3A, 18V, 700kHz ACOT™ Synchronous Step-Down Converter

General Description

The RT7266 is an adaptive on-time ACOT™ mode synchronous buck converter. The adaptive on-time ACOT™ mode control provides a very fast transient response with few external components. The low impedance internal MOSFET can support high efficiency operation with wide input voltage range from 4.5V to 18V . The proprietary circuit of the RT7266 enables to support all ceramic capacitors. The output voltage can be adjustable between 0.8V and 8V. The soft-start is adjustable by an external capacitor.

Ordering Information

RT7266□□

- Package Type
  SP : SOP-8 (Exposed Pad-Option 2)
- Lead Plating System
  Z : ECO (Ecological Element with Halogen Free and Pb free)

Note :

Richtek products are :

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Marking Information

RT7266 ZSPYMDNN •	RT7266ZSP : Product Number YMDNN : Date Code

Features

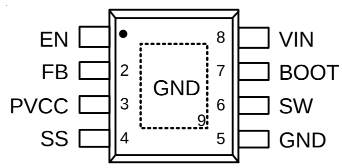
- **ACOT™ Mode Enables Fast Transient Response**
- **4.5V to 18V Input Voltage Range**
- **3A Output Current**
- **60mΩ Internal Low Site N-MOSFET**
- **Adaptive On-Time Control**
- **Fast Transient Response**
- **Support All Ceramic Capacitors**
- **Up to 95% Efficiency**
- **700kHz Switching Frequency**
- **Adjustable Output Voltage from 0.8V to 8V**
- **Adjustable Soft-Start**
- **Cycle-by-Cycle Current Limit**
- **Input Under Voltage Lockout**
- **Thermal Shutdown Protection**
- **RoHS Compliant and Halogen Free**

Applications

- Industrial and Commercial Low Power Systems
- Computer Peripherals
- LCD Monitors and TVs
- Green Electronics/Appliances
- Point of Load Regulation for High-Performance DSPs, FPGAs, and ASICs

Pin Configurations

(TOP VIEW)



SOP-8 (Exposed Pad)

Typical Application Circuit

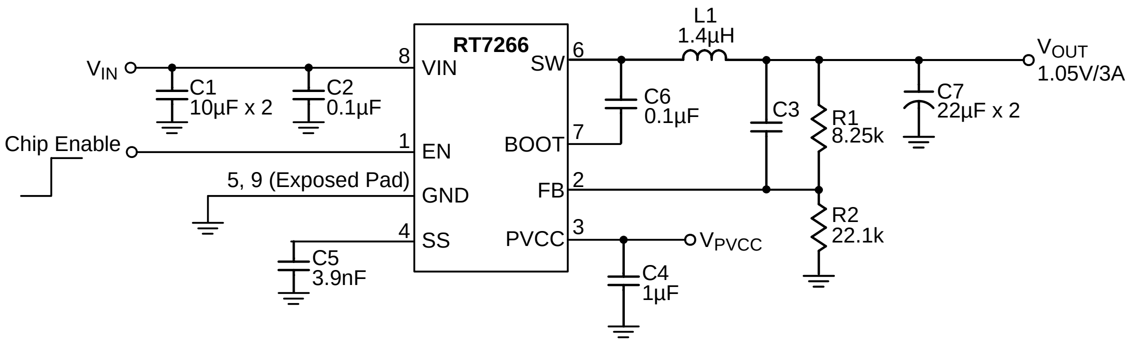


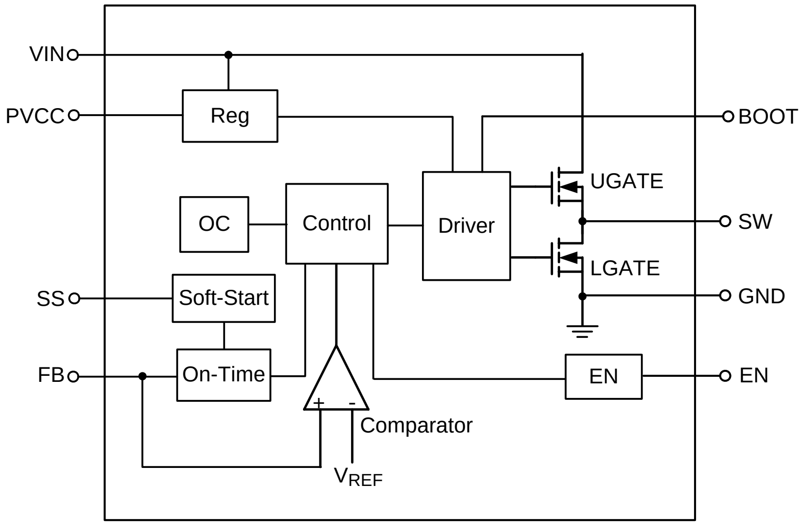
Table 1. Suggested Component Values

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	C3 (pF)	L1 (µH)	C7 (µF)
1	6.81	22.1	--	1.4	22 to 68
1.05	8.25	22.1	--	1.4	22 to 68
1.2	12.7	22.1	--	1.4	22 to 68
1.8	30.1	22.1	5 to 22	2	22 to 68
2.5	49.9	22.1	5 to 22	2	22 to 68
3.3	73.2	22.1	5 to 22	2	22 to 68
5	124	22.1	5 to 22	3.3	22 to 68
7	180	22.1	5 to 22	3.3	22 to 68

Functional Pin Description

Pin No.	Pin Name	Pin Function
1	EN	Enable Input. A logic-high enables the converter; a logic-low forces the RT7266 into shutdown mode reducing the supply current to less than 10µA. Attach this pin to VIN with a 100kΩ pull up resistor for automatic start-up.
2	FB	Feedback Input. It is used to regulate the output of the converter to a set value via an external resistive voltage divider. The feedback reference voltage is 0.765V typically.
3	PVCC	Internal Regulator Output. Connect a 1µF capacitor to GND to stabilize output voltage.
4	SS	Soft-Start Control Input. SS controls the soft-start period. Connect a capacitor from SS to GND to set the soft-start period. A 3.9nF capacitor sets the soft-start period to 1.5ms.
5, 9 (Exposed pad)	GND	Ground. The Exposed pad should be soldered to a large PCB and connected to GND for maximum thermal dissipation.
6	SW	Switch Node. Connect this pin to an external L-C filter.
7	BOOT	Bootstrap for High Side Gate Driver. Connect a 0.1µF or greater ceramic capacitor from BOOT to SW pins.
8	VIN	Supply Input. The input voltage range is from 4.5V to 18V. Must bypass with a suitable large (≥10µF x 2) ceramic capacitor.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Voltage, VIN ---------- –0.3V to 20V
- Switch Voltage, SW ---------- –0.8V to (V_{IN} + 0.3V)
  < 10ns ---------- –5V to 25V
- BOOT to SW ---------- –0.3V to 6V
- All Other Pins ---------- –0.3V to 6V
- Power Dissipation, P_D @ T_A = 25°C
  SOP-8 (Exposed Pad) ---------- 1.333W
- Package Thermal Resistance (Note 2)
  SOP-8 (Exposed Pad), θ_{JA} ---------- 75°C/W
  SOP-8 (Exposed Pad), θ_{JC} ---------- 15°C/W
- Junction Temperature Range ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C

Recommended Operating Conditions (Note 3)

- Supply Voltage, VIN ---------- 4.5V to 18V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

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

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Current							
Shutdown Current		I_{SHDN}	V_{EN} = 0V	--	1	10	μA
Quiescent Current		I_Q	V_{EN} = 3V, V_{FB} = 1V	--	0.7	--	mA
Logic Threshold							
EN Voltage	Logic-High			2	--	5.5	V
	Logic-Low			--	--	0.4	
V_{REF} Voltage and Discharge Resistance							
Feedback Reference Voltage		V_{REF}	4.5V ≤ V_{IN} ≤ 18V	0.753	0.765	0.777	V
Feedback Input Current		I_{FB}	V_{FB} = 0.8V	–0.1	0	0.1	μA
V_{PVCC} Output							
V_{PVCC} Output Voltage		V_{PVCC}	6V ≤ V_{IN} ≤ 18V, 0 < I_{PVCC} < 5mA	4.7	5.1	5.5	V
Line Regulation			6V ≤ V_{IN} ≤ 18V, I_{PVCC} = 5mA	--	--	20	mV
Load Regulation			0 < I_{PVCC} < 5mA	--	--	60	mV
Output Current		I_{PVCC}	V_{IN} = 6V, V_{PVCC} = 4V	--	110	--	mA
$R_{DS(ON)}$							
Switch On Resistance	High Side	$R_{DS(ON)\_H}$		--	90	--	mΩ
	Low Side	$R_{DS(ON)\_L}$		--	60	--	
Current Limit							
Current limit		I_{LIM}		3.5	4.1	5.7	A

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Thermal Shutdown						
Thermal Shutdown Threshold	T_{SD}		--	150	--	°C
Thermal Shutdown Hysteresis	ΔT_{SD}		--	20	--	°C
On-Time Timer Control						
On-Time	t_{ON}	V_{IN} = 12V, V_{OUT} = 1.05V	--	145	--	ns
Minimum On-Time	$t_{ON(MIN)}$		--	60	--	ns
Minimum Off-Time	$t_{OFF(MIN)}$		--	230	--	ns
Soft-Start						
SS Charge Current		V_{SS} = 0V	1.4	2	2.6	μA
SS Discharge Current		V_{SS} = 0.5V	0.05	0.1	--	mA
UVLO						
UVLO Threshold		VIN Rising to Wake up V_{PVCC}	3.55	3.85	4.15	V
Hysteresis			--	0.3	--	V

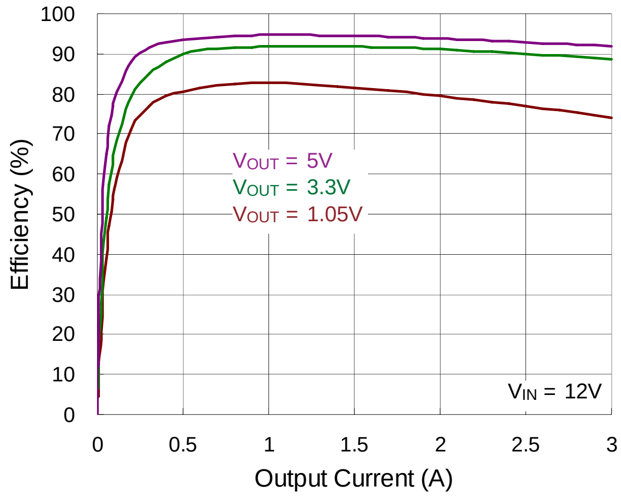
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

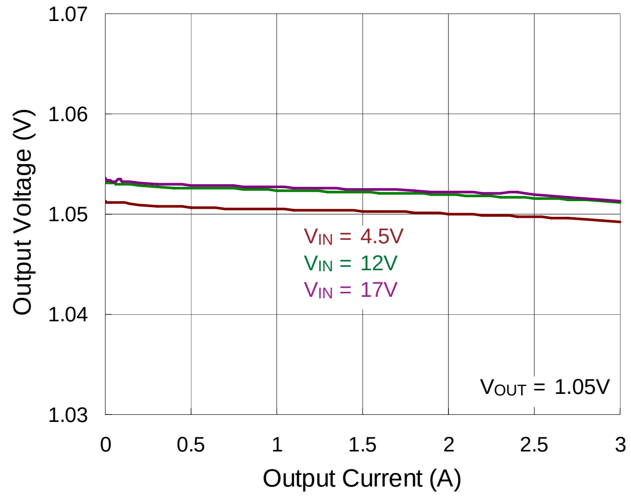
Note 3. The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

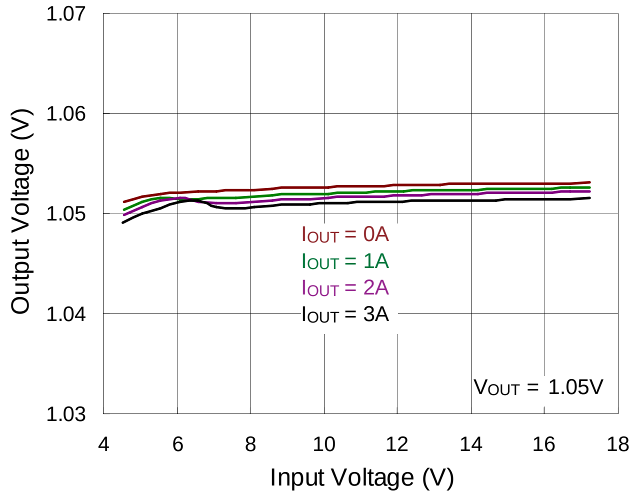
Efficiency vs. Output Current



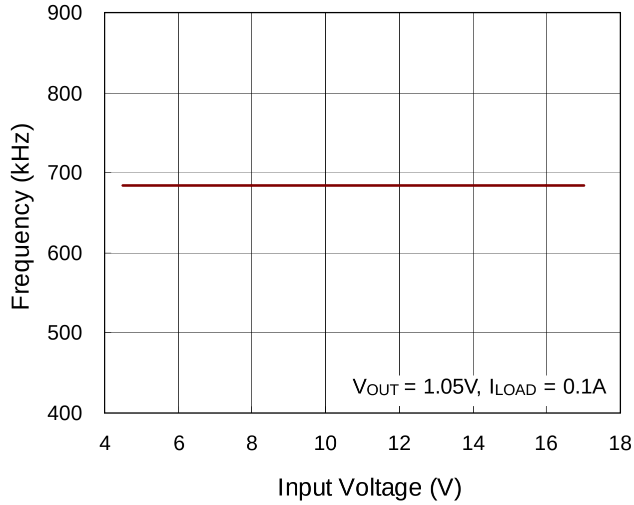
Output Voltage vs. Output Current



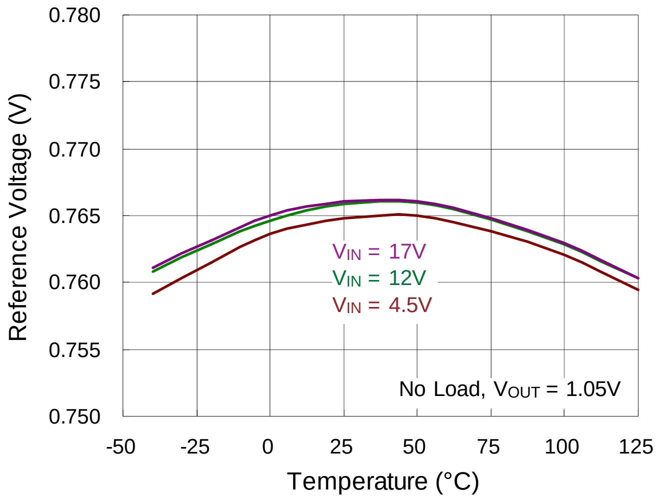
Output Voltage vs. Input Voltage



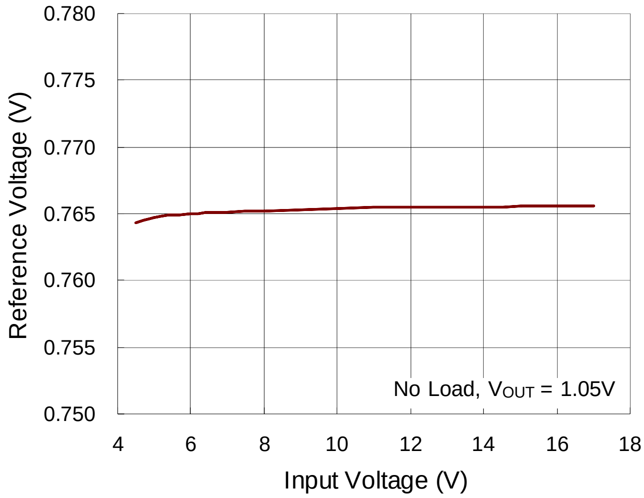
Frequency vs. Input Voltage



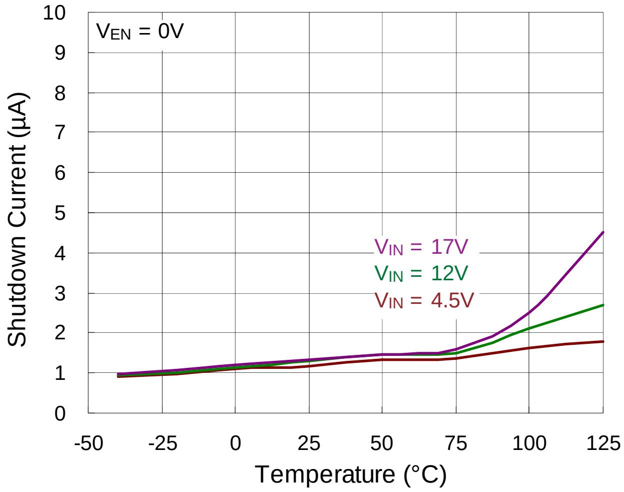
Reference Voltage vs. Temperature



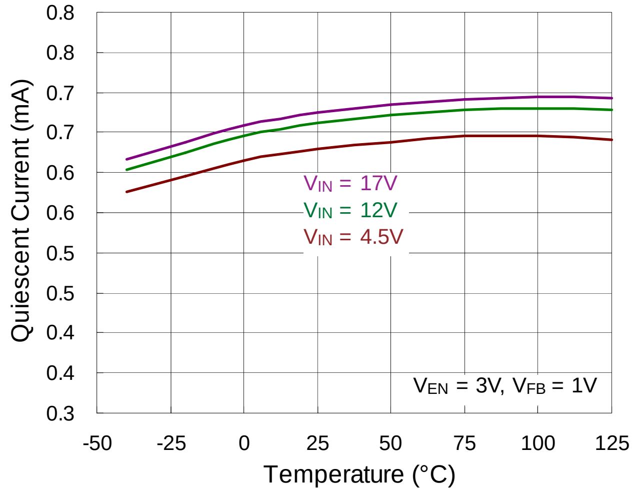
Reference Voltage vs. Input Voltage



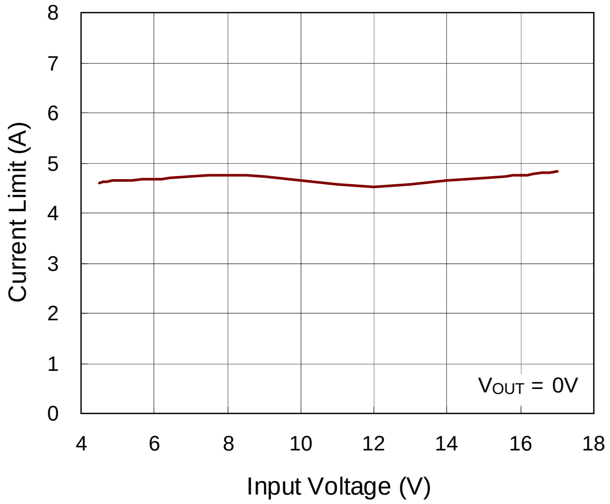
Shutdown Current vs. Temperature



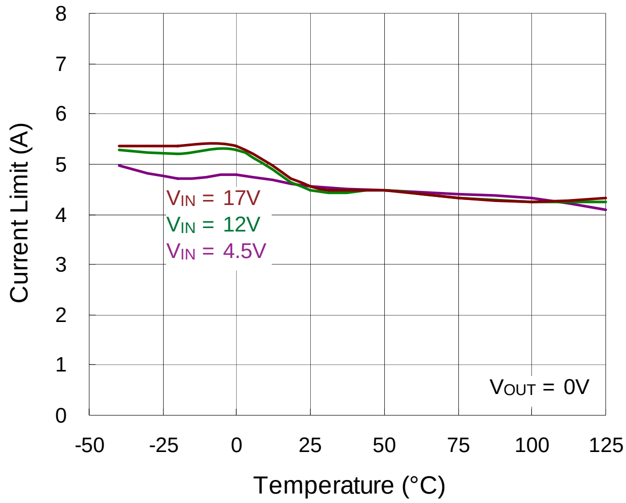
Quiescent Current vs. Temperature



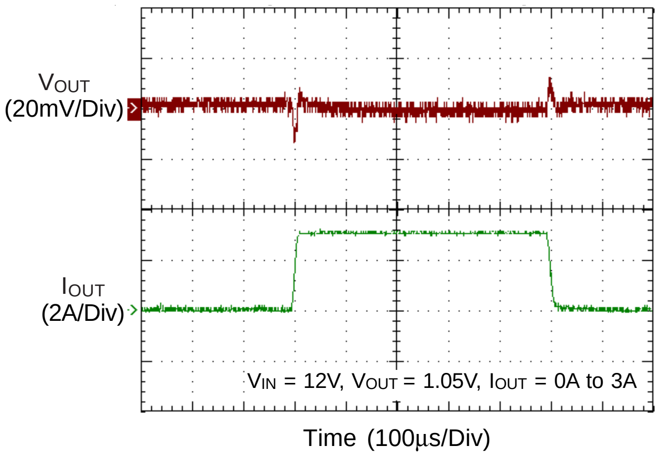
Current Limit vs. Input Voltage



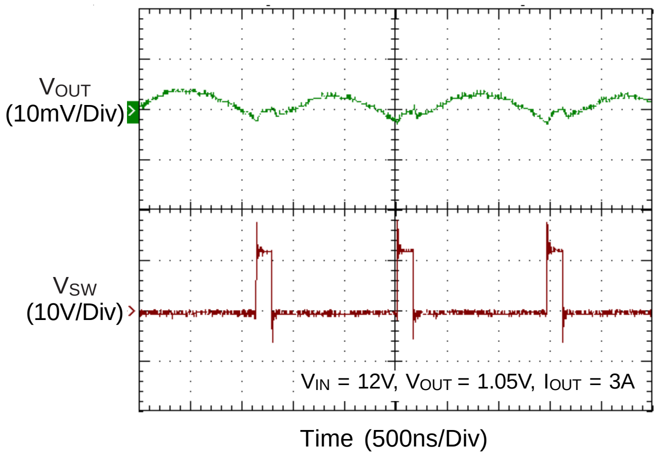
Current Limit vs. Temperature



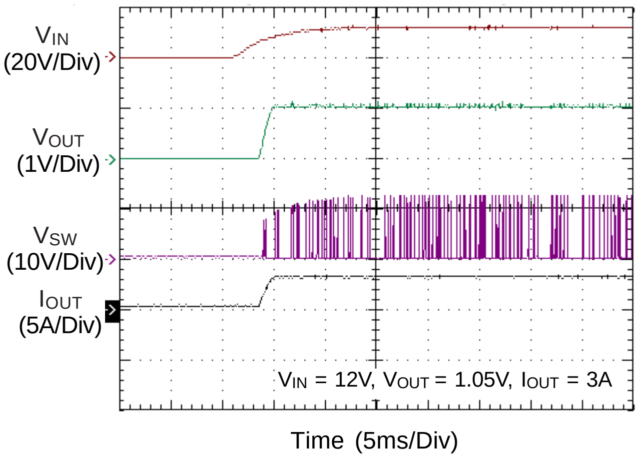
Load Transient Response



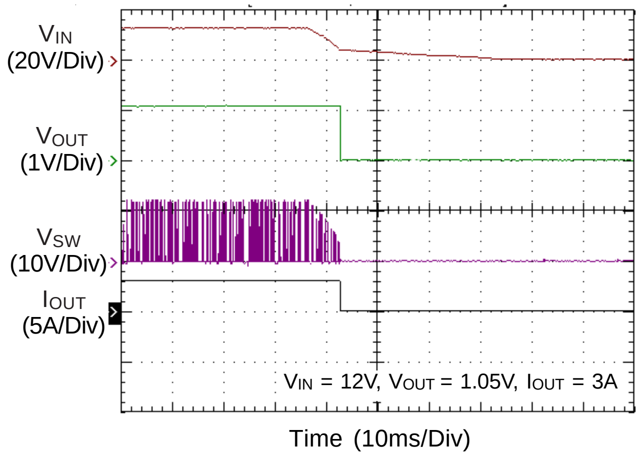
Output Voltage Ripple



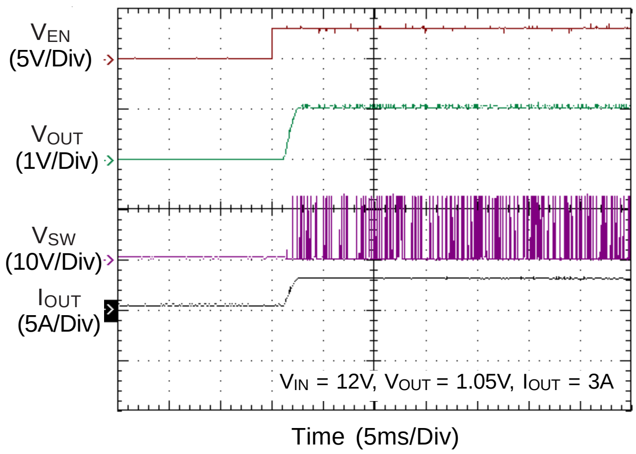
Power On from V_{IN}



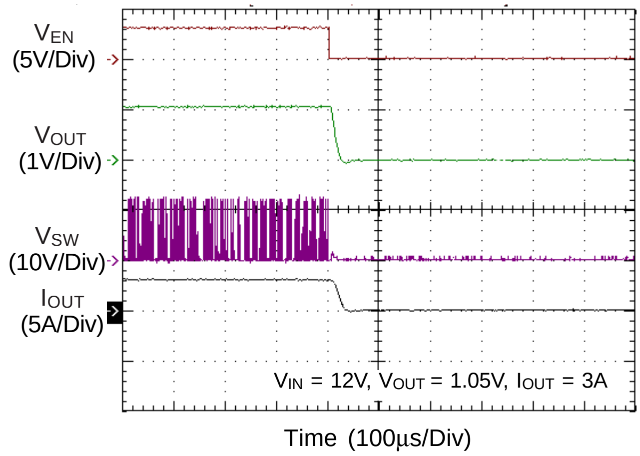
Power Off from V_{IN}



Power On from V_{EN}



Power Off from V_{EN}



Application Information

The RT7266 is a synchronous high voltage buck converter that can support the input voltage range from 4.5V to 18V and the output current can be up to 3A. It operates using adaptive on-time ACOT[TM] mode control and provides a very fast transient response with few external compensation components. The RT7266 allows low external component count configuration with both low ESR and ceramic output capacitors.

PWM Operation

It is suitable for low external component count configuration with appropriate amount of Equivalent Series Resistance (ESR) capacitor(s) at the output. The output ripple valley voltage is monitored at a feedback point voltage. The synchronous high side MOSFET is turned on at the beginning of each cycle. After the internal one shot timer expires, the MOSFET is turned off. The pulse width of this one shot is determined by the converter's input and output voltages to keep the frequency fairly constant over the entire input voltage range.

Adaptive On-Time Control

The RT7266 has a unique circuit to ensure the switching frequency on 700kHz over full input voltage range and full loading range. This circuit sets the on-time one-shot timer by monitoring the input voltage and SW signal. The switching frequency will keep constant if the duty ratio is V_{OUT}/V_{IN}.

Duty Ratio = $V_{OUT}/V_{IN} = t_{ON} / T$

For Fixed T, Ton is proportional to V_{OUT}/V_{IN}.

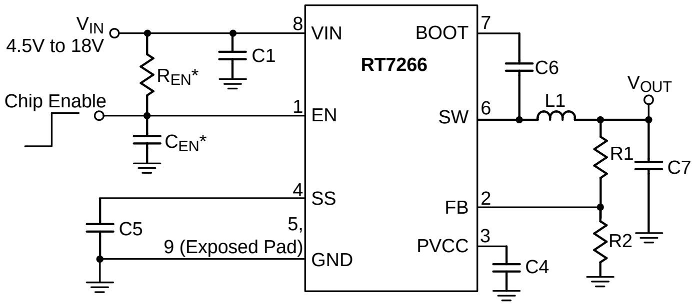
Soft-Start

The RT7266 contains an external soft-start clamp that gradually raises the output voltage. The soft-start timing can be programmed by the external capacitor between SS pin and GND. The chip provides a 2μA charge current for the external capacitor. If a 3.9nF capacitor is used, the soft-start will be 2ms (typ.). The available capacitance range is from 2.7nF to 220nF.

$$t_{SS}\ (ms) = \frac{C5\ (nF) \times 1.065}{I_{SS}\ (\mu A)}$$

Chip Enable Operation

The EN pin is the chip enable input. Pulling the EN pin low (<0.4V) will shutdown the device. During shutdown mode, the RT7266 quiescent current drops to lower than 10μA. Driving the EN pin high (>2V, <5.5V) will turn on the device again. For external timing control, the EN pin can also be externally pulled high by adding a R_{EN}* resistor and C_{EN}* capacitor from the VIN pin (see Figure 1).



* : Optional

Figure 1. External Timing Control

An external MOSFET can be added to implement digital control on the EN pin when no system voltage above 2V is available, as shown in Figure 2. In this case, a 100kΩ pull-up resistor, R_{EN}, is connected between V_{IN} and the EN pin. MOSFET Q1 will be under logic control to pull down the EN pin.

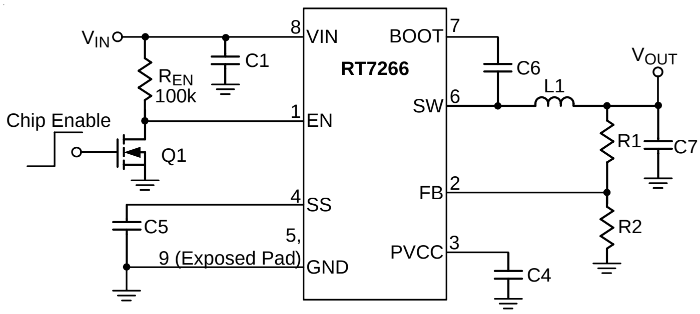


Figure 2. Logic Control with Low Voltage

To prevent enabling circuit when V_{IN} is smaller than the V_{OUT} target value, a resistive voltage divider can be placed between the input voltage and ground and connected to the EN pin to adjust IC lockout threshold, as shown in Figure 3. For example, if an 8V output voltage is regulated from a 12V input voltage, the resistor R_{EN2} can be selected to set input lockout threshold larger than 8V.

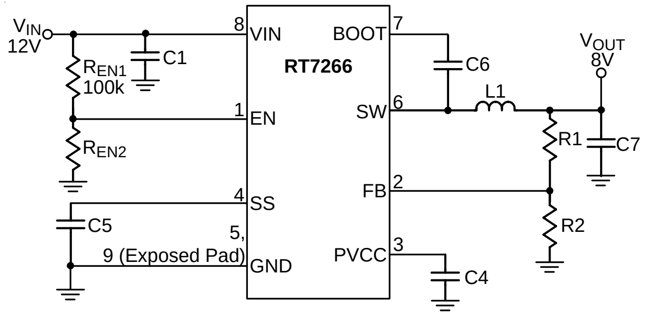


Figure 3. The Resistors can be Selected to Set IC Lockout Threshold

Output Voltage Setting

The resistive divider allows the FB pin to sense the output voltage as shown in Figure 4.

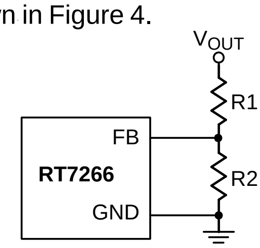


Figure 4. Output Voltage Setting

The output voltage is set by an external resistive divider according to the following equation. It is recommended to use 1% tolerance or better divider resistors.

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

Where V_{FB} is the feedback reference voltage (0.765V typ.).

Under Voltage Lockout Protection

The RT7266 has Under Voltage Lockout Protection (UVLO) that monitors the voltage of PVCC pin. When the V_{PVCC} voltage is lower than UVLO threshold voltage, the RT7266 will be turned off in this state. This is non-latch protection.

Over Temperature Protection

The RT7266 equips an Over Temperature Protection (OTP) circuitry to prevent overheating due to excessive power dissipation. The OTP will shut down switching operation when junction temperature exceeds 150°C. Once the junction temperature cools down by approximately 20°C the main converter will resume operation. To maintain continuous operation maximum, the junction temperature should be prevented from rising above 150°C.

Inductor Selection

The inductor value and operating frequency determine the ripple current according to a specific input and an output voltage. The ripple current ΔI_L increases with higher V_{IN} and decreases with higher inductance.

$$\Delta I_L = \left[\frac{V_{OUT}}{f \times L}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right]$$

Having a lower ripple current reduces not only the ESR losses in the output capacitors but also the output voltage ripple. High frequency with small ripple current can achieve highest efficiency operation. However, it requires a large inductor to achieve this goal. For the ripple current selection, the value of $\Delta I_L = 0.2(I_{MAX})$ will be a reasonable starting point. The largest ripple current occurs at the highest V_{IN}. To guarantee that the ripple current stays below the specified maximum, the inductor value should be chosen according to the following equation :

$$L = \left[\frac{V_{OUT}}{f \times \Delta I_{L(MAX)}}\right] \times \left[1 - \frac{V_{OUT}}{V_{IN(MAX)}}\right]$$

C_{IN} and C_{OUT} Selection

The input capacitance, C_{IN}, is needed to filter the trapezoidal current at the source of the high side MOSFET. To prevent large ripple current, a low ESR input capacitor sized for the maximum RMS current should be used. The RMS current is given by :

$$I_{RMS} = I_{OUT(MAX)} \frac{V_{OUT}}{V_{IN}} \sqrt{\frac{V_{IN}}{V_{OUT}} - 1}$$

This formula has a maximum at $V_{IN} = 2V_{OUT}$, where $I_{RMS} = I_{OUT}/2$. This simple worst-case condition is commonly used for design because even significant deviations do not offer much relief.

Choose a capacitor rated at a higher temperature than required. Several capacitors may also be paralleled to meet size or height requirements in the design. For the input capacitor, two 10µF and 0.1µF low ESR ceramic capacitors are recommended.

The selection of C_{OUT} is determined by the required ESR to minimize voltage ripple.

Moreover, the amount of bulk capacitance is also a key for C_{OUT} selection to ensure that the control loop is stable. The output ripple, ΔV_{OUT} , is determined by :

$$\Delta V_{OUT} \leq \Delta I_L \left[ESR + \frac{1}{8fC_{OUT}} \right]$$

The output ripple will be highest at the maximum input voltage since ΔI_L increases with input voltage. Multiple capacitors placed in parallel may be needed to meet the ESR and RMS current handling requirements.

Higher values, lower cost ceramic capacitors are now becoming available in smaller case sizes. Their high ripple current, high voltage rating and low ESR make them ideal for switching regulator applications. However, care must be taken when these capacitors are used at input and output. When a ceramic capacitor is used at the input and the power is supplied by a wall adapter through long wires, a load step at the output can induce ringing at the input, V_{IN}. At best, this ringing can couple to the output and be mistaken as loop instability. At worst, a sudden inrush of current through the long wires can potentially cause a voltage spike at V_{IN} large enough to damage the part.

External Bootstrap Diode

Connect a 0.1µF low ESR ceramic capacitor between the BOOT and SW pins. This capacitor provides the gate driver voltage for the high side MOSFET. It is recommended to add an external bootstrap diode between an external 5V and the BOOT pin for efficiency improvement when input voltage is lower than 5.5V or duty ratio is higher than 65%. The bootstrap diode can be a low cost one such as 1N4148 or BAT54. The external 5V can be a 5V fixed input from system or a 5V output of the RT7266. Note that the external boot voltage must be lower than 5.5V

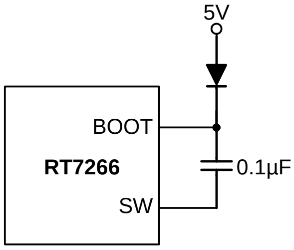


Figure 5. External Bootstrap Diode

PVCC Capacitor Selection

Decouple with a 1µF ceramic capacitor. X7R or X5R grade dielectric ceramic capacitors are recommended for their stable temperature characteristics.

Over Current Protection

When the output shorts to ground, the inductor current decays very slowly during a single switching cycle. A over current detector is used to monitor inductor current to prevent current runaway. The over current detector monitors the voltage between SW and GND during the low-side MOS turn-on state. This is cycle-by-cycle protection. The over current detector also supports temperature compensated.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For SOP-8 (Exposed Pad) packages, the thermal resistance, θ_{JA}, is 75°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formulas :

$P_{D(MAX)}$ = (125°C − 25°C) / (75°C/W) = 1.333W for SOP-8 (Exposed Pad) package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curves in Figure 6 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

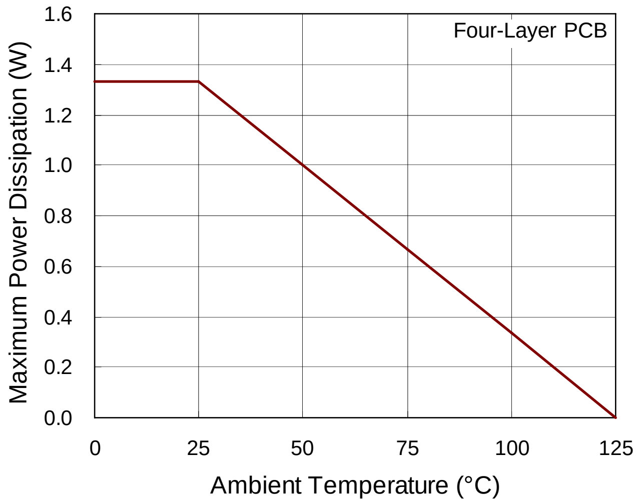


Figure 6. Derating Curve of Maximum Power Dissipation

Layout Consideration

Follow the PCB layout guidelines for optimal performance of the RT7266

- Keep the traces of the main current paths as short and wide as possible.
- Put the input capacitor as close as possible to the device pins (VIN and GND).
- SW node is with high frequency voltage swing and should be kept at small area. Keep sensitive components away from the SW node to prevent stray capacitive noise pickup.
- Connect feedback network behind the output capacitors. Keep the loop area small. Place the feedback components near the RT7266.
- The GND and Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.

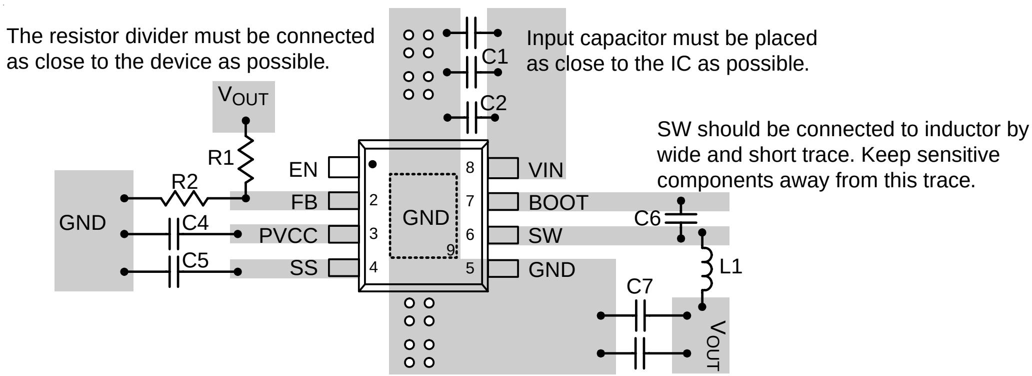
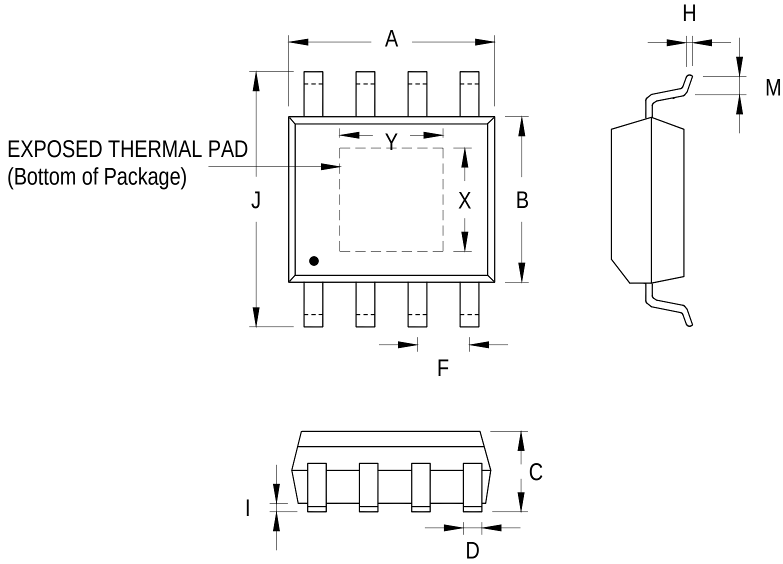


Figure 7. PCB Layout Guide

Outline Dimension



Symbol		Dimensions In Millimeters		Dimensions In Inches	
		Min	Max	Min	Max
A		4.801	5.004	0.189	0.197
B		3.810	4.000	0.150	0.157
C		1.346	1.753	0.053	0.069
D		0.330	0.510	0.013	0.020
F		1.194	1.346	0.047	0.053
H		0.170	0.254	0.007	0.010
I		0.000	0.152	0.000	0.006
J		5.791	6.200	0.228	0.244
M		0.406	1.270	0.016	0.050
Option 1	X	2.000	2.300	0.079	0.091
	Y	2.000	2.300	0.079	0.091
Option 2	X	2.100	2.500	0.083	0.098
	Y	3.000	3.500	0.118	0.138

8-Lead SOP (Exposed Pad) Plastic Package

Richtek Technology Corporation

5F, No. 20, Taiyuen Street, Chupei City

Hsinchu, Taiwan, R.O.C.

Tel: (8863)5526789