GENERAL DESCRIPTION

The CM2596 series are step-down switching regulators with all required active functions. It is capable of driving 3A load with excellent line and load regulations. These devices are available in fixed output voltages of 3.3V, 5V, and an adjustable output version.

The CM2596 series offers a high-efficiency replacement for popular three-terminal linear regulators. Also it requires a minimum number of external components. It substantially not only reduces the area of board size but also the size of the heat sink, and in some cases no heat sink is required.

±4% tolerance on output voltage within specified input voltages and output load conditions is guaranteed. Also, the oscillator frequency accuracy is within ±10%. External shutdown is included, featuring 70µA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.
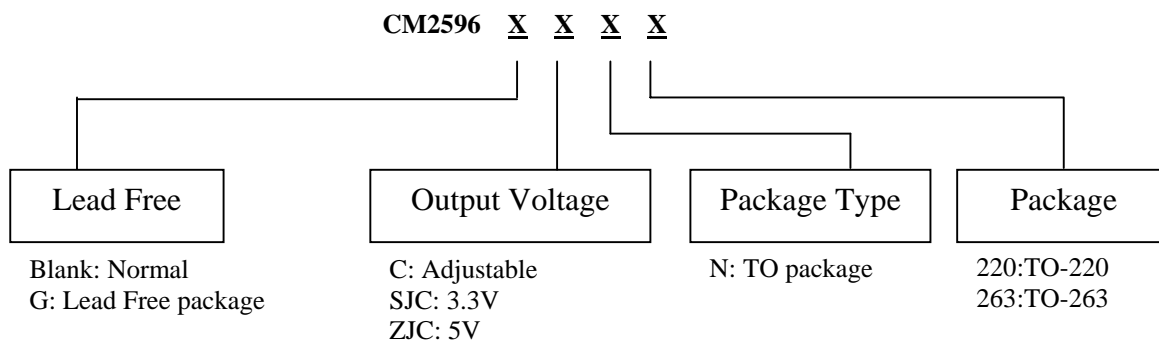
FEATURES

◆ Guaranteed 3A output current
◆ 3.3V, 5V, and adjustable versions
◆ Wide input voltage range, up to 40V
◆ Internal oscillator of 150KHz fixed frequency
◆ Wide adjustable version output voltage range, from 1.23V to 37V±4% max over line and load conditions
◆ Low standby current, typ. 80µA, at shutdown mode
◆ Requires only 4 external components
◆ Thermal shutdown and current limit protection
◆ Requires only 4 external components
◆ Excellent line and load regulation specifications
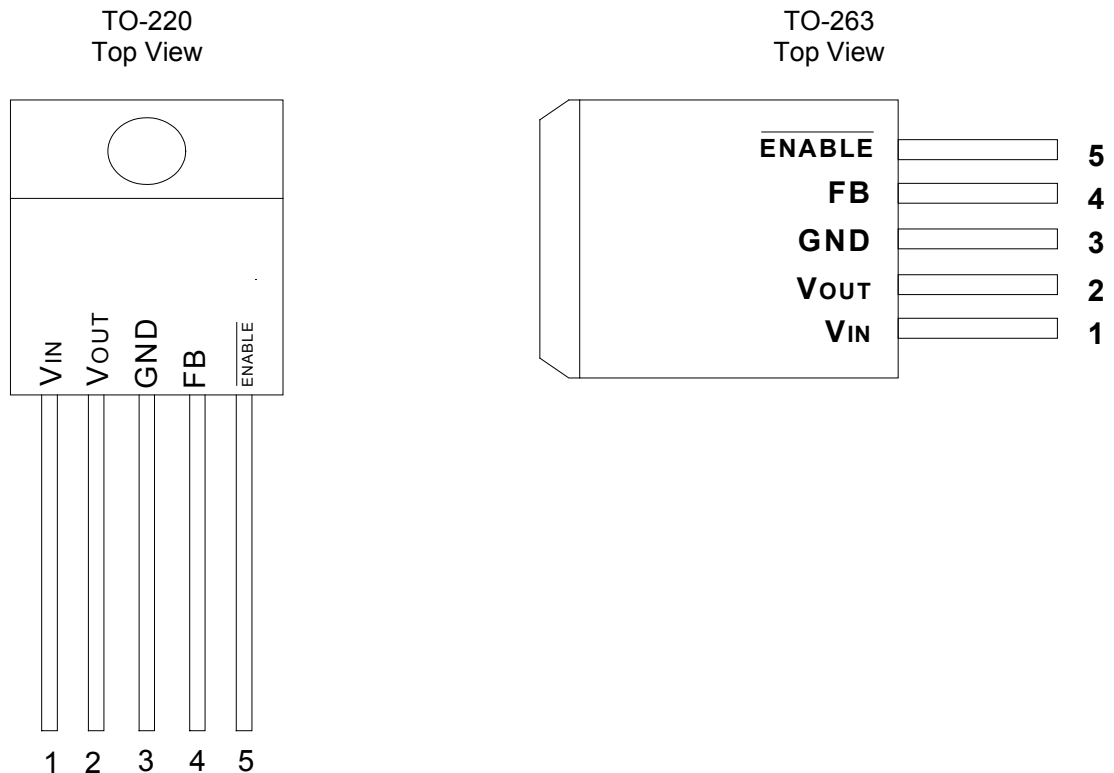◆ TTL shutdown capability

APPLICATIONS

◆ LCD Monitors
◆ ADD-ON Cards Switching Regulators
◆ High Efficiency Step-Down Regulators
◆ Efficient Pre-regulator for Linear Regulators

ORDERING INFORMATION

Package Type		Output Voltage
TO-220	TO-263	
CM2596SJCN220	CM2596SJCN263	3.3V
CM2596ZJCN220	CM2596ZJCN263	5.0V
CM2596CN220	CM2596CN263	ADJ.
CM2596GSJCN220	CM2596GSJCN263	3.3V
CM2596GZJCN220	CM2596GZJCN263	5.0V
CM2596GCN220	CM2596GCN263	ADJ.

CM2596 X X X X

Lead Free	Output Voltage	Package Type	Package
Blank: Normal G: Lead Free package	C: Adjustable SJC: 3.3V ZJC: 5V	N: TO package	220:TO-220 263:TO-263

PIN CONFIGURATION

TO-220
Top View

TO-263
Top View

ENABLE	5
FB	4
GND	3
V$_{OUT}$	2
V$_{IN}$	1

V$_{IN}$ V$_{OUT}$ GND   FB   ENABLE

1   2   3   4   5

ABSOLUTE MAXIMUM RATINGS

Input Voltage (V$_{POWER}$) ……………………………………………………… +45V

$\overline{ENABLE}$ Pin Input Voltage ………………………………… $-0.3V \leqq V \leqq V_{IN}$

Storage Temperature ………………………………………….... -65℃ to +150℃

Lead Temperature (10 sec.) …...……………………..………………... 260℃

Operating Temperature ……..………………...………………....... -40℃ to +125℃

POWER DISSIPATION TABLE

Package	Θ$_{JA}$ (℃/W)	Derating factor (mW/℃) T$_A$ >= 25℃	T$_A$ <= 25℃ Power rating (mW)	T$_A$ = 70℃ Power rating (mW)	T$_A$ = 85℃ Power rating (mW)
TO-220	45	22.2	2775	1776	1443
TO-263	45	22.2	2775	1776	1443

Note:
1. Θ$_{JA}$: Thermal Resistance-Junction to Ambient, D$_F$: Derating factor, P$_O$: Power consumption.
   Junction Temperature Calculation: T$_J$ = T$_A$ + (P$_D$ x Θ$_{JA}$), P$_O$ = D$_F$ x (T$_J$ – T$_A$)
   The Θ$_{JA}$ numbers are guidelines for the thermal performance of the device/PC-board system.
   All of the above assume no ambient airflow.
2. Θ$_{JT}$: Thermal Resistance-Junction to Ambient, T$_C$: case (Tab) temperature, T$_J$ = T$_C$ + (P$_D$ x Θ$_{JA}$)

ELECTRICAL CHARACTERISTICS

Electrical Characteristics at I_{OUT} = 0mA, and T_J = +25℃; unless otherwise noted

Parameter	Device	Test Conditions		CM2596 Min.	CM2596 Typ.	CM2596 Max.	Unit
Output Voltage (Note 1)	CM2596S	Test circuit of Figure 1		3.234	3.300	3.366	V
	CM2596ZJ			4.900	5.000	5.100	V
Output Voltage (Note 1)	CM2596S	6V<=V_{IN} <=40V	0.2A<=I_{LOAD} <=3A	3.168	3.300	3.432	V
	CM2596ZJ	8V<=V_{IN} <=40V		4.800	5.000	5.200	V
Output Voltage (Note 1)	CM2596S	6V<=V_{IN} <=40V	0.2A<=I_{LOAD} <=3A, -40℃ <=T_J<=125℃ Test circuit of Figure 1	3.135	3.300	3.482	V
	CM2596ZJ	8V<=V_{IN} <=40V		4.750	5.000	5.250	V
Feedback Voltage (Note 1)	CM2596 (Adj)	Test circuit of Figure 2	V_{OUT} =5V	1.217	1.230	1.243	V
Feedback Voltage (Note 1)	CM2596 (Adj)	8V<=V_{IN} <=40V, V_{OUT} =5V Test circuit of Figure 2	0.5A<=I_{LOAD} <=3A	1.193	1.230	1.267	V
Feedback Voltage (Note 1)	CM2596 (Adj)	8V<=V_{IN} <=40V, V_{OUT} =5V Test circuit of Figure 2	0.5A<=I_{LOAD} <=3A, -40℃ <=T_J<=125℃	1.180	1.230	1.286	V
Efficiency	CM2596S	I_{LOAD} =3A			75		%
	CM2596ZJ				77		
	CM2596(adj)	I_{LOAD} =3A, V_{OUT} =5V			77		%
Oscillator Frequency		Note 2	T_J=25℃	127	150	173	kHz
			-40℃ <=T_J<=125℃	110	150	173	
Quiescent Current		Note 3			5	10	mA
Standby Current		$\overline{ENABLE}$ = 5V			80	200	µA
Saturation Voltage		I_{LOAD} =3A (Note 4)	T_J=25℃		1.4	1.8	V
			-40℃ <=T_J<=125℃			2.0	
Feedback Bias Current		V_{OUT} =5V (Adj. Version only)	T_J=25℃		50	100	nA
			-40℃ <=T_J<=125℃			500	
Duty Cycle (ON)		Note 5		93	98		%
Current Limit		Note 2,4	T_J=25℃	4.2	7	8.8	A
			-40℃ <=T_J<=125℃	3.5	7.2	9.0	
Output Leakage Current		Note 3	V_{OUT} =0V		0.3	2	mA
			V_{OUT} =-1V		9	20	
$\overline{ENABLE}$ Threshold Voltage		V_{IH} (V_{OUT} =0V)	T_J=25℃	2.2	1.4		V
			-40℃ <=T_J<=125℃	2.4			
		V_{IL} (V_{OUT} = Normal Output Voltage)	T_J=25℃		1.2	1.0	V
			-40℃ <=T_J<=125℃			0.8	
$\overline{ENABLE}$ Input Current		I_{IH} ($\overline{ENABLE}$ = 5V)			12	30	µA
		I_{IH} ($\overline{ENABLE}$ = 0V)			0	10	

Note 1: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. Refer to Application Information for details.

Note 2: The oscillator frequency reduces to approximately 11KHz in the event of fault conditions, such as output short or overload. And the regulated output voltage will drop approximately 40% from the nominal output voltage. This self-protection feature lowers the average power dissipation by lowering the minimum duty cycle from 5% down to approximately 2%.

Note 3: For these parameters, FB is removed from V_{OUT} and connected to +12V to force the output transistor OFF.

Note 4: V_{OUT} pin sourcing current. No diode, inductor or capacitor connect to V_{OUT}.

Note 5: FB is removed from V_{OUT} and connected to 0V.

BLOCK DIAGRAM
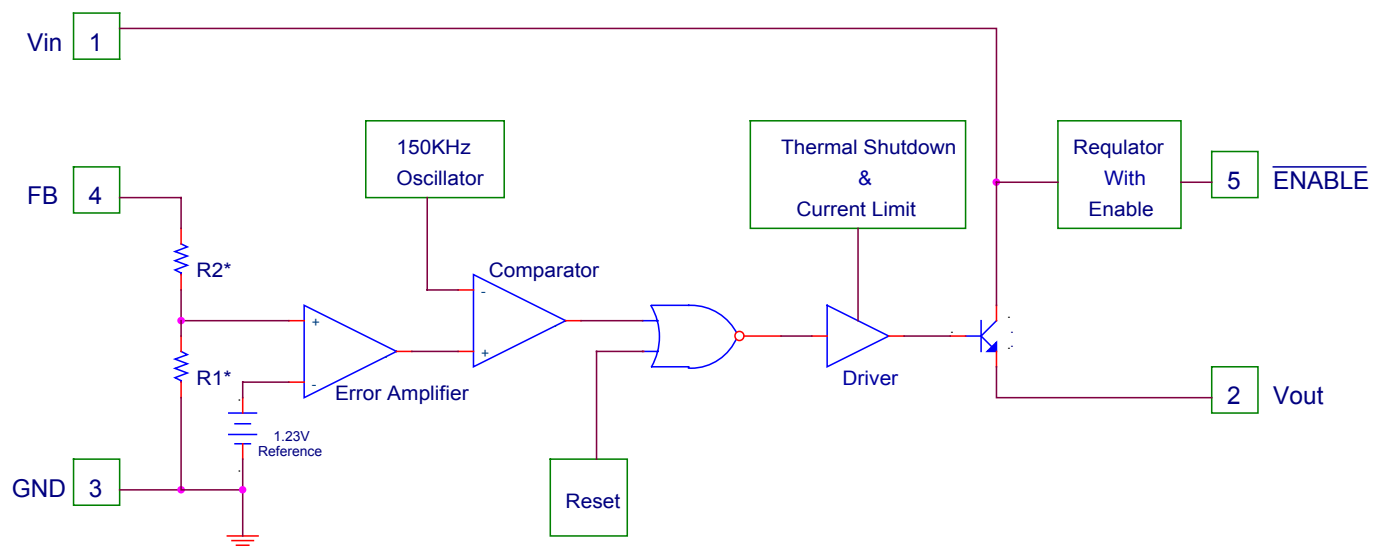
APPLICATION CIRCUIT
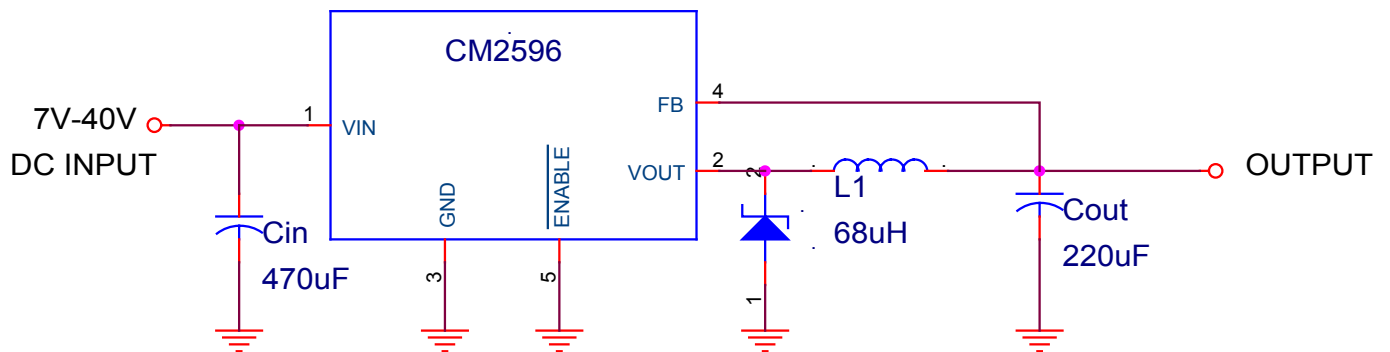
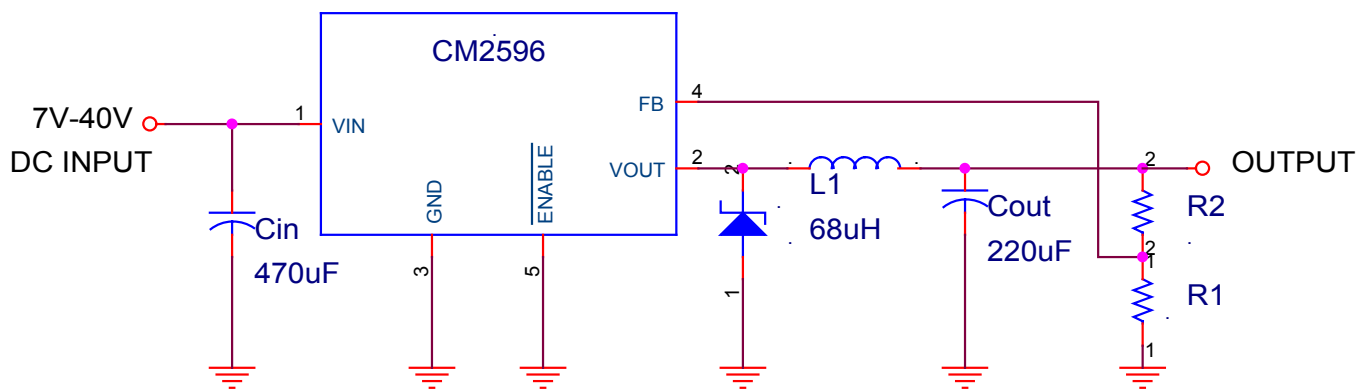Figure1. Fixed Output Voltage Versions
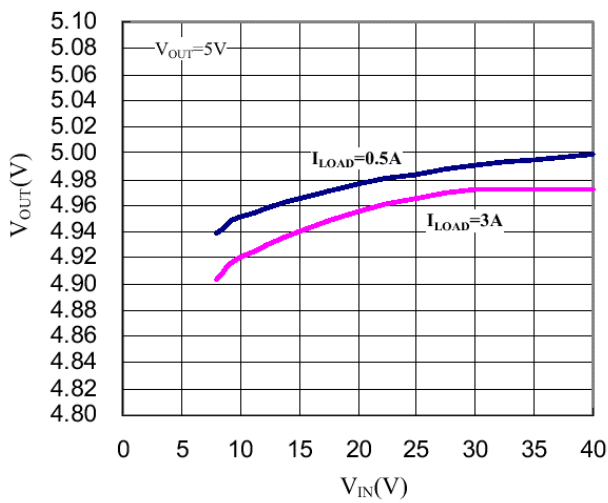

Figure2. Adjustable Output Voltage Versions
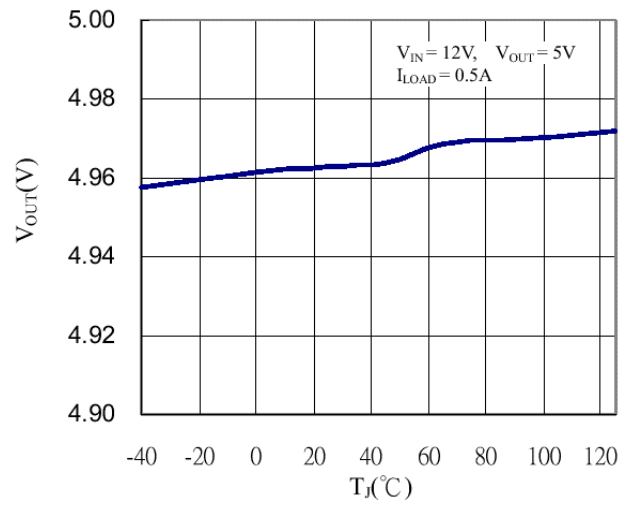
Vout = Vref (1 + R2 / R1)

R2 = R1 (Vout / Vref -1)

Where Vref = 1.23V , R1 between 1K and 5k
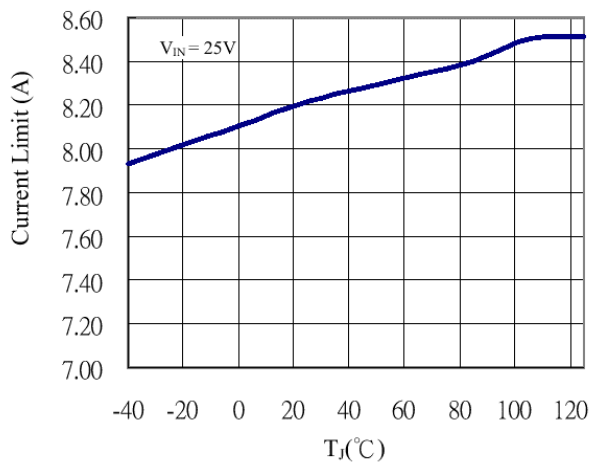
TYPICAL CHARACTERISTICS

Line regulation
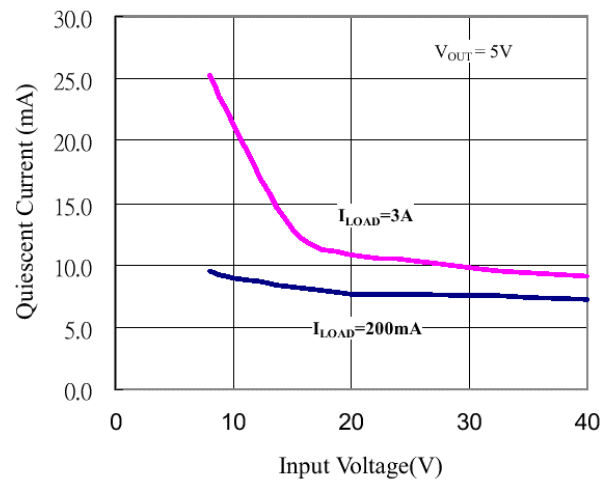
Output voltage vs. temperature
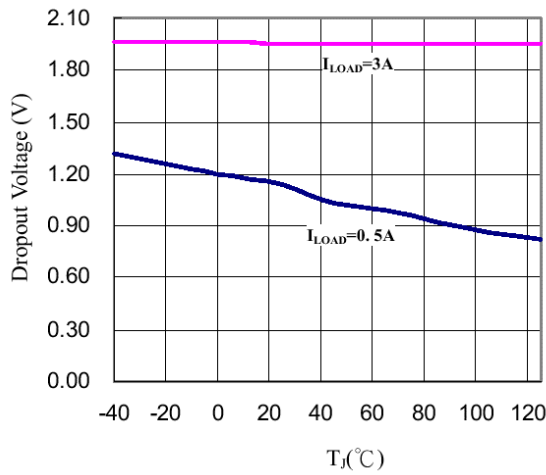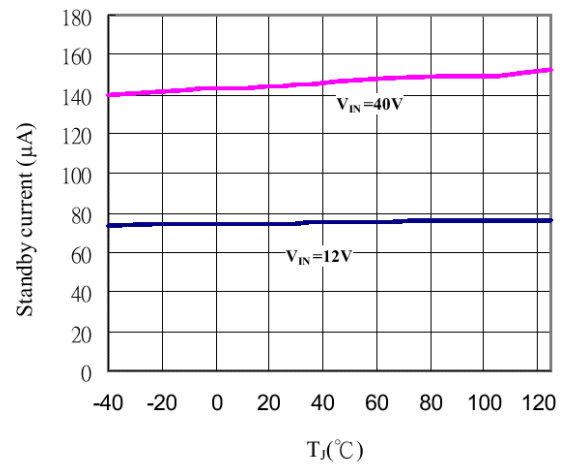
Current limit vs. temperature

Quiescent current vs. input voltage

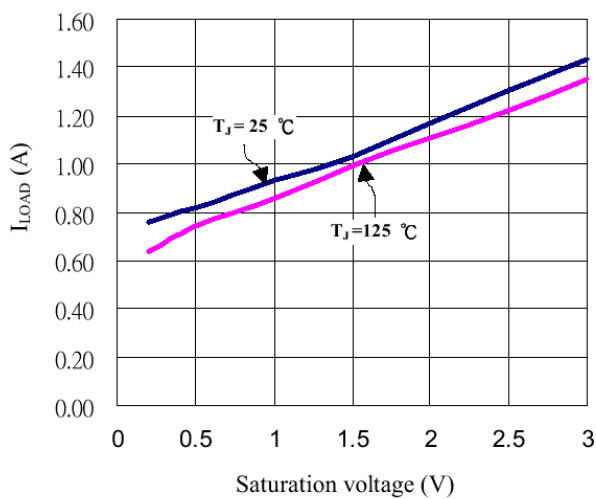## Dropout voltage vs. temperature

Dropout Voltage (V) vs $T_J(°C)$

$I_{LOAD}=3A$

$I_{LOAD}=0.5A$

Standby current vs. temperature

Standby current (μA) vs $T_J(°C)$

$V_{IN}=40V$

$V_{IN}=12V$

Saturation voltage vs. load current

I_{LOAD} (A) vs Saturation voltage (V)

$T_J=25°C$

$T_J=125°C$

Load transient response

5V V_{OUT}

100mV/ Div

3A

1A/ Div

I_{LOAD}

0.5A

Time:100μs/ Div
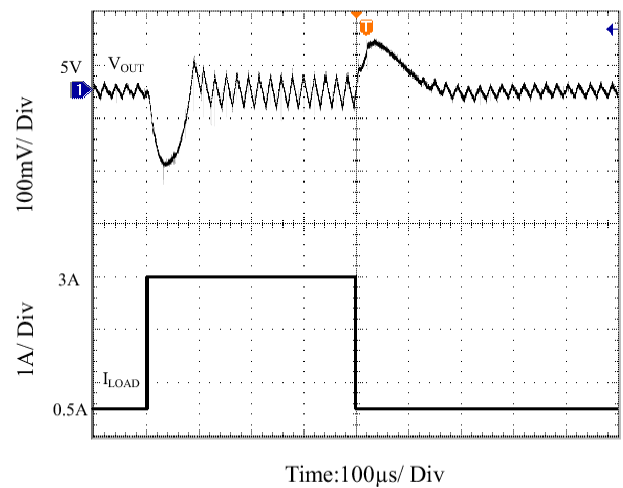
APPLICATION INFORMATION
External component selector

Input Capacitors (Cin)

It is required that VIN must be bypassed with at least a 100uF electrolytic capacitor for stability. Also, it is strongly recommended the capacitor's leads must be short, wide and located near the regulator as possible. The important parameters for the capacitor are the voltage rating and the RMS current rating. For a maximum ambient temperature of 40℃, a general guideline would be to select a capacitor with a ripple current rating of approximately 50% of the DC load current. The capacitor voltage rating must be at least 1.25 times greater than the maximum input voltage.

For low operating temperature range, for example, below -25℃, 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 (C_{OUT})

An output capacitor is also required to filter the output voltage and is needed for loop stability. The capacitor should be located near the CM2596 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 (220uF – 1000uF) will yield typically 50mV to 150mV of output ripple voltage, while larger-value capacitors will reduce the ripple to approximately 20mV to 50mV.

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 ($\triangle I_{IND}$).

Output Ripple Voltage = ($\triangle I_{IND}$) x (ESR of C_{OUT})

Some capacitors called "high-frequency", "low-inductance", or "low-ESR" are recommended to use to further reduce the output ripple voltage to 10mV or 20mV. 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 CM2596 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 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 ripple voltage of a switching power supply will contain a sawtooth ripple voltages at the switcher frequency, typically about 1% of the output voltages, and may also contain short voltage spikes 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 (30uH & 100uF) (as shown in Figure 3) will possibly provide a 10X reduction in output ripple voltage and transients.
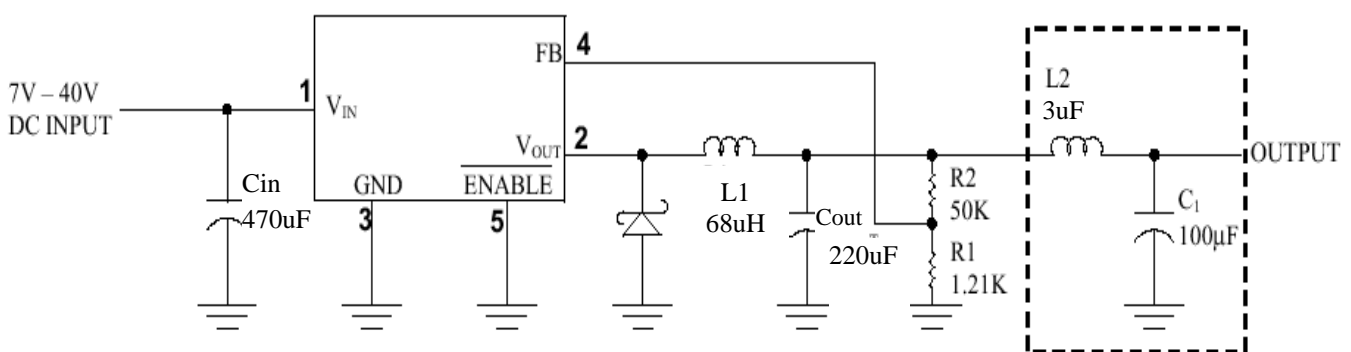

Figure 3. LC Filter for Low Output Ripple

Inductor Selection

The CM2596 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 300mA) 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, toriod, 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 CM2596 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.

Heatsink and Thermal Consideration

Although the CM2596 requires only a small heatsink for most cases, the following thermal consideration is important for all operation. With the package thermal resistances θJA and θJC, 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 heatsink is used, the junction temperature rise can be determined by the following:

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

With the ambient temerpature, 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℃), then a heatsink is required. When using a heatsink, the junction temperature rise will be reduced by the following:

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

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

Layout guideline

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by **heavy lines should be wide printed circuit traces and should be kept as short as possible.** For best results, external components should be located as close to the switcher IC as possible using ground plane construction or single point grounding.

If **open core inductors are used,** special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC ground path and COUT wiring can cause problems.

When using the adjustable version, special care must be taken as to the location of the feedback resistors and the associated wiring. Physically locate both resistors near the IC, and route the wiring away from the inductor, especially an open core type of inductor. (See application section for more information.)
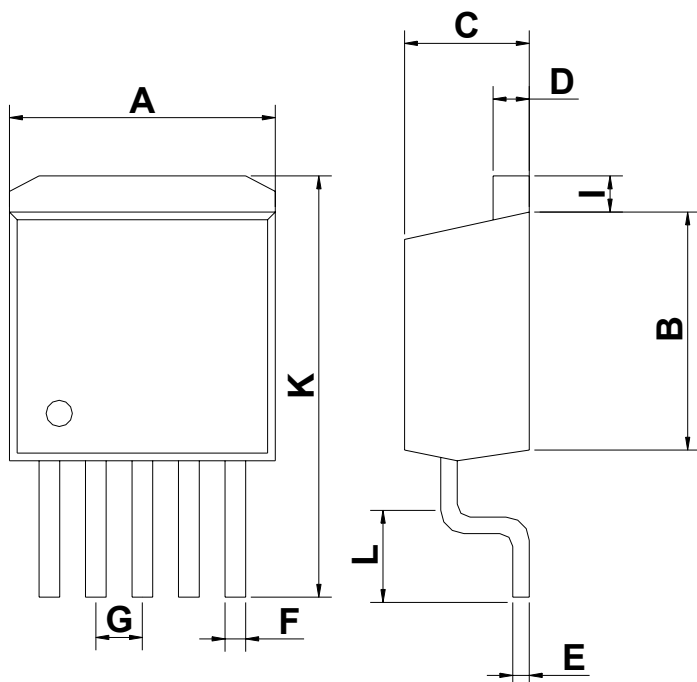
PACKAGE DIMENSION

TO-220 (N220)
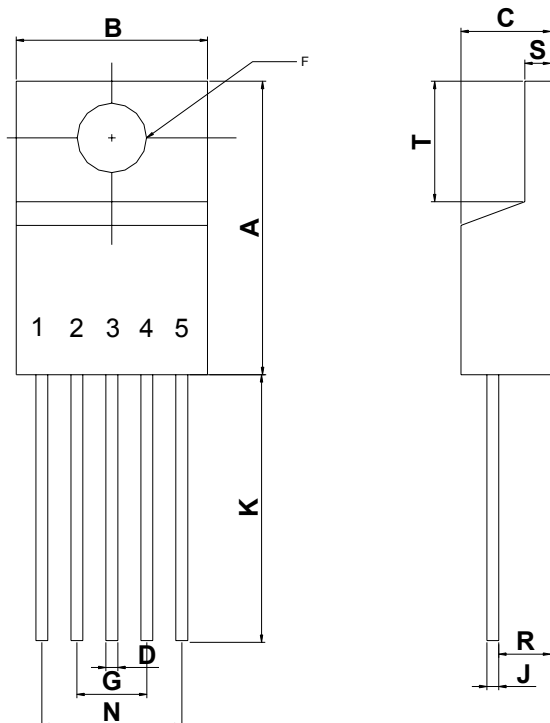
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	14.23	---	16.51	0.560	---	0.650
B	9.66	---	10.66	0.380	---	0.420
C	3.56	---	4.82	0.140	---	0.190
D	0.46	---	0.89	0.018	---	0.035
F	3.56	---	4.06	0.140	---	0.160
G	3.40	---	---	0.134	---	---
J	0.31	---	1.14	0.012	---	0.045
K	12.70	---	14.70	0.500	---	0.580
N	---	6.80	---	---	0.268	---
R	2.04	---	2.92	0.080	---	0.115
S	1.14	---	1.39	0.045	---	0.055
T	5.85	---	6.85	0.230	---	0.270

TO-263 (N263)

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	10.03	---	10.67	0.395	---	0.420
B	8.25	---	9.17	0.325	---	0.361
C	4.34	---	4.59	0.171	---	0.181
D	1.14	---	1.40	0.045	---	0.055
E	0.33	---	0.432	0.013	---	0.017
F	0.737	---	0.889	0.029	---	0.035
G	1.57	---	1.83	0.062	---	0.072
I	---	---	1.65	---	---	0.065
K	14.60	---	16.13	0.575	---	0.635
L	2.29	---	2.79	0.090	---	0.110
V	1.14	---	1.40	0.045	---	0.055

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