

LTC3588EMSE-1
LTC3588EMSE-2
Piezoelectric Energy
Harvesting Power Supply
DESCRIPTION

Demonstration Circuit 1459B is an energy harvesting power supply featuring the LTC3588-1/LTC3588-2. The LTC3588 integrates a low-loss full-wave bridge with a high efficiency buck converter to form a complete energy harvesting solution optimized for high output impedance energy sources such as piezoelectric transducers. An ultralow quiescent current under-voltage lockout mode with a wide hysteresis window allows charge to accumulate on an input capacitor until the buck converter can efficiently transfer a portion of the stored charge to the output. Four output voltages are pin selectable with up to 100mA of continuous output current. A power good comparator

produces a logic high referenced to VOUT on the PGOOD pin when the converter reaches the programmed VOUT, signaling that the output is in regulation.

The LTC3588EMSE-1/LTC3588EMSE-2 are available in a 10-lead (3mm × 3mm) MSE surface mount package with exposed pad.

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TABLE 1
PERFORMANCE SUMMARY LTC3588EMSE-1 Specifications are at $T_A = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNITS
VIN	Input Voltage Range		4.3	18.0	V
VOUT 1.8V	Output Voltage Range	D0 = 0, D1=0	1.71	to 1.89	V
VOUT 2.5V	Output Voltage Range	D0 = 1, D1=0	2.425	to 2.575	V
VOUT 3.3V	Output Voltage Range	D0 = 0, D1=1	3.201	to 3.399	V
VOUT 3.6V	Output Voltage Range	D0 = 1, D1=1	3.491	to 3.708	V

PERFORMANCE SUMMARY LTC3588EMSE-2 Specifications are at $T_A = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	MAX	UNITS
VIN	Input Voltage Range		14.0	18.0	V
VOUT 3.45V	Output Voltage Range	D0 = 0, D1=0	3.346	to 3.554	V
VOUT 4.1V	Output Voltage Range	D0 = 1, D1=0	3.977	to 4.223	V
VOUT 4.5V	Output Voltage Range	D0 = 0, D1=1	4.365	to 4.635	V
VOUT 5.0V	Output Voltage Range	D0 = 1, D1=1	4.850	to 5.150	V

OPERATING PRINCIPLE

Refer to the block diagram within the LTC3588-1/-2 data sheet for its operating principle.

The LTC3588 is an ultralow quiescent current power supply designed specifically for energy harvesting and/or low current step-down applications. The part is designed to interface directly to a piezoelectric or alternative A/C energy source, rectify and store the harvested energy on an external capacitor, bleed off any excess energy via an internal shunt regulator, and maintain a regulated output voltage by means of a nano-power high efficiency synchronous buck regulator.

The LTC3588 has an internal full-wave bridge rectifier accessible via PZ1 and PZ2 that rectifies AC inputs such as those from a piezoelectric element. The rectified output is stored on a capacitor at the VIN pin and can be used as an energy reservoir for the buck converter. The bridge is capable of carrying up to 50mA.

When the voltage on VIN crosses the UVLO rising threshold the buck converter is enabled and charge is transferred from the input capacitor to the output capacitor. A wide (~1V) UVLO hysteresis window is employed with a lower threshold approximately 200mV above the selected regulated output voltage to prevent short cycling during buck power-up.

When the input capacitor voltage is depleted below the UVLO falling threshold the buck converter is disabled.

Two internal rails, CAP and VIN2, are generated from VIN and are used to drive the high side PMOS and low side NMOS of the buck converter, respectively. Additionally the VIN2 rail serves as logic high for output voltage select bits D0 and D1. The VIN2 rail is regulated at 4.8V above GND while the CAP rail is regulated at 4.8V below VIN. These are not intended to be used as external rails. Capacitors should be con-

nected to the CAP and VIN2 pins to serve as energy reservoirs for driving the buck switches.

The buck regulator uses a hysteretic voltage algorithm to control the output through internal feedback from the VOUT sense pin. The buck converter charges an output capacitor through an inductor to a value slightly higher than the regulation point. It does this by ramping the inductor current up to 250mA through an internal PMOS switch and then ramping it down to 0mA through an internal NMOS switch. When the buck brings the output voltage into regulation the converter enters a low quiescent current sleep state that monitors the output voltage with a sleep comparator. During this operating mode load current is provided by the buck output capacitor. When the output voltage falls below the regulation point the buck regulator wakes up and the cycle repeats. This hysteretic method of providing a regulated output reduces losses associated with FET switching and maintains an output at light loads. The buck delivers a minimum of 100mA average load current when it is switching.

A power good comparator produces a logic high referenced to VOUT on the PGOOD pin the first time the converter reaches the programmed VOUT, signaling that the output is in regulation. The PGOOD pin will remain high until VOUT falls to 92% of the desired regulated voltage.

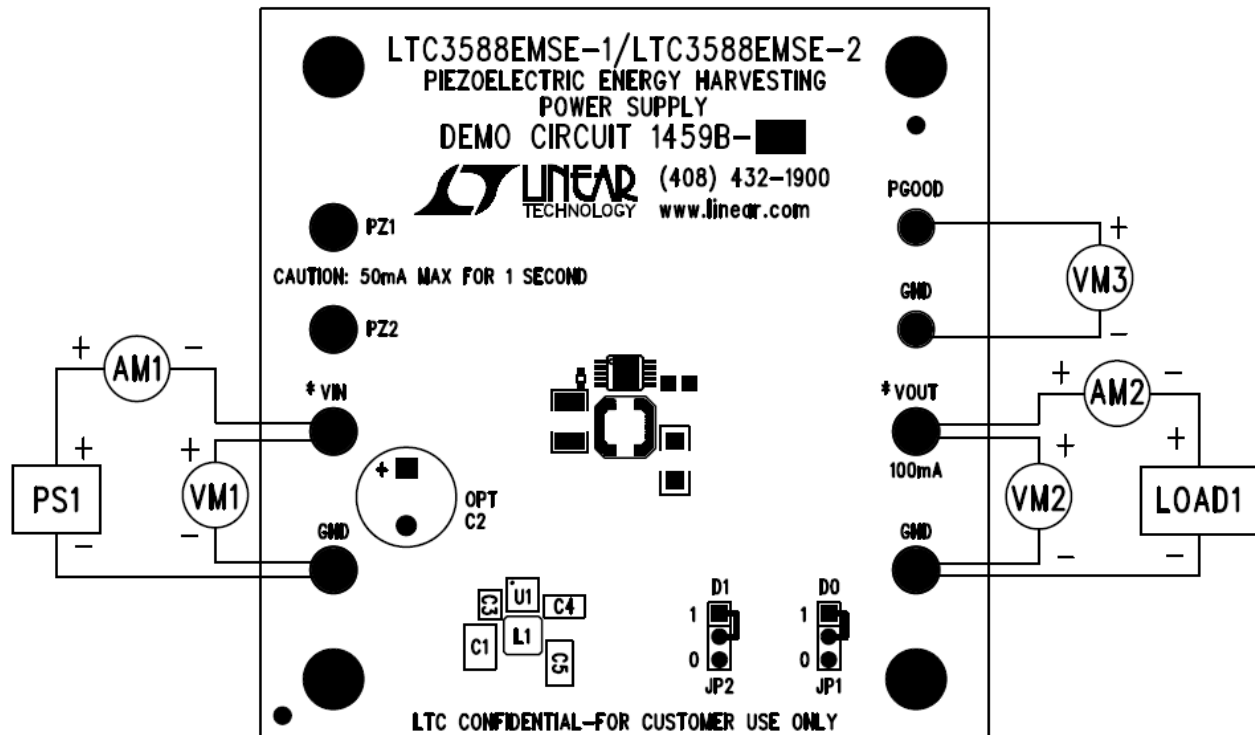


Figure 1. Proper Measurement Equipment Setup

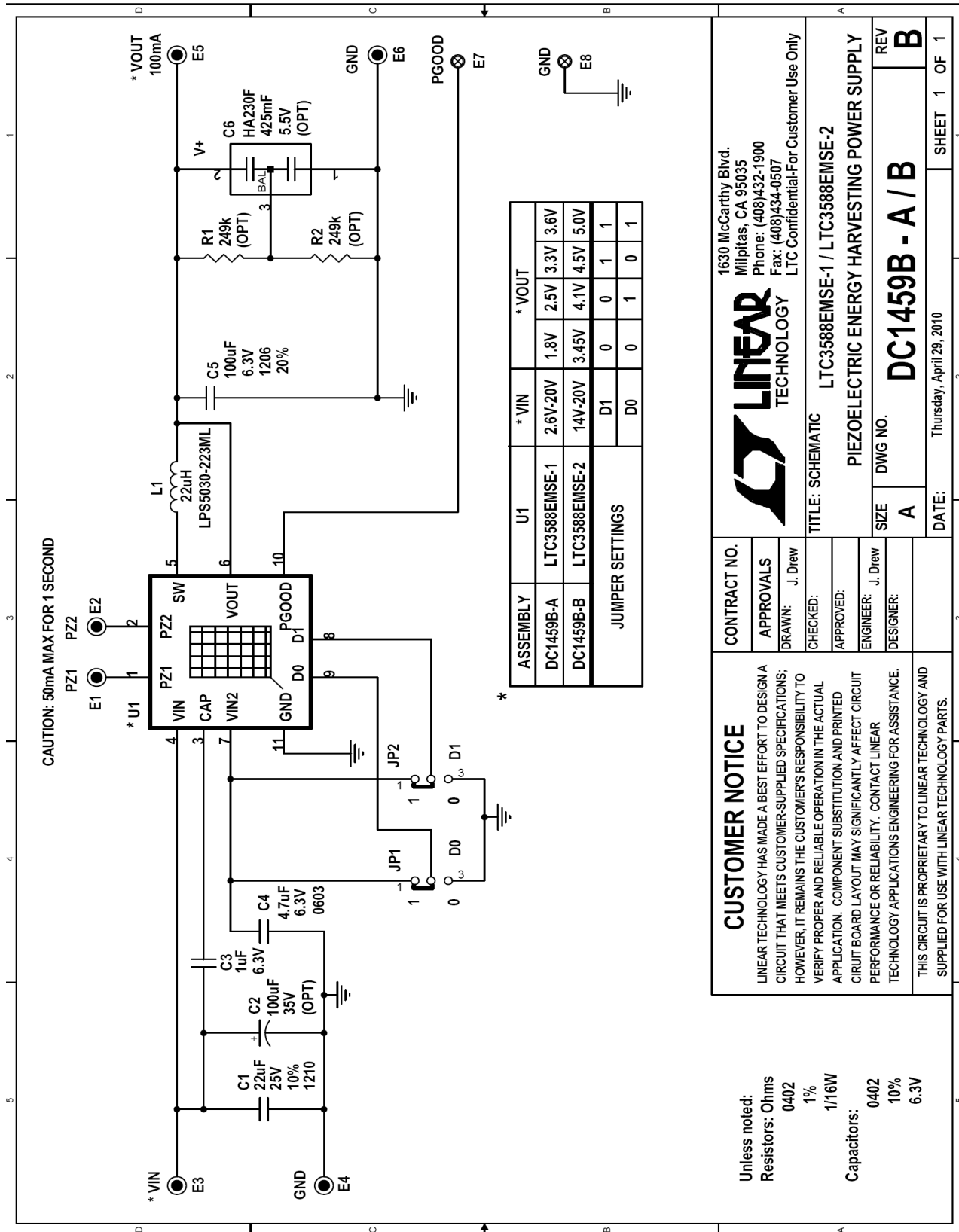


Figure 2: Schematic diagram

Item	Qty	Reference - Des	Part Description	Manufacturer, Part #
REQUIRED CIRCUIT COMPONENTS:				
1	1	C1	CAP, CHIP, X5R, 22uF, 10%, 25V, 1210	AVX, 12103D226KAT1A
2	1	C3	CAP, CHIP, X5R, 1uF, 10%, 6.3V, 0402	TDK, C1005X5R0J105KT
3	1	C4	CAP, CHIP, X5R, 4.7uF, 10%, 6.3V, 0603	TDK, C1608X5R0J475KT
4	1	C5	CAP, CHIP, X5R, 100uF, 20%, 6.3V, 1206	TAIYO YUDEN, JMK316BJ107ML-T
5	1	L1	INDUCTOR, 22UH, 1.4A, 190mΩ, 5mm x 5mm	COILCRAFT, LPS5030-223ML
6	1	U1 (ASSEMBLY- A) U1 (ASSEMBLY- B)	PIEZOELECTRIC ENERGY HARVESTING POWER SUPPLY	LINEAR TECH., LTC3588EMSE-1 LINEAR TECH., LTC3588EMSE-2
ADDITIONAL DEMO BOARD CIRCUIT COMPONENTS:				
1	0	C2 (OPT)	AL ELECT, 100uF, 35V, 20%, 8.2mm x 11.mm	VISHAY, MAL291355101E3
2	0	C6 (OPT)	SUPERCAP, 0.43F, 5.5V, 20mm x 18mm	CAP-XX, HA230F
3	0	R1,R2 (OPT)	RES., CHIP, 249K, 1/16W, 1%, 0402	VISHAY, CRCW0402249KFKED
HARDWARE FOR DEMO BOARD ONLY:				
1	6	E1,E2,E3,E4,E5,E6	TURRET, 0.09 DIA	MILL-MAX, 2501-2
2	2	E7,E8	TURRET, 0.061 DIA	MILL-MAX, 2308-2
3	2	JP1,JP2	HEADER, 3 PINS, 2mm	SAMTEC, TMM-103-02-L-S
4	2	JP1,JP2	SHUNT, 2MM	SAMTEC, 2SN-BK-G

Bill of Materials