# Alternator Voltage Regulator FET Driver

The CS3361 integral alternator regulator integrated circuit provides the voltage regulation for automotive, 3–phase alternators.

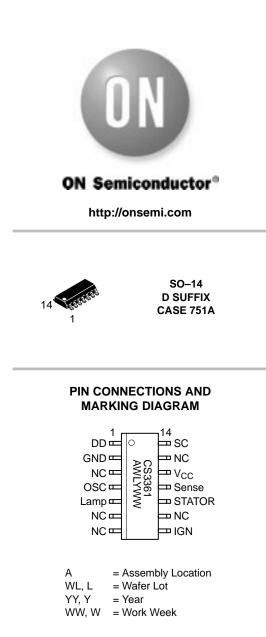
It drives an external logic level N channel enhancement power FET for control of the alternator field current. In the event of a charge fault, a lamp output pin is provided to drive an external darlington transistor capable of switching on a fault indicator lamp. An overvoltage or no Stator signal condition activates the lamp output.

A STATOR Power Up feature is incorporated for systems which require power up activation by sensing the crank cycle of the starter at the stator. This eliminates unnecessary current drain when the ignition is turned on, but the car is not running. The CS3361 is available in an SO–14 package.

This IC has customized current sense circuitry enabling it to drive FET transistors.

## Features

- Drives Logic Level Power NFET
- 80 V Load Dump
- Temperature Compensated Regulation Voltage
- Shorted Field Protection Duty Cycle, Self Clearing
- STATOR Power Up



#### **ORDERING INFORMATION**

Device	Package	Shipping
CS3361YD14	SO-14	55 Units/Rail
CS3361YDR14	SO-14	2500 Tape & Reel

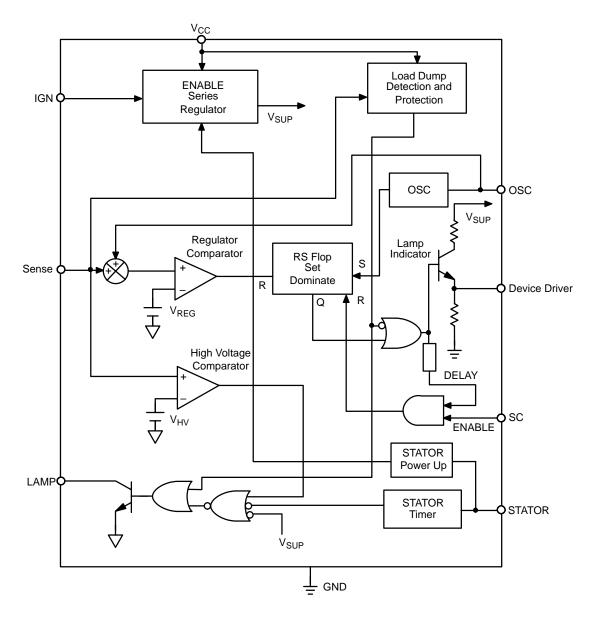


Figure 1. Block Diagram

### **MAXIMUM RATINGS\***

Rating			Unit
Storage Temperature Range, T <sub>S</sub>		-55 to +165	°C
Junction Temperature Range		-40 to 150	°C
Continuous Supply		27	V
I <sub>CC</sub> Load Dump (@ V <sub>CC</sub> = 80 V <sub>peak</sub> )		400	mA
Lead Temperature Soldering:	Reflow: (SMD styles only) (Note 1)	230 peak	°C

1. 60 second maximum above 183°C.

\*The maximum package power dissipation must be observed.

# $\textbf{ELECTRICAL CHARACTERISTICS} \quad (-40^{\circ}C < T_A < 125^{\circ}C, \ -40^{\circ}C < T_J < 150^{\circ}C, \ 9.0 \ V \leq V_{CC} \leq 17 \ V;$

unless otherwise specified.)

Supply Current Disabled         -         -         50 $\mu A$ Driver Stage         -         -         5.5         -         12         V           Output High Voltage $I_{OL} = 25 \ \mu A$ -         -         0.35         V           Output High Current $V_{DD} = 1.2 \ V$ -10         -6.0         -4.0         mm           Minimum ON Time $C_{OSC} = 0.022 \ \mu F$ 200         -         - $\mu A$ Minimum Duty Cycle         -         -         6.0         10         %           Short Circuit Duty Cycle         -         -         1.0         -         5.0         %           Field Switch Tum On Rise Time         -         15         -         7.5 $\mu A$ Field Switch Turn On Rise Time         -         15         -         7.5 $\mu A$ Stator         -         10         -         -         0.0         V           Input High Voltage         -         -         10         -         -         V           Input Low Voltage         I_LAMP @ 3.0 V         -         -         -         0.35         V           Output L	Characteristic	Test Conditions	Min	Тур	Max	Unit
Supply Current Disabled         -         5 $\mu$ Driver Stage           Output High Voltage $l_{OL} = 25 \ \mu$ A         -         12         V           Output Low Voltage $l_{OL} = 25 \ \mu$ A         -         -         0.35         V           Output High Current         VDD = 1.2 V         -         -         0.40         m/           Minimum ON Time         COSC = 0.022 $\mu$ F         200         -         - $\mu$ S           Minimum Duty Cycle         -         -         6.00         100         %           Short Circuit Duty Cycle         -         -         1.00         -         5.00         %           Field Switch Turn On Rise Time         -         -         15         -         7.5 $\mu$ E           Stator         -         100         -         -         0.00         m           Input High Voltage         -         -         100         -         - $1000000000000000000000000000000000000$	Supply					
Driver Stage         Jourput High Voltage         Iourput 200         Iourput 200	Supply Current Enabled	-	-	-	10	mA
Output High Voltage         IoL = 25 $\mu$ A         -         12         V           Output Low Voltage         IoL = 25 $\mu$ A         -         0.35         V           Output High Current         V <sub>DD</sub> = 1.2 V         -10         -6.0         -4.0         mm           Minimum ON Time $C_{OSC} = 0.022  \mu$ F         200         -         - $\mu$ g           Minimum Duty Cycle         -         -         6.0         10 $\sigma$ Short Circuit Duty Cycle         -         -         1.0         -         5.5         75 $\mu$ g           Field Switch Turn On Fall Time         -         -         15         -         75 $\mu$ g           Stator         -         10         -         -         75 $\mu$ g           Stator         -         10         -         -         0         0         00         0         0           Input High Voltage         -         -         0         0         0         0         0         0         0           Stator         -         -         -         -         0         0         0         0         0         0         0         0<	Supply Current Disabled	-	-	_	50	μΑ
Output Low Voltage $l_{OL} = 25  \mu A$ -         -         0.35         V           Output High Current $V_{DD} = 1.2$ V         -10         -6.0         -4.0         m/           Minimum ON Time $C_{OSC} = 0.022  \mu F$ 200         -         - $\mu s$ Minimum Duty Cycle         -         -         6.0         10 $\sqrt{s}$ Short Circuit Duty Cycle         -         -         1.0         -         5.0 $\sqrt{s}$ Field Switch Turn On Rise Time         -         15         -         75 $\mu s$ Field Switch Turn On Rise Time         -         10         -         -         75 $\mu s$ Stator         -         10         -         -         -         V           Input High Voltage         -         -         10         -         -         V           Input Low Voltage         1         -         -         -         0.0         V           Stator         -         -         -         -         0.0         0         V           Uptu Low Voltage         1         -         -         -         - <td< td=""><td>Driver Stage</td><td></td><td></td><td></td><td></td><td></td></td<>	Driver Stage					
Output High Current         V <sub>DD</sub> = 1.2 V         -10         -6.0         -4.0         m/           Minimum ON Time         C <sub>OSC</sub> = 0.022 μF         200         -         -         μs           Minimum Duty Cycle         -         -         6.0         10         %           Short Circuit Duty Cycle         -         -         6.0         10         %           Field Switch Tum On Rise Time         -         15         -         75         μs           Field Switch Tum On Rise Time         -         15         -         75         μs           Stator         -         10         -         -         6.0         100         75           Input High Voltage         -         -         10         -         -         75         μs           Stator         -         10         -         -         -         V         1           Input High Voltage         -         -         0.0         0.0         70         75         μs           Stator         -         -         -         -         0.0         0.0         70           Unput Low Voltage         ILAMP @ 3.0 V         -         -         -	Output High Voltage	-	5.5	-	12	V
Minimum ON Time $C_{OSC} = 0.022 \ \mu F$ 200         -         - $\mu \mu$ Minimum Duty Cycle         -         -         6.0         10         %           Short Circuit Duty Cycle         -         -         6.0         10         %           Short Circuit Duty Cycle         -         -         1.0         -         5.0         %           Field Switch Turn On Rise Time         -         -         15         -         75 $\mu \mu$ Field Switch Turn On Fall Time         -         -         15         -         75 $\mu \mu$ Stator         -         -         10         -         -         V           Input High Voltage         -         -         10         -         -         V           Input Low Voltage         -         -         0.0         100         600         mm           Lamp         Output High Current         VLAMP @ 3.0 V         -         -         -         0.35         V           Input High Voltage         I_LAMP @ 3.0 V         -         -         0.35         V           Input High Voltage         I_CC > 1.0 mA         1.8         -	Output Low Voltage	I <sub>OL</sub> = 25 μA	-	_	0.35	V
Minimum Duty Cycle         -         6.0         10         %           Short Circuit Duty Cycle         -         1.0         -         5.0         %           Field Switch Turn On Rise Time         -         15         -         75 $\mu$ s           Field Switch Turn On Rise Time         -         15         -         75 $\mu$ s           Field Switch Turn On Fall Time         -         15         -         75 $\mu$ s           Stator         -         15         -         75 $\mu$ s           Input High Voltage         -         -         10         -         -         V           Input Low Voltage         -         -         0.0         100         600         mm           Lamp         Output High Current         V <sub>LAMP</sub> @ 3.0 V         -         -         -         0.35         V           Joutput Low Voltage         IL <sub>AMP</sub> @ 3.0 V         -         -         -         0.35         V           Input High Voltage         IL <sub>C</sub> > 1.0 mA         1.8         -         -         V           Input Low Voltage         I <sub>CC</sub> > 1.0 mA         1.8         -         -         V           Input Low Volt	Output High Current	V <sub>DD</sub> = 1.2 V	-10	-6.0	-4.0	mA
Short Circuit Duty Cycle         -         1.0         -         5.0         %           Field Switch Turn On Rise Time         -         15         -         75 $\mu$ s           Field Switch Turn On Fall Time         -         15         -         75 $\mu$ s           Stator         -         15         -         75 $\mu$ s           Stator         -         10         -         -         V           Input High Voltage         -         -         10         -         -         V           Input Low Voltage         -         -         6.0         100         600         mm           Cutput Low Voltage         ILAMP @ 3.0 V         -         -         -         5.0 $\mu$ Output Low Voltage         ILAMP @ 3.0 V         -         -         0.35         V           Input High Current         VLAMP @ 3.0 V         -         -         0.35         V           Input Low Voltage         ILC > 1.0 mA         1.8         -         -         V           Input High Voltage         I_CC < 100 $\mu$ A         -         -         0.5         V           Socillator         OcSC = 0.022 $\mu$ F	Minimum ON Time	C <sub>OSC</sub> = 0.022 μF	200	_	_	μs
Field Switch Turn On Rise Time       -       15       -       75 $\mu$ s         Field Switch Turn On Fall Time       -       15       -       75 $\mu$ s         Stator       -       10       -       -       V         Input High Voltage       -       -       10       -       -       V         Input Low Voltage       -       -       0.0       0.0       ms         Lamp       Use Stator       6.0       100       6.0       V         Stator       -       -       -       6.0       V         Stator Time Out       High to Low       6.0       100       600       ms         Lamp       Output High Current       VLAMP @ 3.0 V       -       -       -       50 $\mu$ A         Output Low Voltage       I_LAMP @ 3.0 V       -       -       0.35       V         Ignition       I       I       -       -       V         Input High Voltage       I <sub>CC</sub> > 1.0 mA       1.8       -       -       V         Input Low Voltage       I <sub>CC</sub> < 100 $\mu$ A       -       -       0.5       V         Oscillator       Cosc = 0.022 $\mu$ F       90	Minimum Duty Cycle	-	-	6.0	10	%
Rise Time         –         15         –         75 $\mu$ s           Field Switch Turn On Fall Time         –         15         –         75 $\mu$ s           Stator         –         15         –         75 $\mu$ s           Input High Voltage         –         –         10         –         –         V           Input Low Voltage         –         –         10         –         –         V           Stator Time Out         High to Low         6.0         100         600         mas           Lamp         Output High Current         VLAMP @ 3.0 V         –         –         50 $\mu$ A           Output Low Voltage         ILAMP @ 3.0 V         –         –         50 $\mu$ A           Output Low Voltage         ILAMP @ 3.0 V         –         –         0.35         V           Input High Voltage         ILAMP @ 3.0 V         –         –         0.35         V           Input Low Voltage         ILCC > 1.0 mA         –         –         –         0.55         V           Input Low Voltage         I <sub>CC</sub> < 100 $\mu$ A         –         –         –         0.55         V           Scillato	Short Circuit Duty Cycle	-	1.0	_	5.0	%
Fall Time         –         75         μs           Stator         Input High Voltage         –         10         –         –         V           Input Low Voltage         –         10         –         –         V           Stator Time Out         High to Low         6.0         100         600         mm           Stator Time Out         High to Low         6.0         100         600         mm           Lamp         Output High Current         V <sub>LAMP</sub> @ 3.0 V         –         –         50         μA           Output Low Voltage         I <sub>LAMP</sub> @ 3.0 V         –         –         –         50         μA           Output Low Voltage         I <sub>LAMP</sub> @ 3.0 V         –         –         –         50         μA           Output Low Voltage         I <sub>LAMP</sub> @ 3.0 V         –         –         –         0.35         V           Input High Voltage         I <sub>LCC</sub> > 1.0 mA         –         –         –         V         N         –         –         V           Input Low Voltage         I <sub>CC</sub> < 1.0 mA		_	15	_	75	μs
Input High Voltage         -         10         -         -         V           Input Low Voltage         -         -         6.0         V           Stator Time Out         High to Low         6.0         100         600         ms           Lamp         Output High Current         VLAMP @ $3.0$ V         -         -         50 $\mu$ A           Output High Current         VLAMP @ $3.0$ V         -         -         50 $\mu$ A           Output Low Voltage $I_{LAMP}$ @ $3.0$ V         -         -         0.35         V           Ignition         I         Lacc > 1.0 mA         1.8         -         -         V           Input Low Voltage $I_{CC} > 1.0$ mA         1.8         -         -         V           Input Low Voltage $I_{CC} < 100$ $\mu$ A         -         0.5         V           Oscillator         -         -         0.5         V           Oscillator Frequency $C_{OSC} = 0.022$ $\mu$ F         90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022$ $\mu$ F         -         17         -         -		_	15	_	75	μs
Input Low Voltage         -         -         6.0         V           Stator Time Out         High to Low         6.0         100         600         ms           Lamp         Output High Current $V_{LAMP} @ 3.0 V$ -         -         50 $\mu A$ Output Low Voltage $I_{LAMP} @ 30 mA$ -         -         0.35         V           Input Low Voltage $I_{LAMP} @ 30 mA$ -         -         0.35         V           Input High Voltage $I_{CC} > 1.0 mA$ 1.8         -         -         V           Input Low Voltage $I_{CC} < 100 \mu A$ -         -         0.5         V           Oscillator         -         -         0.5         V           Oscillator Frequency $C_{OSC} = 0.022 \mu F$ 90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022 \mu F$ -         17         -         -	Stator					•
Image: State Time Out         High to Low         6.0         100         600         ms           Lamp         Output High Current $V_{LAMP} @ 3.0 V$ -         -         50 $\mu A$ Output Low Voltage $I_{LAMP} @ 30 mA$ -         -         50 $\mu A$ Input High Voltage $I_{LAMP} @ 30 mA$ -         -         0.35         V           Input High Voltage $I_{CC} > 1.0 mA$ 1.8         -         -         V           Input High Voltage $I_{CC} < 100 \mu A$ -         0.5         V           Oscillator         -         -         0.5         V           Rise Time/Fall Time $C_{OSC} = 0.022  \mu F$ 90         -         210         Hz	Input High Voltage	-	10	_	-	V
Lamp $  50$ $\mu^A$ Output High Current $V_{LAMP} @ 3.0 V$ $  50$ $\mu^A$ Output Low Voltage $I_{LAMP} @ 30 mA$ $  0.35$ $V$ Ignition         Input High Voltage $I_{CC} > 1.0 mA$ $1.8$ $  V$ Input Low Voltage $I_{CC} < 100 \mu A$ $  0.5$ $V$ Oscillator         Oscillator Frequency $C_{OSC} = 0.022  \mu F$ $90$ $ 210$ $Hz$ Rise Time/Fall Time $C_{OSC} = 0.022  \mu F$ $ 17$ $ -$	Input Low Voltage	-	-	_	6.0	V
Output High Current $V_{LAMP} @ 3.0 V$ -         -         50 $\mu A$ Output Low Voltage $I_{LAMP} @ 30 mA$ -         -         0.35         V           Ignition         Input High Voltage $I_{CC} > 1.0 mA$ 1.8         -         -         V           Input Low Voltage $I_{CC} < 1.0 mA$ 1.8         -         -         V           Input Low Voltage $I_{CC} < 100 \mu A$ -         -         0.5         V           Oscillator         Cosc = 0.022 \mu F         90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022 \mu F$ 90         -         210         Hz	Stator Time Out	High to Low	6.0	100	600	ms
Output Low Voltage $I_{LAMP}$ @ 30 mA         -         -         0.35         V           Ignition         Input High Voltage $I_{CC} > 1.0$ mA         1.8         -         -         V           Input Low Voltage $I_{CC} < 100 \mu A$ -         -         V           Oscillator         Oscillator Frequency $C_{OSC} = 0.022  \mu F$ 90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022  \mu F$ 90         -         17         -         -	Lamp					
Ignition         Input High Voltage         I <sub>CC</sub> > 1.0 mA         1.8         -         -         V           Input Low Voltage         I <sub>CC</sub> < 100 $\mu$ A         -         -         0.5         V           Oscillator         Oscillator Frequency         C <sub>OSC</sub> = 0.022 $\mu$ F         90         -         210         Hz           Rise Time/Fall Time         C <sub>OSC</sub> = 0.022 $\mu$ F         -         17         -         -	Output High Current	V <sub>LAMP</sub> @ 3.0 V	-	-	50	μΑ
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	Output Low Voltage	I <sub>LAMP</sub> @ 30 mA	-	-	0.35	V
Input Low Voltage $I_{CC} < 100 \mu\text{A}$ -         -         0.5         V           Oscillator         Oscillator Frequency $C_{OSC} = 0.022 \mu\text{F}$ 90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022 \mu\text{F}$ -         17         -         -	Ignition					
Oscillator         90         -         210         Hz           Oscillator Frequency $C_{OSC} = 0.022 \mu\text{F}$ 90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022 \mu\text{F}$ -         17         -         -	Input High Voltage	I <sub>CC</sub> > 1.0 mA	1.8	-	-	V
Oscillator Frequency $C_{OSC} = 0.022 \mu\text{F}$ 90         -         210         Hz           Rise Time/Fall Time $C_{OSC} = 0.022 \mu\text{F}$ -         17         -         -	Input Low Voltage	I <sub>CC</sub> < 100 μA	-	-	0.5	V
Rise Time/Fall Time $C_{OSC} = 0.022 \mu\text{F}$ $ 17$ $-$	Oscillator					
	Oscillator Frequency	C <sub>OSC</sub> = 0.022 μF	90	-	210	Hz
Oscillator High Threshold $C_{OSC} = 0.022 \mu\text{F}$ 4.5 V	Rise Time/Fall Time	C <sub>OSC</sub> = 0.022 μF	-	17	-	-
	Oscillator High Threshold	C <sub>OSC</sub> = 0.022 μF	-	-	4.5	V

## CS3361

## $\textbf{ELECTRICAL CHARACTERISTICS (continued) (-40^{\circ}C < T_A < 125^{\circ}C, -40^{\circ}C < T_J < 150^{\circ}C, 9.0 \text{ V} \leq \text{V}_{CC} \leq 17 \text{ V};}$

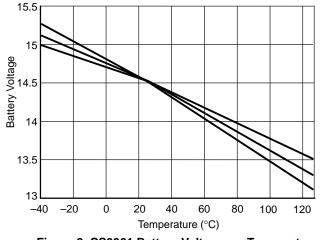
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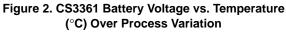
Characteristic	Test Conditions	Min	Тур	Max	Unit		
Battery Sense							
Input Current	-	-10	_	+10	μΑ		
Regulation Voltage	@25°C, R <sub>1</sub> = 100 kΩ, R <sub>2</sub> = 50 kΩ	13.8	_	15.8	V		
Proportional Control	_	0.10	_	0.25	V		
High Voltage Threshold Ratio	VHigh Voltage@LampOn VRegulation@50%Duty Cycle	1.083	_	1.190	V/V		
High Voltage Hysteresis	-	0.020	-	0.600	V		

## PACKAGE PIN DESCRIPTION

PACKAGE PIN #		
SO-14	PIN SYMBOL	FUNCTION
1	Driver	Output driver for external power switch.
2	GND	Ground.
3, 6, 7, 9, 13	NC	No Connection.
4	OSC	Timing capacitor for oscillator.
5	Lamp	Base driver for lamp driver indicates no stator signal or overvoltage condition.
8	IGN	Switched ignition power up.
10	Stator	Stator signal input for stator timer.
11	Sense	Battery sense voltage regulator comparator input and protection.
12	V <sub>CC</sub>	Supply for IC.
14	SC	Short circuit sensing.

## **TYPICAL PERFORMANCE CHARACTERISTICS**





#### APPLICATIONS INFORMATION

The CS3361 is designed for use in an alternator charging system.

In a standard alternator design (Figure 3), the rotor carries the field winding. An alternator rotor usually has several N and S poles. The magnetic field for the rotor is produced by forcing current through a field or rotor winding. The Stator windings are formed into a number of coils spaced around a cylindrical core. The number of coils equals the number of pairs of N and S poles on the rotor. The alternating current in the Stator windings is rectified by the diodes and applied to the regulator. By controlling the amount of field current, the magnetic field strength is controlled and hence the output voltage of the alternator.

Referring to Figure 7, a typical application diagram, the oscillator frequency is set by an external capacitor connected between OSC and ground. The sawtooth waveform ramps between 1.0 V and 3.0 V and provides the timing for the system. For the circuit shown the oscillator frequency is approximately 140 Hz. The alternator voltage is sensed at Terminal A via the resistor divider network R1/R2 on the Sense pin of the IC. The voltage at the sense pin determines the duty cycle for the regulator. The voltage is adjusted by potentiometer R2. A relatively low voltage on the sense pin causes a long duty cycle that increases the Field current. A high voltage results in a short duty cycle.

The ignition Terminal (I) switches power to the IC through the  $V_{CC}$  pin. The Stator pin monitors the voltage from the stator and senses a stopped engine condition. It drives the Lamp pin high after the stator timeout expires. The Lamp pin also goes high when an overvoltage condition

is detected on the sense pin. This causes the darlington lamp drive transistor to switch on and pull current through the lamp. If the system voltage continues to increase, the field and lamp output turn off as in an overvoltage or load dump condition.

The SC or Short Circuit pin monitors the field voltage. If the drive output and the SC voltage are simultaneously high for a predetermined period, a short circuit condition is assumed and the output is disabled. The regulator is forced to a minimum short circuit duty cycle.

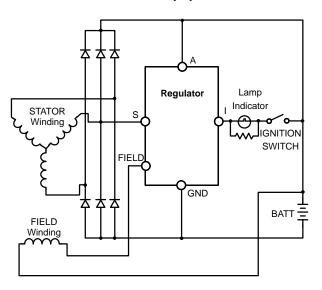


Figure 3. IAR System Block Diagram

## CS3361

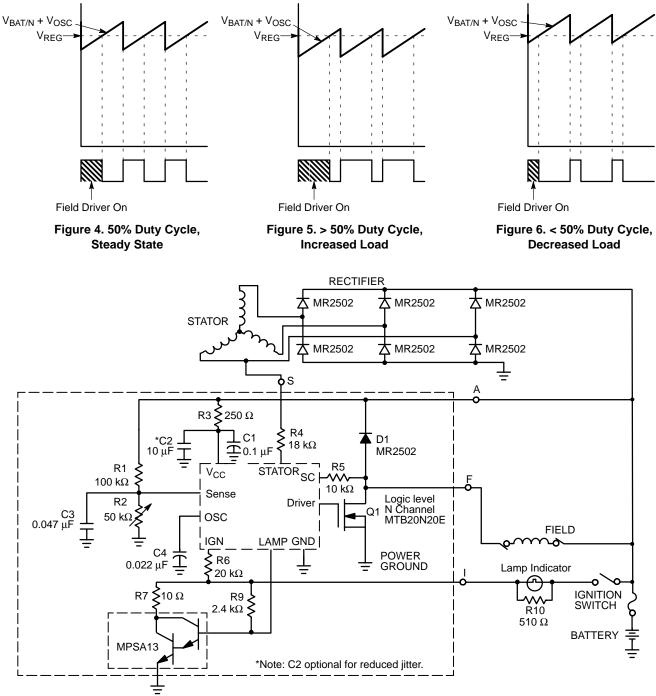
#### **REGULATION WAVEFORMS**

The CS3361 utilizes proportion control to maintain regulation. Waveforms depicting operation are shown in Figures 4, 5 and 6, where  $V_{BAT/N}$  is the divided down voltage present on the Sense pin using R1 and R2 (Figure 7). A sawtooth waveform is generated internally. The amplitude of this waveform is listed in the electric parameter section as proportion control. The oscillator voltage is summed with  $V_{BAT/N}$ , and compared with the internal voltage regulator ( $V_{REG}$ ) in the regulation comparator which controls the field through the output "Device Driver."

Figure 4 shows typical steady-state operation. A 50% duty cycle is maintained.

Figure 5 shows the effect of a drop in voltage on ( $V_{BAT/N}$  +  $V_{OSC}$ ). Notice the duty cycle increase to the field drive.

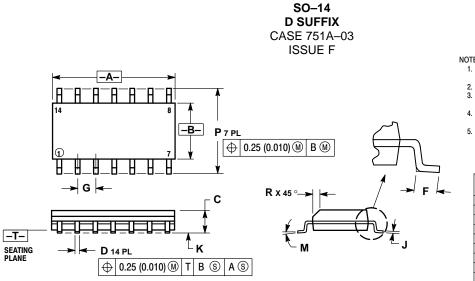
Figure 6 shows the effect of an increase in voltage (above the regulation voltage) on  $(V_{BAT/N} + V_{OSC})$ . Notice the decrease in field drive.





## **CS3361**

## PACKAGE DIMENSIONS



NOTES: 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982. 2. CONTROLLING DIMENSION: MILLIMETER. 3. DIMENSIONS 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.

	MILLIN	IETERS	INCHES		
DIM	MIN	MAX	MIN	MAX	
Α	8.55	8.75	0.337	0.344	
В	3.80	4.00	0.150	0.157	
С	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		
L	0.19	0.25	0.008	0.009	
K	0.10	0.25	0.004	0.009	
Μ	0 °	7°	0 °	7°	
Ρ	5.80	6.20	0.228	0.244	
R	0.25	0.50	0.010	0.019	

#### PACKAGE THERMAL DATA

Parameter	SO-14	Unit	
$R_{\Theta JC}$	Typical	30	°C/W
$R_{\Theta JA}$	Typical	125	°C/W

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