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RP2596

150K Hz, 3A, PWM step down DC/DC Converter

General Description

The RP2596 series of regulators are monolithic integrated circuit that provides all the active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V and an adjustable output version. The RP2596 series operate at a switching frequency of 150 kHz; thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5-lead TO-220 package and a 5-lead TO-263 surface mount package. Other features include a guaranteed ±4% tolerance on output voltage under specified input voltages and output load conditions. The 150Hz±15% is on the oscillator frequency. External shutdown is included, featuring 80μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

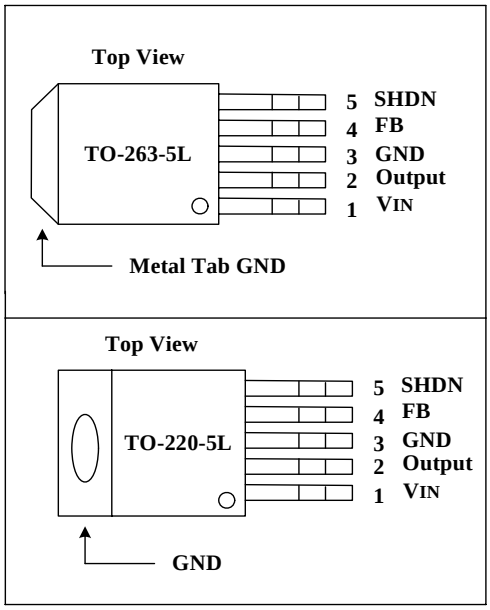
Features

Guaranteed 3A output current
3.3V, 5V,12V and adjustable versions
150kHz fixed frequency internal oscillator
Built-in TTL On/Off control
Thermal shutdown and current limit protection
Uses readily available standard inductors
TTL Shutdown Capability

Application

One-ch switching regulators Simple
High-efficiency step-down regulator
Positive to negative converter

Pin Assignment



Ordering Information

RP2596X-XX

Package Type	Output Voltage
T: TO-220-5L	33: 3.3V
S: TO-263-5L	50: 5.0V
	12: 12V
	ADJ: ADJ

Pin Description

NO.	PIN_NAME	FUNCTION
1	VIN	Supply Voltage Input
2	Output	Switch Pin. Connect inductor/diode here
3	GND	Ground Pin
4	FB	Feedback Pin.
5	SHDN	Shutdown Control Input. Active-Low into shutdown mode

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
VCC	Supply Voltage	24	V
VSD	ON /OFF Pin Input Voltage	-0.3 to +18	V
VFB	Feedback Pin Voltage	-0.3 to +18	V
VOUT	Output Voltage to Ground	-1	V
PD	Power Dissipation	Internally limited	W
TST	Storage Temperature	-65 to +150	°C
TOP	Operating Temperature	-40 to +125	°C
VOP	Operating Voltage	+4.5 to +24	V

Electrical Characteristics

■ RP2596-ADJ

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	5V < VIN < 24V 0.2A < ILOAD < 3A VOUT programmed for3V	1.23	1.193/**1.18** 1.267/**1.28**	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD=3A	74		%

■ RP2596-3.3V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	5.5V < VIN < 24V 0.2A < ILOAD < 3A,	3.3	3.168/**3.135** 3.432/**3.465**	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD = 3A	75		%

■ RP2596-5.0V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	8V < VIN < 24V 0.2A < ILOAD < 3A	5	4.8/**4.75** 5.2/**5.25**	V VMIN VMAX
η	Efficiency	VIN = 12V, ILOAD = 3A	80		%

■ RP2596-12V

Symbol	Parameter	Conditions	Typ.	Limit	Unit
VFB	Output Feedback	15V < VIN < 24V 0.2A < ILOAD < 3A	12	11.52/**11.4** 12.48/**12.6**	V VMIN VMAX
η	Efficiency	VIN = 16V, ILOAD = 3A	89		%

※Specifications in **boldface type** are for full operating temperature range. The other type are for TJ=25ºC.

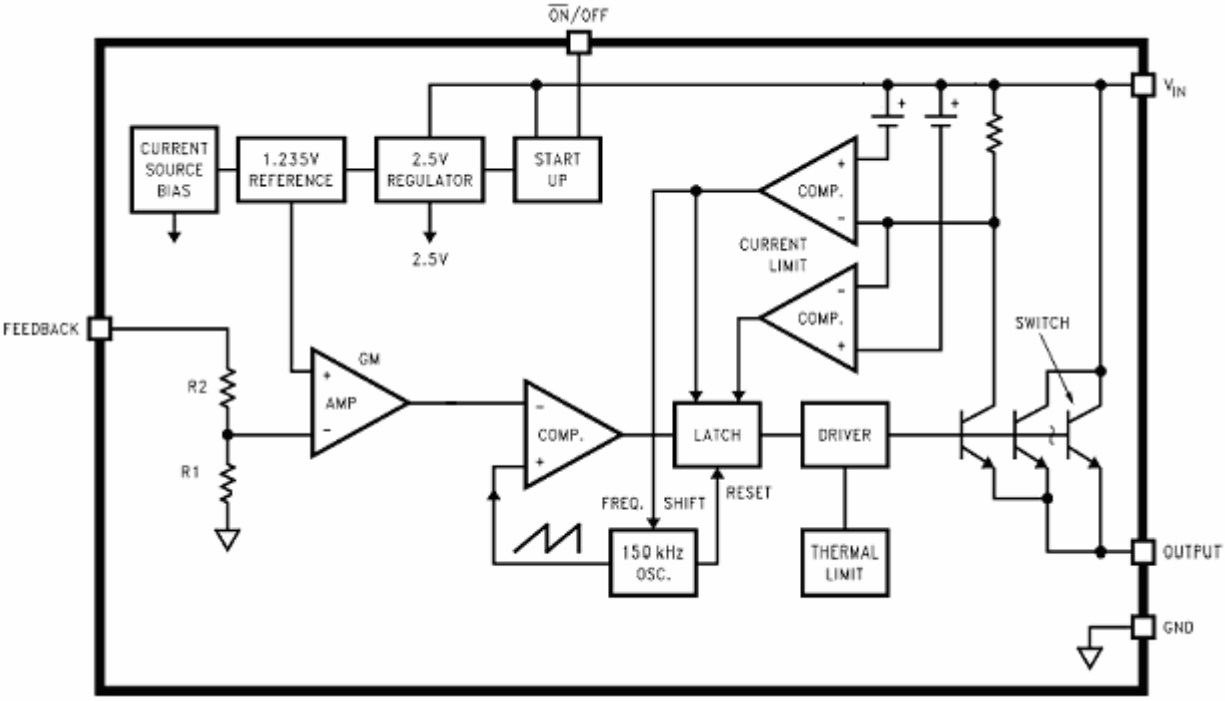
Electrical Characteristics

Specifications with **boldface type** are for full operating temperature range. The other type are for TJ=25ºC.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
IFB	Feedback Bias Current	VFB=1.3V (Adjustable version only)		-10	-50 -100	nA
FOSC	Oscillator Frequency		127 110	150	173 173	KHz
FSCP	Oscillator Frequency of Short Circuit Protect	When current limit occurred and VFB < 0.5V, Ta=25 °C	5	15	25	KHz
VSAT	Saturation Voltage	IOUT=3A No outside circuit VFB=0V force driver on		1.4	1.6 1.7	V
DC	Max. Duty Cycle (ON)	VFB= 0V force driver on		100		%
	Min. Duty Cycle (OFF)	VFB=12V force driver off		0		
ICL	Current Limit	Peak current No outside circuit VFB=0 force driver on	3.6	4.5	5.5 6.5	A
IL	Output = 0V	Output Leakage Current No outside circuit VFB=12 force driver off			-200	uA
	Output =-1V	VIN=22V	-5			
IQ	Quiescent Current	VFB=12 force driver off		5	10	mA
ISTBY	Standby Quiescent Current	ON /OFF pin=5V VIN=12V		250	350	uA
VIL	ON /OFF Pin Logic Input Threshold Voltage	Low (regulator ON)	-	0.6	0.4	V
VIH		High (regulator OFF)	2.0		-	
IH	ON /OFF Pin Logic Input Current	VLOGIC=2.5V (OFF)			-0.01	uA
IL	ON /OFF Pin Input Current	VLOGIC=0.5V (ON)		-0.1	-1	
θJC	Thermal Resistance Junction to Case	TO220-5L		2.5		°C/W
		TO263-5L		3.5		
		PDIP-8L		12		
θJA	Thermal Resistance Junction to Ambient	TO220-5L with copper area of approximately 3 in2		28		°C/W
		TO263-5L		23		
		PDIP-8L		35		

Unless otherwise specified, VIN=12V for 3.3V, 5V, adjustable version and VIN=18V for the 12V version. ILOAD = 0.5A

Block Diagram



Function Description (Pin Functions)

+V_{IN}

This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

Ground

Circuit ground.

Output

Internal switch. The voltage at this pin switches between (+V_{IN} – V_{SAT}) and approximately – 0.5V, with a duty cycle of approximately V_{OUT} / V_{IN}. To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should be kept at minimum.

Feedback (FB)

Sense the regulated output voltage to complete the feedback loop.

ON/OFF (SD)

Allow the switching regulator circuit to be shutdown using logic level signals. Thus drop the total input supply current to approximately 150uA. Pulling this pin below a threshold voltage of approximately 1.3V turns the regulator on, and pulling this pin above 1.3V (up to a maximum of 18V) shuts the regulator down. If this shutdown feature is not needed, the ON / OFF pin can be wired to the ground pin.

Thermal Considerations

The RP2596 is available in two packages: a 5-pin TO-220 and a 5-pin surface mount TO-263. The TO-220 package needs a heat sink under most conditions. The size of the heat sink depends on the input voltage, the output voltage, the load current and the ambient temperature. The RP2596 junction temperature rises above ambient temperature for a 3A load and different input and output voltages. The data for these curves was taken with the RP2596 (TO-220 package) operating as a buck-switching regulator in an ambient temperature of 25°C (still air). These temperature rise numbers are all approximate and there are many factors that can affect these temperatures. Higher ambient temperatures require more heat sinking.

The TO-263 surface mount package tab was designed to be soldering to the copper on a printed circuit board. The copper and the board are the heat sink for this package and the other heat producing components, such as the catch diode and inductor. The PC board copper area that the package is soldered to should be at least 0.8 in_2, and ideally should have 2 or more square inches of 2 oz. Additional copper area improves the thermal characteristics, but with copper areas greater than approximately 6 in_2, only small improvements in heat dissipation are realized. If further thermal improvements are needed, double sided, multi-layer PC board with large copper areas and/or airflow will be recommended.

The RP2596 (TO-263 package) junction temperature rises above ambient temperature with a 2A load for various input and output voltages. This data was taken with the circuit operating as a buck-switching regulator with all components mounted on a PC board to simulate the junction temperature under actual operating conditions. This curve can be used for a quick check for the approximate junction temperature for various conditions, but be aware that there are many factors that can affect the junction temperature. When load currents higher than 3A are used, double sided or multi-layer PC boards with large copper areas and/or airflow might be needed, especially for high ambient temperatures and high output voltages.

For the best thermal performance, wide copper traces and generous amounts of printed circuit board copper should be used in the board layout. (One exception to this is the output (switch) pin, which should not have large areas of copper.) Large areas of copper provide the best transfer of heat (lower thermal resistance) to the surrounding air, and moving air lowers the thermal resistance even further.

Function Description

Package thermal resistance and junction temperature rise numbers are all approximate, and there are many factors that will affect these numbers. Some of these factors include board size, shape, thickness, position, location, and even board temperature. Other factors are, trace width, total printed circuit copper area, copper thickness, single or double-sided, multi-layer board and the amount of solder on the board. The effectiveness of the PC board to dissipate heat also depends on the size, quantity and spacing of other components on the board, as well as whether the surrounding air is still or moving. Furthermore, some of these components such as the catch diode will add heat to the PC board and the heat can vary as the input voltage changes. For the inductor, depending on the physical size, type of core material and the DC resistance, it could either act as a heat sink taking heat away from the board, or it could add heat to the board.

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 / 31DQ04
50	SK35 / MBRS360	SR305 / MBR350 / 31DQ05 / MUR320

Quick Design Component Selection Table for Adjustable Output

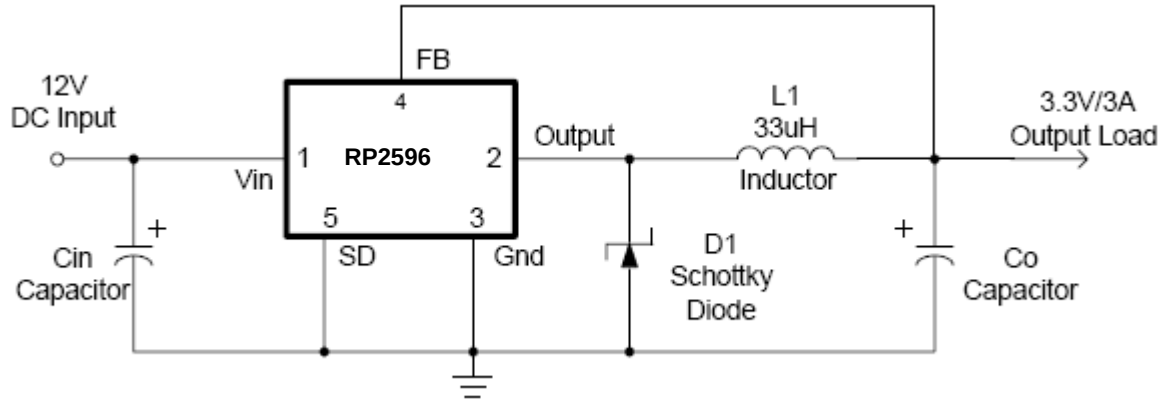
Output Voltage (V)	Through Hole Output Capacitor			Surface Mount Output Capacitor		
	Panasonic HFQ Series (μF/V)	Nichicon PL Series (μF/V)	Feed forward Capacitor	Panasonic HFQ Series (μF/V)	Nichicon PL Series (μF/V)	Feed forward Capacitor
2	820/35	820/35	33nF	330/6.3	470/4	33nF
4	560/35	470/35	10nF	330/6.3	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	680pF	68/20	120/20	680pF

Quick Design Component Selection Table for Fixed Output

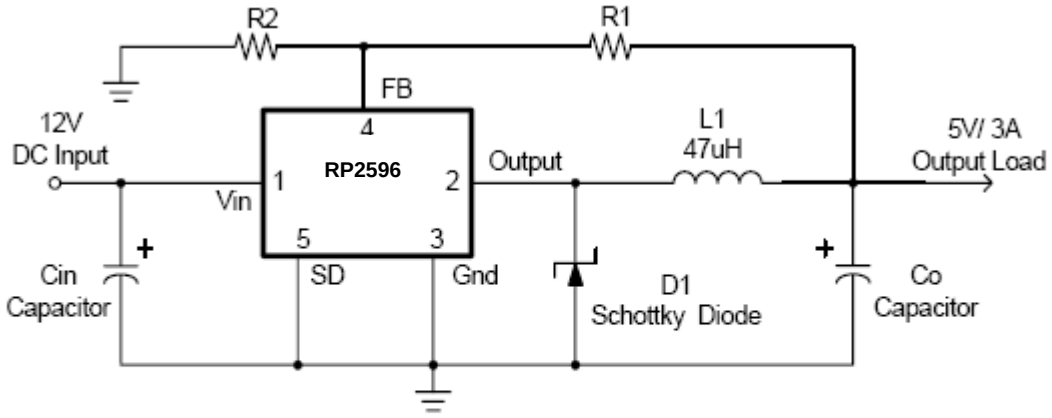
Input/Output Condition			Inductor		Output Capacitor(μF/V)			
					Through Hole Electrolytic		Surface Mount Tantalum	
Output Voltage (V)	Load Current (A)	Max. Input Voltage (V)	Inductance (μH)	Current (A)	Nichicon PL Series	Panasonic HFQ Series	Sprague 595D Series	AVX TPS Series
5	3	8	22	3.5	560/25	560/25	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

Typical Application Circuit

1. **Fixed Type Circuit**



2. **Adjustable Type Circuit**

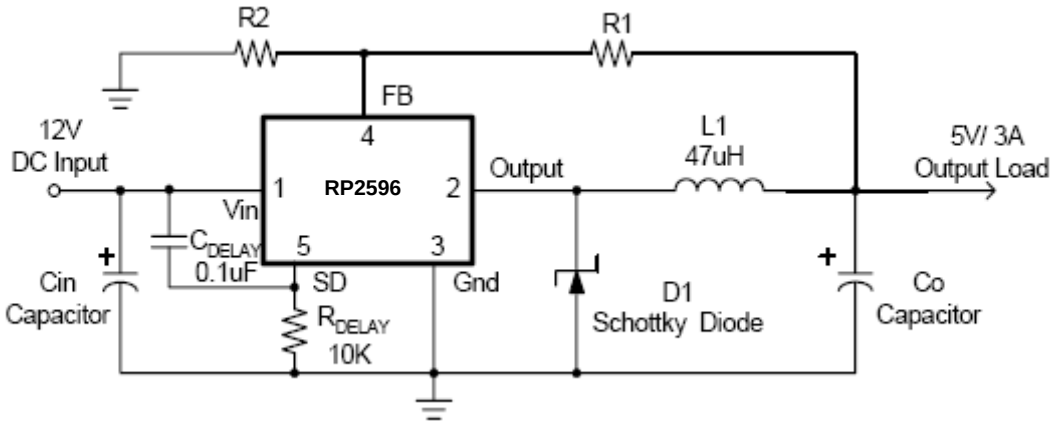


$$Vout = V_{FB} \times (1 + \frac{R1}{R2})$$

V_{FB} = 1.23V

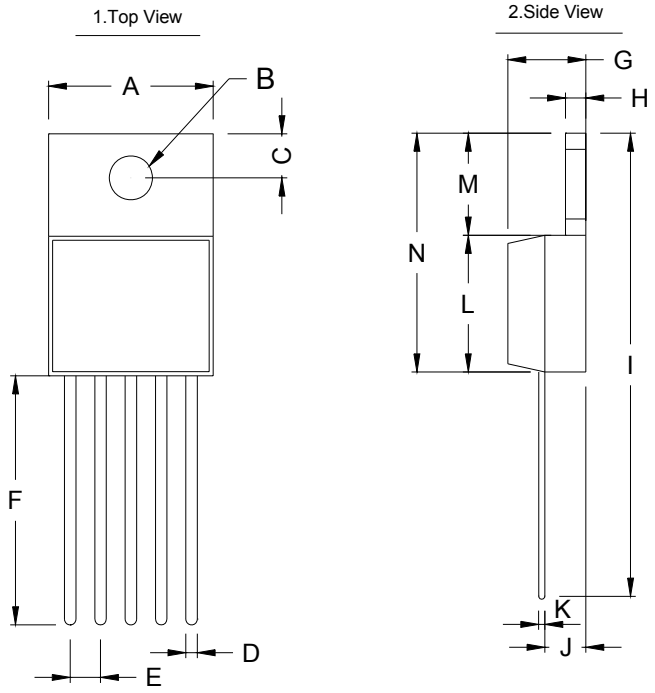
R2 = 1K ~ 3K

3. **Delay Start Circuit**



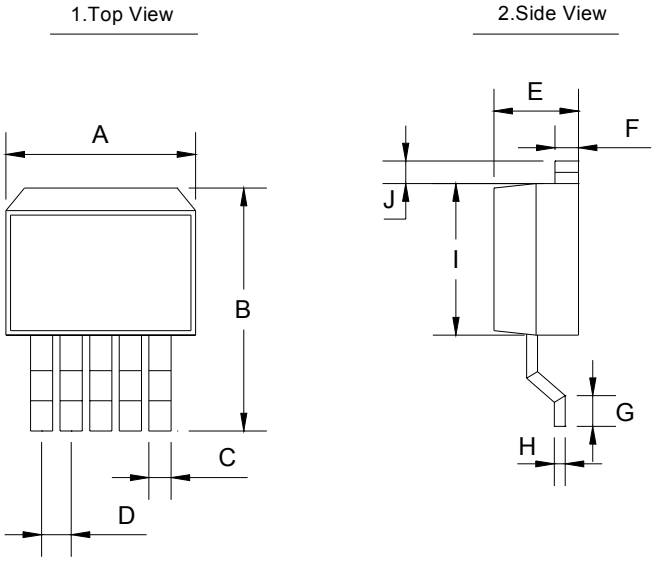
Package Information

Package Type: TO220-5L



TO-220-5L DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.00	10.50	0.394	0.413
B	3.24	3.90	0.128	0.154
C	2.44	2.94	0.096	0.116
D	0.26	1.02	0.010	0.040
E	1.57	1.83	0.062	0.072
F	13.31	14.13	0.524	0.556
G	4.475	5.225	0.176	0.206
H	1.17	1.37	0.046	0.054
I	27.6	29.44	1.087	1.159
J	2.175	2.925	0.086	0.115
K	0.297	0.477	0.012	0.019
L	8.28	8.8	0.326	0.346
M	6.01	6.51	0.237	0.256
N	14.29	15.31	0.563	0.603

Package Type: TO263-5L



TO-263-5L DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.00	10.50	0.393	0.413
B	14.595	15.875	0.574	0.625
C	0.255	1.015	0.010	0.040
D	1.573	1.827	0.061	0.072
E	4.31	4.83	0.169	0.190
F	1.14	1.40	0.044	0.055
G	2.285	2.785	0.089	0.110
H	0.45	0.73	0.017	0.029
I	8.28	8.80	0.325	0.346
J	1.14	1.40	0.044	0.055