VPE2510

18V, 3A, COT, Synchronous Step-Down DC/DC Converter

Description

VPE2510 is a high efficiency step down DC/DC converter. It features very fast transient response, and excellent line and load regulation via constant on time (COT) control architecture. The device can accept input voltage from 4.5V to 18V and deliver up to 3A output current. Furthermore, the built-in synchronous switch improves efficiency and eliminates external schottky diode. The VPE2510 uses pulse skip modulation (PSM) for improving light load efficiency, the adjustable version of this device is available in TSOT-23-6 package.

Key Features

- Achieve 92% efficiency
- Input voltage: 4.5V to 18V
- Output current up to 3A
- Constant On Time (COT) operation
- Cycle by cycle over current protection
- Adjust output voltage
- No schottky diode needed
- Shutdown current $<4\mu A$
- Excellent line and load transient response
- Over-temperature protection
- Short circuit protection
- Available in TSOT-23-6 package
- RoHS compliant

Applications

- Set Top Box
- AP Router
- LCD TV
- Wireless Networking

Typical Application

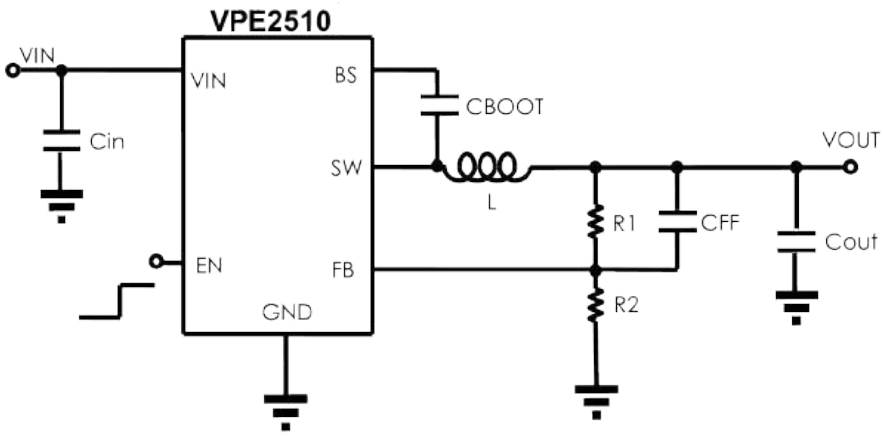
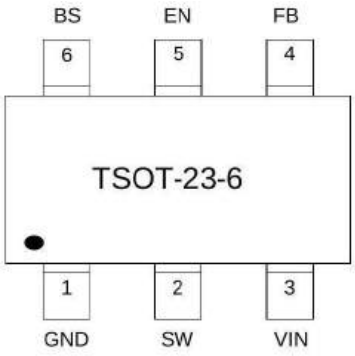


Figure. 1 VPE2510 application circuit

Package Configuration



TSOT-23-6

VPE2510-00VU06NRR

00 Adjustable

VU06 TSOT-23-6 Package

NRR RoHS & Halogen free package

Commercial Grade Temperature

Rating: -40 to 85℃

Package in Tape & Reel

Order, Mark & Packing information

Package	Vout(V)	Product ID	Marking Code	Packing
TSOT-23-6	Adjustable	VPE2510-00VU06NRR	2510	Tape & Reel 3K units

Pin Functions

Name	TSOT-23-6	Function
GND	1	**Ground Pin.**
SW	2	**Switch Pin.** Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
VIN	3	**Power Input Pin.** Must be closely decoupled to GND pin with a 4.7μF or greater ceramic capacitor.
FB	4	**Feedback Pin.** Receives the feedback voltage from an external resistive divider across the output.
EN	5	**Enable Pin.** Minimum 1.6V to enable the device. Maximum 0.6V to shut down the device. Don't allow it floating.
BS	6	**Boot-strap Pin.** This is the positive power supply for the internal floating high-side MOSFET driver. Connect a bypass capacitor (0.1μF) between BS and SW pin.

Functional Block Diagram

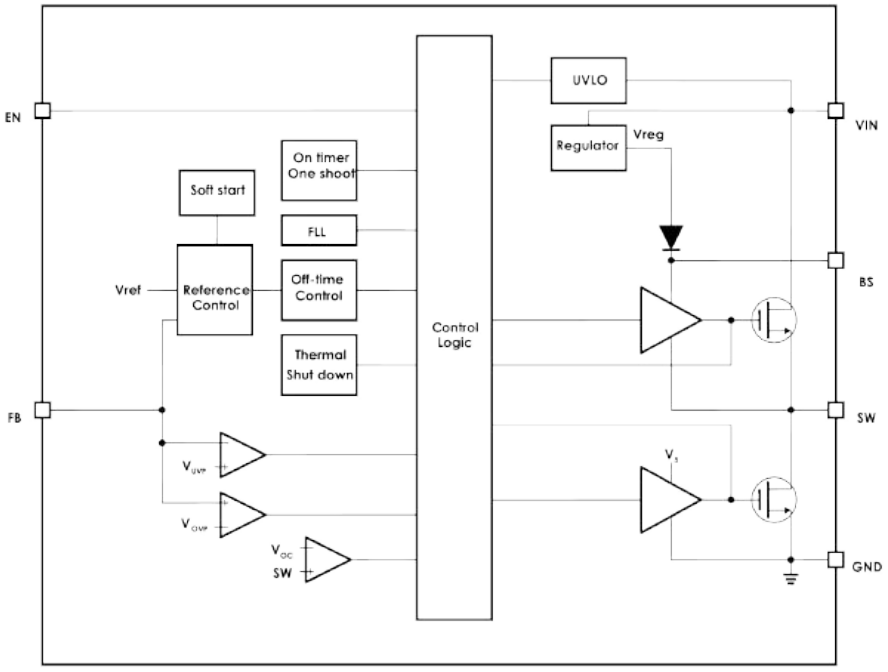


Fig. 2 Functional Block Diagram of VPE2510

Absolute Maximum Ratings

Devices are subjected to fail if they stay above absolute maximum ratings.

Input Voltage (V_{IN}) ..... –0.3V to +20V
VFB Voltages ..... –0.3V to +6V
SW Voltage ..... –0.3V to V_{IN}+0.3V
Switch Voltage (SW, 10ns transient) .... –3.5V to V_{IN}+0.3V
Boost Voltage (BS) ..... V_{SW}–0.3V to V_{SW}+6V
Enable Voltage (EN) ..... –0.3V to V_{IN}
Lead Temperature (Soldering, 10 sec) ..... 260°C

Ambient Operating Temperature Range ... –40°C to 85°C
Junction Temperature (Note 1, 3) ..... 150°C
Storage Temperature Range ..... –65°C to 150°C
ESD Susceptibility HBM 2KV
ESD Susceptibility CDM 750V

Recommended Operating Conditions

Input Supply Voltage V_{IN} ..... 4.5~18V
Output Voltage V_{OUT} ..... <6.5V
Junction Operating Temperature Range ..... –40°C to 125°C

Thermal data

Package	Thermal Resistance	Parameter	Value
TSOT-23-6	θ_{JA} (Note 4)	Junction-ambient	92.6°C/W
	θ_{JC} (Note 5)	Junction-case	48.5°C/W

- **Note 1:** T_J is a function of the ambient temperature T_A and power dissipation P_D ($T_J = T_A + (P_D * 92.6°C/W)$).
- **Note 2:** Dynamic quiescent current is higher due to the gate charge being delivered at the switching frequency.
- **Note 3:** This IC has a built-in over-temperature protection to avoid damage from overloaded conditions.
- **Note 4:** θ_{JA} is measured in the natural convection at T_A=25°C on a highly effective thermal conductivity test board according to the JEDEC 51-7 thermal measurement standard.
- **Note 5:** θ_{JC} represents the heat resistance between the chip and the package top case.

Electrical Characteristics

V_{IN}=12V, T_A=+25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input Voltage Range	V_{IN}	-	4.5	-	18	V
Feedback Current	I_{VFB}	-	-	-	±100	nA
Regulated Feedback Voltage	V_{FB}	-	755	770	785	mV
No switching Quiescent Current	I_Q	V_{FB}=0.85V	-	370	580	μA
Shutdown Current	I_{SD}	V_{EN}=0V	-	1	4	μA
$R_{DS(ON)}$ of Highside	R_{ON}	V_{BST}-SW=5V	-	100	-	mΩ
$R_{DS(ON)}$ of Lowside	R_{ON}	-	-	55	-	mΩ
VIN UVLO Threshold	V_{UVLO}	VIN Raise	-	3.8	-	V
UVLO Hysteresis	$V_{UVLO(Hys)}$	Hysteresis VIN	-	320	-	mV
Inductor Current (Note 6)	I_{OCL}	V_{FB}=0.5V	3.1	4.3	-	A
Switching Frequency	F_{SW}	V_{IN}=12V, V_{OUT}=5V	-	600	-	kHz
Enable Threshold	V_{EN}	V_{EN}	1.6	-	-	V
Shutdown Threshold	V_{EN}	V_{EN}	-	-	0.6	V
EN Input Current	I_{EN}	V_{EN}=2V	-	2	10	μA
Thermal Shutdown	T_{SD}	-	-	155	-	°C
Thermal Shutdown Hysteresis	$T_{SD(Hys)}$	-	-	35	-	°C
OVP detect (Note 6)	V_{OV}	V_{FB}	-	125%	-	V
UVP detect (Note 6)	V_{UV}	V_{FB}	-	55%	-	V
Max duty cycle	D_{MAX}	-	-	70	-	%
Min on time (Note 6)	T_{ON}	-	-	135	-	ns
Minimum off Time	T_{OFF}	-	-	280	-	ns
Soft-Start Time	T_{SS}	-	-	1	-	ms

- **Note 6:** Design guaranteed.

Typical Performance Characteristics

V_{IN}=12V, T_A=25°C, unless otherwise specified.

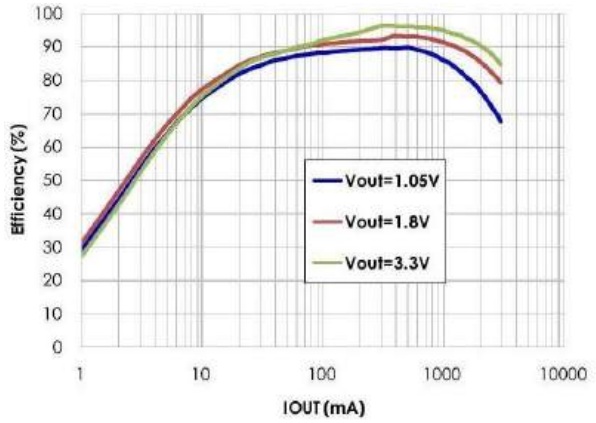


Figure 3. Efficiency vs. Output Current (VIN=5V)

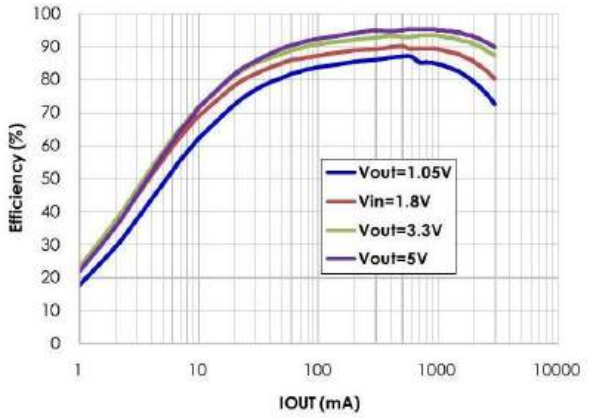


Figure 4. Efficiency vs. Output Current (VIN=12V)

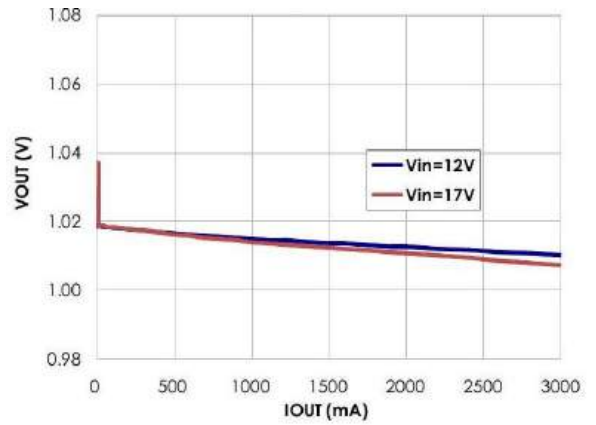


Figure 5. Output Voltage vs. Output Current

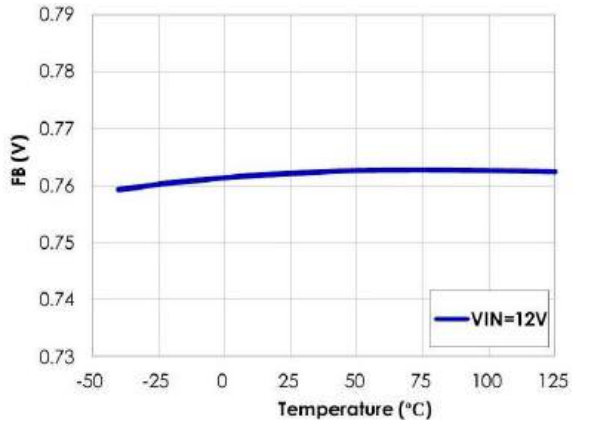


Figure 6. FB Voltage vs. Temperature

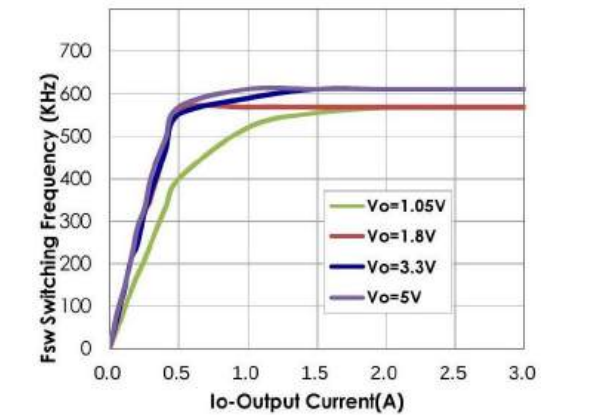


Figure 7. Fsw vs. Output Current

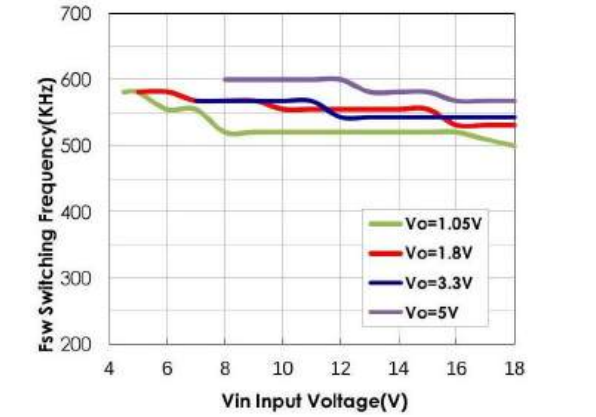


Figure 8. Fsw vs. Input Voltage

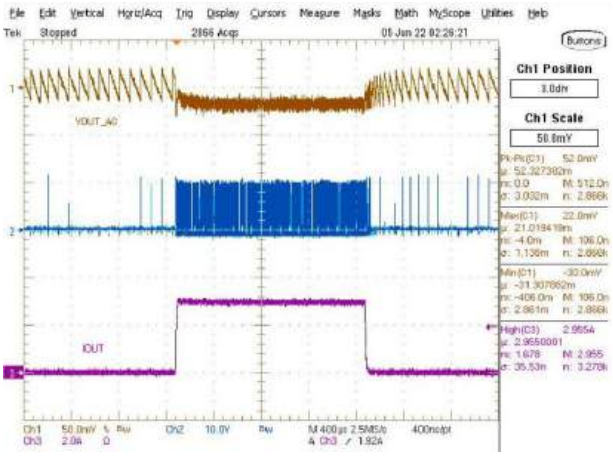


Figure 9. Load Transient (10mA to 3A)

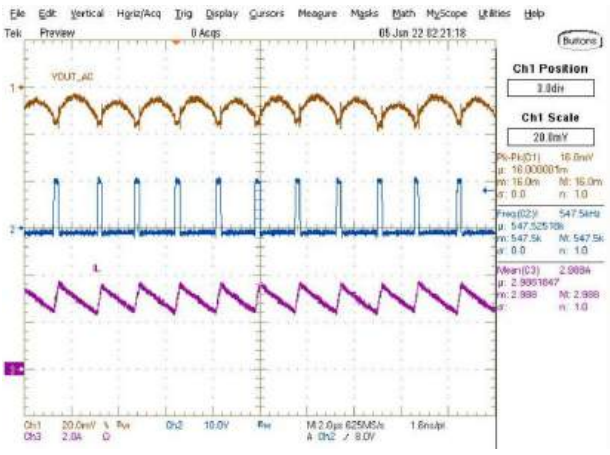


Figure 10. Output Ripple Voltage (Vo=1.05V, Io=3A)

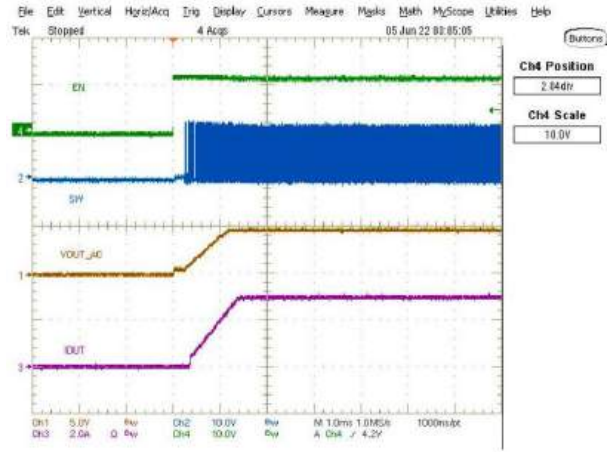


Figure 11. Power On from EN

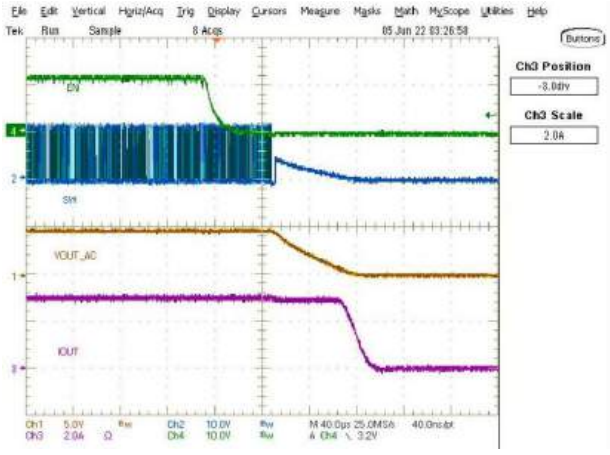


Figure 12. Power Off from EN

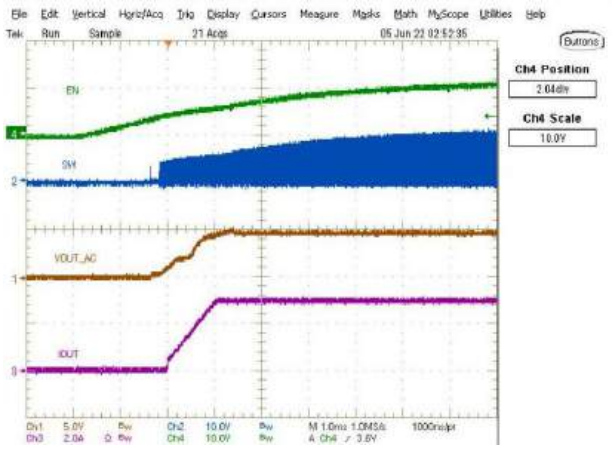


Figure 13. Power On from VIN

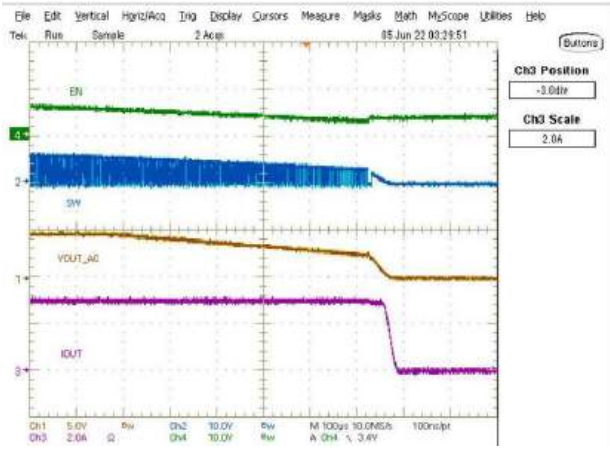


Figure 14. Power Off from VIN

Functional Description

Detailed Descriptions

The VPE2510 is a Constant On Time (COT) operation buck converter with an integrated high and low side switch. The device operates with input voltages from 4.5V to 18V. The constant on time control with an internal compensation circuit for pseudo-fixed frequency, it supports with low-ESR output ceramic capacitors.

At the beginning of each cycle, the high-side MOSFET is turned on. This MOSFET is turned off after internal oneshot timer expires. This one shot duration is set proportional to the converter input voltage, VIN, and inversely proportional to the output voltage, VO, to maintain a pseudo-fixed frequency over the input voltage range, hence it is called adaptive on-time control. The one-shot timer is reset and the high-side MOSFET is turned on again when the feedback voltage falls below the reference voltage.

VPE2510 with adaptive on-time control, which can reduce the output capacitance and provide ultrafast transient responses, and allow minimal component sizes without any additional external compensation network.

Enable Control

Enable input control to turn on/off device, don't allow it floating. When EN pin voltage was exceeded threshold voltage to enable the device. If EN pin voltage is lower than the shutdown threshold voltage, the device will be disable.

Over-Temperature Protection (OTP)

OTP limits the total power dissipation in the device. When the junction temperature exceeds 155°C, the internal thermal sensor will shuts down the whole chip directly. Once the junction temperature drops below 120°C, OTP is deactivated and VPE2510 turns to normal operation.

Output Over-Voltage Protection (OVP)

Once the FB pin voltage of VPE2510 is over (∼1.25 times of VFB), the high-side switch would be turned off and the low-side switch would be turned on immediately. When inductor current is down to around zero current, the low-side switch would be turned off.

Input Under Voltage Lock-out (UVLO)

UVLO is implemented to protect the chip from operating at insufficient supply voltage. When VIN exceed the input threshold voltage, the internal circuit and driver are active. When Vin below the input UVLO threshold voltage, the driver will be disable. The UVLO falling threshold is about 3.5V, and rising threshold is about 3.8V.

Boost Capacitor

Connect a 0.1μF capacitor between the BS and SW. This capacitor provides the gate driver voltage for the high-side MOSFET. In addition, an UVLO in the floating supply is implemented to protect the high-side MOSFET and its driver from operating at insufficient supply voltage. The UVLO rising threshold is about 2.3V while its hysteresis is about 0.15V.

Over-Current Protection (OCP)

Over-current limitation is implemented by sensing the current across the low-side MOSFET. If the monitored current is above the OCL level, the converter maintains low-side FET on and delays the creation of a new set pulse, even the voltage feedback loop requires one, until the current level becomes OCL level or lower the new switching cycle will be start.

Output Under-Voltage Protection and Short Circuit Protection (Hiccup Mode)

The VPE2510 includes output under-voltage protection (UVP) against over-load or short-circuited condition by constantly monitoring the feedback voltage VFB. If VFB drops below the under-voltage protection trip threshold (typically 55% of the internal feedback reference voltage), the UV comparator will go high to turn off both the internal high-side and low-side MOSFET switches. If the output under-voltage condition continues for a period of time, the VPE2510 will enter short circuit protection with hiccup mode. During hiccup mode, the drive will shut down for $HICCUP_{OFF}$ (8ms), and then attempt to recover automatically for driver on (2.7ms).

Application Information

Inductor Selection

Inductor ripple current and core saturation current are the two main factors that decide the Inductor value. A low DCR inductor is preferred.

C_{IN} and C_{OUT} Selection

A low ESR input capacitor can prevent large voltage transients at V_{IN}. The RMS current of input capacitor is required larger than I_{RMS} calculated by:

$$I_{RMS} \cong I_{OMAX} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}} \quad \text{(Eq. 1)}$$

ESR is an important parameter to select C_{OUT}, which can be seen in the following output ripple V_{OUT} equation:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8 f C_{OUT}} \right) \quad \text{(Eq. 2)}$$

Cheaper and smaller ceramic capacitors with higher capacitance values are now commercially available. These ceramic capacitors have low ripple currents, high voltage ratings and low ESR which make them suitable for switching regulator applications. It is feasible to optimize very low output ripples by C_{OUT} since C_{OUT} does not affect the internal control loop stability. X5R or X7R types are recommended since they have the best temperature and voltage characteristics of all ceramics capacitors.

Output Voltage

In the adjustable version, the output voltage can be determined by:

$$V_{OUT} = 0.77V \left(1 + \frac{R_1}{R_2} \right) \quad \text{(Eq. 3)}$$

Thermal Considerations

Although the thermal shutdown circuit is designed in VPE2510 to protect the device from thermal damage, the total power dissipation that VPE2510 can sustain depends on the thermal capability of the package. The formula to ensure the safe operation is shown in note 1 on page 3.

To avoid the VPE2510 from exceeding the maximum junction temperature, the user should perform some thermal analysis during PCB design.

Guidelines for PCB Layout

To ensure proper operation of the VPE2510, please note the following PCB layout guidelines:

1. The GND, SW and the VIN trace should be kept short, direct and wide.

2. VFB pin must be connected directly to the feedback resistors. Resistive divider R1/R2 must be connected parallel to the output capacitor C_{OUT}.

3. The Input capacitor C_{IN} must be connected to the pin VIN as close as possible.

4. Keep SW node away from the sensitive VFB node since this node has high frequency and voltage swing.

5. Keep the (-) plates of C_{IN} and C_{OUT} as close as possible.

Applications

Typical schematic for PCB layout

PCB Layout hints: The R1, R2 and C5 should as close to FB pin as possible to avoid noise coupling.

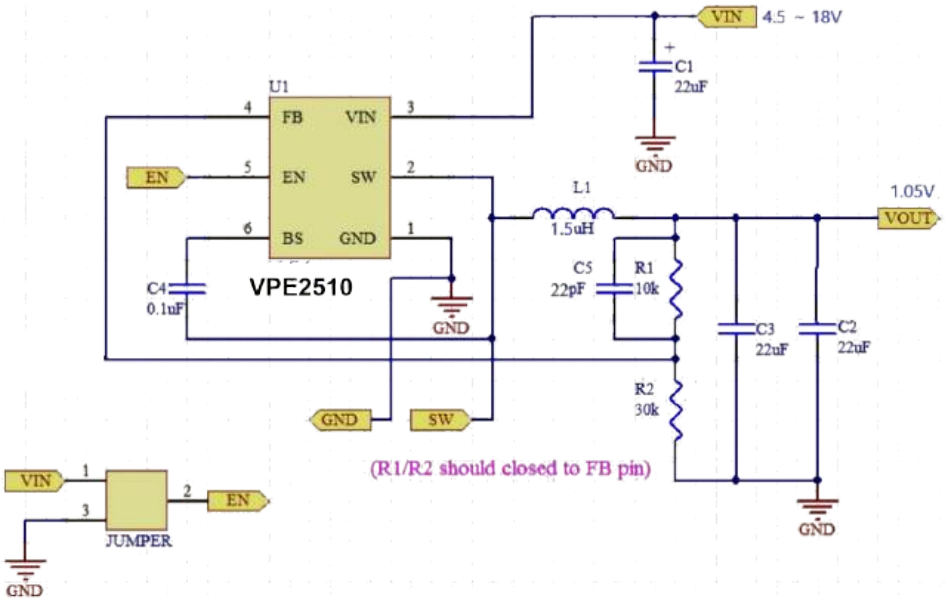
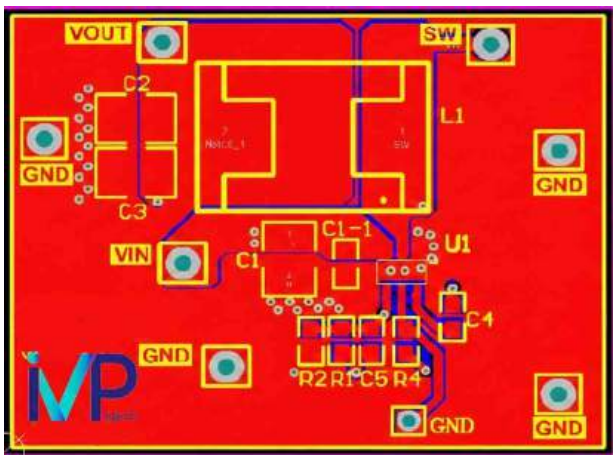


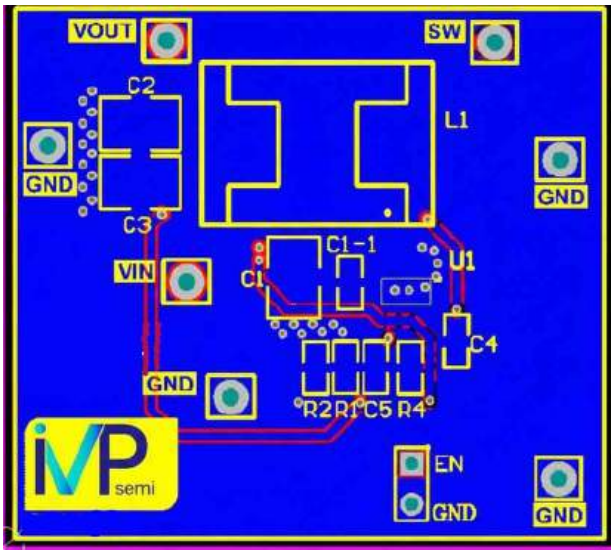
Table 1. Suggested Component Values (VIN=12V)

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	L (μH)	C_{OUT} (μF)	C_{FF} (pF)
1.05	10	30	1.5	22*2	22
1.2	15	30	2.2	22*2	22
1.8	39	30	3.3	22*2	22
2.5	68	30	3.3	22*2	22
3.3	20	6.2	3.3	22*2	22
5	30	5.6	4.7	22*2	22

Typical schematic for PCB layout (cont.)

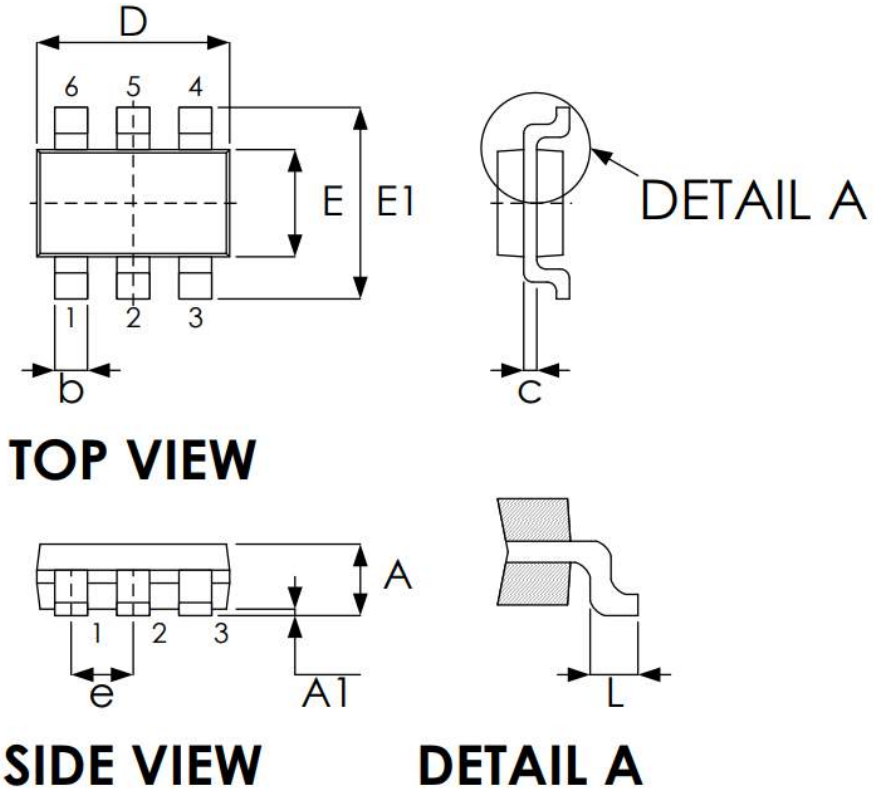


Top Layer



Bottom Layer

Package Outline Drawing



TSOT-23-6

Symbol	Dimension in mm	
	Min.	Max.
A	0.70	1.10
A1	0.00	0.15
b	0.30	0.50
c	0.08	0.25
D	2.70	3.10
E	1.40	1.80
E1	2.60	3.00
e	0.95 BSC	
L	0.30	0.60

All dimensions are in millimeters.

Disclaimer

The information provided in this datasheet is believed to be accurate and reliable. Errors or omissions are expected. indiaVP Semiconductor Pvt. Ltd. reserves the right to make changes to the product specifications without prior notice. Users should verify the suitability of the product for their specific applications. Please visit our website for the latest datasheet.

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