EVAL-LTC7890-AZ

High Frequency, Dual Output, Step-Down Supply with EPC GaN FETs

General Description

Evaluation circuit EVAL-LTC7890-AZ is a dual output synchronous step-down converter that drives all N-channel gallium nitride (GaN) field effect transistors (FETs). The EVAL-LTC7890-AZ evaluation board features EPC2218 100V FETs from EPC.

EVAL-LTC7890-AZ features the LTC®7890: a low quiescent current high frequency (programmable fixed frequency from 100kHz up to 3MHz) dual step-down DC/DC synchronous controller, with a dedicated driver feature for GaN FETs housed in a small 6mm × 6mm QFN package.

The EVAL-LTC7890-AZ operates over an input voltage range from 14V to 72V, while the LTC7890 can operate up to 100V. The EVAL-LTC7890-AZ evaluation circuit produces two outputs: 5V and 12V with up to 20A on each output. EVAL-LTC7890-AZ is configured with sense resistors for current sensing. A mode selector allows the EVAL-LTC7890-AZ to operate in forced continuous operation, pulse-skipping or Burst Mode® operation during light loads. The EXTVCC pin permits the LTC7890 to be powered from the output of the switching regulator or other available source, reducing power dissipation, and improving efficiency. Refer to the LTC7890 data sheet for a complete description of the part operation and application information.

The performance summary table summarizes the performance of the evaluation circuit at room temperature. The evaluation circuit can be easily modified for different applications, including 2-phase single output. The LTC7890 is housed in a 40-lead (6mm × 6mm), side wettable, QFN package. Refer to the data sheet in conjunction with this EVAL-LTC7890-AZ evaluation circuit 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	Maximum Component Temperature <100°C, I_{OUT1} = I_{OUT2} = 20A, With Heatsink and 400LFM Airflow, After 10-minute run time	14		72	V
	Maximum Component Temperature = 100°C, I_{OUT1} = I_{OUT2} = 20A, With Heatsink, No Airflow, After 10-minute run time	14		52	V
	Maximum Component Temperature = 100°C, I_{OUT1} = I_{OUT2} = 20A, No Heatsink, No Airflow, After 10-minute run time	14		32	V
	I_{OUT1} = I_{OUT2} = 20A, <1 minute run time maximum	14		72	V
Output Voltage, V_{OUT1}	V_{IN} = 14V – 72V, VPRG1 = 0V	4.925	5	5.075	V
Output Voltage Ripple, $V_{OUT1(AC)}$	V_{IN} = 48V, I_{OUT} = 20A		40		mV_{P-P}
Output Voltage, V_{OUT2}	V_{IN} = 14V – 72V	11.76	12	12.24	V
Output Voltage Ripple, $V_{OUT2(AC)}$	V_{IN} = 48V, I_{OUT} = 20A		80		mV_{P-P}
Input Current	FCM, V_{IN} = 48V, I_{OUT1} = I_{OUT2} = 0A		48.9		mA
	Burst Mode, V_{IN} = 48V, I_{OUT1} = I_{OUT2} = 0A		10		µA
Typical Switching Frequency	P3 = DISABLE SS (SSFM OFF)		500		kHz
	P3 = ENABLE SS (SSFM ON)	500		600	kHz
Efficiency	V_{IN} = 48V, V_{OUT1} = 5V, I_{OUT1} = 20A		94.0		%
	V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 20A		96.9		%

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Quick Start Procedure

The EVAL-LTC7890-AZ evaluation circuit is easy to set up to evaluate the performance of the LTC7890. See *Figure 1* for proper measurement equipment setup and follow the procedure below:

1. With power off, connect the input power supply to V_{IN} and GND.
2. Connect the output loads between V_{OUT1} and GND, and V_{OUT2} and GND.
3. Turn on the power at the input. Increase V_{IN} slowly to 14V. Make sure RUN1 and RUN2 switches are on the ON position.
   NOTE: Make sure that the input voltage is always within the specified range.
4. Check for the proper output voltages. The output should be regulated at 5V for Channel 1 and 12V for channel 2.
5. Once the proper output voltage is established, adjust the input voltage and load current within the operating range and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.
   NOTE: When measuring the input or output voltage ripples, take care to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the V_{IN} or V_{OUT} and GND terminals or directly across the relevant capacitor. See *Figure 2* for the proper probe technique.

Adjusting the Output Voltage

The LTC7890 includes an output voltage control pin for Channel 1 VPRG1. This pin allows for the output voltage of Channel 1 to be set to a fixed 12V, 5V or an external feedback resistor divider can be used to set the output voltage from 0.8V to 60V. EVAL-LTC7890-AZ has the Channel 1 output voltage set to 5V by connecting VPRG1 to GND and connecting V_{FB1} to V_{OUT1} through R18. To change the output voltage from the programmed 5V, float the VPRG1 pin by removing R43 and change R18 and R19. Refer to the Setting the Output Voltage section on the data sheet for calculating the V_{FB1} 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.

For Channel 2 of the LTC7890, the output voltage can be set from a range of 0.8V to 60V using a feedback resistor divider. To change the output voltage from the programmed 12V, change R23 and R32. Refer to the Setting the Output Voltage section on the data sheet for calculating the V_{FB2} 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. R37 programs the desired switching frequency. The switching frequency is set using FREQ and PLLIN/SPREAD pins. Refer to the Setting the Operating Frequency section in the LTC7890 data sheet for details.

RUN Control (RUN1, S1, RUN2, S2)

The RUN1 and RUN2 turrets of the evaluation circuit serve as an external on/off control for Channel 1 and Channel 2, respectively. The EVAL-LTC7890-AZ includes a resistive voltage divider for each channel connected between V_{IN} and GND to turn on the device at the required input voltage. Turn switch 1 (S1) to the ON position to connect the RUN1 pin to the center of this resistor divider for Channel 1, and turn switch 2 (S2) to the ON position to connect the RUN2 pin to the center of this resistor divider for Channel 2. The EVAL-LTC7890-AZ connects the run pin of both channels to the V_{IN} for always-on operation. Both channels will begin switching once the input voltage rises above the INTVCC UVLO threshold off 3.8V. A desired threshold can be easily added by changing the resistor divider on each channel. See *Table 3* to configure S1 and *Table 4* to configure S2.

TRACK and Soft-Start Inputs (TRACK/SS)

LTC7890's TRACK/SS1 and TRACK/SS2 pins can be used to program an external soft-start function or to allow V_{OUT} to track another supply during startup for Channel 1 and Channel 2, respectively. The adjustable soft-start function is used to limit the inrush current during startup. The soft-start time is adjusted by C17. An external supply can be connected to the TRK/SS turrets to make the startup of the V_{OUT} track an external supply. Typically, this requires connecting to the TRK/SS turret through an external resistor divider from the external supply to GND. Refer to the Soft-Start and Tracking section on the data sheet.

Mode Selection (MODE, P1)

EVAL-LTC7890-AZ provides a jumper (P1) to allow the LTC7890 to operate in either Forced Continuous, Pulse Skipping, or Burst modes at lighter loads. Refer to the LTC7890 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, P3)

The LTC7890 features spread spectrum mode operation to improve 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 $INTV_{CC}$. EVAL-LTC7890-AZ includes a jumper (P3) to conveniently enable or disable the spread spectrum operation. See Table 2 to configure P3.

The LTC7890 also features a phase-locked loop to synchronize the internal oscillator to an external clock source. EVAL-LTC7890-AZ provides a SYNC turret to connect the external clock source to synchronize with the device switching. Keep the jumper (P3) in the external sync position when the external clock signal is applied. Refer to the LTC7890 data sheet for more details about external clock synchronization.

Open-Drain PGOOD Outputs (PGOOD)

EVAL-LTC7890-AZ provides PGOOD1 and PGOOD2 turrets to monitor the status of the PGOOD output for Channel 1 and Channel 2, respectively. 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 0.8V ±10% or the RUN pin is low (shutdown). The voltage on the PGOOD pins 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-LTC7890-AZ, the $EXTV_{CC}$ pin is connected to V_{OUT1}. 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 V_{OUT} connection to the $EXTV_{CC}$ pin by removing R59. Populate R61 with a 0Ω resistor.

2-Phase Single Output Operation

The two channels of the LTC7890 can be operated in a 2-phase single output configuration for high-current applications. EVAL-LTC7890-AZ includes all the necessary component place holders to configure the board to 2-phase single output operation. Refer to the 2-Phase Single Output Operation section of the LTC7890 data sheet for the required modifications.

Thermal Performance

The EVAL-LTC7890-AZ features excellent thermal performance due to the high efficiency of the synchronous step-down GaN FET controller circuitry. The component temperatures of EVAL-LTC7890-AZ with a 32V input and 20A load on both channels at the same time are shown in Figure 13. The capture was taken after 10 minutes of operation. For short pulses, the board can perform at the maximum power rating for the entire input voltage range. The six-layer PCB layout features solid copper planes that provide adequate heat spreading across the whole board.

With an input voltage higher than 32V, the circuit needs a heatsink and/or forced air flow to keep the maximum temperature of the board under 100°C to achieve full power and run for more than 10 minutes. With a heatsink, the board can operate with a 20A load on both channels at the same time, up to an input voltage of 52V. With a heatsink and 400 LFM of airflow, the board can operate at the full input voltage range of 14V to 72V with a 20A load on both channels at the same time. See Figure 11 for the recommended maximum load current on each channel.

Heatsink

The EVAL-LTC7890-AZ 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 Wurth Elektronik 9774010243R spacers. The spacers should be soldered onto P10, P11, P12, and P13, and a thermal pad placed between the heatsink and the GaN FETs. Properly screw in the heatsink to fully extend the power capabilities of the board.

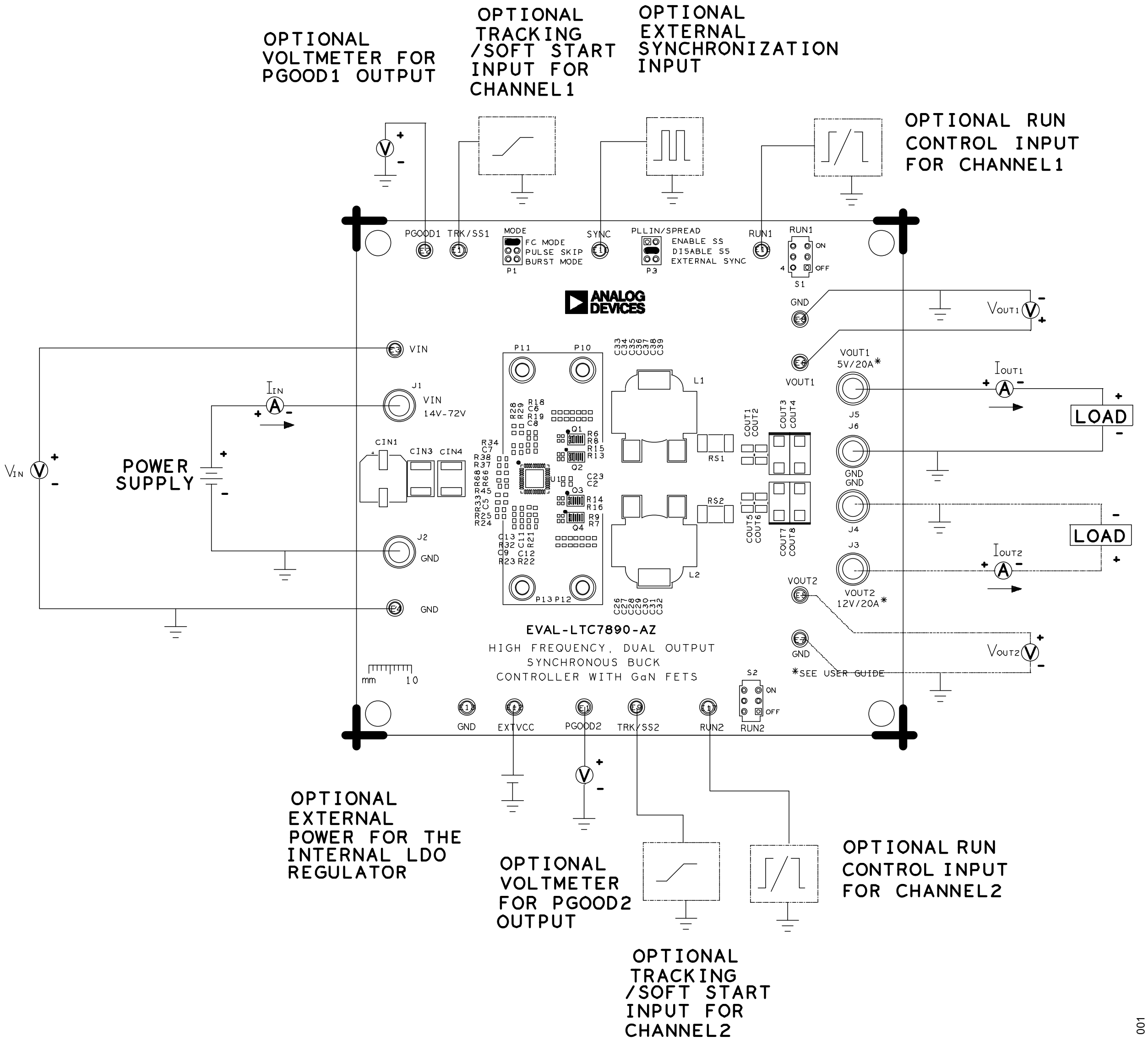


Figure 1. EVAL-LTC7890-AZ Board Connections

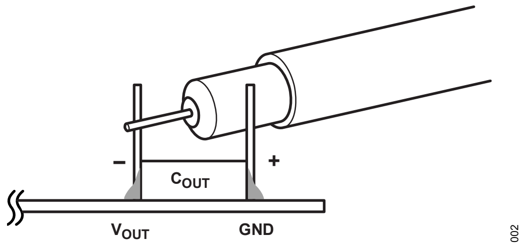


Figure 2. EVAL-LTC7890-AZ Ripple Measurement

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	Pulse-Skipping mode of operation
5-6	Connected to GND	Bust mode of operation

**Default position*

Table 2. PLLIN/SPREAD Jumper (P3) 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. RUN1 Switch (S1) Settings

SWITCH POSITION	RUN PIN	CONTROLLER
ON	Connected to V_{IN}	Set to startup Channel 1 when V_{IN} is applied
OFF*	Connected to GND	Disabled

**Default position*

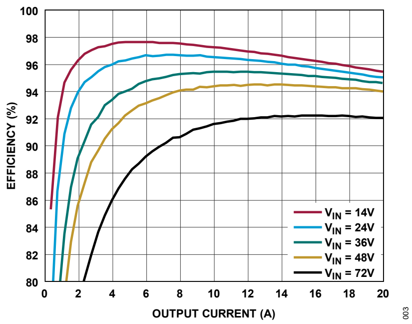
Table 4. RUN2 Switch (S2) Settings

SWITCH POSITION	RUN PIN	CONTROLLER
ON	Connected to V_{IN}	Set to startup Channel 2 when V_{IN} is applied
OFF*	Connected to GND	Disabled

**Default position*

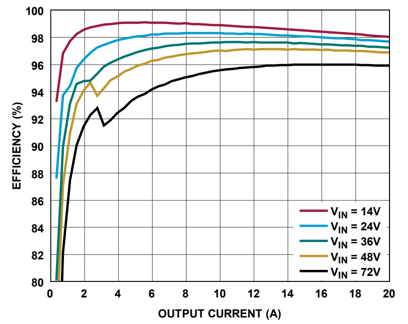
Performance

(T_A = +25°C, unless otherwise noted.)



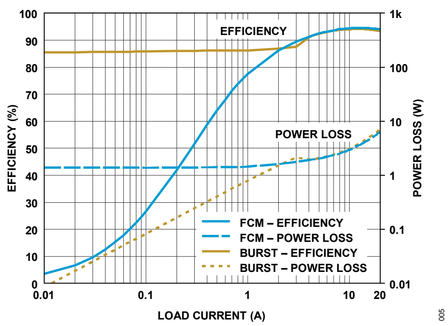
V_{OUT1} = 5V, f_{sw} = 500kHz, FCM Mode

Figure 3. Channel 1 Efficiency vs. Load Current



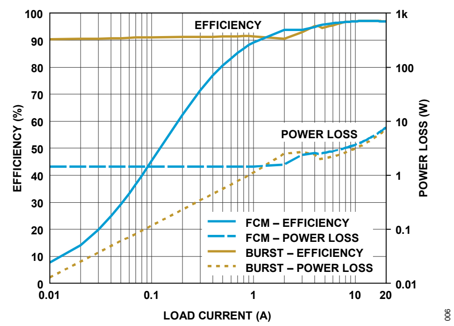
V_{OUT2} = 12V, f_{sw} = 500kHz, FCM Mode

Figure 4. Channel 2 Efficiency vs. Load Current



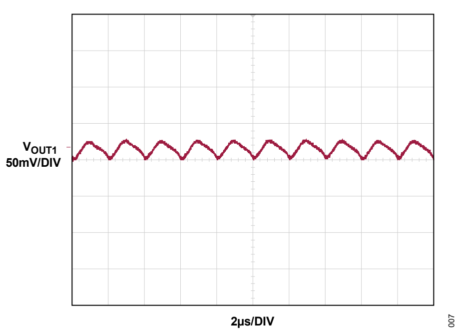
V_{IN} = 48V, V_{OUT1} = 5V, f_{sw} = 500kHz

Figure 5. Channel 1, Efficiency and Power Loss vs. Load Current



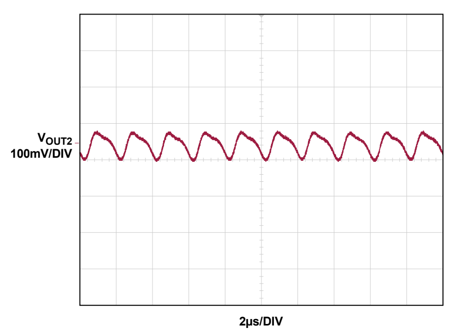
V_{IN} = 48V, V_{OUT2} = 12V, f_{sw} = 500kHz

Figure 6. Channel 2, Efficiency and Power Loss vs. Load Current



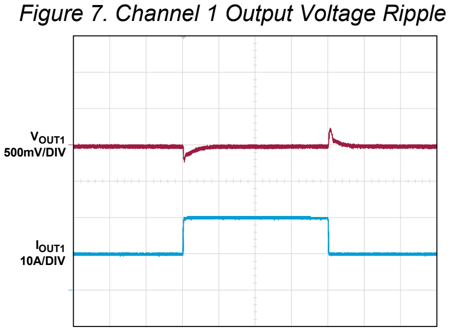
V_{IN} = 48V, V_{OUT1} = 5V, I_{OUT1} = 20A (20MHz BW)

Figure 7. Channel 1 Output Voltage Ripple



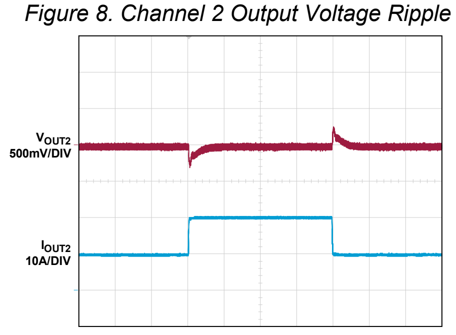
V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 20A (20MHz BW)

Figure 8. Channel 2 Output Voltage Ripple



V_{IN} = 48V, V_{OUT1} = 5V, I_{OUT1} = 10A-20A-10A

Figure 9. Channel 1 Load Transient Response



V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 10A-20A-10A

Figure 10. Channel 2 Load Transient Response

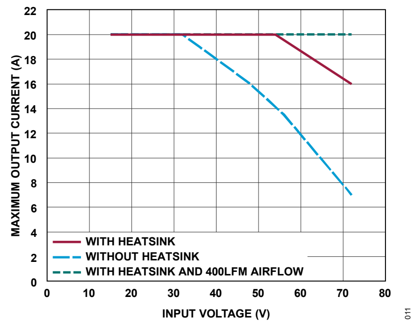
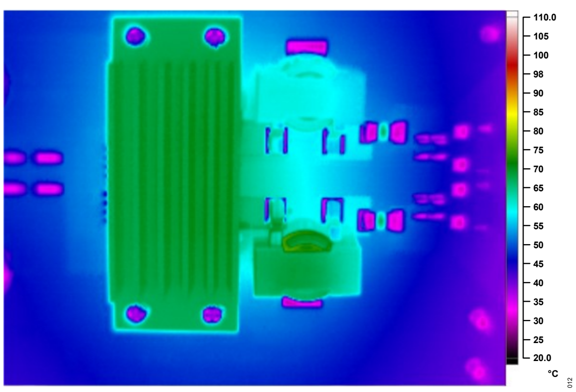


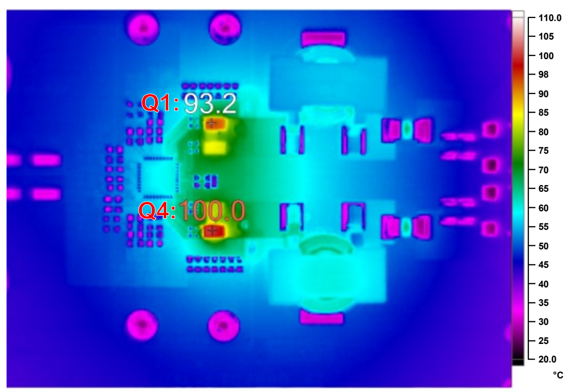
Figure 11. Maximum recommended output current vs. V_{IN} with the same load current on both channels while simultaneously keeping the maximum board temperature under 100°C after running for 10 minutes. With a heatsink, the board can operate at maximum load on both channels simultaneously from an input of 14V to 52V. With a Heatsink and airflow, the board can operate at the maximum load current for the full input voltage range.



V_{IN} = 48V, V_{OUT1} = 5V, I_{OUT1} = 20A, V_{OUT2} = 12V, I_{OUT2} = 20A

With Heatsink, No Airflow

Figure 12. Full power can be achieved on both channels simultaneously with the addition of the heatsink.



V_{IN} = 32V, V_{OUT1} = 5V, I_{OUT1} = 20A, V_{OUT2} = 12V, I_{OUT2} = 20A

No Heatsink, No Airflow

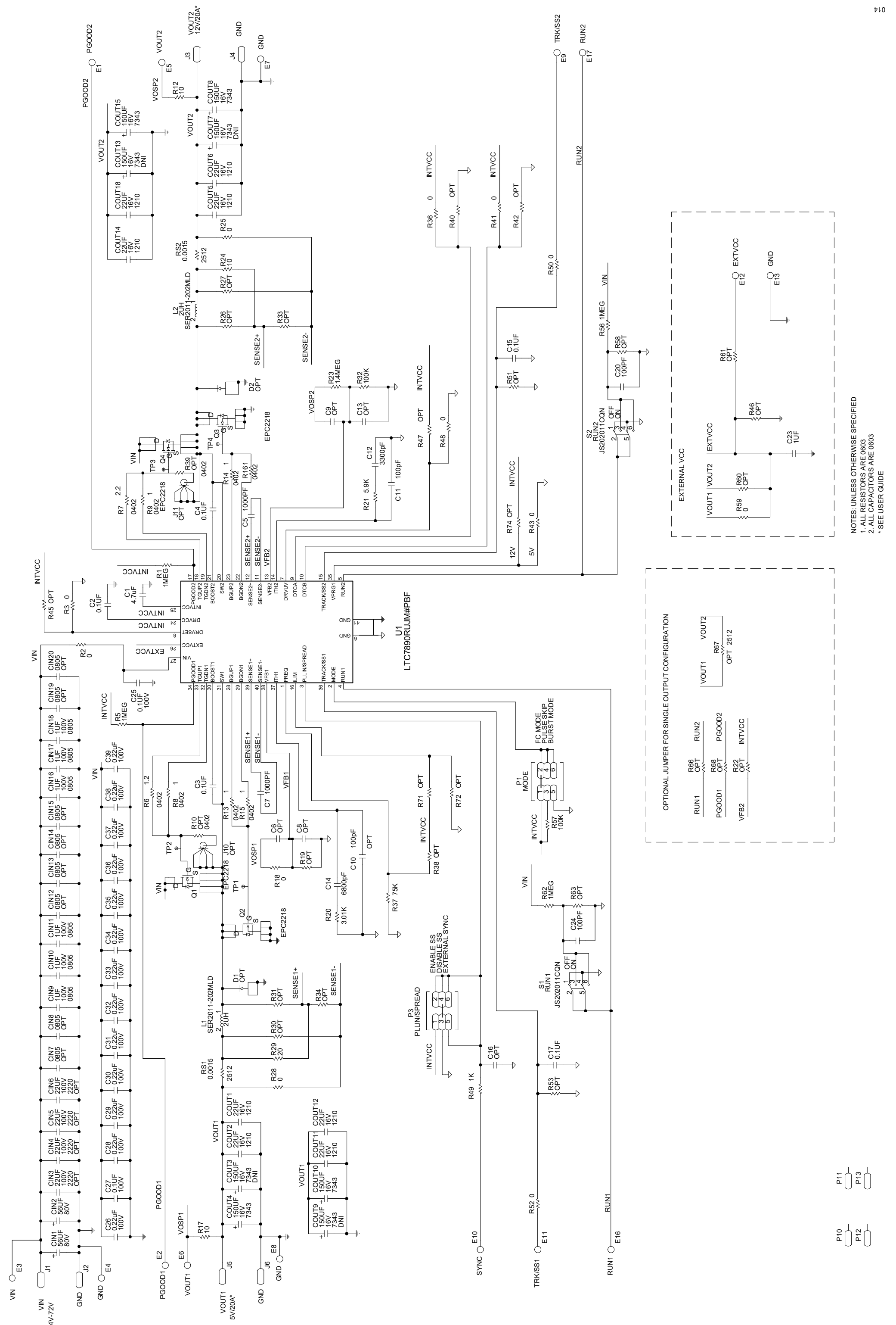
Figure 13. Without the heatsink, the component temperature can rise to 100°C after running for 10 minutes at $32V_{IN}$.

Bill of Materials

ITEM	QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER PART NUMBER
		REQUIRED CIRCUIT COMPONENTS		
1	1	C1	CAP. 4.7µF, X5R, 25V, 10%, 0603, AEC-Q200	MURATA, GRM188R61E475KE13D
2	1	C11	CAP., 100pF, X8R, 50V, 10%, 0603	TDK, C1608X8R1H101K
3	1	C12	CAP., 3300pF, X7R, 50V, 10%, 0603	YAGEO, CC0603KRX7R9BB332
4	1	C14	CAP., 6800pF, X7R, 50V, 10%, 0603	YAGEO, CC0603KRX7R9BB682
5	5	C2, C3, C4, C15, C17	CAP., 0.1µF, X7R, 25V, 10%, 0603	KEMET, C0603C104K3RACTU
6	2	C20, C24	CAP., 100pF, X7R, 50V, 10%, 0603	KEMET, C0603C101K5RAC
7	1	C23	CAP., 1µF, X7R, 25V, 10%, 0603, AEC-Q200	MURATA, GCM188R71E105KA64D
8	1	C25, C27	CAP., 0.1µF, X7R, 100V, 10%, 0603	MURATA, GRM188R72A104KA35D
9	13	C26, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39	CAP., 0.22µF, X7S, 100V, 10%, 0603, AEC-Q200	TAIYO YUDEN, HMK107C7224KAHTE
10	2	C5, C7	CAP., 1000pF, X7R, 25V, 10%, 0603	AVX, 06033C102KAT2A
11	2	CIN1, CIN2	CAP., 56µF, AL-POLY, 80V, 20%	PANASONIC, 80SXV56M
12	6	CIN9, CIN10, CIN11, CIN16, CIN17, CIN18	CAP., 1µF, X7S, 100V, 10%, 0805	TDK, C2012X7S2A105K125AB
13	8	COUT1, COUT2, COUT5, COUT6, COUT11, COUT12, COUT14, COUT18	CAP., 22µF, X7R, 16V, 10%, 1210	MURATA, GRM32ER71C226KEA8L
14	1	COUT4, COUT8, COUT10, COUT15	CAP., 150µF, TANT., 16V, 20%, 7343	PANASONIC, 16TQC150MYF
15	2	L1, L2	IND., 2µH, PWR, 20%, 40A, 1.34mΩ 18.7X19.18mm, AEC-Q200	COILCRAFT, SER2011-202MLD
16	4	Q1, Q2, Q3, Q4	XSTR., PWR, GaNFET, 100V, 60A/231A, DIE SIZE: 3.5 x 1.95mm	EFFICIENT POWER CONVERSION, EPC2218
17	12	R2, R3, R18, R25, R28, R36, R41, R43, R48, R50, R52, R59	RES., 0Ω, 1/10W,0603, AEC-Q200	VISHAY, CRCW06030000Z0EA
18	2	R1, R5	RES., 1MΩ, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031M00JNEA
19	1	R12	RES., 10Ω, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060310R0FKEA
20	6	R8, R9, R13, R14, R15, R16	RES., 1Ω, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021R00JNED
21	2	R17, R24	RES., 10Ω, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF10R0V
22	1	R20	RES., 3.01kΩ, 1%, 1/10W, 0603	TE CONNECTIVITY, CPF0603B3K01E1
23	1	R21	RES., 5.9kΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF5901V
24	1	R23	RES., 1.4MΩ, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW06031M40FKEA
25	1	R29	RES., 20Ω, 1%, 1/10W, 0603, AEC-Q200	VISHAY, CRCW060320R0FKEA
26	1	R32	RES., 100kΩ, 1%, 1/10W, 0603	VISHAY, CRCW0603100KFKEA
27	1	R37	RES., 75kΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF7502V
28	1	R49	RES., 1kΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF1001V
29	2	R56, R62	RES., 1MΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-2RKF1004X
30	1	R57	RES., 100kΩ, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ-3EKF1003V

31	1	R6	RES., 1.2Ω, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04021R20FKED
32	1	R7	RES., 2.2Ω, 5%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022R20JNED
33	2	RS1, RS2	RES., 0.0015Ω, 1%, 3W, 2512, AEC-Q200	VISHAY, WSLP25121L500FEA
34	2	S1, S2	SWITCH SLIDE DPDT 300MA 6V Through Hole	C&K, JS202011CQN
35	1	U1	IC, Dual Step-Down Controller for GaN FETs, side wettable plastic QFN-40	ANALOG DEVICES, LTC7890RUJM#PBF
OPTIONAL CIRCUIT COMPONENTS				
1	0	C10	CAP., 100pF, X7R, 50V, 10%, 0603	KEMET, C0603C101K5RAC
2	0	C6, C8, C9, C13, C16	CAP., OPTION, 0603	
3	0	CIN7, CIN8, CIN12, CIN13, CIN15, CIN19, CIN20	CAP., 1µF, X7S, 100V, 10%, 0805	TDK, C2012X7S2A105K125AB
4	0	CIN3, CIN4, CIN5, CIN6	CAP., 22µF, X7S, 100V, 20%, 2 Stacked	TDK, CKG57NX7S2A226M500JH
5	0	COUT3, COUT7, COUT9, COUT13	CAP., 150µF, TANT., 16V,20%, 7343	PANASONIC, 16TQC150MYF
6	0	D1, D2	DIODE, SCHOTTKY, 100V, 10A, TO-277A, AEC-Q101	VISHAY, SS10PH10-M3/86A
7	0	J10, J11	CONN., RF/COAX, MMCX, JACK, FEMALE, VERT, ST, SMT	MOLEX, 73415-2063
8	0	R10, R39	RES., OPTION, 0402	
9	0	R19, R22, R26, R27, R30, R31, R33, R34, R38, R40, R42, R45, R46, R47, R51, R53, R58, R60, R61, R63, R66, R68, R71, R72, R74	RES., OPTION, 0603	
10	0	R67	RES., OPTION, 2512	
11	0		THERMAL INTERFACE MATERIAL	T-GLOBAL, TG-A1780 X 0.5mm
12	0	MP5	HEATSINK 1/8 BRICK 55X20.7X11.4M	WAKEFIELD-VETTE, 567-45AB
HARDWARE – FOR EVALUTATION CIRCUIT ONLY				
1	15	E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E16, E17	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THICK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	6	J1, J2, J3, J4, J5, J6	THREADED BROACHING STUD, 625MIL LENGTH	PENN ENGINEERING, KFH-032-10ET
3	2	P1, P3	CONN., HDR, MALE, 2x3, 2mm, VERT, STR, THT	WURTH ELEKTRONIK, 62000621121
4	4	MP1, MP2, MP3, MP4	STANDOFF, NYLON, SNAP-ON, 0.625 (5/8"), 15.9mm	KEYSTONE, 8834
5	2	XP1, XP3	CONN., SHUNT, FEMALE, 2 POS, 2mm	WURTH ELEKTRONIK, 60800213421
6	4	P10, P11, P12, P13	CONN-PCB 1POS STEEL SPACER WITH M2X0.4 THD	WURTH ELEKTRONIK, 9774010243R

Schematic



Revision History

Revision Number	Revision Date	Nature of Change	Page Number
Rev 0	12/23	Initial Release	—