

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).

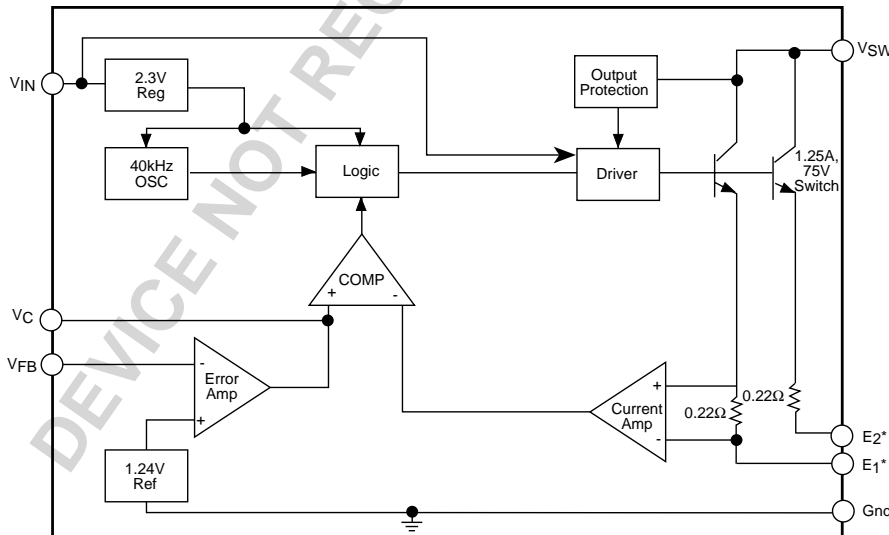
Synchronization mode is achieved by applying a pulsating V_C voltage of less than 0.2V with a duration of about 0.5 μ s to V_C pin. The switching frequency can be adjusted from 50kHz to 70kHz. The IC's synchronization mode is set externally.

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

Features

- 75V_{MAX}, 2A_{PEAK} 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

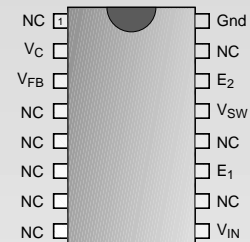
Block Diagram



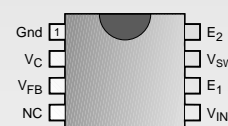
*Always connect E1 to Ground Pin on DIP package. Both emitters are tied to ground on TO-220 Package.

Package Options

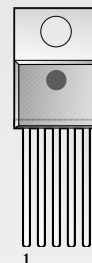
16L SO Wide



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)..... | ±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 |
| ■ Error Amplifier | | | | | |
| Transconductance | $V_C=0.8V$; $V_{FB}=V_{REF}$, $\Delta I_C = \pm 25\mu A$ | 2400 | 4400 | 7000 | μmho |
| Source/Sink Current | $V_C=1.5V$ | 120 | 200 | 400 | μA |
| 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 |
| ■ Output Switch | | | | | |
| 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 | Ω |
| 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 |

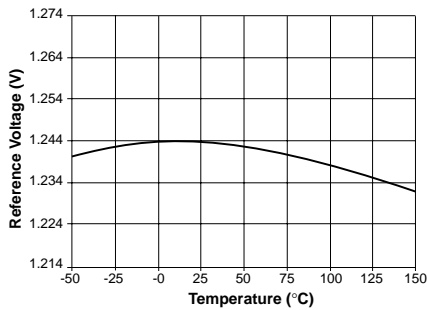
Note 1: 16 lead SO wide package only.

Package Pin Description

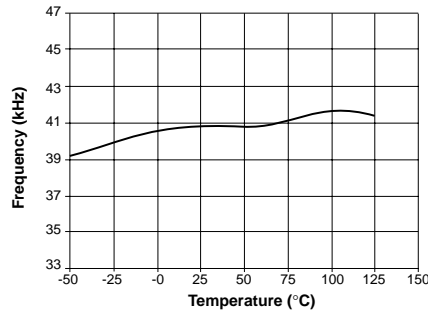
| PACKAGE PIN # | | | PIN SYMBOL | FUNCTION |
|--------------------------|--------------|------------|------------|---|
| 16L SO Wide | 5L TO-220 | 8L PDIP | | |
| 16 | 3 | 1 | Gnd | Logic and power ground on TO-220. Logic ground only on 8L PDIP. |
| 2 | 1 | 2 | V_C | Control voltage can be used for 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

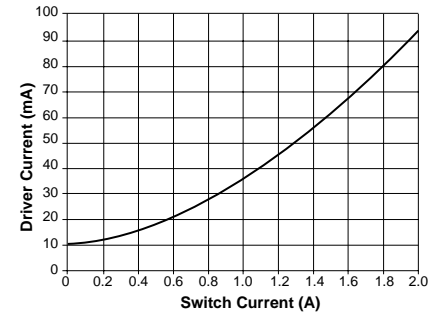
Reference Voltage vs. Temperature



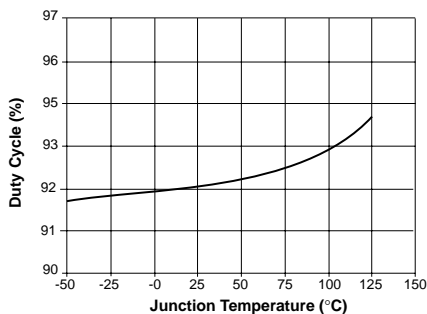
Switching Frequency vs. Temperature



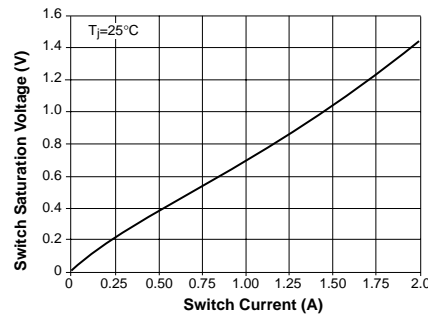
Driver Current vs. Switch Current



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 μ 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 Ω) 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

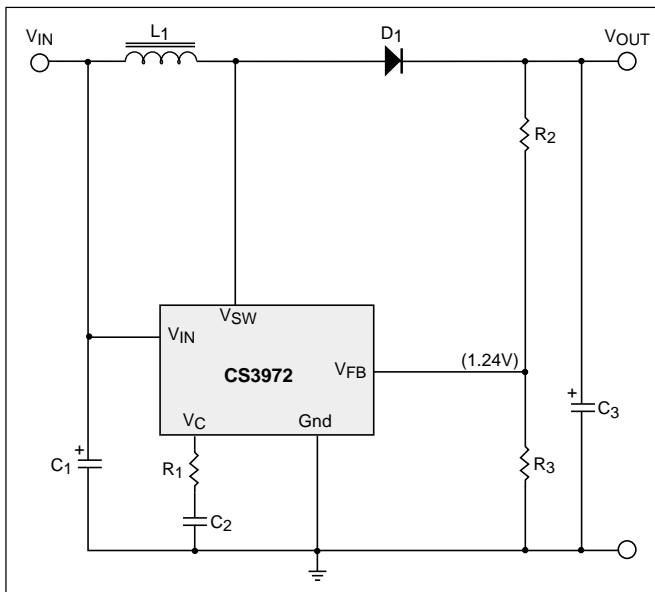


Figure 1: Boost Regulator

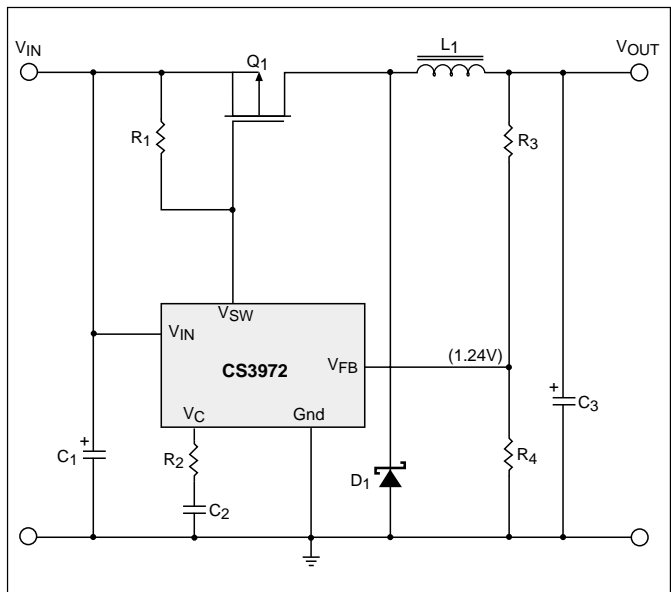


Figure 2: Buck Regulator with the External Switch

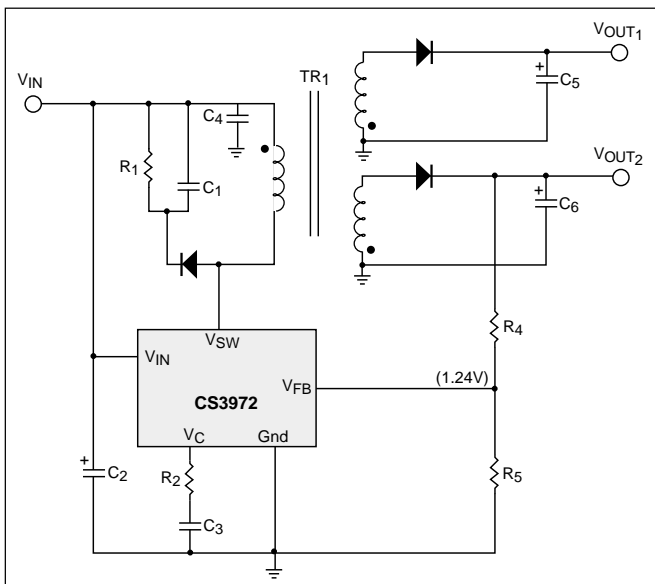


Figure 3: Flyback Multiple Output Regulator

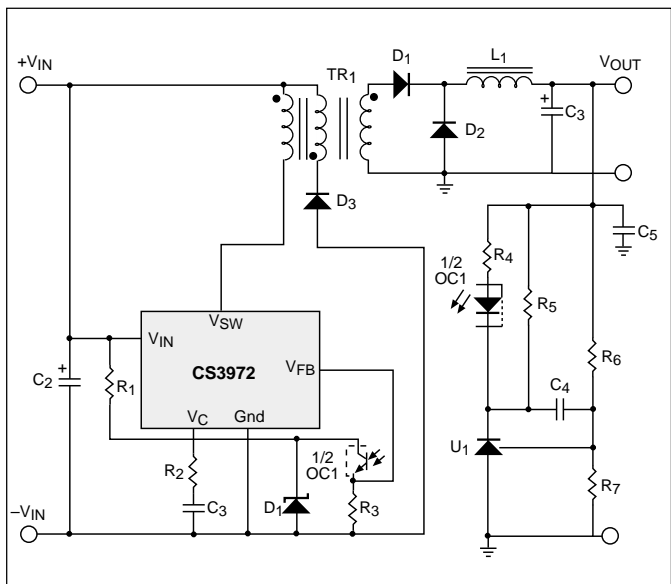


Figure 4: Isolated Forward Regulator

Package Specification

CS3972

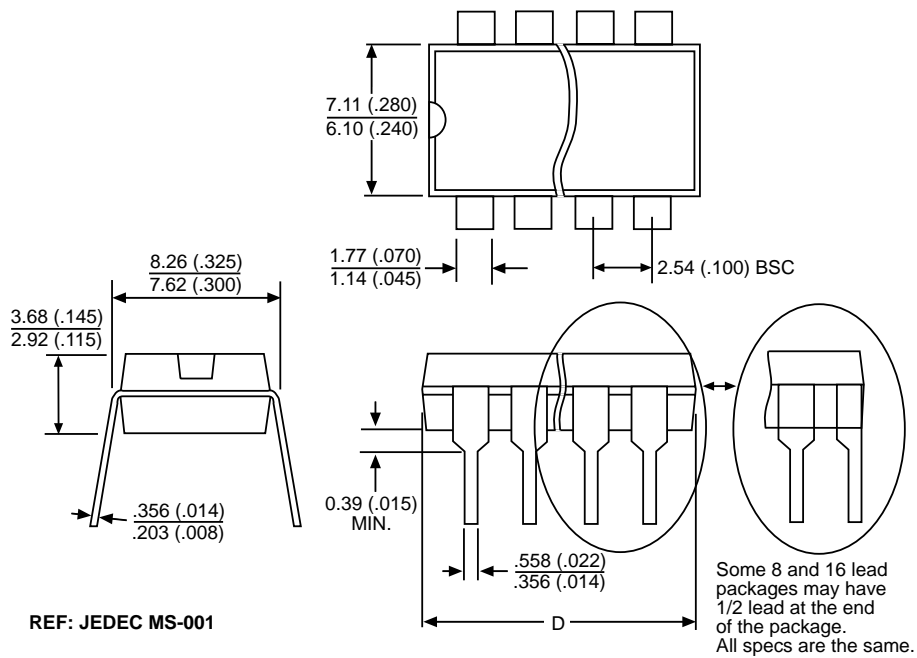
PACKAGE DIMENSIONS IN mm (INCHES)

| 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 |

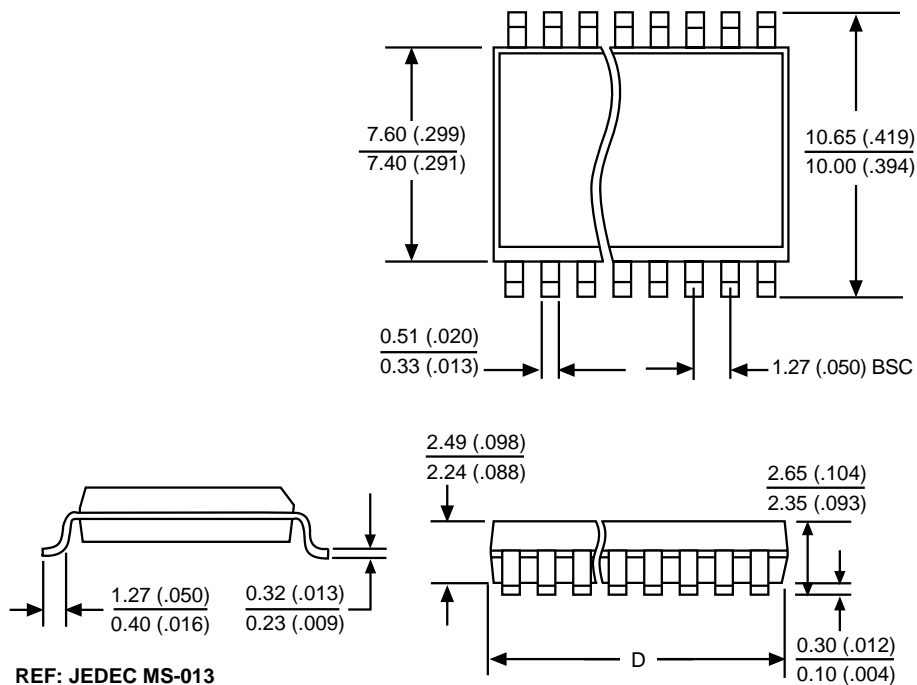
PACKAGE THERMAL DATA

| Thermal Data | | 5L TO-220 | 8L PDIP | 16L SO Wide | |
|-----------------|-----|--------------|------------|----------------|---------------|
| $R_{\theta JC}$ | typ | 1.7 | 52 | 23 | $^{\circ}C/W$ |
| $R_{\theta JA}$ | typ | 50 | 100 | 105 | $^{\circ}C/W$ |

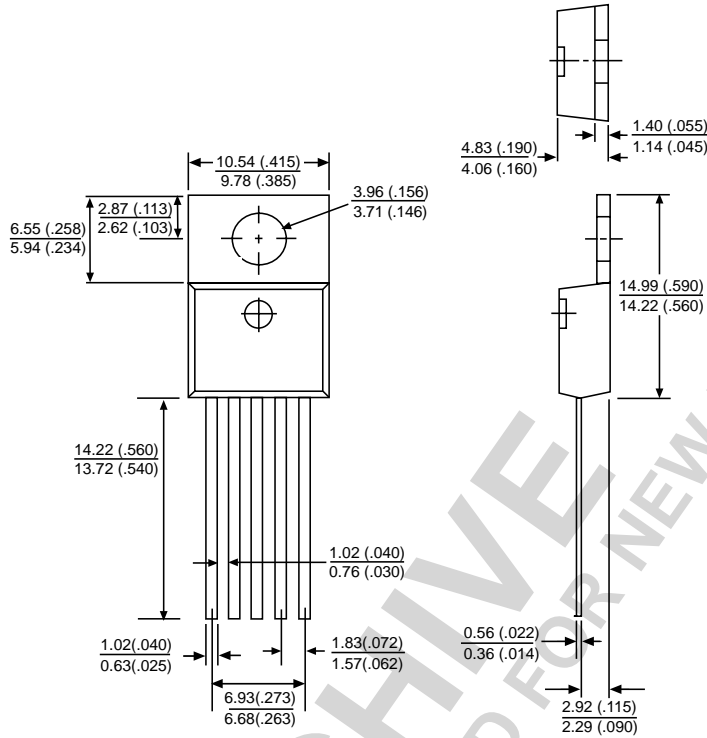
Plastic DIP (N); 300 mil wide



Surface Mount Wide Body (DW); 300 mil wide



5 Lead TO-220 (T) Straight



Ordering Information

| Part Number | Description |
|--------------|---------------------------|
| CS3972YN8 | 8L PDIP |
| CS3972YDW16 | 16L SO Wide |
| CS3972YDWR16 | 16L SO Wide (tape & reel) |
| CS3972YT5 | TO-220 Straight |

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