

## 2A, 25V Non Synchronous PWM Step Down Regulator

September 2009

Rev. 1.0.0

### GENERAL DESCRIPTION

The XRP7657 is a non synchronous voltage mode PWM step down (buck) regulator capable of a constant output current up to 2Amps. A wide 4.75V to 25V input voltage range allows for single supply operations from industry standard 5V, 12V and 24V power rails.

With a 420kHz constant operating frequency and integrated high side switch, the XRP7657 reduces the overall component count and solution footprint. In addition to a 2% output setpoint accuracy, this device provides high efficiency, low ripple and excellent line and load regulation. An enable function and soft start feature allow for controlled power up sequencing implementation.

Built-in over current, output short-circuit and over temperature protection insure safe operations under abnormal operating conditions.

The XRP7657 is offered in a RoHS compliant, "green"/halogen free 8-pin SOIC package.

### APPLICATIONS

- **Distributed Power Architectures**
- **Point of Load Converters**
- **Audio-Video Equipments**
- **Medical & Industrial Equipments**

### FEATURES

- **2A Constant Output Current**
- **4.75V to 25V Wide Input Voltage**
- **PWM Voltage Mode Control**
  - 420kHz Constant Operations
  - Up to 94% Efficiency
- **Adjustable Output Voltage**
  - 0.8V to 21V Range
  - 2% Accuracy
- **Soft-Start and Enable Function**
- **Built-in Thermal, Over Current and Output Short Circuit Protection**
- **RoHS Compliant, "Green"/Halogen Free 8-Pin SOIC Package**

### TYPICAL APPLICATION DIAGRAM

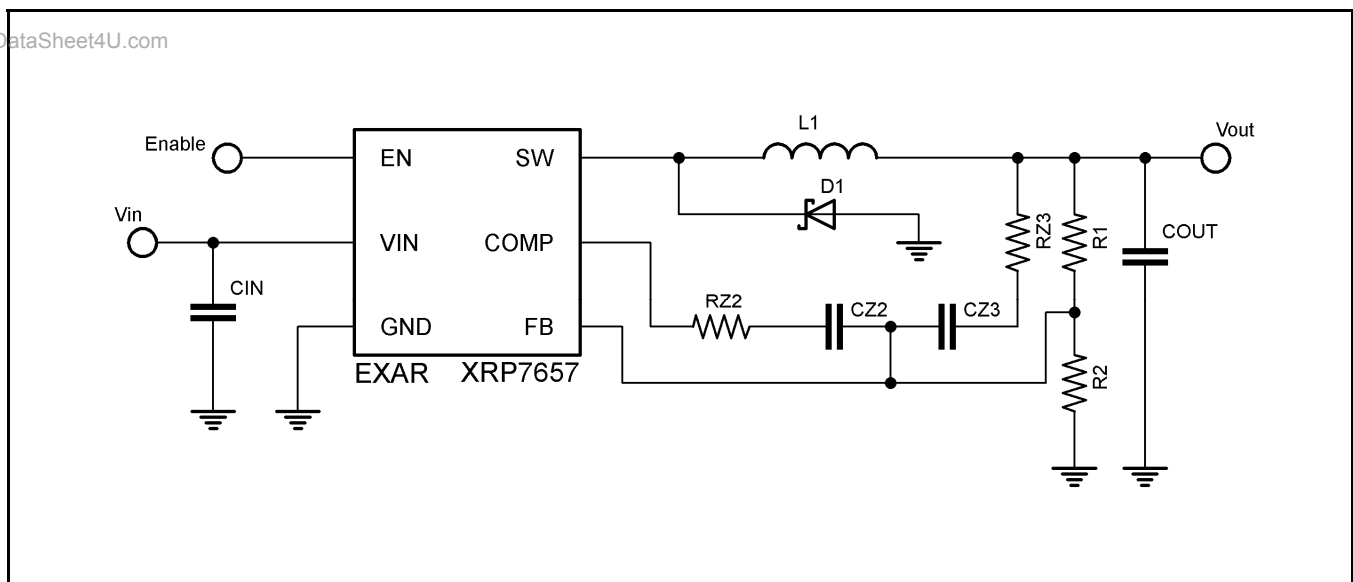


Fig. 1: XRP7657 Application Diagram



## 2A, 25V Non Synchronous PWM Step Down Regulator

### ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

$V_{IN}$ ..... -0.3V to 30V  
 COMP, FB pin voltage..... -0.3V to 6V  
 SW, EN pin voltage..... -0.3V to  $V_{IN}$   
 Storage Temperature..... -65°C to 150°C  
 Power Dissipation..... Internally Limited  
 Junction Temperature  $T_J$ ..... 150°C  
 Lead Temperature (Soldering, 10 sec)..... 260°C  
 ESD Rating (HBM - Human Body Model)..... 2kV

### OPERATING RATINGS

Input Voltage Range  $V_{IN}$ ..... 4.75V to 25V  
 Output Voltage Range  $V_{OUT}$ ..... 0.8V to 21V  
 Junction Temperature  $T_J$  Range..... -40°C to 125°C  
 Thermal Resistance  $\theta_{JA}$   
 (junction to ambient, no heat sink, free air) .....100°C/W

### ELECTRICAL SPECIFICATIONS

Specifications with standard type are for an Ambient Temperature of  $T_A = 25^\circ\text{C}$  only; limits applying over the full Operating Junction Temperature range are denoted by a "•". Minimum and Maximum limits are guaranteed through test, design, or statistical correlation. Typical values represent the most likely parametric norm at  $T_A = 25^\circ\text{C}$ , and are provided for reference purposes only. Unless otherwise indicated,  $V_{IN} = 12\text{V}$ ,  $V_{OUT} = 5\text{V}$ ,  $T_A = 25^\circ\text{C}$ .

| Parameter                                | Min.  | Typ.  | Max.  | Units            | Conditions   |
|--|-------|-------|-------|------------------|--|
| Input Voltage $V_{IN}$                   | 4.75  |       | 25    |                  |  |
| Shutdown Quiescent Current $I_{SHDN}$    |       | 44    | 60    | $\mu\text{A}$    | $V_{EN}=0.4\text{V}$   |
| Quiescent Current $I_Q$                  |       | 1.3   | 2     | mA               | $V_{EN}=2.0\text{V}$ , $V_{FB}=1.3\text{V}$                                      |
| Feedback Voltage $V_{FB}$                | 0.784 | 0.800 | 0.816 | V                | $V_{IN}=5\text{V}$ to 25V  |
| Feedback Bias Current $I_{FB}$           |       | -0.1  | -0.5  | $\mu\text{A}$    | $V_{FB}=1.3\text{V}$   |
| Switch Current Limit $I_{LIM}$           | 2.5   | 3.4   |       | A                |  |
| Oscillator Frequency $f_{OSC}$           | 336   | 420   | 504   | kHz              |  |
| Oscillator Frequency $f_{OSC1}$          |       | 40    |       | kHz              | $V_{FB}=0.52\text{V}$ , Current limit activated or short circuit protection mode |
| Error Amplifier Voltage Gain $G_V$       |       | 1000  |       | V/V              |  |
| Error Amplifier Transconductance $G_S$   |       | 700   |       | $\mu\text{A/V}$  |  |
| EN Pin Threshold High $V_H$              | 1.5   |       |       | V                |  |
| EN Pin Threshold Low $V_L$               |       |       | 0.7   | V                |  |
| EN Pin Input Leakage Current $I_{EN}$    |       | -5    | -10   | $\mu\text{A}$    | $V_{EN}=2.5\text{V}$   |
| Internal PMOS ON Resistance $R_{DS(ON)}$ |       | 130   | 150   | m $\Omega$       | $V_{IN} = V_{EN}=12\text{V}$ , $V_{FB}=0.65\text{V}$ , $I_{OUT}=12\text{A}$      |
| Maximum Duty Cycle $D_{MAX}$             |       |       | 100   | %                | $V_{FB}=0.65\text{V}$ , $I_{SW}=0.1\text{A}$                                     |
| Thermal Shutdown $T_{OTSD}$              |       | 155   |       | $^\circ\text{C}$ |  |
| Thermal Shutdown Hysteresis $T_{HYS}$    |       | 20    |       | $^\circ\text{C}$ |  |

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### BLOCK DIAGRAM

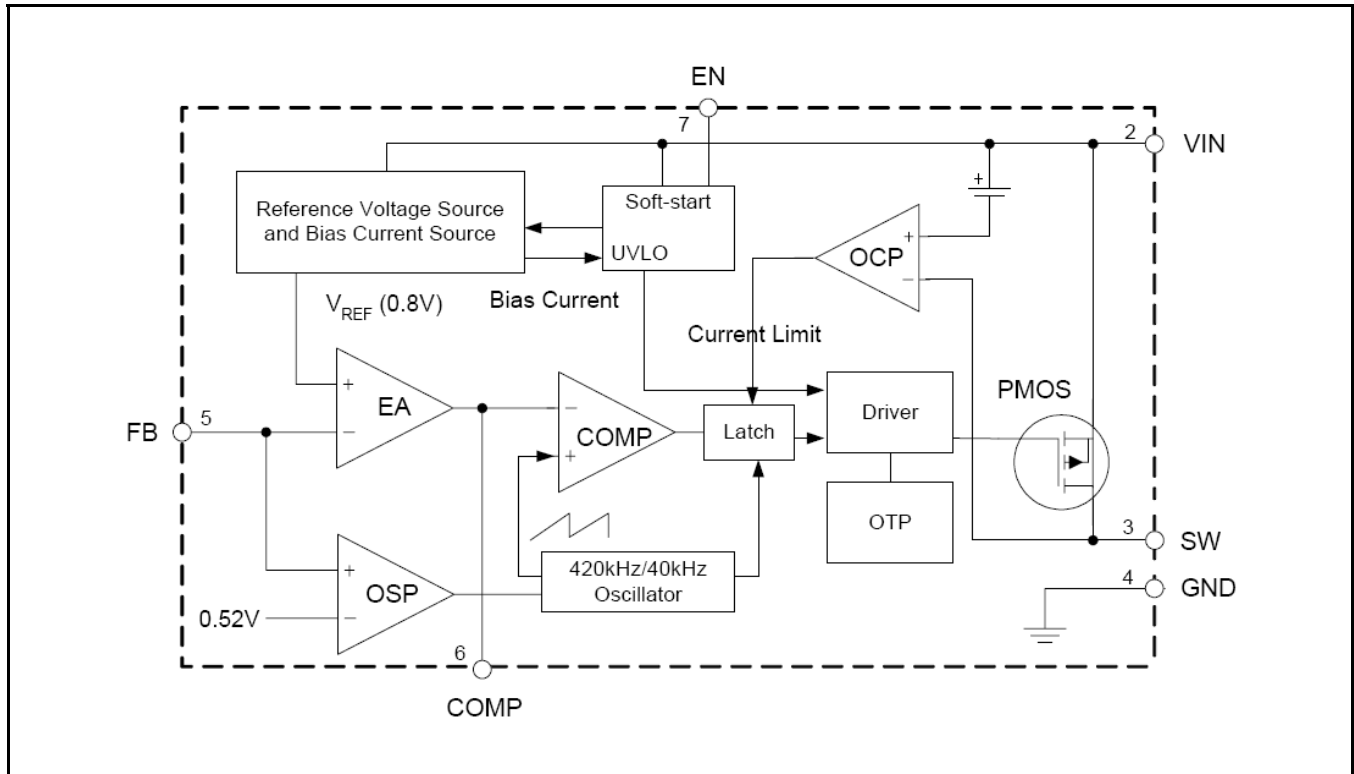


Fig. 2: XRP7657 Block Diagram

### PIN ASSIGNMENT

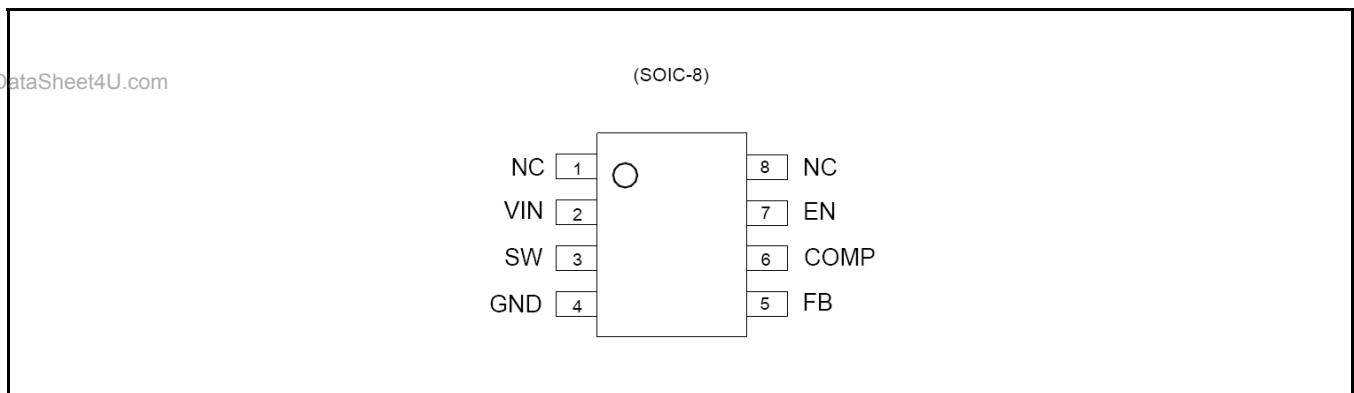


Fig. 3: XRP7657 Pin Assignment



## 2A, 25V Non Synchronous PWM Step Down Regulator

### PIN DESCRIPTION

| Name | Pin Number | Description   |
|------|------------|---|
| NC   | 1          | No connect  |
| VIN  | 2          | Supply Voltage Input Pin.<br>Bypass VIN to GND with a suitable large capacitor to eliminate noise on the input  |
| SW   | 3          | Power Switch Output Pin.<br>SW is the switch node that supplies power to the output   |
| GND  | 4          | Ground signal pin   |
| FB   | 5          | Feedback Pin.<br>Through an external resistor divider network, FB senses the output voltage and regulates it. To prevent current limit run away in a short circuit fault condition, the frequency feedback comparator lowers the oscillator frequency to 40kHz when the FB voltage is below 0.52V. The feedback threshold voltage is 0.8V |
| COMP | 6          | Compensation Pin.<br>This pin is the output of the error amplifier. Frequency compensation is done at this pin by connecting a series RC to ground (parallel a C if necessary)  |
| EN   | 7          | Enable Pin.<br>Drive EN pin high to turn on the device, drive it low to turn off. Default of this pin is high level.  |
| NC   | 8          | No connect  |

### ORDERING INFORMATION

| Part Number   | Junction Temperature Range      | Marking               | Package | Packing Quantity | Note 1                         | Note 2 |
|---------------|---------------------------------|-----------------------|---------|------------------|--------------------------------|--------|
| XRP7657EDTR-F | -40°C ≤ T <sub>A</sub> ≤ +125°C | XRP7657E<br>YYWW<br>X | SOIC8   | 2.5K/Tape & Reel | RoHS Compliant<br>Halogen Free |        |
| XRP7657EVB    | XRP7657 Evaluation Board        |                       |         |                  |                                |        |

"YY" = Year - "WW" = Work Week - "X" = Lot Number

## 2A, 25V Non Synchronous PWM Step Down Regulator

### TYPICAL PERFORMANCE CHARACTERISTICS

All data taken at  $V_{IN}=12V$ ,  $V_{OUT}=5V$ ,  $T_A=25^\circ C$ , unless otherwise specified - Schematic and BOM from Application Information section of this datasheet.

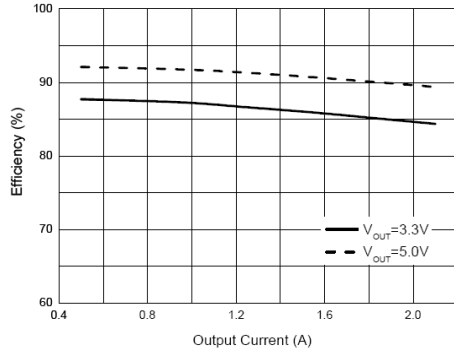


Fig. 4: Efficiency vs. Output Current

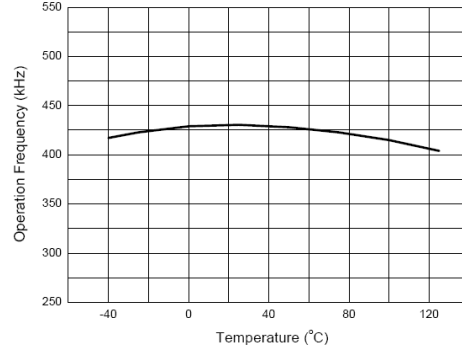


Fig. 5: Operation Frequency vs. Temperature

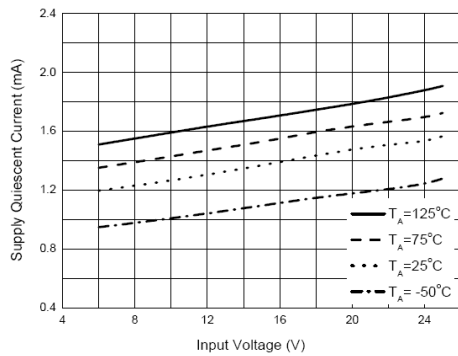


Fig. 6: Supply Quiescent Current vs. Input Voltage

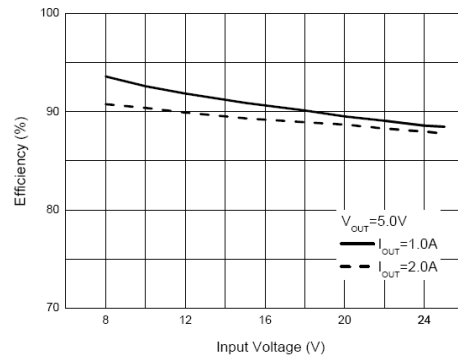


Fig. 7: Efficiency vs. Input Voltage

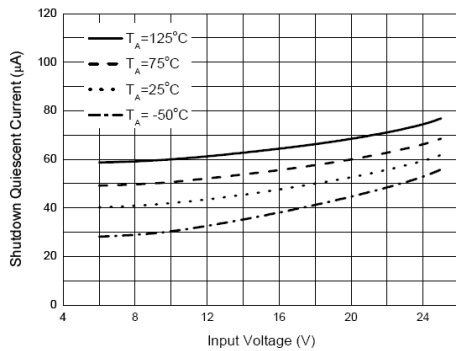


Fig. 8: Shutdown Quiescent Current vs. Input Voltage

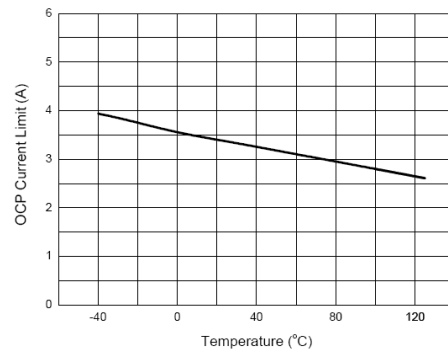


Fig. 9: OCP Current Limit vs. Temperature

## 2A, 25V Non Synchronous PWM Step Down Regulator

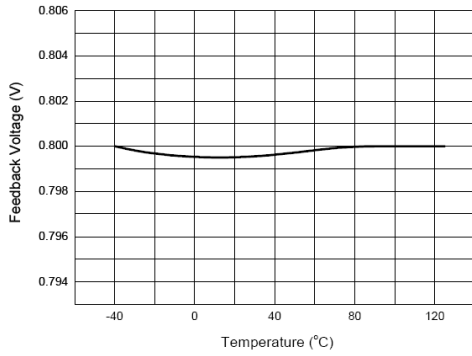


Fig. 10: Feedback Voltage vs. Temperature

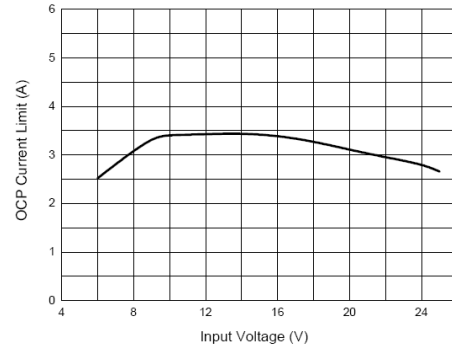


Fig. 11: OCP Current Limit vs. Input Voltage

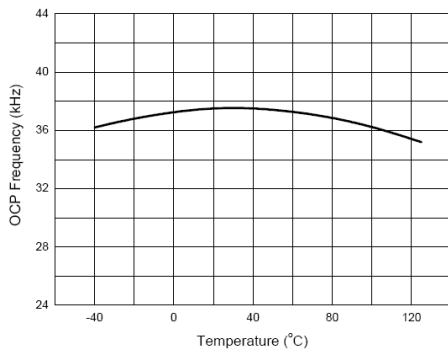


Fig. 12: OCP Frequency vs. Temperature

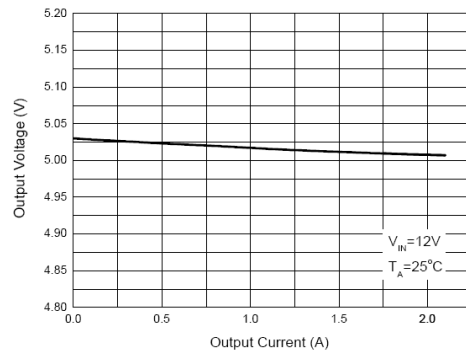


Fig. 13: Output Voltage vs. Output Current

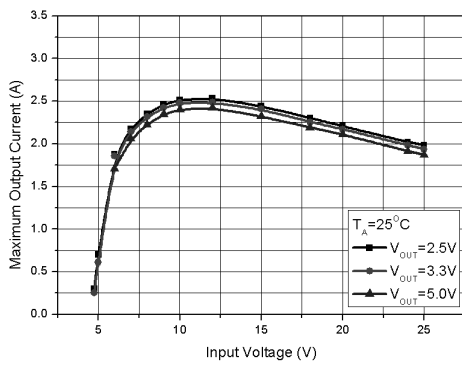


Fig. 14: Output Current vs. Input voltage ( $T_A=25^\circ\text{C}$ )

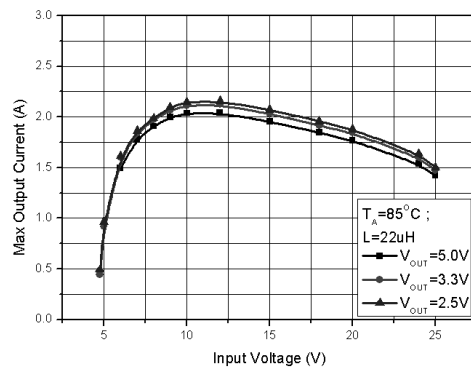


Fig. 15: Output Current vs. Input Voltage ( $T_A=85^\circ\text{C}$ )

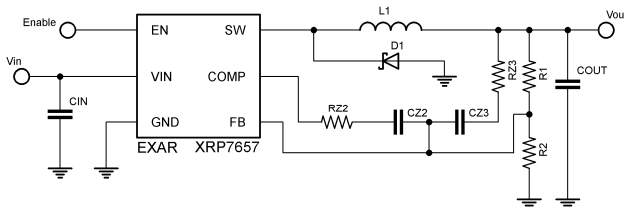
## 2A, 25V Non Synchronous PWM Step Down Regulator

### APPLICATION INFORMATION

#### THEORY OF OPERATION

XRP7657 is a non-synchronous voltage mode PWM buck regulator featuring an integrated P-channel switching FET. Using a PFET enables the regulator to operate at 100% duty cycle. Additional features include preset switching frequency of 420kHz and preset soft-start. Safety features include under-voltage lock-Out (UVLO), over-current protection (OCP), over-temperature protection (OVP) and short-circuit protection.

#### TYPICAL APPLICATION SCHEMATICS



#### SETTING THE OUTPUT VOLTAGE

Output voltage  $V_{OUT}$  is set by placing a resistor divider between output of the regulator and feedback pin. Resistors  $R_1$  and  $R_2$  are calculated from the following equation:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R_1}{R_2}\right)$$

Where  $V_{REF}$  is the reference voltage set internally at 0.8V nominal.

#### ENABLE SIGNAL

The Enable pin can be used to turn the regulator on and off. Pulling the Enable below 0.7V puts the regulator in shutdown mode with a corresponding quiescent current of less than 60 $\mu$ A. If Enable is not going to be used it should be tied to  $V_{IN}$ .

#### SELECTING DIODE D1

D1 must be a Schottky diode and selected for Voltage rating  $V_R$ , current rating  $I_F$  and power rating  $P$ . The voltage rating should be greater than  $V_{IN}$  in order to block the input voltage when the internal PFET is on. As a rule of thumb D1 voltage rating should be 50% larger than  $V_{IN}$ . A simplified rule for current rating is to select a diode capable of conducting the converter's output current.

#### SELECTING INDUCTOR L1

L1 should have saturation current rating  $I_{SAT}$  greater than the converter output current. As a rule of thumb  $I_{SAT}$  should be twice the output current.

The inductance value can be calculate from the following equation:

$$L = (V_{IN} - V_{OUT}) \times \left(\frac{V_{OUT}}{V_{IN}}\right) \times \left(\frac{1}{f}\right) \times \left(\frac{1}{\Delta_{IL}}\right)$$

Where:

$V_{IN}$  is converter input voltage

$V_{OUT}$  is converter output voltage

$f$  is the nominal switching frequency, 420kHz

$\Delta_{IL}$  is the peak to peak inductor current ripple usually set to 30% of  $I_{OUT}$

#### OUTPUT CAPACITOR SELECTION

Either ceramic or ALEL capacitors can be used. Select the output capacitor for voltage rating, capacitance and Equivalent Series Resistance (ESR). Nominally the voltage rating is selected to be twice as large as the output voltage. Select the capacitance to satisfy the specification for output voltage overshoot/undershoot caused by current step load. A steady-state output current  $I_{OUT}$  corresponds to inductor stored energy of  $\frac{1}{2} \times L \times I_{OUT}^2$ . A sudden decrease in  $I_{OUT}$  forces the energy surplus in L to be absorbed by  $C_{OUT}$ . This causes an overshoot in output voltage that is corrected by power switch reduced duty cycle. Use the following equation to calculate  $C_{OUT}$ :

## 2A, 25V Non Synchronous PWM Step Down Regulator

$$C_{OUT} = L \times \left( \frac{I_2^2 - I_1^2}{V_{OUTS}^2 - V_{OUT}^2} \right)$$

Where:

$I_2$  is the load step high current

$I_1$  is the load step low current

$V_{OUTS}$  is output voltage including overshoot

$V_{OUT}$  is steady-state output voltage

### INPUT CAPACITOR SELECTION

Ceramic capacitors are recommended since they have low ESR and low ESL. Therefore they are more effective in providing the

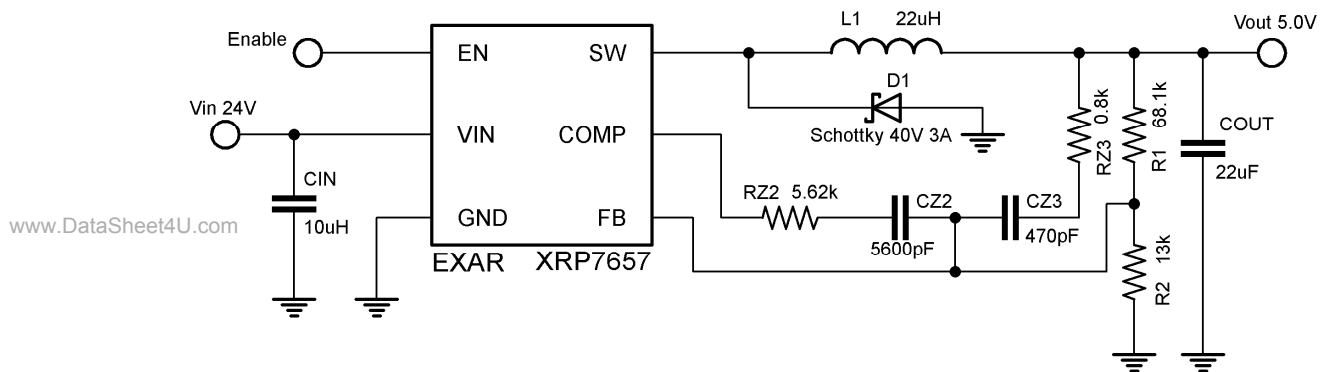
pulsating input current required by the buck converter. Voltage rating of the capacitor should be at least 50% higher than the converter input voltage. See following design examples for required value of  $C_{IN}$ .

### COMPENSATION

A type-III compensation is used to stabilize the loop. A detailed explanation of calculating component values for type-III compensations is given in EXAR's application note ANP-16. Compensation was calculated based on a cross-over frequency ( $f_c$ ) of 40kHz and ramp voltage of 0.5V. Component  $C_p$ , which is mentioned in ANP-16, has not been used here.

## TYPICAL APPLICATIONS

### 24V TO 5V – 2A POINT OF LOAD CONVERTER

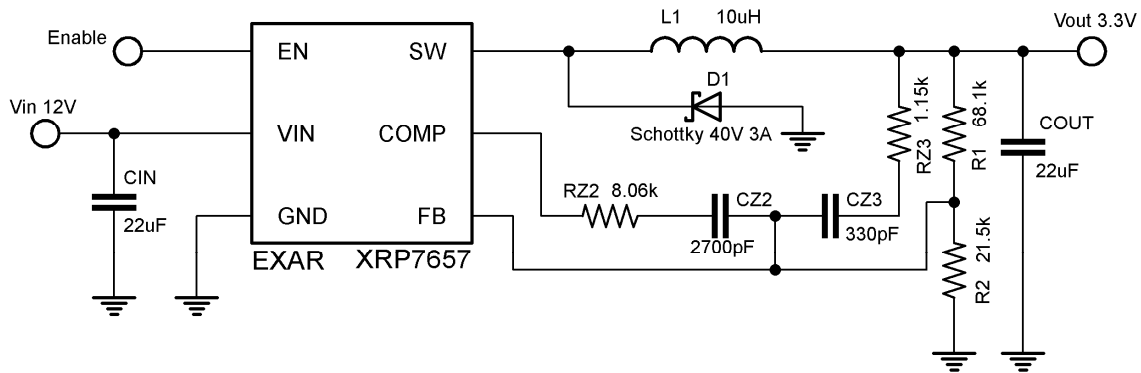


| Ref.      | Qty | Manufacturer     | Part Number    | Size      | Description                           |
|-----------|-----|------------------|----------------|-----------|---------------------------------------|
| U1        | 1   | EXAR             | XRP7657        | SOIC-8    | 2A 25V Non-synchronous Buck Regulator |
| D1        | 1   | Central Semicon. | CMSH3-40MA     | SMA       | Schottky, 40V, 3A                     |
| L1        | 1   | Cooper Bussmann  | DR74-220       | 7.6x7.6mm | 22uH Coil 2.4A 48.9mOhm               |
| $C_{IN}$  | 1   | Murata Corp.     | GRM32ER61E106K | 1210      | Ceramic Cap 10μF, 25V,X5R,1210        |
| $C_{OUT}$ | 1   | Murata Corp.     | GRM31CR61C226M | 1206      | Ceramic Cap 22μF, 16V,X5R, 1206       |
| CZ3       | 1   | Murata Corp.     | GRM188R71H471K | 0603      | Ceramic Cap 470pF, 50V,X7R, 0603      |
| CZ2       | 1   | Murata Corp.     | GRM188R71H562K | 0603      | Ceramic Cap 5600pF, 50v,X7R,0603      |
| R1        | 1   | Panasonic        | ERJ-3EKF6812V  | 0603      | Res 68.1k Ohm, 1%, 0603, SMD          |
| R2        | 1   | Panasonic        | ERJ-3EKF1302V  | 0603      | Res 13k Ohm, 1%, 0603 SMD             |
| RZ3       | 1   | Panasonic        | ERJ-3EKF0801V  | 0603      | Res 0.8k Ohm, 1%, 0603 SMD            |
| RZ2       | 1   | Panasonic        | ERJ-3EKF5621V  | 0603      | Res 5.62k Ohm, 1%, 0603 SMD           |



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### 12V TO 3.3V – 2A POINT OF LOAD CONVERTER



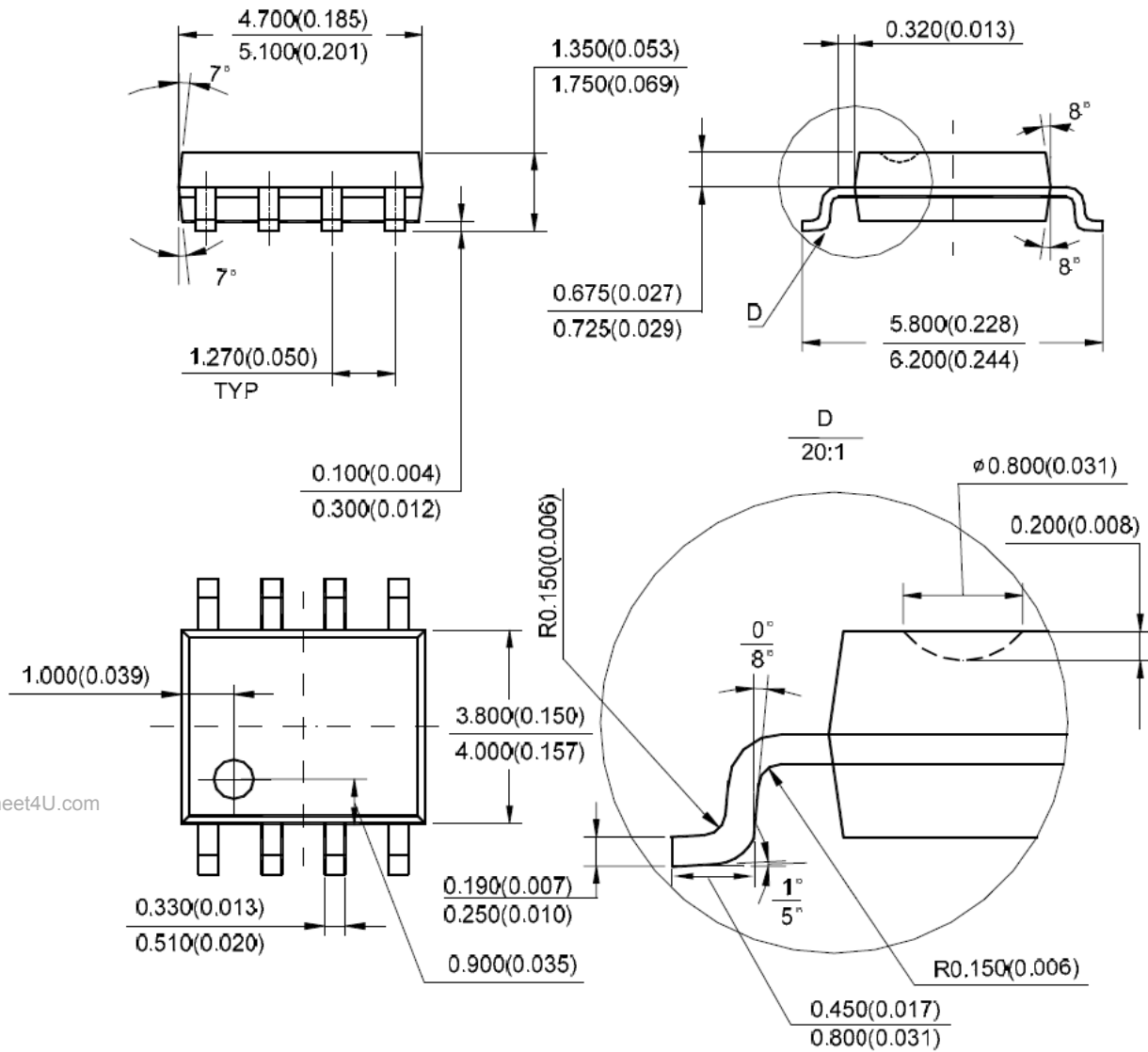
| Ref.             | Qty | Manufacturer     | Part Number    | Size      | Description                           |
|------------------|-----|------------------|----------------|-----------|---------------------------------------|
| U1               | 1   | EXAR             | XRP7657        | SOIC-8    | 2A 25V Non-synchronous Buck Regulator |
| D1               | 1   | Central Semicon. | CMSH3-40MA     | SMA       | Schotkky, 40V, 3A                     |
| L1               | 1   | Cooper Bussmann  | DR74-100       | 7.6x7.6mm | 10uH Coil 2.4A 48.9mOhm               |
| C <sub>IN</sub>  | 1   | Murata Corp.     | GRM32ER61E226K | 1210      | Ceramic Cap 22μF, 25V,X5R,1210        |
| C <sub>OUT</sub> | 1   | Murata Corp.     | GRM31CR61C226M | 1206      | Ceramic Cap 22μF, 16V,X5R, 1206       |
| CZ3              | 1   | Murata Corp.     | GRM188R71H331K | 0603      | Ceramic Cap 330pF, 50V,X7R, 0603      |
| CZ2              | 1   | Murata Corp.     | GRM188R71H272K | 0603      | Ceramic Cap 2700pF, 50v,X7R,0603      |
| R1               | 1   | Panasonic        | ERJ-3EKF6812V  | 0603      | Res 68.1k Ohm, 1%, 0603, SMD          |
| R2               | 1   | Panasonic        | ERJ-3EKF2152V  | 0603      | Res 21.5k Ohm, 1%, 0603 SMD           |
| RZ3              | 1   | Panasonic        | ERJ-3EKF1151V  | 0603      | Res 1.15k Ohm, 1%, 0603 SMD           |
| RZ2              | 1   | Panasonic        | ERJ-3EKF8061V  | 0603      | Res 8.06k Ohm, 1%, 0603 SMD           |

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## 2A, 25V Non Synchronous PWM Step Down Regulator

### PACKAGE SPECIFICATION

#### SOIC-8



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## 2A, 25V Non Synchronous PWM Step Down Regulator

### REVISION HISTORY

| Revision | Date     | Description                  |
|----------|----------|------------------------------|
| 1.0      | 09/25/09 | Initial Release of Datasheet |
|          |          |                              |
|          |          |                              |
|          |          |                              |

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