EVAL-LT8292-BZ

60V Synchronous Buck-Boost Controller

General Description

The evaluation circuit EVAL-LT8292-BZ features the LT®8292: a parallelable 4-switch synchronous buck-boost controller. The LT8292 regulates the output voltage and output or input current from an input voltage below, equal to, or above the output voltage. With a wide 5.5V to 60V input range and a seamless transition between operating regions, the LT8292 is ideal for automotive, industrial, and telecom systems. The buck-boost peak current mode architecture allows adjustable phase-lockable 100kHz to 650kHz fixed frequency operation or internal spread spectrum operation for low electromagnetic interference (EMI). Additionally, the LT8292 features ISHARE and IGND pins, allowing for multi-IC leaderless current-sharing capabilities for higher-power applications.

The EVAL-LT8292-BZ operates from a 9V to 36V input voltage range and generates an output of 12V. A maximum output current of 25A allows up to 300W power delivery while achieving efficiencies that exceed 97%. The switching frequency is set to 100kHz to achieve high power and efficiency. The board can also be modified to support larger MOSFETs for higher power.

The output voltage and EN/UVLO are both programmed by resistor dividers. The LT8292 supports an output voltage range from 1V to 60V with a 2% tolerance. EN/UVLO is set so the circuit will turn off when the input voltage falls below 8.1V and will turn on when the input voltage rises above 8.5V.

The LT8292 utilizes split pull-up/pull-down gate drivers and four selectable dead time settings. The EVAL-LT8292-BZ allows for simple alterations to optimize these features.

The PGOOD status flag indicates when the output voltage is within ±8% of the final regulation voltage.

The EVAL-LT8292-BZ features MOSFETs that complement the 5V gate drive of the LT8292 to achieve high efficiency. 40V MOSFETs are used on the input and output sides of the four-switch topology. Ceramic capacitors are used at both the circuit input and output because of their small size and high ripple current capability. In addition to ceramic capacitors, there are bulk aluminum polymer capacitors on the input and output to make input and output stable during the transient period.

The ICTRL input is pulled up to the V_{REF} pin through a 100kΩ resistor to set the output current limit to its maximum, and an external voltage on the ICTRL pin can be used to lower the current limit. A capacitor at the SS pin programs soft-start.

High power operation, parallel capability, 5.5V input voltage operation, 4-switch buck-boost topology, proprietary peak current mode architecture, fault protection, and output current limiting make the LT8292 attractive for high power voltage regulator circuits.

The LT8292AFE is available in a thermally enhanced 38-lead TSSOP package. The LT8292 data sheet gives a complete description of this part, its operation, and applications information. The LT8292 data sheet must be read in conjunction with this user guide to properly use the evaluation circuit EVAL-LT8292-BZ. The evaluation circuit is designed to be easily reconfigured to suit other applications. Consult the factory for assistance.

Design files for this circuit board are available.

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Performance Summary (T_A = 25°C)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			9		36	V
Output Voltage	V_{OUT}				12		V
Maximum Output Current	I_{OUT}	No Heatsink, No Airflow			25		A
Gate Driver Supply Voltage	$INTV_{CC}$				5.0		V
V_{IN} Undervoltage Lockout (UVLO) Falling	$V_{EN/UVLO(-)}$	R9 = 499kΩ, R10 = 80.6kΩ			8.1		V
V_{IN} Enable Turn-On (EN) Rising	$V_{EN/UVLO(+)}$	R9 = 499kΩ, R10 = 80.6kΩ			8.5		V
Switching Dead Time	t_{DELAY}	$R_{DT1,DT2}$ = 0Ω to $INTV_{CC}$			40		ns
Switching Frequency	f_{SW}	R_T = 523kΩ			100		kHz
Efficiency	η	I_{OUT} = 25A	V_{IN} = 9V		96.5		%
			V_{IN} = 12V		97.1		%
			V_{IN} = 36V		96.3		%

Quick Start Procedure

The EVAL-LT8292-BZ is easy to set up to evaluate the performance of the LT8292AFE. See *Figure 1* for proper equipment setup and use the following procedure:

1. Set JP1 to Burst.
2. Connect the EN/UVLO to the ground with clip-on leads.
3. With the power supply off, connect the positive terminal of the power supply to V_{IN} and the negative terminal to GND.
4. Connect the load (<10A) between the OUT and GND terminals.
5. Set the power supply to 12V and turn it on.
   Note: Ensure that the voltage applied to V_{IN} does not exceed 40V, which is the voltage rating for input side MOSFETs.
6. Remove the clip-on leads from EN/UVLO. Verify that the output voltage is 12V.
   Note: If the output voltage is low, temporarily disconnect the load to ensure that it is not set too high.
7. Once the proper output voltage is established, adjust the input voltage and load within the operating ranges and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.
   Note: When measuring the input or output voltage ripple, care must be taken to minimize the length of the oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the V_{IN} or V_{OUT} and GND terminals, preferably across the input or output capacitors.

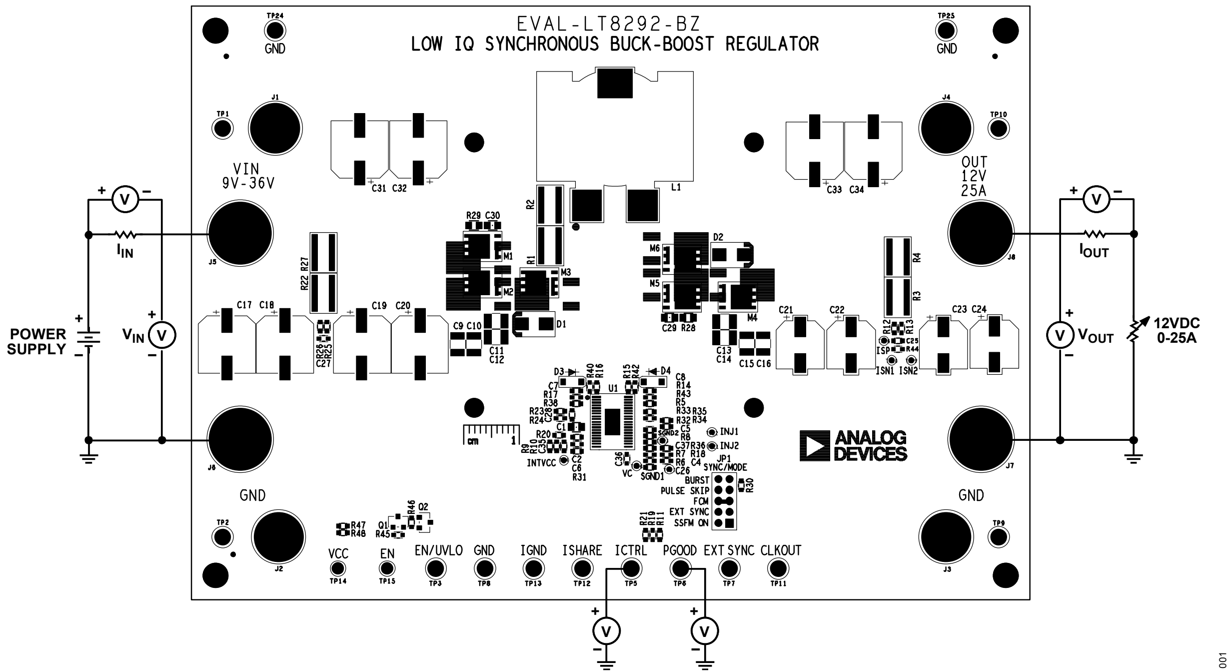


Figure 1. EVAL-LT8292-BZ Board Connections

Adjust Output Voltage

To change the output voltage from the programmed 12V, change R7 and R8. Refer to the Programming Output Voltage and Thresholds section in the data sheet to calculate the V_{FB} resistor divider values for the desired output voltage. All the corresponding components must also be adjusted to handle the desired output voltage.

Thermal Performance

The EVAL-LT8292-BZ features excellent thermal performance across its entire input voltage range due to the high efficiency of the synchronous buck-boost circuit operation. The component temperatures of EVAL-LT8292-BZ with a typical 12V output and 25A load are shown in Figure 9–Figure 11. The four-layer printed circuit board (PCB) layout features solid copper planes that help spread the heat across the entire board.

Parallel Multiple ICs

The LT8292 is designed to easily be paralleled for even higher output power. This can be achieved by tying all ISHARE pins together and kelvin connecting all IGND pins to a common GND.

The CLKOUT pin of the LT8292 IC provides a 180° out-of-phase clock signal fixed at a 50% duty cycle. For an interleaved dual-phase operation, the CLKOUT pin of the first phase can be connected to the SYNC/MODE pin of the second IC. In this configuration, it is recommended the first phase be set to fixed-frequency forced continuous mode (FCM) by floating the SYNC/MODE pin.

Start-Up and Shutdown with a Microcontroller

The circuit enable and undervoltage lockout is set with a resistor divider to the EN/UVLO pin. The EVAL-LT8292-BZ also has optional circuitry that can be populated to enable and disable the channels through a microcontroller. The circuitry ensures proper start-up and shutdown when using a microcontroller. To utilize, populate Q1, Q2, R45, and either R47 or R48. The microcontroller signal can be applied to EN.

Select Mode of Operation

JP1 on EVAL-LT8292-BZ selects the different modes of operation.

1. EXT SYNC: For external frequency synchronization and FCM.
2. SSFM ON: For spread spectrum around internal oscillator frequency and FCM.
3. FCM: For internal oscillator frequency and FCM at light load.
4. PULSE SKIP: For internal oscillator frequency and pulse-skipping mode at light load.
5. BURST: For internal oscillator frequency and low ripple Burst® mode at light load.

Select Dead Times

The LT8292 has four selectable dead time settings for the Buck side switching and the Boost side switching, pins R_{DT1} and R_{DT2}, respectively. A single resistor is used for each pin, R_{DT1} and R_{DT2}, to set the dead times. Setting the dead time too small or too large could cause shoot-through or extended body-diode conduction, respectively. Both cases can damage the corresponding MOSFETs; therefore, careful consideration must be given to optimizing dead times for specific applications. The EVAL-LT8292-BZ is assembled with R32, R33 = OPEN and R34, R35 = 0Ω, setting a default dead time of 40ns for both the Buck and Boost side switching.

R32, R33	R34, R35	R_{DT1}, R_{DT2} CONNECTION	DEAD TIME
OPEN	0Ω	To $INTV_{CC}$	40ns*
130kΩ	OPEN	To GND	20ns
82kΩ	OPEN	To GND	10ns
51kΩ	OPEN	To GND	2ns

**Denotes default.*

Performance

(T_A = 25°C, unless otherwise noted.)

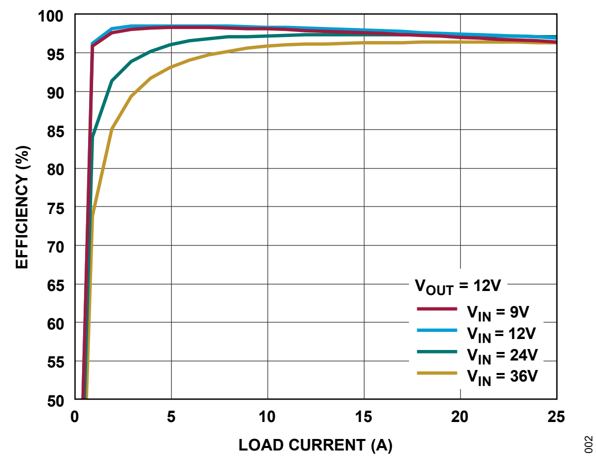


Figure 2. Efficiency vs. Load Current (no Heatsink)

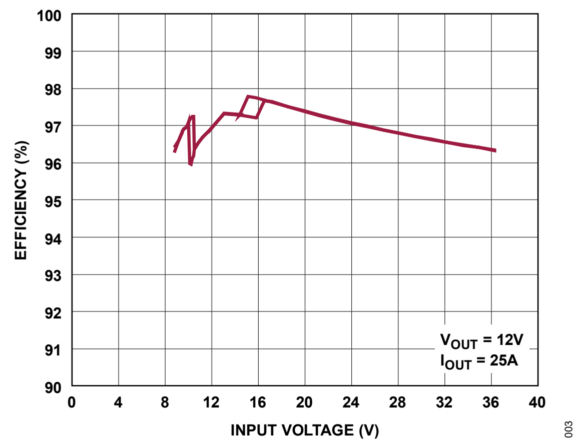


Figure 3. Efficiency vs. Input voltage at I_{OUT} = 25A (No Heatsink)

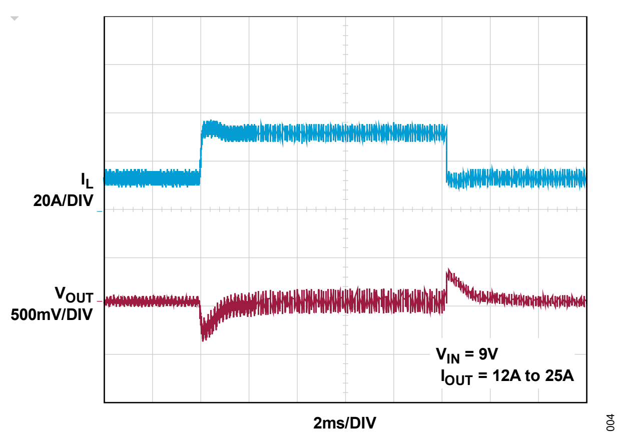


Figure 4. Load Transient Response at V_{IN} = 9V, I_{OUT} = 12A to 25A

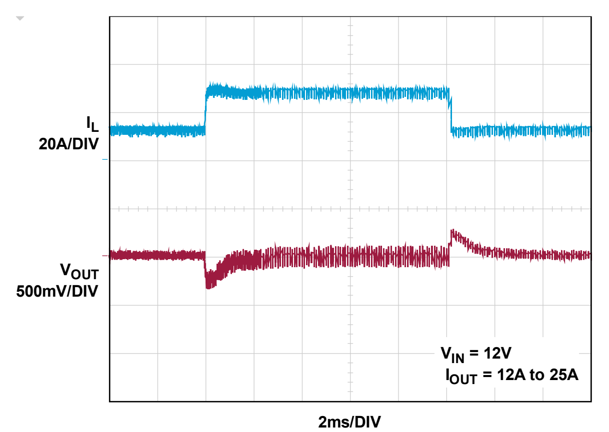


Figure 5. Load Transient Response at V_{IN} = 12V, I_{OUT} = 12A to 25A

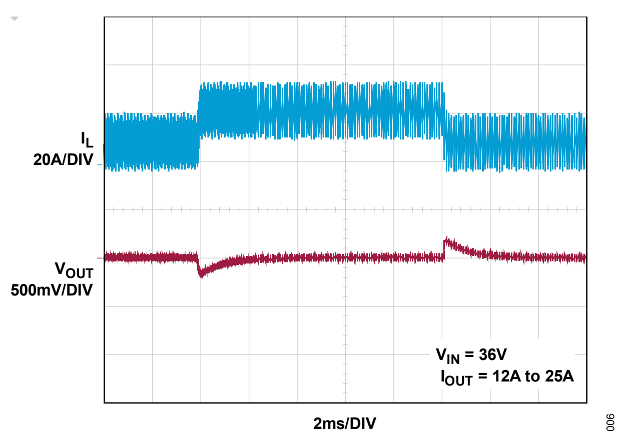


Figure 6. Load Transient Response at V_{IN} = 36V, I_{OUT} = 12A to 25A

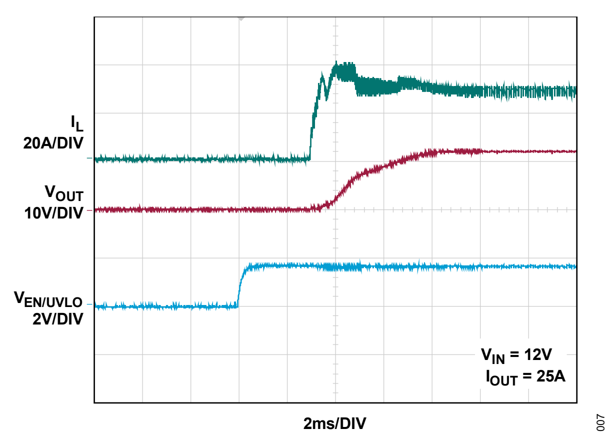


Figure 7. Start-Up at V_{IN} = 12V, I_{OUT} = 25A

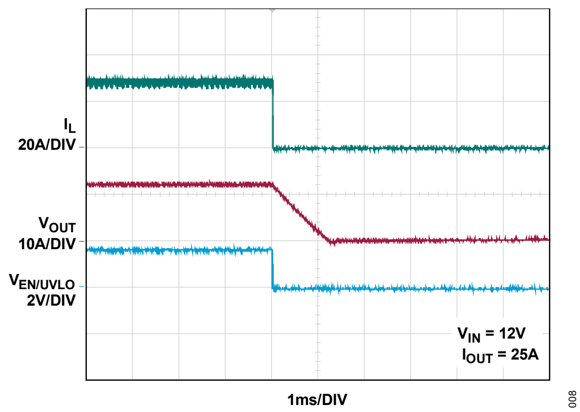


Figure 8. Shutdown at V_{IN} = 12V, I_{OUT} = 25A

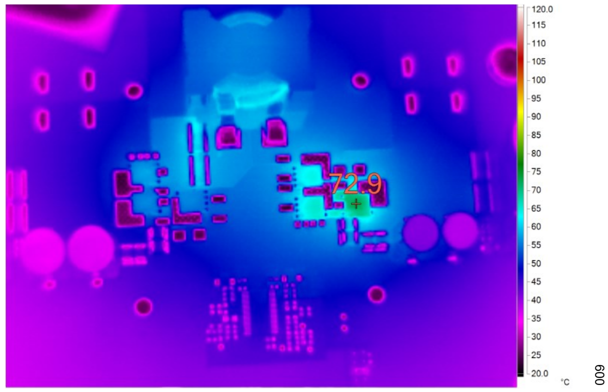


Figure 9. Thermal Image at V_{IN} = 9V, V_{OUT} = 12V, I_{OUT} = 25A

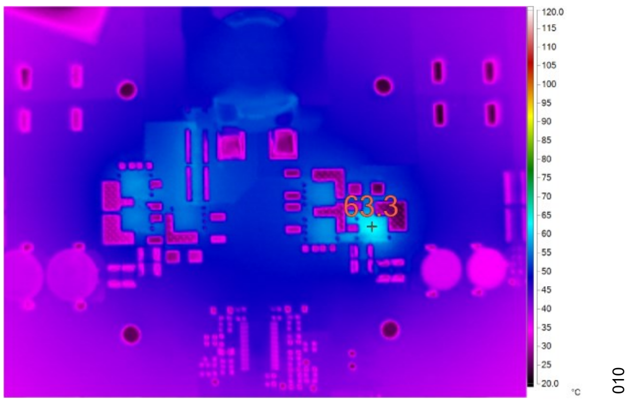


Figure 10. Thermal Image at V_{IN} = 12V, V_{OUT} = 12V, I_{OUT} = 25A

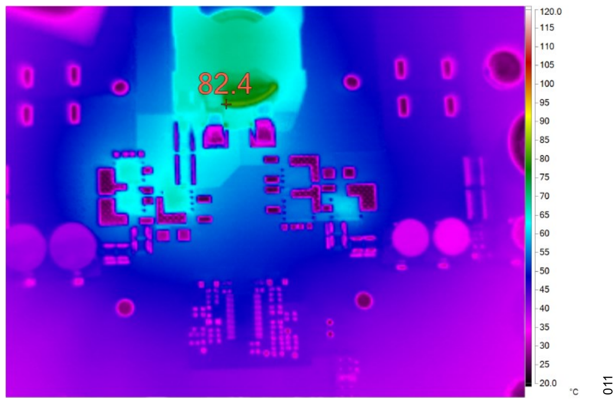


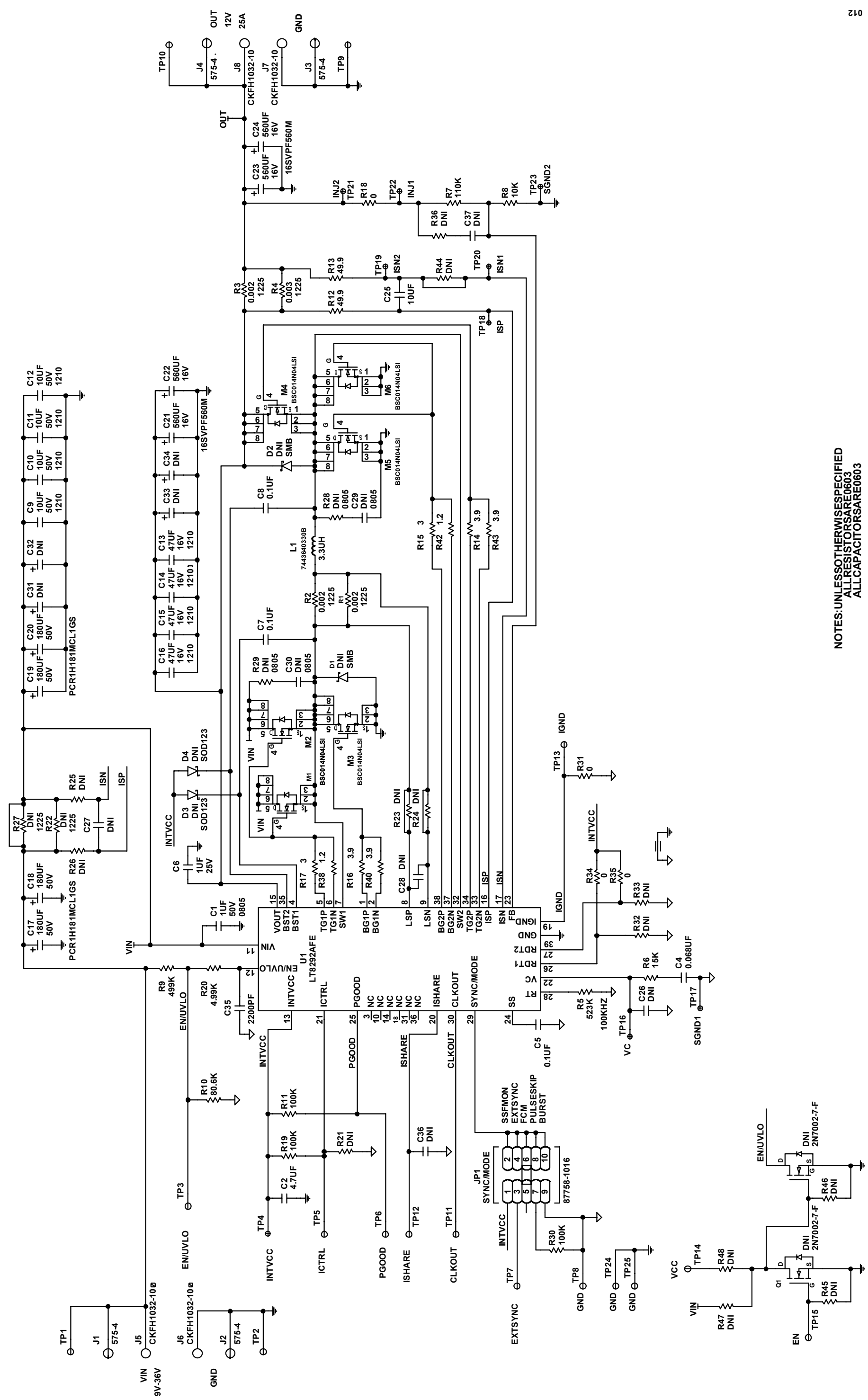
Figure 11. Thermal Image at V_{IN} = 36V, V_{OUT} = 12V, I_{OUT} = 25A

Bill of Materials

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART #
REQUIRED CIRCUIT COMPONENTS				
1	1	C1	CAP CER, 1µF, 50V, 10%, X7R 0805, AEC-Q200	MURATA, GCM21BR71H105KA03L
2	4	C9, C10, C11, C12	CAP CER 10µF, 50V, 10%, X7R 1210	MURATA, GRM32ER71H106KA12L
3	4	C13, C14, C15, C16	CAP CER 47µF, 16V, 20%, X5R 1210	AVX CORPORATION, 1210YD476MAT2A
4	4	C17, C18, C19, C20	CAP ALUM POLY 180UF, 50V, 20%, 10x12.7mm, AEC-Q200 0.038Ω 3.5A 4000H	NICHICON CORPORATION, PCR1H181MCL1GS
5	1	C2	CAP CER 4.7µF, 10V, 10%, X5R 0603	KEMET, C0603C475K8PACTU
6	4	C21, C22, C23, C24	CAP ALUM POLY 560UF, 16V, 20%, 8x10mm, 0.014Ω, 4.95A 5000H	PANASONIC, 16SVPF560M
7	1	C25	CAP CER 10µF, 25V, 20%, X5R 0603	MURATA, GRM188R61E106MA73D
8	1	C35	CAP CER 2200pF, 50V, 10%, X7R 0603	SAMSUNG, CL10B222KB8NNNC
9	1	C4	CAP CER 0.068UF, 25V, 10%, X7R 0603	KYOCERA, KGM15BR71E683KT
10	3	C5, C7, C8	CAP CER 0.1µF, 25V, 10%, X7R 0603	KEMET, C0603C104K3RACTU
11	1	C6	CAP CER 1µF, 25V, 10%, X7R 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
12	1	L1	IND POWER CHOKE SHIELDED WIREWOUND 3.3UH, 20%, 100KHZ, 47.5A 0.00088Ω, AEC-Q200	WURTH ELEKTRONIK, 7443640330B
13	6	M1, M2, M3, M4, M5, M6	TRAN N-CH POWER MOSFET 100A	INFINEON TECHNOLOGIES, BSC014N04LSI
14	3	R1, R2, R3	RES SMD 0.002Ω, 2%, 3W, 2512, AEC-Q200 LONG SIDE TERM	SUSUMU CO, LTD, KRL6432E-M-R002-G-T1
15	1	R10	RES SMD 80.6KΩ, 1%, 1/10W, 0603 AEC-Q200	VISHAY, CRCW060380K6FKEA
16	3	R11, R19, R30	RES SMD 100KΩ, 1%, 1/10W, 0603 AEC-Q200	PANASONIC, ERJ-3EKF1003V
17	2	R12, R13	RES SMD 49.9Ω, 1%, 1/10W, 0603 AEC-Q200	PANASONIC, ERJ-3EKF49R9V
18	4	R14, R16, R40, R43	RES SMD 3.9Ω, 1%, 1/10W, 0603 AEC-Q200	VISHAY, CRCW06033R90FKEA
19	2	R15, R17	RES SMD 3Ω, 1%, 1/10W, 0603 AEC-Q200	VISHAY, CRCW06033R00FKEA
20	1	R20	RES SMD 4.99KΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF4991V
21	2	R38, R42	RES SMD 1.2Ω, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031R20FKEA
22	1	R4	RES SMD 0.003Ω, 1%, 3W, 2512, AEC-Q200	SUSUMU CO, LTD, KRL6432E-M-R003-F-T1
23	1	R5	RES SMD 523KΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF5233V
24	1	R6	RES SMD 15KΩ, 1%, 1/10W, 0603	YAGEO, RC0603FR-0715KL
25	1	R7	RES SMD 110KΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF1103V
26	1	R8	RES SMD 10KΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF1002V
27	1	R9	RES SMD 499KΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF4993V
28	1	U1	IC 60V LOW IQ FULL-FEATURED SYNCHRONOUS BUCK BOOST CONTROLLER	ANALOG DEVICES, LT8292AFE#PBF

OPTIONAL CIRCUIT COMPONENTS				
1	0	C26, C27, C28, C36, C37	DO NOT INSTALL (TBD_C0603), PLEASE USE SYM_3 AND/OR SYM_4	TBD0603, TBD0603
2	0	C29, C30	DO NOT INSTALL (TBD_C0805), PLEASE USE SYM_3 AND/OR SYM_4	TBD0805, TBD0805
3	0	C31, C32	CAP ALUM POLY 180UF, 50V, 20%, 10x12.7mm, AEC-Q200, 0.038Ω, 3.5A, 4000H	NICHICON CORPORATION, PCR1H181MCL1GS
4	0	C33, C34	CAP ALUM POLY 330UF, 25V, 20%, 10x12.6mm, 0.014Ω, 5000MA, 5000H	PANASONIC, 25SVPF330M
5	0	D1, D2	DIODE SCHOTTKY POWER RECTIFIER SMD	ON SEMICONDUCTOR, MBRS2040LT3G
6	0	D3, D4	DIODE SCHOTTKY POWER RECTIFIER SMD	ON SEMICONDUCTOR, MBR130T3G
7	0	Q1, Q2	TRANS N-CHA ENHANCE MODE MOSFET	DIODES INCORPORATED, 2N7002-7-F
8	0	R21, R23, R24, R25, R26, R32, R33, R36, R44, R45, R46, R47, R48	DO NOT INSTALL (TBD_R0603), PLEASE USE SYM_3 AND/OR SYM_4	TBD0603, TBD0603
9	0	R22, R27	RES SMD 0.002Ω, 2%, 3W, 2512, AEC-Q200, LONG SIDE TERM	SUSUMU CO, LTD, KRL6432E-M-R002-G-T1
10	0	R28, R29	DO NOT INSTALL (TBD_R0805), PLEASE USE SYM_3 AND/OR SYM_4	TBD0805, TBD0805
11	4	R18, R31, R34, R35	RES SMD, 0Ω, JUMPER 1/10W 0603, AEC-Q200	PANASONIC, ERJ-3GEY0R00V
HARDWARE – FOR EVALUATION CIRCUIT ONLY				
1	1		SHUNT, 2POS, 2mm PITCH, BLACK	SAMTEC INC., 2SN-BK-G
2	4		STANDOFF, BRD SPT SNAP FIT, 15.9mm LENGTH	KEYSTONE, 8834
3	4		CONNECTOR RING LUG TERMINAL, 10 CRIMP, NON-INSULATED	KEYSTONE, 8205
4	4		WASHER, EXT TOOTH LOCK #10, 0.19x0.41x0.03	MCMASTER-CARR, 98438A230
5	8		NUT, BRASS NARROW HEX 10-32 THREAD, 5/16 IN WIDTH	MCMASTER CARR, 95130A160
6	14	TP1, TP2, TP3, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP24, TP25	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094" MTG. HOLE PCB 0.062 INCH THK	MILL-MAX, 2501-2-00-80-00-00-07-0
7	2	TP14, TP15	CONN-PCB SOLDER TERMINAL TURRETS FOR CLIP LEADS	MILL-MAX, 2308-2-00-80-00-00-07-0
8	4	J1, J2, J3, J4	CONN-PCB, BANANA JACK, FEMALE, NON-INSULATED, THT, SWAGE, 0.218 INCHES LENGTH	KEYSTONE ELECTRONICS, 575-4
9	4	J5,J6,J7,J8	CONN-PCB THREADED BROACHING STUD 10-32 FASTENER 0.625, USE ALT_SYMBOL FOR C450D200 PAD	CAPTIVE FASTENER, CKFH1032-10
10	1	JP1	CONN-PCB 10POS MALE HDR UNSHROUDED DOUBLE ROW ST, 2mm PITCH, 4mm POST HEIGHT, 2.6mm SOLDER TAIL	MOLEX, 87758-1016

Schematic Diagram



Notes