

## 3A / 150kHz Step-Down DC-DC Converter

### GENERAL DESCRIPTION

The TS2596 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 TS2596 series operates at a switching frequency of 150kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. It substantially not only reduces the area of board size but also the size of heat sink, and in some cases no heat sink is required. The  $\pm 4\%$  tolerance on output voltage within specified input voltages and output load conditions is guaranteed. Also, the oscillator frequency accuracy is within  $\pm 10\%$ . External shutdown is included. Featuring 100 $\mu$ A (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

### FEATURES

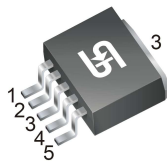
- Output voltage: 3.3V, 5V & adjustable version
- Adjustable output voltage range 1.23V~38.5V
- 150kHz fixed switching frequency
- Voltage mode Non-synchronous PWM control
- Thermal shutdown and current limit protection
- ON/OFF shutdown control input
- Short circuit protect (SCP)
- Operating voltage can be up to 40V
- Output load current 3A
- Low power standby mode
- Built-in switching transistor on chip
- Compliant to RoHS Directive 2011/65/EU and in accordance to WEEE 2002/96/EC.
- Halogen-free according to IEC 61249-2-21

### APPLICATION

- Simple High-efficiency Step down Regulator
- On-Card Switching Regulators
- Positive to Negative Converter



TO-263-5L (D<sup>2</sup>PAK)



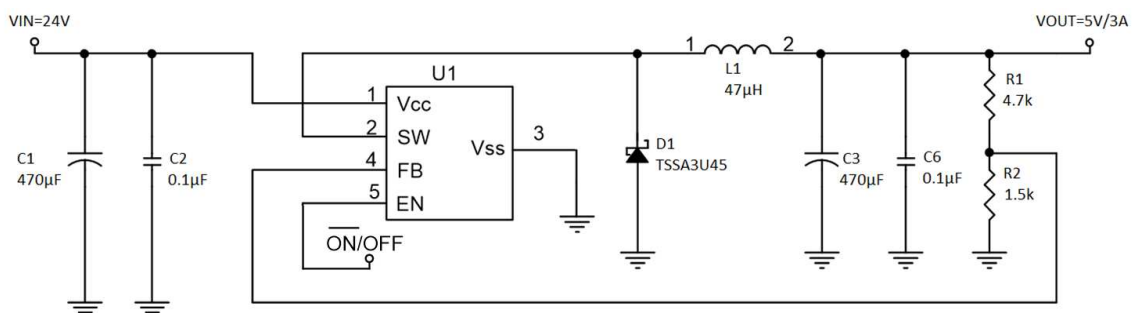
#### Pin Definition:

1. Input
2. SW Output
3. Ground
4. Feedback
5. Enable

**Notes:** Moisture sensitivity level: level 3. Per J-STD-020

### TYPICAL APPLICATION CIRCUIT

#### Adjustable Output Voltage Version



$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R2}\right), V_{FB} = 1.23V, R2 = 0.7k \sim 3k$$

**ABSOLUTE MAXIMUM RATINGS**

PARAMETER	SYMBOL	LIMIT	UNIT
Maximum Supply Voltage	$V_{CC}$	+45	V
Recommend Operating Supply Voltage	$V_{OP}$	+4.5 to +40	V
SW, EN Pin Input Voltage	$V_{SW}, V_{EN}$	-0.3 to +40	V
Feedback Pin Voltage	$V_{FB}$	-0.3 to +12	V
Power Dissipation	$P_D$	Internally Limited	W
Output Voltage to Ground	$V_{OUT}$	-1	V
Storage Temperature Range	$T_{ST}$	-65 ~ +150	°C
Operating Temperature Range	$T_{OP}$	-40 ~ +125	°C
ESD Susceptibility (HBM)		2	kV

**THERMAL INFORMATION**

PARAMETER	SYMBOL	LIMIT	UNIT
Junction to Case Thermal Resistance	$R_{\theta JC}$	2	°C/W
Junction to Ambient Thermal Resistance	$R_{\theta JA}$	50	°C/W

**Note:**  $R_{\theta JA}$  is measured with the PCB copper area (need connect to GROUND pins) of approximately 1.5 in<sup>2</sup> (Multi-layer)

**ELECTRICAL CHARACTERISTICS**

( $V_{IN} = 12V$  for 3.3V, 5V, Adjustable Version,  $I_{LOAD} = 0.3A$ ,  $T_A = 25^\circ C$  unless otherwise noted)

PARAMETER		CONDITION	SYMBOL	MIN	TYP	MAX	UNIT
Output Feedback	ADJ	$4.5V \leq V_{IN} \leq 40V$ $0.2A \leq I_{LOAD} \leq 3A$	$V_{FB}$	1.180	1.23	1.280	V
Efficiency		$V_{IN} = 12V$ , $I_{LOAD} = 3A$ , $V_{OUT} = 5V$	$\eta$	--	77	--	%
Output Feedback	3.3V	$4.75V \leq V_{IN} \leq 40V$ $0.2A \leq I_{LOAD} \leq 3A$	$V_{FB}$	3.135	3.3V	3.465	V
Efficiency		$V_{IN} = 12V$ , $I_{LOAD} = 3A$	$\eta$	--	75	--	%
Output Feedback	5V	$7V \leq V_{IN} \leq 40V$ $0.2A \leq I_{LOAD} \leq 3A$	$V_{FB}$	4.75	5	5.25	V
Efficiency		$V_{IN} = 12V$ , $I_{LOAD} = 3A$	$\eta$	--	80	--	%
Feedback Bias Current		$V_{FB} = 1.3V$ (Adj version only)	$I_{FB}$	--	10	100	nA
Oscillator Frequency			$F_{OSC}$	127	150	173	kHz
Soft-Start Time		Rising edge of EN on to $I_{CL}$	$T_{SS}$	--	3	--	ms
Current Limit		Pear Current, no outside circuit $V_{FB} = 0V$ force driver on	$I_{CL}$	3.3	--	--	A
Oscillator Frequency of Short Circuit Protect		When current limit occurred and $V_{FB} < 0.5V$ , $T_A = 25^\circ C$	$F_{SCP}$	110	150	173	KHz
Saturation Voltage		$I_{OUT} = 3A$ , No outside circuit $V_{FB} = 0V$ force driver on	$V_{SAT}$	--	1.15	1.50	V
ON/OFF Pin Logic Input Threshold Voltage		Low (regulator ON)	$V_{IL}$	--	1.3	0.6	V
		High (regulator OFF)	$V_{IH}$	2.0	1.3	--	V

## ELECTRICAL CHARACTERISTICS

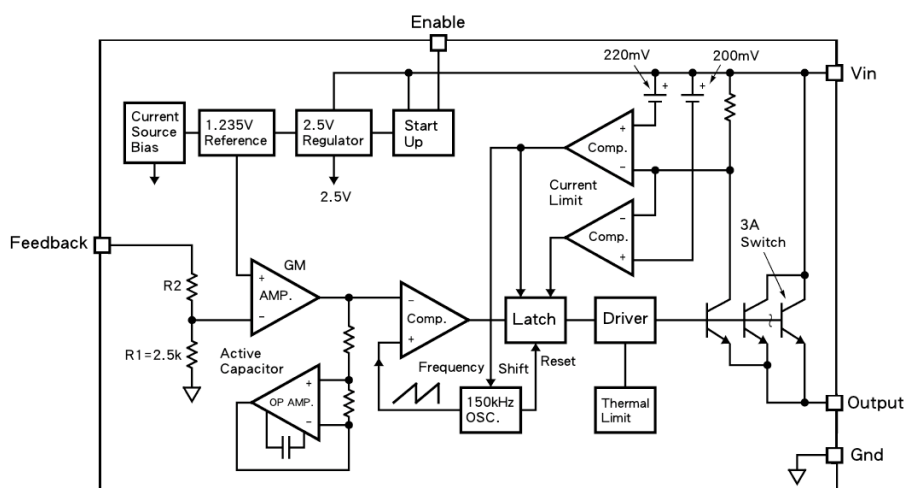
( $V_{IN} = 12V$  for 3.3V, 5V, Adjustable Version,  $I_{LOAD} = 0.3A$ ,  $T_A = 25^\circ C$  unless otherwise noted)

PARAMETER		CONDITION	SYMBOL	MIN	TYP	MAX	UNIT
ON/OFF Pin Logic Input Current		$V_{LOGIC} = 2.5V$ (OFF)	$I_H$	--	5	15	$\mu A$
		$V_{LOGIC} = 0.5V$ (ON)	$I_L$	--	0.02	5	
Maximum Duty Cycle (ON)		$V_{FB} = 0V$ force driver on	DC	--	100	--	%
Maximum Duty Cycle (OFF)		$V_{FB} = 12V$ force driver off		--	0	--	
Quiescent Current		$V_{FB} = 12V$ force driver off	$I_Q$	--	5	10	mA
Standby Quiescent Current		ON/OFF pin=5V	$I_{STBY}$	--	80	200	$\mu A$
		$V_{IN} = 40V$		--		250	
SW Pin Leakage Current	SW pin = 0	No outside circuit, $V_{FB} = 12V$ force driver off	$I_{SWL}$	--	0.3	2	mA
	SW pin = -1	$V_{IN} = 12V$		--	7.5	30	mA

## ORDERING INFORMATION

OUTPUT VOLTAGE	PART NO.	PACKAGE	PACKING
3.3V	TS2596CM533 RNG	TO-263-5L (D <sup>2</sup> PAK)	800pcs / 13" Reel
5.0V	TS2596CM550 RNG	TO-263-5L (D <sup>2</sup> PAK)	800pcs / 13" Reel
ADJ	TS2596CM5 RNG	TO-263-5L (D <sup>2</sup> PAK)	800pcs / 13" Reel

## BLOCK DIAGRAM



## **PIN FUNCTION DESCRIPTION**

### **V<sub>CC</sub>**

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

### **Ground**

Circuit ground

### **SW Output**

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

### **Feedback**

Sense the regulated output voltage to complete the feedback loop.

### **Enable**

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately  $100\mu A$ . 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  $V_{CC}$ ) shuts the regulator down. If this shutdown feature is not needed, the EN pin can be wired to the ground pin.

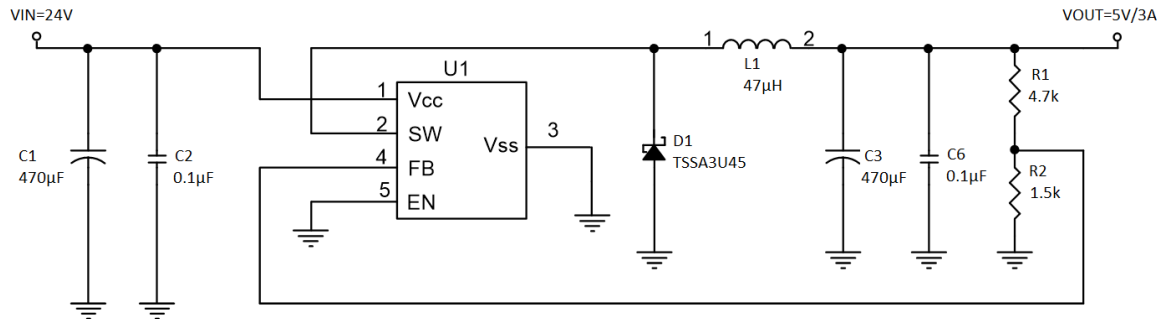
### **Thermal Considerations**

The TS2596 (TO-263-5L package) junction temperature rise above ambient temperature with a 3A 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 multilayer 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. (Once 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.

## TYPICAL APPLICATIN CIRCUIT

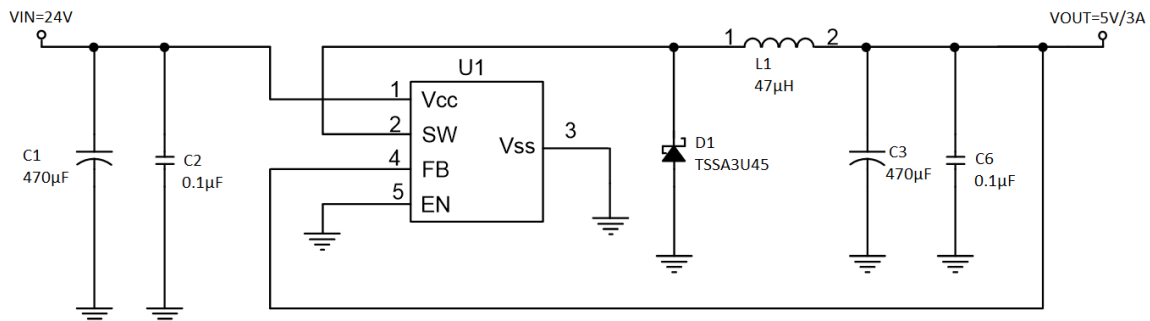
### Adjustable Output Voltage Version



$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R2}\right), V_{FB} = 1.23V, R2 = 0.7k \sim 3k$$

V <sub>OUT</sub>	R2	R1
5.0V	1.5kΩ	4.7kΩ
3.3V	1.5kΩ	2.5kΩ
2.5V	1.5kΩ	1.5kΩ

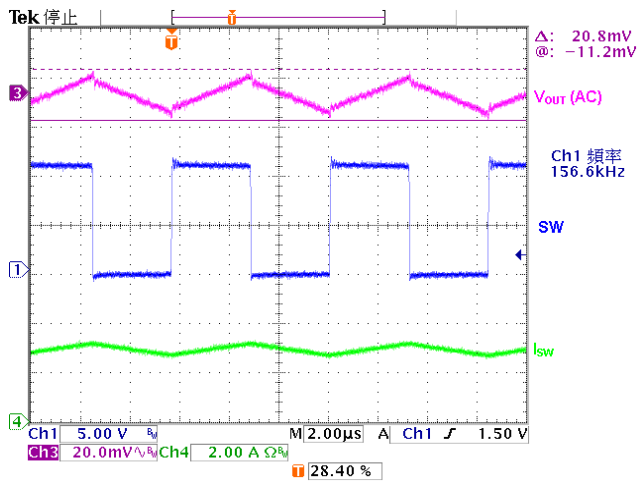
### Fixed Output Voltage Version



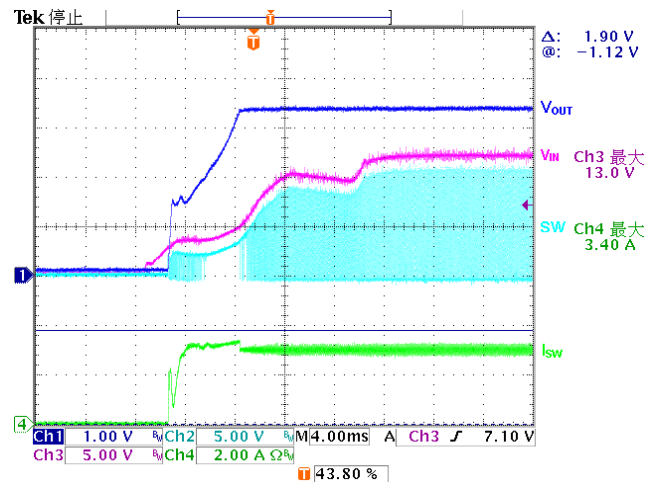
L1 recommend value (I <sub>OUT</sub> =3A,)				
V <sub>OUT</sub>	2.5V	3.3V	5V	12V
V <sub>IN</sub> =12V	33µH	33µH	33~47µH	NA
V <sub>IN</sub> =24V	33µH	33µH	47µH	68µH

## ELECTRICAL CHARACTERISTICS CURVES

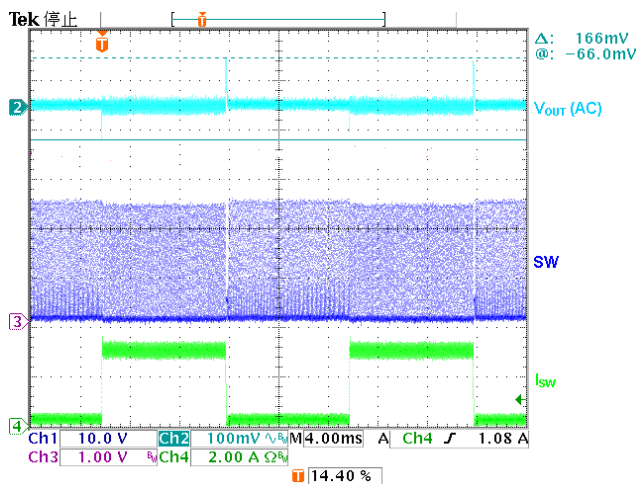
( $T_C = 25^\circ\text{C}$  unless otherwise noted)



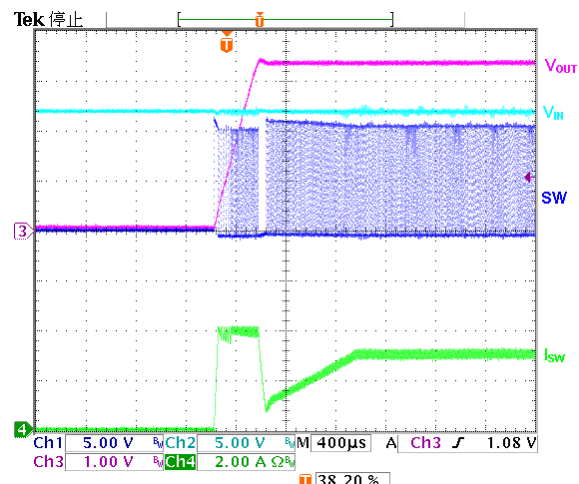
**Figure 1. Output Ripple**  
( $V_{IN}=12\text{V}$ ,  $V_{OUT}=5\text{V}$ ,  $I_O=3\text{A}$ )



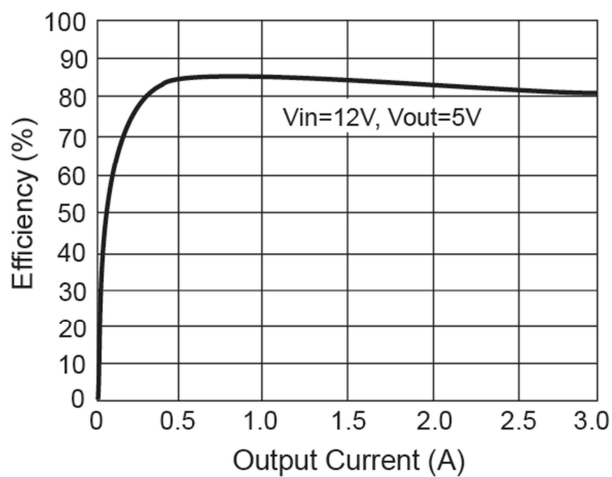
**Figure 2. Power On Test Wave**  
( $V_{IN}=12\text{V}$ ,  $V_{OUT}=5\text{V}$ ,  $I_O=3\text{A}$ )



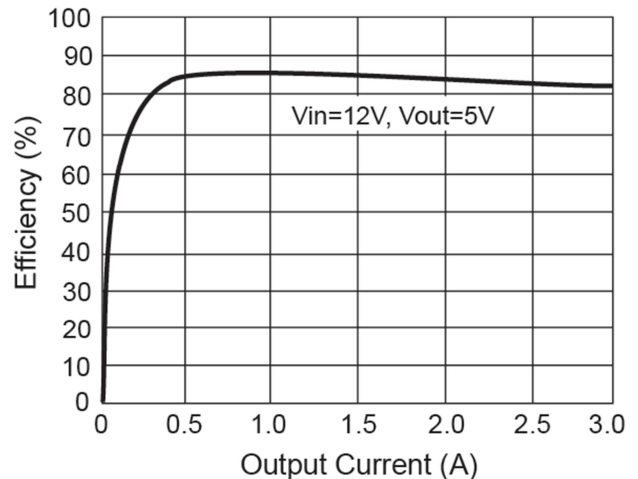
**Figure 3. Load Transient Response**  
( $V_{IN}=12\text{V}$ ,  $V_{OUT}=5\text{V}$ ,  $I_O=0.2\sim 3\text{A}$ )



**Figure 4. EN On Test Wave**  
( $V_{IN}=12\text{V}$ ,  $V_{OUT}=5\text{V}$ ,  $I_O=3\text{A}$ )



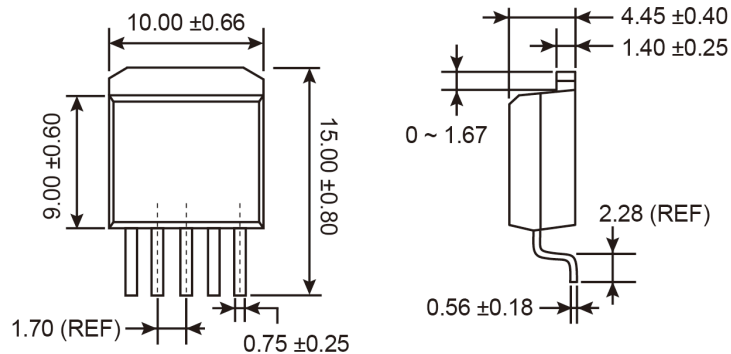
**Figure 5. Efficiency**



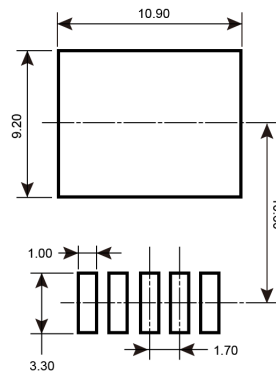
**Figure 6. Efficiency**

**PACKAGE OUTLINE DIMENSIONS** (Unit: Millimeters)

**TO-263-5L (D<sup>2</sup>PAK)**



**SUGGESTED PAD LAYOUT** (Unit: Millimeters)



**MARKING DIAGRAM**



- Y** = Year Code
- M** = Month Code for Halogen Free Product
  - O** =Jan    **P** =Feb    **Q** =Mar    **R** =Apr
  - S** =May    **T** =Jun    **U** =Jul    **V** =Aug
  - W** =Sep    **X** =Oct    **Y** =Nov    **Z** =Dec
- L** = Lot Code
- XX** = Voltage Code
  - (3.3=3.3V, 5.0=5V)
  - = Package Code for Adjustable type
  - (CM5 = TO-263-5L)

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