

POWER MANAGEMENT

BiCMOS Current-Mode PWM Controllers

- 1MHz Operation
- No Cross-Conduction Current
- 50ns Current-Sense Delay

The IMP38C4x and IMP38HC4x are fixed frequency, high performance, current-mode PWM controllers that are pin compatible with bipolar 384x devices but feature improvements resulting from IMP's BiCMOS processing and circuit design. Notable among the improvements are zero cross-conduction/shoot-through current, reduced start-up and operating current, lower current-sense delay, higher frequency operation, full supply voltage swing at the output and a 1% trimmed voltage reference.

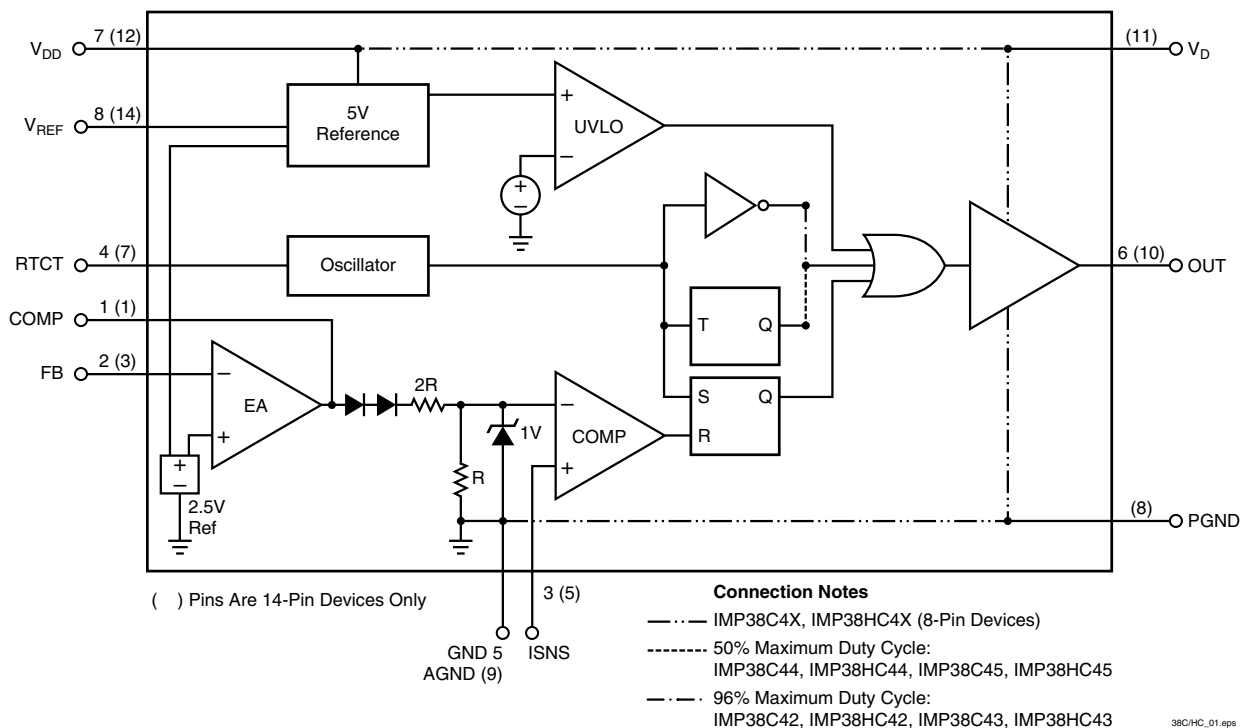
IMP38C4x and IMP38HC4x output driver stage has zero cross-conduction current. A proprietary output state-machine monitors each output MOSFET and guarantees by design zero cross-conduction current. This is an industry first for 384x PWM devices.

Under-voltage lockout (UVL) performance has been improved. When the power supply voltage is below the startup voltage, internal circuitry puts the output into a low impedance state. The output will sink 20mA and remain below 1.3V, well below the turn-on threshold voltage of the external MOSFET. Even when V_{DD} drops to zero volts, the out pin will not rise above approximately 1.3V because the output UVLO circuit is

Key Features

- ◆ 384x Series Pinout with BiCMOS Technology
- ◆ Zero Cross-Conduction Current by Design
- ◆ 1MHz Operation
- ◆ 65ns Maximum Current-Sense Delay
- ◆ 120µA Maximum Start-Up Current
- ◆ 1.5mA Maximum Operating Current
- ◆ High Output Current Drive
 - 1.0A, IMP38HC4x
 - 0.5A, IMP38C4x
- ◆ 20V Maximum Supply Voltage
- ◆ 2.5V, 1%, Trimmed Error Amplifier Reference
- ◆ Trimmed Oscillator Discharge Current
- ◆ Pin-for-Pin Enhanced Replacements for Micrel MIC38C/HC4x and GMT38C4x/HC4x

Block Diagrams



powered through the out pin. Leakage current from the external power MOSFETs will not force the PWM output to rise and turn the external MOSFETs on.

Current-sense propagation delay time is 35ns typical, 65ns maximum, representing an up to 75 percent reduction over other 38xx implementations.

Output stage drive is 0.5A for IMP38C4x devices. The high-drive IMP38HC4x family is rated at 1.0A peak current drive.

Like conventional 384x controllers, the IMP38C4x and IMP38HC4x controllers use the current-mode architecture for superior load regulation, pulse-by-pulse current limiting and output MOSFET protection. All versions operate up to 20 volts.

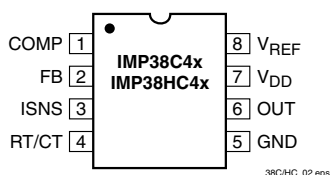
For maximum application flexibility, start-up voltage ranges from 14.5V to 8.4V. Start-up current has been reduced to 120µA maximum and operating current has been reduced to 1.5mA maximum.

The IMP38C4x/IMP38HC4x are available in 8-pin and 14-pin DIP and SO packages as well as the 8-pin MicroSO package. The 14-pin devices provide separate pins for the controller power supply and the output driver supply. This configuration maximizes application flexibility and performance. The 14-pin package can also dissipate more power. Devices in the compact 8-pin packages do not have separate output drive supply connections.

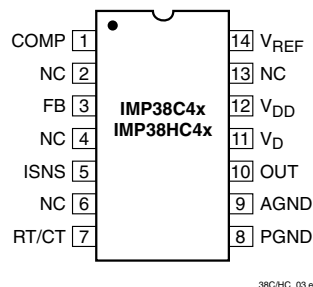
The IMP38C4x and IMP38HC4x families operate over the -40°C to +85°C temperature range.

Pin Configuration

SO/MicroSO/DIP



SO/DIP



Pin Descriptions

Pin Number		Name	Function
8-Pin Package	14-Pin Package		
1	1	COMP	Output of the Error amplifier and input to the PWM comparator.
2	3	FB	Inverting input of the Error Amplifier.
3	5	ISNS	Current sense comparator input. It is internally limited to 1V.
4	7	RT/CT	Oscillator RC timing component connection. Resistor RT is connected to V _{REF} and capacitor CT is connected to ground. Different values of RT and CT determine the maximum duty cycle.
5	8	GND/PGND	Combined power and analog ground for 8-pin packaged devices and power ground for 14-pin package.
6	10	OUT	High-power, totem-pole driver output. OUT pin is actively held LOW when V _{CC} is below the UVLO threshold.
7	12	V _{DD}	Supply voltage input.
8	14	V _{REF}	5V-reference voltage output.
	9	AGND	Analog ground connection for 14-pin package.
	11	V _D	Output driver supply voltage for 14-pin package.
	2, 4, 6, 13	NC	No internal connection.

38C-HC_101.eps

Ordering Information

IMP Ordering Part Number	Package	Operating Temperature Range	Startup Voltage	Minimum Operating Voltage	Maximum Duty Cycle	Reference Voltage	Peak Output Current Drive
IMP38C42EPA	8-Plastic DIP	-40°C to 85°C	14.5V	9.0V	96%	2.5V	0.5A
IMP38C42EPD	14-Plastic DIP	-40°C to 85°C	14.5V	9.0V	96%	2.5V	0.5A
IMP38C42ESA	8-SO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	0.5A
IMP38C42ESD	14-SO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	0.5A
IMP38C42EMA	8-MicroSO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	0.5A
IMP38C42/D	DIE						
IMP38C43EPA	8-Plastic DIP	-40°C to 85°C	8.4V	7.6V	96%	2.5V	0.5A
IMP38C43EPD	14-Plastic DIP	-40°C to 85°C	8.4V	7.6V	96%	2.5V	0.5A
IMP38C43ESA	8-SO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	0.5A
IMP38C43ESD	14-SO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	0.5A
IMP38C43EMA	8-MicroSO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	0.5A
IMP38C43/D	DIE						
IMP38C44EPA	8-Plastic DIP	-40°C to 85°C	14.5V	9.0V	50%	2.5V	0.5A
IMP38C44EPD	14-Plastic DIP	-40°C to 85°C	14.5V	9.0V	50%	2.5V	0.5A
IMP38C44ESA	8-SO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	0.5A
IMP38C44ESD	14-SO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	0.5A
IMP38C44EMA	8-MicroSO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	0.5A
IMP38C44/D	DIE						
IMP38C45EPA	8-Plastic DIP	-40°C to 85°C	8.4V	7.6V	50%	2.5V	0.5A
IMP38C45EPD	14-Plastic DIP	-40°C to 85°C	8.4V	7.6V	50%	2.5V	0.5A
IMP38C45ESA	8-SO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	0.5A
IMP38C45ESD	14-SO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	0.5A
IMP38C45EMA	8-MicroSO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	0.5A
IMP38C45/D	DIE						
IMP38HC42EPA	8-Plastic DIP	-40°C to 85°C	14.5V	9.0V	96%	2.5V	1.0A
IMP38HC42EPD	14-Plastic DIP	-40°C to 85°C	14.5V	9.0V	96%	2.5V	1.0A
IMP38HC42ESA	8-SO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	1.0A
IMP38HC42ESD	14-SO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	1.0A
IMP38HC42EMA	8-MicroSO	-40°C to 85°C	14.5V	9.0V	96%	2.5V	1.0A
IMP38HC42/D	DIE						
IMP38HC43EPA	8-Plastic DIP	-40°C to 85°C	8.4V	7.6V	96%	2.5V	1.0A
IMP38HC43EPD	14-Plastic DIP	-40°C to 85°C	8.4V	7.6V	96%	2.5V	1.0A
IMP38HC43ESA	8-SO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	1.0A
IMP38HC43ESD	14-SO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	1.0A
IMP38HC43EMA	8-MicroSO	-40°C to 85°C	8.4V	7.6V	96%	2.5V	1.0A
IMP38HC43/D	DIE						
IMP38HC44EPA	8-Plastic DIP	-40°C to 85°C	14.5V	9.0V	50%	2.5V	1.0A
IMP38HC44EPD	14-Plastic DIP	-40°C to 85°C	14.5V	9.0V	50%	2.5V	1.0A
IMP38HC44ESA	8-SO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	1.0A
IMP38HC44ESD	14-SO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	1.0A
IMP38HC44EMA	8-MicroSO	-40°C to 85°C	14.5V	9.0V	50%	2.5V	1.0A
IMP38HC44/D	DIE						
IMP38HC45EPA	8-Plastic DIP	-40°C to 85°C	8.4V	7.6V	50%	2.5V	1.0A
IMP38HC45EPD	14-Plastic DIP	-40°C to 85°C	8.4V	7.6V	50%	2.5V	1.0A
IMP38HC45ESA	8-SO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	1.0A
IMP38HC45ESD	14-SO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	1.0A
IMP38HC45EMA	8-MicroSO	-40°C to 85°C	8.4V	7.6V	50%	2.5V	1.0A
IMP38HC45/D	DIE						

For SO and MicroSO packages, append "IT" to the ordering part number for tape and reel packaging.

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Absolute Maximum Ratings

V _{CC} Supply Voltage	20V
V _{CC} Supply Current	30mA
I _{OUT} Current	1.0A
Current-Sense and Feedback Inputs	0.3V to 5.5V
Operation Junction Temperature	+150°C
Storage Temperature	-65°C to +150°C
Lead Soldering Temperature (10 seconds)	+300°C

Package Thermal Resistance	
8-Pin Plastic DIP (θ_{JA})	125°C/W
8-Pin MicroSO (θ_{JA})	250°C/W
8-Pin SO (θ_{JA})	170°C/W
14-Pin Plastic DIP (θ_{JA})	90°C/W
14-Pin SO (θ_{JA})	145°C/W

Note: All voltages are referenced to GND.

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability.

Electrical Characteristics

Unless otherwise noted, V_{CC} = 15V, R_T = 10k Ω and C_T = 3.3nF. Specifications are over the -40°C to +85°C ambient temperature range.

Bold/blue specifications indicate enhanced performance features.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Reference						
Output voltage	V _{REF}	T _A = +25°C, I _O = 1mA	4.90	5.00	5.10	V
Line Regulation		12V ≤ V _{CC} ≤ 18V, I _{OUT} = 5 μ A		2	20	mV
Load Regulation		1mA ≤ I _O ≤ 20mA		1	25	mV
Temperature Stability	TC _{REF}	Note 1		0.2		mV/°C
Total Reference Variation		Line, Load, Temperature, Note 1	4.82		5.18	V
Output Noise Voltage	V _N	10Hz ≤ f ≤ 10kHz, T _A = +25°C, Note 1		50		μ V
Long Term Stability		T _A = 125°C, 1000 Hours, Note 1			TBD	mV
Output Short Circuit	I _{SC}		-30	-40	-180	mA
Oscillator Section						
Initial Accuracy	f _{INIT}	T _A = 25°C, Note 5	49	52	55	kHz
Voltage Stability		12V ≤ V _{CC} ≤ 18V		0.2	1.0	%
Temperature Stability	TC _{OSC}	Note 1		0.04		%/°C
Discharge Current		V _{RT/CT} = 2V	7.2	8.4	12.0	mA
Amplitude peak-to-peak	V _{OSC, P-P}	V _{RT/CT} peak-to-peak	1.1	1.7	2.3	V
Error Amplifier Section						
Input Voltage	V_{IN}	V_{COMP} = 2.5V	2.45	2.50	2.55	V
Input Bias Current	I _B	V _{FB} = 4.5V	-1		1	μ A
Open Loop Gain	A _{VOL}	2V ≤ V _O ≤ 4V, Note 1	65	90		dB
Unity Gain Bandwidth	UGBW	Note 1	0.7	1.0		MHz
Power Supply Rejection Ratio	PSRR	V _{START} ≤ V _{CC} ≤ V _{CCMAX}	60			dB
Output Sink Current	I _{OL}	V _{FB} = 2.7V, V _{comp} = 1.1V	2	6		mA
Output Source Current	I _{OH}	V _{FB} = 2.3V, V _{comp} = 5.0V	-0.5	-1.0		mA
V _{OUT} High	V _{OH}	V _{FB} = 2.3V, R _L = 15k Ω to ground	4.5	4.6	5.0	V
V _{OUT} Low	V _{OL}	V _{FB} = 2.7V, R _L = 15k Ω to V _{REF}		0.30	0.50	V

Electrical Characteristics

Unless otherwise noted, $V_{CC} = 15V$, $R_T = 10k\Omega$ and $C_T = 3.3nF$. Specifications are over the $-40^\circ C$ to $+85^\circ C$ ambient temperature range. **Bold/blue** specifications indicate enhanced performance features.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Current Sense						
Gain	A_{VOL}	Notes 1, 2 and 3	2.90	3.00	3.10	V/V
Over Current Protection Threshold		$V_{comp} = \max$, Note 2	0.9	0.98	1.1	V
Power Supply Rejection Ratio	PSRR	$V_{START} \leq V_{CC} \leq 18V$		70		dB
Input Bias Current	I_B			-0.1	-2.0	μA
Delay to Output	T_{PD}	$V_{FB} = 0V$, ISNS 0V to 2V, $C_L = 1nF$		50	65	ns
Output						
IMP38C4x ON Resistance, High ON Resistance, Low	$R_{DS(ON)}$	$I_{SOURCE} = 0.2A$ $I_{SINK} = 0.2A$		20 11		Ω
IMP38HC4x ON Resistance, High ON Resistance, Low	$R_{DS(ON)}$	$I_{SOURCE} = 0.2A$ $I_{SINK} = 0.2A$		10 5.5		Ω
Peak Drive Current		HC devices H devices	1.0 0.5			A
IMP38C4x Rise Time	T_R	$T_A = 25^\circ C$, $C_L = 1nF$		40	70	ns
IMP38C4x Fall Time	T_F	$T_A = 25^\circ C$, $C_L = 1nF$		30	50	ns
IMP38HC4x Rise Time	T_R	$T_A = 25^\circ C$, $C_L = 1nF$		20	50	ns
IMP38HC4x Fall Time	T_F	$T_A = 25^\circ C$, $C_L = 1nF$		15	40	ns
Shoot-through Current				0		mA
Undervoltage Lockout						
Start Threshold		IMP38C42/4, IMP38HC42/4 IMP38C43/5, IMP38HC43/5	13.5 7.8	14.5 8.4	15.5 9.0	V
Minimum Operating Voltage		IMP38C42/4, IMP38HC42/4 IMP38C43/5, IMP38HC43/5	8 7.0	9 7.6	10 8.2	V
Pulse Width Modulator						
Maximum Duty Cycle		IMP38C42/3, IMP38HC42/3,	94	96		%
Maximum Duty Cycle		IMP38C44/5, IMP38HC44/5	48	50		%
Minimum Duty Cycle					0	%
Supply Current						
Start-Up Current		$V_{CC} = 13V$ for IMP38C42/44, IMP38HC42/44 $V_{CC} = 7.5V$ for IMP38C43/45, IMP38HC43/45		95	120	μA
Operating Current	I_{CC}	$V_{FB} = V_{IS} = 0$		0.5	1.5	mA

Note 1. Guaranteed by design. Not 100% tested in production.

Note 2. Measured at trip point of $V_{FB} = 0V$.

Note 3. Gain is defined as:

$$A = \frac{\Delta V_{COMP}}{\Delta V_{CS}}, 0 \leq V_{CS} \leq 0.8V$$

Note 4. Adjust V_{CC} above the start threshold before setting at 15V.

Note 5. Output frequency equals the oscillator frequency for IMP38C42/3 and IMP38HC42/3 devices. Output frequency equals one-half the oscillator frequency for IMP38C44/5 and IMP38HC44/5 devices.

Table 1. Startup and Operating Voltage Selection Guide

Duty Cycle	UVLO Thresholds	
	Start-up at 8.4V Operating Minimum = 7.6V	Start-up at 14.5V Operating Minimum = 9.0V
0% to 96%	IMP38C43/HC43	IMP38C42/HC42
0% to 50%	IMP38C45/HC45	IMP38C44/HC44

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Application Information

The IMP38C and IMP38HC devices are compatible with generic 384x PWM devices. The following discussion highlights the differences and advantages of the IMP 'C' and 'HC' designs.

Start-up Current

IMP's BiCMOS process allows for substantial reduction in the start-up current. Typical start-up current is 95µA, with a maximum limit of 120µA. Low start-up current allows high resistance, lower-wattage, start-up resistors to supply controller start-up power.

Operating Current

Operating current has been reduced to 1.5mA maximum. Compared to the 11mA needed for a typical bipolar controller and 6mA for competitive BiCMOS controllers, IMP's low operating current allows the controller to run cooler and with better efficiency. In addition, the V_{CC} hold-up capacitance (used during start-up) can be reduced.

Output Driver

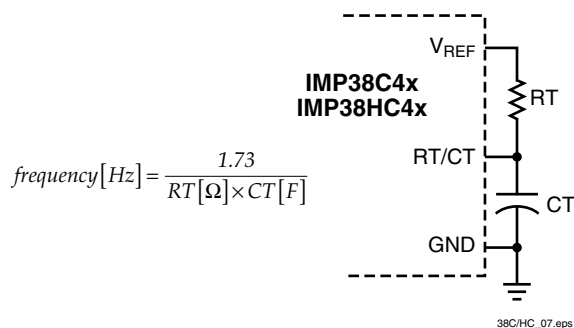
The IMP38HC4x/38C4x CMOS output stage drives external power MOSFETs to the full supply voltage. Low ON-resistance and high peak current drive combine to give greater than 1000pF gate capacitance drive capability. Rise and fall time requirements may dictate the appropriate value of output capacitance. Within the restrictions of output capacity and controller power dissipation, switching frequencies can exceed 1MHz.

The CMOS output stage "break-before-make" action is guaranteed by design and insures that no cross-conduction current will flow. This minimizes heat dissipation, increases efficiency and enhances reliability.

Oscillator Operation

Two external components, RT and CT, set the switching frequency.

With V_{CC} = 14V, RT = 10k and CT = 3.3nF, nominal switching frequency is 50kHz.



$$frequency [Hz] = \frac{1.73}{RT[\Omega] \times CT[F]}$$

Figure 1. Oscillator Component Selection

Transient Protection

Good high-frequency layout practices should be followed. Avoid long printed-circuit traces and component leads. Locate oscillator and compensation components near the IC. Avoid capacitive and inductive coupling of the switching waveform into the high-impedance inputs of the error amplifier, oscillator, and current-sense amplifier. V_{REF} and V_{CC} stability will be aided by using high-frequency decoupling capacitors.

Undervoltage Lockout

Several different thresholds are available.

Undervoltage Lockout Thresholds	
Start-up at 8.4V Operating Minimum = 7.6V	Start-up at 14.5V Operating Minimum = 9.0V
IMP38C43/HC43	IMP38C42/HC42
IMP38C45/HC45	IMP38C44/HC44

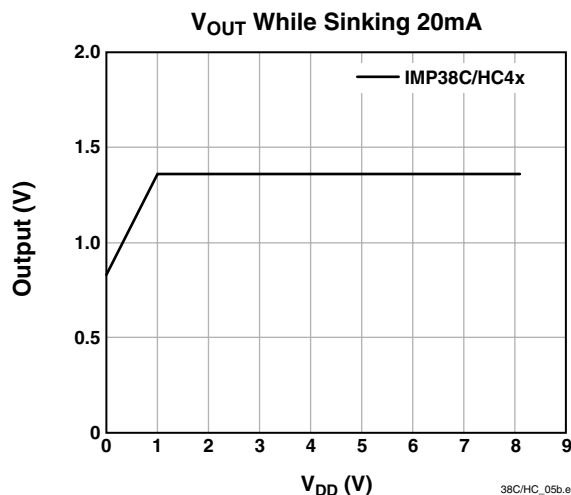
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Under-voltage lockout (UVL) performance has been improved. When the power supply voltage is below the startup voltage, internal circuitry puts the output into a low impedance state and sets the output to zero. The output will sink up to 20mA in this controlled state and remain below 1.3V, well below the turn-on threshold voltage of the external MOSFET.

With the IMP38C/HC4x output stage design, leakage current from the external power MOSFETs will not force the PWM output to rise and turn the external MOSFET on.

Even when V_{DD} drops to zero volts, the OUT pin will not rise above approximately 1.3V because the UVLO circuit is powered through the OUT pin.

The IMP output stage performance in UVL mode, while sinking 20mA, is shown in Figure 2.



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Figure 2. Output Stage Performance in UVL Mode

Application Information

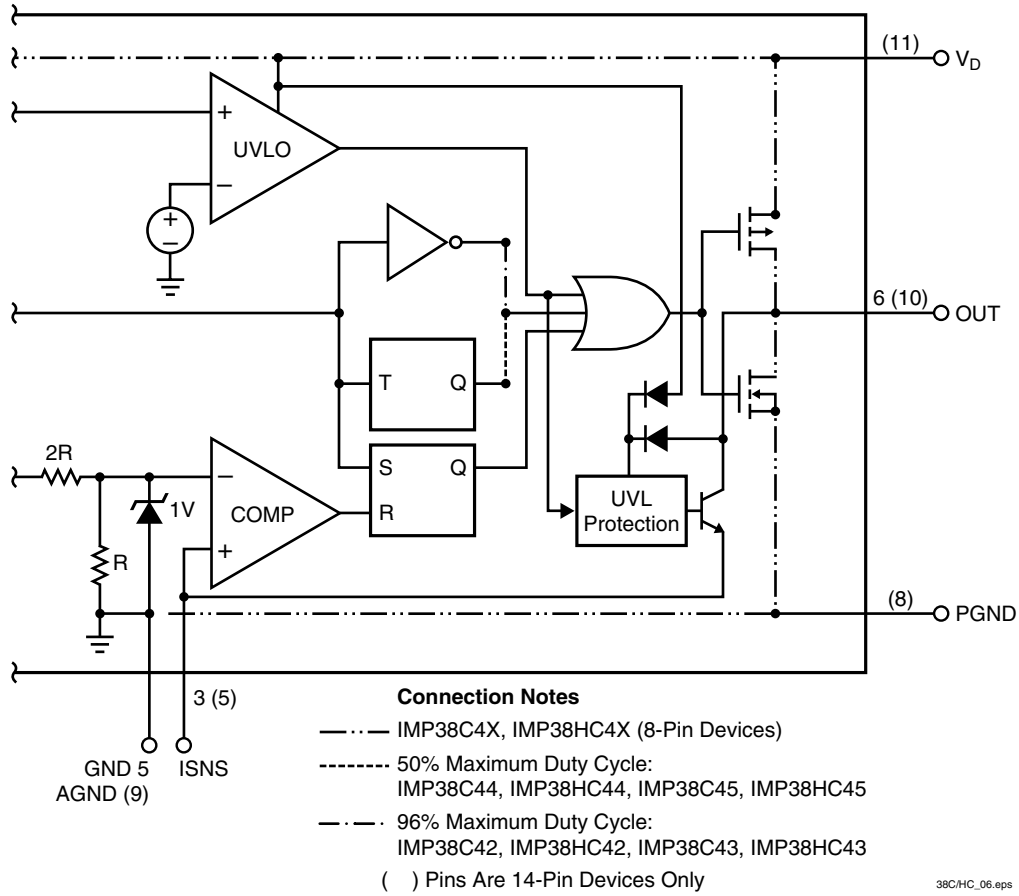
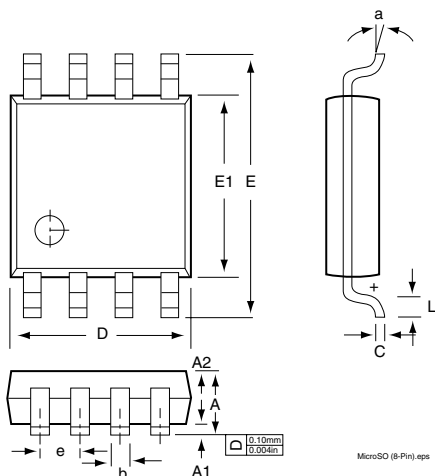


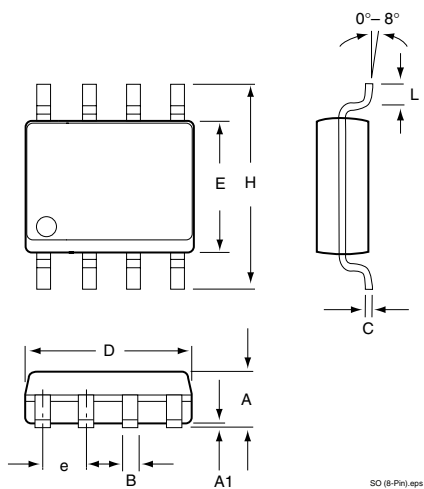
Figure 3. UVL Protection Circuit

Package Dimensions

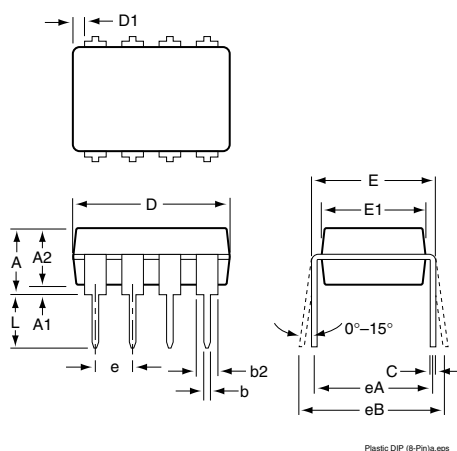
SO (8-Pin)



SO (8-Pin)



Plastic DIP (8-Pin)



	Inches		Millimeters	
	Min	Max	Min	Max
MicroSO (8-Pin)*				
A	—	0.0433	—	1.10
A1	0.0020	0.0059	0.050	0.15
A2	0.0295	0.0374	0.75	0.95
b	0.0098	0.0157	0.25	0.40
C	0.0051	0.0091	0.13	0.23
D	0.1142	0.1220	2.90	3.10
e	0.0256 BSC		0.65 BSC	
E	0.193 BSC		4.90 BSC	
E1	0.1142	0.1220	2.90	3.10
L	0.0157	0.0276	0.40	0.70
a	0°	6°	0°	6°
SO (8-Pin)**				
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.013	0.020	0.33	0.51
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27
D	0.189	0.197	4.80	2.00
Plastic DIP (8-Pin)***				
A	—	0.210	—	5.33
A1	0.015	—	0.38	—
A2	0.115	0.195	2.92	4.95
b	0.014	0.022	0.36	0.56
b2	0.045	0.070	1.14	1.78
b3	0.030	0.045	0.80	1.14
D	0.355	0.400	9.02	10.16
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	—	2.54	
eA	0.300	—	7.62	
eB	—	0.430	—	10.92
eC	—	0.060	—	—
L	0.115	0.150	2.92	3.81

* JEDEC Drawing MO-187AA

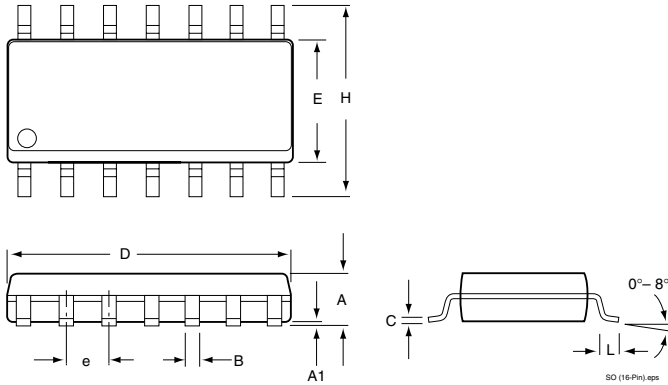
** JEDEC Drawing MS-112AA

*** JEDEC Drawing MS-001BA

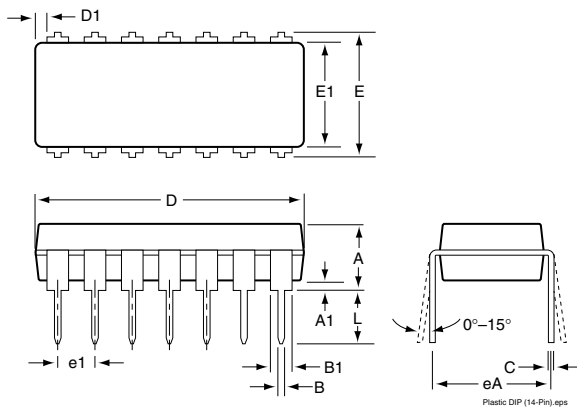
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Package Dimensions

SO (14-Pin)



Plastic DIP (14-Pin)



	Inches		Millimeters	
	Min	Max	Min	Max
SO (14-Pin)*				
A	0.0926	0.1043	2.35	2.65
A1	0.0040	0.118	0.10	0.30
B	0.013	0.020	0.33	0.51
C	0.0091	0.0125	0.23	0.32
D	0.3465	0.3622	8.80	9.20
E	0.214	0.2992	7.40	7.60
e	0.050 BSC		1.27 BSC	
H	0.394	0.419	10.00	10.65
L	0.016	0.050	0.40	1.27
Plastic DIP (14-Pin)**				
A	0.155	0.200	3.94	5.08
A1	0.20	0.50	0.51	1.27
B	0.014	0.020	0.356	0.508
B1	0.050	0.065	1.27	1.65
C	0.008	0.012	0.204	0.304
D	0.745	0.770	18.93	19.55
E	0.300	0.325	7.62	8.25
E1	0.240	0.260	6.10	6.60
e1	0.100 TYP		2.54 TYP	
eA	0.300 TYP		7.62 TYP	
L	0.100	—	3.18	3.81

* JEDEC Drawing MS-013 AF

** JEDEC Drawing MO-001 AA-AB

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