EVAL-LTC7890-BZ

High Frequency, Dual Output, Step-Down Supply with Si FETs

General Description

Evaluation circuit EVAL-LTC7890-BZ is a dual output synchronous step-down converter that drives N-channel silicon (Si) field effect transistors (FETs). The EVAL-LTC7890-BZ evaluation board features 100V logic-level Si FETs.

EVAL-LTC7890-BZ 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, which can also be used to drive logic-level silicon FETs. To evaluate the LTC7890 with GaN FETs, refer to the EVAL-LTC7890-AZ evaluation board, which does $12V_{OUT}$ at 20A and $5V_{OUT}$ at 20A.

The EVAL-LTC7890-BZ operates over an input voltage range from 16V to 72V, while the LTC7890 can operate up to 100V. The EVAL-LTC7890-BZ evaluation circuit produces two outputs: 5V and 12V, with up to 10A on each output. EVAL-LTC7890-BZ is configured with sense resistors for current sensing. A mode selector allows the EVAL-LTC7890-BZ to operate in forced continuous operation, pulse-skipping or Burst Mode® operation during light loads. The $EXTV_{CC}$ 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-BZ 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, $I_{OUT1} = I_{OUT2}$ = 10A	16		52	V
	400LFM Airflow, $I_{OUT1} = I_{OUT2}$ = 10A	16		72	
Output Voltage, V_{OUT1}	V_{IN} = 16V – 72V, VPRG1 = 0V	4.925	5	5.075	V
Output Voltage Ripple, $V_{OUT1(AC)}$	V_{IN} = 48V, I_{OUT} = 10A		30		mV_{P-P}
Output Voltage, V_{OUT2}	V_{IN} = 16V – 72V	11.76	12	12.24	V
Output Voltage Ripple, $V_{OUT2(AC)}$	V_{IN} = 48V, I_{OUT} = 10A		35		mV_{P-P}
Run Rising Threshold, RUN1, RUN2			15.0		V
Run Falling Threshold, RUN1, RUN2			13.5		V
Input Current	FCM, V_{IN} = 48V, $I_{OUT1} = I_{OUT2}$ = 0A		33.5		mA
	Burst Mode, V_{IN} = 48V, $I_{OUT1} = I_{OUT2}$ = 0A		14		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} = 10A		90.5		%
	V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 10A		95.1		%

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Quick Start Procedure

The EVAL-LTC7890-BZ evaluation circuit is easy to set up to evaluate the performance of the LTC7890 when used with logic-level silicon FETs. 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. Enable the input power supply. Increase the V_{IN} to 16V. Make sure the RUN1 and RUN2 switches are in the ON position.
   NOTE: Make sure that the input voltage is always within the specified range.
4. Check for the proper output voltages and verify that V_{OUT1} = 5V and V_{OUT2} =12V.
5. Once the proper output voltage is established, adjust the input voltage and load current within the operating range and measure the output voltage regulation, ripple voltage, efficiency, and other parameters.
   NOTE: When measuring the input or output voltage ripple, 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 probing 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-BZ 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 in the data sheet for calculating the V_{FB1} resistor divider values for the desired output voltage. The corresponding power components may 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 in the data sheet for calculating the V_{FB2} resistor divider values for the desired output voltage. The corresponding power components may 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-BZ 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-BZ connects the run pins of each channel to a divider set to turn on the LTC7890 at ~15V. The threshold can be easily adjusted 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 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 and C15 for Channel 1 and Channel 2, respectively. 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 in the data sheet.

Mode Selection (MODE, P1)

EVAL-LTC7890-BZ 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, P2)

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-BZ includes a jumper (P2) to conveniently enable or disable the spread spectrum operation. See Table 2 to configure P2.

The LTC7890 also features a phase-locked loop to synchronize the internal oscillator to an external clock source. EVAL-LTC7890-BZ provides a SYNC turret to connect the 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 LTC7890 data sheet for more details about external clock synchronization.

Open-Drain PGOOD Outputs (PGOOD)

EVAL-LTC7890-BZ 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 voltage 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-BZ, 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-BZ 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-BZ features excellent thermal performance. The component temperatures of EVAL-LTC7890-BZ with a 48V input and 10A load on both channels at the same time are shown in Figure 11. The six-layer PCB layout features solid copper planes that provide adequate heat spreading across the whole board. For input voltages greater than 52V, the output current must be derated to keep the maximum component temperature under 100°C. See Figure 12 for maximum output current vs. input voltage.

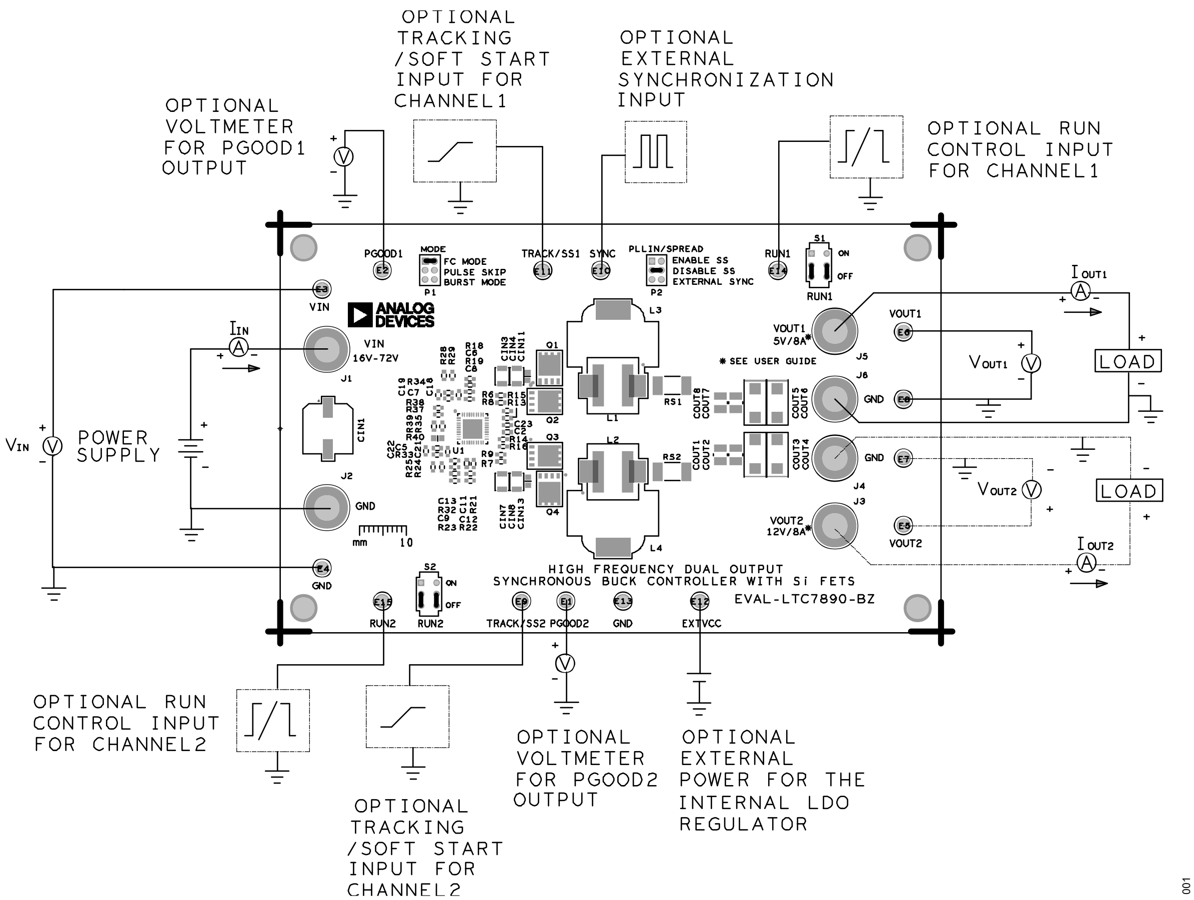


Figure 1. EVAL-LTC7890-BZ Board Connections

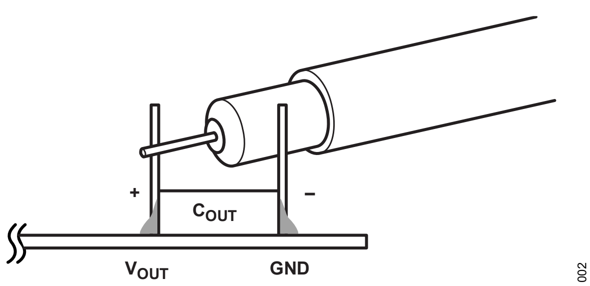


Figure 2. EVAL-LTC7890-BZ Ripple Measurement

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	Burst 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. RUN1 Switch (S1) Settings

SWITCH POSITION	RUN PIN	CONTROLLER
ON	Connected to the center node of the resistor-divider R62 and R63	Programmed to enable Channel 1 at the desired input voltage level
OFF*	Connected to GND	Disabled

**Default position*

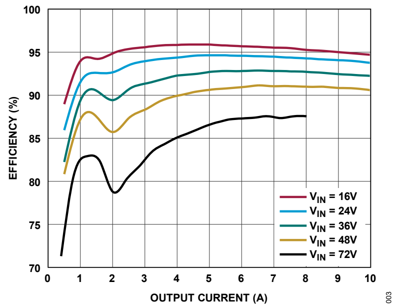
Table 4. RUN2 Switch (S2) Settings

SWITCH POSITION	RUN PIN	CONTROLLER
ON	Connected to the center node of the resistor-divider R56 and R58	Programmed to enable Channel 2 at the desired input voltage level
OFF*	Connected to GND	Disabled

**Default position*

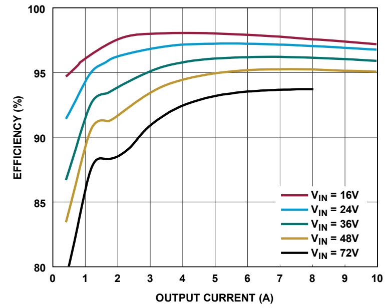
Performance

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



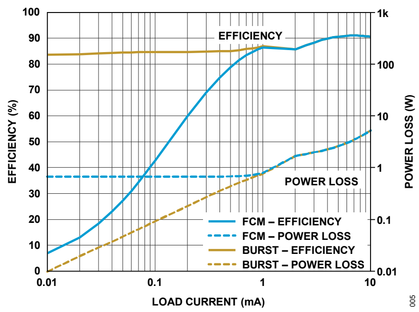
V_{OUT1} = 5V, f_{SW} = 500kHz, FCM Mode, Channel 2 OFF

Figure 3. Channel 1 Efficiency vs. Load Current



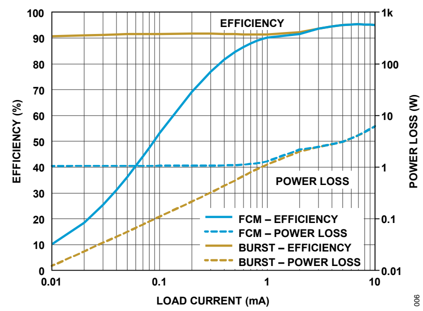
V_{OUT2} = 12V, f_{SW} = 500kHz, FCM Mode, Channel 1 OFF

Figure 4. Channel 2 Efficiency vs. Load Current



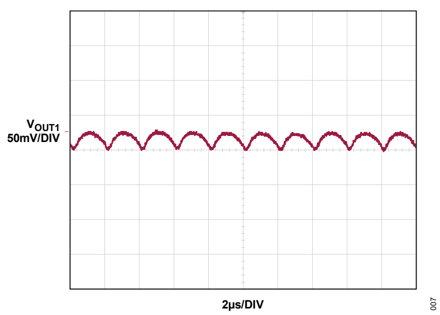
V_{IN} = 48V, V_{OUT1} = 5V, f_{SW} = 500kHz, Channel 2 OFF

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



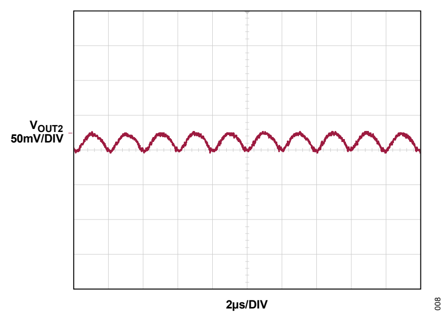
V_{IN} = 48V, V_{OUT2} = 12V, f_{SW} = 500kHz, Channel 1 OFF

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



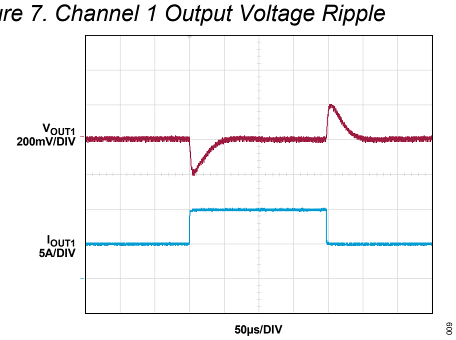
V_{IN} = 48V, V_{OUT1} = 5V, I_{OUT1} = 10A (20MHz BW)

Figure 7. Channel 1 Output Voltage Ripple



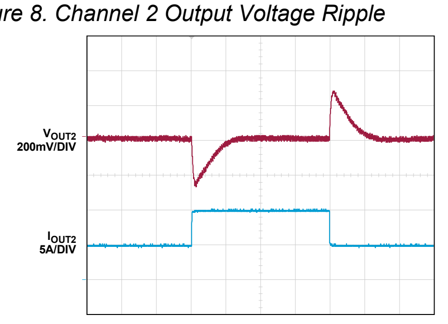
V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 10A (20MHz BW)

Figure 8. Channel 2 Output Voltage Ripple



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

Figure 9. Channel 1 Load Transient Response



V_{IN} = 48V, V_{OUT2} = 12V, I_{OUT2} = 5A-10A-5A

Figure 10. Channel 2 Load Transient Response

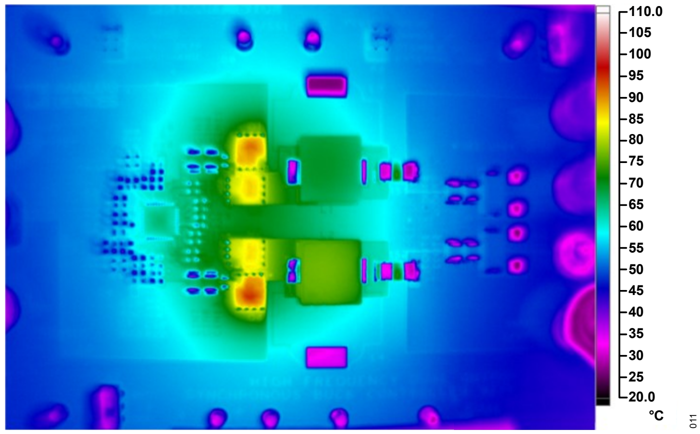


Figure 11. Typical thermal performance with a 48V input, 5V output 10A load on Channel 1, 12V output 10A load on Channel 2, 500kHz switching frequency, running in free air at an ambient temperature of 25°C

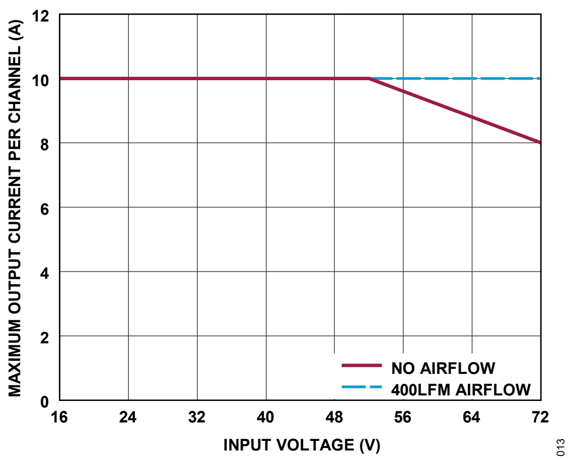
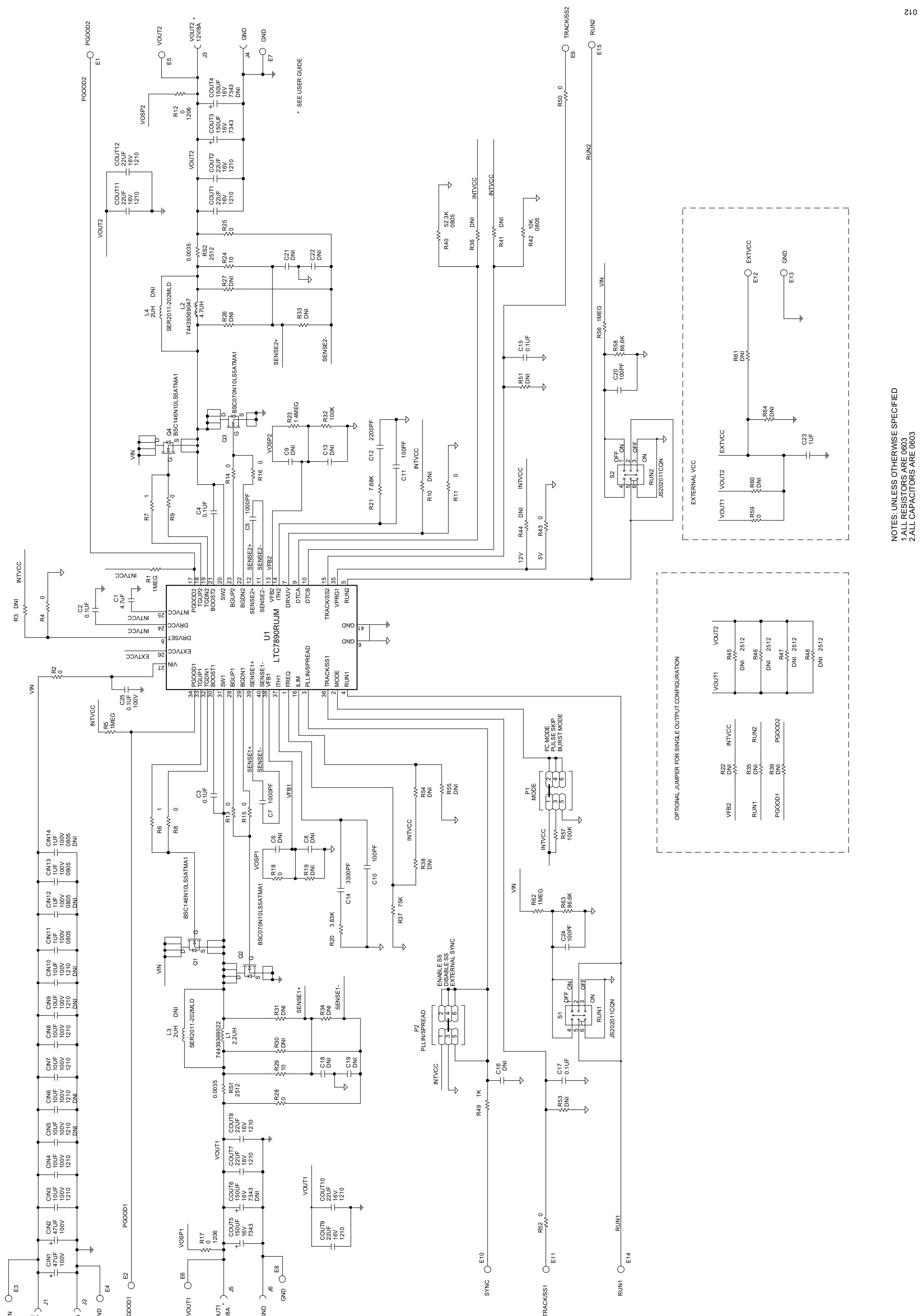


Figure 12. Maximum Output Current per Channel vs. Input Voltage. The EVAL-LTC7890-BZ can output 10A on each channel from an input voltage of 16V to 52V; for input voltages above 52V, the maximum output current must be derated to keep the maximum component temperature under 100°C. With 400 LFM of airflow, the board can operate at 10A on each channel for the full input voltage range of 16V to 72V.

Schematic


U1
LTC7890RUJM
* SEE USER GUIDE
OPTIONAL JUMPER FOR SINGLE OUTPUT CONFIGURATION
EXTERNAL VCC
NOTES: UNLESS OTHERWISE SPECIFIED
1.ALL RESISTORS ARE 0603
2.ALL CAPACITORS ARE 0603

Revision History

REVISION NUMBER	REVISION DATE	NATURE OF CHANGE	PAGE NUMBER
Rev 0	4/24	Initial Release	—

Notes