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Features

- ◆ 9V ~ 32V Supply Voltage Range
- ◆ 36V Input Voltage Surge
- ◆ 2% Voltage Reference Accuracy
- ◆ 7% Constant Current Accuracy
- ◆ External Current Limit Setting
- ◆ Programmable Operation Frequency
- ◆ Programmable the current limit point of high side MOS
- ◆ Duty Cycle Range (0~95%)
- ◆ Single Pin to External Compensation and Shutdown Control
- ◆ Built in Adjustable Line-Compensation
- ◆ Internal Soft Start 3ms
- ◆ CC/CV Mode Control
- ◆ QFN20L-5×5 Package

Applications

- ◆ Car Chargers
- ◆ Portable Charger Devices
- ◆ General-Purpose DC/DC Converters with Current Limit

General Description

The SP1253HN is a synchronous buck converter with output current to 4.8A. It is designed to allow for operating a wide supply voltage range from 9V to 32V. The external shutdown function can be controlled by logic level to pull COMP/EN pin down, and then comes into standby mode. The external compensation makes feedback control have good line and load regulation with flexible external design.

The SP1253HN operates in the CC (Constant output Current) mode or CV (Constant output Voltage) mode, and the OCP current value is set by current sensing resistors.

The SP1253HN is suitable for the DC/DC switching power applications when requested the current limit function. The devices are available in QFN20L-5×5 package and require very few external devices for operation.

Simplified Application

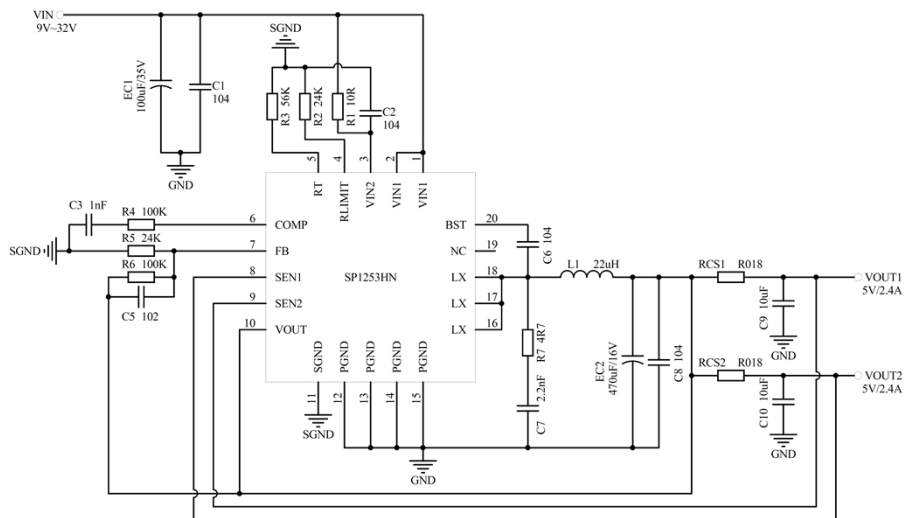


Figure 1 Typical Application of SP1253HN

Note: If output only one port, the other Sense pin need connect with VOUT.

Pin Function Description

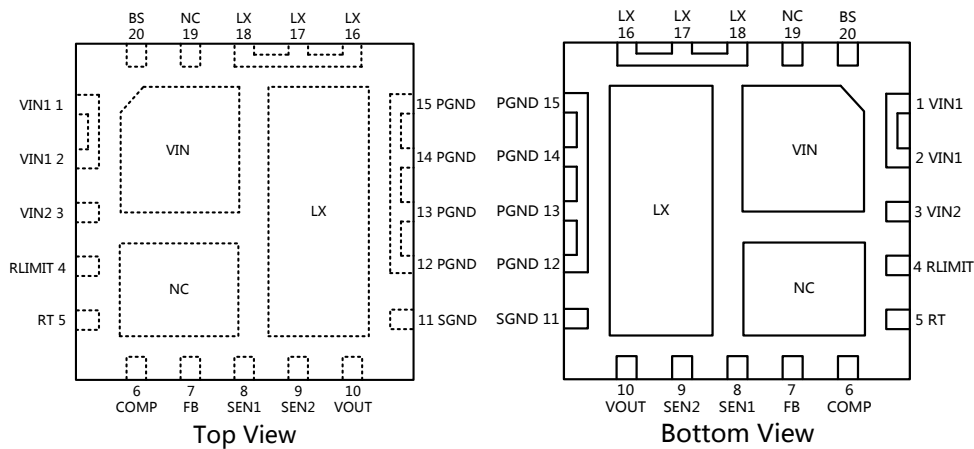
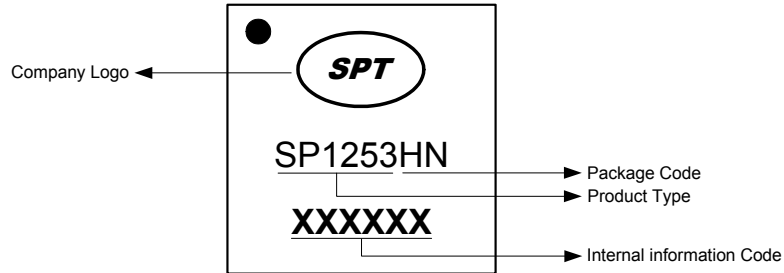


Figure 2 Pin Configuration

| Pin No. | Pin Name | Function Description |
|---------|----------|--|
| 1, 2 | VIN1 | Power supply input of high side MOS |
| 3 | VIN2 | Power Supply Input. Bypass this pin with a 1uF ceramic capacitor to GND, placed as close to the IC as possible. |
| 4 | RLIMIT | Programmable the current limit point of high side MOS |
| 5 | RT | Programmable Operation Frequency |
| 6 | COMP | Error Amplifier Output. This is the output of the error amplifier (EA) and the non-inverting input of the PWM comparator. Use this pin in combination with the FB pin to compensate the voltage control feedback loop of the converter. Pulling COMP to a level below 0.4V nominal disables the controller, causes the oscillator to stop, and no switch wave. |
| 7 | FB | Feedback Pin. The voltage at this pin is regulated to 1.0V. Connect to the resistor divider between output and GND to set the output voltage. |
| 8 | SEN1 | The Current Sense Input1 Pin. When the VOUT-SEN1 is larger than the current sense voltage, OCP function will enable. |
| 9 | SEN2 | The Current Sense Input2 Pin. When the VOUT-SEN2 is larger than the current sense voltage, OCP function will enable. |
| 10 | VOUT | Output Port. |
| 11 | SGND | Signal Ground. Return FB, and COMP to this GND and connect this GND to power GND at a single point for best noise immunity. |
| 12~15 | PGND | Power Ground. Connect this pin to a large PCB copper area for best heat dissipation. |
| 16~18 | LX | Power Switching Output to External Inductor. |
| 19 | NC | No connection |
| 20 | BS | Bootstrap Pin. This provides power to the internal higher MOSFET gate driver. Connect a 100nF capacitor from BS pin to LX pin. |

Ordering and Marking Information

| Part Number | Package Description | Top Marking | Package Form |
|-------------|---------------------|-------------|--------------|
| SP1253 | QFN20L-5×5 | SP1253HN | QFN20L-5×5 |



Absolute Maximum Ratings

| Characteristics | Symbol | Rating | Units |
|---|---------------|----------------------------|---------------|
| Supply Input Voltage | V_{IN} | -0.3 to +36 | V |
| VOUT,SEN1,SEN2 to SGND | | -0.3 to +30 | V |
| BS to LX | | -0.3 to +7 | V |
| LX to SGND | | -1 to $V_{IN}+1$ | V |
| BS to SGND | | $V_{SW}-0.3$ to $V_{SW}+7$ | V |
| FB, COMP, RLIMIT,RT to SGND | | -0.3 to +7 | V |
| ESD HBM(Human Body Mode) | | ±2K | V |
| ESD MM(Machine Mode) | | ±200 | V |
| Power Dissipation, PD @ $T_A=25^{\circ}C$ | P_D | $(T_J-T_A)/\theta_{JA}$ | W |
| Thermal Resistance from Junction to case | θ_{JC} | 16 | $^{\circ}C/W$ |
| Thermal Resistance from Junction to ambient | θ_{JA} | 42 | $^{\circ}C/W$ |

Note:

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. Devices are ESD sensitive. Handling precaution recommended.

Recommended Operating Conditions

| Symbol | Description | Value | Units |
|--------|---|-------------|-------------|
| TST | Storage Temperature Range | -65 to +150 | $^{\circ}C$ |
| TJ | Junction Temperature | -40 to +150 | $^{\circ}C$ |
| TOP | Operating Temperature | -25 to +85 | $^{\circ}C$ |
| | Lead Temperature Range(Soldering 10sec) | 260 | $^{\circ}C$ |

Block Diagram

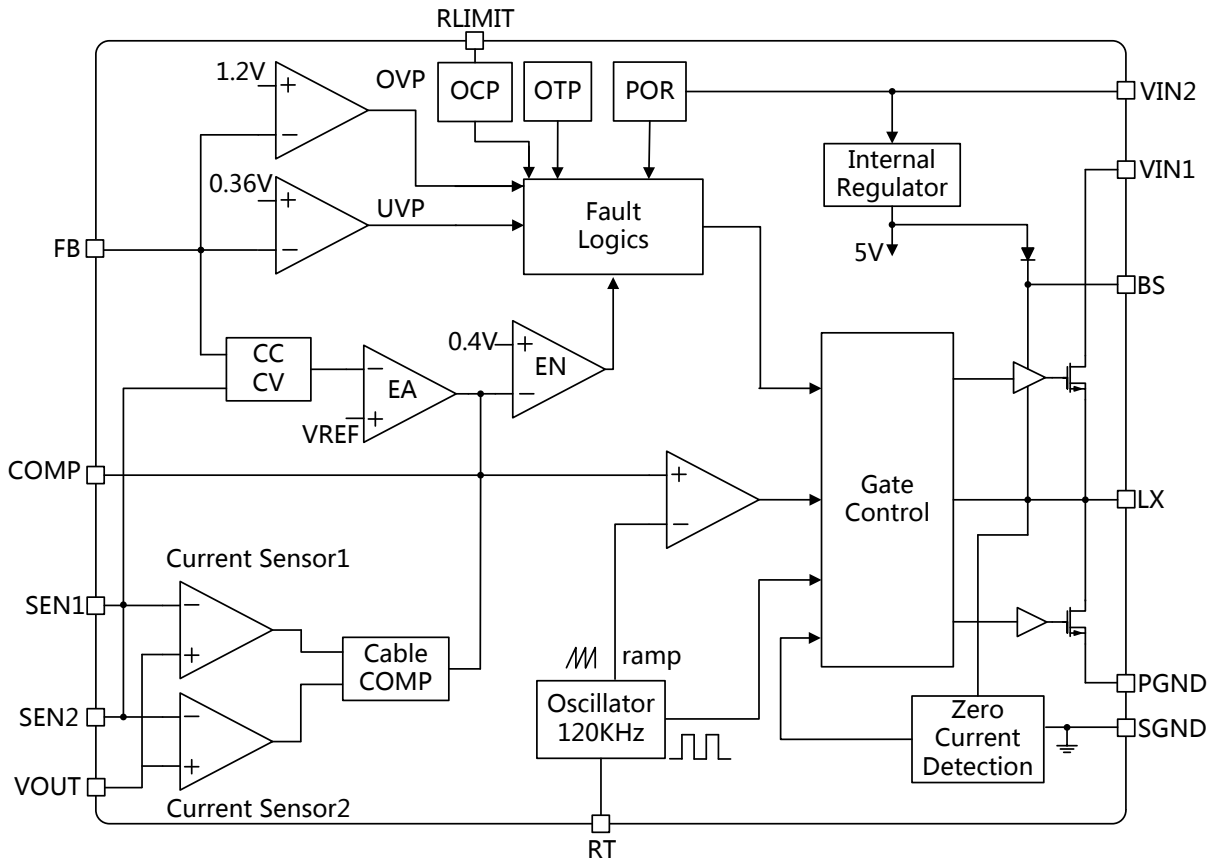


Figure 3 Block diagram of SP1253HN

Electrical Characteristics

$V_{CC} = 12V$, $T_A = +25^{\circ}C$, unless otherwise specified

| Characteristics | Symbol | Test Conditions | Min | Typ | Max | Units |
|---------------------------------|---------------|-------------------------------|------|------|------|-------------|
| Supply Voltage Range V_{IN} | V_{CC} | | 9 | - | 32 | V |
| Supply Input Current | I_{CCQ} | COMP/EN=GND | - | 0.65 | - | mA |
| | I_{CC} | 12Vin Vout=5V, No load | - | 0.8 | - | mA |
| | I_{CC} | 24Vin Vout=5V, No load | - | 0.7 | - | mA |
| Power-On-Reset | | | | | | |
| VCC POR Threshold | V_{CCRTH} | Vcc Rising. | - | 7.5 | - | V |
| | V_{CCFTH} | Vcc Falling. | - | 7 | - | |
| Oscillator | | | | | | |
| PWM Frequency | F_{OSC} | RT=56K | 96 | 120 | 144 | KHz |
| Minimum On-Time | T_{ON-MIN} | | - | 200 | - | ns |
| Duty Cycle Range | Duty | | 0 | - | 95 | % |
| Reference | | | | | | |
| Reference Voltage | V_{REF} | | - | 1.0 | - | V |
| Reference Voltage Tolerance | | | -2 | - | +2 | % |
| Line compensation Current | I_{FB} | | - | 2.5 | - | uA |
| PWM Error Amplifier | | | | | | |
| COMP Shutdown Threshold Voltage | | | - | 0.4 | - | V |
| COMP Source Current | | $V_{COMP} = V_{COMP_H} - 1V$ | - | -60 | - | uA |
| COMP Sink Current | | $V_{COMP} = 1V$ | - | 60 | - | uA |
| Current Sense Amplifier | | | | | | |
| VOUT-SEN1 Voltage | V_{SEN1} | | 55.8 | 60 | 64.2 | mV |
| VOUT-SEN2 Voltage | V_{SEN2} | | 55.8 | 60 | 64.2 | mV |
| Protection | | | | | | |
| FB Over Voltage Level | V_{OVP_FB} | Recent of V_{REF} | | 120 | | % |
| Over Temperature Shutdown | T_{SD} | | - | 145 | - | $^{\circ}C$ |
| Over Temperature Hysteresis | T_{SDHYS} | | - | 40 | - | $^{\circ}C$ |
| Short Circuit Fold Back Voltage | V_{SCP} | | - | 0.4 | - | V |
| Recycle Time | | | - | 0.5 | - | s |
| Soft Start | | | | | | |
| Soft Start Time | T_{SS} | | - | 3 | - | ms |
| MOSFET | | | | | | |
| High Side NMOS RDSON | Rdson | | - | 18 | - | m Ω |
| Low Side NMOS RDSON | Rdson | | - | 14 | - | m Ω |

Functional Description

CV/CC mode control

The SP1253HN provides CC/CV function. The Constant output Current control Mode and Constant output Voltage control Mode.

Over Current Protection

The SP1253HN provides over current protection. A drop voltage on the current sensing resistor is over the OCP value, the OCP function will shut down the controller.

Soft Start

The SP1253HN has internal soft start function to control rise rate of the output voltage and limits the large inrush current at start up. The typical soft start interval is about 3ms.

Power on Reset

A power-on reset circuit monitors the input voltage. When the input voltage exceeds 7.5V, the converter will start operation. Once input voltage falls below 6.5V, the controller will shut down.

Over Temperature Protection

The SP1253HN provides over temperature protection. The OTP will shut down the converter when junction temperature exceeds 145°C. Once the junction temperature cools down by approximately 40°C, the converter will resume normal operation.

High Side MOS Current Limit Protection

The SP1253HN provides high side MOS Over-Current Protection (OCP). The OCP is set by outside resistance (R_{RLIMIT}). The OCP set according to the following equation:

$$IOCP(A) = \frac{24K}{R_{RLIMIT}} \cdot 10A$$

Programmable Operation Frequency

The SP1253HN provides programmable operation frequency. The frequency set according to the following equation:

$$Fosc(KHz) = \frac{56K}{R_T} \cdot 120KHz$$

Current Limit Protection

The Current limit is set by outside resistance (R_{SENSE}),

When the ($V_{OUT-SEN1}$) or ($V_{OUT-SEN2}$) voltage larger than 60mV, the current limit is happened that driver can be turned off. The current limit set according to the following equation:

$$CurrentLimit(A) = \frac{60mV}{R_{SENSE}}$$

Output Over Voltage Protection

The SP1253HN provides output over voltage protection function. Once the feedback voltage is over the 120% of the internal reference voltage, the OVP will be triggered to shut down the controller.

Output Short-Circuit Protection

The SP1253HN provides output short-circuit protection function. When V_{OUT} is short ($V_{FB} < 0.4V$), the auto restart function can be started that restart the regulator cycle by cycle. The cycle time is set by internal counter.

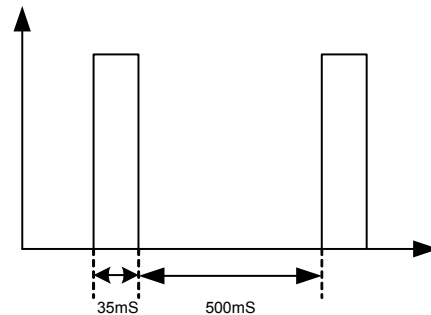


Figure 4 short-circuit protection time

APPLICATION INFORMATION

Output Voltage Setting

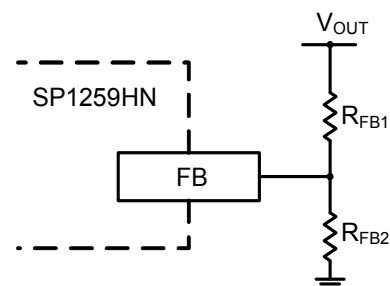


Figure 5 Output Voltage Setting

Figure 5 shows the connections for setting the output voltage. Select the proper ratio of the two feedback resistors R_{FB1} and R_{FB2} based on the output voltage.

Typically, use $R_{FB2} \approx 1k\Omega$ and determine R_{FB1} from the following equation:

$$R_{FB1} = R_{FB2} \left(\frac{V_{OUT}}{V_{FB}} - 1 \right)$$

Output Cable Resistance Compensation

To compensate for resistive voltage drop across the charger's output cable, the SP1253HN integrates a simple, user-programmable cable voltage drop compensation using the impedance at the FB pin. Use the curve in Figure 6 to choose the proper feedback resistance values for cable compensation. R_{FB1} is the high side resistor of voltage divider. The V_{out} - V_{sen1} or V_{out} - V_{sen2} take the big one.

$$V_{OUT} = \left[\left(1 + \frac{R_{FB1}}{R_{FB2}} \right) \cdot V_{FB} \right] + \left[R_{FB1} \cdot \left(\frac{\Delta V_{SEN}}{16.6K} - 1\mu A \right) \cdot 0.5 \right]$$

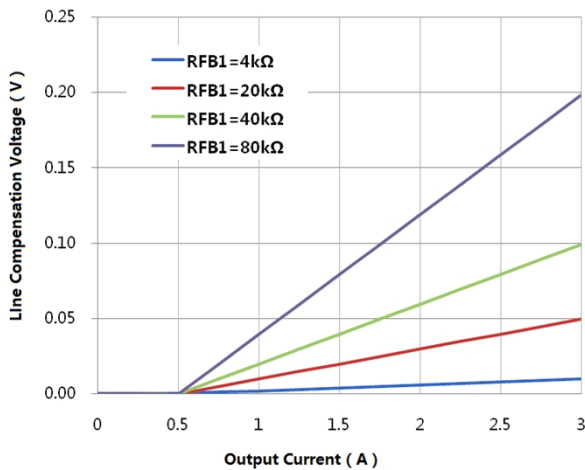


Figure 6 12Vin to 5Vout Cable Compensation
($R_{SEN} = 33m\Omega$)

Inductor Selection

The inductor maintains a continuous current to the output load. This inductor current has a ripple that is dependent on the inductance value.

Higher inductance reduces the peak-to-peak ripple current. The tradeoff for high inductance value is the increase in inductor core size and series resistance, and the reduction in current handling capability. In general, select an inductance value L based on ripple current requirement:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} f_{LX} I_{OUTMAX} K_{RIPPLE}}$$

Where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_{LX} is the switching frequency, I_{OUTMAX} is the maximum output current, and K_{RIPPLE} is the ripple factor. Typically, choose $K_{RIPPLE} = 30\%$ to correspond to the peak-to-peak ripple current being 30% of the maximum output current.

With this inductor value, the peak inductor current is $I_{OUT} \times (1 + K_{RIPPLE}/2)$. Make sure that this peak inductor current is less than the controller's current limit. Finally, select the inductor core size so that it does not saturate at the peak inductor current.

Input Capacitor

The input capacitor needs to be carefully selected to maintain sufficiently low ripple at the supply input of the converter. A low ESR capacitor is highly recommended. Since large current flows in and out of this capacitor during switching, its ESR also affects efficiency.

The input capacitance needs to be higher than $100\mu F$. The best choice is the ceramic type, however, low ESR tantalum or electrolytic types may also be used provided that the RMS ripple current rating is higher than 50% of the output current. The input capacitor should be placed close to the V_{IN} and $SGND$ pins of the IC, with the shortest traces possible. In the case of tantalum or electrolytic types, they can be further away if a small parallel $1\mu F$ ceramic capacitor is placed right next to the IC. Especially $C2$ capacitor should be placed as close as possible to the V_{IN} pin.

Output Capacitor

The output capacitor also needs to have low ESR to keep low output voltage ripple. The output ripple voltage is:

$$V_{RIPPLE} = I_{OUT} K_{RIPPLE} R_{ESR} + \frac{V_{IN}}{28 \times f_{LX}^2 L C_{OUT}}$$

Where I_{OUTMAX} is the maximum output current, K_{RIPPLE} is the ripple factor, R_{ESR} is the ESR of the output capacitor, f_{LX} is the switching frequency, L is the inductor value, and C_{OUT} is the output capacitance. In the case of ceramic output capacitors, R_{ESR} is very small and does not

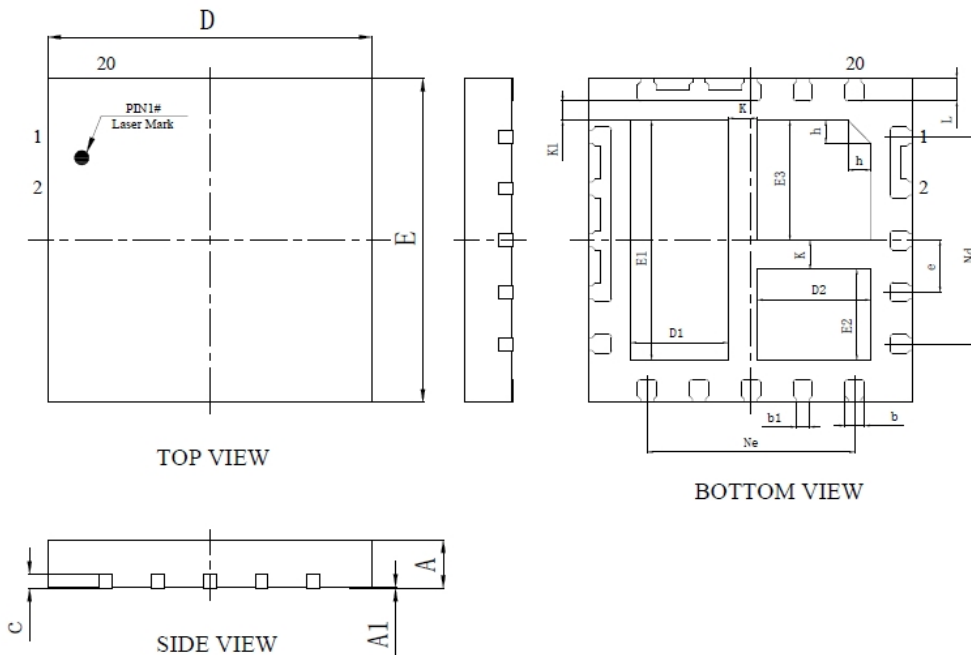
contribute to the ripple. Therefore, a lower capacitance value can be used for ceramic type. In the case of tantalum or electrolytic capacitors, the ripple is dominated by R_{ESR} multiplied by the ripple current. In that case, the output capacitor is chosen to have sufficiently low ESR.

For ceramic output capacitor, typically choose a capacitance of about 470 μ F. For tantalum or electrolytic capacitors, choose a capacitor with less than 50m Ω ESR.

PCB Layout Recommendations

1. PCB trace defined as LX node, which connects to the inductor, should be as short and wide as possible.
2. Inductance between the LX terminal and the output VOUT as far as possible with the ground wire to reduce the output side of the switch coupling.
3. ALL sensitive analog traces such as SEN1, SEN2, COMP and FB should place away from high-voltage switching nodes LX nodes to avoid coupling.
4. C2 input bypass capacitor should be placed to the IN pin as close as possible.
5. R5 and R6 feedback resistor should be placed to the FB pin as close as possible.
6. The compensation network R4, C3 should be placed to the COMP pin as close as possible.
7. Signal ground and power ground should be connected strongly together near the device.
8. The ground of input capacitance and output capacitance should be placed as close as possible.

Package Information (Units:mm)



| Symbol | Dimensions in Millimeters | | |
|--------|---------------------------|------|------|
| | Min. | Nom. | Max. |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0 | 0.02 | 0.05 |
| b | 0.25 | 0.30 | 0.35 |
| b1 | 0.20REF | | |
| c | 0.18 | 0.20 | 0.25 |
| D | 4.90 | 5.00 | 5.10 |
| D1 | 1.40 | 1.50 | 1.60 |
| D2 | 1.65 | 1.75 | 1.85 |
| e | 0.80BSC | - | - |
| Ne | 3.20BSC | - | - |
| Nd | 3.20BSC | - | - |
| E | 4.90 | 5.00 | 5.10 |
| E1 | 3.60 | 3.70 | 3.80 |
| E2 | 1.30 | 1.40 | 1.50 |
| E3 | 1.75 | 1.85 | 1.95 |
| L | 0.30 | 0.35 | 0.40 |
| h | 0.30 | 0.35 | 0.40 |
| K | 0.40 | 0.45 | 0.50 |
| K1 | 0.25 | 0.30 | 0.35 |

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