Evaluation Board User Guide

EVAL-LTC7892-BZ

High Frequency Step-Up Controller with 100V GaN FETs

General Description

Evaluation circuit EVAL-LTC7892-BZ features the LTC®7892. The LTC7892 is a 100V step-up synchronous Gallium Nitride (GaN) field effect transistor (FET) controller optimized in this application with 100V GaN FETs for an operational 9V–36V input range at 500kHz. The EVAL-LTC7892-BZ is specifically designed to drive GaN FETs safely and easily up to 1.4kW power levels through internally optimized bootstrap switches and adaptive time control. Split gate drivers allow for easily adjustable turn-on and turn-off of FETs. Additionally, the IC features low I_Q, up to 3MHz programmable/synchronizable switching frequency, spread spectrum, and a small 40-lead (6mm x 6mm) side wettable QFN package. These features allow various applications, including industrial, military, medical, and telecommunications systems.

The EVAL-LTC7892-BZ operates from a 9V–36V input voltage range and generates a maximum 48V, 30A output.

The LTC7892 has a precision voltage reference that can generate an output voltage with 2% tolerance over the full operating conditions. The EVAL-LTC7892-BZ is set to a 500kHz switching frequency, which results in a small and efficient circuit. The converter achieves over 98% efficiency with 30A load at full operating V_{IN}, with a peak efficiency near 99%.

This board can be easily modified to regulate output voltages from 1.2V to 90V. Various FETs of a similar footprint can be used to fit a wide array of applications. The EVAL-LTC7892-BZ provides a high-performance cost-effective solution for generating a 48V output. The LTC7892 data sheet includes a complete description of the part, its operation, and application information. Read the data sheet in conjunction with the user guide.

Design files for this circuit board are available at www.analog.com.

Performance Summary (T_A = 25°C)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	I_{OUT} = 0A to 30A, heatsink	9		36	V
	I_{OUT} = 0A to 26A, no heatsink, maximum board temperature < 100°C	9		36	V
Maximum Recommended Output Current Levels*	V_{IN} = 12V, no heatsink, maximum temperature < 100°C		7.6		A
	V_{IN} = 24V, no heatsink, maximum temperature < 100°C		16.5		A
	V_{IN} = 12V, heatsink, maximum temperature < 100°C		10.2		A
	V_{IN} = 24V, heatsink, maximum temperature < 100°C		20		A
Output Voltage	V_{IN} = 9V to 36V	46.5	48	49.5	V
Output Voltage Ripple (Peak-to-Peak)	V_{IN} = 24V, I_{OUT} = 16A (Force continuous mode (FCM))			400	mV_{P-P}
Run Rising Threshold			8.6		V
Run Falling Threshold			7.8		V
Switching Frequency	JP2 = Disable SS (spread spectrum frequency modulation (SSFM) off)		500		kHz
	JP2 = Enable SS (SSFM on)	500		600	kHz
Typical Efficiency	V_{IN} = 9V, I_{OUT} = 6A		95		%
	V_{IN} = 12V, I_{OUT} = 8A		96		%
	V_{IN} = 24V, I_{OUT} = 16A		98		%
	V_{IN} = 36V, I_{OUT} = 26A		98		%

*See Maximum Power vs Input Voltage chart (Figure 6).

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Quick Start Procedure

Evaluation circuit EVAL-LTC7892-BZ is easy to set up to evaluate the performance of the LTC7892. For a proper measurement equipment setup, see *Figure 1*, and use the following procedure.

1. Set the input power supply to a voltage between 9V and 36V. Disable the power supply.

   NOTE: Make sure that the input voltage V_{IN} does not exceed 36V.
2. Connect the positive terminal of the power supply to V_{IN} and the negative terminal to GND.
3. Connect the load (See *Figure 6*) between V_{OUT} and GND.
4. Verify that the RUN switch (SW1) is set to the ON position.
5. Turn the input power supply on and adjust the input voltage to 24V.
6. Verify that the output voltage is 48V on the DMM connected to V_{OUT}. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
7. Once the proper output voltage is established, adjust the load 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.

The EVAL-LTC7892-BZ is a fully assembled and tested board that demonstrates the performance of the LTC7892. The evaluation circuit is designed to deliver 48V output at load current up to 26A from a 9V to 36V input supply (30.6A with heat sink). The board is programmed at a 500kHz switching frequency for optimum efficiency and component size.

Adjusting the Output Voltage

The LTC7892 supports an adjustable output voltage range, from 1.2V to 100V. To change the output voltage from the programmed 48V, change R18 and R19. Refer to the *Setting the Output Voltage* section in the LTC7892 data sheet on how to calculate the V_{FB} resistor divider values for the desired output voltage. All the corresponding power components will also need to be changed to meet the desired output voltage.

Setting the Switching Frequency

Selecting the switching frequency is a trade-off between efficiency and component size. For optimal performance, a switching frequency of 500kHz is chosen for 12V output. R37 programs the desired switching frequency. The switching frequency is set using the FREQ and PLLIN/SPREAD pins. Refer to the *Setting the Operating Frequency* section in the LTC7892 data sheet for more details.

RUN Control (RUN, SW1)

The RUN turret of the evaluation circuit serves as an external on/off control for the controller. The EVAL-LTC7892-BZ includes a resistive voltage divider (R62 and R63) connected between the V_{IN} and GND pins to turn on the device at the required input voltage. Turn the switch (SW1) to the ON position to connect the RUN pin to the center of this resistor divider. The EVAL-LTC7892-BZ is designed to turn on LTC7892 at around 9V. However, this threshold can be easily adjusted by changing R62 and R63. Turn SW1 to the off position to disable the controller. See *Table 3* to configure SW1.

Soft-Start Input (SS1, SS2)

The LTC7892's SSx pins can program an external soft-start function or allow V_{OUT} to track another supply during startup. The adjustable soft-start function is used to limit the inrush current during startup. The soft-start time is adjusted by C17 (and C15 with independent operation). An external supply can be connected to the SSx turrets to make the startup of the V_{OUT} track an external supply. Typically, this requires connecting to the SSx turret through an external resistor divider from the external supply to GND. Refer to the *Soft-Start* section in the LTC7892 data sheet for more details.

Mode Selection (MODE)

The EVAL-LTC7892-BZ provides a jumper (P1) to allow the LTC7892 to operate in either forced continuous mode (FCM), pulse-skipping (PS) mode, or Burst mode® at lighter loads. Refer to the LTC7892 data sheet for more details on the modes of operation. *Table 1* shows the mode selection P1 settings that can be used to configure the desired mode of operation.

Spread Spectrum, Phase-Locked Loop, and External Frequency Synchronization (PLLIN/SPREAD, P2)

The LTC7892 features spread-spectrum mode operation to improve electromagnetic interference (EMI). This mode varies the switching frequency within the typical boundaries of the frequency set by the FREQ pin and +20%. Spread-spectrum operation is enabled by tying the PLLIN/SPREAD pin to $INTV_{CC}$. The EVAL-LTC7892-BZ includes a jumper (P2) to conveniently enable or disable the spread-spectrum operation. See *Table 2* to configure P2.

The LTC7892 also features a phase-locked loop to synchronize the internal oscillator to an external clock source. The EVAL-LTC7892-BZ provides a SYNC turret to connect an external clock source to synchronize with the device switching. Keep the jumper (P2) in the external sync position when the external clock signal is applied. Refer to the LTC7892 data sheet for more details about the external clock synchronization feature.

Open-Drain PGOOD Output (PGOOD)

The EVAL-LTC7892-BZ provides a PGOOD turret to monitor the status of the PGOOD output. PGOOD is high when the V_{FB} voltage is within ±10% of the 0.8V reference. PGOOD is pulled low when the V_{FB} voltage is not within 1.2V ± 10%, or the RUN pin is low (shutdown). When both channels are tied together for a single output operation, PGOOD1 is used as the status for both channels, and PGOOD 2 pin should be left floating (or optionally tied to ground). The voltage on the PGOOD pin should not exceed 6V.

$EXTV_{CC}$ Linear Regulator

The $EXTV_{CC}$ pin allows the $INTV_{CC}$ power to be derived from a high-efficiency external source. On EVAL-LTC7892-BZ, the $EXTV_{CC}$ pin is connected to GND. The $EXTV_{CC}$ turret can be used to connect an external power supply to source the $EXTV_{CC}$ LDO. When using an external power supply on the $EXTV_{CC}$ turret, make sure to disconnect the GND connection to the $EXTV_{CC}$ pin by removing R46. Populate R61 with a 0Ω resistor and place a 0.1µF cap at the R46 location.

Thermal Performance

The LTC7892 features excellent thermal performance due to the high efficiency of the synchronous step-up GaN FET controller circuitry. The component temperatures of EVAL-LTC7892-BZ with a typical 24V input and 16A load are shown in *Figure 7*. The six-layer printed circuit board (PCB) layout features solid copper planes that provide adequate heat spreading across the whole board.

The board will operate within the thermal limit power curve shown in *Figure 6* labeled “No Heat Sink”, at room temperature with transient conditions. If sustained operation beyond this is required, the circuit will require a heatsink and/or forced air flow to keep the maximum temperature of the board under 100°C at room temperature. With a heatsink, the board can operate at the higher output power range curve labeled “Heatsink” from 9V to 36V for a steady state.

Heatsink

The EVAL-LTC7892-BZ features space for a heatsink to extend the power and thermal capabilities significantly. The board is designed for the Wakefield-Vette 567-45AB heatsink and is to be used in conjunction with thermal pads and Würth Elektronik 9774010243R spacers. The spacers should be soldered onto P1, P2, P3, and P4, and a thermal pad should be placed between the heatsink and the GaN FETs. Properly screw in the heatsink to fully extend the power capabilities of the board.

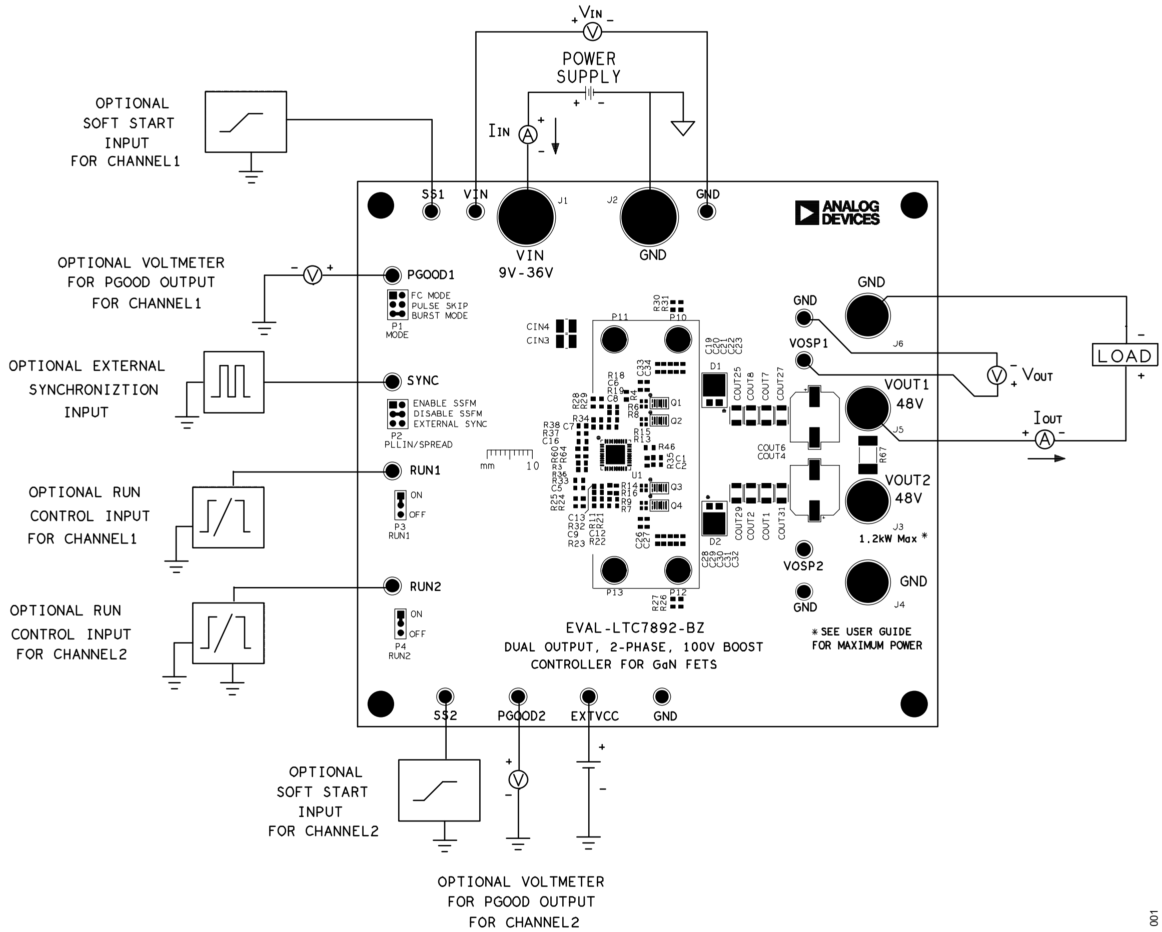


Figure 1. EVAL-LTC7892-BZ Board Connections

Table 1. MODE Selection Jumper (P1) Settings

SHUNT POSITION	MODE PIN	MODE
1–2*	Connected to $INTV_{CC}$	FCM mode of operation
3–4	Connected to $INTV_{CC}$ with a 100kΩ	PS mode of operation
5–6	Connected to GND	Bust mode of operation

**Default position*

Table 2. PLLIN/SPREAD Jumper (P2) Settings

SHUNT POSITION	PLLIN/SPREAD PIN	DESCRIPTION
1-2	Connected to $INTV_{CC}$	Enable SS
3-4*	Connected to GND	Disable SS
5-6	Connected to the center node of R49 and C16	External SYNC input

**Default position*

Table 3. RUN Jumper (P3 and P4) Settings

SHUNT POSITION (RUN1)	SHUNT POSITION (RUN2)	RUN PINS**	CONTROLLER
ON	ON*	Connected to the center node of the resistor-divider R62 and R63 (P3)	Programmed to startup at the desired input voltage level
ON	OFF	Connected to GND	Disabled
OFF*	OFF	Connected to GND	Disabled

*Default position

**Single output application circuit ties RUN1 & RUN2 together with 0Ω resistor R64. Setting either shunt OFF disables IC.

Performance

(V_{IN} = 24V, V_{OUT} = 48V, I_{OUT} = 16A, f_{SW} = 500kHz, MODE = FCM, T_A = +25°C, unless otherwise noted.)

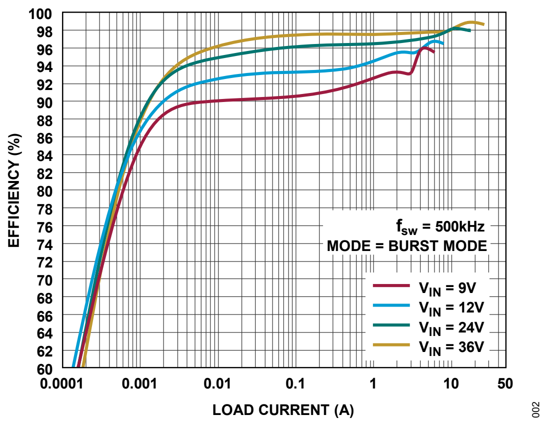


Figure 2. Efficiency vs. Load Current. At V_{IN} = 36V, EVAL-LTC7892-BZ performs with an efficiency of over 98% with 48V Output and 26A Load

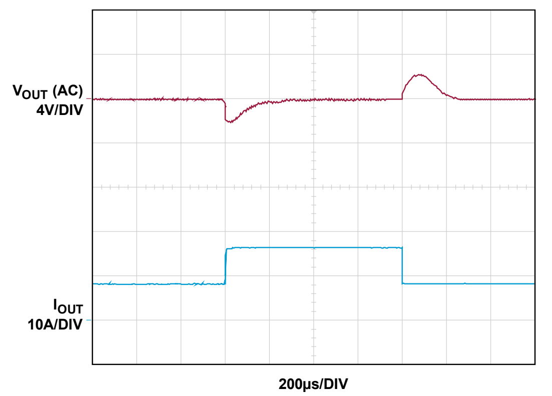


Figure 3. Load Step Response. EVAL-LTC7892-BZ has a Good Load Step Response with Small Output Capacitors

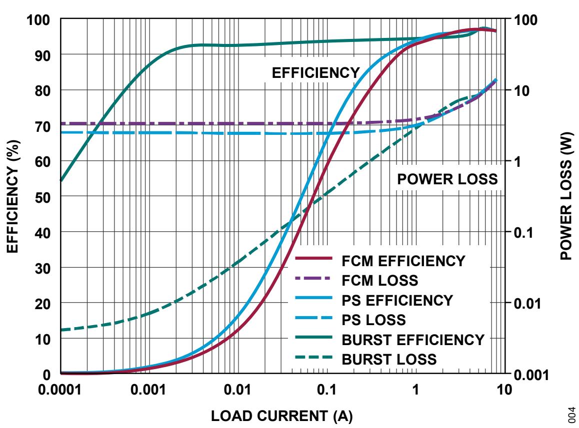


Figure 4. Efficiency and Power Loss vs. Load Current at V_{IN} = 12V. At low load, burst mode significantly improves power loss compared to pulse skip and FCM.

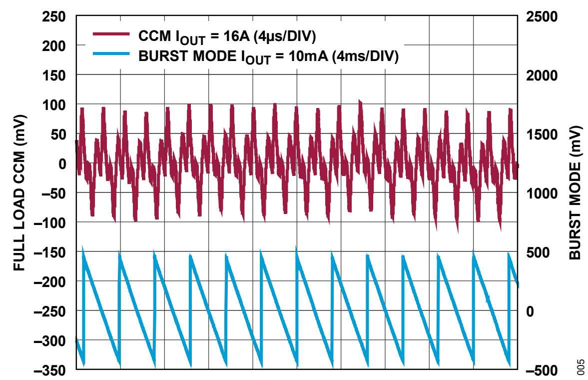


Figure 5. Output Voltage Ripple magnitude variation in Burst Mode vs FCM at V_{IN} = 24V. Burst Mode trades noise spectral density for greatly improved light load efficiency, as shown in Figure 4.

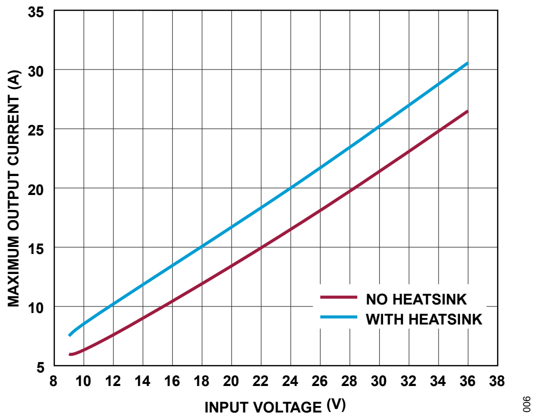


Figure 6. Maximum recommended output current vs. V_{IN} keeping maximum board temperature under 100°C at room temperature. Do not operate outside the safe operating area of these curves without increased heatsink or airflow.

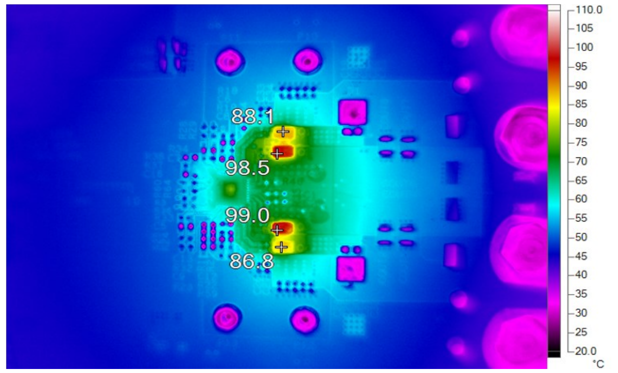


Figure 7. Thermal Performance with 24V Input, 48V Output, and 16.5A Load. No heatsink or airflow. The hottest component on EVAL-LTC7892-BZ stays under 100°C.

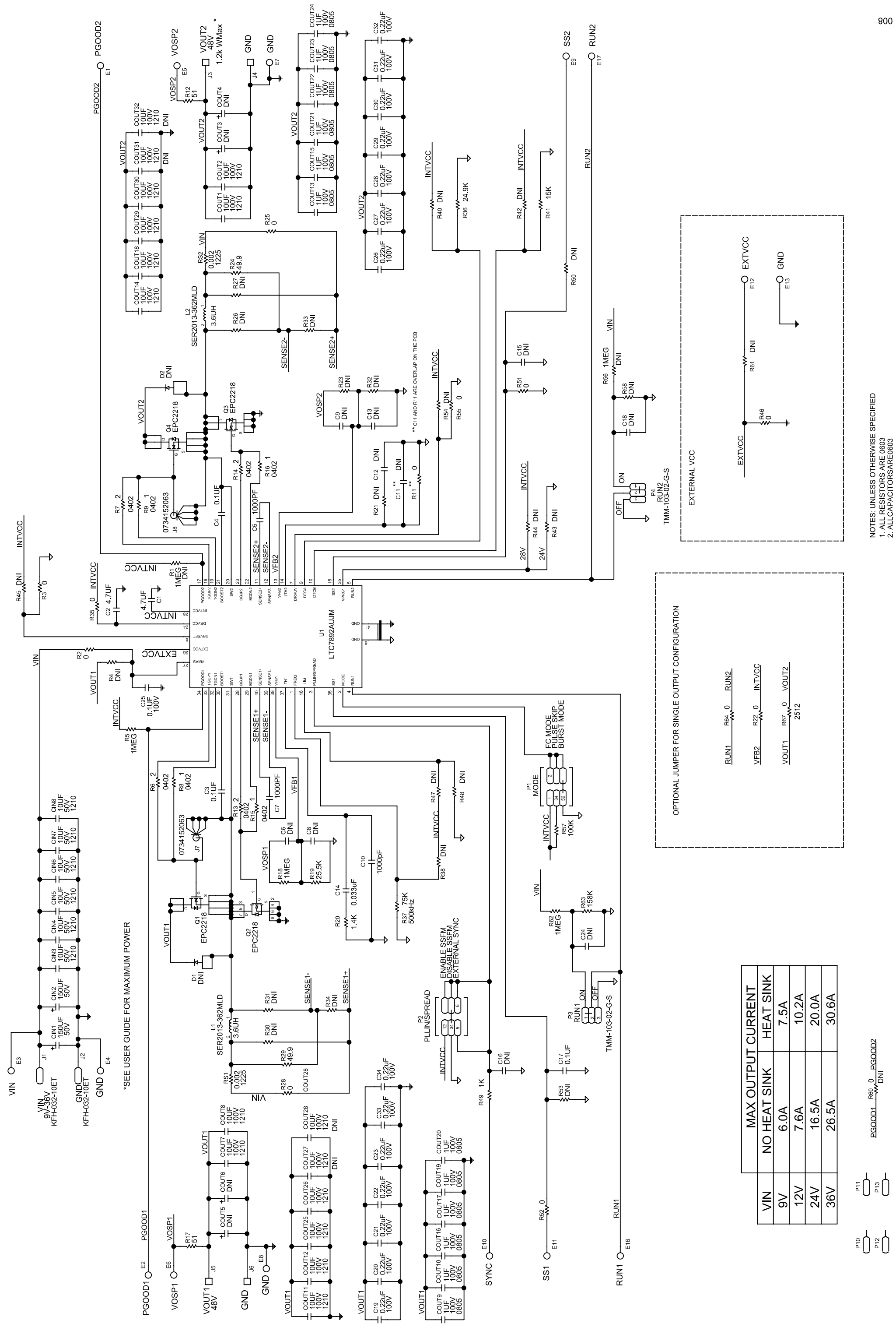
Bill of Materials

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER PART NUMBER
REQUIRED CIRCUIT COMPONENTS				
1	2	C1, C2	CAP CER 4.7µF 25V 10% X5R 0603 AEC-Q200	GRT188R61E475KE13D
2	1	C10	CAP CER 1000pF 50V 10% X8R 0603	C1608X8R1H102K080AA
3	1	C14	CAP CER 0.033µF 50V 5% X7R 0603	06035C333JAT2A
4	3	C3, C4, C17	CAP CER 0.1µF 25V 10% X7R 0603	C0603C104K3RACTU
5	14	C19, C20, C21, C22, C23, C26, C27, C28, C29, C30, C31, C32, C33, C34	NRND - CAP CER 0.22µF 100V 10% X7S 0603 AEC-Q200	HMK107C7224KAHTE
6	1	C25	CAP CER 0.1µF 100V 10% X7R 0603	GRM188R72A104KA35D
7	16	C35, C36, C37, C38, C39, C40, C41, C42, COUT1, COUT2, COUT7, COUT8, COUT11, COUT12, COUT14, COUT18	CAP CER 10UF 100V 10% X7S 1210	GRM32EC72A106KE05L
8	2	C5, C7	CAP CER 1000pF 25V 10% X7R 0603	06033C102KAT2A
9	2	CIN1, CIN2	CAP ALUM POLY 150UF 50V 20% 10.3X12.8MM AEC-Q200	EEH-ZU1H151P
10	12	CIN3, CIN4, CIN5, CIN6, CIN7, CIN8	CAP CER 10µF 50V 10% X7R 1210	GRM32ER71H106KA12L
11	12	COUT1, COUT2, COUT7, COUT8, COUT11, COUT12, COUT14, COUT18, COUT25, COUT26, COUT29, COUT30	CAP CER 1µF 100V 10% X7S 0805	C2012X7S2A105K125AB
12	2	L1, L2	IND POWER SHIELDED WIREWOUND, 0.0018Ω DCR, 25A	SER2013-362MLD
13	4	Q1, Q2, Q3, Q4	TRAN MOSFET N-CH GAN 100V 60A	EPC2218
14	2	R12, R17	RES SMD 51Ω 1% 1/10W 0603 AEC-Q200	ERJ-3EKF51R0V
15	4	R6, R7, R13, R14	RES SMD 2Ω 1% 1/16W 0402	RC0402FR-072RL
16	4	R8, R9, R15, R16	RES SMD 1Ω 1% 1/6W 0402 AEC-Q200	ERJ-2BQF1R0X
17	3	R5, R18, R62	RES SMD 1MEG Ohm 1% 1/10W 0603 AEC-Q200	CRCW06031M00FKEA

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER PART NUMBER
18	1	R19	RES SMD 25.5KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF2552V
10	1	R20	RES SMD 1.4KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF1401V
20	2	R24, R29	RES SMD 49.9Ω 1% 1/10W 0603 AEC-Q200	ERJ-3EKF49R9V
21	1	R36	RES SMD 24.9KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF2492V
22	1	R37	RES SMD 75KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF7502V
23	1	R41	RES SMD 15KΩ 0.1% 1/10W 0603 AEC-Q200 HIGH RELIABILITY	ERA-3AEB153V
24	1	R49	RES SMD 1KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF1001V
25	1	R57	RES SMD 100KΩ 1% 1/10W 0603 AEC-Q200	ERJ-3EKF1003V
26	1	R63	RES SMD 158KΩ 1% 1/10W 0603 AEC-Q200	CRCW0603158KFKEA
27	2	RS1, RS2	RES SMD 0.002 2% 3W 1225 AEC-Q200	KRL6432E-C-R002-G-T1
28	1	U1	IC-ADI LOW I_Q, DUAL, 2-PHASE SYNCHRONOUS BOOST CONTROLLER FOR GAN FETS	LTC7892AUJM#TRPBF
OPTIONAL CIRCUIT COMPONENTS				
1	0	C6, C8, C9, C12, C13, C15, C16, C18, C24	DO NOT INSTALL (TBD_C0603) USE SYM_3 AND/OR SYM_4	TBD0603
2	0	COUT27, COUT28, COUT31, COUT32	CAP CER 10UF 100V 10% X7S 1210	GRM32EC72A106KE05L
3	0	COUT3, COUT4, COUT5, COUT6	CAP ALUM POLY 68UF 63V 20% 10X10.2MM AEC-Q200 0.03Ω 1400MA 4000H	EEHZC1J680P
4	0	D1, D2	DIODE SCHOTTKY 100V 10A, AEC-Q101 COMMON CATHODE TO-277A	SS10PH10-M3/86A
5	0	R1, R56	RES SMD 1MEG Ohm 1% 1/10W 0603 AEC-Q200	CRCW06031M00FKEA
6	0	R4, R21, R23, R26, R27, R30, R31, R32, R33, R34, R38, R40, R42, R43, R44, R45, R47, R48, R50, R53, R54, R58, R60, R61	RES., OPTION, 0603	
7	12	R2, R3, R11, R22, R25, R28, R35, R46, R51, R52, R55, R64	RES SMD 0Ω JUMPER 1/10W 0603 AEC-Q200 PRECISION POWER	CRCW06030000Z0EA
8	1	R67	RES SMD 0Ω JUMPER 2512 AEC-Q200	WSL251200000ZEA9

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER PART NUMBER
HARDWARE – FOR EVALUATION CIRCUIT ONLY				
12	15	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E16, E17	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094" MTG. HOLE PCB 0.062 INCH THK	2501-2-00-80-00-00-07-0
13	2	J1, J2	CONN-PCB THREADED BROACHING STUD, 625MIL LENGTH	KFH-032-10ET
14	4	J3, J4, J5, J6	CONN-PCB, BANANA JACK, FEMALE, NON-INSULATED, THT, SWAGE, 0.218 INCHES LENGTH	575-4
15	2	J7, J8	CONN-PCB MMCX JACK STR 50Ω 0-6GHZ	734152063
17	2	P1, P2	CONN-PCB 6POS UNSHROUDED HEADER VERT 2MM PITCH	TMM-103-02-L-D
18	4	P10, P11, P12, P13	CONN-PCB 1POS STEEL SPACER WITH M2X0.4 THD	9774010243R
19	2	P3, P4	CONN-PCB 3POS MALE HDR UNSHROUDED SINGLE ROW, 2MM PITCH, 3MM SOLDER TAIL	TMM-103-02-G-S
17	2	P1, P2	CONN-PCB 6POS UNSHROUDED HEADER VERT 2MM PITCH	TMM-103-02-L-D
1	2		CONNECTOR RING LUG TERMINAL, 10 CRIMP, NON-INSULATED	8205
2	2		WASHER, #10 FLAT STEEL	4703
3	4		SHUNT, 2MM JUMPER WITH TEST POINT	60800213421
4	4		NUT, HEX STEEL, 10-32 THREAD, 9.27MM OUT DIA	4705
5	4		STANDOFF, BRD SPT SNAP FIT 15.9MM LENGTH	8834
6	4		SHUNT, 2MM JUMPER WITH TEST POINT	60800213421
7	4		NUT, HEX STEEL, 10-32 THREAD, 9.27MM OUT DIA	4705
8	4		SCREW, MACHINE PAN HEAD PHILLIPS M2 8MM LENGTH	MPMS 002 0008 PH
9	4		WASHER, FLAT, M2, STAINLESS STEEL	MFWS2-7B2

Schematic


LTC7892AUJM
U1
OPTIONAL JUMPER FOR SINGLE OUTPUT CONFIGURATION
EXTERNAL VCC
*SEE USER GUIDE FOR MAXIMUM POWER
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE 0603
2. ALLCAPACITORSARE0603
MAX OUTPUT CURRENT
VIN | NO HEAT SINK | HEAT SINK
9V | 6.0A | 7.5A
12V | 7.6A | 10.2A
24V | 16.5A | 20.0A
36V | 26.5A | 30.6A
VIN 9V-36V
VOUT1 48V
VOUT2 48V 1.2k WMax
PGOOD1
PGOOD2
VOSP1
VOSP2
SYNC
SS1
SS2
RUN1
RUN2
FC MODE
PULSE SKIP
BURST MODE
ENABLE SSFM
DISABLE SSFM
EXTERNAL SYNC
800

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGE NUMBER
0	12/24	Initial Release	—

Notes