MC34067, MC33067, NCV33067

High Performance Resonant Mode Controllers

The MC34067/MC33067 are high performance zero voltage switch resonant mode controllers designed for off−line and dc−to−dc converter applications that utilize frequency modulated constant off−time or constant deadtime control. These integrated circuits feature a variable frequency oscillator, a precise retriggerable one−shot timer, temperature compensated reference, high gain wide bandwidth error amplifier, steering flip−flop, and dual high current totem pole outputs ideally suited for driving power MOSFETs.

Also included are protective features consisting of a high speed fault comparator and latch, programmable soft−start circuitry, input undervoltage lockout with selectable thresholds, and reference undervoltage lockout. These devices are available in dual−in−line and surface mount packages.

Features

- Zero Voltage Switch Resonant Mode Operation
- Variable Frequency Oscillator with a Control Range Exceeding 1000:1
- Precision One−Shot Timer for Controlled Off−Time
- Internally Trimmed Bandgap Reference
- 4.0 MHz Error Amplifier
- Dual High Current Totem Pole Outputs
- Selectable Undervoltage Lockout Thresholds with Hysteresis
- Enable Input
- Programmable Soft−Start Circuitry
- Low Startup Current for Off−Line Operation
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

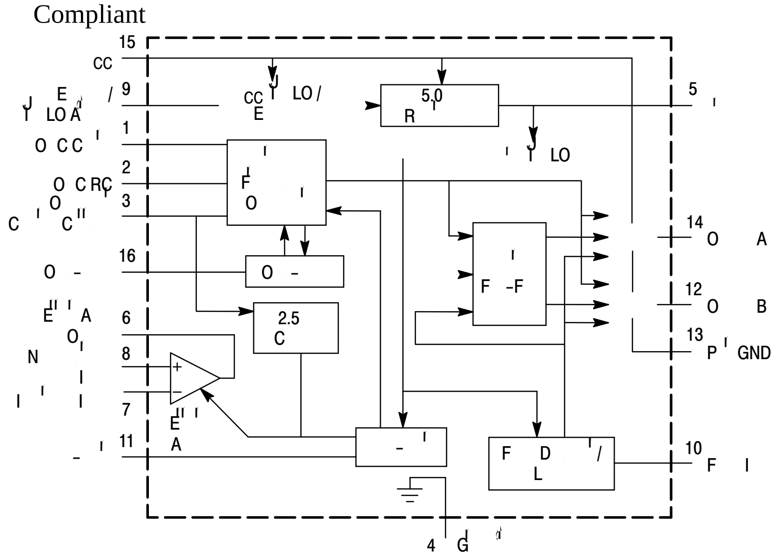

Figure 1. Simplified Block Diagram

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Publication Order Number:
MC34067/D

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC}	20	V
Drive Output Current, Source or Sink (Note 1) − Continuous − Pulsed (0.5 μs), 25% Duty Cycle	I_O	 0.3 1.5	A
Error Amplifier, Fault, One−Shot, Oscillator and Soft−Start Inputs	V_{in}	− 1.0 to + 6.0	V
UVLO Adjust Input	$V_{in(UVLO)}$	− 1.0 to V_{CC}	V
Power Dissipation and Thermal Characteristics DW Suffix, Plastic Package, Case 751G T_A = 25 C Thermal Resistance, Junction−to−Air P Suffix, Plastic Package, Case 648 T_A = 25 C Thermal Resistance, Junction−to−Air	 P_D $R_{\theta JA}$ P_D $R_{\theta JA}$	 862 145 1.25 100	 mW C/W W C/W
Operating Junction Temperature	T_J	+ 150	C
Operating Ambient Temperature MC34067 MC33067, NCV33067	T_A	 0 to + 70 − 40 to + 85	C
Storage Temperature	T_{stg}	− 55 to + 150	C
ESD Capability, HBM Model per JEDEC JESD22−A114F	−	2.0	kV
ESD Capability, CDM Model per JEDEC JESD22−C101E	−	1.0	kV

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

NOTE: This device contains latch−up protection and exceeds 100 mA per JEDEC Standard JESD78.

ORDERING INFORMATION

Device	Package	Shipping†
MC33067DWG	SOIC−16W (Pb−Free)	47 Units / Rail
MC33067DWR2G	SOIC−16W (Pb−Free)	1000 / Tape & Reel
NCV33067DWR2G*	SOIC−16W (Pb−Free)	1000 / Tape & Reel
MC33067PG	PDIP−16 (Pb−Free)	25 Units / Rail
MC34067DWG	SOIC−16W (Pb−Free)	47 Units / Rail
MC34067DWR2G	SOIC−16W (Pb−Free)	1000 / Tape & Reel
MC34067PG	PDIP−16 (Pb−Free)	25 Units / Rail

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 12 V [Note 2], R_{OSC}= 18.2 k, R_{VFO} = 2940 Ω, C_{OSC} = 300 pF, R_T = 2370 Ω, C_T = 300 pF, C_L = 1.0 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.)

Characteristic	Symbol	Min	Typ	Max	Unit
REFERENCE SECTION					
Reference Output Voltage (I_O = 0 mA, T_J = 25 C)	V_{ref}	5.0	5.1	5.2	V
Line Regulation (V_{CC} = 10 V to 18 V)	Reg_{line}	−	1.0	20	mV
Load Regulation (I_O = 0 mA to 10 mA)	Reg_{load}	−	1.0	20	mV
Total Output Variation Over Line, Load, and Temperature	V_{ref}	4.9	−	5.3	V
Output Short Circuit Current (0 C to 70 C) (−40 C to 85 C)	I_O	 30 25	 100 100	 190 225	mA
Reference Undervoltage Lockout Threshold	V_{th}	3.8	4.3	4.8	V
ERROR AMPLIFIER					
Input Offset Voltage (V_{CM} = 1.5 V)	V_{IO}	−	1.0	10	mV
Input Bias Current (V_{CM} = 1.5 V)	I_{IB}	−	0.2	1.0	

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OPERATING DESCRIPTION

Introduction

As power supply designers have strived to increase power conversion efficiency and reduce passive component size, high frequency resonant mode power converters have emerged as attractive alternatives to conventional pulse−width modulated control. When compared to pulse−width modulated converters, resonant mode control offers several benefits including lower switching losses, higher efficiency, lower EMI emission, and smaller size. A new integrated circuit has been developed to support this trend in power supply design. The MC34067 Resonant Mode Controller is a high performance bipolar IC dedicated to variable frequency power control at frequencies exceeding 1.0 MHz. This integrated circuit provides the features and performance specifically for zero voltage switching resonant mode power supply applications.

The primary purpose of the control chip is to provide a fixed off−time to the gates of external power MOSFETs at a repetition rate regulated by a feedback control loop. Additional features of the IC ensure that system startup and fault conditions are administered in a safe, controlled manner.

A simplified block diagram of the IC is shown on the front page, which identifies the main functional blocks and the block−to−block interconnects. Figure 14 is a detailed functional diagram which accurately represents the internal circuitry. The various functions can be divided into two sections. The first section includes the primary control path which produces precise output pulses at the desired frequency. Included in this section are a variable frequency Oscillator, a One−Shot, a pulse Steering Flip−Flop, a pair of power MOSFET Drivers, and a wide bandwidth Error Amplifier. The second section provides several peripheral support functions including a voltage reference, undervoltage lockout, soft−start circuit, and a fault detector.

Primary Control Path

The output pulse width and repetition rate are regulated through the interaction of the variable frequency Oscillator, One−Shot timer and Error Amplifier. The Oscillator triggers the One−Shot which generates a pulse that is alternately steered to a pair of totem pole output drivers by a toggle Flip−Flop. The Error Amplifier monitors the output of the regulator and modulates the frequency of the Oscillator. High speed Schottky logic is used throughout the primary control channel to minimize delays and enhance high frequency characteristics.

Oscillator

The characteristics of the variable frequency Oscillator are crucial for precise controller performance at high operating frequencies. In addition to triggering the One−Shot timer and initiating the output deadtime, the oscillator also determines the initial voltage for the one−shot capacitor. The Oscillator is designed to operate at frequencies exceeding 1.0 MHz. The Error Amplifier can control the oscillator frequency over a 1000:1 frequency range, and both the minimum and maximum frequencies are easily and accurately programmed by the proper selection of external components.

The functional diagram of the Oscillator and One−Shot timer is shown in Figure 16. The oscillator capacitor (C_{OSC}) is initially charged by transistor Q1. When C_{OSC} exceeds the 4.9 V upper threshold of the oscillator comparator, the base of Q1 is pulled low allowing C_{OSC} to discharge through the external resistor, (R_{OSC}), and the oscillator control current, (I_{OSC}). When the voltage on C_{OSC} falls below the 3.6 V lower threshold of the comparator, Q1 turns on and again charges C_{OSC}.

C_{OSC} charges from 3.6 V to 5.1 V in less than 50 ns. The high slew rate of C_{OSC} and the propagation delay of the comparator make it difficult to control the peak voltage. This accuracy issue is overcome by clamping the base of Q1 through a diode to a voltage reference. The peak voltage of the oscillator waveform is thereby precisely set at 5.1 V.

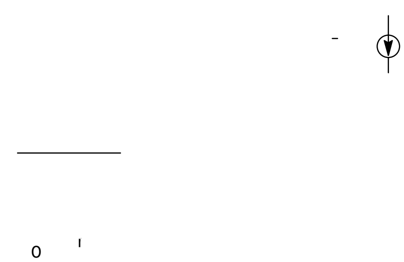

Figure 16. Oscillator and One−Shot Timer

The minimum frequency is programmed by R_{OSC} using Equation 1:

$$R_{OSC} = \frac{\frac{1}{(min)} - t_{PD}}{C_{OSC}\ \ell n\left(\frac{5.1}{3.6}\right)} = \frac{t_{(max)} - 70\text{ ns}}{0.348\ C_{OSC}} \qquad \text{(eq. 1)}$$

where t_{PD} is the internal propagation delay.

The maximum oscillator frequency is set by the current through resistor R_{VFO}. The current required to discharge C_{OSC} at the maximum oscillator frequency can be calculated by Equation 2:

$$I_{(max)} = C_{OSC}\frac{5.1 - 3.6}{\frac{1}{(max)}} = 1.5C_{OSC}\ (max) \qquad \text{(eq. 2)}$$

The discharge current through R_{OSC} must also be known and can be calculated by Equation 3:

$$I_{R_{OSC}} = \frac{5.1 - 3.6}{R_{OSC}}\frac{\left(-\frac{\frac{1}{(min)}}{R_{OSC}C_{OSC}}\right)}{\left(-\frac{1}{(min)\ R_{OSC}C_{OSC}}\right)} = \frac{1.5}{R_{OSC}} \qquad \text{(eq. 3)}$$

Resistor R_{VFO} can now be calculated by Equation 4:

$$R_{VFO} = \frac{2.5 - V_{EAsat}}{I_{(max)} - I_{R_{OSC}}} \qquad \text{(eq. 4)}$$

One−Shot Timer

The One−Shot is designed to disable both outputs simultaneously providing a deadtime before either output is enabled. The One−Shot capacitor (C_T) is charged concurrently with the oscillator capacitor by transistor Q1, as shown in Figure 16. The one−shot period begins when the oscillator comparator turns off Q1, allowing C_T to discharge. The period ends when resistor R_T discharges C_T to the threshold of the One−Shot comparator. The lower threshold of the One−Shot is 3.6 V. By choosing C_T, R_T can by solved by Equation 5:

$$R_T = \frac{t_{OS}}{C_T\ \ell n\left(\frac{5.1}{3.6}\right)} = \frac{t_{OS}}{0.348\ C_T} \qquad \text{(eq. 5)}$$

Errors in the threshold voltage and propagation delays through the output drivers will affect the One−Shot period. To guarantee accuracy, the output pulse of the control chip is trimmed to within 5% of 250 ns with nominal values of R_T and C_T.

The outputs of the Oscillator and One−Shot comparators are OR'd together to produce the pulse t_{OS}, which drives the Flip−Flop and output drivers. The output pulse (t_{OS}) is initiated by the Oscillator and terminated by the One−Shot comparator. With zero voltage resonant mode converters, the oscillator discharge time should never be set less than the one−shot period.

Error Amplifier

A fully accessible high performance Error Amplifier is provided for feedback 8 267.255aD2D-.0006 TQc.0ded for Tw6Tj/F5 122

The totem−pole output drivers are ideally suited for driving power MOSFETs and are capable of sourcing and sinking 1.5 A. Rise and fall times are typically 20 ns and 15 ns respectfully when driving a 1.0 nF load. High source/sink capability in a totem−pole driver normally increases the risk

The maximum duty cycle is controlled by the leakage inductance, not by the MC34067. The One−Shot in the MC34067 only assures that the power switch is turned on under a zero voltage condition. Adjust the one−shot period so that the output switch is activated while the primary current is slewing but before the current changes polarity. The resonant stage should then be designed to be as long as the time for the primary current to go to 0 A.

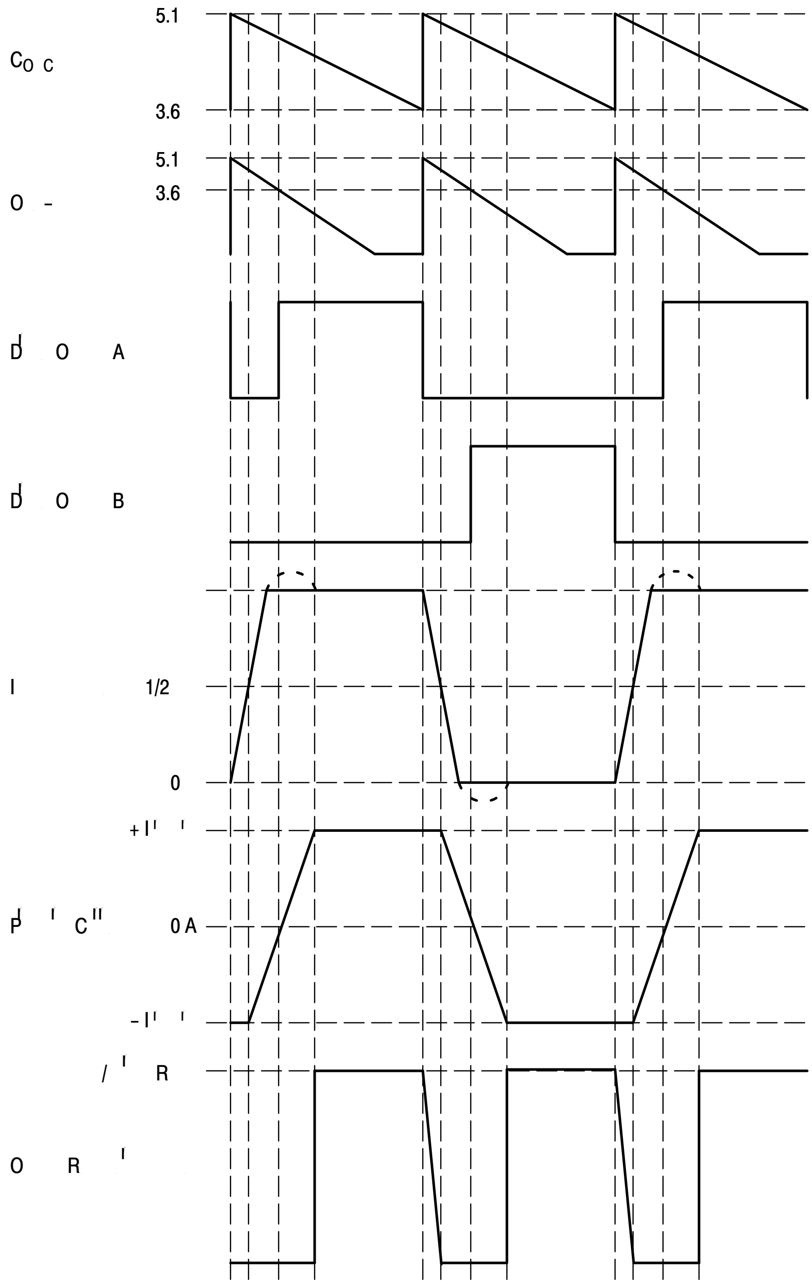

Figure 21. Application Timing Diagram

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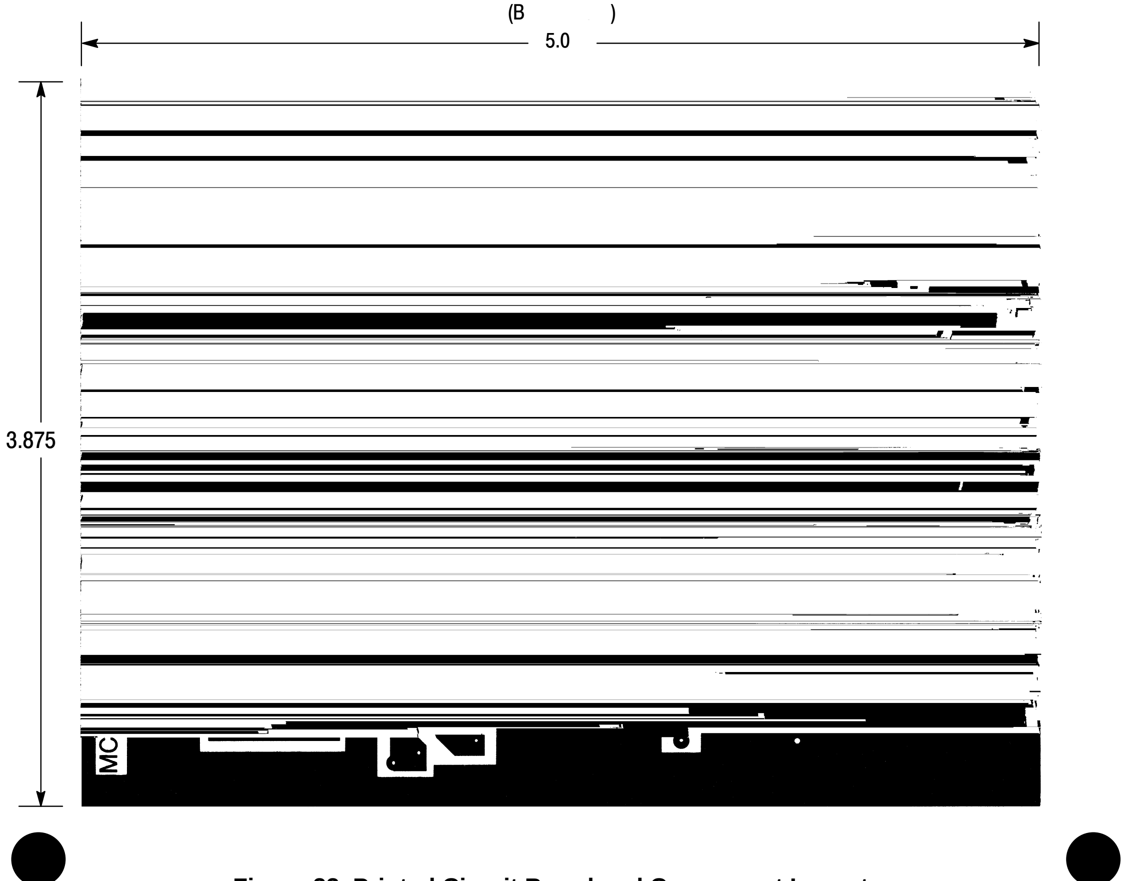
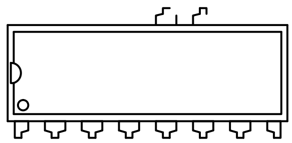
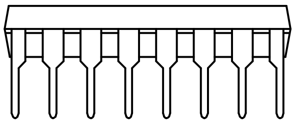


Figure 23. Printed Circuit Board and Component Layout





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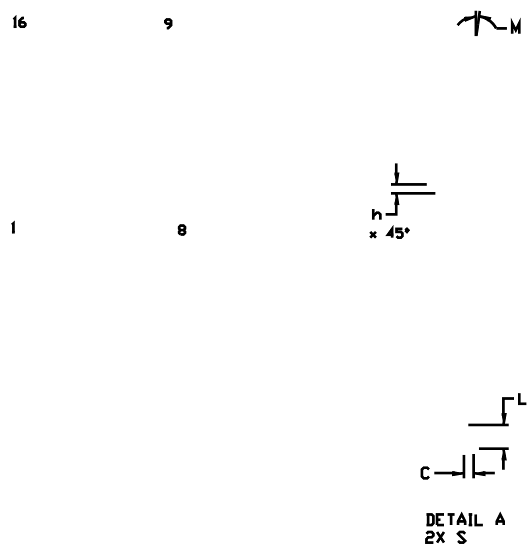

−Free indicator, “G” or microdot “▪”, may or may not be present. Some products may not follow the Generic Marking.