



About

  = Input Box

TERMS OF USE

## Step 1: Operating Specifications

Input Voltage - Min, $V_{IN(min)}$	10 V
Input Voltage - Nom, $V_{IN(nom)}$	13 V
Input Voltage - Max, $V_{IN(max)}$	15 V
Output Voltage, $V_{OUT}$	12 V
Full Load Output Current, $I_{OUT(max)}$	4 A
Switching Frequency	400 kHz
Frequency Set Resistor, $R_T$	61.9 k $\Omega$

## Step 2: Filter Inductor

Recommended Filter Inductance	2.3 $\mu$ H
Inductance, $L_F$	2.2 $\mu$ H
Inductor DCR	17 m $\Omega$
PK-to-PK Ripple Current at $V_{IN(min)}$ , $\Delta I_{L1}$	2.0 A <sub>pk-pk</sub>
PK-to-PK Ripple Current at $V_{IN(nom)}$ , $\Delta I_{L2}$	1.1 A <sub>pk-pk</sub>
PK-to-PK Ripple Current at $V_{IN(max)}$ , $\Delta I_{L3}$	2.7 A <sub>pk-pk</sub>
$\Delta I_L$ as a % at $V_{IN(nom)}$	40 %
$\Delta I_L$ as a % at $V_{IN(min)}$	26 %
$\Delta I_L$ as a % at $V_{IN(max)}$	69 %

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

Required $I_{OCP(MIN)}$ Setpoint at $V_{IN(nom)}$	5 A
Recommended Sense Resistance	17.9 m $\Omega$
Sense Resistance, $R_S$	18 m $\Omega$
Peak Inductor Current, $I_{L(pk)}$	8.9 A
Power Loss in $R_S$ at Full Load (Min VIN)	0.08 W
Recommended SLOPE Capacitance	33 pF
SLOPE Capacitance, $C_{SLOPE}$	33 pF
$V_{IN(min)}$	6.5 A
$I_{OUT(tp)}$ at OCP Inception: $V_{IN(nom)}$	5.0 A
$V_{IN(nom)}$	5.8 A
$V_{IN(max)}$	5.8 A
Required Const Current Loop Setpoint	N/A A
Output Leg Shunt Resistance, $R_{CS(OUT)}$	0 m $\Omega$

## Step 4: Output Capacitor

Output Voltage Ripple Spec	120 mV <sub>pk-pk</sub>
Minimum Output Capacitance	22.0 $\mu$ F
Output Capacitance, $C_{OUT}$	89 $\mu$ F
Maximum Permitted ESR	25.0 m $\Omega$
Output Capacitor ESR	4 m $\Omega$
Resulting Output Voltage Ripple (max)	36 mV <sub>pk-pk</sub>
Output Capacitor RMS Current (max)	1.8 A (rms)

## Step 5: Input Capacitor

Input Voltage Ripple Spec	180 mV <sub>pk-pk</sub>
Minimum Input Capacitance	10.0 $\mu$ F
Input Capacitance, $C_{IN}$	22 $\mu$ F
Maximum Permitted ESR	20.2 m $\Omega$
Input Capacitor ESR	4 m $\Omega$
Resulting Input Voltage Ripple (max)	93 mV <sub>pk-pk</sub>
Input Capacitor RMS Current (max)	1.6 A (rms)

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

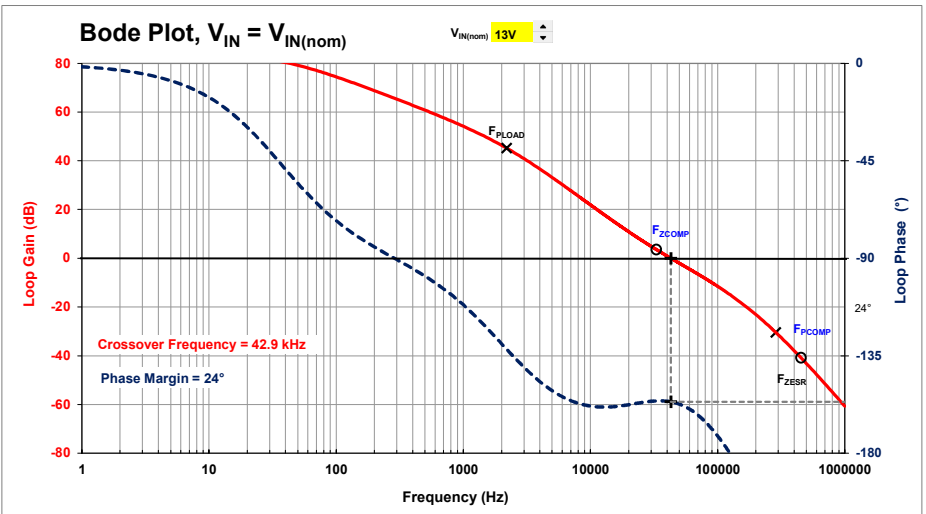
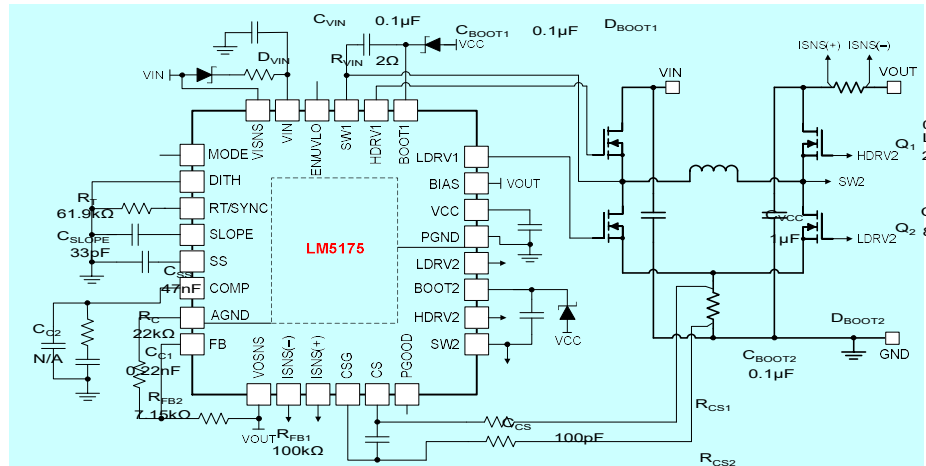
Soft-Start Time, $t_{SS}$	8 ms
Soft-Start Capacitance, $C_{SS}$	47 nF
DITHER Disabled	
*Short DITH pin to GND	
Required Input Voltage UVLO On	5.5 V
Input Voltage UVLO Off	4.84 V
Upper UVLO Resistor, $R_{UV1}$	200 k $\Omega$
Lower UVLO Resistor, $R_{UV2}$	52.3 k $\Omega$

## Step 7: Compensation Design

Load Pole Frequency	2191 Hz
$C_{OUT}$ ESR Zero Frequency	452 kHz
Boost RHP Zero Frequency	1 kHz
Desired Crossover Frequency	50 kHz
Error Amp Pole Frequency	36 Hz
Upper Feedback Resistor, $R_{FB1}$	100 k $\Omega$
Lower Feedback Resistor, $R_{FB2}$	7.15 k $\Omega$

## Compensation Components

Calculated / Std Values	Selected	Actual P/Z Frequencies
$R_C$ 29.4 / 29.4	22 k $\Omega$	36 Hz ( $F_{FEA}$ )
$C_{C1}$ 0.2 / 0.22	0.22 nF	32.9 kHz ( $F_{ZCOMP}$ )
$C_{C2}$ 0 / 0	0 pF	286 kHz ( $F_{PCOMP}$ )



## Efficiency / Power Loss Analyzer

### Step 8: Efficiency

Buck-Leg Power MOSFETs ( $Q_1, Q_2$ ) BSC0702LS		Hi-side	Low-side
On-State Resistance, $R_{DS(on)}$	2.7	2.7	m $\Omega$
Total Gate Charge, $Q_G$	24	24	nC
Gate-Drain Charge, $Q_{GD}$	8	8	nC
Gate-Source Charge, $Q_{GS}$	10	10	nC
Gate Resistance, $R_G$	1.3	1.3	$\Omega$
Transconductance, $g_{FS}$	120	120	S
Gate-Source Threshold Voltage, $V_{TH}$	1.7	1.7	V
Body Diode Forward Voltage, $V_{BD}$	0.8	0.8	V
Body Diode Rev Recovery Charge, $Q_{RR}$		36	nC
Thermal Resistance, $\theta_{JA}$	50	50	°C/W

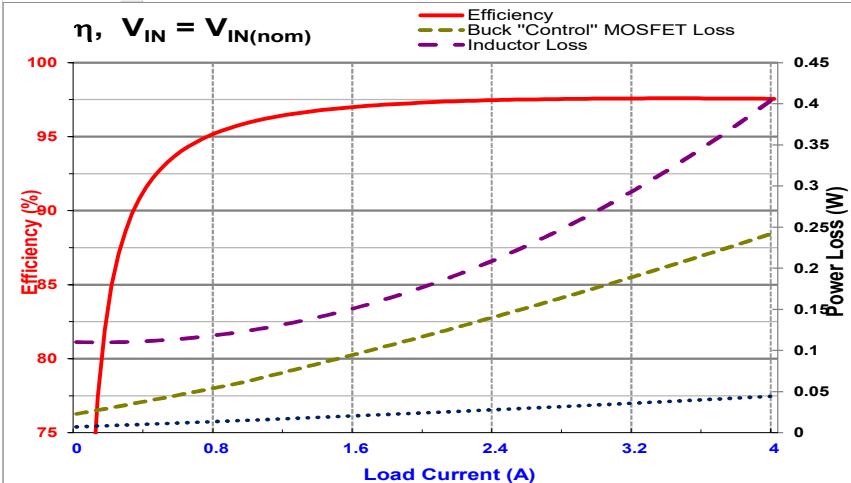
  

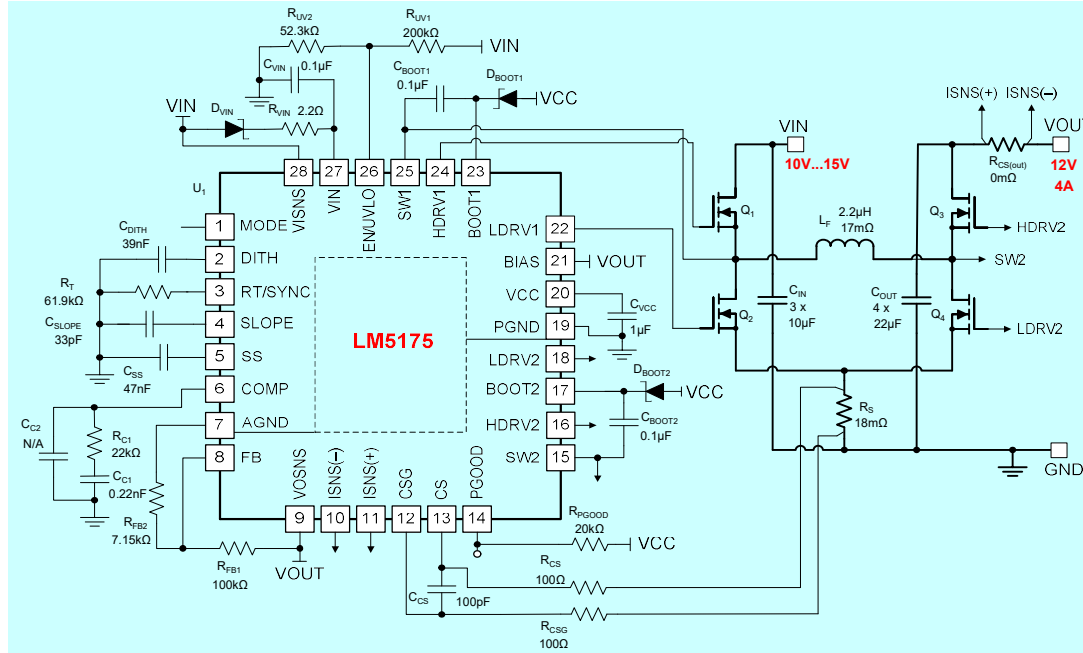
Boost-Leg Power MOSFETs ( $Q_1, Q_2$ ) RU3040M2		Hi-side	Low-side
On-State Resistance, $R_{DS(on)}$	5.8	8.2	m $\Omega$
Total Gate Charge, $Q_G$	13	13	nC
Gate-Drain Charge, $Q_{GD}$	5.5	5.5	nC
Gate-Source Charge, $Q_{GS}$	3.8	3.8	nC
Gate Resistance, $R_G$	1	1	$\Omega$
Transconductance, $g_{FS}$	125	125	S
Gate-Source Threshold Voltage, $V_{TH}$	1.8	1.8	V
Body Diode Forward Voltage, $V_{BD}$	1.2	1.2	V
Body Diode Rev Recovery Charge, $Q_{RR}$	9	9	nC
Thermal Resistance, $\theta_{JA}$	35	35	°C/W

External Schottky Diode (if applicable)		Buck Leg	Boost Leg
Schottky Fwd Voltage, $V_{FSDsch}$	0.35	0.35	V
Schottky Rev Recovery Charge, $Q_{RRsch}$	0	0	nC

Efficiency vs IOUT Plot





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

VIN = 10 V to 15 V, VOUT = 12 V, IOUT = 4 A, Fsw = 400 kHz, Current Limit = 5 A

### High Efficiency Synchronous Buck-Boost Regulator BOM

Count	Ref Des	Value	Description	Size	Part Number	MFR
2	C <sub>BOOT1</sub> , C <sub>BOOT2</sub>	0.1µF	Capacitor, Ceramic, 0.1-µF, 50V, X7R, 20%	0603	Std	Std
1	C <sub>C1</sub>	0.22nF	Capacitor, Ceramic, 0.22-nF, 16V, X7R, 10%	0603	Std	Std
1	C <sub>C2</sub>	0pF	Capacitor, Ceramic, 0-pF, 50V, NP0, 5%	0603	Std	Std
1	C <sub>SLOPE</sub>	33pF	Capacitor, Ceramic, 33-pF, 50V, NP0, 5%	0603	Std	Std
1	C <sub>CS</sub>	100pF	Capacitor, Ceramic, 100-pF, 16V, X7R, 10%	0603	Std	Std
1	C <sub>DITH</sub>	39nF	Capacitor, Ceramic, 39-nF, 16V, X7R, 10%	0603	Std	Std
3	C <sub>IN</sub>	10µF	Capacitor, Ceramic, 10-µF, 50V, X7R, 20%	1210	Std	Std
4	C <sub>OUT</sub>	22µF	Capacitor, Ceramic, 22-µF, 25V, X5R, 20%	1210	Std	Std
1	C <sub>SS</sub>	47nF	Capacitor, Ceramic, 47-nF, 16V, X7R, 10%	0603	Std	Std
1	C <sub>VCC</sub>	1µF	Capacitor, Ceramic, 1-µF, 25V, X7R, 20%	0603	Std	Std
1	C <sub>VIN</sub>	0.1µF	Capacitor, Ceramic, 0.1-µF, 100V, X7R, 20%	0603	Std	Std
3	D <sub>BOOT1</sub> , D <sub>BOOT2</sub> , D <sub>VIN</sub>	See description	Schottky Diode, 200mA	-	-	Various
1	L <sub>F</sub>	2.2µH	Inductor, 2.2µH, 17mΩ, >10A	-	-	Various
2	Q <sub>1</sub> , Q <sub>2</sub>	See description	MOSFET, N-CH, 60V, 2.7mΩ	Std	BSC0702LS	-
2	Q <sub>3</sub> , Q <sub>4</sub>	See description	MOSFET, N-CH, 60V, 5.8mΩ	Std	RU3040M2	-
1	R <sub>C1</sub>	22k	Resistor, Chip, 22-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>S</sub>	18m	Resistor, Chip, 18-mΩ, 2W, 1%	2512	Std	Std
1	R <sub>CS(out)</sub>	0m	Resistor, Chip, 0-mΩ, 2W, 1%	2512	Std	Std
1	R <sub>T</sub>	61.9k	Resistor, Chip, 61.9-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>FB1</sub>	100k	Resistor, Chip, 100-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>FB2</sub>	7.15k	Resistor, Chip, 7.15-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>PG00D</sub>	20k	Resistor, Chip, 20-kΩ, 1/16W, 1%	0603	Std	Std
2	R <sub>CS</sub> , R <sub>CSG</sub>	100	Resistor, Chip, 100-Ω, 1/16W, 1%	0603	Std	Std
1	R <sub>UV1</sub>	200k	Resistor, Chip, 200-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>UV2</sub>	52.3k	Resistor, Chip, 52.3-kΩ, 1/16W, 1%	0603	Std	Std
1	R <sub>VIN</sub>	2.2	Resistor, Chip, 2.2-Ω, 1/16W, 1%	0603	Std	Std
1	U <sub>1</sub>	LM5175	IC, LM5175, Buck-Boost PWM Controller, 3.5V-42V Input	QFN-28 TSSOP-28	LM5175RHF 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 \*\*