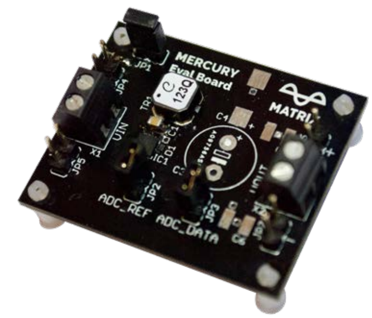
Mercury Boost Converter Evaluation Kit
MCRY-EVALKIT

DESCRIPTION

Matrix Mercury evaluation kit provides a simple platform for engineers to measure the performance of the Mercury energy harvesting PMIC, a family of highly integrated DC/DC boost converters that are ideal for harvesting and managing surplus energy from extremely low input voltage sources such as TEGs (thermoelectric generators) and thermopiles.

The board allows the addition of an energy storage media to accommodate for various applications, and it has been optimized for low start-up voltage with a 50:1 turns ratio transformer that is on the board. Mercury features an 8-bit on-chip ADC that detects when the open circuit voltage VOC exceeds the programmed limit and turns off the input to ensure reliable operation. The outputs of the ADC are broken out on the board to allow real-time measurements.



The evaluation kit is equipped with MCRY12-125Q-42DI, which is optimized for 12Ω input impedance, 12.5μH inductor and 4.2V output. Please contact info@matrixindustries.com for customization options.

ORDERING INFORMATION

Part Number	Type
MCRY-EVALKIT	Evaluation Kit for MATRIX Mercury Energy Harvesting Boost Converter

TYPICAL SPECIFICATIONS (25°C)

V_{OC}	Start-up happens at Voc=24mV and the maximum Voc for operation is 500mV.
V_{OUT}	4.2V with the default setup.

KIT FILES

MCRY-EVALKIT BOM
MCRY-EVALKIT PCB Layout Diagrams
MCRY-EVALKIT Schematic

REQUIREMENTS

- An isolated voltage source with millivolt-scale precision should be used, and source-measure units (SMUs) are recommended.
- To measure voltages, isolated meters with input impedances >1GΩ are ideal, and SMUs are useful here as well.
- Handheld voltage meters are isolated but generated have lower input impedances between 1MΩ or 10MΩ, which can add additional loading when connected to Mercury's VOUT pin. Use high impedance meters or avoid connecting them to VOUT pin.
- Line-powered voltage sources and SMUs must have isolated outputs. Non-isolated instruments can inadvertently connect Mercury's VINM and GND pins, which will prevent Mercury from operating.
- When used, ADC_REF and ADC_CLK pins should be connected to impedance of 10MΩ or greater to minimize loading of Mercury's data outputs. Short them to GND if unused.
- If using a TEG source, select one with output impedance $R_{TEG} = R_{TEG,AC} * \sqrt{(1 + ZT)}$ at the operating temperature. See INPUT IMPEDANCE AND LOAD MATCHING in the Mercury datasheet for more details.

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QUICK START GUIDE

This section describes how to get started using Mercury with a voltage source.

Voltage output

1. Open jumper JP1, and close jumpers JP2 and JP3. This simulates the output impedance of a TEG, and disables the ADC outputs.
2. Connect voltage source positive lead to JP4 and negative lead to JP5. This is the source voltage V_{OC}.
3. Connect voltage sense leads to JP4 and JP5. This is the output voltage V_{OUT} provided by Mercury.
4. Source a small voltage $V_{OC} < 500mV$ with the voltage source and note the rising output voltage V_{OUT}.

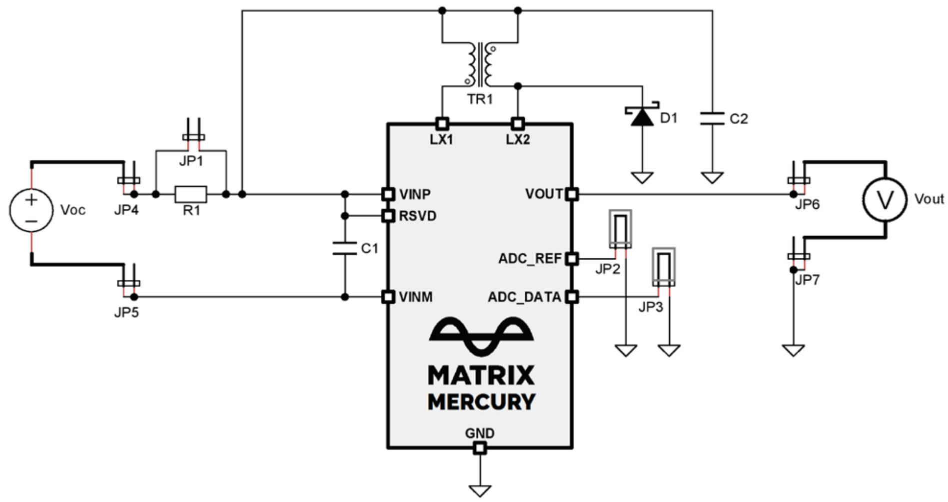

Figure 1: Connection block diagram of MCRY-EVALKIT during quick start

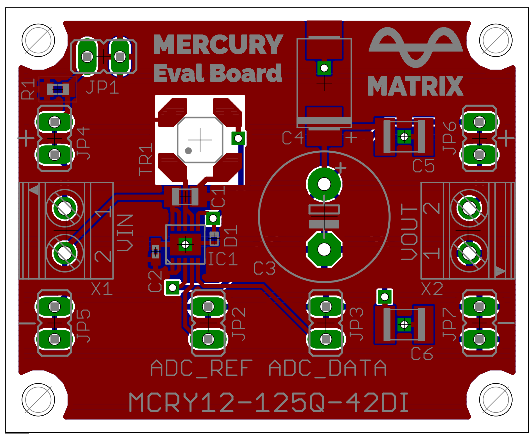

Figure 2: MCRY-EVALKIT

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DETAILED MEASUREMENTS

This section describes how to measure Mercury's performance characteristics using either a voltage source or a thermoelectric generator (TEG).

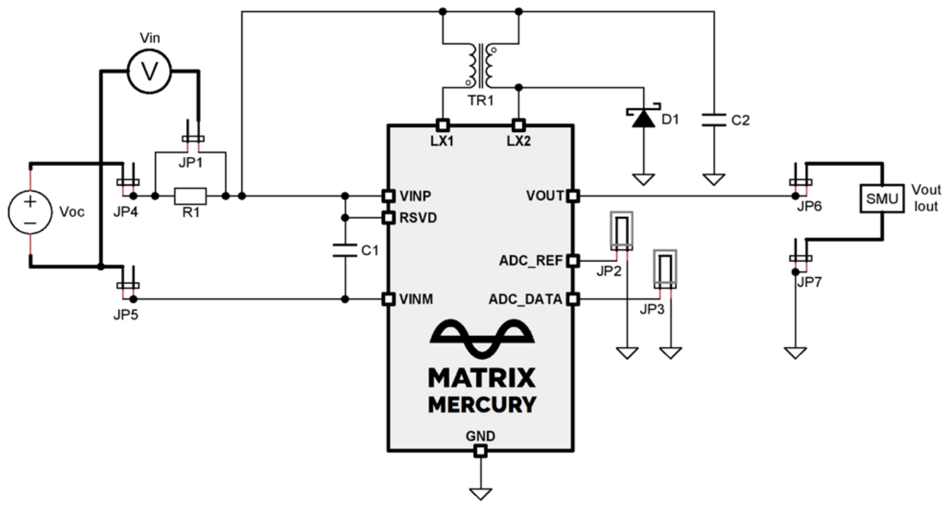

Figure 3: Connection block diagram of MCRY-EVALKIT for detailed measurements

Cold-start voltage measurement

The following steps describe how to measure Mercury's cold-start voltage VOC,CS.

1. Open jumper JP1 to insert resistor R1 = RTEG between the voltage source and Mercury. This simulates the output impedance of a TEG. Close jumper JP1 if using a TEG.
2. Close jumpers JP2 and JP3. This shorts the ADC outputs to ground and disables them.
3. Connect voltage source positive lead to JP4 and negative lead to JP5, and do not turn it on yet.
   - *Important! Connecting a non-isolated instrument here may prevent proper operation.*
4. Connect voltage sense leads to:

   a) JP4 and JP5 to measure V_{OC}. This is the source voltage V_{OC}. (Skip this if using a TEG Source.)

   b) JP5 and the rightmost pin of JP1 to measure $V_{IN} = V_{IN+} - V_{IN-}$. This is the input voltage V_{IN} supplied to Mercury.

   c) JP6 and JP7 to measure V_{OUT}. This is the output voltage V_{OUT} provided by Mercury.
   - *Connecting a meter with low input impedance here will increase the cold-start voltage.*
5. Discharge all capacitors C2-C6 on Mercury's output by shorting the jumpers JP6 and JP7 together. This ensures that Mercury is ready for cold-start.
6. Turn on the voltage source at a low starting V_{OC}, for example, 10mV. Ramp up V_{OC} slowly in 1mV increments until the voltage at V_{OUT} begins rising. This value of V_{OC} is the cold-start voltage $V_{OC,CS}$.

DETAILED MEASUREMENTS CONT'D.

Conversion efficiency measurement

The following steps describe how to measure Mercury's efficiency curve POUT/PMAX for a given output voltage $V_{OUT} \leq V_{OUT,MAX}$.

1. Open jumper JP1 to insert resistor R1 = RTEG between the voltage source and Mercury. This simulates the output impedance of a TEG. Close jumper JP1 if using a TEG.
2. Close jumpers JP2 and JP3. This shorts the ADC outputs to ground and disables them.
3. Connect voltage source positive lead to JP4 and negative lead to JP5, and do not turn it on yet.
   - *Important! Connecting a non-isolated instrument here may prevent proper operation.*
4. Connect voltage sense leads to:

   a) JP4 and JP5 to measure V_{OC}. This is the source voltage V_{OC}. (Skip this if using a TEG Source.)

   b) JP5 and the rightmost pin of JP1 to measure $V_{IN} = V_{IN+} - V_{IN-}$. This is the input voltage VIN supplied to Mercury.

   c) JP6 and JP7 to measure V_{OUT}. This is the output voltage V_{OUT} provided by Mercury.
   - *Connecting a meter with low input impedance here will increase the cold-start voltage.*
5. Connect SMU positive lead to JP6 and negative lead to JP7, and do not turn it on yet.
6. If needed, insert a current meter inline with JP6. This is the output current IOUT provided by Mercury.
7. Adjust the SMU voltage to the desired output voltage V_{OUT}, for example, 3.0V. Start the SMU by sourcing voltage and sensing current.
8. Start the voltage source at a starting $V_{OC} < V_{OC,MAX}$, for example 490mV. Sweep V_{OC} gradually towards 0V. Starting at a high source voltage ensures that Mercury is past the cold-start threshold. The source should not exceed $V_{OC,MAX}$, otherwise Mercury will stop the flyback converter to protect itself.
9. At each point in the sweep, note the following quantities:

   a) Source voltage, V_{OC}. (Skip this if using a TEG Source.)

   b) Input voltage into Mercury, V_{IN}.

   c) Output voltage at Mercury, V_{OUT}.

   d) Current flowing out of Mercury, I_{OUT}.
10. When using voltage source, it is possible to measure the overall efficiency (including impedance matching):

    a) Maximum input power, $P_{MAX} = V_{OC}^2 \div (4R_{TEG})$

    b) Output power, $P_{OUT} = V_{OUT} \times I_{OUT}$

    c) Overall efficiency = Electrical efficiency × Matching efficiency = $P_{OUT} / P_{IN} * P_{IN} / P_{MAX} = P_{OUT} / P_{MAX}$
11. When using TEG source, the ADC data outputs encode the VOC measurement. Without decoding the data, it is only possible to measure the electrical efficiency:

    a) Maximum input power, $P_{IN} = V_{IN} \times I_{IN} = V_{IN} \times (V_{OC} - V_{IN}) / R_{TEG}$

    b) Output power, $P_{OUT} = V_{OUT} \times I_{OUT}$

    c) Electrical efficiency = $P_{OUT} \div P_{IN}$

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DETAILED MEASUREMENTS CONT'D.

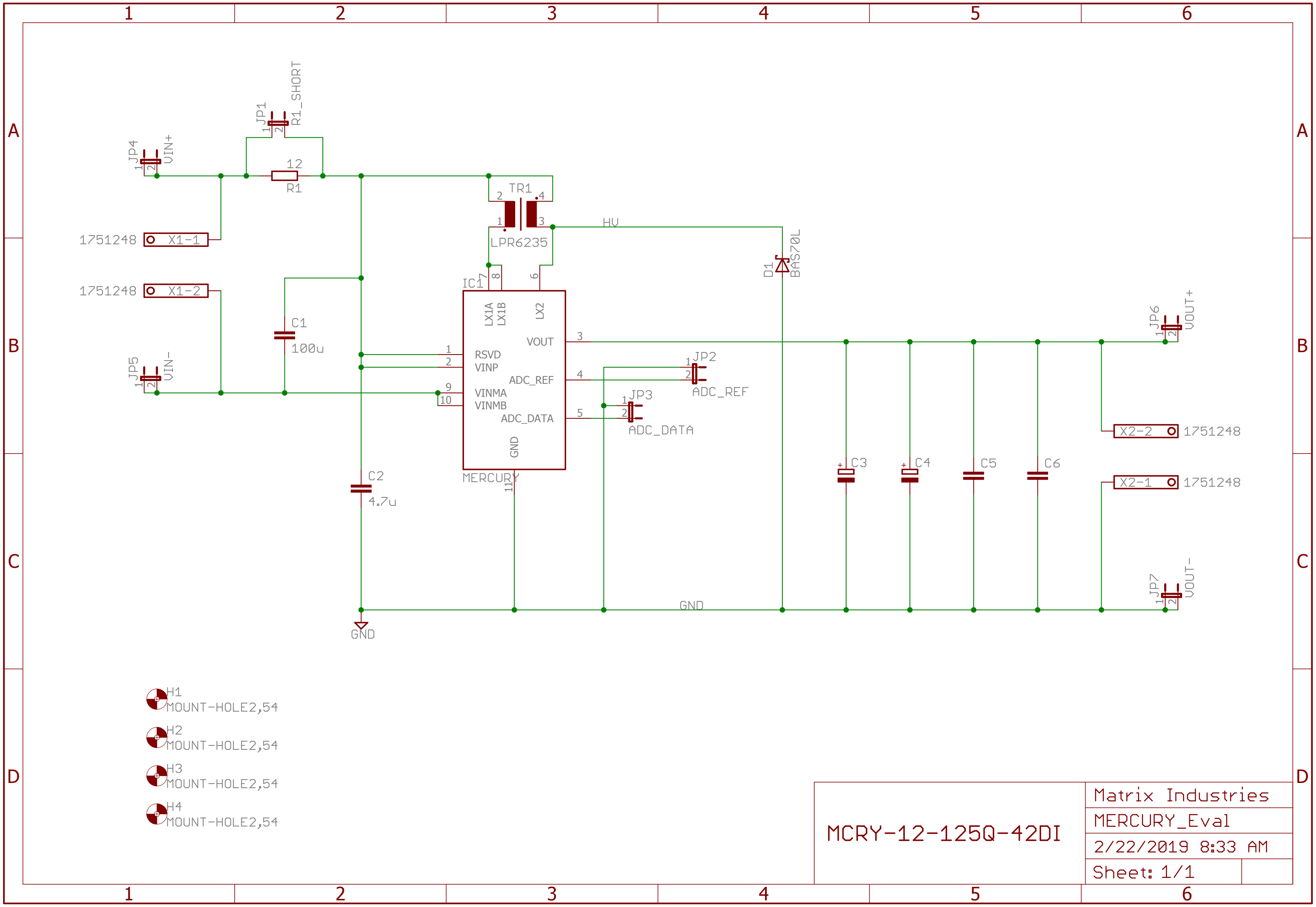

Figure 4: MCEY-EVALKIT Schematics

DETAILED MEASUREMENTS CONT'D.

Table 1: MCRY-EVALKIT Bill of Materials

Item	DES	QTY	MFG Part #	MFG	Description
1	C1	1	GRM21BR60E107ME15L	Murata	100uF multilayer Ceramic Capacitors MLCC - SMD/SMT 100UF 2.5V 20% 0805, 2012L metric
2	C2	1	GRM155R60J475ME87D	Murata	4.7µF ±20% 6.3V Ceramic Capacitor X5R 0402, 1005 metric
3	C3-C6	0			
4	D1	1	BAS70L,315	Nexperia	Schottky Diodes & Rectifiers in SOD-882
5	JP1 - JP7	7	M20-9990245	Harwin	Headers & Wire Housings 02 SIL Vertical Pin Header Gold HT, 1x2 100mil
6	R1	1	ERA-2AKD120X	Panasonic	Thin Film Resistors - SMD 0402 12ohm .5% AEC-Q200, 1005 metric
7	TR1	1	LPR6235-123QMRC	Coilcraft	Coupled Inductors LPR6235 Mini Step-Up 12.5 uH 1:50 Turn, 6x6 mm^2
8	IC1	1	MCRY12-125Q-42DI	MATRIX Industries	Nanopower Energy Harvesting Synchronous Boost Converter in DFN10 3x3mm^2
9	X1, X2	2	1985807	Phoenix Contact	Fixed Terminal Blocks MKDS 1/2-3.5 HT BK

REVISION HISTORY

Revision	Date	Description
*A	April 2019	Initial Datasheet Release

DISCLAIMER

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