RICHTEK

Typical Application Circuit

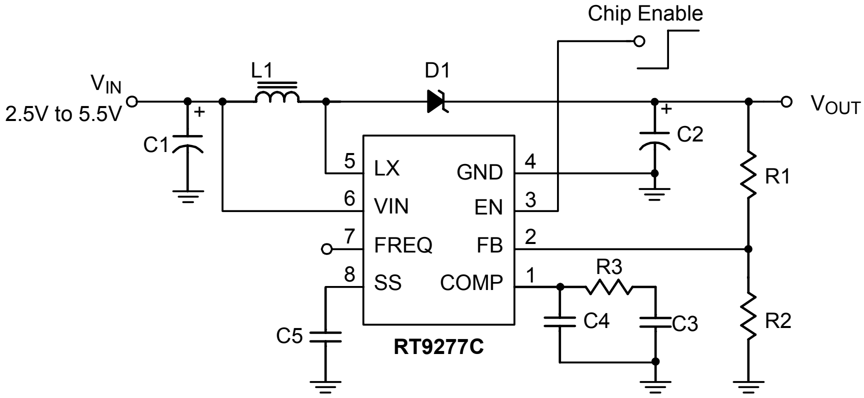


Figure 1

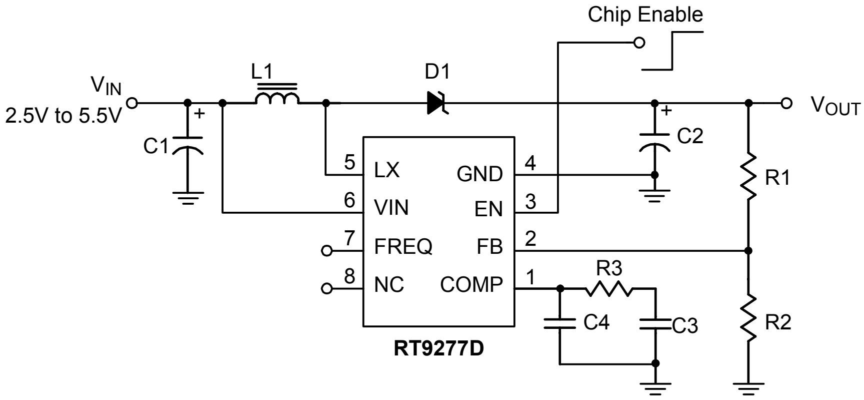
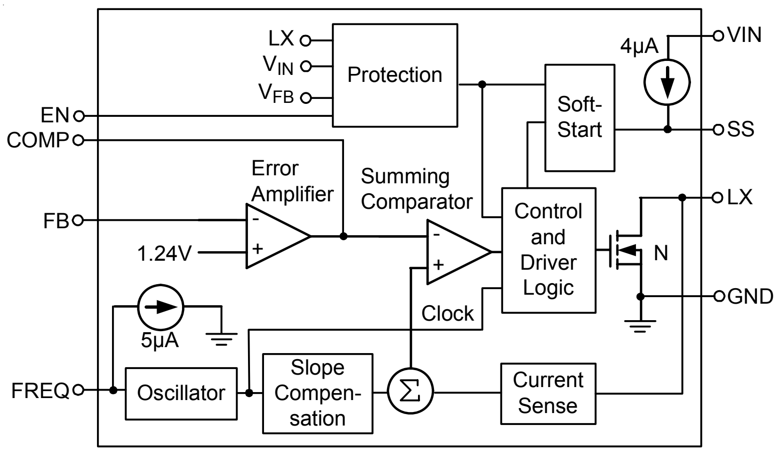


Figure 2

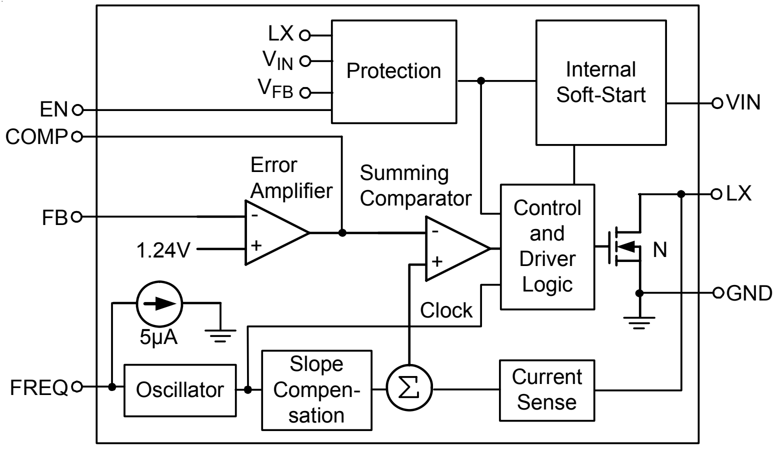
Table 1. Recommended Components

Symbol (unit)	V_{IN} (V)	V_{OUT} (V)	F_{OSC} (Hz)	C1 (μF)	L1 (μH)	C2 (μF)	R3 (kΩ)	C3 (pF)	C4 (pF)
Application 1	3.3	9	1.2M	10	4.7(TDK SLF6028)	33 (ceramic)	82	820	10
Application 2	3.3	12	1.2M	10	4.7(TDK SLF6028)	33 (ceramic)	180	680	22
Application 3	3.3	12	640K	10	10(TDK SLF6028)	33 (ceramic)	120	1200	22

Function Block Diagram



RT9277C



RT9277D

Operation

The RT9277C/D is a high efficiency step-up Boost converter with a fixed-frequency, current-mode PWM architecture. It performs fast transient response and low noise operation with appropriate component selection. The output voltage is regulated through a feedback control consisting of an error amplifier, a summing comparator, and several control signal generators (as shown in function block diagram). The feedback reference voltage is 1.24V. The error amplifier varies the COMP voltage by sensing the FB pin. The slope compensation signal summed with the current -sense signal will be compared with the COMP voltage through the summing comparator to determine the current trip point and duty cycle.

Soft-Start

The RT9277C provides programmable soft-start function. When the EN pin is connected to high, a 4μA constant current is sourced to charge an external capacitor. The voltage rate of rise on the COMP pin is limited during the charging period, and so is the peak inductor current.

When the EN pin is connected to GND, the external capacitor will be discharged to ground for the next time soft-start.

Current Limitation

The switch current is monitored to limit the value not to exceed 1.6A typically. When the switch current reaches 1.6A, the output voltage will be pulled down to limit the total output power to protect the power switch and external components.

Shutdown

Connect the EN to GND to turn the RT9277C/D off and reduce the supply current to 0.1μA. In this operation, the output voltage is the value of V_{IN} to subtract the forward voltage of catch diode.

Frequency Selection

The switching frequency of RT9277C/D can be selected to operate at either 640kHz or 1.2MHz. When the FREQ pin is connected to GND for 640kHz operation, and connected to VIN for 1.2MHz operation. FREQ is preset to 640kHz operation for allowing the FREQ pin unconnected.

Functional Pin Description

Pin No.		Pin Name	Pin Function
RT9277C	RT9277D		
1	1	COMP	Compensation Pin for Error Amplifier. Connect a compensation network to ground. See the Component Selection Table for the loop compensation.
2	2	FB	Feedback Pin. Connect an external resistor-divider tap to FB. The typical reference voltage is 1.24V.
3	3	EN	Shutdown Control Input. Connect EN to GND to turn off the RT9277C/D.
4, 9 (Exposed pad)	4, 9 (Exposed pad)	GND	Ground Pin. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
5	5	LX	Switch Pin. Connect the inductor and catch diode to LX pin. Widen and shorten the connected trace to minimize EMI.
6	6	VIN	Supply Pin. Place at least a 1μF ceramic capacitor close to RT9277C/D for bypassing noise.
7	7	FREQ	Frequency Select Pin. Oscillator frequency is 640kHz as FREQ is connected to GND, and 1.2MHz as FREQ is connected to VIN. A 5μA pull-down current is sinking on this pin.
8	--	SS	Soft-Start Control Pin. Connect a soft-start capacitor (C_{SS}) to this pin. A 4μA constant current charges the soft-start capacitor. When EN is connected to GND, the soft-start capacitor is discharged. When EN is connected to VIN high, the soft-start capacitor is charged to VIN. Leave floating for not using soft-start.
--	8	NC	No Internal Connection.

Absolute Maximum Ratings (Note 1)

- Supply Voltage (V_{IN}) ---------- −0.3 to 6V
- LX to GND ---------- −0.3V to 16V
- The other pins ---------- −0.3V to 6V
- Power Dissipation, P_D @ T_A = 70°C
  MSOP-8 ---------- 625mW
  WDFN-8L 3x3 ---------- 926mW
- Package Thermal Resistance (Note 2)
  MSOP-8, θ_{JA} ---------- 160°C/W
  WDFN-8L 3x3, θ_{JA} ---------- 108°C/W
  WDFN-8L 3x3, θ_{JC} ---------- 7.5W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- −65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 4)

- Junction Temperature Range ---------- −40°C to 125°C
- Ambient Temperature Range ---------- −40°C to 85°C

Electrical Characteristics

(V_{IN} = 3V, FREQ left floating, T_A = 25°C, Unless Otherwise specification)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
System Supply Input						
Operation voltage Range	V_{IN}		2.5	--	5.5	V
Under Voltage Lock Out	UVLO		1.9	2	2.1	V
Power On Reset Hysteresis			–	100	--	mV
Quiescent Current	I_Q	V_{FB} = 1.3V, No switching	–	250	500	μA
		V_{FB} = 1.0V, Switching, No load	–	2	5	mA
Shut Down Current	I_{SHDN}	EN = GND	–	--	1	μA
Soft start Current (RT9277C)	I_{SS}	V_{SS} = 1.2V	1.5	4	7	μA
Switching Regulator Oscillator						
Free Run Frequency	f_{OSC}	FREQ = GND	540	640	740	kHz
		FREQ = V_{IN}	–	1200	--	
Maximum Duty Cycle			82	90	96	%
Reference Voltage						
Feedback Reference Voltage	V_{REF}	V_{COMP} = 1.24V	1.227	1.24	1.253	V

To be continued

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Error Amplifier						
Transconductance	G_m		70	140	240	μΩ
Voltage Gain	A_V		--	700	–	V/V
Feedback Voltage Line Regulation		V_{COMP} = 1.24V, 2.5V < V_{IN} < 5.5V	–	0.05	0.15	%/V
MOSFET						
On Resistance of MOSFET	$R_{DS(ON)}$		--	200	500	mΩ
Current Limitation			1.2	1.6	–	A
Enable Control Input						
Input Low Voltage	V_{IL}	2.5V < V_{IN} < 5.5V	--	–	0.3 x V_{IN}	V
Input High Voltage	V_{IH}	2.5V < V_{IN} < 5.5V	0.7 x V_{IN}	–	–	V
Hysteresis			--	0.1	–	V
Protection Function						
Over Temperature Protection			--	170	–	°C
Hysteresis			--	20	–	°C

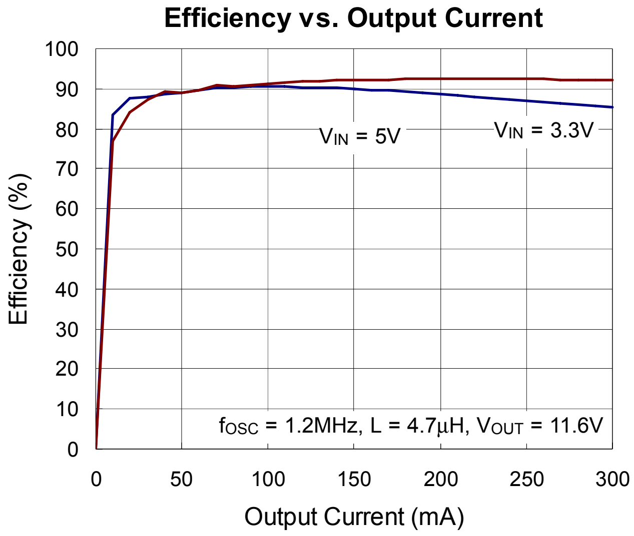
Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

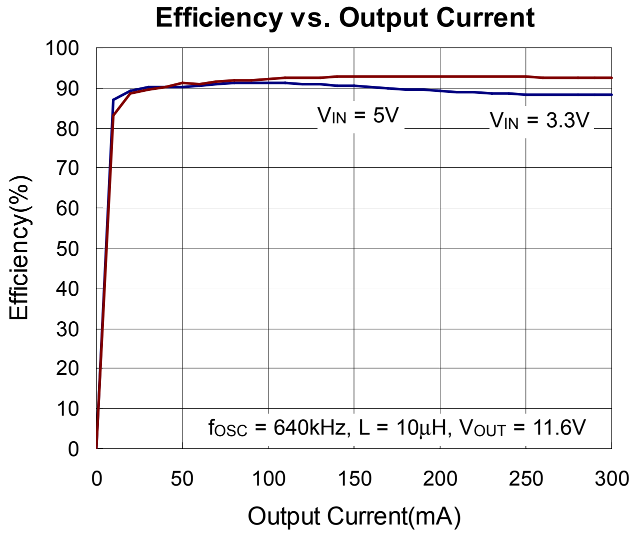
Note 2. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

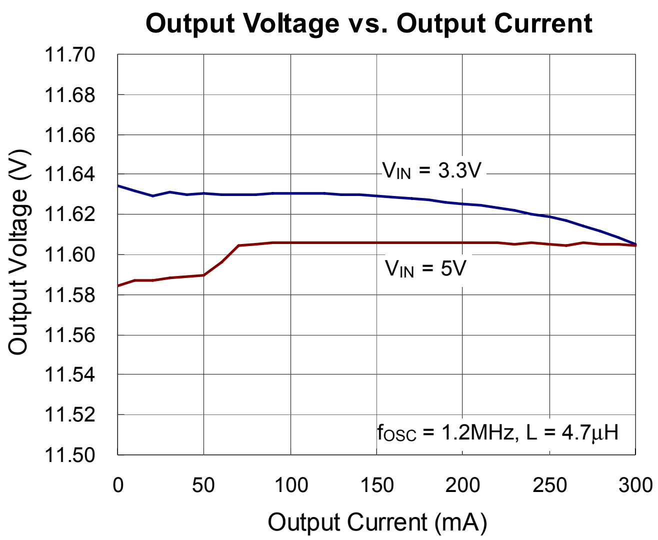
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

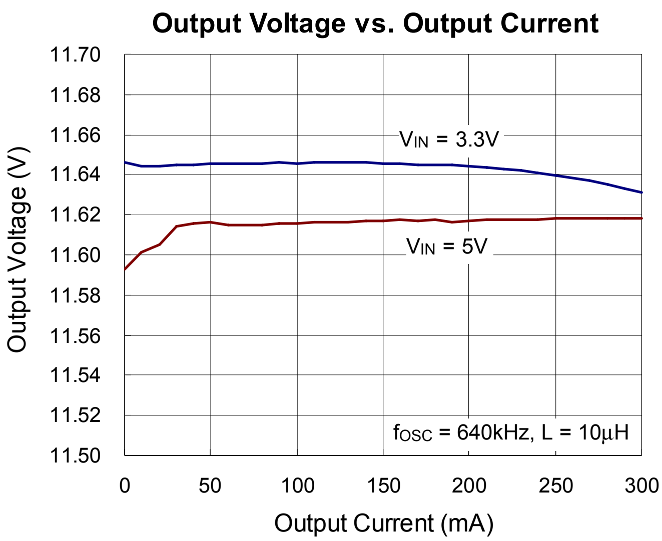
Note 4. The device is not guaranteed to function outside its operating conditions.

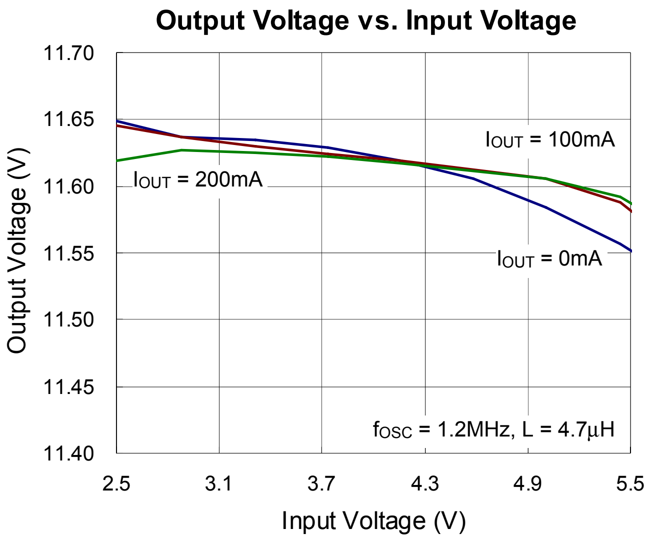
Typical Operating Characteristics

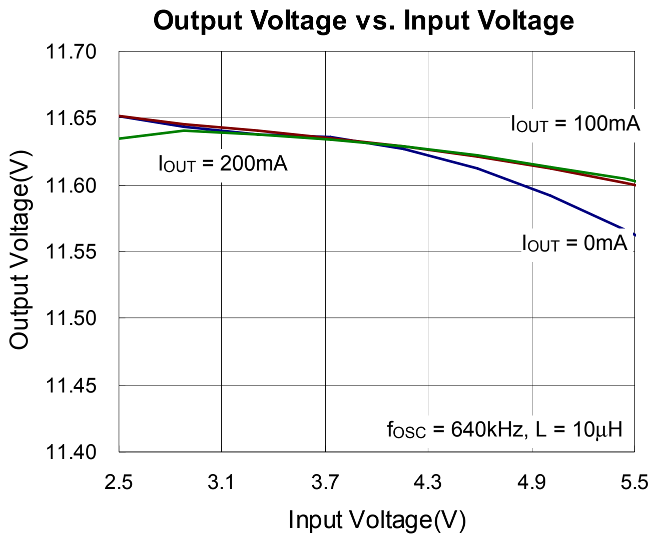




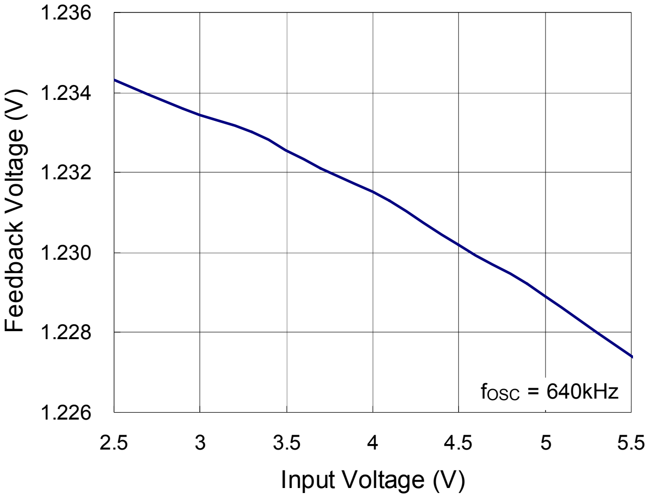




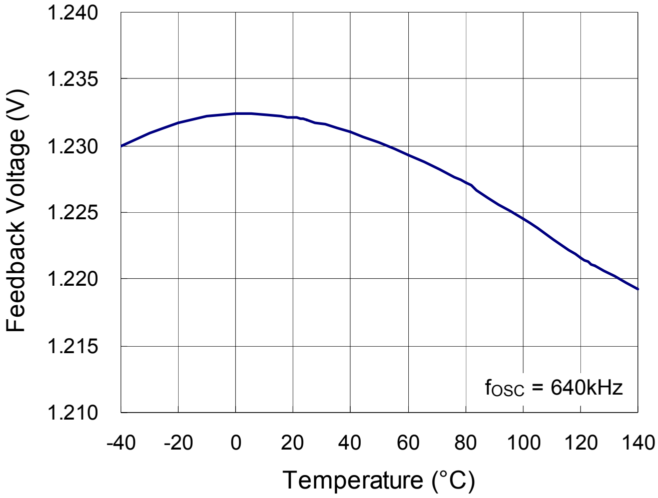




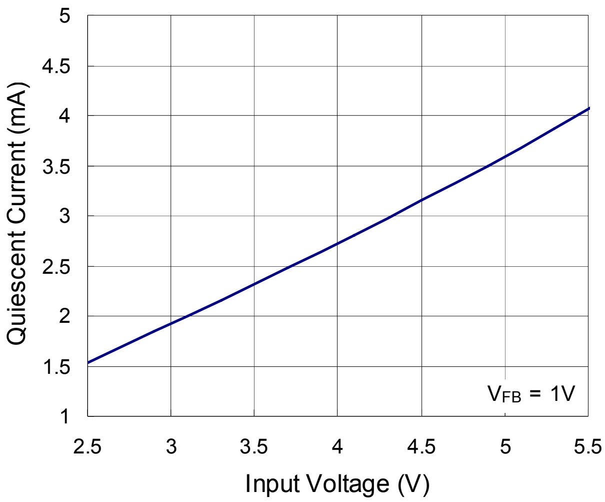
Feedback Voltage vs. Input Voltage



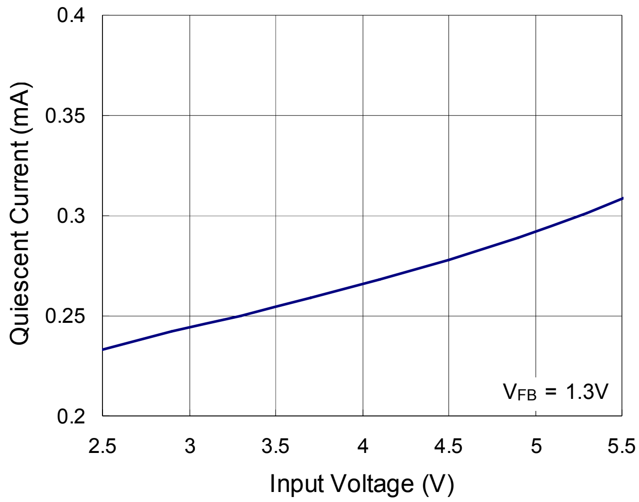
Feedback Voltage vs. Temperature



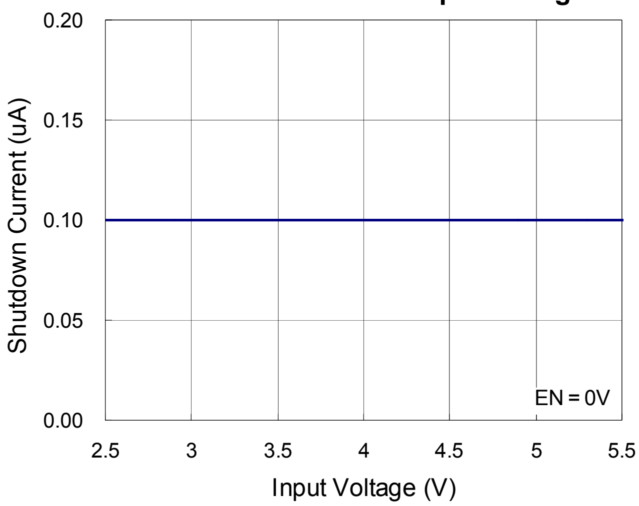
Quiescent Current vs. Input Voltage



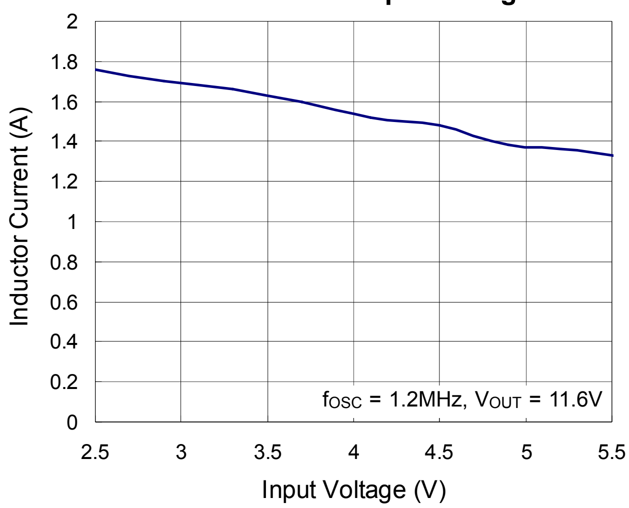
Quiescent Current vs. Input Voltage

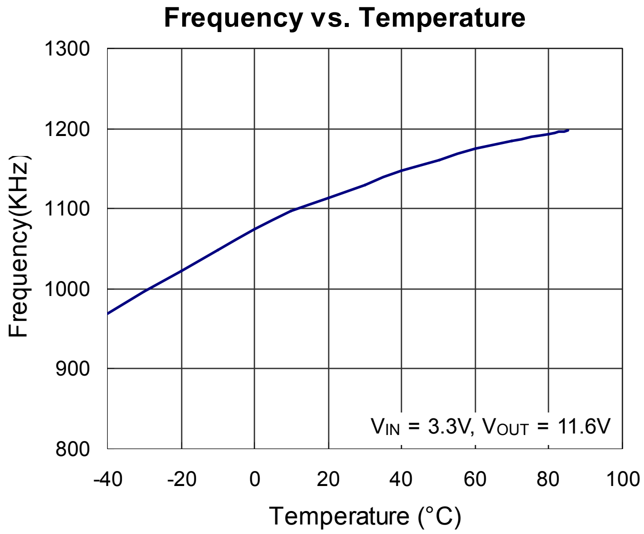


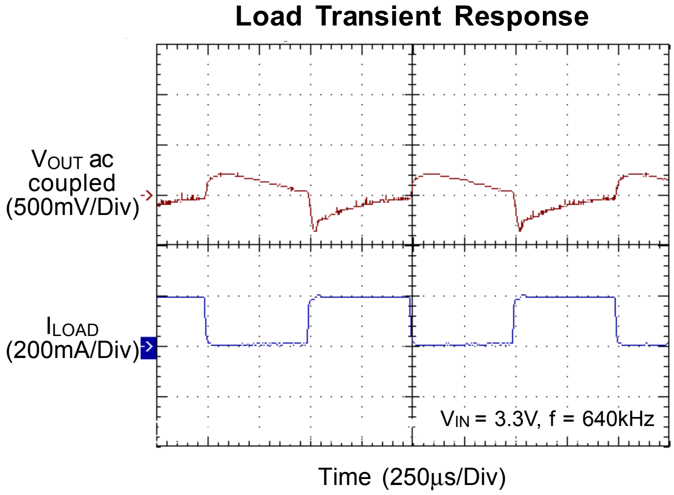
Shutdown Current vs. Input Voltage

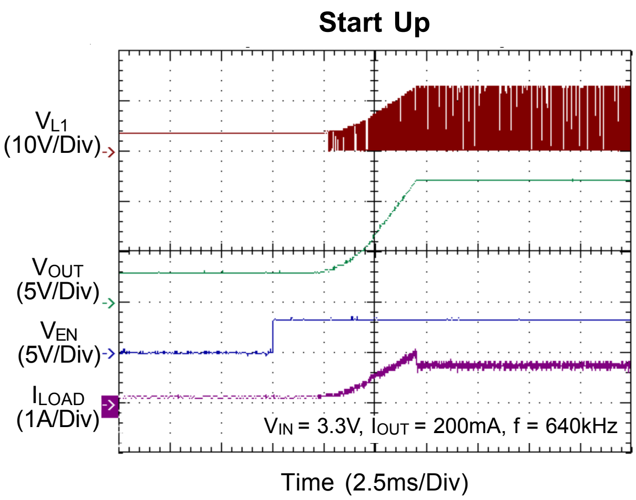


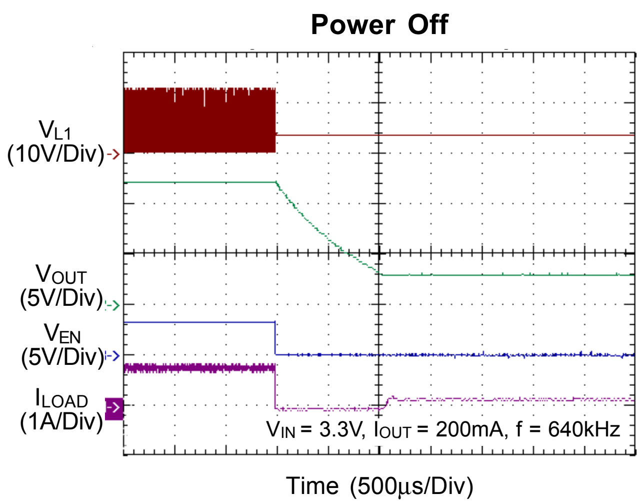
Current Limit vs. Input Voltage

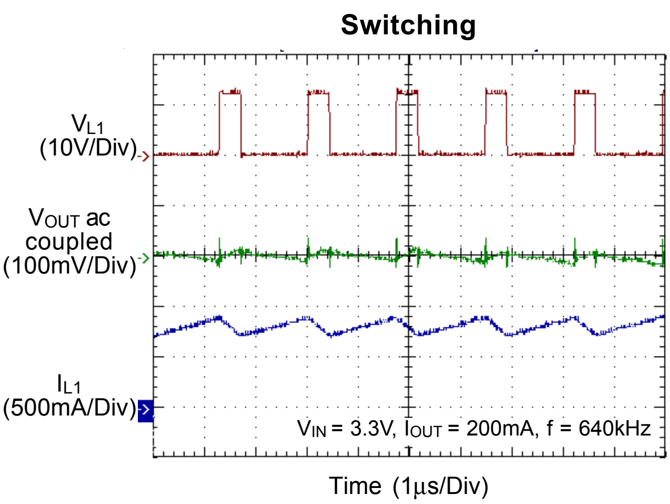


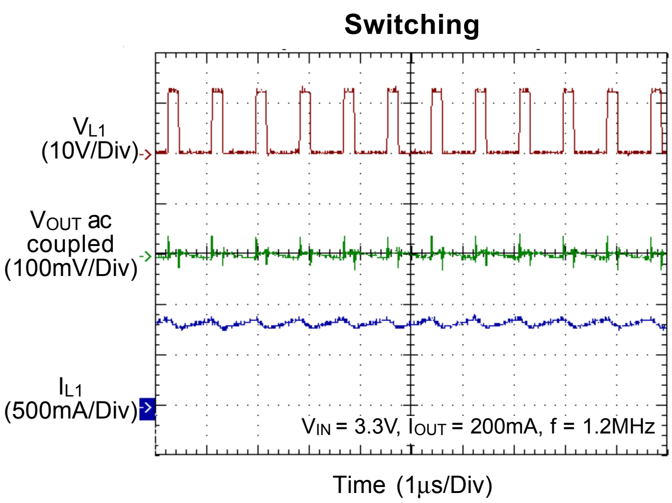

Frequency vs. Temperature
1300
1200
1100
1000
900
800
Frequency(KHz)
VIN = 3.3V, VOUT = 11.6V
-40
-20
0
20
40
60
80
100
Temperature (°C)


Load Transient Response
VOUT ac coupled (500mV/Div)
ILOAD (200mA/Div)
VIN = 3.3V, f = 640kHz
Time (250μs/Div)


Start Up
VL1 (10V/Div)
VOUT (5V/Div)
VEN (5V/Div)
ILOAD (1A/Div)
VIN = 3.3V, IOUT = 200mA, f = 640kHz
Time (2.5ms/Div)


Power Off
VL1 (10V/Div)
VOUT (5V/Div)
VEN (5V/Div)
ILOAD (1A/Div)
VIN = 3.3V, IOUT = 200mA, f = 640kHz
Time (500μs/Div)


Switching
VL1 (10V/Div)
VOUT ac coupled (100mV/Div)
IL1 (500mA/Div)
VIN = 3.3V, IOUT = 200mA, f = 640kHz
Time (1μs/Div)


Switching
VL1 (10V/Div)
VOUT ac coupled (100mV/Div)
IL1 (500mA/Div)
VIN = 3.3V, IOUT = 200mA, f = 1.2MHz
Time (1μs/Div)

Application Information

The IC contains a high performance boost regulator to generate voltage for the panel source driver ICs. The following content contains the detailed description and the information of component selection.

Inductor Selection

For a better efficiency in high switching frequency converter, the inductor selection has to use a proper core material such as ferrite core to reduce the core loss and choose low ESR wire to reduce copper loss. The most important point is to prevent the core saturated when handling the maximum peak current. Using a shielded inductor can minimize radiated noise in sensitive applications. The maximum peak inductor current is the maximum input current plus the half of inductor ripple current. The calculated peak current has to be smaller than the current limitation in the electrical characteristics. A typical setting of the inductor ripple current is 20% to 40% of the maximum input current. If the selection is 40%, the maximum peak inductor current is :

$$I_{PEAK} = I_{IN(MAX)} + \frac{1}{2} I_{RIPPLE} = 1.2 \times I_{IN(MAX)}$$
$$= 1.2 \times \left[\frac{I_{OUT(MAX)} \times V_{OUT}}{\eta \times V_{IN(MIN)}} \right]$$

Where I_{PK} is the maximum peak current of inductor, I_{RIPPLE} is the ripple current of inductor and η is the efficiency of boost converter.

The minimum inductance value is derived from the following equation :

$$L = \frac{\eta \times V_{IN(MIN)}^2 \times \left[V_{OUT} - V_{IN(MIN)}\right]}{0.4 \times I_{OUT(MAX)} \times V_{OUT}^2 \times f_{OSC}}$$

Where f_{OSC} is the switching frequency of boost converter.

Depending on the application, the recommended inductor value is between 2.2µH to 10µH.

Diode Selection

To achieve high efficiency, Schottky diode is a good choice for low forward drop voltage and fast switching time. The output diode rating should be able to handle the maximum output voltage, average power dissipation and the pulsating diode peak current.

Input Capacitor Selection

For better input bypassing, low-ESR ceramic capacitors are recommended for performance. A 10µF input capacitor is sufficient for most applications. For a lower output power requirement application, this value can be decreased.

Output Capacitor Selection

For lower output voltage ripple, low-ESR ceramic capacitors are recommended. The output voltage ripple consists of two components: one is the pulsating output ripple current flows through the ESR, and the other is the capacitive ripple caused by charging and discharging.

$$V_{RIPPLE} = V_{RIPPLE\_ESR} + V_{RIPPLE\_C}$$
$$\cong I_{PEAK} \times ESR_{COUT} + \frac{I_{PEAK}}{C_{OUT}} \left(\frac{V_{OUT} - V_{IN}}{V_{OUT} \times f_{OSC}} \right)$$

Where I_{PEAK} is the ripple current of C_{OUT} and ESR_{COUT} is equivalent series resistance of C_{OUT}.

Output Voltage

The regulated output voltage is calculated by :

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

Where V_{REF} is the feedback referecne voltage and typical value is 1.24V.

For most applications, R2 is a suggested a value up to 100kΩ Place the resistor-divider as close to the IC as possible to reduce the noise sensitivity.

Loop Compensation

The RT9277C/D voltage feedback loop can be compensated with an external compensation network consisted of R3, C3 and C4 (As shown in Figure 1). Choose R3 to set the high-frequency integrator gain for fast transient response without over or under compensation. Once R3 is determined, C3 is selected to set the integrator zero to maintain loop stability. The purpose of C4 is to cancel the zero caused by output capacitor and the capacitor ESR. If the ceramic capacitor is selected to be the output capacitor, C4 can be taken off because of the small ESR. C2 is the output capacitor as shown in Figure 1. The following equations give approximate calculations of each component :

$$R3 = \frac{200 \times V_{OUT}^{2} \times C2}{L1}$$

$$C3 = \frac{0.4 \times 10^{-3} \times L1}{V_{IN}}$$

$$C4 = \frac{0.005 \times R_{ESR} \times L1}{V_{OUT}^{2}}$$

The best criterion to optimize the loop compensation is by inspecting the transient response and adjusting the compensation network.

Soft-Start Capacitor

The soft-start function begins from V_{SS} = 0V to 1.24V with a 4μA constant current charging to the soft-start capacitor, so the capacitor should be large enough for the output voltage to reach regulation inside the soft-start cycle. Typical value of soft-start capacitor range is from 10nF to 200nF.

Layout Consideration

For best performance of the RT9277C/D, the following guidelines must be strictly followed.

- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND and Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as possible as short and wide.
- LX node of DC/DC converter is with high frequency voltage swing. It should be kept at a small area.
- Place the feedback and compensation components as close as possible to the IC and keep away from the noisy devices.

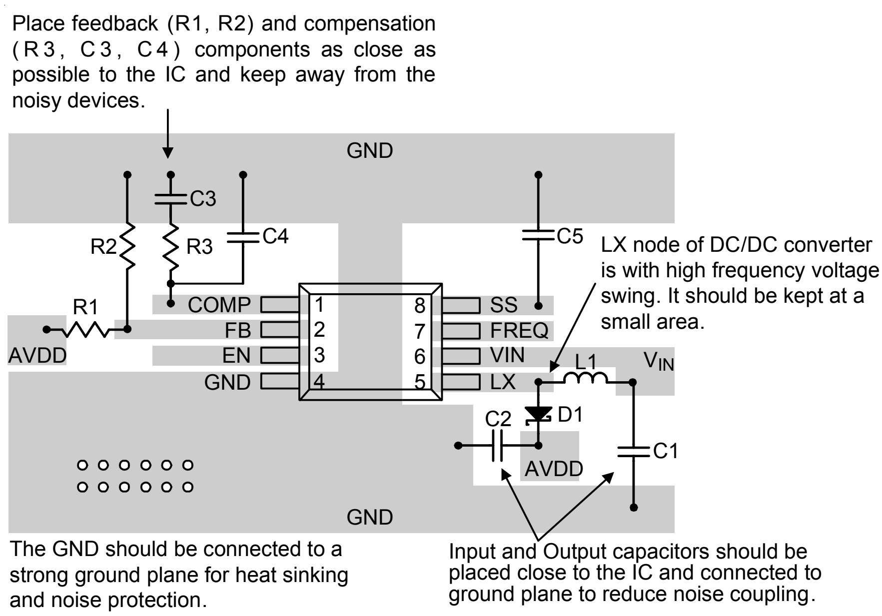
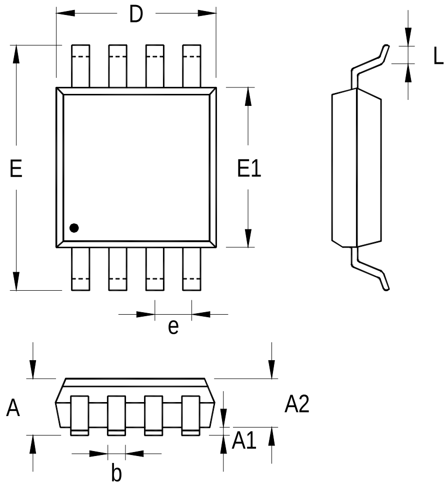


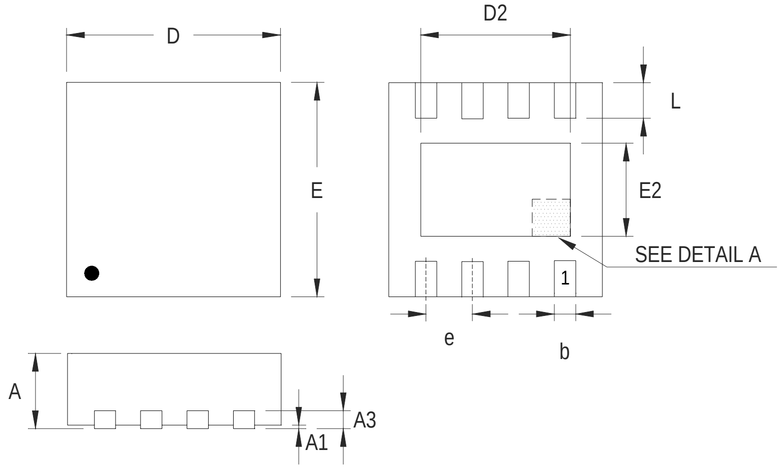
Figure 3. PCB Layout Guide

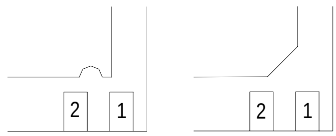
Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.810	1.100	0.032	0.043
A1	0.000	0.150	0.000	0.006
A2	0.750	0.950	0.030	0.037
b	0.220	0.380	0.009	0.015
D	2.900	3.100	0.114	0.122
e	0.650		0.026	
E	4.800	5.000	0.189	0.197
E1	2.900	3.100	0.114	0.122
L	0.400	0.800	0.016	0.031

8-Lead MSOP Plastic Package





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.200	0.300	0.008	0.012
D	2.950	3.050	0.116	0.120
D2	2.100	2.350	0.083	0.093
E	2.950	3.050	0.116	0.120
E2	1.350	1.600	0.053	0.063
e	0.650		0.026	
L	0.425	0.525	0.017	0.021

W-Type 8L DFN 3x3 Package

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