

# MC34060A, MC33060A

## Fixed Frequency, PWM, Voltage Mode Single Ended Controllers

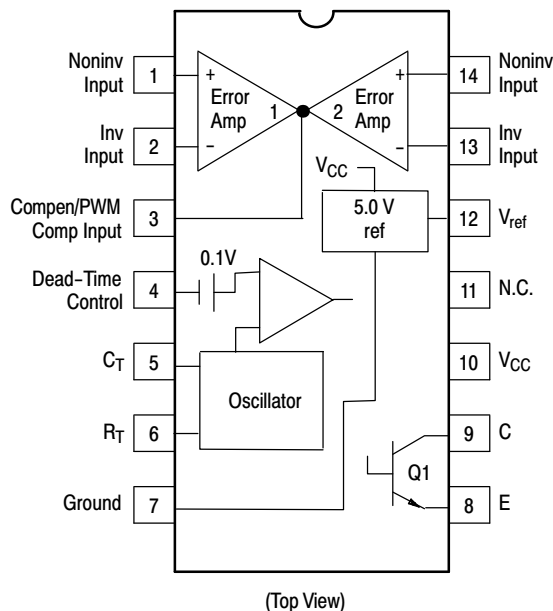
The MC34060A is a low cost fixed frequency, pulse width modulation control circuit designed primarily for single-ended SWITCHMODE™ power supply control.

The MC34060A is specified over the commercial operating temperature range of 0° to +70°C, and the MC33060A is specified over an automotive temperature range of -40° to +85°C.

### Features

- Complete Pulse Width Modulation Control Circuitry
- On-Chip Oscillator with Master or Slave Operation
- On-Chip Error Amplifiers
- On-Chip 5.0 V Reference, 1.5% Accuracy
- Adjustable Dead-Time Control
- Uncommitted Output Transistor Rated to 200 mA Source or Sink
- Undervoltage Lockout
- These are Pb-Free and Halide-Free Devices

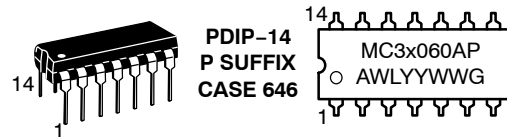
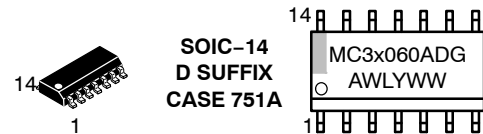
### PIN CONNECTIONS



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### MARKING DIAGRAMS



- x = 3 or 4
- A = Assembly Location
- WL = Wafer Lot
- Y, YY = Year
- WW = Work Week
- G = Pb-Free Package

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 14 of this data sheet.

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## MAXIMUM RATINGS (Full operating ambient temperature range applies, unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltage	$V_{CC}$	42	V
Collector Output Voltage	$V_C$	42	V
Collector Output Current (Note 3)	$I_C$	500	mA
Amplifier Input Voltage Range	$V_{in}$	-0.3 to +42	V
Power Dissipation @ $T_A \leq 45^\circ\text{C}$	$P_D$	1000	mW
Operating Junction Temperature	$T_J$	125	$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-55 to +125	$^\circ\text{C}$
Operating Ambient Temperature Range For MC34060A For MC33060A	$T_A$	0 to +70 -40 to +85	$^\circ\text{C}$
ESD Capability Machine Model Human Body Model		200 2.0	V kV

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

- This device series contains ESD protection and exceeds the following tests:  
Pins 1– 14: Human Body Model 2000 V per JEDEC Standard JESD22–A114E.  
Machine Model Method 200 V per JEDEC Standard JESD22–A115–A.
- This device contains Latch–Up protection and exceeds  $\pm 100$  mA per JEDEC Standard JESD78.

## THERMAL CHARACTERISTICS

Characteristics	Symbol	P Suffix Package	D Suffix Package	Unit
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	80	120	$^\circ\text{C}/\text{W}$
Derating Ambient Temperature	$T_A$	45	45	$^\circ\text{C}$

## RECOMMENDED OPERATING CONDITIONS

Condition/Value	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	$V_{CC}$	7.0	15	40	V
Collector Output Voltage	$V_C$	–	30	40	V
Collector Output Current	$I_C$	–	–	200	mA
Amplifier Input Voltage	$V_{in}$	-0.3	–	$V_{CC} - 2$	V
Current Into Feedback Terminal	$I_{fb}$	–	–	0.3	mA
Reference Output Current	$I_{ref}$	–	–	10	mA
Timing Resistor	$R_T$	1.8	47	500	$k\Omega$
Timing Capacitor	$C_T$	0.00047	0.001	10	$\mu\text{F}$
Oscillator Frequency	$f_{osc}$	1.0	25	200	kHz
PWM Input Voltage (Pins 3 and 4)	–	-0.3	–	5.3	V

- Maximum thermal limits must be observed.

# MC34060A, MC33060A

**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = 15\text{ V}$ ,  $C_T = 0.01\ \mu\text{F}$ ,  $R_T = 12\ \text{k}\Omega$ , unless otherwise noted. For typical values  $T_A = 25^\circ\text{C}$ , for min/max values  $T_A$  is the operating ambient temperature range that applies, unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
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## REFERENCE SECTION

Reference Voltage ( $I_O = 1.0\ \text{mA}$ , $T_A = 25^\circ\text{C}$ ) $T_A = T_{\text{low}}$ to $T_{\text{high}}$ – MC34060A – MC33060A	$V_{\text{ref}}$	4.925 4.9 4.85	5.0 – –	5.075 5.1 5.1	V
Line Regulation ( $V_{CC} = 7.0\ \text{V}$ to $40\ \text{V}$ , $I_O = 10\ \text{mA}$ )	$\text{Reg}_{\text{line}}$	–	2.0	25	mV
Load Regulation ( $I_O = 1.0\ \text{mA}$ to $10\ \text{mA}$ )	$\text{Reg}_{\text{load}}$	–	2.0	15	mV
Short Circuit Output Current ( $V_{\text{ref}} = 0\ \text{V}$ )	$I_{\text{SC}}$	15	35	75	mA

## OUTPUT SECTION

Collector Off-State Current ( $V_{CC} = 40\ \text{V}$ , $V_{CE} = 40\ \text{V}$ )	$I_{C(\text{off})}$	–	2.0	100	$\mu\text{A}$
Emitter Off-State Current ( $V_{CC} = 40\ \text{V}$ , $V_{CE} = 40\ \text{V}$ , $V_E = 0\ \text{V}$ )	$I_{E(\text{off})}$	–	–	–100	$\mu\text{A}$
Collector-Emitter Saturation Voltage (Note 4) Common-Emitter ( $V_E = 0\ \text{V}$ , $I_C = 200\ \text{mA}$ ) Emitter-Follower ( $V_C = 15\ \text{V}$ , $I_E = -200\ \text{mA}$ )	$V_{\text{sat}(C)}$  $V_{\text{sat}(E)}$	–  –	1.1  1.5	1.5  2.5	V
Output Voltage Rise Time ( $T_A = 25^\circ\text{C}$ ) Common-Emitter (See Figure 12) Emitter-Follower (See Figure 13)	$t_r$	– –	100 100	200 200	ns
Output Voltage Fall Time ( $T_A = 25^\circ\text{C}$ ) Common-Emitter (See Figure 12) Emitter-Follower (See Figure 13)	$t_r$	– –	40 40	100 100	ns

## ERROR AMPLIFIER SECTION

Input Offset Voltage ( $V_{O[\text{Pin } 3]} = 2.5\ \text{V}$ )	$V_{\text{IO}}$	–	2.0	10	mV
Input Offset Current ( $V_{C[\text{Pin } 3]} = 2.5\ \text{V}$ )	$I_{\text{IO}}$	–	5.0	250	nA
Input Bias Current ( $V_{O[\text{Pin } 3]} = 2.5\ \text{V}$ )	$I_{\text{IB}}$	–	–0.1	–2.0	$\mu\text{A}$
Input Common Mode Voltage Range ( $V_{CC} = 40\ \text{V}$ )	$V_{\text{ICR}}$	0 to $V_{CC} - 2.0$	–	–	V
Inverting Input Voltage Range	$V_{\text{IR(INV)}}$	–0.3 to $V_{CC} - 2.0$	–	–	V
Open-Loop Voltage Gain ( $\Delta V_O = 3.0\ \text{V}$ , $V_O = 0.5\ \text{V}$ to $3.5\ \text{V}$ , $R_L = 2.0\ \text{k}\Omega$ )	$A_{\text{VOL}}$	70	95	–	dB
Unity-Gain Crossover Frequency ( $V_O = 0.5\ \text{V}$ to $3.5\ \text{V}$ , $R_L = 2.0\ \text{k}\Omega$ )	$f_c$	–	600	–	kHz
Phase Margin at Unity-Gain ( $V_O = 0.5\ \text{V}$ to $3.5\ \text{V}$ , $R_L = 2.0\ \text{k}\Omega$ )	$\phi_m$	–	65	–	deg.
Common Mode Rejection Ratio ( $V_{CC} = 40\ \text{V}$ , $V_{\text{in}} = 0\ \text{V}$ to $38\ \text{V}$ )	CMRR	65	90	–	dB
Power Supply Rejection Ratio ( $\Delta V_{CC} = 33\ \text{V}$ , $V_O = 2.5\ \text{V}$ , $R_L = 2.0\ \text{k}\Omega$ )	PSRR	–	100	–	dB
Output Sink Current ( $V_{O[\text{Pin } 3]} = 0.7\ \text{V}$ )	$I_{O-}$	0.3	0.7	–	mA
Output Source Current ( $V_{O[\text{Pin } 3]} = 3.5\ \text{V}$ )	$I_{O+}$	–2.0	–4.0	–	mA

4. Low duty cycle techniques are used during test to maintain junction temperature as close to ambient temperatures as possible.

$T_{\text{low}} = -40^\circ\text{C}$  for MC33060A  
=  $0^\circ\text{C}$  for MC34060A

$T_{\text{high}} = +85^\circ\text{C}$  for MC33060A  
=  $+70^\circ\text{C}$  for MC34060A

# MC34060A, MC33060A

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{CC} = 15\text{ V}$ ,  $C_T = 0.01\ \mu\text{F}$ ,  $R_T = 12\ \text{k}\Omega$ , unless otherwise noted.)

For typical values  $T_A = 25^\circ\text{C}$ , for min/max values  $T_A$  is the operating ambient temperature range that applies, unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
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## PWM COMPARATOR SECTION (Test circuit Figure 11)

Input Threshold Voltage (Zero Duty Cycle)	$V_{TH}$	–	3.5	4.5	V
Input Sink Current ( $V_{[Pin\ 3]} = 0.7\ \text{V}$ )	$I_I$	0.3	0.7	–	mA

## DEAD-TIME CONTROL SECTION (Test circuit Figure 11)

Input Bias Current (Pin 4) ( $V_{in} = 0\ \text{V}$ to $5.25\ \text{V}$ )	$I_{IB(DT)}$	–	–1.0	–10	$\mu\text{A}$
Maximum Output Duty Cycle ( $V_{in} = 0\ \text{V}$ , $C_T = 0.01\ \mu\text{F}$ , $R_T = 12\ \text{k}\Omega$ ) ( $V_{in} = 0\ \text{V}$ , $C_T = 0.001\ \mu\text{F}$ , $R_T = 47\ \text{k}\Omega$ )	$DC_{max}$	90 –	96 92	100 –	%
Input Threshold Voltage (Pin 4) (Zero Duty Cycle) (Maximum Duty Cycle)	$V_{TH}$	– 0	2.8 –	3.3 –	V

## OSCILLATOR SECTION

Frequency ( $C_T = 0.01\ \mu\text{F}$ , $R_T = 12\ \text{k}\Omega$ , $T_A = 25^\circ\text{C}$ ) $T_A = T_{low}$ to $T_{high}$ – MC34060A – MC33060A ( $C_T = 0.001\ \mu\text{F}$ , $R_T = 47\ \text{k}\Omega$ )	$f_{osc}$	9.7 9.5 9.0 –	10.5 – – 25	11.3 11.5 11.5 –	kHz
Standard Deviation of Frequency* ( $C_T = 0.001\ \mu\text{F}$ , $R_T = 47\ \text{k}\Omega$ )	$\sigma_{f_{osc}}$	–	1.5	–	%
Frequency Change with Voltage ( $V_{CC} = 7.0\ \text{V}$ to $40\ \text{V}$ )	$\Delta f_{osc}(\Delta V)$	–	0.5	2.0	%
Frequency Change with Temperature ( $\Delta T_A = T_{low}$ to $T_{high}$ ) ( $C_T = 0.01\ \mu\text{F}$ , $R_T = 12\ \text{k}\Omega$ )	$\Delta f_{osc}(\Delta T)$	– –	4.0 –	– –	%

## UNDERVOLTAGE LOCKOUT SECTION

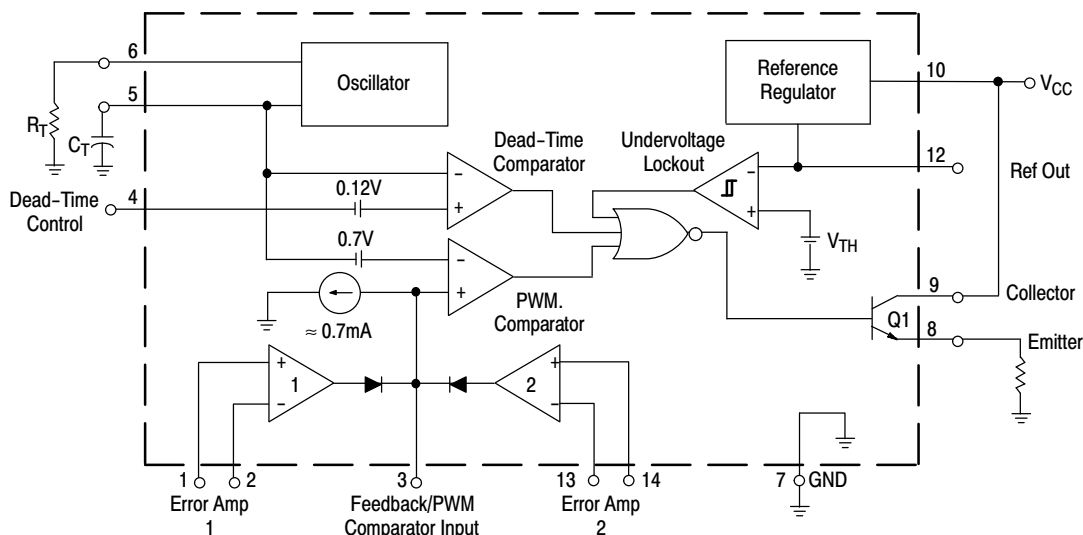
Turn-On Threshold ( $V_{CC}$ increasing, $I_{ref} = 1.0\ \text{mA}$ )	$V_{th}$	4.0	4.7	5.5	V
Hysteresis	$V_H$	50	150	300	mV

## TOTAL DEVICE

Standby Supply Current (Pin 6 at $V_{ref}$ , all other inputs and outputs open) ( $V_{CC} = 15\ \text{V}$ ) ( $V_{CC} = 40\ \text{V}$ )	$I_{CC}$	– –	5.5 7.0	10 15	mA
Average Supply Current ( $V_{[Pin\ 4]} = 2.0\ \text{V}$ , $C_T = 0.001\ \mu\text{F}$ , $R_T = 47\ \text{k}\Omega$ ). See Figure 11.	$I_S$	–	7.0	–	mA

\*Standard deviation is a measure of the statistical distribution about the mean as derived from the formula;  $\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N-1}}$

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This device contains 46 active transistors.

**Figure 1. Block Diagram**

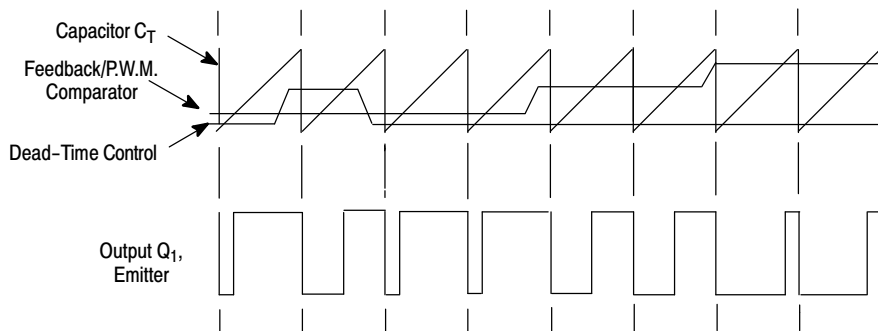
## Description

The MC34060A is a fixed-frequency pulse width modulation control circuit, incorporating the primary building blocks required for the control of a switching power supply (see Figure 1). An internal-linear sawtooth oscillator is frequency-programmable by two external components,  $R_T$  and  $C_T$ . The approximate oscillator frequency is determined by:

$$f_{osc} \cong \frac{1.2}{R_T \cdot C_T}$$

For more information refer to Figure 3.

Output pulse width modulation is accomplished by comparison of the positive sawtooth waveform across capacitor  $C_T$  to either of two control signals. The output is enabled only during that portion of time when the sawtooth voltage is greater than the control signals. Therefore, an increase in control-signal amplitude causes a corresponding linear decrease of output pulse width. (Refer to the Timing Diagram shown in Figure 2.)



**Figure 2. Timing Diagram**

APPLICATIONS INFORMATION

The control signals are external inputs that can be fed into the dead-time control, the error amplifier inputs, or the feed-back input. The dead-time control comparator has an effective 120 mV input offset which limits the minimum output dead time to approximately the first 4% of the sawtooth-cycle time. This would result in a maximum duty cycle of 96%. Additional dead time may be imposed on the output by setting the dead time-control input to a fixed voltage, ranging between 0 V to 3.3 V.

The pulse width modulator comparator provides a means for the error amplifiers to adjust the output pulse width from the maximum percent on-time, established by the dead time control input, down to zero, as the voltage at the feedback

pin varies from 0.5 V to 3.5 V. Both error amplifiers have a common mode input range from -0.3 V to ( $V_{CC} - 2.0$  V), and may be used to sense power supply output voltage and current. The error-amplifier outputs are active high and are ORed together at the noninverting input of the pulse-width modulator comparator. With this configuration, the amplifier that demands minimum output on time, dominates control of the loop.

The MC34060A has an internal 5.0 V reference capable of sourcing up to 10 mA of load currents for external bias circuits. The reference has an internal accuracy of  $\pm 5\%$  with a typical thermal drift of less than 50 mV over an operating temperature range of 0° to +70°C.

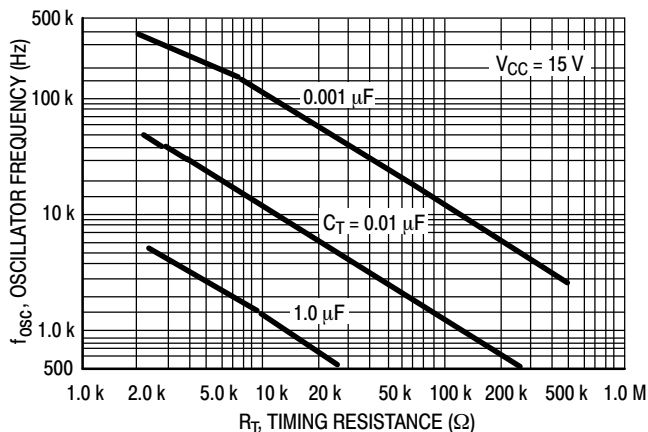


Figure 3. Oscillator Frequency versus Timing Resistance

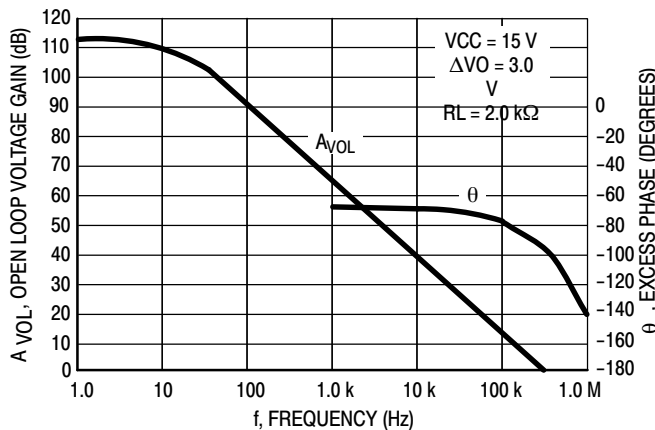


Figure 4. Open Loop Voltage Gain and Phase versus Frequency

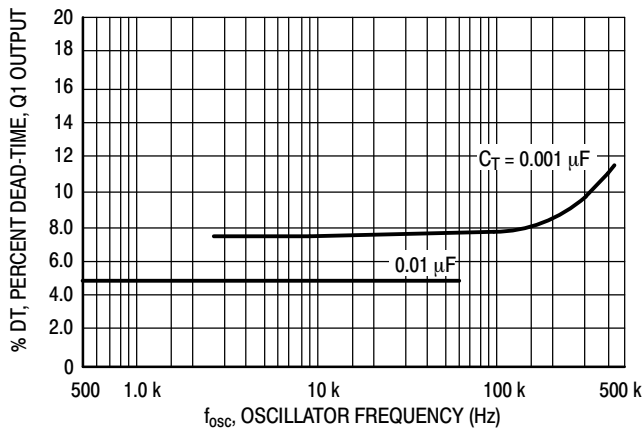


Figure 5. Percent Deadtime versus Oscillator Frequency

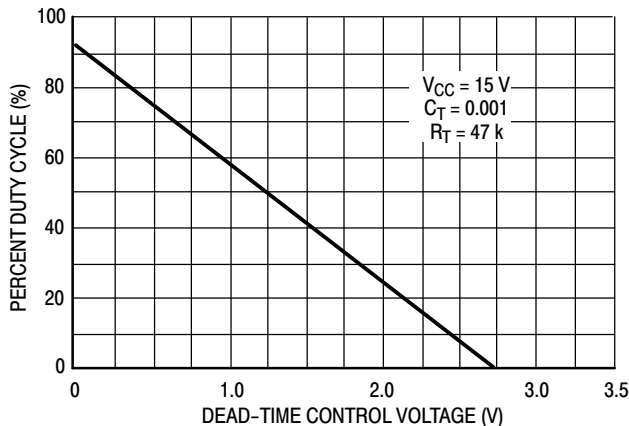
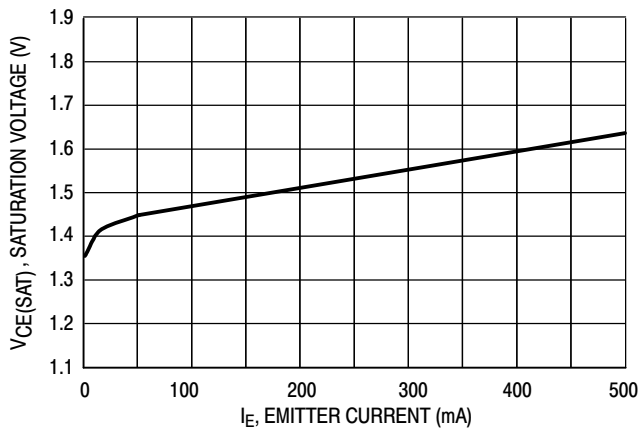
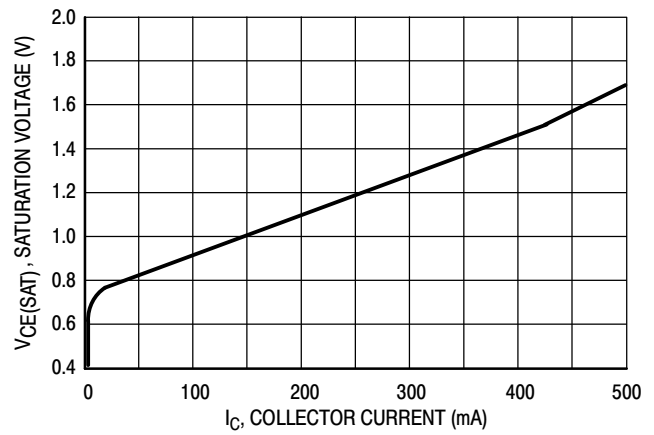


Figure 6. Percent Duty Cycle versus Dead-Time Control Voltage

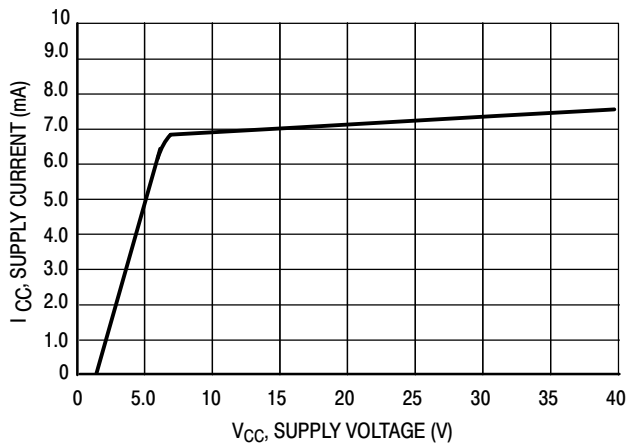
# MC34060A, MC33060A



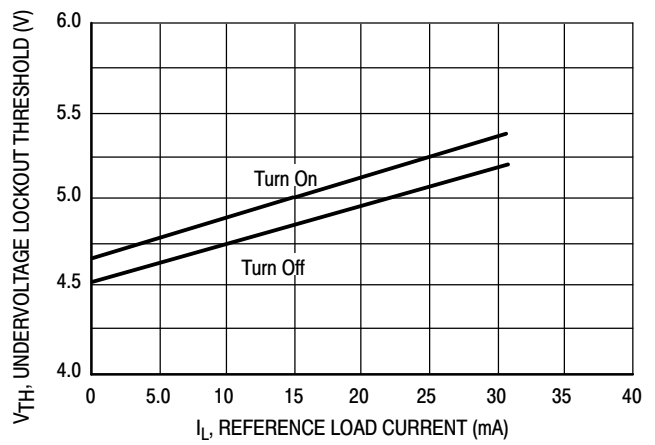
**Figure 7. Emitter-Follower Configuration Output Saturation Voltage versus Emitter Current**



**Figure 8. Common-Emitter Configuration Output Saturation Voltage versus Collector Current**



**Figure 9. Standby Supply Current versus Supply Voltage**



**Figure 10. Undervoltage Lockout Thresholds versus Reference Load Current**

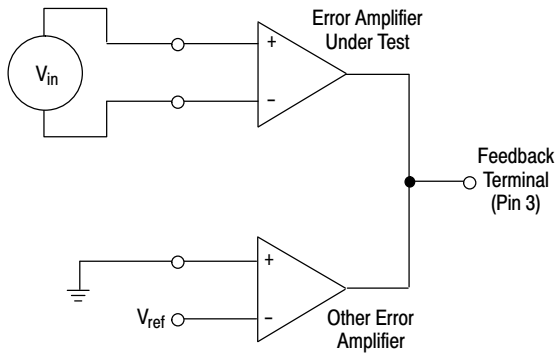


Figure 11. Error Amplifier Characteristics

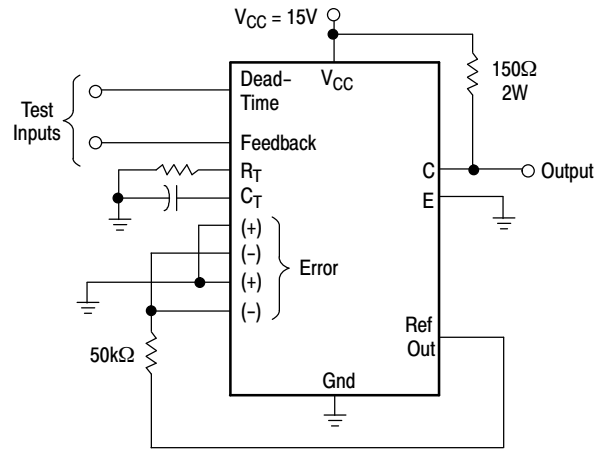


Figure 12. Deadtime and Feedback Control

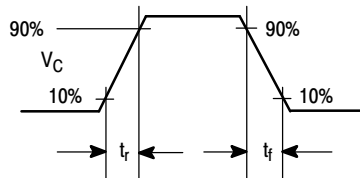
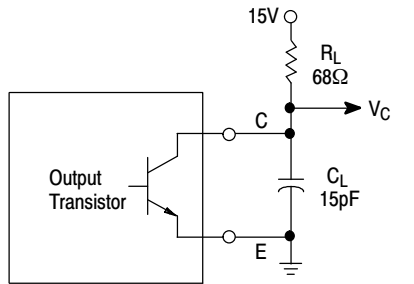


Figure 13. Common-Emitter Configuration and Waveform

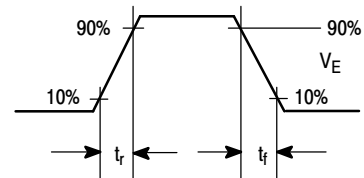
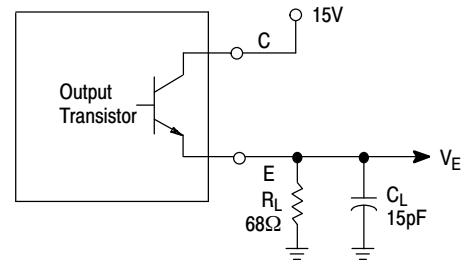


Figure 14. Emitter-Follower Configuration and Waveform



# MC34060A, MC33060A

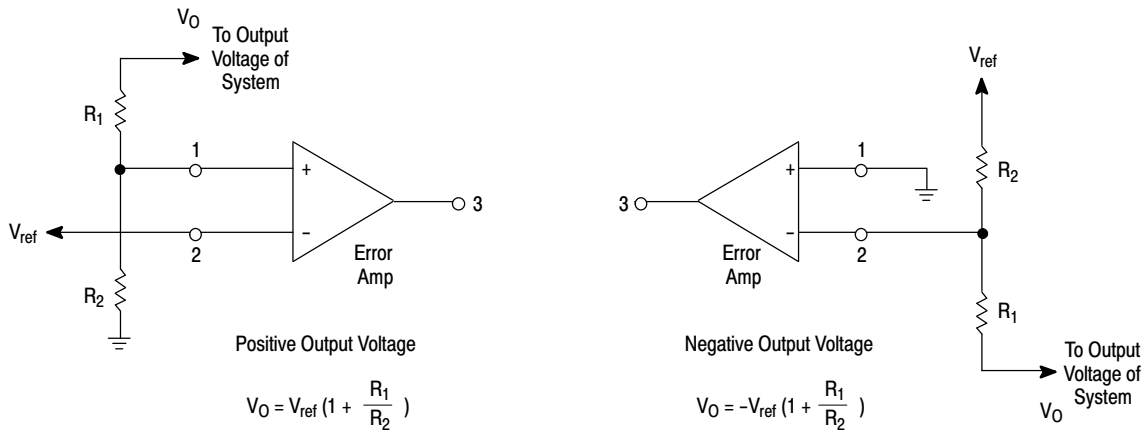


Figure 15. Error Amplifier Sensing Techniques

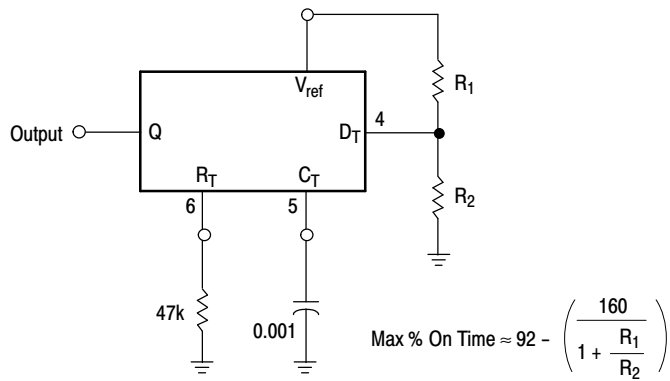


Figure 16. Deadtime Control Circuit

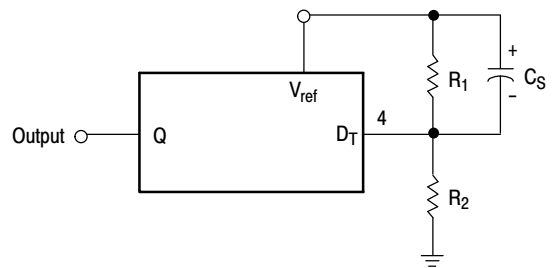


Figure 17. Soft-Start Circuit

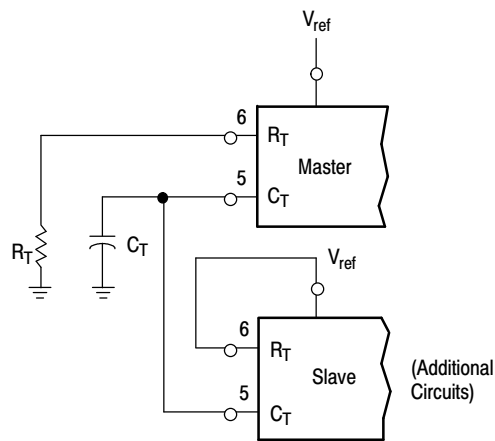
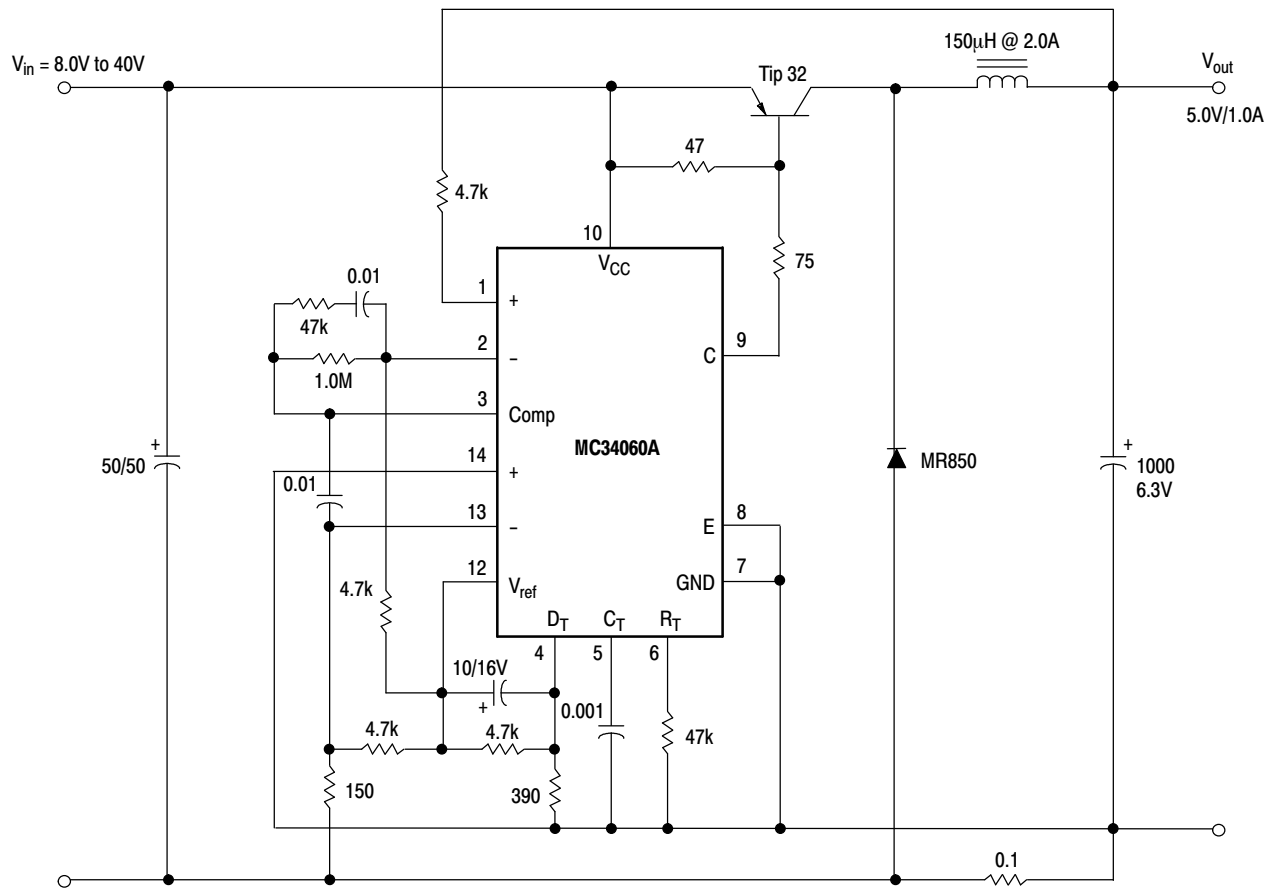


Figure 18. Slaving Two or More Control Circuits

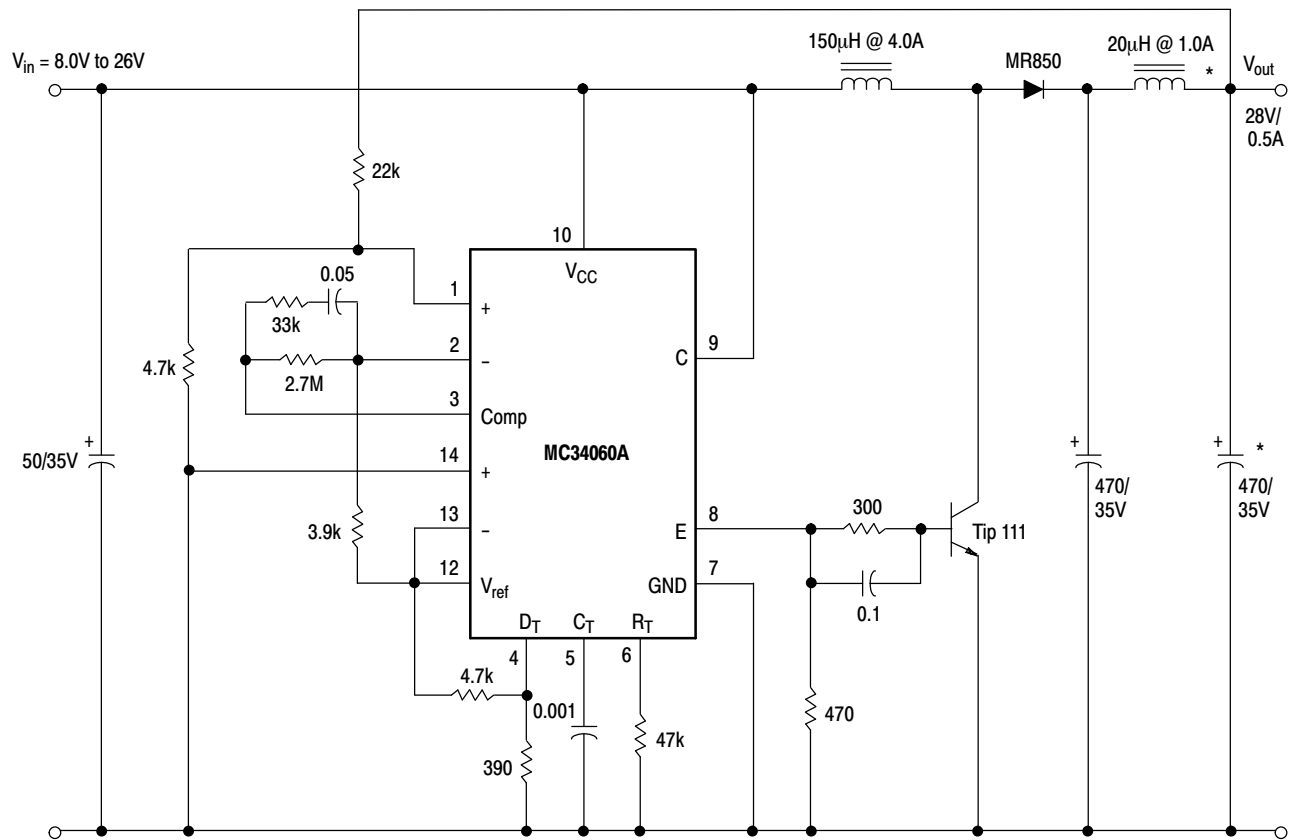
## MC34060A, MC33060A



Test	Conditions	Results
Line Regulation	$V_{in} = 8.0 \text{ V to } 40 \text{ V}$ , $I_O = 1.0 \text{ A}$	25 mV    0.5%
Load Regulation	$V_{in} = 12 \text{ V}$ , $I_O = 1.0 \text{ mA to } 1.0 \text{ A}$	3.0 mV    0.06%
Output Ripple	$V_{in} = 12 \text{ V}$ , $I_O = 1.0 \text{ A}$	75 mV p-p P.A.R.D.
Short Circuit Current	$V_{in} = 12 \text{ V}$ , $R_L = 0.1 \Omega$	1.6 A
Efficiency	$V_{in} = 12 \text{ V}$ , $I_O = 1.0 \text{ A}$	73%

**Figure 19. Step-Down Converter with Soft-Start and Output Current Limiting**

## MC34060A, MC33060A

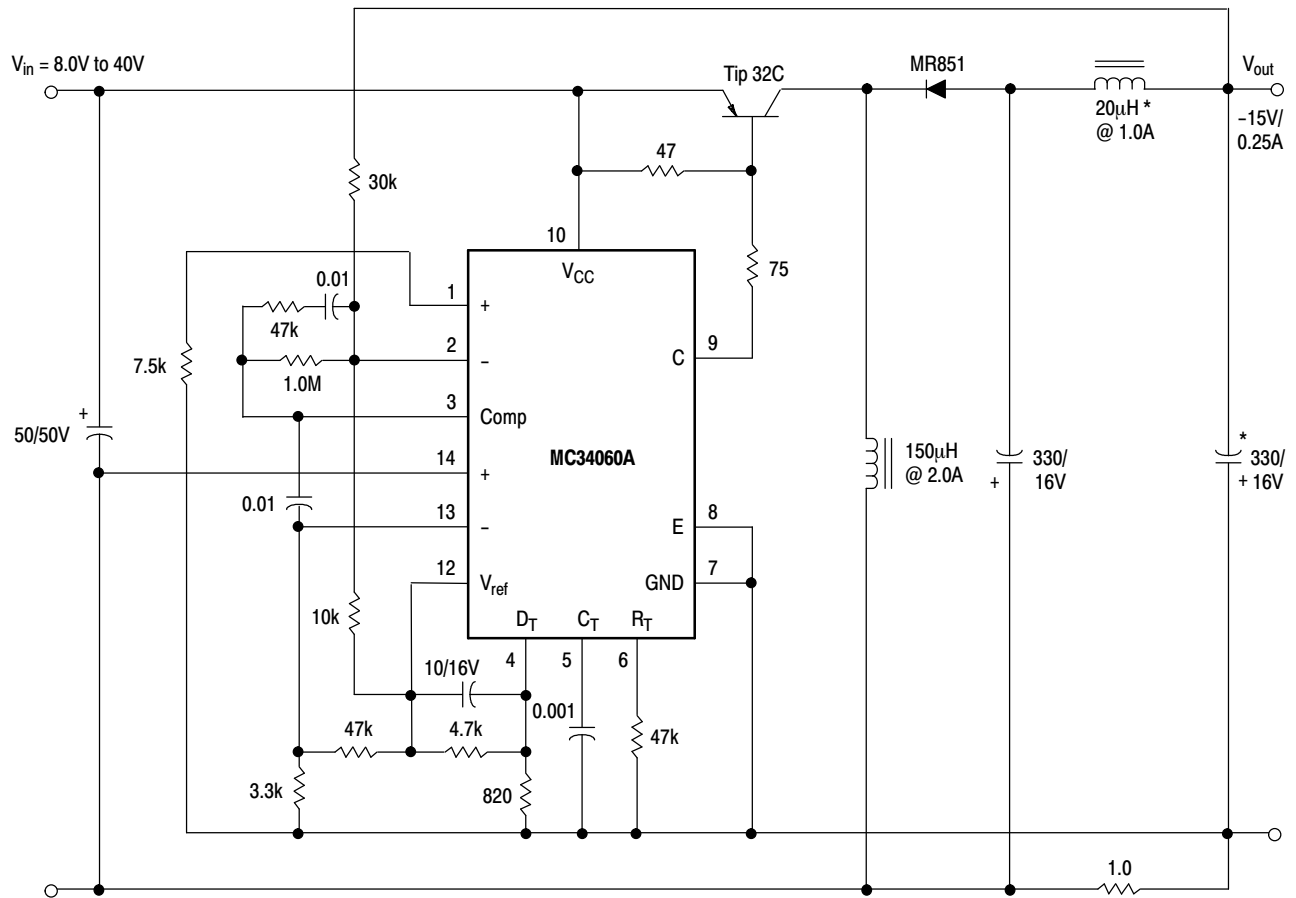


Test	Conditions	Results
Line Regulation	$V_{in} = 8.0 \text{ V to } 26 \text{ V}, I_O = 0.5 \text{ A}$	40 mV 0.14%
Load Regulation	$V_{in} = 12 \text{ V}, I_O = 1.0 \text{ mA to } 0.5 \text{ A}$	5.0 mV 0.18%
Output Ripple	$V_{in} = 12 \text{ V}, I_O = 0.5 \text{ A}$	24 mV p-p P.A.R.D.
Efficiency	$V_{in} = 12 \text{ V}, I_O = 0.5 \text{ A}$	75%

\*Optional circuit to minimize output ripple

**Figure 20. Step-Up Converter**

## MC34060A, MC33060A

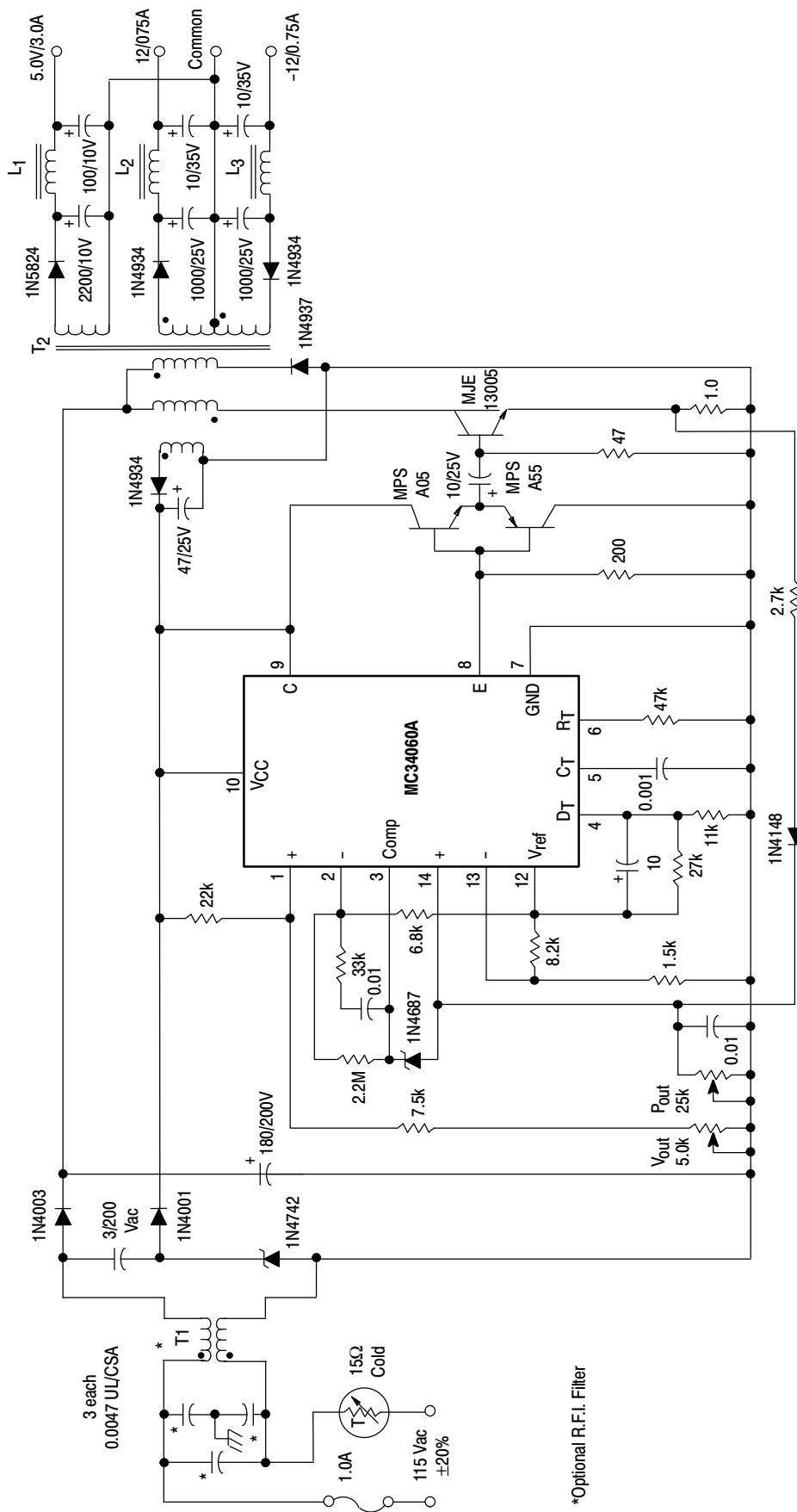


Test	Conditions	Results
Line Regulation	$V_{in} = 8.0 \text{ V to } 40 \text{ V}$ , $I_O = 250 \text{ mA}$	52 mV 0.35%
Load Regulation	$V_{in} = 12 \text{ V}$ , $I_O = 1.0 \text{ to } 250 \text{ mA}$	47 mV 0.32%
Output Ripple	$V_{in} = 12 \text{ V}$ , $I_O = 250 \text{ mA}$	10 mV p-p P.A.R.D.
Short Circuit Current	$V_{in} = 12 \text{ V}$ , $R_L = 0.1 \Omega$	330 mA
Efficiency	$V_{in} = 12 \text{ V}$ , $I_O = 250 \text{ mA}$	86%

\*Optional circuit to minimize output ripple

**Figure 21. Step-Up/Down Voltage Inverting Converter with Soft-Start and Current Limiting**

# MC34060A, MC33060A



T1 – Coilcraft W2961  
 T2 – Core: Coilcraft 11-464-16,  
 0.025" gap in each leg.  
 Bobbin: Coilcraft 37-573  
 Windings:  
 Primary, 2 each, 75 turns #25 Awg Bifilar wound  
 Feedback: 15 turns #26 Awg  
 Secondary, 5.0 V, 6 turns @33 Awg Bifilar wound  
 Secondary, 2 each, 14 turns #24 Awg Bifilar wound  
 L1 – Coilcraft Z7156, 15  $\mu$ H @ 5.0 A  
 L2, L3 – Coilcraft Z7157, 25  $\mu$ H @ 1.0 A

Test	Conditions	Results
Line Regulation 5.0 V	$V_{in} = 95 \text{ Vac}$ , $I_O = 3.0 \text{ A}$	20 mV 0.40%
Line Regulation $\pm 12 \text{ V}$	$V_{in} = 95 \text{ Vac}$ to $135 \text{ Vac}$ , $I_O = \pm 0.75 \text{ A}$	52 mV 0.26%
Load Regulation 5.0 V	$V_{in} = 115 \text{ Vac}$ , $I_O = 1.0 \text{ A}$ to $4.0 \text{ A}$	476 mV 9.5%
Load Regulation $\pm 12 \text{ V}$	$V_{in} = 115 \text{ Vac}$ , $I_O = \pm 0.4 \text{ A}$ to $\pm 0.9 \text{ A}$	300 mV 2.5%
Output Ripple 5.0 V	$V_{in} = 115 \text{ Vac}$ , $I_O = 3.0 \text{ A}$	45 mV p-p P.A.R.D.
Output Ripple $\pm 12 \text{ V}$	$V_{in} = 115 \text{ Vac}$ , $I_O = \pm 0.75 \text{ A}$	75 mV p-p P.A.R.D.
Efficiency	$V_{in} = 115 \text{ Vac}$ , $I_O 5.0 \text{ V} = 3.0 \text{ A}$ $I_O \pm 12 \text{ V} = \pm 0.75 \text{ A}$	74%

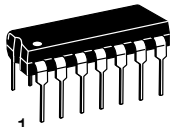
Figure 22. 33 W Off-Line Flyback Converter with Soft-Start and Primary Power Limiting

# MC34060A, MC33060A

## ORDERING INFORMATION

Device	Operating Temperature Range	Package	Shipping <sup>†</sup>
MC34060ADG	$T_A = 0^\circ \text{ to } +70^\circ\text{C}$	SOIC-14 (Pb-Free)	55 Units / Rail
MC34060ADR2G		SOIC-14 (Pb-Free)	2500 / Tape & Reel
MC34060APG		PDIP-14 (Pb-Free)	25 Units / Rail
MC33060ADG	$T_A = -40^\circ \text{ to } +85^\circ\text{C}$	SOIC-14 (Pb-Free)	55 Units / Rail
MC33060ADR2G		SOIC-14 (Pb-Free)	2500 / Tape & Reel
MC33060APG		PDIP-14 (Pb-Free)	25 Units / Rail

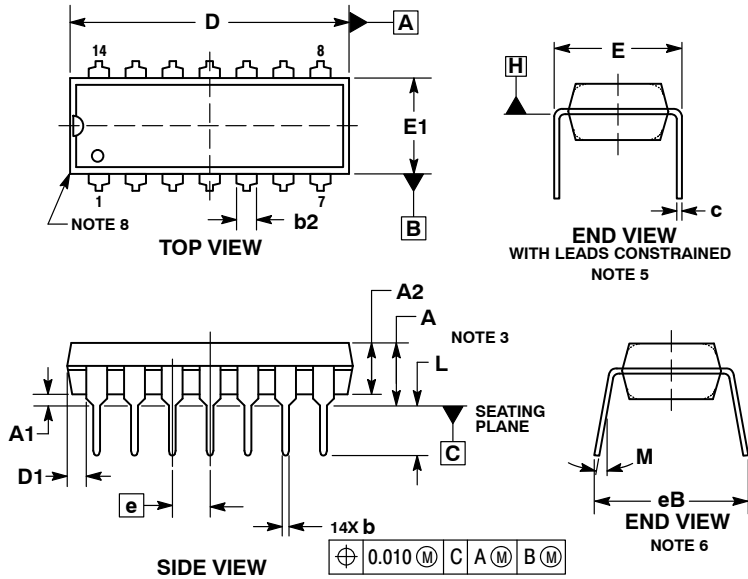
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



1  
SCALE 1:1

PDIP-14  
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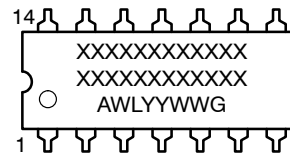


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSIONS A, A1 AND L ARE MEASURED WITH THE PACKAGE SEATED IN JEDEC SEATING PLANE GAUGE GS-3.
4. DIMENSIONS D, D1 AND E1 DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS ARE NOT TO EXCEED 0.10 INCH.
5. DIMENSION E IS MEASURED AT A POINT 0.015 BELOW DATUM PLANE H WITH THE LEADS CONSTRAINED PERPENDICULAR TO DATUM C.
6. DIMENSION eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED.
7. DATUM PLANE H IS COINCIDENT WITH THE BOTTOM OF THE LEADS, WHERE THE LEADS EXIT THE BODY.
8. PACKAGE CONTOUR IS OPTIONAL (ROUNDED OR SQUARE CORNERS).

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.210	---	5.33
A1	0.015	---	0.38	---
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.35	0.56
b2	0.060 TYP 1.52 TYP			
C	0.008	0.014	0.20	0.36
D	0.735	0.775	18.67	19.69
D1	0.005	---	0.13	---
E	0.300	0.325	7.62	8.26
E1	0.240	0.280	6.10	7.11
e	0.100 BSC 2.54 BSC			
eB	---	0.430	---	10.92
L	0.115	0.150	2.92	3.81
M	---	10°	---	10°

GENERIC  
MARKING DIAGRAM\*



- XXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- YY = Year
- WW = Work Week
- G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

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**PDIP-14**  
**CASE 646-06**  
**ISSUE S**

DATE 22 APR 2015

STYLE 1:  
 PIN 1. COLLECTOR  
 2. BASE  
 3. EMITTER  
 4. NO  
 CONNECTION  
 5. EMITTER  
 6. BASE  
 7. COLLECTOR  
 8. COLLECTOR  
 9. BASE  
 10. EMITTER  
 11. NO  
 CONNECTION  
 12. EMITTER  
 13. BASE  
 14. COLLECTOR

STYLE 2:  
 CANCELLED

STYLE 3:  
 CANCELLED

STYLE 4:  
 PIN 1. DRAIN  
 2. SOURCE  
 3. GATE  
 4. NO  
 CONNECTION  
 5. GATE  
 6. SOURCE  
 7. DRAIN  
 8. DRAIN  
 9. SOURCE  
 10. GATE  
 11. NO  
 CONNECTION  
 12. GATE  
 13. SOURCE  
 14. DRAIN

STYLE 5:  
 PIN 1. GATE  
 2. DRAIN  
 3. SOURCE  
 4. NO CONNECTION  
 5. SOURCE  
 6. DRAIN  
 7. GATE  
 8. GATE  
 9. DRAIN  
 10. SOURCE  
 11. NO CONNECTION  
 12. SOURCE  
 13. DRAIN  
 14. GATE

STYLE 6:  
 PIN 1. COMMON CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. NO CONNECTION  
 5. ANODE/CATHODE  
 6. NO CONNECTION  
 7. ANODE/CATHODE  
 8. ANODE/CATHODE  
 9. ANODE/CATHODE  
 10. NO CONNECTION  
 11. ANODE/CATHODE  
 12. ANODE/CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

STYLE 7:  
 PIN 1. NO CONNECTION  
 2. ANODE  
 3. ANODE  
 4. NO CONNECTION  
 5. ANODE  
 6. NO CONNECTION  
 7. ANODE  
 8. ANODE  
 9. ANODE  
 10. NO CONNECTION  
 11. ANODE  
 12. ANODE  
 13. NO CONNECTION  
 14. COMMON  
 CATHODE

STYLE 8:  
 PIN 1. NO CONNECTION  
 2. CATHODE  
 3. CATHODE  
 4. NO CONNECTION  
 5. CATHODE  
 6. NO CONNECTION  
 7. CATHODE  
 8. CATHODE  
 9. CATHODE  
 10. NO CONNECTION  
 11. CATHODE  
 12. CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

STYLE 9:  
 PIN 1. COMMON CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. NO CONNECTION  
 5. ANODE/CATHODE  
 6. ANODE/CATHODE  
 7. COMMON ANODE  
 8. COMMON ANODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. NO CONNECTION  
 12. ANODE/CATHODE  
 13. ANODE/CATHODE  
 14. COMMON CATHODE

STYLE 10:  
 PIN 1. COMMON  
 CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. ANODE/CATHODE  
 5. ANODE/CATHODE  
 6. NO CONNECTION  
 7. COMMON ANODE  
 8. COMMON  
 CATHODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. ANODE/CATHODE  
 12. ANODE/CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

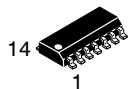
STYLE 11:  
 PIN 1. CATHODE  
 2. CATHODE  
 3. CATHODE  
 4. CATHODE  
 5. CATHODE  
 6. CATHODE  
 7. CATHODE  
 8. ANODE  
 9. ANODE  
 10. ANODE  
 11. ANODE  
 12. ANODE  
 13. ANODE  
 14. ANODE

STYLE 12:  
 PIN 1. COMMON CATHODE  
 2. COMMON ANODE  
 3. ANODE/CATHODE  
 4. ANODE/CATHODE  
 5. ANODE/CATHODE  
 6. COMMON ANODE  
 7. COMMON CATHODE  
 8. ANODE/CATHODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. ANODE/CATHODE  
 12. ANODE/CATHODE  
 13. ANODE/CATHODE  
 14. ANODE/CATHODE

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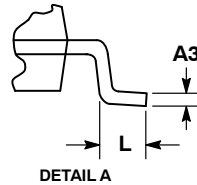
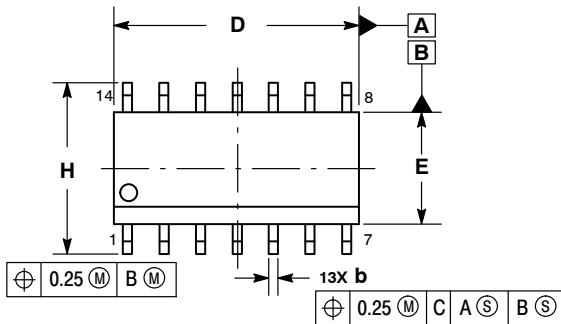




SCALE 1:1

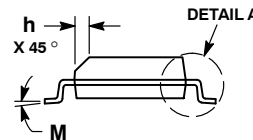
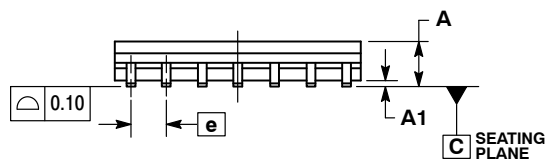
SOIC-14 NB  
CASE 751A-03  
ISSUE L

DATE 03 FEB 2016

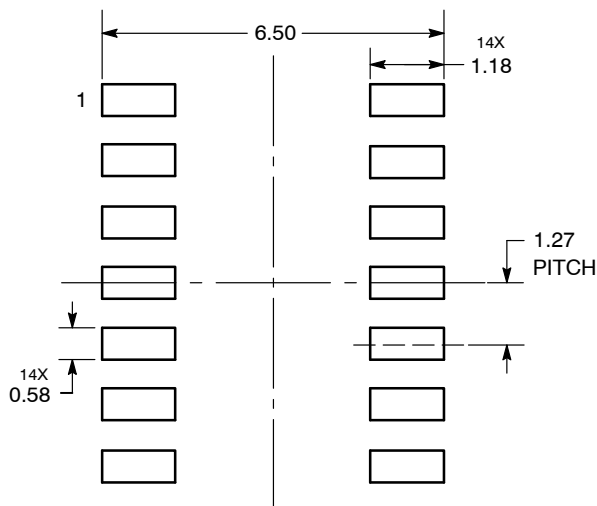


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF AT MAXIMUM MATERIAL CONDITION.
  4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
  5. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.054	0.068
A1	0.10	0.25	0.004	0.010
A3	0.19	0.25	0.008	0.010
b	0.35	0.49	0.014	0.019
D	8.55	8.75	0.337	0.344
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.019
L	0.40	1.25	0.016	0.049
M	0°	7°	0°	7°



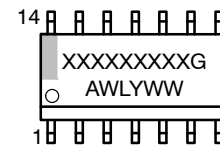
SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*For additional information on our Pb-Free strategy and soldering details, please download the onsemi Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM\*



- XXXXXX = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

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**SOIC-14**  
**CASE 751A-03**  
**ISSUE L**

DATE 03 FEB 2016

STYLE 1:  
 PIN 1. COMMON CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. NO CONNECTION  
 5. ANODE/CATHODE  
 6. NO CONNECTION  
 7. ANODE/CATHODE  
 8. ANODE/CATHODE  
 9. ANODE/CATHODE  
 10. NO CONNECTION  
 11. ANODE/CATHODE  
 12. ANODE/CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

STYLE 2:  
 CANCELLED

STYLE 3:  
 PIN 1. NO CONNECTION  
 2. ANODE  
 3. ANODE  
 4. NO CONNECTION  
 5. ANODE  
 6. NO CONNECTION  
 7. ANODE  
 8. ANODE  
 9. ANODE  
 10. NO CONNECTION  
 11. ANODE  
 12. ANODE  
 13. NO CONNECTION  
 14. COMMON CATHODE

STYLE 4:  
 PIN 1. NO CONNECTION  
 2. CATHODE  
 3. CATHODE  
 4. NO CONNECTION  
 5. CATHODE  
 6. NO CONNECTION  
 7. CATHODE  
 8. CATHODE  
 9. CATHODE  
 10. NO CONNECTION  
 11. CATHODE  
 12. CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

STYLE 5:  
 PIN 1. COMMON CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. ANODE/CATHODE  
 5. ANODE/CATHODE  
 6. NO CONNECTION  
 7. COMMON ANODE  
 8. COMMON CATHODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. ANODE/CATHODE  
 12. ANODE/CATHODE  
 13. NO CONNECTION  
 14. COMMON ANODE

STYLE 6:  
 PIN 1. CATHODE  
 2. CATHODE  
 3. CATHODE  
 4. CATHODE  
 5. CATHODE  
 6. CATHODE  
 7. CATHODE  
 8. ANODE  
 9. ANODE  
 10. ANODE  
 11. ANODE  
 12. ANODE  
 13. ANODE  
 14. ANODE

STYLE 7:  
 PIN 1. ANODE/CATHODE  
 2. COMMON ANODE  
 3. COMMON CATHODE  
 4. ANODE/CATHODE  
 5. ANODE/CATHODE  
 6. ANODE/CATHODE  
 7. ANODE/CATHODE  
 8. ANODE/CATHODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. COMMON CATHODE  
 12. COMMON ANODE  
 13. ANODE/CATHODE  
 14. ANODE/CATHODE

STYLE 8:  
 PIN 1. COMMON CATHODE  
 2. ANODE/CATHODE  
 3. ANODE/CATHODE  
 4. NO CONNECTION  
 5. ANODE/CATHODE  
 6. ANODE/CATHODE  
 7. COMMON ANODE  
 8. COMMON ANODE  
 9. ANODE/CATHODE  
 10. ANODE/CATHODE  
 11. NO CONNECTION  
 12. ANODE/CATHODE  
 13. ANODE/CATHODE  
 14. COMMON CATHODE

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