	A
Output Energy (Capacitive Load per Cycle)	W	5.0	μJ
Current Sense and Voltage Feedback Inputs	V_{in}	– 0.3 to + 5.5	V
Error Amp Output Sink Current	I_O	10	mA
Power Dissipation and Thermal Characteristics D Suffix, Plastic Package, SO–14 Case 751A Maximum Power Dissipation @ T_A = 25°C Thermal Resistance, Junction–to–Air D1 Suffix, Plastic Package, SO–8 Case 751 Maximum Power Dissipation @ T_A = 25°C Thermal Resistance, Junction–to–Air N Suffix, Plastic Package, Case 626 Maximum Power Dissipation @ T_A = 25°C Thermal Resistance, Junction–to–Air	 P_D $R_{\theta JA}$ P_D $R_{\theta JA}$ P_D $R_{\theta JA}$	 862 145 702 178 1.25 100	 mW °C/W mW °C/W W °C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature UC3842B/3B/4B/5B UC2842B/3B	T_A	 0 to + 70 – 25 to + 85	°C
Storage Temperature Range	T_{stg}	– 65 to +150	°C

Electrical Characteristics (V_{CC} = 15 V [Note 2], R_T = 10 k, C_T = 3.3 nF. For typical values T_A = 25°C, for min/max values T_A is the operating ambient temperature range that applies [Note 3], unless otherwise noted.)

Characteristics	Symbol	UC284XB			UC384XB			Unit
		Min	Typ	Max	Min	Typ	Max	
Reference Section								
Reference Output Voltage (I_O = 1.0 mA, T_J = 25°C)	V_{ref}	4.95	5.0	5.05	4.9	5.0	5.1	V
Line Regulation (V_{CC} = 12 V to 25 V)	Reg_{line}	–	2.0	20	–	6.0	20	mV
Load Regulation (I_O = 1.0 mA to 20 mA)	Reg_{load}	–	3.0	25	–	6.0	25	mV
Temperature Stability	T_S	–	0.2	–	–	0.2	–	mV/°C
Total Output Variation over Line, Load, and Temperature	V_{ref}	4.9	–	5.1	4.82	–	5.18	V
Output Noise Voltage (f = 10 Hz to 10 kHz, T_J = 25°C)	V_n	–	50	–	–	50	–	μV
Long Term Stability (T_A = 125°C for 1000 Hours)	S	–	5.0	–	–	5.0	–	mV
Output Short Circuit Current	I_{SC}	– 30	– 85	–180	– 30	–100	–180	mA
Oscillator Section								
Frequency T_J = 25°C T_A = T_{low} to T_{high} T_J = 25°C (R_T = 6.2 k, C_T = 1.0 nF)	f_{OSC}	 49 48 225	 52 – 250	 55 56 275	 47 47 225	 50 52 250	 55 56 275	kHz
Frequency Change with Voltage (V_{CC} = 12 V to 25 V)	$\Delta f_{OSC}/\Delta V$	–	0.2	1.0	–	0.2	1.0	%
Frequency Change with Temperature, T_A = T_{low} to T_{high}	$\Delta f_{OSC}/\Delta T$	–	1.0	–	–	0.5	–	%
Oscillator Voltage Swing (Peak–to–Peak)	V_{OSC}	–	1.6	–	–	1.6	–	V
Discharge Current (V_{OSC} = 2.0 V) T_J = 25°C T_A = T_{low} to T_{high} (UC284XB, UC384XB)	I_{dischg}	 7.8 7.5	 8.3 –	 8.8 8.8	 7.8 7.6	 8.3 –	 8.8 8.8	mA

1. Maximum Package power dissipation limits must be observed.
2. Adjust V_{CC} above the Startup threshold before setting to 15 V.
3. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient as possible.
   T_{low} = 0°C for UC3842B/3B/4B/5B; –25 °C for UC2842B/3B
   T_{high} = +70°C for UC3842B/3B/4B/5B; +85°C for UC2842B/3B

Electrical Characteristics (V_{CC} = 15 V [Note 4], R_T = 10 k, C_T = 3.3 nF. For typical values T_A = 25°C, for min/max values T_A is the operating ambient temperature range that applies [Note 5], unless otherwise noted.)

Characteristics	Symbol	UC284XB			UC384XB			Unit
		Min	Typ	Max	Min	Typ	Max	
Error Amplifier Section								
Voltage Feedback Input (V_O = 2.5 V)	V_{FB}	2.45	2.5	2.55	2.42	2.5	2.58	V
Input Bias Current (V_{FB} = 5.0 V)	I_{IB}	–	– 0.1	–1.0	–	– 0.1	– 2.0	μA
Open Loop Voltage Gain (V_O = 2.0 V to 4.0 V)	A_{VOL}	65	90	–	65	90	–	dB
Unity Gain Bandwidth (T_J = 25°C)	BW	0.7	1.0	–	0.7	1.0	–	MHz
Power Supply Rejection Ratio (V_{CC} = 12 V to 25 V)	PSRR	60	70	–	60	70	–	dB
Output Current								mA
Sink (V_O = 1.1 V, V_{FB} = 2.7 V)	I_{Sink}	2.0	12	–	2.0	12	–	
Source (V_O = 5.0 V, V_{FB} = 2.3 V)	I_{Source}	– 0.5	–1.0	–	– 0.5	–1.0	–	
Output Voltage Swing								V
High State (R_L = 15 k to ground, V_{FB} = 2.3 V)	V_{OH}	5.0	6.2	–	5.0	6.2	–	
Low State (R_L = 15 k to V_{ref}, V_{FB} = 2.7 V) (UC284XB, UC384XB)	V_{OL}	–	0.8	1.1	–	0.8	1.1	
Current Sense Section								
Current Sense Input Voltage Gain (Notes 6 & 7) (UC284XB, UC384XB)	A_V	2.85	3.0	3.15	2.85	3.0	3.15	V/V
Maximum Current Sense Input Threshold (Note 6) (UC284XB, UC384XB)	V_{th}	0.9	1.0	1.1	0.9	1.0	1.1	V
Power Supply Rejection Ratio (V_{CC} = 12 V to 25 V, Note 6)	PSRR	–	70	–	–	70	–	dB
Input Bias Current	I_{IB}	–	– 2.0	–10	–	– 2.0	–10	μA
Propagation Delay (Current Sense Input to Output)	$t_{PLH(In/Out)}$	–	150	300	–	150	300	ns
Output Section								
Output Voltage								V
Low State (I_{Sink} = 20 mA)	V_{OL}	–	0.08	0.4	–	0.08	0.4	
(I_{Sink} = 200 mA) (UC284XB, UC384XB)		–	1.4	2.2	–	1.4	2.2	
High State (I_{Source} = 20 mA) (UC284XB, UC384XB)	V_{OH}	13	13.5	–	13	13.5	–	
(I_{Source} = 200 mA)		12	13.0	–	12	13.0	–	
Output Voltage with UVLO Activated (V_{CC} = 6.0 V, I_{Sink} = 1.0 mA)	$V_{OL(UVLO)}$	–	0.1	1.1	–	0.1	1.1	V
Output Voltage Rise Time (C_L = 1.0 nF, T_J = 25°C)	t_r	–	45	150	–	45	150	ns
Output Voltage Fall Time (C_L = 1.0 nF, T_J = 25°C)	t_f	–	35	150	–	35	150	ns
Undervoltage Lockout Section								
Startup Threshold (V_{CC})	V_{th}							V
UCX842B/4B		15	16	17	14.5	16	17.5	
UCX843B/5B		7.8	8.4	9.0	7.8	8.4	9.0	
Minimum Operating Voltage After Turn–On (V_{CC})	$V_{CC(min)}$							V
UCX842B/4B		9.0	10	11	8.5	10	11.5	
UCX843B/5B		7.0	7.6	8.2	7.0	7.6	8.2	

4. Adjust V_{CC} above the Startup threshold before setting to 15 V.
5. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient as possible.
   T_{low} = 0°C for UC3842B/3B/4B/5B; –25°C for UC2842B/3B
   T_{high} = +70°C for UC3842B/3B/4B/5B; +85°C for UC2842B/3B
6. This parameter is measured at the latch trip point with V_{FB} = 0 V.
7. Comparator gain is defined as: $A_V \frac{\Delta V \text{ Output Compensation}}{\Delta V \text{ Current Sense Input}}$

Electrical Characteristics (V_{CC} = 15 V [Note 8], R_T = 10 k, C_T = 3.3 nF, for typical values T_A = 25°C, for min/max values T_A is the operating ambient temperature range that applies [Note 9], unless otherwise noted.)

Characteristics	Symbol	UC284XB			UC384XB, BV			Unit
		Min	Typ	Max	Min	Typ	Max	
Pwm Section								
Duty Cycle								%
Maximum (UC284XB, UC384XB)	$DC_{(max)}$	94	96	–	94	96	–	
Minimum	$DC_{(min)}$	–	–	0	–	–	0	
Total Device								
Power Supply Current	$I_{CC} + I_C$							mA
Startup (V_{CC} = 6.5 V for UCX843B, (V_{CC} 14 V for UCX842B)		–	0.17	0.3	–	0.17	0.3	
Operating (Note 8)		–	13	17	–	13	17	
Power Supply Zener Voltage (I_{CC} = 25 mA)	V_Z	30	36	–	30	36	–	V

8. Adjust V_{CC} above the Startup threshold before setting to 15 V.
9. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient as possible.
   T_{low} = 0°C for UC3842B/3B/4B/5B; –25°C for UC2842B/3B
   T_{high} = +70°C for UC3842B/3B/4B/5B; +85 °C for UC2842B/3B

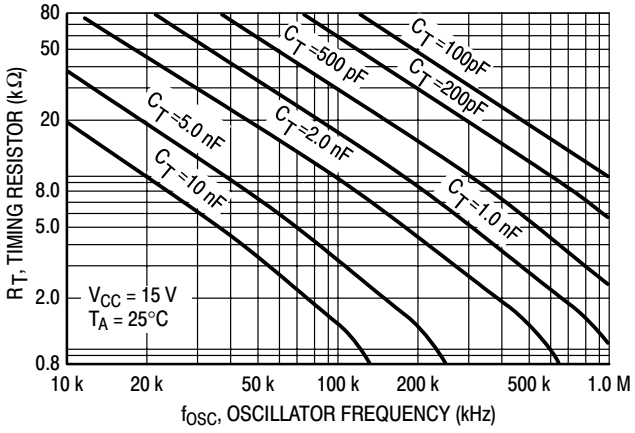


Figure 2. Timing Resistor versus Oscillator Frequency

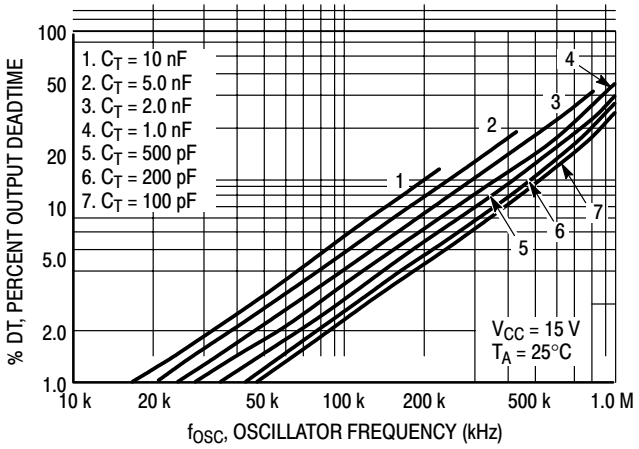


Figure 3. Output Deadtime versus Oscillator Frequency

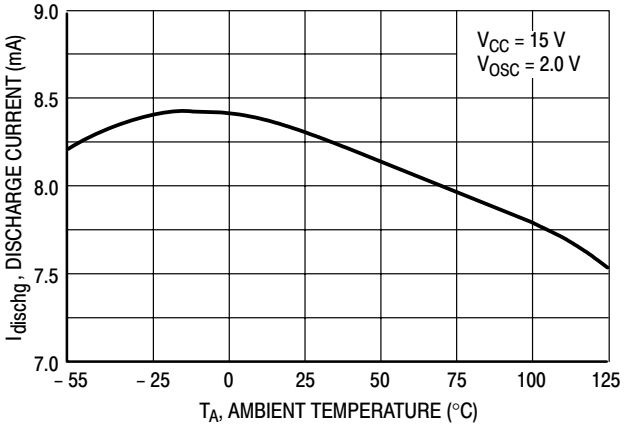


Figure 4. Oscillator Discharge Current versus Temperature

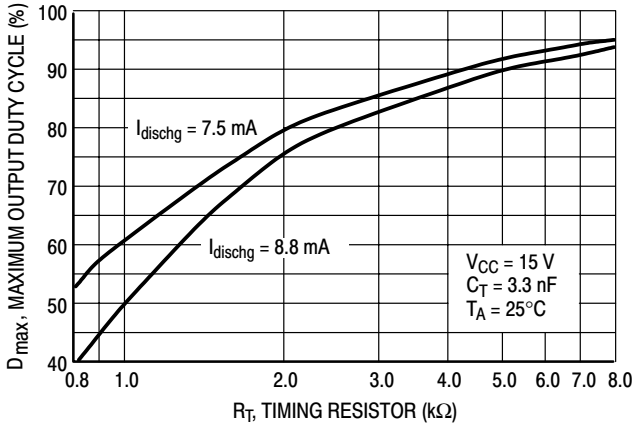


Figure 5. Maximum Output Duty Cycle versus Timing Resistor

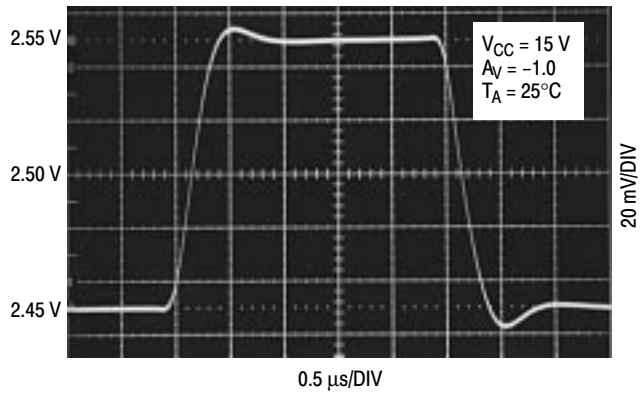


Figure 6. Error Amp Small Signal Transient Response

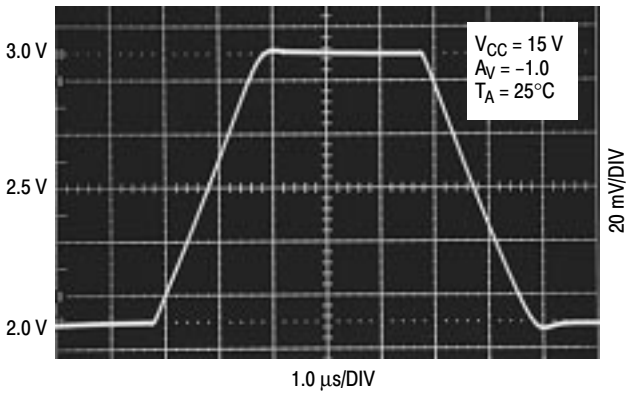


Figure 7. Error Amp Large Signal Transient Response

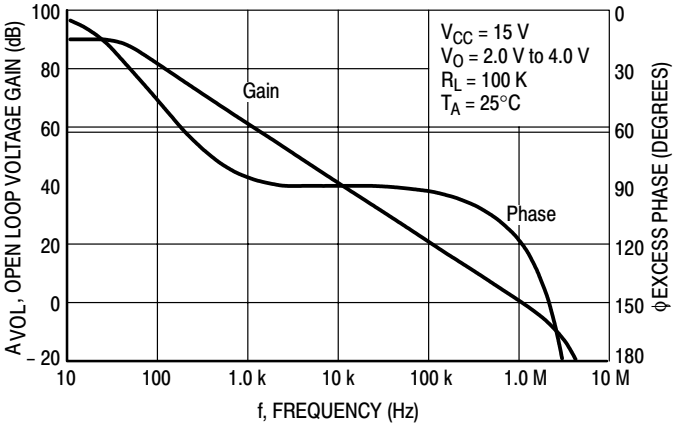


Figure 8. Error Amp Open Loop Gain and Phase versus Frequency

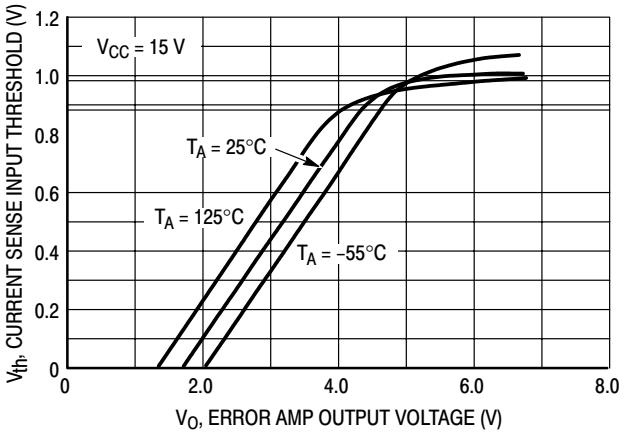


Figure 9. Current Sense Input Threshold versus Error Amp Output Voltage

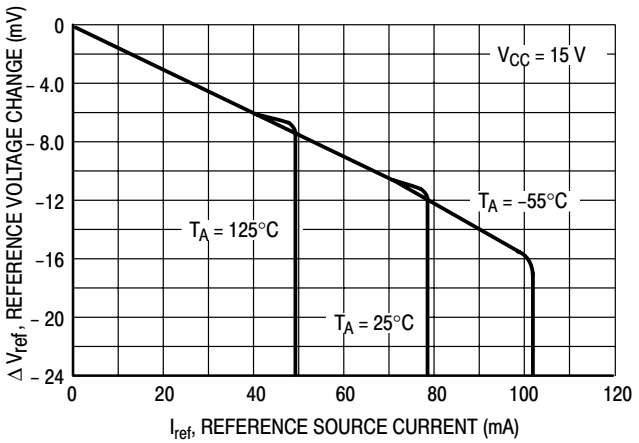


Figure 10. Reference Voltage Change versus Source Current

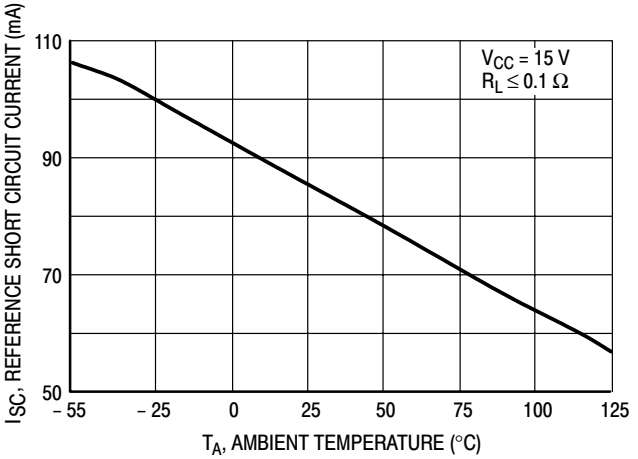


Figure 11. Reference Short Circuit Current versus Temperature

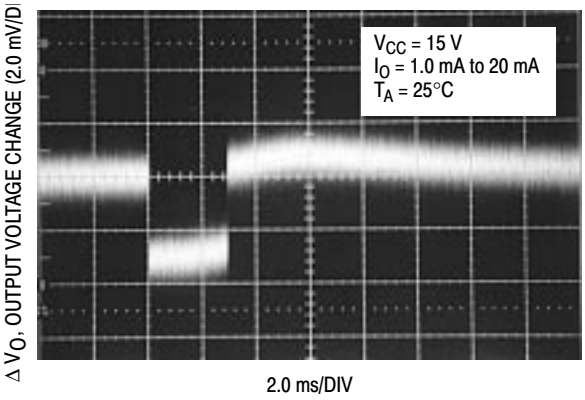


Figure 12. Reference Load Regulation

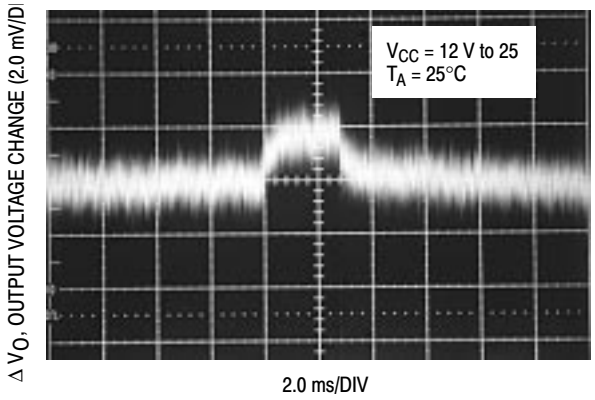


Figure 13. Reference Line Regulation

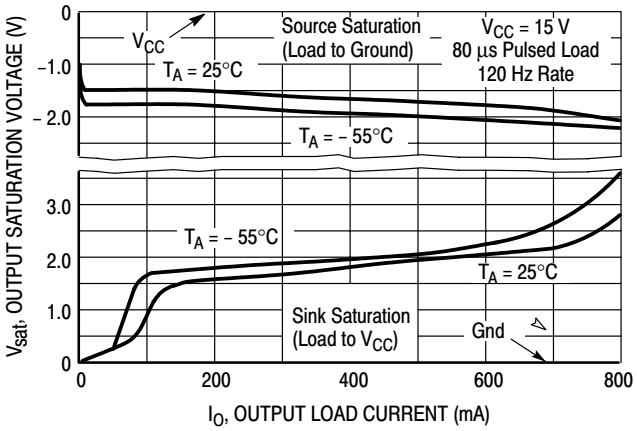


Figure 14. Output Saturation Voltage versus Load Current

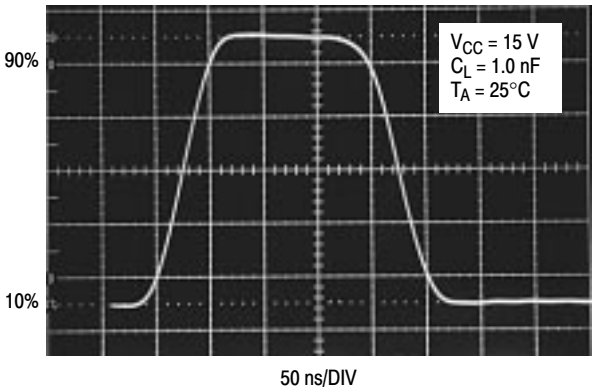


Figure 15. Output Waveform

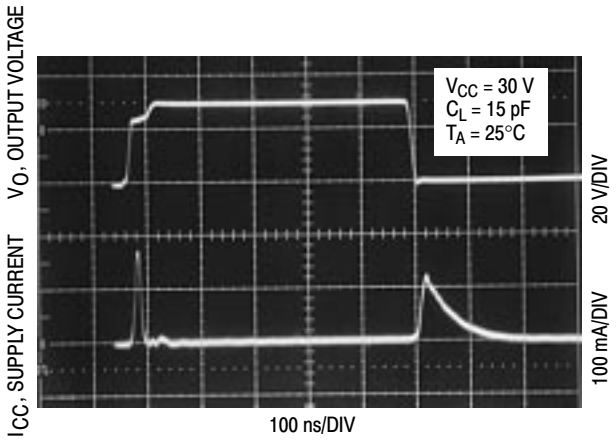


Figure 16. Output Cross Conduction

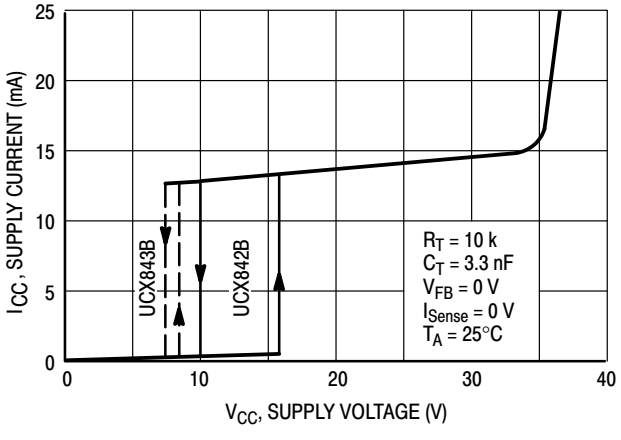


Figure 17. Supply Current versus Supply Voltage

Pin Function Description

Pin		Function	Description
8–Pin	14–Pin		
1	1	Compensation	This pin is the Error Amplifier output and is made available for loop compensation.
2	3	Voltage Feedback	This is the inverting input of the Error Amplifier. It is normally connected to the switching power supply output through a resistor divider.
3	5	Current Sense	A voltage proportional to inductor current is connected to this input. The PWM uses this information to terminate the output switch conduction.
4	7	R_T/C_T	The Oscillator frequency and maximum Output duty cycle are programmed by connecting resistor R_T to V_{ref} and capacitor C_T to ground. Operation to 500 kHz is possible.
5		Gnd	This pin is the combined control circuitry and power ground.
6	10	Output	This output directly drives the gate of a power MOSFET. Peak currents up to 1.0 A are sourced and sunk by this pin.
7	12	V_{CC}	This pin is the positive supply of the control IC.
8	14	V_{ref}	This is the reference output. It provides charging current for capacitor C_T through resistor R_T.
	8	Power Ground	This pin is a separate power ground return that is connected back to the power source. It is used to reduce the effects of switching transient noise on the control circuitry.
	11	V_C	The Output high state (V_{OH}) is set by the voltage applied to this pin. With a separate power source connection, it can reduce the effects of switching transient noise on the control circuitry.
	9	Gnd	This pin is the control circuitry ground return and is connected back to the power source ground.
	2,4,6,13	NC	No connection. These pins are not internally connected.

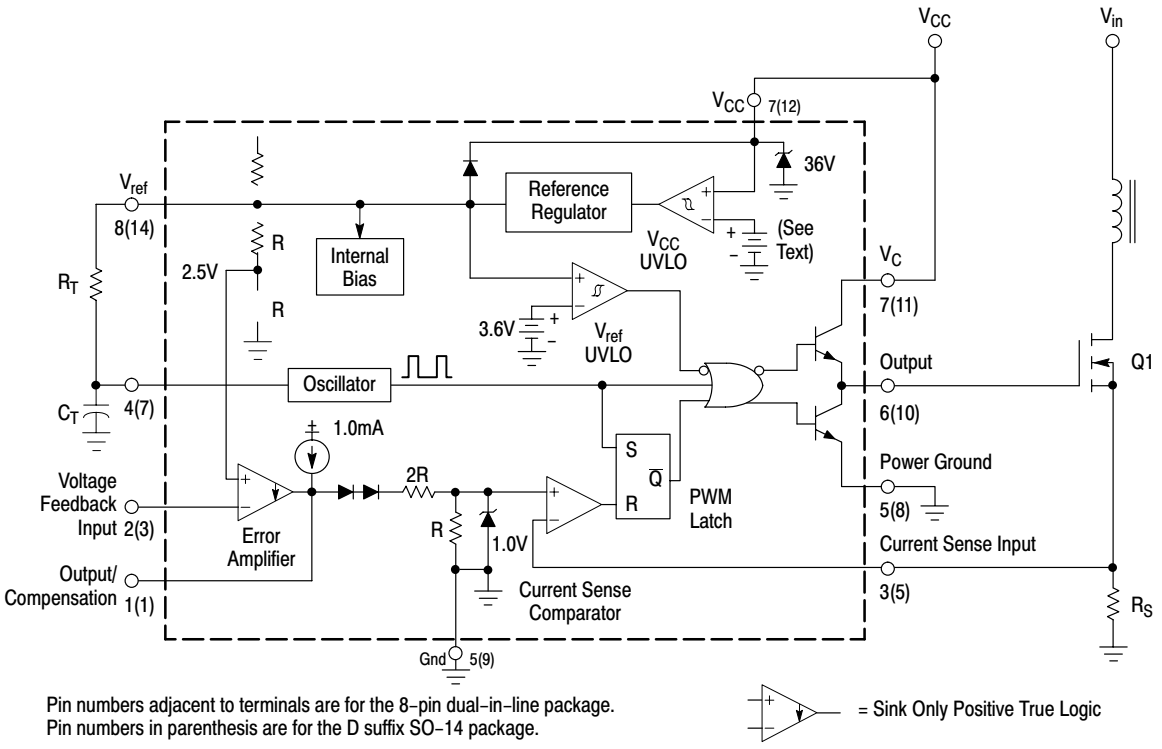


Figure 18. Representative Block Diagram

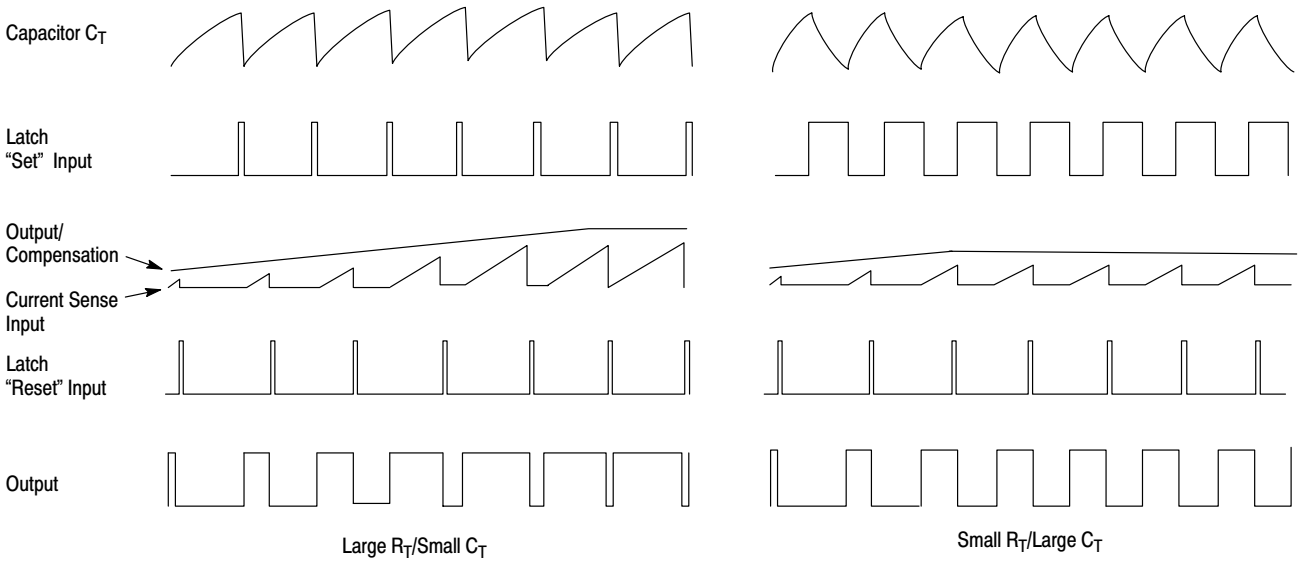


Figure 19. Timing Diagram

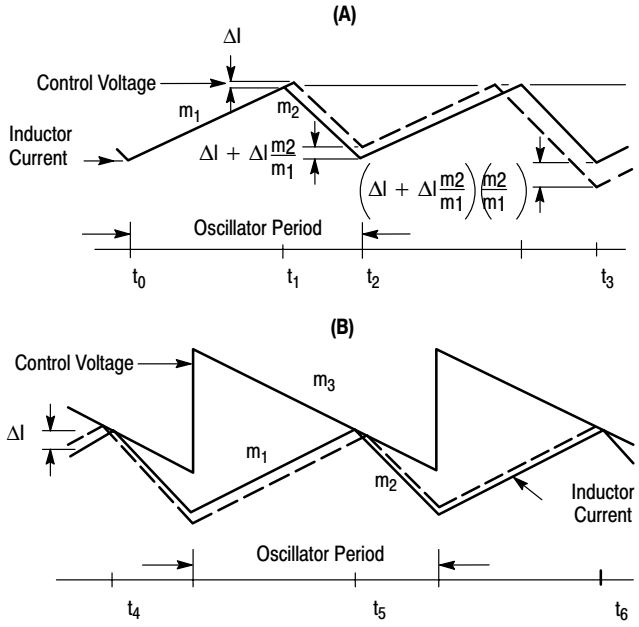
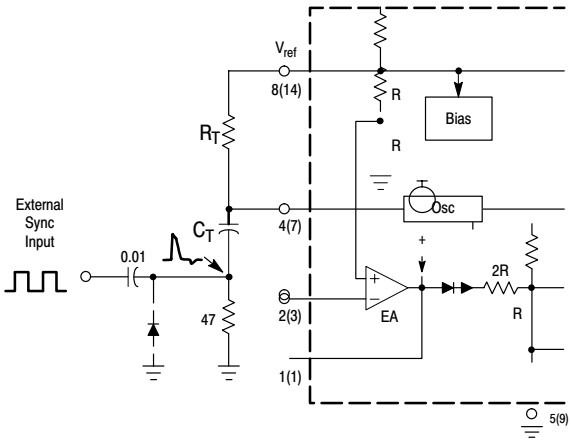
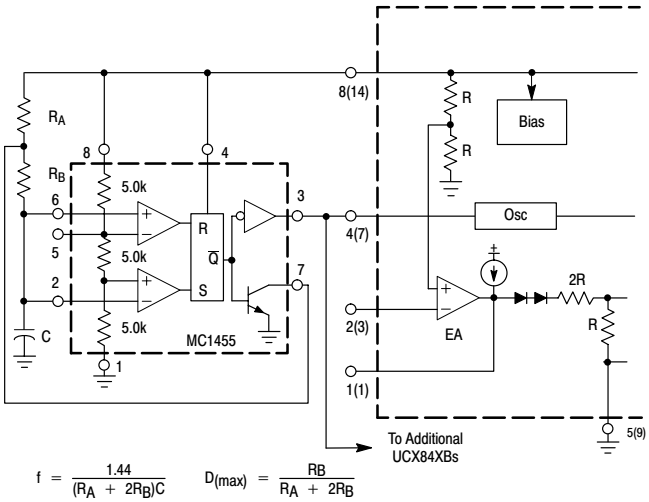


Figure 20. Continuous Current Waveforms



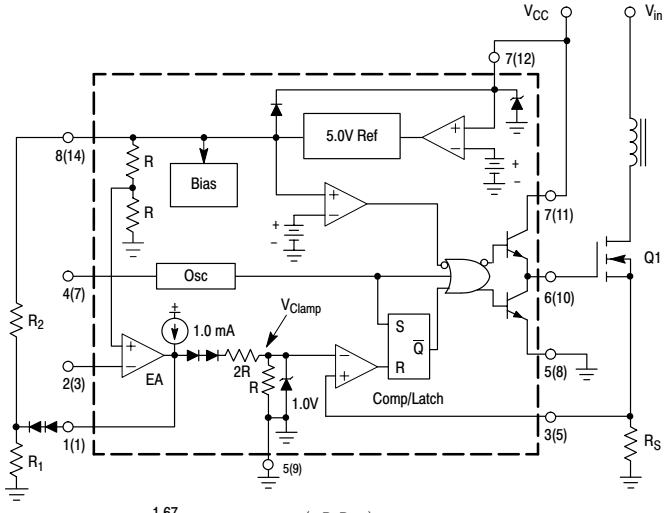
The diode clamp is required if the Sync amplitude is large enough to cause the bottom side of C_T to go more than 300 mV below ground.

Figure 21. External Clock Synchronization



$$f = \frac{1.44}{(R_A + 2R_B)C} \qquad D(max) = \frac{RB}{R_A + 2R_B}$$

Figure 22. External Duty Cycle Clamp and Multi–Unit Synchronization



$$V_{Clamp} \approx \frac{1.67}{\left(\frac{R_2}{R_1} + 1\right)} + 0.33 \times 10^{-3} \left(\frac{R_1 R_2}{R_1 + R_2}\right) \qquad \text{Where: } 0 \le V_{Clamp} \le 1.0\ V$$

$$I_{pk(max)} \approx \frac{V_{Clamp}}{R_S}$$

Figure 23. Adjustable Reduction of Clamp Level

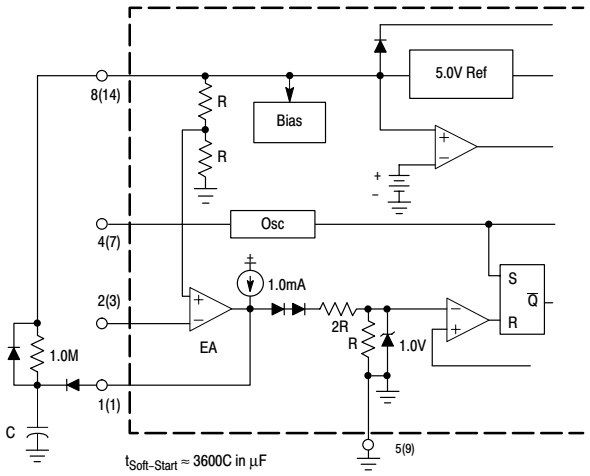


Figure 24. Soft–Start Circuit

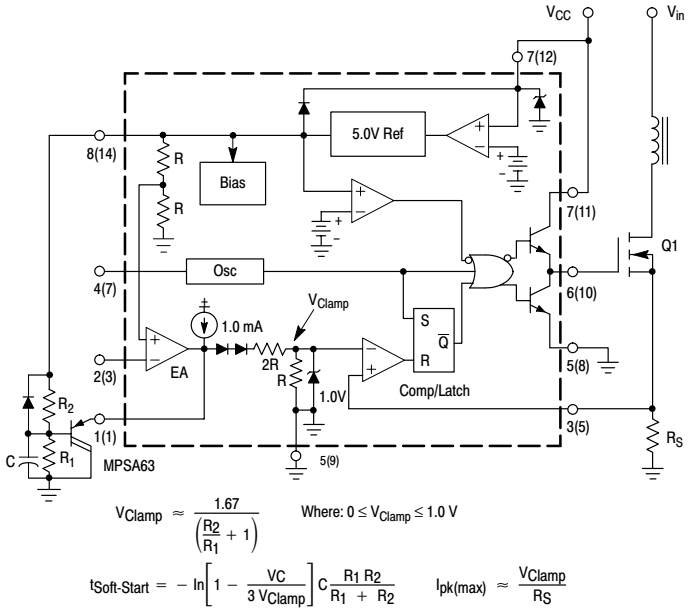
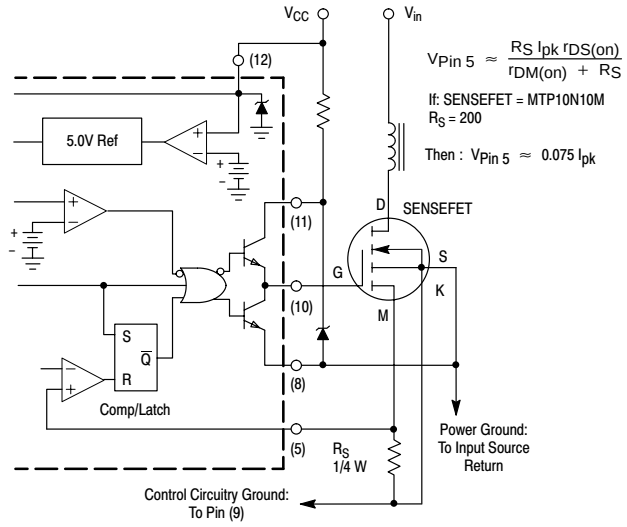
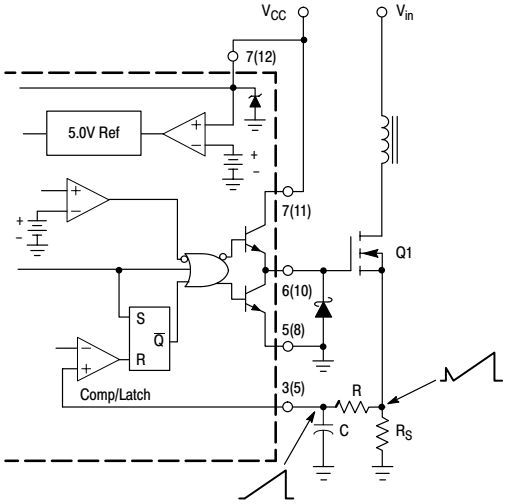


Figure 25. Adjustable Buffered Reduction of Clamp Level with Soft–Start



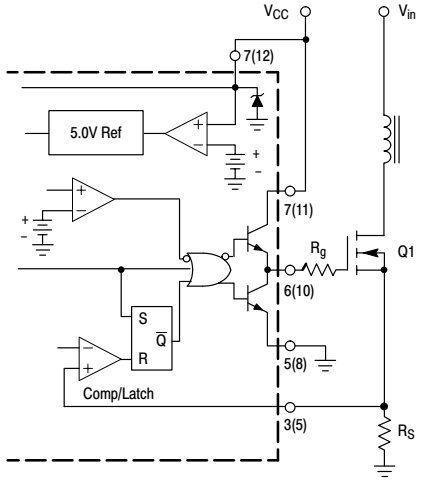
Virtually lossless current sensing can be achieved with the implementation of a SENSEFET power switch. For proper operation during over–current conditions, a reduction of the $I_{pk(max)}$ clamp level must be implemented. Refer to Figures 23 and 25.

Figure 26. Current Sensing Power MOSFET



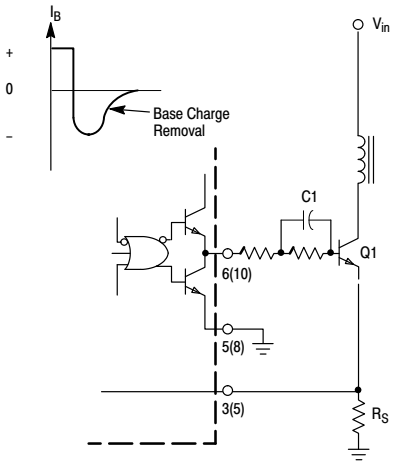
The addition of the RC filter will eliminate instability caused by the leading edge spike on the current waveform.

Figure 27. Current Waveform Spike Suppression



Series gate resistor R_g will damp any high frequency parasitic oscillations caused by the MOSFET input capacitance and any series wiring inductance in the gate−source circuit.

Figure 28. MOSFET Parasitic Oscillations



The totem pole output can furnish negative base current for enhanced transistor turn−off, with the addition of capacitor C_1.

Figure 29. Bipolar Transistor Drive

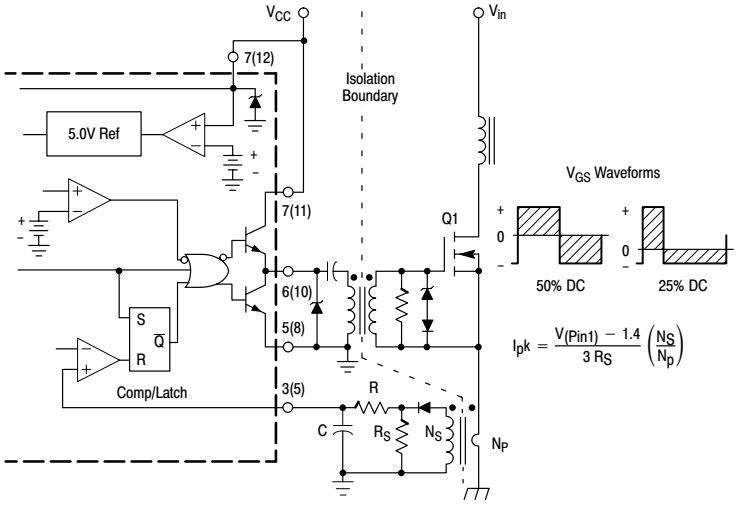
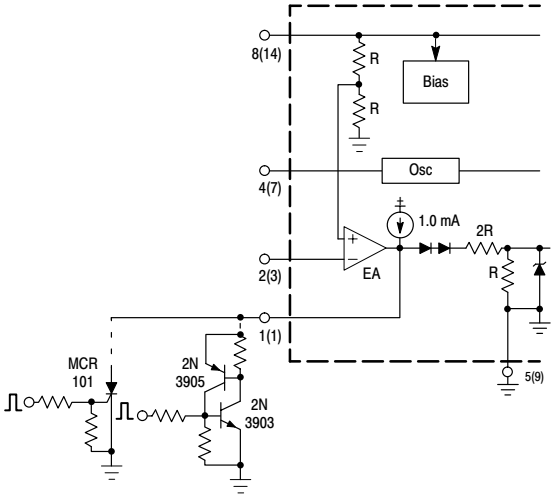
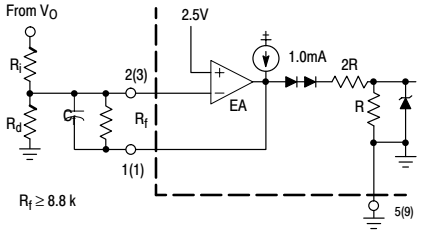


Figure 30. Isolated MOSFET Drive

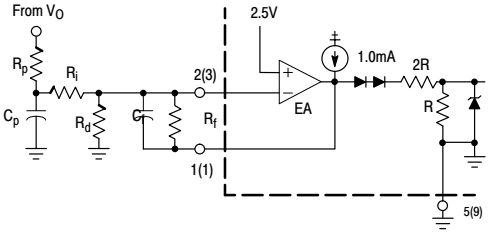


The MCR101 SCR must be selected for a holding of < 0.5 mA @ $T_{A(min)}$. The simple two transistor circuit can be used in place of the SCR as shown. All resistors are 10 k.

Figure 31. Latched Shutdown

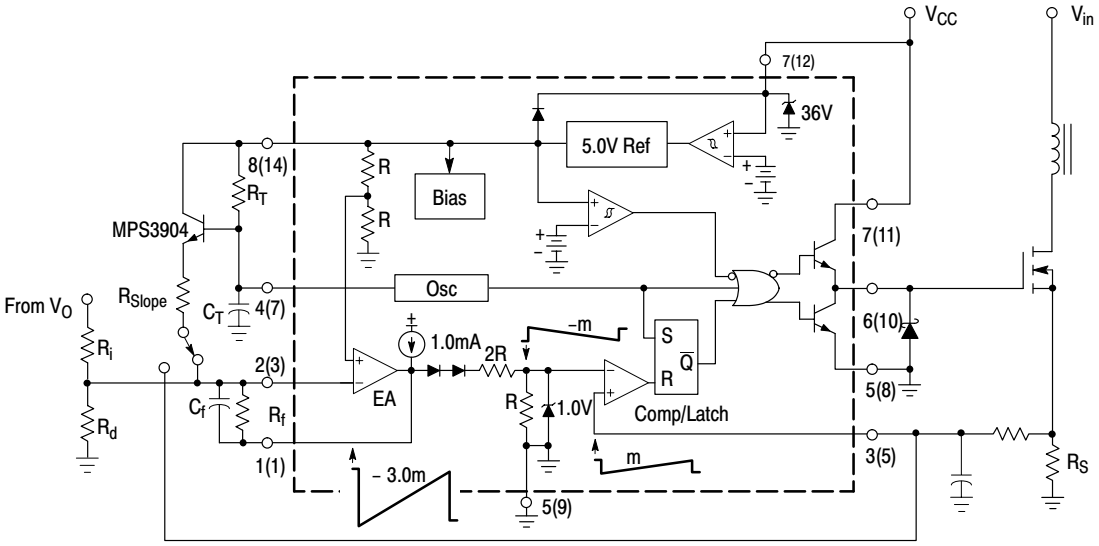


Error Amp compensation circuit for stabilizing any current mode topology except for boost and flyback converters operating with continuous inductor current.



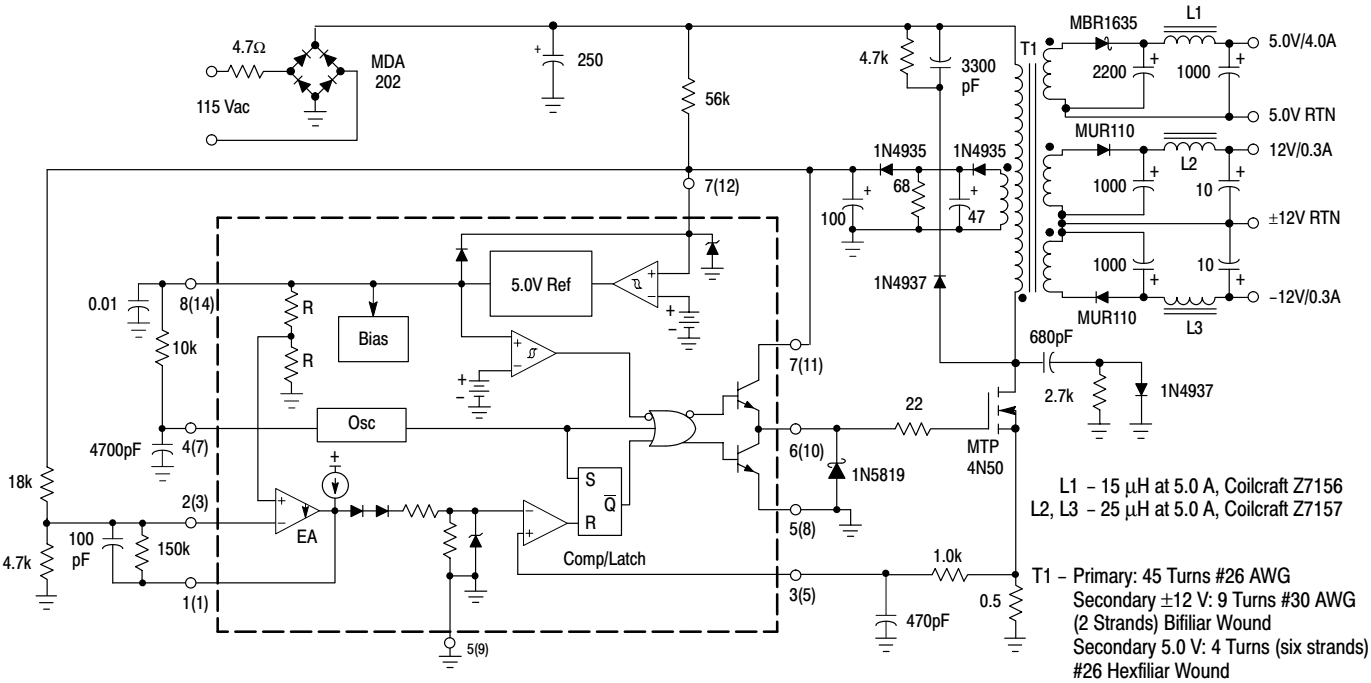
Error Amp compensation circuit for stabilizing current mode boost and flyback topologies operating with continuous inductor current.

Figure 32. Error Amplifier Compensation



The buffered oscillator ramp can be resistively summed with either the voltage feedback or current sense inputs to provide slope compensation.

Figure 33. Slope Compensation



L1 – 15 μH at 5.0 A, Coilcraft Z7156
L2, L3 – 25 μH at 5.0 A, Coilcraft Z7157

T1 – Primary: 45 Turns #26 AWG
Secondary ±12 V: 9 Turns #30 AWG (2 Strands) Bifiliar Wound
Secondary 5.0 V: 4 Turns (six strands) #26 Hexfiliar Wound
Secondary Feedback: 10 Turns #30 AWG (2 strands) Bifiliar Wound
Core: Ferroxcube EC35−3C8
Bobbin: Ferroxcube EC35PCB1
Gap: ≈ 0.10" for a primary inductance of 1.0 mH

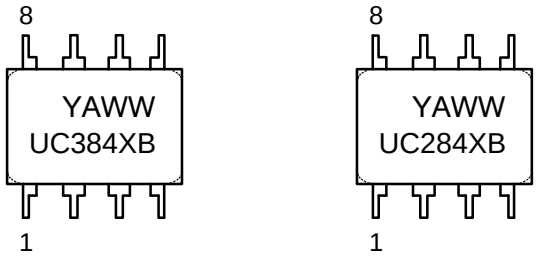
Figure 34. 27 W Off–Line Flyback Regulator

Test	Conditions	Results
Line Regulation: 5.0 V ±12 V	V_{in} = 95 to 130 Vac	Δ = 50 mV or ± 0.5% Δ = 24 mV or ± 0.1%
Load Regulation: 5.0 V ±12 V	V_{in} = 115 Vac, I_{out} = 1.0 A to 4.0 A V_{in} = 115 Vac, I_{out} = 100 mA to 300 mA	Δ = 300 mV or ± 3.0% Δ = 60 mV or ± 0.25%
Output Ripple: 5.0 V ±12 V	V_{in} = 115 Vac	40 mV_{pp} 80 mV_{pp}
Efficiency	V_{in} = 115 Vac	70%

All outputs are at nominal load currents, unless otherwise noted

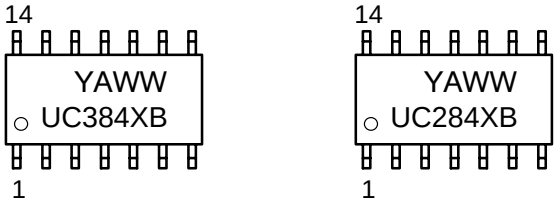
Marking Diagpams

DIP-8



SOP–8

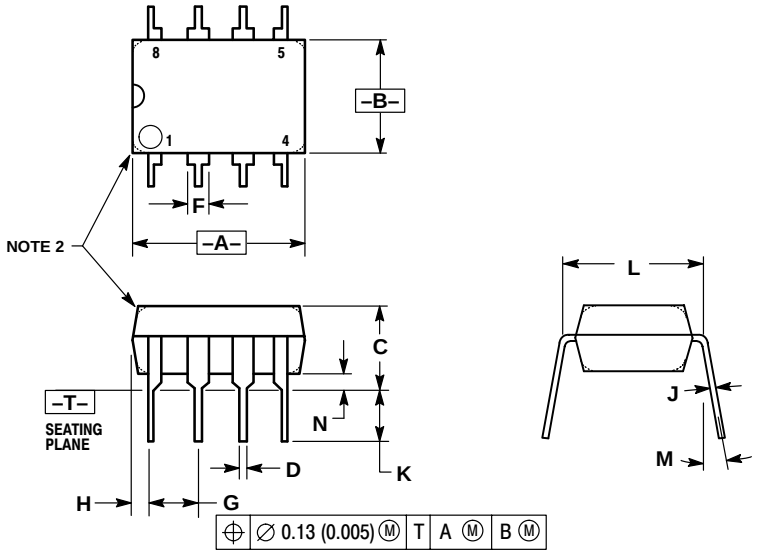
SOP–14



Y	= Year
A	= Assembly Location
WW	= Work Week
UCX84XB	= Device Code
x	= 2, 3, 4or 5

Package Dimensions

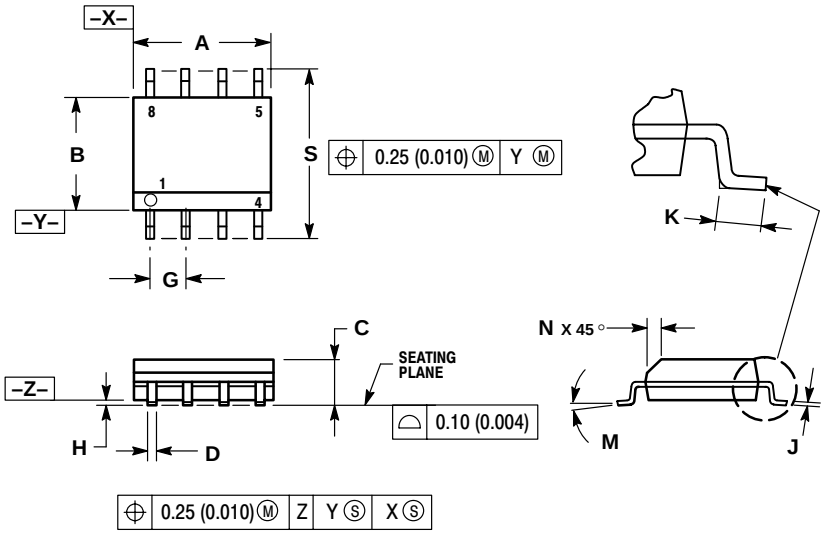
DIP-8



NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	---	10°	---	10°
N	0.76	1.01	0.030	0.040

SOP–8

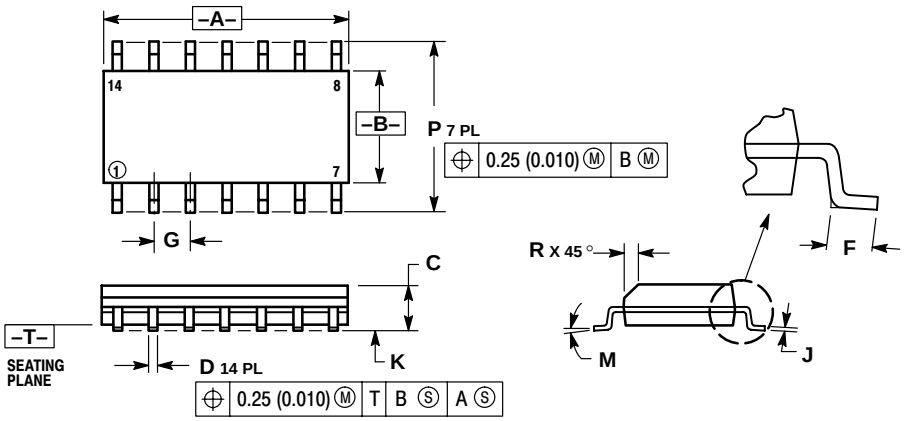


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0°	8°	0°	8°
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

Package Dimensions

SOP–14



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	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0 °	7 °	0 °	7 °
P	5.80	6.20	0.228	0.244
R	0.25	0.50	0.010	0.019