



# 1.25A High Efficiency Switching Regulator

## Description

The CS3972 is a 1.25A, 60V, current mode, high efficiency, switching regulator circuit. It can be configured in buck, boost, forward, isolated and non-isolated topologies, using a single-ended switch.

The IC contains a 1.25A high efficiency output switch, precision bandgap reference, voltage regulator, error amplifier, oscillator, control, and protection circuitry.

Output transistor efficiency is achieved by keeping the switch in quasi-saturation when it is on. This minimizes the switch turn-off delay time and power dissipation, an important consideration for applications with wide ranging loads.

The precision reference is internally trimmed to 1.24V, while the oscillator frequency is internally trimmed to 40kHz. The on board 2.3V regulator powers the internal circuitry. By keeping the voltage regulator at 2.3V, the IC is able to operate down to 3V and maintain a constant input supply current of 6mA(typ).

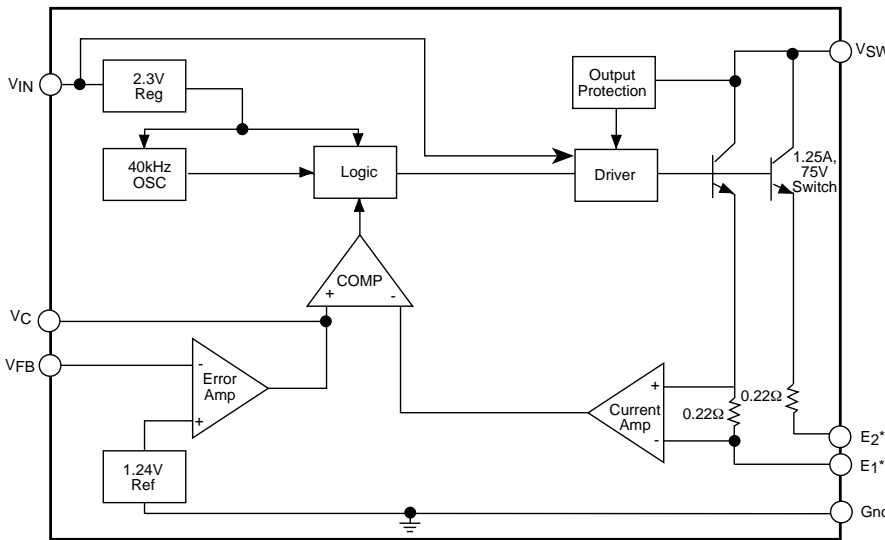
Synchronization mode is achieved by applying a pulsating  $V_C$  voltage of less than 0.2V with a duration of about  $0.5\mu s$  to  $V_C$  pin. The switching frequency can be adjusted from 50kHz to 70kHz. The IC's synchronization mode is set externally.

Protection circuitry includes a variable current limit with external voltage clamp, under-voltage and over-temperature protection.

## Features

- 75V<sub>MAX</sub>, 2A<sub>PEAK</sub> Internal Switch
- 3V to 60V Input Voltage Range
- 6mA Input Supply Current
- 1.24V Precision Reference
- 40kHz Switching Frequency
- Variable Current Limit with External Voltage Clamp
- Under-Voltage Protection
- Over-Temperature Protection
- External Synchronization

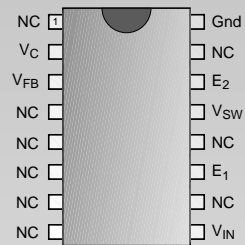
## Block Diagram



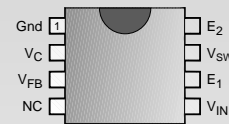
\*Always connect E1 to Ground Pin on DIP package. Both emitters are tied to ground on TO-220 Package.

## Package Options

### 16L SO Wide

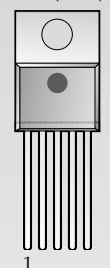


### 8L PDIP



### 5L TO-220

Tab (Gnd)



## Absolute Maximum Ratings

Input Voltage Range .....	3V to 60V
Output Switching Voltage.....	75V
Voltage Transient ( $t_r=10\mu s$ , $t_f=400ms$ ) .....	60V
ESD (Human Body Model; $R=1.5k\Omega$ , $C=100pF$ ) .....	2kV
Junction Temperature Range.....	-40°C to +150°C
Storage Temperature Range .....	-65°C to +150°C
Lead Temperature Soldering	
Wave Solder (through hole styles only).....	10 sec. max, 260°C peak
Reflow (SMD styles only) .....	60 sec. max above 183°C, 230°C peak
Feedback Pin Voltage (1ms transient).....	$\pm 15V$

### Electrical Characteristics: For $3V \leq V_{CC} \leq 60V$ , $-40^\circ C \leq T_A \leq 125^\circ C$ unless otherwise specified.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Reference Voltage	$V_C=0.8V$ ; $V_{FB}=V_{REF}$	1.214	1.244	1.274	V
Line Regulation	$V_C=0.8V$ ; $V_{FB}=V_{REF}$ , $3V \leq V_{IN} \leq 60V$			0.03	%/V
Feedback Input Current	$V_C=0.8V$ ; $V_{FB}=V_{REF}$		350	1100	nA
Minimum Input Voltage	$V_C=V_{FB}=V_{REF}$		2.6	3.0	V
Supply Current	$V_C=0.6V$ ; $3V \leq V_{IN} \leq 60V$		6.0	9.0	mA
Supply Current Increase during switch on time	$V_C=open$ , $1.0V \leq V_{FB} \leq 1.5V$		25		mA/A
Switching Frequency	$V_C=V_{FB}=V_{REF}$ ; $V_{SW}=15V$	33	40	47	kHz
Maximum Duty Cycle	$V_C=2V$ ; $V_{FB}=open$ , $V_{SW}=15V$		92		%
$V_C$ Threshold	$V_{FB}=open$ ; $V_{SW}=15V$ , duty cycle=0%	0.60	0.90	1.25	V
<b>■ Error Amplifier</b>					
Transconductance	$V_C=0.8V$ ; $V_{FB}=V_{REF}$ , $\Delta I_C = \pm 25\mu A$	2400	4400	7000	$\mu mho$
Source/Sink Current	$V_C=1.5V$	120	200	400	$\mu A$
High Voltage Clamp	$V_{FB}=1.0V$		2.0		V
Low Voltage Clamp	$V_{FB}=1.5V$		0.38		V
Gain	$0.9V \leq V_C \leq 1.4V$ , $V_{FB}=V_{REF}$		800		V/V
<b>■ Output Switch</b>					
Breakdown Voltage	$V_C=0.5V$ ; $3V \leq V_{IN} \leq 60V$ , $I_{OUT}=5mA$	75	90		V
On Resistance	$V_C=open$ , $V_{FB}=0.8V$ , $I_{OUT}=1.25A$		0.6	1.0	$\Omega$
Control Voltage to Switch Current Transconductance	$1.2V \leq V_C \leq 1.8V$		2		A/V
Current Limit	Duty Cycle $\leq 50\%$ , $T_J \geq 25^\circ C$	1.25		3.00	A
	Duty Cycle $\leq 50\%$ , $T_J < 25^\circ C$	1.25		3.50	A
	Duty Cycle = 80%	1.00		2.50	A
	Duty Cycle = 80% (Note 1)	0.50		2.50	A

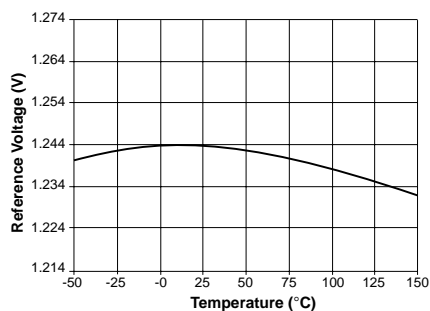
Note 1: 16 lead SO wide package only.

## Package Pin Description

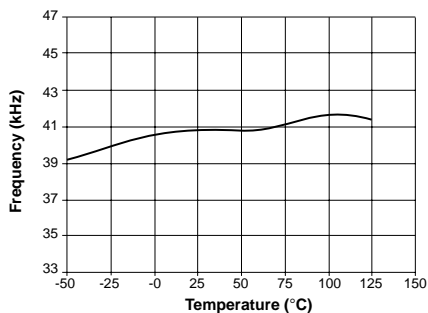
PACKAGE PIN #			PIN SYMBOL	FUNCTION
16L SO Wide	5L TO-220	8L PDIP		
16	3	1	Gnd	Logic and power ground on TO-220. Logic ground only on 8L PDIP.
2	1	2	$V_C$	Control voltage can be used for frequency compensation, current limit threshold, frequency synchronization, and soft start.
3	2	3	$V_{FB}$	Feedback voltage is the negative input to the error amplifier.
1,4,5,6,7,8, 10,12,15		4	NC	No connection.
9	5	5	$V_{IN}$	Supply input voltage with a range of 3V to 60V.
11		6	$E_1$	Emitter One is a power ground which should always be connected to logic ground since it is used as the negative input to the current sense amp.
13	4	7	$V_{SW}$	Collector of internal 75V NPN power switch.
14		8	$E_2$	Emitter Two is a power ground which can be left disconnected to reduce the switch rating to 625mA.

## Typical Performance Characteristics

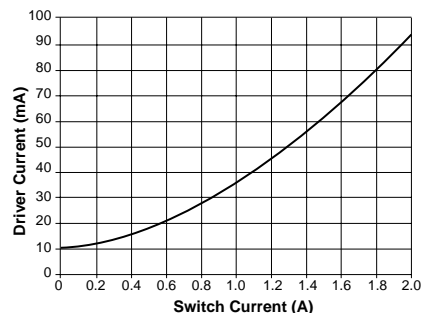
### Reference Voltage vs. Temperature



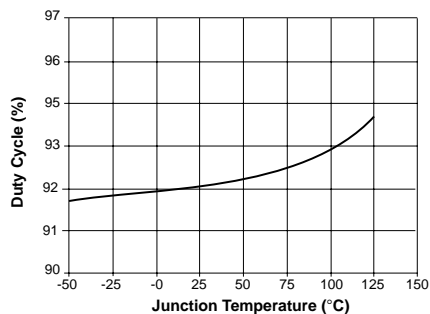
### Switching Frequency vs. Temperature



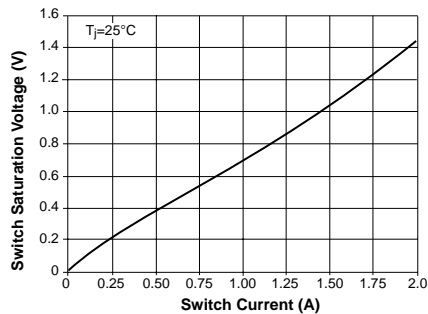
### Driver Current vs. Switch Current



### Maximum Duty Cycle



### Switch Saturation Voltage



The CS3972 has an on board, high current NPN transistor in its output stage. The output transistor is switched on every  $25\mu\text{s}$  by the on board 40 kHz oscillator. The output is switched off as soon as the output current reaches a dynamically controlled level. That level is determined by three factors: the current drawn by the load, the input voltage, and the output voltage. This control scheme has several benefits. The IC reacts quickly to overvoltage and short circuit conditions and it is less sensitive to input voltage fluctuation.

Current drawn by the load influences when the output stage turns off. The voltage across the internal high precision resistor ( $0.11\Omega$ ) in the emitter of the output transistor generating the input to the current sensing amplifier. The output of the current sensing amplifier provides one of the inputs to the comparator.

The other input to the comparator connected to the output of the error amplifier whose inverting input is connected to the output voltage through the feedback circuitry while its noninverting input is set to an internal reference voltage of 1.24V. When the current sensing amplifier output exceeds the error amplifier output, the comparator switches off, triggering the logic which turns off the output stage.

All on board amplifier, logic and protection circuitry uses the internal 2.3V reference to minimize quiescent current drain (6mA) and permits IC operation down to 3V.

The anti-saturation circuitry minimizes output switch turn off time and power dissipation, by keeping the power NPN at the edge of saturation.

### Application Diagrams

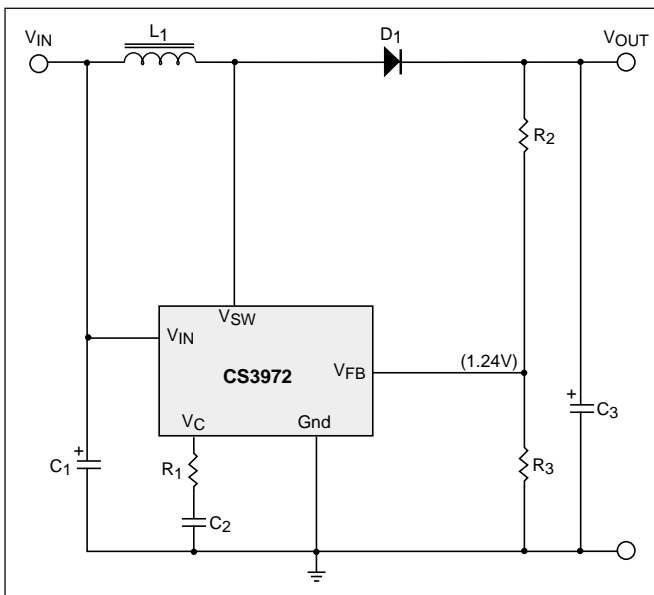


Figure 1: Boost Regulator

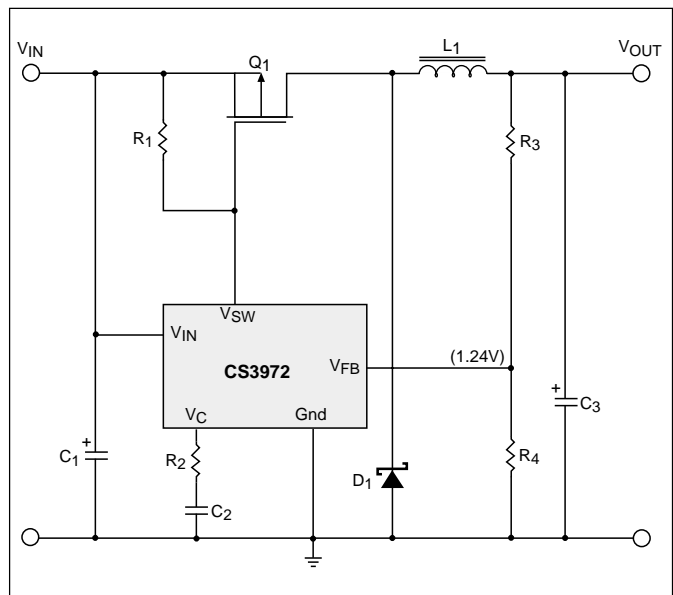


Figure 2: Buck Regulator with the External Switch

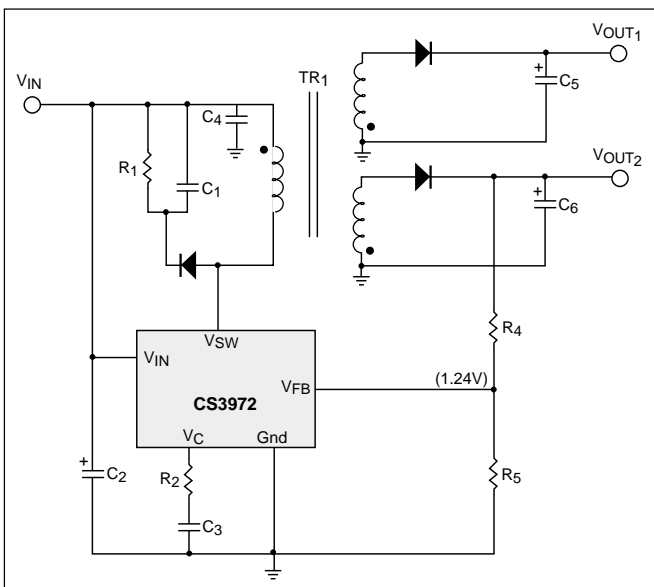


Figure 3: Flyback Multiple Output Regulator

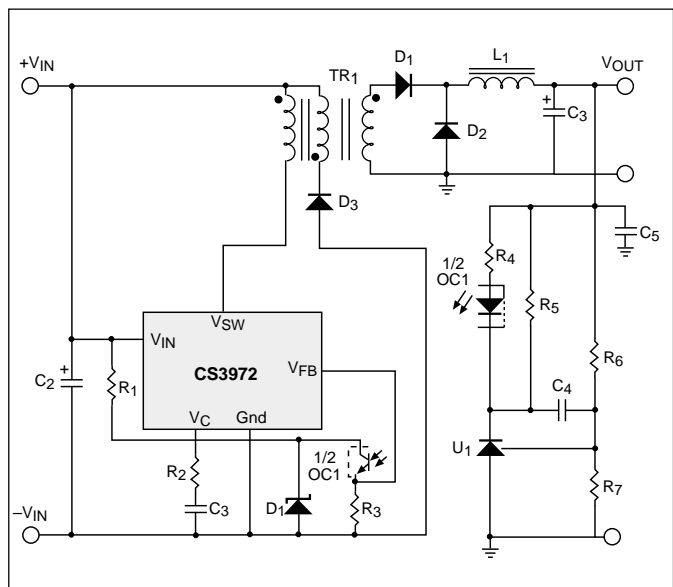


Figure 4: Isolated Forward Regulator

Package Specification

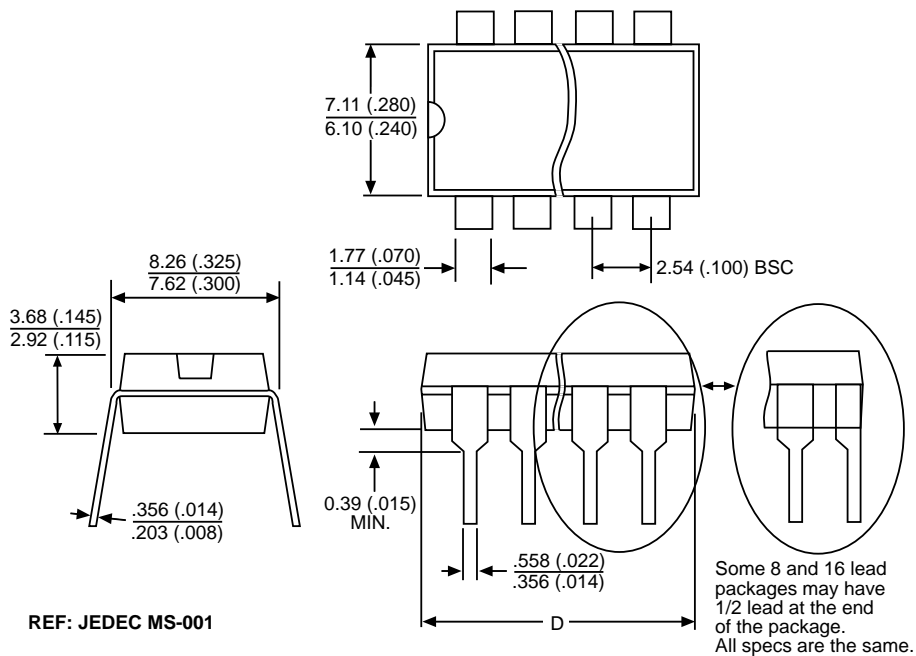
PACKAGE DIMENSIONS IN mm (INCHES)

Lead Count	D			
	Metric		English	
	Max	Min	Max	Min
8 Lead PDIP	10.16	9.02	.400	.355
16 Lead SO Wide	10.50	10.10	.413	.398

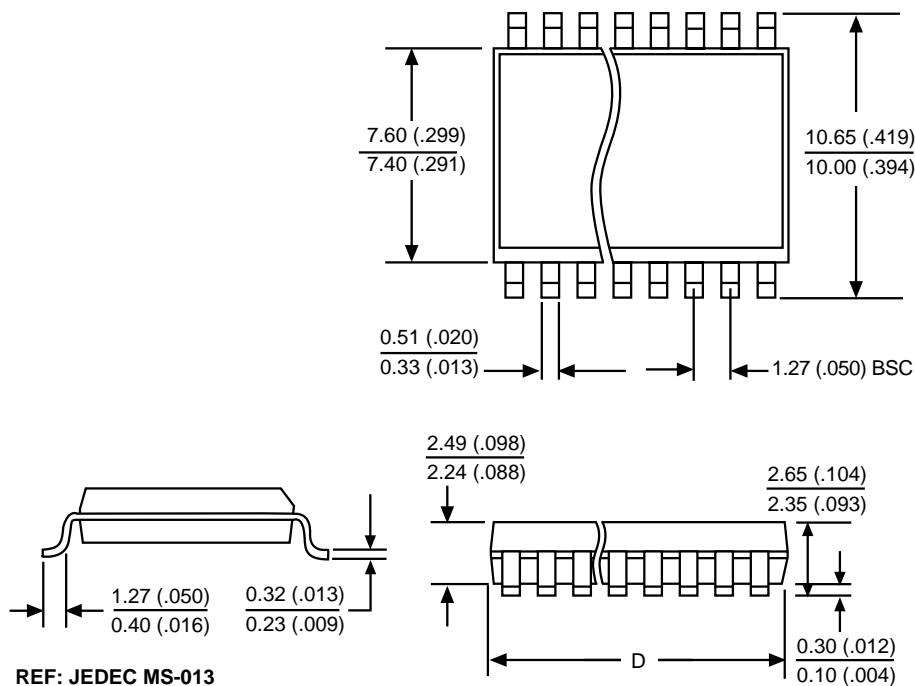
PACKAGE THERMAL DATA

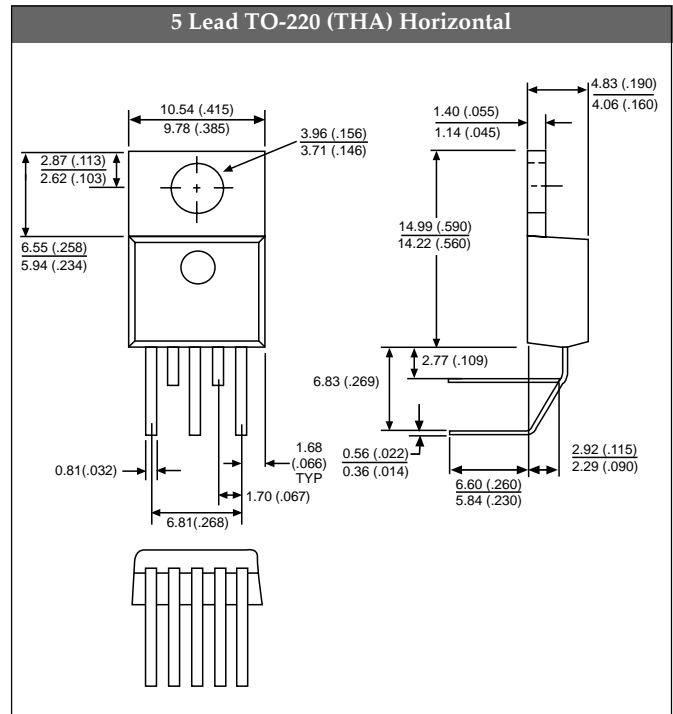
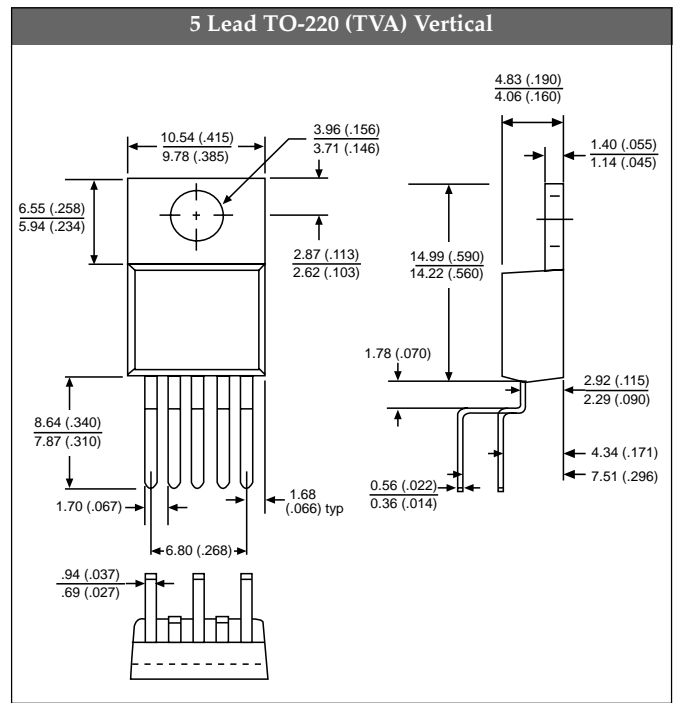
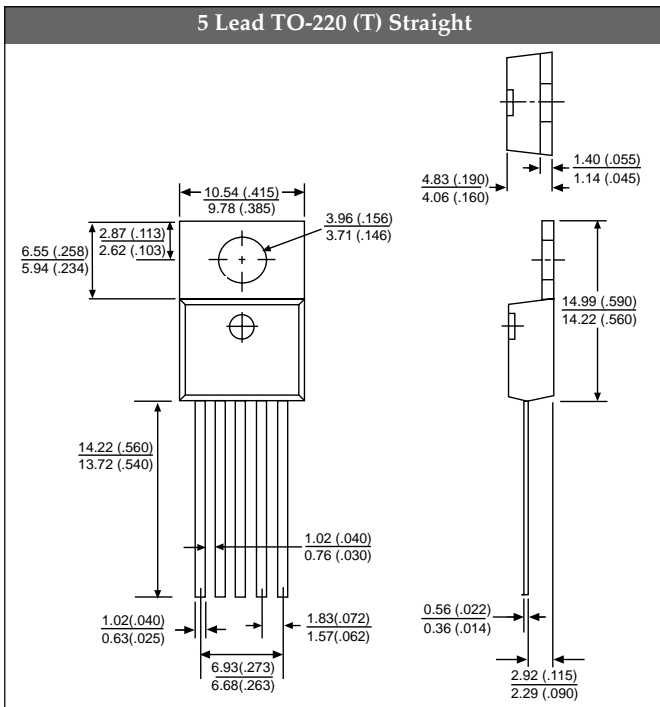
Thermal Data		5L TO-220	8L PDIP	16L SO Wide	
R <sub>θJC</sub>	typ	1.7	52	23	°C/W
R <sub>θJA</sub>	typ	50	100	105	°C/W

Plastic DIP (N); 300 mil wide



Surface Mount Wide Body (DW); 300 mil wide





Ordering Information	
Part Number	Description
CS3972YN8	8L PDIP
CS3972YDW16	16L SO Wide
CS3972YDWR16	16L SO Wide (tape & reel)
CS3972YT5	TO-220 Straight
CS3972YTVA5	TO-220 Vertical
CS3972YTHA5	TO-220 Horizontal

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