# LM5175 DC/DC Controller Design Tool

WIDE VIN DC/DC Power Solutions — Reliable Power for Demanding Systems

About xx = Input Box

http://www.ti.com/product/lm5175 TERMS OF USE

Industrial Automotive

## Step 1: Operating Specifications

| | |
|---|---|
| **Input Voltage - Min, $V_{IN(min)}$** | **9 V** |
| **Input Voltage - Nom, $V_{IN(nom)}$** | **15 V** |
| **Input Voltage - Max, $V_{IN(max)}$** | **42 V** |
| **Output Voltage, $V_{OUT}$** | **18 V** |
| **Full Load Output Current, $I_{OUT(max)}$** | **12 A** |
| **Switching Frequency** | **400 kHz** |
| Frequency Set Resistor, $R_T$ | 61.9 kΩ |

## Step 2: Filter Inductor

| | |
|---|---|
| Recommended Filter Inductance | 2.1 µH |
| **Inductance, $L_F$** | **3.3 µH** |
| **Inductor DCR** | **6 mΩ** |
| Pk-to-Pk Ripple Current at $V_{IN(min)}$, $\Delta I_{L1}$ | 3.5 $A_{pk-pk}$ |
| Pk-to-Pk Ripple Current at $V_{IN(nom)}$, $\Delta I_{L2}$ | 2.0 $A_{pk-pk}$ |
| Pk-to-Pk Ripple Current at $V_{IN(max)}$, $\Delta I_{L3}$ | 7.8 $A_{pk-pk}$ |
| $\Delta I_L$ as a % at $V_{IN(min)}$ | 14 % |
| $\Delta I_L$ as a % at $V_{IN(nom)}$ | 13 % |
| $\Delta I_L$ as a % at $V_{IN(max)}$ | 65 % |

## Step 3: OCP, Sense Resistors, Slope Comp

| | |
|---|---|
| **Required $I_{OCP(MIN)}$ Setpoint at $V_{IN(nom)}$** | **8 A** |
| Recommended Sense Resistance | 6.1 mΩ |
| **Sense Resistance, $R_S$** | **7 mΩ** |
| Peak Inductor Current, $I_{LPK}$ | 22.9 A |
| Power Loss in Rs at Full Load (Min VIN) | 2.25 W |
| Recommended SLOPE Capacitance | 120 pF |
| **SLOPE Capacitance, $C_{SLOPE}$** | **120 pF** |
| $V_{IN(min)}$ | 10.3 A |
| $I_{OUT(typ)}$ at OCP Inception: $V_{IN(nom)}$ | 8.6 A |
| $V_{IN(max)}$ | 15.4 A |
| **Required Const Current Loop Setpoint** | **N/A A** |
| Output Leg Shunt Resistance, $R_{CS(out)}$ | 0 mΩ |

## Step 4: Output Capacitor

| | |
|---|---|
| **Output Voltage Ripple Spec** | **120 $mV_{pk-pk}$** |
| Minimum Output Capacitance | 128.3 µF |
| **Output Capacitance, $C_{OUT}$** | **100 µF** |
| Maximum Permitted ESR | N/A mΩ |
| **Output Capacitor ESR** | **2 mΩ** |
| Resulting Output Voltage Ripple (max) | 178 $mV_{pk-pk}$ |
| Output Capacitor RMS Current (max) | 12.0 A (rms) |

## Step 5: Input Capacitor

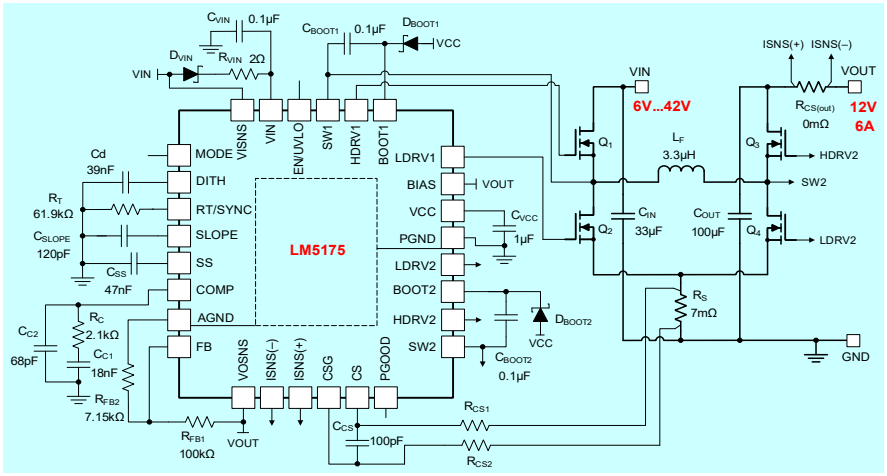
| | |
|---|---|
| **Input Voltage Ripple Spec** | **180 $mV_{pk-pk}$** |
| Minimum Input Capacitance | 41.7 µF |
| **Input Capacitance, $C_{IN}$** | **33 µF** |
| Maximum Permitted ESR | N/A mΩ |
| **Input Capacitor ESR** | **2 mΩ** |
| Resulting Input Voltage Ripple (max) | 259 $mV_{pk-pk}$ |
| Input Capacitor RMS Current (max) | 5.9 A (rms) |

## Step 6: Soft-start, Dither, UVLO

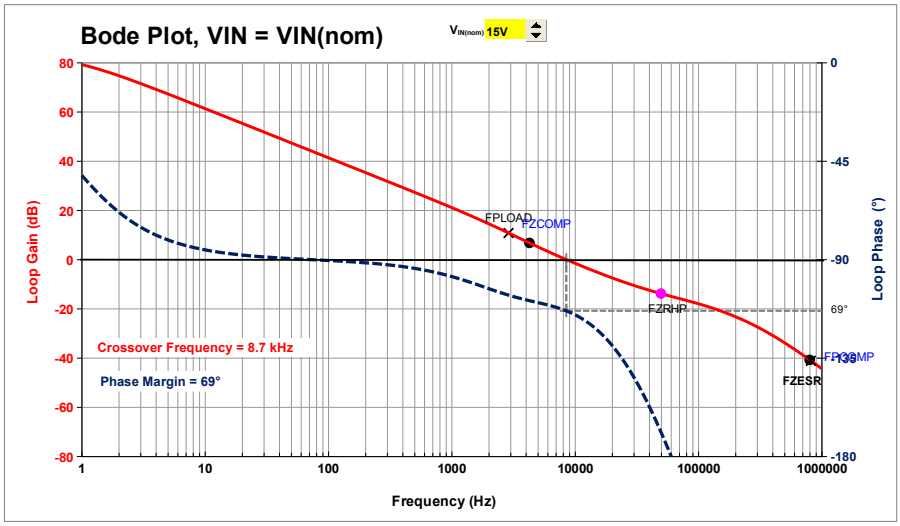
| | |
|---|---|
| **Soft-Start Time, $t_{SS}$** | **8 ms** |
| Soft-Start Capacitance, $C_{SS}$ | 47 nF |
| **Modulating Frequency** | **1 kHz** |
| DITH Capacitance, Cd | 39 nF |
| **Required Input Voltage UVLO On** | **5.5 V** |
| Input Voltage UVLO Off | 4.84 V |
| **Upper UVLO Resistor, $R_{UV1}$** | **200 kΩ** |
| Lower UVLO Resistor, $R_{UV2}$ | 52.3 kΩ |

## Step 7: Compensation Design

| | |
|---|---|
| Load Pole Frequency | 2878 Hz |
| $C_{OUT}$ ESR Zero Frequency | 796 kHz |
| Boost RHP Zero Frequency | 50 kHz |
| **Desired Crossover Frequency** | **8 kHz** |
| Error Amp Pole Frequency | 1 Hz |
| **Upper Feedback Resistor, $R_{FB1}$** | **100 kΩ** |
| Lower Feedback Resistor, $R_{FB2}$ | 4.64 kΩ |








### Compensation Components

| | Calculated / Std Values | | Selected | Actual P/Z Frequencies |
|---|---|---|---|---|
| $R_C$ | 3.7 | 3.74 | **3.74 kΩ** | 1 Hz ($F_{FEA}$) |
| $C_{C1}$ | 10.7 | 10 | **10 nF** | 4.3 kHz ($F_{ZCOMP}$) |
| $C_{C2}$ | 29 | 27 | **27 pF** | 814 kHz ($F_{PCOMP}$) |

Min COMP Voltage **0.85V**
Max COMP Voltage **2.77V**

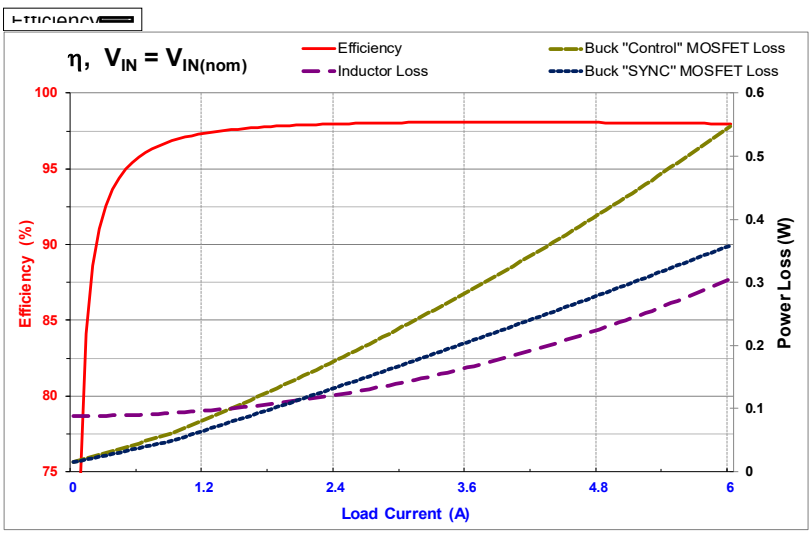
# Efficiency / Power Loss Analyzer

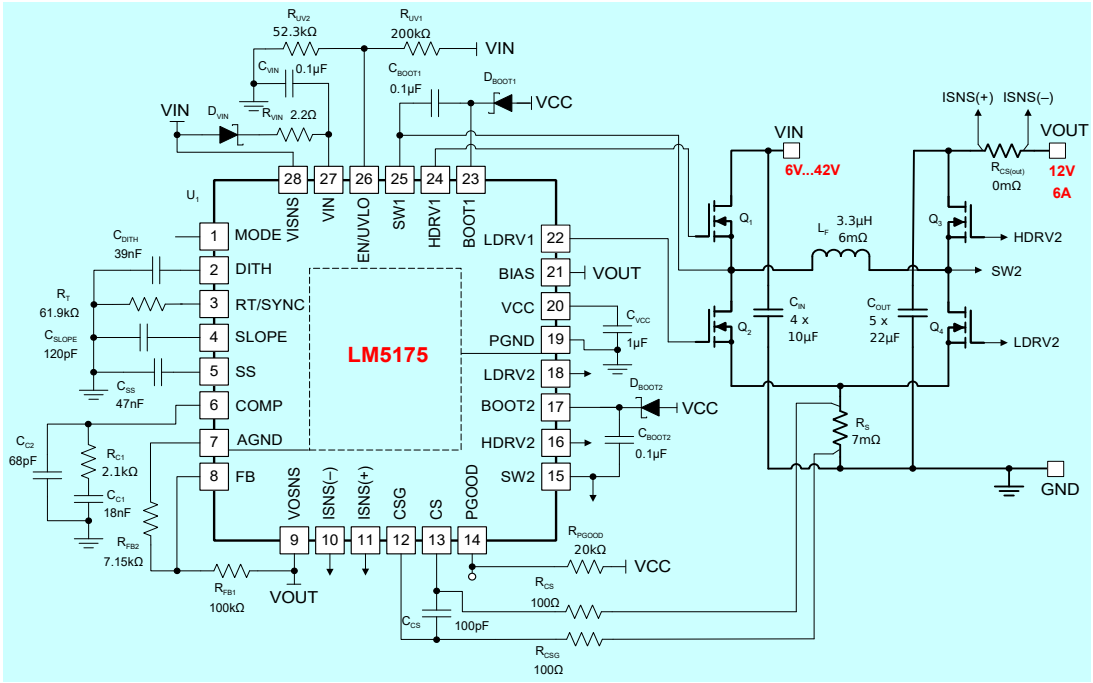
## Step 8: Efficiency

| *Buck*-Leg Power MOSFETs ($Q_1$, $Q_2$) CSD18563Q5A | Hi-side | Low-side |
|---|---|---|
| **On-State Resistance, $R_{DS(on)}$** | **5.7** | **5.7** mΩ |
| **Total Gate Charge, $Q_G$** | **11** | **11** nC |
| **Gate-Drain Charge, $Q_{GD}$** | **2.9** | **2.9** nC |
| **Gate-Source Charge, $Q_{GS}$** | **3.3** | **3.3** nC |
| **Gate Resistance, $R_G$** | **1.5** | **1.5** Ω |
| **Transconductance, $g_{FS}$** | **60** | **60** S |
| **Gate-Source Threshold Voltage, $V_{TH}$** | **4** | **4** V |
| **Body Diode Forward Voltage, $V_{SD}$** | **0.8** | **0.8** V |
| **Body Diode Rev Recovery Charge, $Q_{RR}$** | | **63** nC |
| **Thermal Resistance, $\theta_{JA}$** | **50** | **50** °C/W |

| *Boost*-Leg Power MOSFETs ($Q_3$, $Q_4$) CSD16321Q5 | Hi-side | Low-side |
|---|---|---|
| **On-State Resistance, $R_{DS(on)}$** | **1.9** | **1.9** mΩ |
| **Total Gate Charge, $Q_G$** | **22** | **22** nC |
| **Gate-Drain Charge, $Q_{GD}$** | **2.5** | **2.5** nC |
| **Gate-Source Charge, $Q_{GS}$** | **4** | **4** nC |
| **Gate Resistance, $R_G$** | **1.5** | **1.5** Ω |
| **Transconductance, $g_{FS}$** | **150** | **150** S |
| **Gate-Source Threshold Voltage, $V_{TH}$** | **2** | **2** V |
| **Body Diode Forward Voltage, $V_{SD}$** | **0.8** | **0.8** V |
| **Body Diode Rev Recovery Charge, $Q_{RR}$** | **33** | nC |
| **Thermal Resistance, $\theta_{JA}$** | **50** | **50** °C/W |

| External Schottky Diode (if applicable) | *Buck* Leg | *Boost* Leg |
|---|---|---|
| **Schottky Fwd Voltage, $V_{FWDsch}$** | **0** | **0** V |
| **Schottky Rev Recovery Charge, $Q_{RRsch}$** | **0** | **0** nC |






** Tie MODE to VCC (or voltage > 2.4V) for CCM, GND for DCM **

**VIN = 9 V to 42 V, VOUT = 18 V, IOUT = 12 A, Fsw = 400 kHz, Current Limit = 8 A**

## High Efficiency Synchronous Buck-Boost Regulator BOM

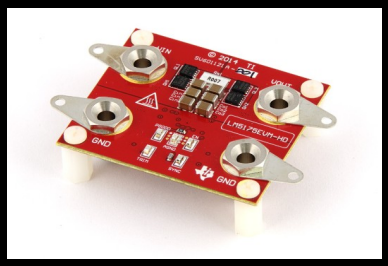
| Count | Ref Des | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|
| 2 | $C_{BOOT1}$, $C_{BOOT2}$ | 0.1µF | Capacitor, Ceramic, 0.1-µF, 50V, X7R, 20% | 0603 | Std | Std |
| 1 | $C_{C1}$ | 10nF | Capacitor, Ceramic, 10-nF, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | $C_{C2}$ | 27pF | Capacitor, Ceramic, 27-pF, 50V, NP0, 5% | 0603 | Std | Std |
| 1 | $C_{SLOPE}$ | 120pF | Capacitor, Ceramic, 120-pF, 50V, NP0, 5% | 0603 | Std | Std |
| 1 | $C_{CS}$ | 100pF | Capacitor, Ceramic, 100-pF, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | $C_{DITH}$ | 39nF | Capacitor, Ceramic, 39-nF, 16V, X7R, 10% | 0603 | Std | Std |
| 4 | $C_{IN}$ | 10µF | Capacitor, Ceramic, 10-µF, 50V, X7R, 20% | 1210 | Std | Std |
| 5 | $C_{OUT}$ | 22µF | Capacitor, Ceramic, 22-µF, 25V, X5R, 20% | 1210 | Std | Std |
| 1 | $C_{SS}$ | 47nF | Capacitor, Ceramic, 47-nF, 16V, X7R, 10% | 0603 | Std | Std |
| 1 | $C_{VCC}$ | 1µF | Capacitor, Ceramic, 1-µF, 25V, X7R, 20% | 0603 | Std | Std |
| 1 | $C_{VIN}$ | 0.1µF | Capacitor, Ceramic, 0.1-µF, 100V, X7R, 20% | 0603 | Std | Std |
| 3 | $D_{BOOT1}$, $D_{BOOT2}$, $D_{VIN}$ | See description | Schottky Diode, 200mA | - | - | Various |
| 1 | $L_F$ | 3.3µH | Inductor, 3.3µH, 6mΩ, >26A | - | - | Various |
| 2 | $Q_1$, $Q_2$ | See description | MOSFET, N-CH, 60V, 5.7mΩ | Std | CSD18563Q5A | - |
| 2 | $Q_3$, $Q_4$ | See description | MOSFET, N-CH, 60V, 1.9mΩ | Std | CSD16321Q5 | - |
| 1 | $R_{C1}$ | 3.74k | Resistor, Chip, 3.74-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_S$ | 7m | Resistor, Chip, 7-mΩ, 2W, 1% | 2512 | Std | Std |
| 1 | $R_{CS(out)}$ | 0m | Resistor, Chip, 0-mΩ, 2W, 1% | 2512 | Std | Std |
| 1 | $R_T$ | 61.9k | Resistor, Chip, 61.9-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{FB1}$ | 100k | Resistor, Chip, 100-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{FB2}$ | 4.64k | Resistor, Chip, 4.64-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{PGOOD}$ | 20k | Resistor, Chip, 20-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 2 | $R_{CS}$, $R_{CSG}$ | 100 | Resistor, Chip, 100-Ω, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{UV1}$ | 200k | Resistor, Chip, 200-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{UV2}$ | 52.3k | Resistor, Chip, 52.3-kΩ, 1/16W, 1% | 0603 | Std | Std |
| 1 | $R_{VIN}$ | 2.2 | Resistor, Chip, 2.2-Ω, 1/16W, 1% | 0603 | Std | Std |
| **1** | **$U_1$** | **LM5175** | **IC, LM5175, Buck-Boost PWM Controller, 3.5V–42V Input** | **QFN-28**<br>**TSSOP-28** | **LM5175RHF**<br>**LM5175PWP** | **TI** |

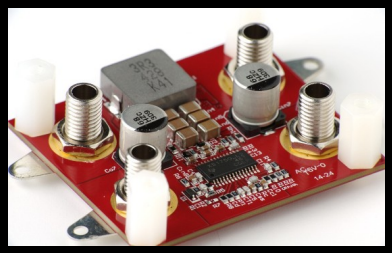
**NOTES:**

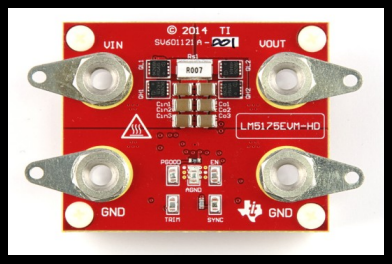
** For information on TI NexFET™ MOSFETs, see ** http://www.ti.com/nexfet **
** Inductor saturation current should be higher than the peak inductor current at the OCP setpoint for all input voltages and operating temperatures **
** Effective input and output capacitances should be appropriately derated for applied voltage and temperature, particularly with ceramics **

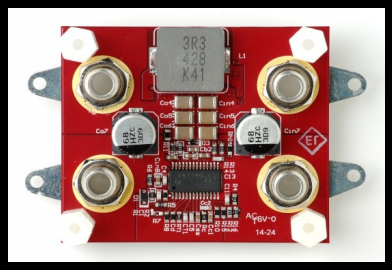
# LM5175 Quickstart Design Tool

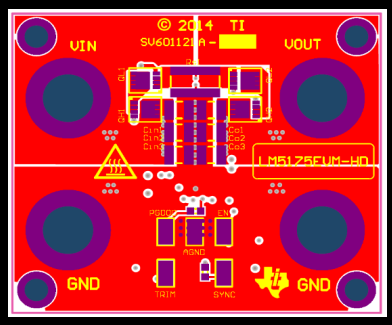
LM5175EVM-HD PCB Layout

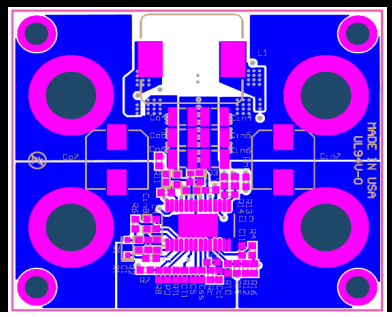




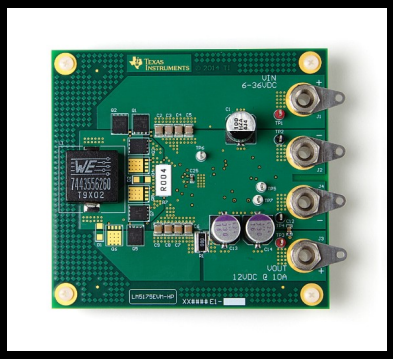


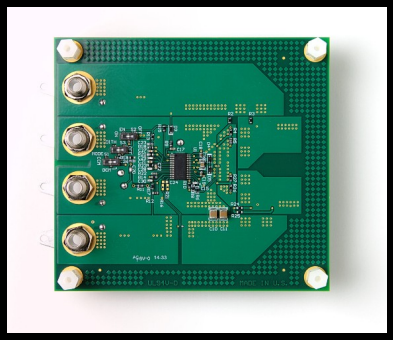





LM5175EVM-HP PCB Layout





LM5175EVM PCB Layout