3A 150KHz Step-Down DC/DC Converter

◆ DESCRIPTION

The MT2596 series are monolithic integrated circuits that provide a step-down switching regulator, and capable of driving a 3A load with excellent line and load regulations.

These devices are available in fixed output voltage of 3.3V, 5V,12V, and adjustable output version. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator. The MT2596 operates at a switching frequency of 150KHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators.

The device features include a guaranteed ±4% tolerance on output voltage under specified input voltage and output load conditions, and ±15% on the oscillator frequency. It does also provide external shutdown, current limited and over temperature shutdown functions for complete protection under fault conditions.

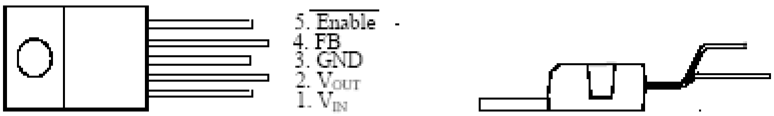
◆ FEATURES

- Guaranteed 3A output current
- 3.3V, 5V, 12V and adjustable output versions
- Thermal shutdown and current limit protection
- Internal oscillator of 150KHz fixed frequency.
- TO-220 and TO-263 packages available

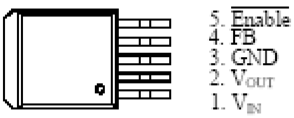
◆ APPLICATIONS

- ADD-ON-Cards switching regulator
- Simple high efficiency step-down(buck) regulator
- LCD Monitors

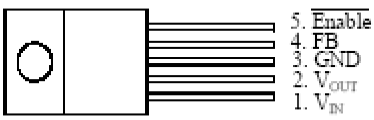
◆ PIN CONFIGURATIONS



MT2596-X.XC



MT2596-X.XD



MT2596-X.XK

◆ ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MAXIMUM	UNIT
Input supply voltage	V_{IN}	24	V
Thermal resistance junction to ambient TO-220(K) TO-220(C) TO-263(D)	θ_{JA}	45	°C/W
Operating temperature	T_{op}	-40 to +125	°C
Storage temperature range	T_{STG}	- 65 to 150	°C
Lead temperature (soldering) 10sec	T_{LEAD}	260	°C

Note :

Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.

◆ ORDERING INFORMATION

DEVICE	PACKAGE		VOUT VOLTS	TA (°C)
MT2596-X.XK	K	TO-220	X.X_ 3.3/ 5.0/ 12/ ADJ	0-70
MT2596-X.XC	C	TO-220		0-70
MT2596-X.XD	D	TO-263		0-70

◆ POWER DISSIPATION TABLE:

Package	θ_{JA} (°C /W)	$T_A \le 25$°C Power rating(mW)	T_A=70°C Power rating(mW)	T_A= 85°C Power rating (mW)
K	45	4464	2857	2321
C	45	4464	2857	2321
D	45	5435	3478	2826

NOTE :

1.Exceeding the maximum allowable ower dissipation will result in excessive die temperature, and the regulator will go into Themal shutdown.

2.T_J:Junction Temperature Calculation:

$$T_J = T_A + (P_D \times \theta_{JA})$$

The θ_{JA} numbers are guidelines for the thermal performance of the device/PC-board system.All of the above assume no Ambient airflow.

3.θ_{JA}: Thermal Resistance-Junction to Ambient, DF:Derating factor, Po:Power consumption

◆ RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	RECOMMENDED OPERATING MIN.	TYP.	MAX.	UNIT
V_{IN}	Input Voltage	-	-	24	V
T_J	Junction temperature Range	$-40 \le TJ \le 125$			°C

◆ ELECTRICAL CHARACTERISTICS

T_A=25℃, V_{IN}=12V for 3.3V,5V and Adjustable version, Io=0.5A, unless otherwise specified

PARAMETER		SYMBOL	CONDITIONS		MIN.	TYP.	MAX.	UNIT
Output Voltage	MT2596-3.3	V_{OUT}	4.75V≤V_{IN}≤24V,0.2A≤I_{LOAD}≤3A		3.168	3.3	3.432	V
Efficiency		η	V_{IN}=12V,I_{LOAD}=3A(Note1)		-	75	-	%
Output Voltage	MT2596-5.0	V_{OUT}	7V≤V_{IN}≤24V,0.2A≤I_{LOAD}≤3A		4.800	5.0	5.200	V
Efficiency		η	V_{IN}=12V,I_{LOA}D=3A(Note1)		-	80	-	%
Feedback Voltage	MT2596-ADJ	V_{FB}	4.5V≤V_{IN}≤24V,02A≤I_{LOAD}≤3A		1.193	1.230	1.267	V
Efficiency		η	V_{IN}=12V,I_{LOAD}=3A(Note1)		-	74	-	%
Feedback bias Current		I_{FB}	V_{FB} = 1.3V (Adjustable Only)		-	10	60	nA
Oscillator Frequency		F_{OSC}	T_J=25 ℃		127	150	173	KHz
			-40℃ < T_J < 125℃(Note2)		110	150	173	
Saturation Voltage		V_{SAT}	I_o = 3A, (Note3.4)		-	1.4	1.6	V
Max. Duty Cycle (ON)		D_C	V_{FB} = 0V force driver on (Note5)		-	100	-	%
Min. Duty Cycle (OFF)		D_C	V_{FB} = 12V force driver off		-	0	-	%
Current Limit		I_{LIMIT}	Peak current, No outside circuit and V_{FB}= 0V force driver on (Note3.4)		3.6	4.5	5.5	A
Output Leakage Current		I_{LEAK}	Output = 0V		-	-	-200	μA
			Output=-1V, V_{IN}=22V		-5	-	-	
Quiescent Current		I_Q	V_{FB} = 12V force driver off		-	5	10	mA
Standby Current		I_{STBY}	$\overline{\text{ENABLE}}$ P_{IN}=5V,V_{IN}=12V		-	250	350	μA
$\overline{\text{ENABLE}}$ Pin logic Input Threshold Voltage		V_{IL}	Low(Regulator ON)		-	0.6	0.4	V
		V_{IH}	High(Regulator OFF)		20		-	
$\overline{\text{ENABLE}}$ Pin logic Input Current		I_{IH}	V_{LOGIC}=2.5V(OFF)		-	-	-0.01	μA
		I_{IL}	V_{LOGIC}=0.5V(ON)		-	-0.1	-1	
Thermal Resistance, θ_{JC}		θ_{JC}	TO-220-5L	Junction to case	-	2.5	-	℃/W
			TO-263-5L		-	3.5	-	
Thermal Resistance, With Copper area of approximately 3 in^2 ,		θ_{JA}	TO-220-5L	Junction to ambient	-	28	-	℃/W
			TO-263-5L		-	23	-	

NOTE:

Note 1：External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors can affect switching regulator system performance. When the MT2596 is used as shown in the Figure 1 test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 2：The switching frequency is reduced when the second stage current limit is activated. The amount of reduction is determined by the severity of current over-load.

Note 3：No diode, inductor or capacitor connected to output pin.

Note 4：Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

Feedback pin removed from output and connected to 12V for the 3.3V, 5V, and the ADJ. version, and 15V for the 12V version, to force the output transistor switch OFF.

Note 5：VIN＝24V

◆ TYPICAL APPLICATIONS

Fixed Output Voltage Version:

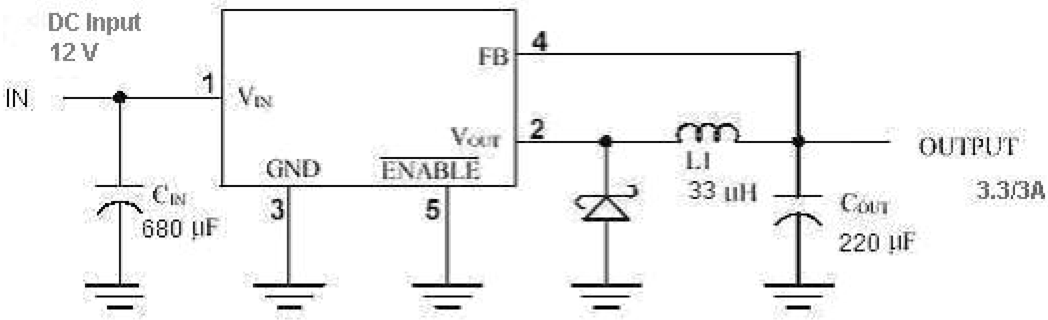


Figure 1. Fixed Output Voltage Versions

Adjustable Voltage Version:

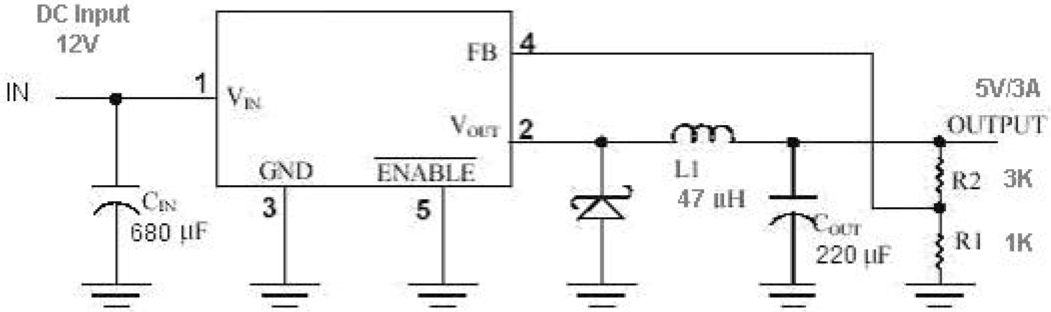


Figure 2. Adjustable Output Voltage Versions

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right)$$

$$R2 = R1\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

Where V_{REF} = 1.23V, R1 between 1K and 5K

◆ APPLICATION DATA

Diode Selection Table

VR(V)	3A Diode	
	Surface Mount	Through Hole
	Schottky	Schottky
20	SK32	1N5820 SR302 MBR320
30	SK33	1N5821 MBR330 31DQ03
40	SK34 MBRS340	1N5822 SR304 MBR340 31DO04
50	SK35 MBRS360	SR305 MBR350 31DQ05 MUR320

◆ QUICK DESIGN COMPONENT SELECTION TABLE FOR ADJUSTABLE OUTPUT

Output Voltage (V)	Through Hole Output Capacitor			Surface Mount Output Capacitor		
	Panasonic HFQ Series (μF/V)	Nichicon PL Series (μF/V)	Feed forward Capacitor	Panasonic HFQ Series (μF/V)	Nichicon PL Series (μF/V)	Feed forward Capacitor
2	820/35	820/35	33nF	330/6.3	470/4	33nF
4	560/35	470/35	10nF	330/6.3	390/6.3	10nF
6	470/25	470/25	3.3nF	220/10	330/10	3.3nF
9	330/35	330/25	1.5nF	100/16	180/16	1.5nF
12	330/25	330/25	1nF	100/16	180/16	1nF
15	220/35	220/25	680nF	68/20	120/20	680pF

◆ QUICK DESIGN COMPONENT SELECTION TABLE FOR ADJUSTABLE OUTPUT

Input/Output Condition			Inductor		Output Capacitor(μF/V)			
					Through Hole Electrolytic		Surface Mount Tantalum	
Output Voltage (V)	Load Curent (A)	Max. Input Voltage (V)	Inductance (μH)	Currnet (A)	Nichicon PL Series	Panasonic HFQ Series	Sprague 595D Series	AVX TPS Series
5	3	8	22	3.5	560/25	560/25	330/10	220/10
		15	33	3.5	330/35	330/35	330/10	220/10
	2	9	22	3.1	560/16	470/25	330/10	220/10
		15	68	3.1	180/35	180/35	270/10	100/10
3.3	3	5	22	3.5	560/16	470/25	390/6.3	330/6.3
		12	22	3.5	560/25	560/35	390/6.3	330/6.3
	2	6	22	3.1	470/35	470/25	390/6.3	330/6.3
		12	33	3.1	330/35	330/35	390/6.3	330/6.3

◆ APPLICATION NOTE

1. **Maximum Power Dissipation Calculation:**

$$P_{D(max)} = [(V_{IN(max)} - V_{O(nom)})] \times I_{O(nom)} + V_{IN(max)} \times I_Q$$

$$P_{D(max)} = [(V_{IN(max)} - V_{O(nom)})] \times I_{O(nom)} + V_{IN(max)} \times I_Q$$

Where: $V_{O(nom)}$: The nominal output voltage

$I_{O(nom)}$: The nominal output current, and

I_Q : The quiescent current the regulator consumes at $I_{O(MAX)}$

$V_{IN(max)}$: The maximum input voltage

Application Information:

Input Capacitors (CIN)

It is required that VIN must be bypassed with at least a 100μF electrolytic capacitor for stability. Also, it is strongly recommended the capacitor's leads must be dept short, and located near the regulator as possible.

For low operating temperature range, for example, below -25°C, the input capacitor value may need to be larger. This is due to the reason that the capacitance value of electrolytic capacitors decreases and the ESR increases with lower temperatures and age. Paralleling a ceramic or solid tantalum capacitor will increase the regulator stability at cold temperatures.

Output Capacitors (COUT)

An output capacitor is also required to filter the output voltage and is needed for loop stability. The capacitor should be located near the MT2596 using short PC board traces. Low ESR types capacitors are recommended for low output ripple voltage and good stability. Generally, low value or low voltage (less than 12V) electrolytic capacitors usually have higher ESR numbers. For example, the lower capacitor values (220μF–1000μF) will yield typically 50 mV to 150 mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20 mV to 50 mV.

The amount of output ripple voltage is primarily a function of the ESR (Equivalent Series Resistance) of the output capacitor and the amplitude of the inductor ripple current (ΔIIND).

Output Ripple Voltage = (ΔIIND) × (ESR of COUT)

Some capacitors called "high-frequency," "low-inductance," or "low-ESR." are recommended to use to further reduce the output ripple voltage to 10 mV or 20 mV. However, very low ESR capacitors, such as Tantalum capacitors, should be carefully evaluated.

Catch Diode

This diode is required to provide a return path for the inductor current when the switch is off. It should be located close to the MT2596 using short leads and short printed circuit traces as possible. To satisfy the need of fast switching speed and low forward voltage drop, Schottky diodes are widely used to provide the best efficiency, especially in low output voltage switching regulators (less than 5V). Besides, fast-Recovery, high-efficiency, or ultra-fast recovery diodes are also suitable. But some types with an abrupt turn-off characteristic may cause instability and EMI problems. A fast-recovery diode with soft recovery characteristics is a better choice.

Output Voltage Ripple and Transients

The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor.

The output voltage of a switching power supply will contain a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and may also contain short voltage spikes at the peaks of the sawtooth waveform.

Due to the fast switching action, and the parasitic inductance of the output filter capacitor, there is voltage spikes presenting at the peaks of the sawtooth waveform. Cautions must be taken for stray capacitance, wiring inductance, and even the scope probes used for transients evaluation. To minimize these voltage spikes, shortening the lead length and PCB traces is always the first thought. Further more, an additional small LC filter (20μH & 100μF) (as shown in Figure 3) will possibly provide a 10X reduction in output ripple voltage and transients.

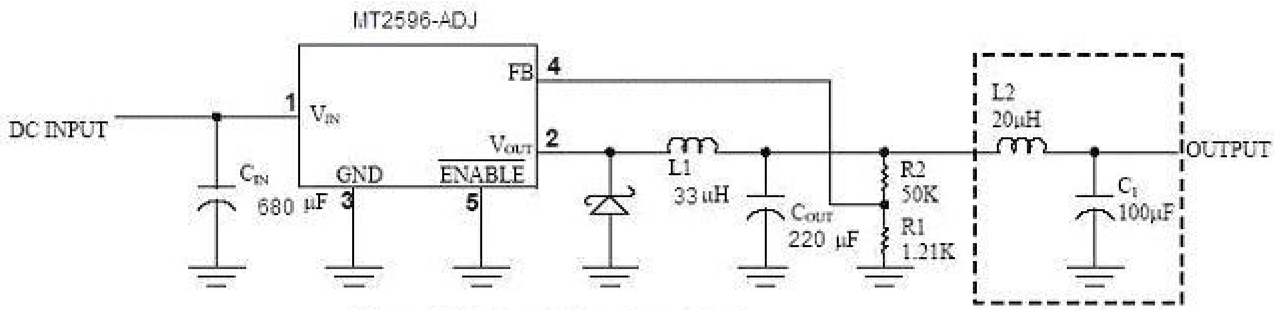


Figure 3. LC Filter for Low Output Ripple

Inductor Selection

The MT2596 can be used for either continuous or discontinuous modes of operation. Each mode has distinctively different operating characteristics, which can affect the regulator performance and requirements.

With relatively heavy load currents, the circuit operates in the continuous mode (inductor current always flowing), but under light load conditions, the circuit will be forced to the discontinuous mode (inductor current falls to zero for a period of time). For light loads (less than approximately 300 mA) it may be desirable to operate the regulator in the discontinuous mode, primarily because of the lower inductor values required for the discontinuous mode.

Inductors are available in different styles such as pot core, toroid, E-frame, bobbin core, et., as well as different core materials, such as ferrites and powdered iron. The least expensive, the bobbin core type, consists of wire wrapped on a ferrite rod core. This type of construction makes for an inexpensive inductor, but since the magnetic flux is not completely contained within the core, it generates more electromagnetic interference (EMI). This EMI can cause problems in sensitive circuits, or can give incorrect scope readings because of induced voltages in the scope probe.

An inductor should not be operated beyond its maximum rated current because it may saturate. When an inductor begins to saturate, the inductance decreases rapidly and the inductor begins to look mainly resistive (the DC resistance of the winding). This will cause the switch current to rise very rapidly. Different inductor types have different saturation characteristics, and this should be well considered when selecting as inductor.

Feedback Connection

For fixed output voltage version, the FB (feedback) pin must be connected to V_{OUT}. For the adjustable version, it is important to place the output voltage ratio resistors near MT2596 as possible in order to minimize the noise introduction.

$\overline{\text{ENABLE}}$

It is required that the $\overline{\text{ENABLE}}$ must not be left open. For normal operation, connect this pin to a “LOW” voltage (typically, below 1.6V). On the other hand, for standby mode, connect this pin with a “HIGH” voltage. This pin can be safely pulled up to $+V_{IN}$ without a resistor in series with it.

Grounding

To maintain output voltage stability, the power ground connections must be low-impedance. For the 5-lead TO-220 and TO-263 style package, both the tab and pin 3 are ground and either connection may be used.

Heat Sink and Thermal Consideration

Although the MT2596 requires only a small heat sink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances θ_{JA} and θ_{JC}, total power dissipation can be estimated as follows:

$$P_D = (V_{IN} \times I_Q)+(V_{OUT} / V_{IN})(I_{LOAD} \times V_{SAT});$$

When no heat sink is used, the junction temperature rise can be determined by the following:

$$\Delta T_J = P_D \times \theta_{JA};$$

With the ambient temperature, the actual junction temperature will be:

$$T_J = \Delta T_J + T_A;$$

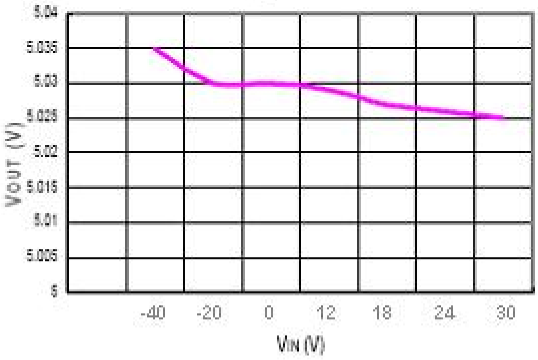
If the actual operating junction temperature is out of the safe operating junction temperature (typically 125°C), then a heat sink is required. When using a heat sink, the junction temperature rise will be reduced by the following:

$$\Delta T_J = P_D \times (\theta_{JC} + \theta_{interface} + \theta_{Heat\ sink});$$

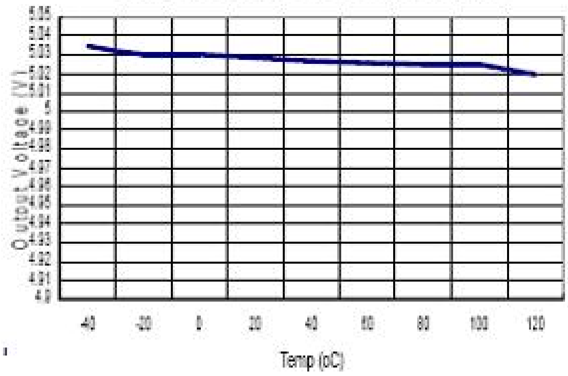
As one can see from the above, it is important to choose an heat sink with adequate size and thermal resistance, such that to maintain the regulator’s junction temperature below the maximum operating temperature.

◆ **Typical application circuit, TJ =25°C, unless otherwise specified.**

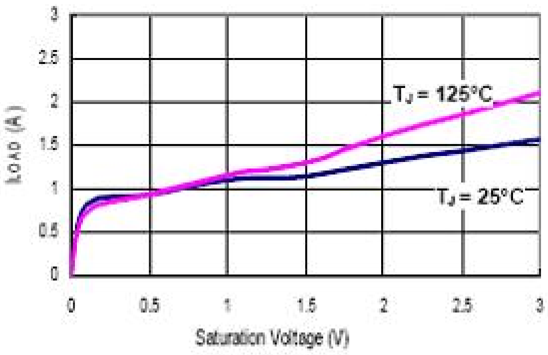
Line Regulation



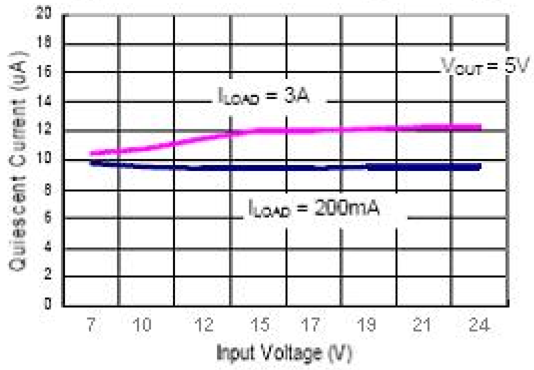
Output Voltage vs. Temperature



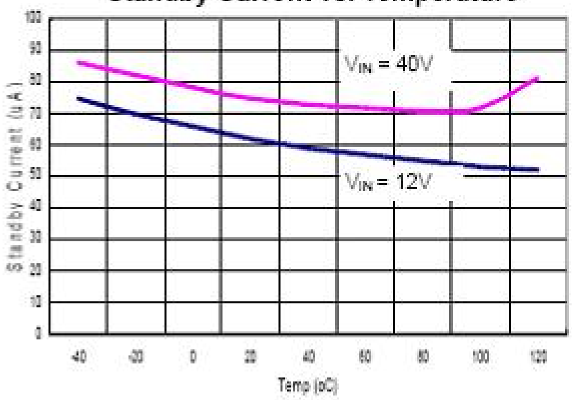
Saturation Voltage vs. Load Current



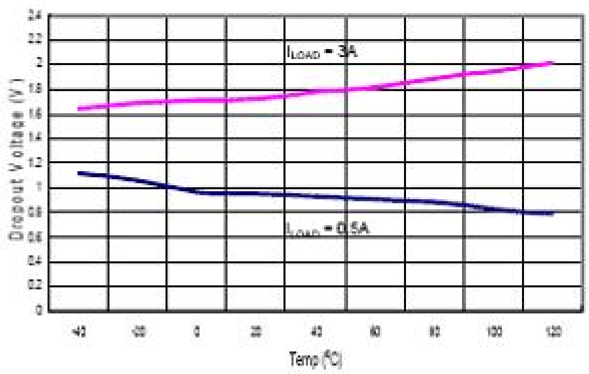
Quiescent Current vs. Input Voltage



Standby Current vs. Temperature

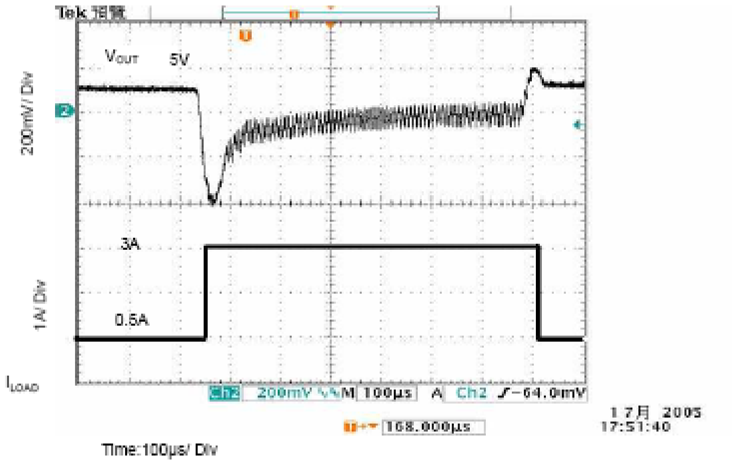


Dropout Voltage vs. Temperature



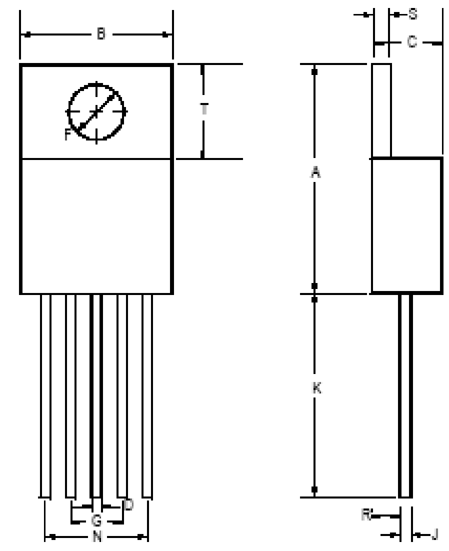
Typical application circuit, T_J =25°C, unless otherwise specified.

Load Transient Response



◆ PHYSICAL DIMENSIONS

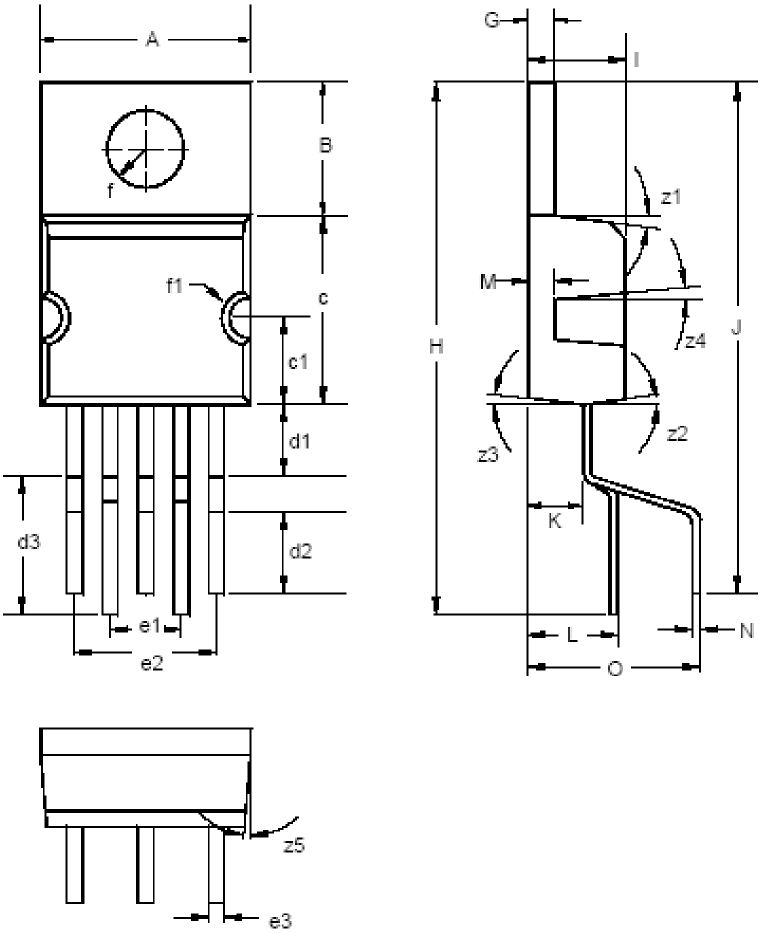
5-Pin Plastic TO- 220 (K)



	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.560	-	0.650	14.23	-	16.51
B	0.380	-	0.420	9.66	-	10.66
C	0.140	-	0.190	3.56	-	4.82
D	0.018	-	0.035	0.46	-	0.89
F	0.140	-	0.160	3.56	-	4.06
G	0.134	-	-	3.40	-	-
J	0.012	-	0.045	0.31	-	1.14
K	0.500	-	0.580	12.70	-	14.73
N	0.268 TYP			6.80 TYP		
R	0.080	-	0.115	2.04	-	2.92
S	0.045	-	0.055	1.14	-	1.39
T	0.230	-	0.270	5.85	-	6.85

◆ PHYSICAL DIMENSIONS

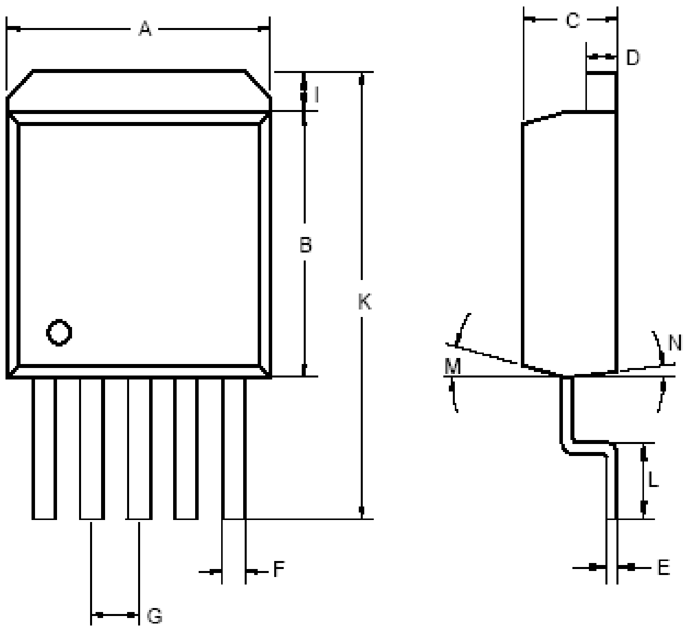
5-Pin Plastic TO- 220 (C)



	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.380	0.401	0.420	9.65	10.20	10.65
B		0.248			6.30	
c	0.348	0.358	0.368	8.85	9.10	9.35
c1		0.167			4.25	
d1		0.138			3.50	
d2		0.154			3.90	
d3		0.213			5.40	
e1		0.134			3.40	
e2		0.268			6.80	
e3		0.032			0.81	
f		0.151			3.84	
f1		0.039			1.00	
G	0.048	0.05	0.052	1.22	1.27	1.32
H		0.996			25.30	
I	0.175	0.180	0.185	4.44	4.57	4.70
J		0.965			24.50	
K		0.105			2.67	
L	0.164	0.173	0.182	4.17	4.40	4.63
M		0.05			1.27	
N	0.013	0.015	0.025	0.33	0.381	0.63
O	0.322	0.331	0.340	8.17	8.40	8.63
z1		7°			7°	
z2		7°			7°	
z3		7°			7°	
z4		5°			5°	
Z5		5°			5°	

◆ PHYSICAL DIMENSIONS

5-Pin Plastic TO- 220 (D)



	INCHES			MILLIMETERS		
	MIN	TYP	MAX	MIN	TYP	MAX
A	0.395	-	0.420	10.03	-	10.67
B	0.325	-	0.361	8.25	-	9.17
C	0.171	-	0.181	4.34	-	4.59
D	0.045	-	0.055	1.14	-	1.40
E	0.013	-	0.017	0.330	-	0.432
F	0.029	-	0.035	0.737	-	0.889
G	0.062	-	0.072	1.57	-	1.83
I	-	-	0.065	-	-	1.65
K	0.575		0.635	14.60		16.13
L	0.090		0.110	2.29		2.79
M	7°			7°		
N	3°			3°		