Energy Harvesting (EH) Multi-Source Demo Board with Transducers

DESCRIPTION

The DC2080 is a versatile energy harvesting demo board that is capable of accepting piezoelectric, solar, 4mA to 20mA loops, thermal powered energy sources or any high impedance AC or DC source. The board contains four independent circuits consisting of the following EH ICs:

- LTC®3588-1: Piezoelectric Energy Harvesting Power Supply
- LTC3108: Ultralow Voltage Step-Up Converter and Power Manager
- LTC3105: Step-Up DC/DC Converter with Power Point Control and LDO Regulator
- LTC3459: 10V Micropower Synchronous Boost Converter
- LTC2935-2 and LTC2935-4: Ultralow Power Supervisor with Power-Fail Output Selectable Thresholds

The board is designed to connect to the Energy Micro STK development kit. It also includes two energy harvester transducers (TEG and Solar) and a terminal block for connecting a high impedance AC source.

In addition, many turrets are provided, making it easy to connect additional transducers to the board.

The board contains multiple jumpers that allow the board to be configured in various ways. The standard build for the board has 4 jumpers installed out of the possible 12 jumpers. The board is very customizable to the end users' needs. This compatibility makes it a perfect evaluation tool for any low power energy harvesting system.

Please refer to the individual data sheets for the operation of each power management circuit. The application section of this demo manual describes the system level functionality of this board and the various ways it can be used in early design prototyping.

Design files for this circuit board are available.

BOARD PHOTO

Figure 1. DC2080A Connected to an Energy Micro Starter Kit in the "To Go" Design Kit for Energy Harvesting

QUICK START PROCEDURE

Refer to Figures 2, 3 and 4 for the proper equipment setup and jumper settings for the following quick start procedure.

1. Configure the equipment and jumpers as shown in Figure 2. Verify the jumper settings are as follows:

   JP1 OPEN

   JP2 OPEN

   JP3 OPEN

   JP4 OPEN

   JP5 OPEN

   JP6 OPEN

   JP7 OPEN

   JP8 **OPEN**

   JP9 **INSTALLED in "ON" Position**

   JP10 OPEN

   JP11 OPEN

   JP12 **INSTALLED**

2. Slowly increase PS1 and observe the voltage at which VM2 turns on. VM1 should be equal to approximately 3.15V.
3. Slowly decrease PS1 towards zero. Observe the voltage on VM1 at which VM2 drops rapidly to 0V. VM1 should be equal to approximately 2.25V.
4. Turn off PS1 and remove all test equipment.
5. **Install JP4** and connect the Energy Micro starter kit board to J1.
6. Apply a light source and observe the starter kit turning on and displaying the temperature of the microcontroller.
7. **MOVE JP4 to JP2** and place a warm object, such as your hand, firmly on the entire TEG1, thermal electric generator.
8. Observe the starter kit turning on and displaying the temperature of the microcontroller.
9. **MOVE JP4 to JP1**. Disconnect the Energy Micro starter kit from J1.
10. Set PS2 equal to 6.0V. Reconfigure the test equipment as shown in Figure 3.
11. Turn on PS2. Observe the voltage on VM1 and VM2. The voltage on VM1 should be approximately 5.77 Volts and on VM2 should be 3.3V.
12. Use VM3 to observe the voltage on JP5-2. The voltage should be equal to the same level observed on VM2.
13. Turn off PS2
14. **MOVE JP1 to JP3.** Disconnect PS2 from the board and set PS3 equal to 5.0V. Reconfigure the test equipment as shown in Figure 4.
15. Turn on PS3. Observe the voltage on VM1 and VM2. The voltage on VM1 should be approximately 0.34 Volts and on VM2 should be 3.3V.
16. Use VM3 to observe the voltage on JP7-2. The voltage should be approximately equal to the level observed on VM2.
17. Turn off PS3
18. Reset the Jumpers as shown in Figure 5a.

    JP1 OPEN

    JP2 OPEN

    JP3 OPEN

    JP4 **INSTALLED**

    JP5 OPEN

    JP6 OPEN

    JP7 OPEN

    JP8 **OPEN**

    JP9 **INSTALLED in "ON" Position**

    JP10 OPEN

    JP11 **INSTALLED**

    JP12 OPEN

QUICK START PROCEDURE

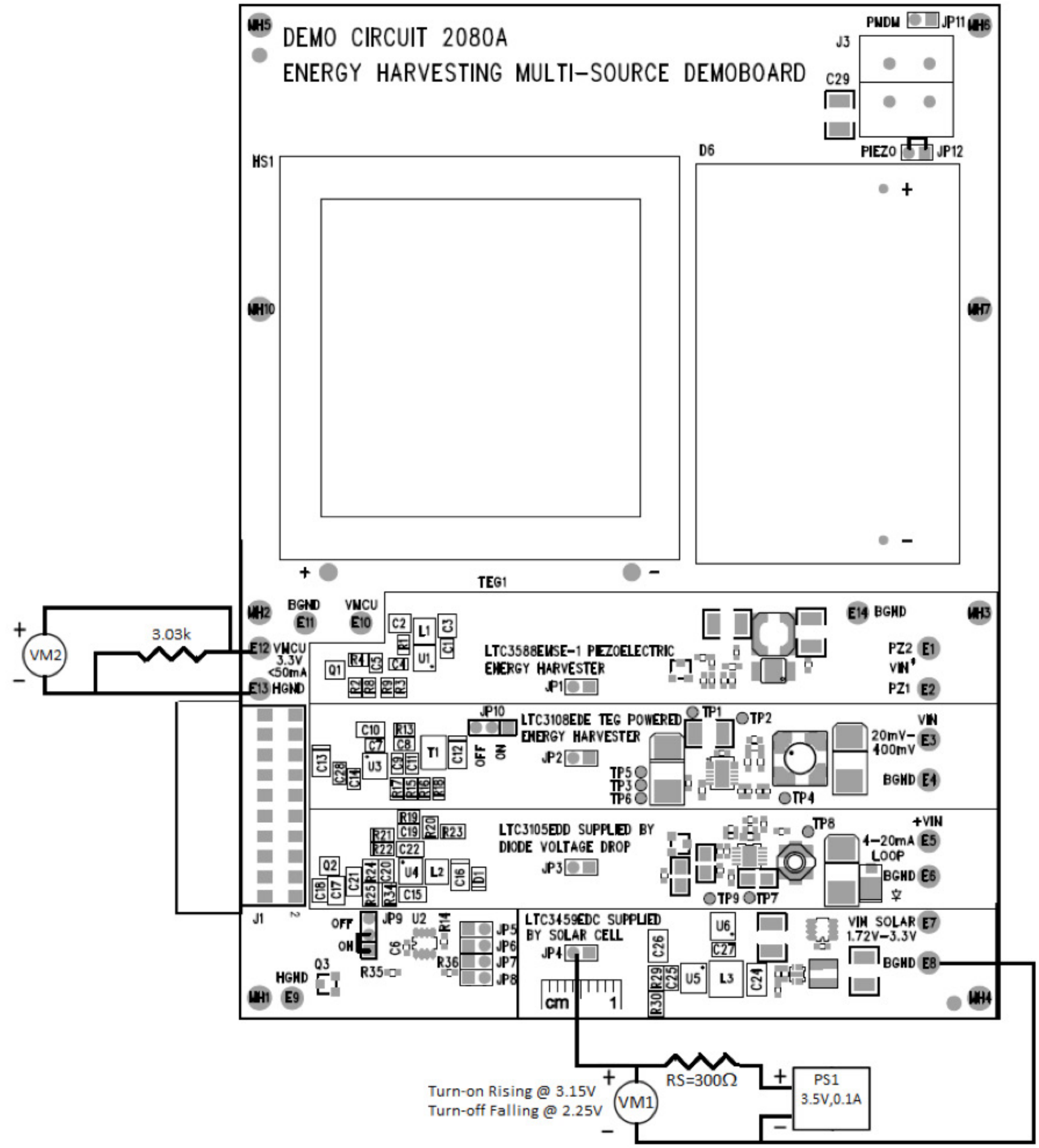

Figure 2. VMCU Power Switchover Test Setup

QUICK START PROCEDURE

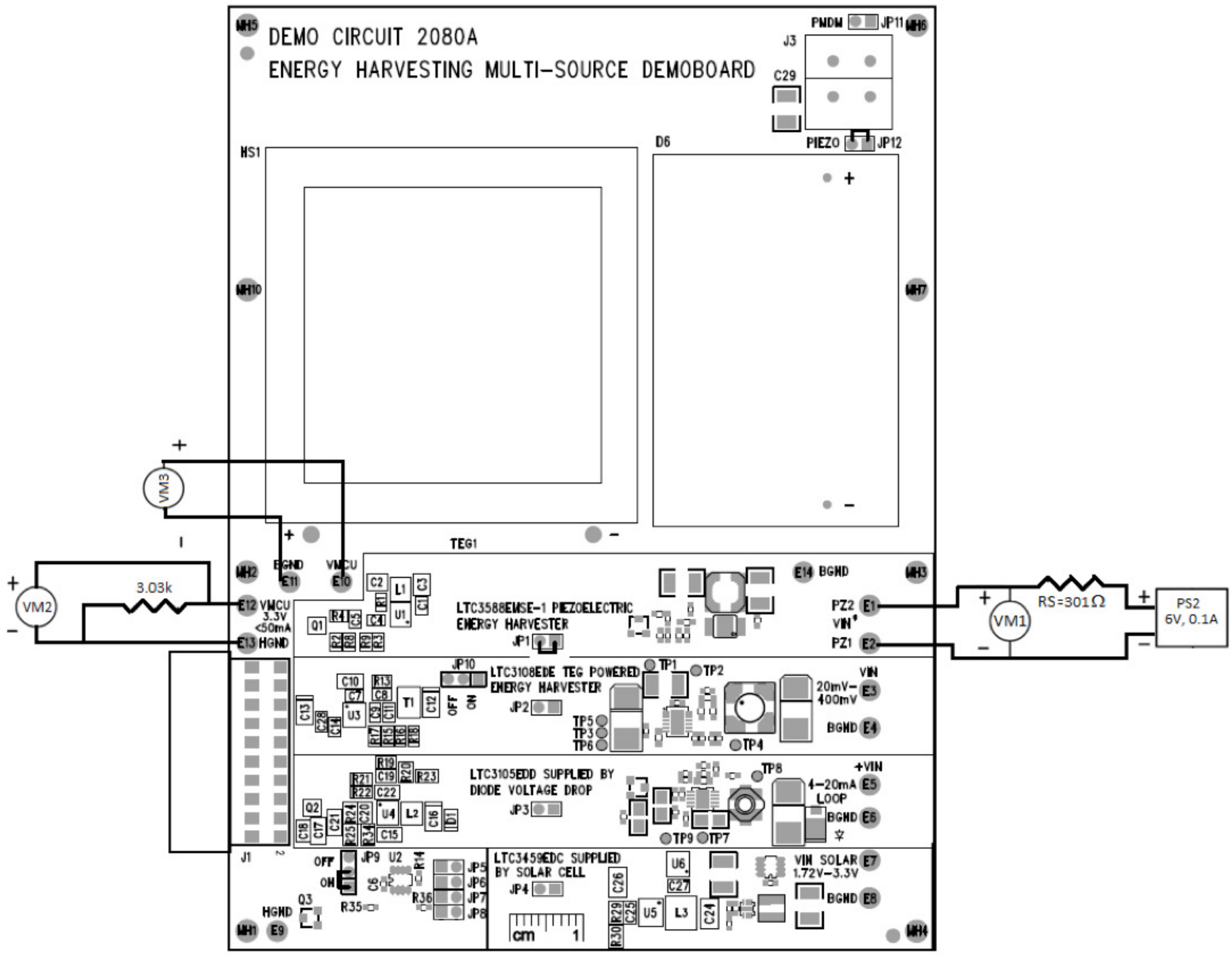

Figure 3. Piezoelectric Circuitry Test Setup. Proper Measurement Equipment Setup for DC2080A Piezoelectric Circuit Testing

QUICK START PROCEDURE

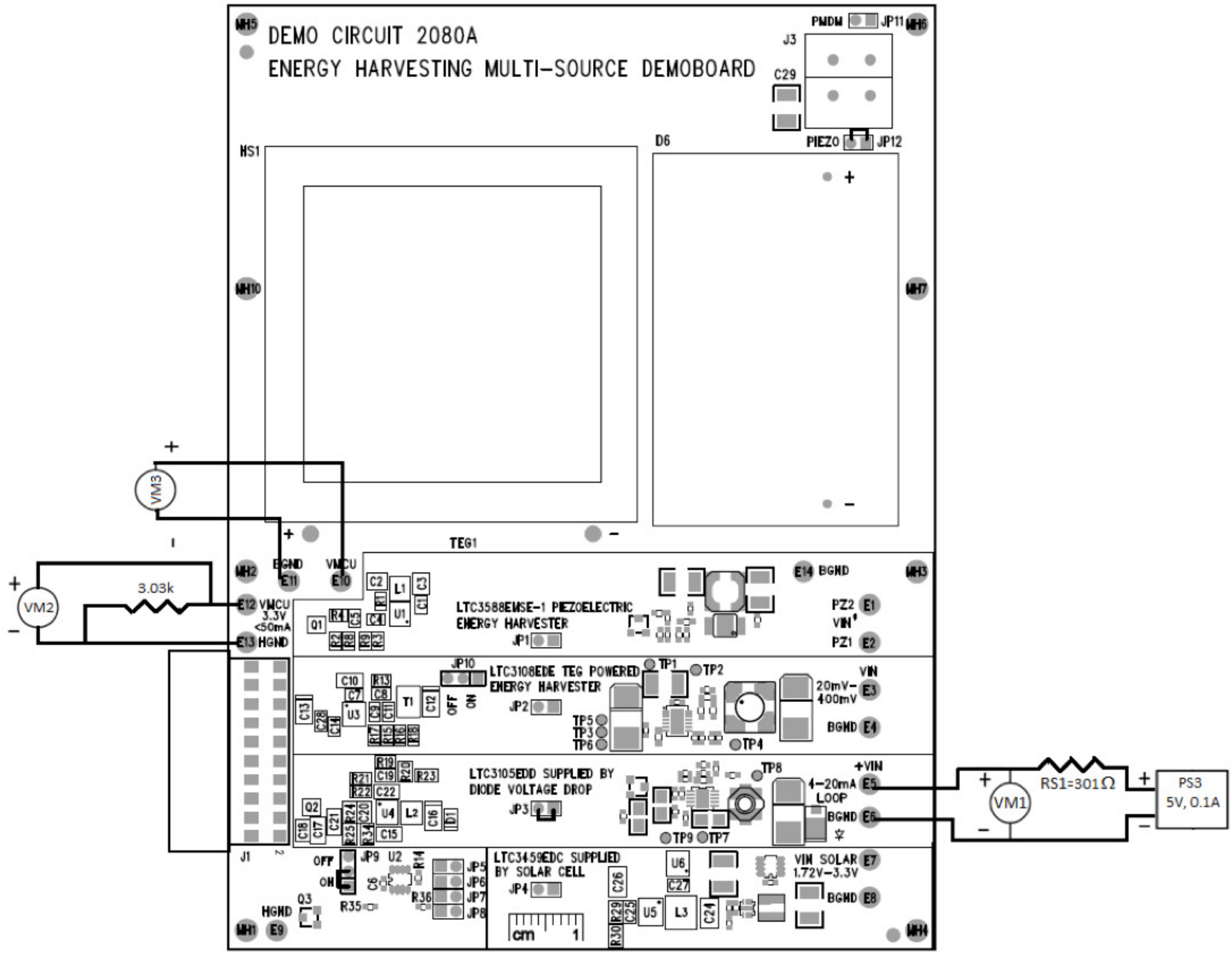

Figure 4. 4mA to 20mA Loop Circuitry Test Setup. Proper Measurement Equipment Setup for DC2080A 4mA to 20mA Loop Circuit Testing

QUICK START PROCEDURE

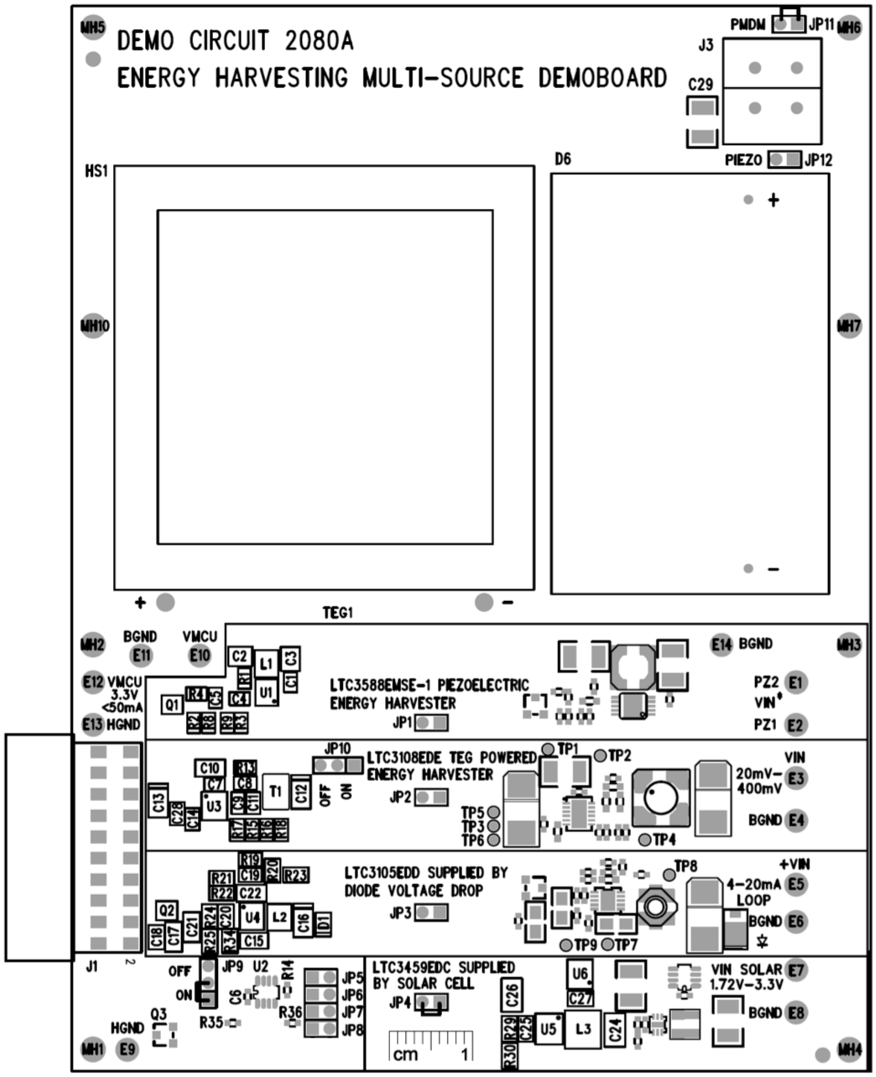

Figure 5a. DC2080A Top Assembly Drawing

Rev.A

QUICK START PROCEDURE

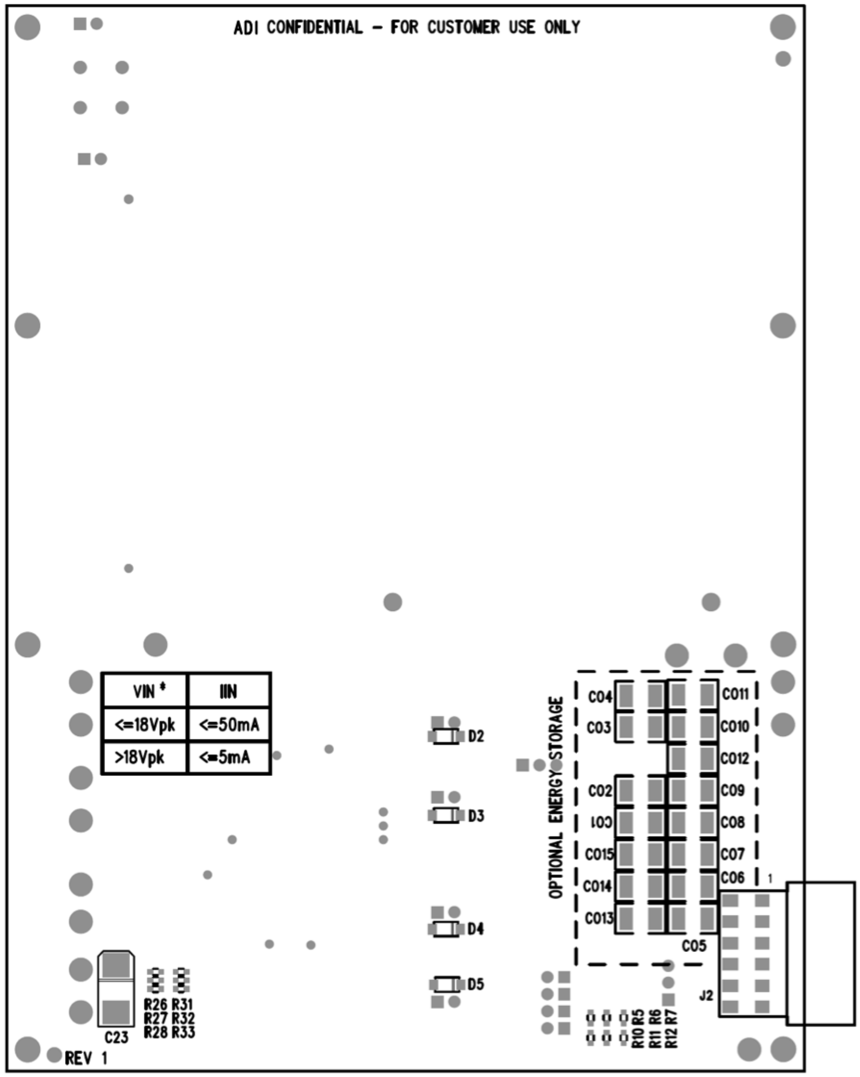

Figure 5b. DC2080A Bottom Assembly Drawing

APPLICATION

Jumper Functions

JP1: Power selection jumper used to select the LTC3588-1, Piezoelectric Energy Harvesting Power Supply.

JP2: Power selection jumper used to select the LTC3108, TEG Powered Energy Harvester.

JP3: Power selection jumper used to select the LTC3105, powered by a diode voltage drop in a 4mA to 20mA loop.

JP4: Power selection jumper used to select the LTC3459, powered by a solar panel.

JP5: Routes the LTC3588-1 PGOOD signal to the Dust header PGOOD output. The LTC3588-1 PGOOD comparator produces a logic high referenced to V_{OUT} on the PGOOD pin the first time the converter reaches the sleep threshold of the programmed V_{OUT}, signaling that the output is in regulation. The PGOOD pin will remain high until V_{OUT} falls to 92% of the desired regulation voltage. Additionally, if PGOOD is high and V_{IN} falls below the UVLO falling threshold, PGOOD will remain high until V_{OUT} falls to 92% of the desired regulation point. This allows output energy to be used even if the input is lost.

JP6: Routes the LTC3108 PGOOD signal to the header PGOOD output.

JP7: Routes the LTC3105 PGOOD signal to the header PGOOD output.

JP8: Routes the LTC3459 PGOOD signal to the header PGOOD output.

JP9: Connects the fifteen optional energy storage capacitors directly to V_{OUT} to be used by the load to store energy at the output voltage level. The 100µF capacitors have a voltage coefficient of 0.61 of their labeled value at 3.3V and 0.47V at 5.25V. **CAUTION: Only JP9 OR JP10 may be connected at any one time. Do not populate both JP9 and JP10.**

JP10: Connects the fifteen optional energy storage capacitors directly to VSTORE of the LTC3108 TEG powered energy harvester circuit, which is the output for the storage capacitor or battery. A large capacitor may be connected from VSTORE to GND for powering the system in the event the input voltage is lost. It will be charged up to the maximum VAUX clamp voltage, typically 5.25 Volts. The 100µF capacitors have a voltage coefficient of 0.47V at 5.25V. **CAUTION: Only JP9 OR JP10 may be connected at any one time. Do not populate both JP9 and JP10.**

JP11: Configures the AC input for use with a PMDM vibration harvester, **CAUTION: Only JP11 OR JP12 may be connected at any one time. Do not populate both JP11 and JP12.**

JP12: Configures the AC input for use with any high impedance source including piezoelectric transducers, electromechanical transducers or AC mains supplies with high series resistance. C**AUTION: Only JP11 OR JP12 may be connected at any one time. Do not populate both JP11 and JP12.**

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Turret Functions

PZ1 (E1): Input connection for piezoelectric element or other AC source (used in conjunction with PZ2). A high impedance DC source may be applied between this pin and BGND to power the LTC3588-1 circuit. **CAUTION: The maximum current into this pin is 50mA.**

PZ2 (E2): Input connection for piezoelectric element or other AC source (used in conjunction with PZ1). A high impedance DC source may be applied between this pin and BGND to power the LTC3588-1 circuit. **CAUTION: The maximum current into this pin is 50mA.**

VIN, 20mV to 400mV (E3): Input to the LTC3108, TEG powered Energy Harvester. The input impedance of the LTC3108 power circuit is approximately 3Ω, so the source impedance of the TEG should be less than 10Ω to have good power transfer. TEG's with approximately 3Ω will have the best power transfer. The input voltage range is 20mV to 400mV.

BGND (E4,E6,E8,E11,E14): This is the board ground. BGND is connected to all the circuits on the board except the headers. BGND and HGND, the header ground are connected through Q3 when the VMCU voltage with respect to BGND reaches the rising RESET Threshold of U2 and disconnected when VMCU falls to the falling reset threshold. The board is configured from the factory to connect BGND and HGND when VMCU equals 3.15V and disconnect them when VMCU equals 2.25V.

+VIN, 4mA to 20mA LOOP (E5): Input to the LTC3105 supplied by a diode voltage drop. The current into this terminal must be limited to between 4mA and 20mA. The current into this turret flows through diode D1 to generate the diode voltage drop and into the LTC3105 power management circuit.

VIN SOLAR (E7): Input to the LTC3459, solar powered circuit with maximum power point control, provided by the LTC2935-4. The input regulation point for the MPPC function is 1.73V. The input range is 1.72V to 3.3V.

HGND (E9,E13): This is the header ground. HGND is the switched ground to the header that ensures the load is presented with a quickly rising voltage. BGND and HGND are connected through Q3 when the VMCU voltage with respect to BGND reaches the rising RESET Threshold of U2 and disconnected when VMCU falls to the falling reset threshold. The board is configured from the factory to connect BGND and HGND when VMCU equals 3.15V and disconnect them when VMCU equals 2.25 Volts.

VMCU (E10,E12): Regulated output of all the active energy harvester power management circuits, referenced to BGND. When VMCU is referenced to HGND it is a switched output that is passed through header, J1 to power the load.

APPLICATION

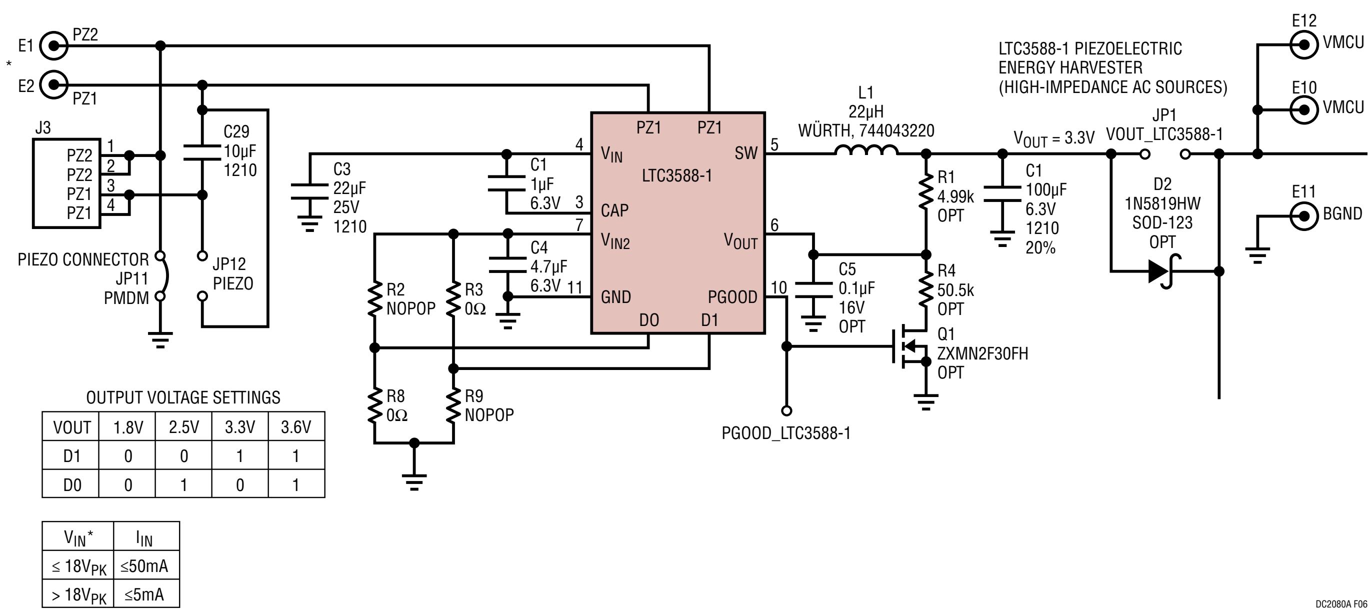
LTC3588-1: Piezoelectric Energy Harvesting Power Supply (Vibration or High-Impedance AC Source)

The LTC3588-1 piezoelectric energy harvesting power supply is selected by installing the power selection jumper JP1. The PGOOD signal can be routed to the header by installing jumper JP5.

If the application requires a wide hysteresis window for the PGOOD signal, the board has the provision to use the independent PGOOD signal, shown in Figure 10, generated by the LTC2935-2 and available on JP8. This signal is labeled as the PGOOD signal for the LTC3459 circuit (PGOOD_LTC3459), because the LTC3459 does not have its own PGOOD output. The PGOOD_LTC3459 signal can be used in place of any of the PGOOD signals generated by the harvester circuits. The board is configured from the factory to use the PGOOD_LTC3459 signal as the PGOOD signal to switch from battery power to energy harvesting power.

The PGOOD_LTC3459 signal is always used to switch the output voltage on the header. Some loads do not like to see a slowly rising input voltage. Switch Q3 ensures that VMCU on the header is off until the energy harvested output voltage is high enough to power the load. The LTC2935-2 is configured to turn on Q3 at 3.15V and turn off Q3 at 2.25V. With this circuit, the load will see a fast voltage rise at startup and be able to utilize all the energy stored in the output capacitors between the 3.15V and 2.25V levels.

The optional components R1, R4, Q1 and C5 shown on the schematic are not populated for a standard assembly. The function of R1, R4, Q1 and C5 is to generate a short PGOOD pulse that will indicate when the output capacitor is charged to its maximum value. The short pulse occurs every time the output capacitor charges up to the output sleep threshold, which for a 3.3V output is 3.312V. By populating these components the application can use this short pulse as a sequence timer to step through the



VOUT	1.8V	2.5V	3.3V	3.6V
D1	0	0	1	1
D0	0	1	0	1

V_{IN}*	I_{IN}
≤ $18V_{PK}$	≤50mA
> $18V_{PK}$	≤5mA

Figure 6. Detailed Schematic of LTC3588-1 Piezoelectric Energy Harvesting Power Supply

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program sequence or as an indication of when it can perform energy-intensive functions, such as a sensor read or a wireless transmission and/or receive, knowing precisely how much charge is available in the output capacitors. When this optional circuit is not used, the amount of charge in the output capacitors is anywhere between the maximum ($C_{OUT} \bullet V_{OUT\_SLEEP}$) to eight percent low. In the case where the energy harvesting source can support the average load continuously, this optional circuit is not needed.

Diode D2 is an optional component used to diode-OR multiple energy harvesting sources together. This diode would be used in conjunction with one or more of the other Or-ing diodes, D3, D4 or D5. When the Or-ing diodes are installed the parallel jumper would not be populated. The diode drop will be subtracted from the output voltage regulation point, so it is recommended to change the feedback resistors or select a higher output voltage setpoint to compensate for the diode drop. When more than one of these diodes is installed and the associated energy harvester inputs are powered, the board will switch between energy harvester power circuits as needed to maintain the output voltage.

LTC3108: TEG Powered Energy Harvester

The LTC3108 TEG powered energy harvester is selected by installing the power selection jumper JP2. The PGOOD signal, PGOOD_LTC3108 can be routed to the header by installing Jumper JP6. The LTC3108 PGOOD signal is pulled up to the on-chip 2.2V LDO through a 1MΩ pull-up resistor.

If the application requires a wide hysteresis window for the PGOOD signal, please refer to the above section for a complete operational description of and how to use the independent PGOOD signal (PGOOD_LTC3459), shown in Figure 10, generated by the LTC2935-2 and available on JP8.

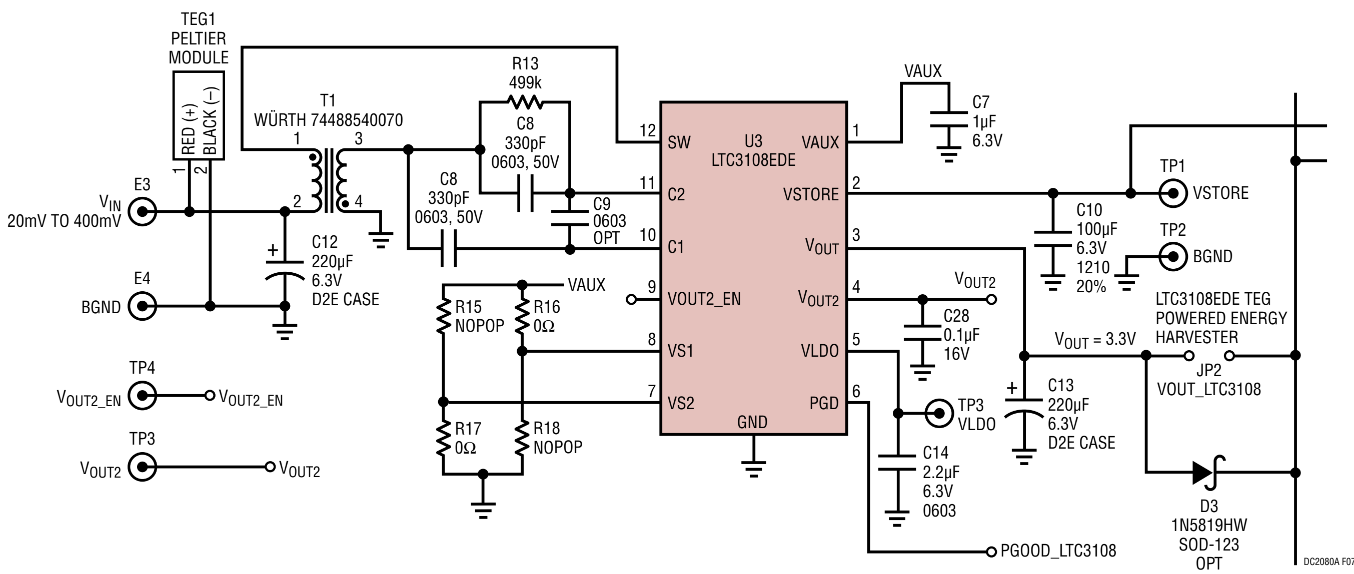

Figure 7. Detailed Schematic of LTC3108 TEG Powered Energy Harvester

APPLICATION

The PGOOD_LTC3459 signal is always used to switch the output voltage on the header. Some loads do not like to see a slowly rising input voltage. Switch Q3 ensures that VMCU on the header is off until the energy harvested output voltage is high enough to power the load.

When the PGOOD signal from the LTC3108 is used as the header signal, the setpoint for the LTC2935-2 circuit needs to be changed so the turn-on threshold is below the PGOOD_LTC3108 turn-on threshold of 3.053V. For example, by changing R36 to a 0Ω Jumper and R5 to NOPOP, the turn-on threshold for Q3 will be 2.99V rising and 2.25V falling.

Diode D3 is an optional component used to diode-OR multiple energy harvesting sources together. This diode would be used in conjunction with one or more of the other Or-ing diodes, D2, D4 or D5. When the Or-ing diodes are installed the parallel jumper would not be populated. The diode drop will be subtracted from the output voltage setpoint, so it is recommended to change the feedback resistors or select a higher output voltage setpoint to compensate for the diode drop. When more than one of these diodes is installed and the associated energy harvester inputs are powered, the board will switch between energy harvester power circuits as needed to maintain the output voltage.

LTC3105: Supplied By Diode Voltage Drop In 4mA to 20mA Loop

The LTC3105 4-20mA Loop, Diode Voltage Drop powered energy harvester is selected by installing the power selection jumper JP3. The PGOOD signal, PGOOD_LTC3105 can be routed to the Header by installing Jumper JP7. The PGOOD_LTC3105 signal is an open-drain output. The pull-down is disabled at the beginning of the first sleep event after the output voltage has risen above 90% of its regulation value. PGOOD_LTC3105 remains asserted until V_{OUT} drops below 90% of its regulation value at which point PGOOD_LTC3105 will pull low. The pull-down is also disabled while the IC is in shutdown or start-up mode.

If the application would benefit from a wider PGOOD hyteresis window than the LTC3105 provides (sleep to V_{OUT} minus 10%), the PGOOD_LTC3459 signal can be used in place of any of the PGOOD signals generated by the harvester circuits.

The PGOOD_LTC3459 signal is always used to switch the output voltage on the header. Some loads do not like to see a slowly rising input voltage. Switch Q3 ensures that VMCU on the header is off until the energy harvested output voltage is high enough to power the load.

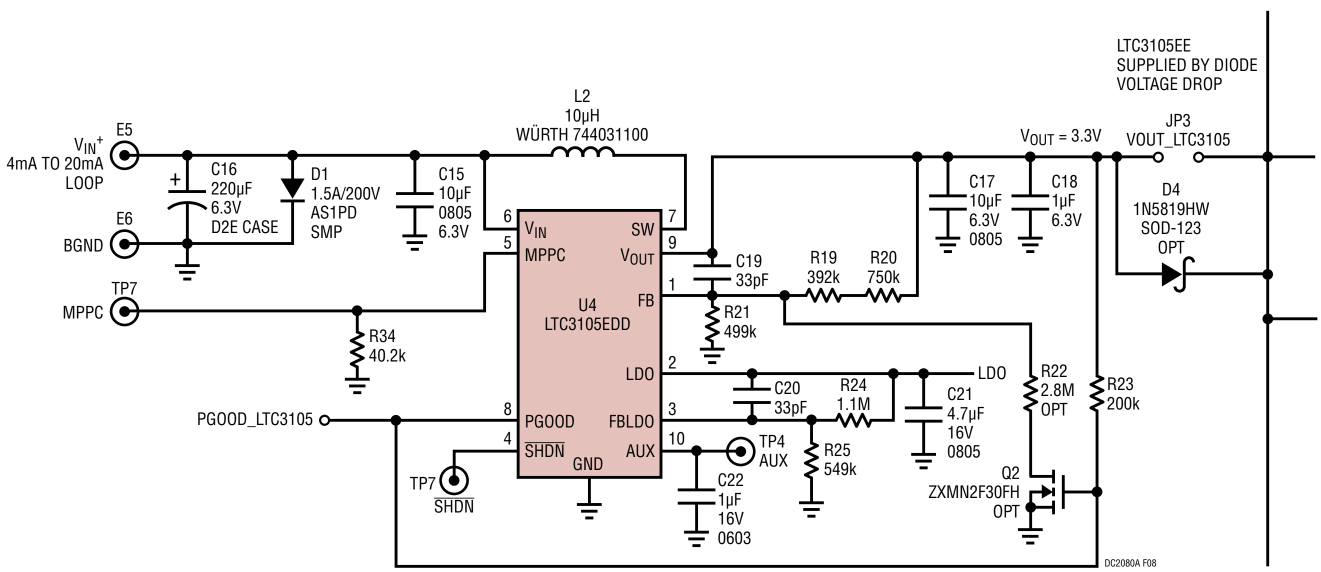

Figure 8. Detailed Schematic of LTC3105 4mA to 20mA Loop, Diode Voltage Drop Energy Harvester

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The optional components shown on the schematic are not populated for a standard assembly. The function of R22 and Q2 is to generate a short PGOOD pulse that will indicate when the output capacitor is charged to its maximum value. The short pulse occurs every time the output capacitor charges up to the output sleep threshold, which for a 3.3V output is 3.312V. By populating these components the application can use this short pulse as a sequence timer to step through the program sequence or as an indication of when it can perform energy intensive functions, such as a sensor read or a wireless transmission and/or receive, knowing precisely how much charge is available in the output capacitors. When this optional circuit is not used, the amount of charge in the output capacitors is anywhere between the maximum (C_{OUT} • V_{OUT_SLEEP}) to ten percent low. In the case where the energy harvesting source can support the average load continuously, this optional circuit is not needed.

Diode D4 is an optional component used to Diode-OR multiple energy harvesting sources together. This diode would be used in conjunction with one or more of the other Or-ing diodes, D2, D3 or D5. When the Or-ing diodes are installed the parallel jumper would not be populated. The diode drop will be subtracted from the output voltage setpoint so it is recommended to change the feedback resistors or select a higher output voltage setpoint to compensate for the diode drop. When more than one of these diodes is installed and the associated energy harvester inputs are powered, the board will switch between energy harvester power circuits as needed to maintain the output voltage.

LTC3459 Supplied By Solar Cell

The LTC3459 solar powered energy harvester is selected by installing the power selection jumper JP4. The PGOOD signal, PGOOD_LTC3459 can be routed to the Header by installing Jumper JP8.

The LTC2935-4 adds a hysteretic input-voltage regulation function to the LTC3459 application circuit. The PFO output of the LTC2935-4 is connected to the SHDN input on the LTC3459, which means that the LTC3459 will be off until VIN_LTC3459 rises above 1.743V (1.72V + 2.5%) and will then turn off when VIN_LTC3459 falls below 1.72V. The result is that the input voltage to the LTC3459 circuit will be regulated to, 1.73V, the average of the LTC2934-4 rising and falling PFO thresholds. The threshold can be adjusted for the peak operating point of the solar panel selected. In this design, because the LTC3459 output is set to 3.3V and is a boost topology, the input voltage is limited to 3.3V.

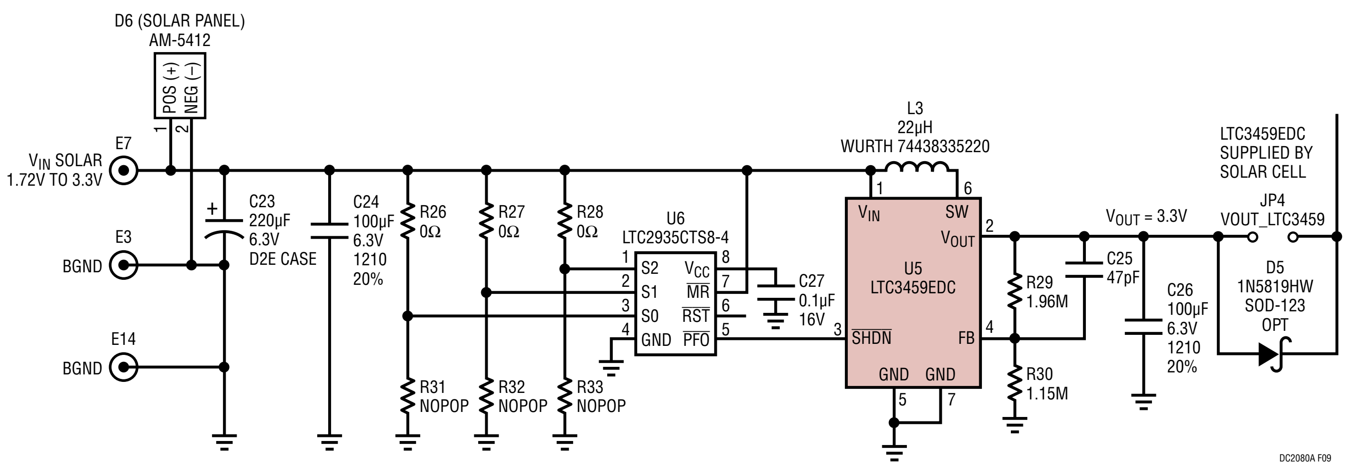


Figure 9. Detailed Schematic of LTC3459 Supplied by a Solar Cell

APPLICATION

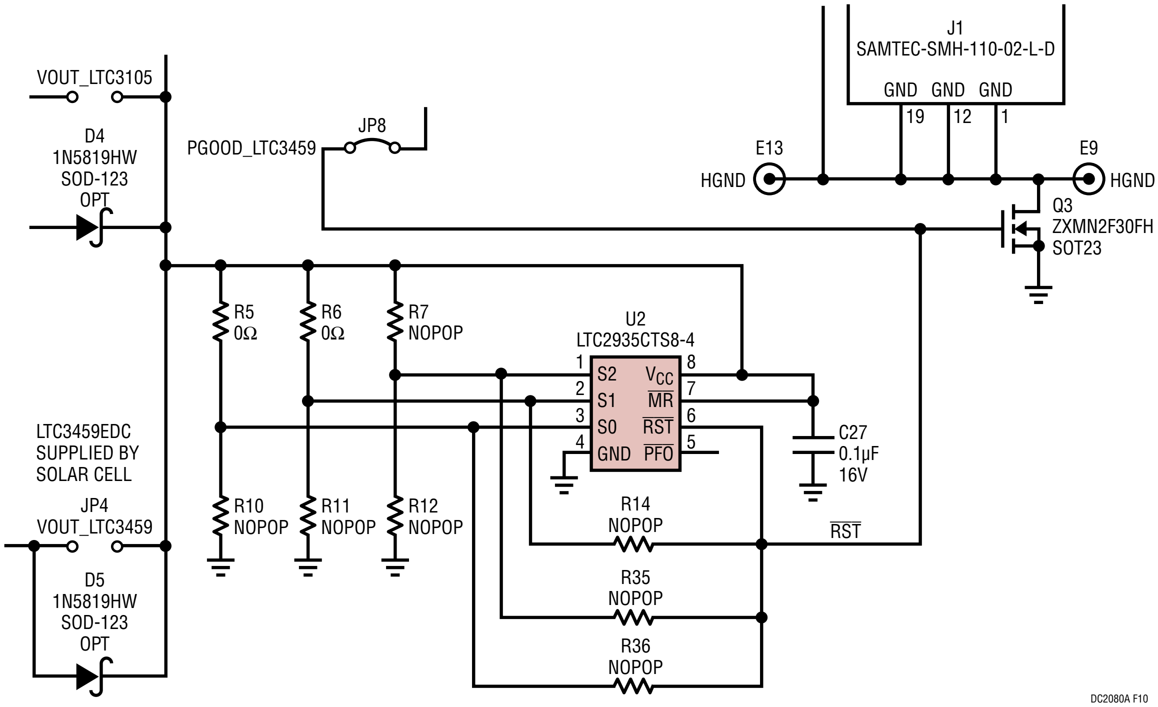


Figure 10. Detailed Schematic of PGOOD_LTC3459 Circuit Using LTC2935-2

The LTC3459 does not have an internally generated PGOOD signal so the LTC2935-2 was used to generate a PGOOD function with an adjustable hysteresis window. The NOPOP and 0Ω resistors around the LTC2935-2 allow for customization of the PGOOD thresholds and hysteresis window. By using R14, R35 and R36 the inputs can be changed after the rising Threshold is reached, creating a large hysteresis window.

The PGOOD_LTC3459 signal can be used in place of any of the PGOOD signals generated by the harvester circuits. The PGOOD_LTC3459 signal is always used to switch the output voltage on the header. The board is configured from the factory to use the PGOOD_LTC3459 signal as the PGOOD signal to switch from battery power to energy harvesting power.

The PGOOD_LTC3459 signal is always used to switch the output voltage on the header. Some loads do not like to see a slowly rising input voltage. Switch Q3 ensures that VMCU on the header is off until the energy harvested output voltage is high enough to power the load. The LTC2935-2 is configured to turn on Q3 at 3.15V and turn off Q3 at 2.25V. With this circuit, the load will see a fast voltage rise at start-up and be able to utilize all the energy stored in the output capacitors between the 3.15V and 2.25V levels.

Diode D5 is an optional component used to Diode-OR multiple energy harvesting sources together. This diode would be used in conjunction with one or more of the other Or-ing diodes, D2, D3 or D4. When the Or-ing diodes are installed the parallel jumper would not be populated. The diode drop will be subtracted from the output voltage setpoint, so it is recommended to change the feedback resistors or select a higher output voltage setpoint to compensate for the diode drop. When more than one of these diodes is installed and the associated energy harvester inputs are powered, the board will switch between energy harvester power circuits as needed to maintain the output voltage.

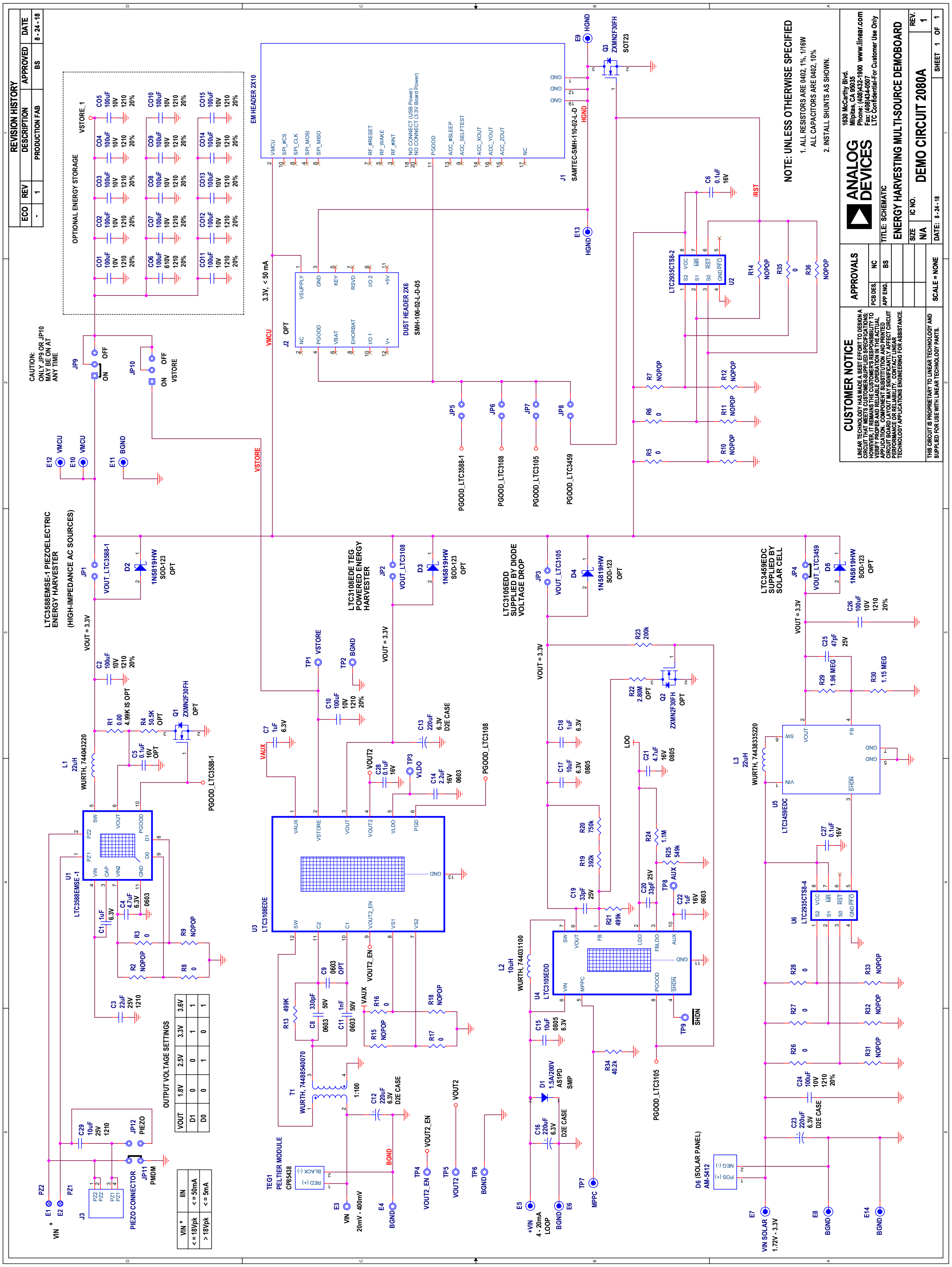
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	3	C1, C7, C18	CAP, CHIP, X5R, 1µF, 10%, 6.3V, 0402	TDK, C1005X5R0J105KT
2	4	C2, C10, C24, C26	CAP, CHIP, X5R, 100µF, 20%, 10V, 1210	TAIYO YUDEN, LMK325ABJ107MM
	15	C01 - C015 (OPTIONAL ENERGY STORAGE)		
3	1	C3	CAP, CHIP, X5R, 22µF, 10%, 25V, 1210	AVX, 12103D226KAT2A
4	1	C4	CAP, CHIP, X5R, 4.7µF, 10%, 6.3V, 0603, Height = 0.80mm	TDK, C1608X5R0J475K/0.80
5	3	C6, C27, C28	CAP, CHIP, X7R, 0.1µF, 10%, 16V, 0402	MURATA, GRM155R71C104KA88D
6	1	C8	CAP, CHIP, X7R, 330pF, 50V, 10%, 0603	MURATA, GRM188R71H331KA01D
7	1	C11	CAP, CHIP, X7R, 1000pF, 50V, 10%, 0603	MURATA, GRM188R71H102KA01D
8	4	C12, C13, C16, C23	CAP, POLYMER SMD, 220µF, 6.3V, 18mΩ, 2.8Arms, D2E CASE	SANYO, 6TPE220MI
9	1	C14	CAP, CHIP, X5R, 2.2µF, 16V, 10%, 0603	MURATA, GRM188R61C225KE15D
10	2	C15, C17	CAP, CHIP, X5R, 10µF, 10%, 6.3V, 0805	AVX, 08056D106KAT2A
11	2	C19, C20	CAP, CHIP, NPO, 33pF, 5%, 25V, 0402	AVX, 04023A330JAT2A
12	1	C21	CAP, CHIP, X5R, 4.7µF, 10%, 16V, 0805	TAIYO YUDEN, EMK212BJ475MG-T
13	1	C22	CAP, CHIP, X5R, 1µF, 10%, 16V, 0603	AVX, 0603YD105KAT2A
14	1	C25	CAP, CHIP, NPO, 47pF, 5%, 25V, 0402	AVX, 04023A470JAT2A
15	1	C29	CAP, CHIP X5R, 10µF,10%, 25V,1210	AVX, 12103D106KAT2A
16	1	D1	DIODE, STANDARD, 200V, 1.5A, SMP	VISHAY, AS1PD-M3/84A
17	1	D6	SANYO, AMORPHOUS SOLAR CELL	SANYO, AM-5412
18	1	HS1	HEAT SINK, 50.8mm × 50mm	FISCHER, SK 426
19	1	L1	INDUCTOR, 22µH , 0.70A, 185mΩ, 4.8mm × 4.8mm	WÜRTH, 744043220
20	1	L2	INDUCTOR, 10µH, 560mA, 0.205Ω, 3.8mm × 3.8mm	WÜRTH, 744031100
21	1	L3	INDUCTOR, 22µH, 600mA, 940mΩ, 3mm × 3mm	WÜRTH, 74438335220
22	1	T1	TRANSFORMER, 100:1 TURNS RATIO	WÜRTH, 74488540070
23	1	TEG1	PELTIER MODULE CP85438	CUI INC., CP85438
24	1	Q3	N-CHANNEL MOSFET, 20V, SOT23	DIODES/ZETEX, ZXMN2F30FHTA
25	11	R1, R3, R5, R6, R8, R16, R17, R26, R27, R28, R35	RES, CHIP, 0Ω JUMPER, 1/16W, 0402	VISHAY, CRCW04020000Z0ED
26	2	R13, R21	RES, CHIP, 499kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW0402499KFKED
27	1	R19	RES, CHIP, 392kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW0402392KFKED
28	1	R20	RES, CHIP, 750kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW0402750KFKED
29	1	R23	RES, CHIP, 200kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW0402200KFKED
30	1	R24	RES, CHIP, 1.10MΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW04021M10FKED
31	1	R25	RES, CHIP, 549kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW0402549KFKED
32	1	R29	RES, CHIP, 1.96MΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW04021M96FKED
33	1	R30	RES, CHIP, 1.15MΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW04021M15FKED
34	1	R34	RES, CHIP, 40.2kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW040240K2FKED
35	1	U1	PIEZOELECTRIC ENERGY HARVESTING POWER SUPPLY, DFN 3mm × 3mm	ANALOG DEVICES, LTC3588EMSE-1
36	1	U2	IC, ULTRALOW POWER SUPERVISOR WITH POWER-FAIL OUTPUT, TSOT-23, 8-PIN	ANALOG DEVICES, LTC2935CTS8-2

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
37	1	U3	IC, ULTRALOW VOLTAGE STEP-UP CONVERTER AND POWER MANAGER, DFN 3mm × 4mm	ANALOG DEVICES, LTC3108EDE
38	1	U4	IC, 400mA STEP-UP DC/DC CONVERTER WITH MPPC AND 250mV START-UP, DFN 3mm × 3mm	ANALOG DEVICES, LTC3105EDD
39	1	U5	IC, 10V MICROPOWER SYNC BOOST CONVERTER, DFN 2mm × 2mm	ANALOG DEVICES, LTC3459EDC
40	1	U6	IC, ULTRALOW POWER SUPERVISOR WITH POWER-FAIL OUTPUT, TSOT-23, 8-PIN	ANALOG DEVICES, LTC2935CTS8-4
Additional Demo Board Circuit Components				
1	0	C5 (OPT)	CAP, CHIP, X7R, 0.1µF, 10%, 16V, 0402	MURATA, GRM155R71C104KA88D
2	0	C9 (OPT)	OPT, 0603	
3	0	D2 - D5 (OPT)	DIODE, SCHOTTKY, 40V, 1A, SOD-123	DIODES INC, 1N5819HW-7-F
4	0	Q1, Q2 (OPT)	N-CHANNEL MOSFET, 20V, SOT23	DIODES/ZETEX, ZXMN2F30FHTA
5	0	R1 (OPT)	RES, CHIP, 4.99KΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW04024K99FKED
6	0	R2, R7, R9, R10, R11, R12, R14, R15, R18, R31, R32, R33, R36	RES., CHIP, 0402	NOPOP
7	0	R4 (OPT)	RES, CHIP, 50.5kΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW040250K5FKED
8	0	R22 (OPT)	RES, CHIP, 2.80MΩ, ±1%, 1/16W, 0402, ±100ppm/°C	VISHAY, CRCW04022M80FKED
Hardware for Demo Board Only				
1	14	E1 - E14	TURRET, 0.061 DIA	MILL-MAX, 2308-2
2	10	JP1 - JP8, JP11, JP12	HEADER, 2 PINS, 2mm	SAMTEC, TMM-102-02-L-S
3	2	JP9, JP10	HEADER, 3 PINS, 2mm	SAMTEC, TMM-103-02-L-S
4	3	JP4, JP9, JP11	SHUNT 2mm	SAMTEC, 2SN-BK-G
5	0	JP1, JP2, JP3, JP5, JP6, JP7, JP8, JP10, JP12	SHUNT 2mm, (DO NOT INSTALL)	SAMTEC, 2SN-BK-G
6	1	J1	HEADER, 2×10, 20-PIN, SMT HORIZONTAL SOCKET, 0.100"	SAMTEC, SMH-110-02-L-D
7	0	J2 (OPT)	HEADER, 2×6, 12-PIN, SMT HORIZONTAL SOCKET WITH KEY, 0.100"	SAMTEC, SMH-106-02-L-D-05
8	1	J3	PIEZO CONNECTOR 4 PIN, TERMINAL BLOCK, WR-TBL	WÜRTH, 691411710002
9	4		ADHESIVE CABLE MOUNT U-STYLE CLIP	WÜRTH, 523252000
10	1		KERAFOL, KL 90 40mm × 40mm × 3mm DOUBLE-SIDED ADHESIVE TAPE	KERATHERM, KL 90 40mm × 40mm × 3mm
11	0.007		DOUBLE-SIDED MOUNTING TAPE, 35mm × 38mm FOR SOLAR CELL	TESA, 55742 (KIT QTY = NUMBER OF REELS, ROUND UP)

SCHEMATIC DIAGRAM



ESD Caution

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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