EPC9162
Bi-directional Evaluation Board
12 V Input, 60 V, 50 W Output (Boost)
48 V Input, 12 V, 60 W Output (Buck)
Quick Start Guide

January 19, 2024

Version 1.0

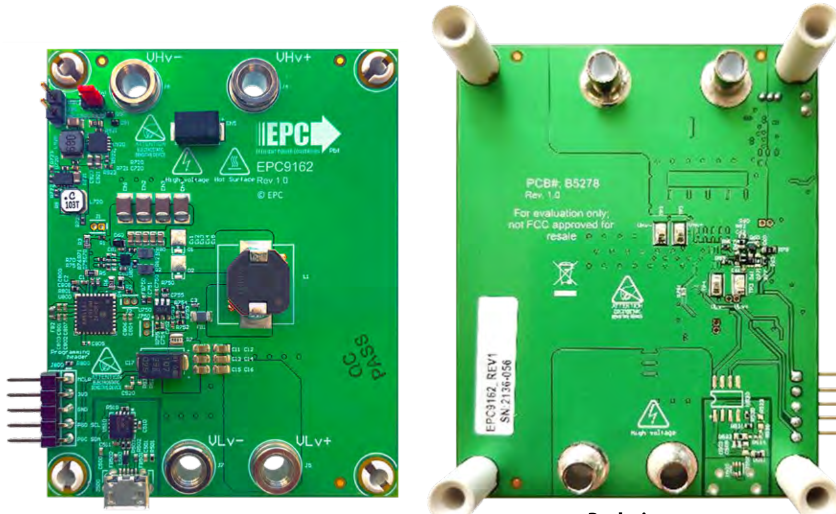
EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9162 evaluation board is a bi-directional buck or reverse-boost converter. It has a low and high voltage port. When powered from the low voltage port it can boost the voltage with output on the high voltage port up to 60 V maximum. If powered from the high voltage port, it operates as a buck converter. The simplified schematic diagram is shown in Figure 1. The synchronous converter features the 100 V **EPC2052** GaN FET, while the **EPC2038** GaN FET is used in the synchronous Bootstrap FET circuit. The EPC9162 is by default programmed as reverse boost converter that is powered from the low voltage port.

Other features include:

- High efficiency:
  - 96% @ 48 V input, 12 V/5 A output (buck)
  - 95% @ 12 V input, 60 V/0.85 A output (reverse-boost)
- Temperature rise: < 40 °C @ 60 V/0.85 A output
- Constant switching frequency: 500 kHz
- Digital control: Re-programmable



Front view **Back view**

EPC9162 board

REGULATORY INFORMATION

This converter is for evaluation purposes only. It is not a full-featured converter and cannot be used in final products. No EMI test was conducted. It is not FCC approved.

FIRMWARE UPDATES

Every effort has been made to ensure all control features function as specified. It may be necessary to provide updates to the firmware. Please check the EPC website for the latest firmware updates.

Table 1: Electrical Characteristics (T_A = 25°C unless specified otherwise)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{HV}	High voltage bus port	Buck		48	65	V
		Boost		60	65	
V_{LV}	Low voltage bus port			12	40	
I_{HV}	HV bus current				0.85[1]	A
I_{LV}	LV bus Current				5[1]	
f_s	Switching Frequency			500		kHz
T_{rise}	Temperature Rise	Still air (natural convection)		40		°C

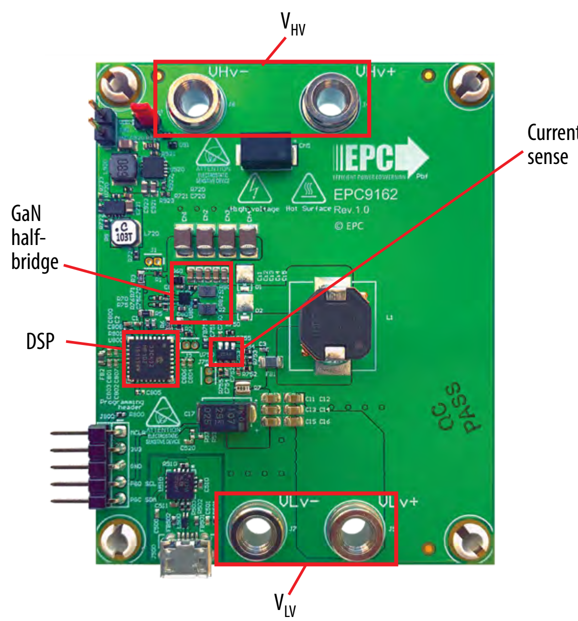


Figure 1: Functional diagram of the EPC9162 bi-directional DC-DC converter

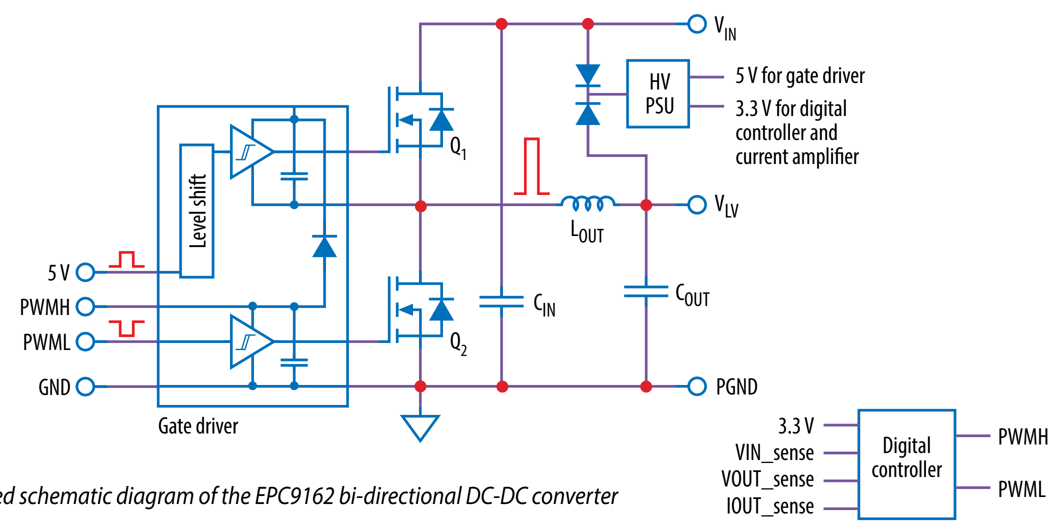


Figure 2: Simplified schematic diagram of the EPC9162 bi-directional DC-DC converter

ELECTRICAL PERFORMANCE

Typical efficiency and power loss

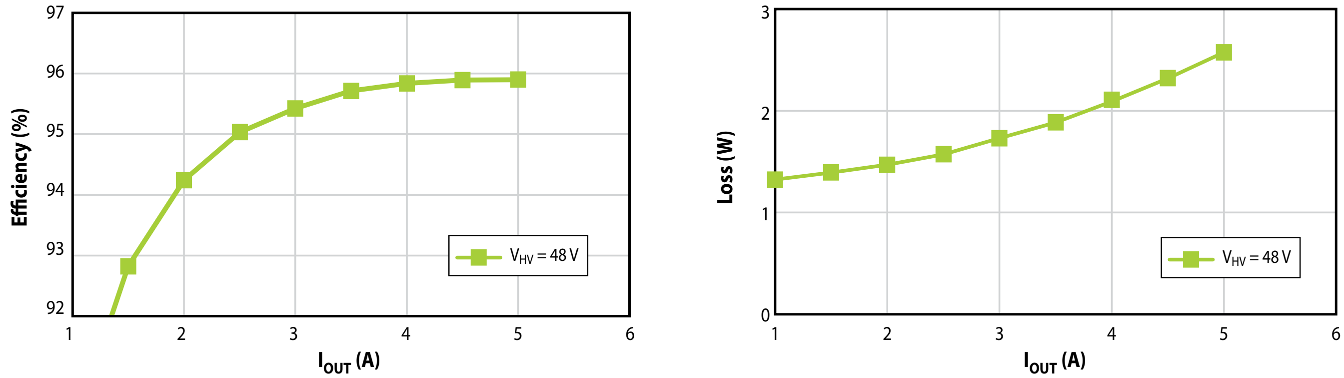


Figure 3: Buck mode of operation: 48 V input on high voltage port, 12 V output on low voltage port

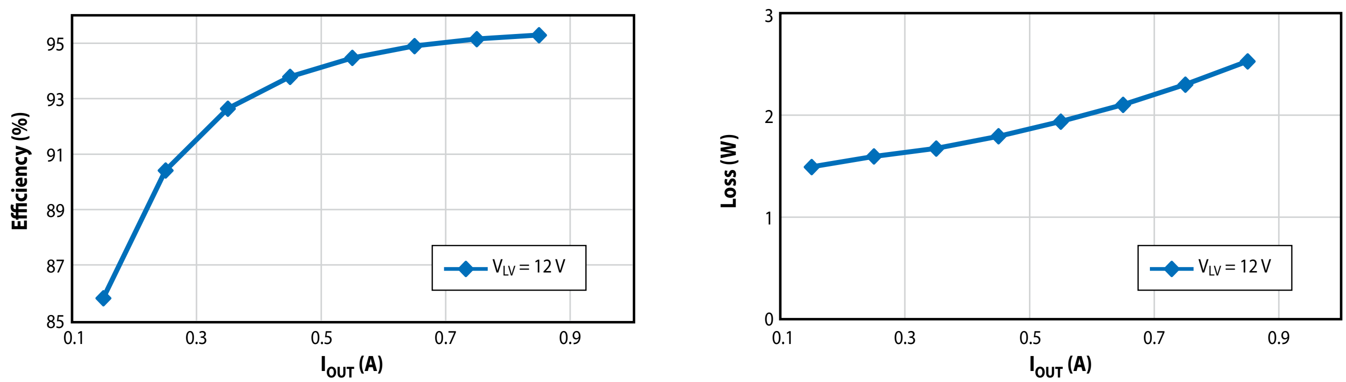


Figure 4: Reverse-boost mode of operation: 12 V input on low voltage port, 60 V output on high voltage port

Typical output voltage ripple

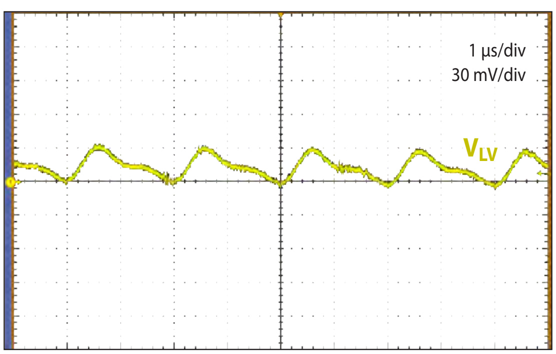


Figure 5: V_{HV} = 48 V, V_{LV} = 12 V, I_{LV} = 1 A

Typical transient response

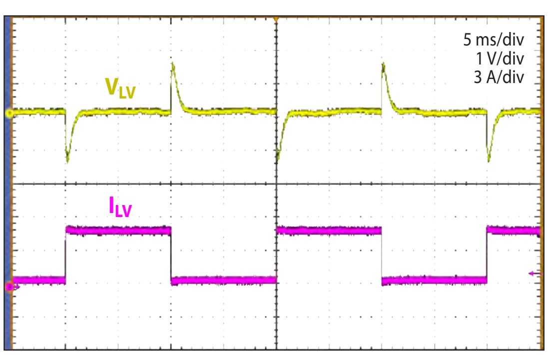


Figure 6: Transient response for buck operation at V_{HV} = 48 V, V_{LV} = 12 V, 10% (0.5 A) to 100% (5 A)

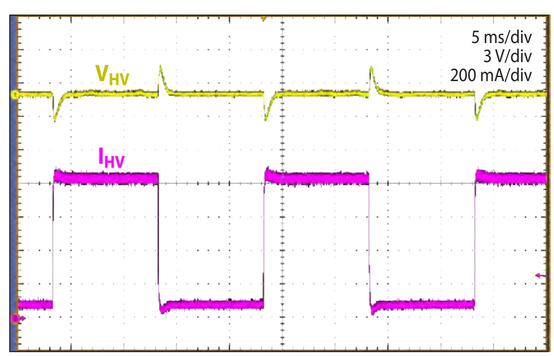
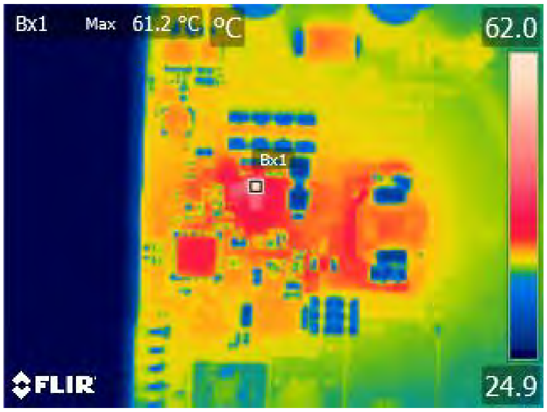
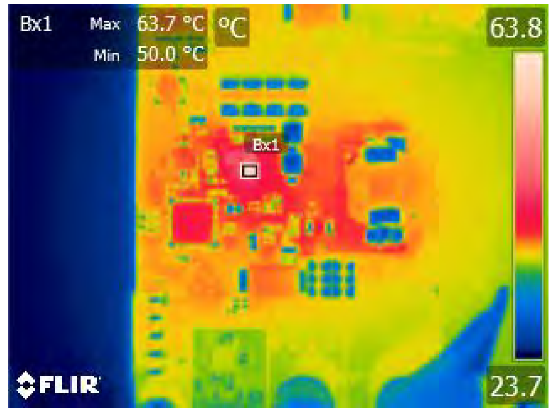


Figure 7: Transient response for boost operation at V_{LV} = 12 V, V_{HV} = 60 V, 10% (85 mA) to 100% (0.85 A)

Thermal Performance



(a)



(b)

Figure 8: Thermal image taken at still air (no forced air cooling) for: (a) buck operation: V_{HV} = 48 V, V_{LV} = 12 V, I_{LV} = 5 A; (b) Boost operation: V_{LV} = 12 V, V_{HV} = 60 V, I_{HV} = 0.85 A

THERMAL CONSIDERATIONS

The EPC9162 evaluation board showcases the EPC2052 eGaN® FET. The EPC9162 is intended for bench evaluation with low ambient temperature and with or without forced air cooling. There is no provision for attaching a heat-sink and so care must be taken to not exceed the absolute maximum die temperature of 150° C. The EPC9162 evaluation board does not have any current or thermal protection on board.

OPERATING CONSIDERATIONS

Controller

The EPC9162 power module features a Microchip dsPIC33CK32MP102 Digital Signal Controller DSC. This 100 MHz single core device is equipped with dedicated peripheral modules for Switched-Mode Power Supply (SMPS) applications, such as a feature-rich 4-channel (8x output), 250 ps resolution pulse width modulation (PWM) logic, three 3.5 Msps Analog-To-Digital Converters (ADC), three 15 ns propagation delay analog comparators with integrated Digital-To-Analog Converters (DAC) supporting ramp signal generation, three operational amplifiers as well as Digital Signal Processing (DSP) core with tightly coupled data paths for high performance real-time control applications. The device used is the smallest derivative of the dsPIC33CK single core and dsPIC33CH dual core DSC families. The device used in this design comes in a 28 pin 6x6 mm UQFN package, specified for ambient temperatures from -40 to +125° C. Other packages including a 28 pin UQFN package with only 4x4 mm are available.

The dsPIC33CK device is used to drive and control the converter in a fully digital fashion where the feedback loops are implemented and executed in software. Migrating control loop execution from analog circuits to embedded software enhances the flexibility in terms of applied control laws as well as making modifications to the feedback loop and control signals during runtime, optimizing control schemes and adapting control accuracy and performance to most recent operating conditions. As a result, digital control allows users to tailor the behavior of the converter to application specific requirements without the need for modifying hardware.

Programming

The Microchip dsPIC33CK controller can be re-programmed using the in-circuit serial programming port (ICSP) available on the 5-pin header. This interface supports the Microchip in-circuit programmers/debuggers, such as MPLAB® ICD4, MPLAB® REAL ICE or MPLAB® PICkit4 and previous derivatives.

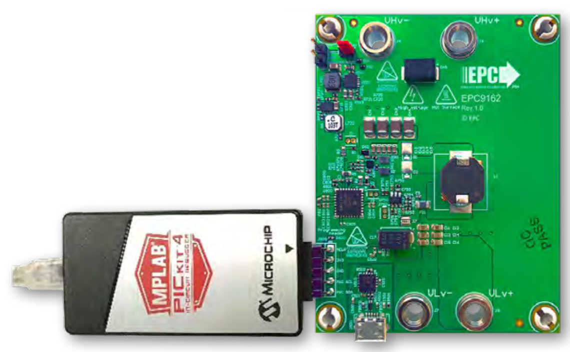


Figure 9: Programming connection

Control loop

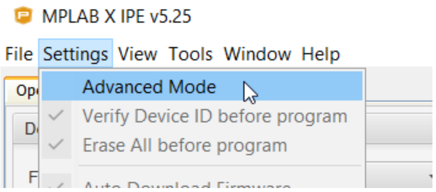
The EPC9162 bi-directional converter module adopts constant frequency, average current mode control implemented by a Microchip dsPIC33CK32MP102 Digital Signal Controller (DSC). The error between the output voltage feedback signal and the voltage reference is fed to an error amplifier and generate a current reference signal. Another error amplifier compares the sensed inductor average current with this current reference, and generates a command signal that drives the pulse width modulator. When the output current increases, the decrease in the voltage feedback signal causes the command signal to increase until the average inductor current matches the new output current.

Programming with HEX file

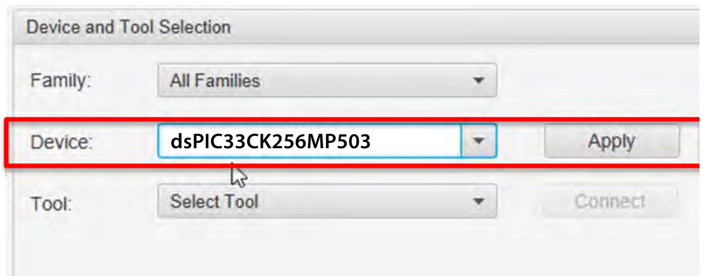
Download the latest MPLAB® X IPE from Microchip website and follow the five steps below:

https://www.microchip.com/mplab/mplab-integrated-programming-environment

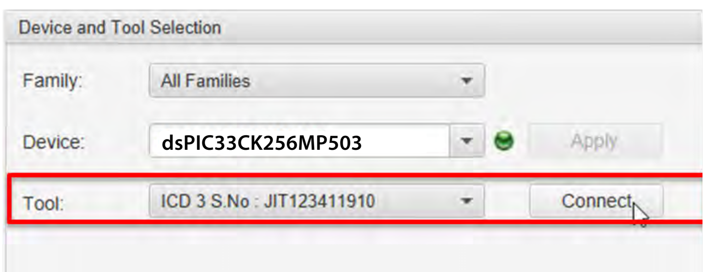
1. **Enable Advanced Mode:**



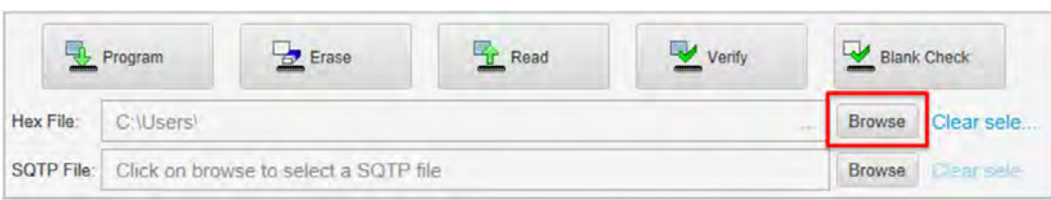
2. **Select Device: dsPIC33CK256MP503 and then apply:**



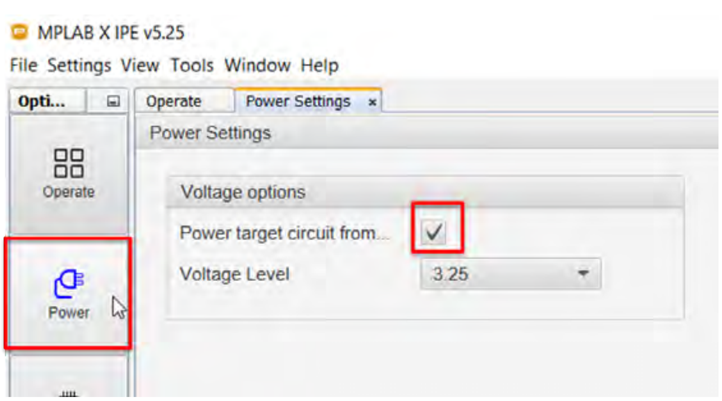
3. **Select programming tool and then connect:**



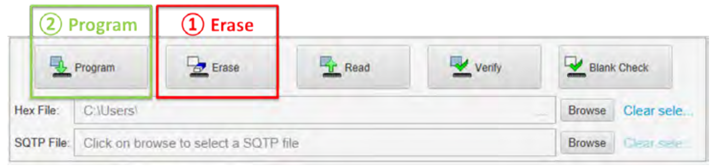
4. **Click 'Browse' to select the provided .hex file:**



Optional:



5. **Erase device, and then program device:**



QUICK START OPERATING PROCEDURE

The EPC9162 power module is easy to set up for evaluation. Refer to Figures 10-11 and follow the procedure below for proper connection and measurement setup (**Note: Make sure the correct firmware (either buck or boost) is programmed [Contact Microchip for firmware support].** The firmware for buck and boost mode are separate. Please make sure the correct firmware is programmed. The firmware is for demonstration purposes only and does not support advanced protection features. If you need more functionalities for your application, please contact EPC.

1. With power off, connect the input power supply to V_{LV} or V_{HV} as shown in Figure 10 for buck operation and Figure 11 for boost operation.
2. With power off, connect the load to V_{LV} or V_{HV} as in Figure 10 for buck operation and Figure 11 for boost operation.
3. Making sure the initial input supply voltage is 0 V, turn on the power and increase the voltage to the required value (do not exceed the absolute maximum voltage on each port.
4. Once operational, adjust the load within the operating range and observe the switching behavior, efficiency, transient response and other parameters.
5. For shutdown, please follow the above steps in reverse.

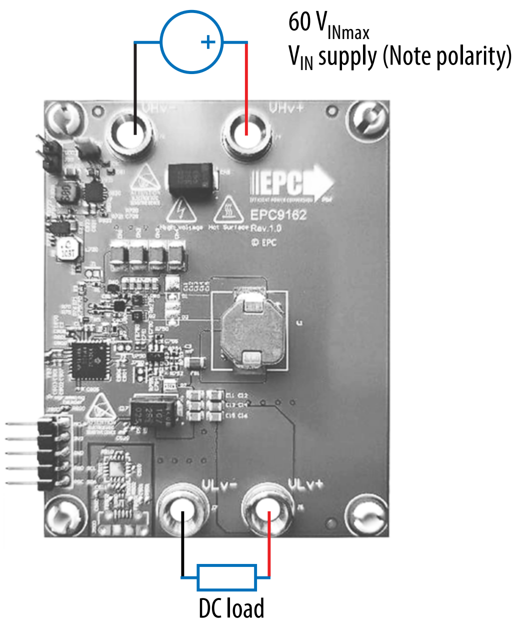


Figure 10: Input and output connection (buck)

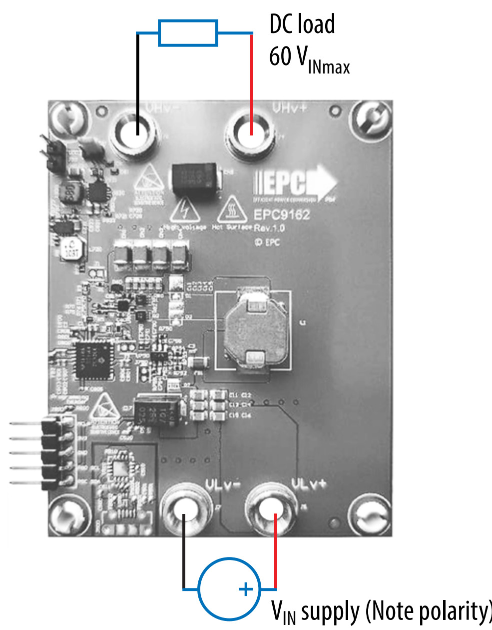


Figure 11: Input and output connection (boost)

MECHNICAL SPECIFICATIONS

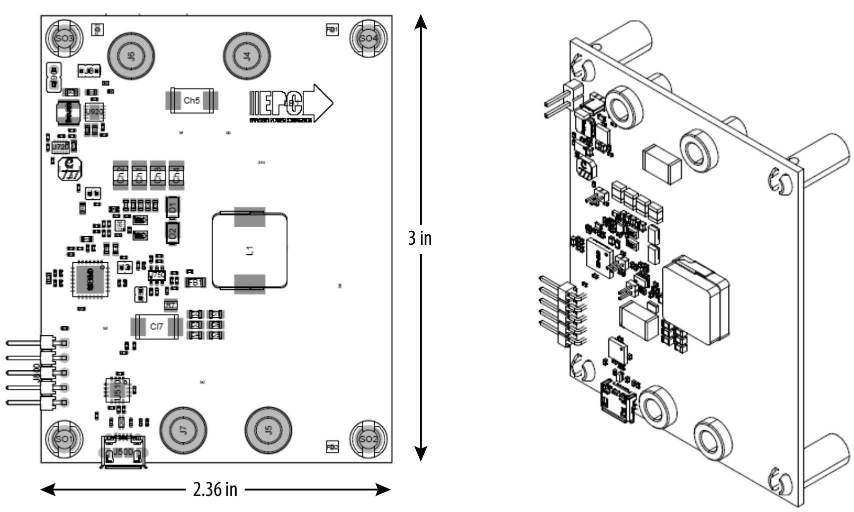


Figure 12: EPC9162 mechanical dimensions

For support files including schematic, Bill of Materials (BOM), and gerber files please visit the EPC9162 landing page at: https://epc-co.com/epc/Products/Demo-Boards/EPC9162

EPC would like to acknowledge Microchip Technology Inc. (**www.microchip.com**) for their support of this project.

Microchip Technology Incorporated is a leading provider of smart, connected and secure embedded control solutions. Its easy-to-use development tools and comprehensive product portfolio enable customers to create optimal designs, which reduce risk while lowering total system cost and time to market. The company's solutions serve customers across the industrial, automotive, consumer, aerospace and defense, communications and computing markets.

The EPC9162 system features the **dsPIC33CK32MP102** 16-Bit Digital Signal Controller with High-Speed ADC, Op Amps, Comparators and High-Resolution PWM. Learn more at **www.microchip.com**.

For More Information:

Please contact **info@epc-co.com**
or your local sales representative

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Evaluation Board Notification

The EPC9162 board is intended for product evaluation purposes only. It is not intended for commercial use nor is it FCC approved for resale. Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Quick Start Guide. Contact an authorized EPC representative with any questions. This board is intended to be used by certified professionals, in a lab environment, following proper safety procedures. Use at your own risk.

As an evaluation tool, this board is not designed for compliance with the European Union directive on electromagnetic compatibility or any other such directives or regulations. As board builds are at times subject to product availability, it is possible that boards may contain components or assembly materials that are not RoHS compliant. Efficient Power Conversion Corporation (EPC) makes no guarantee that the purchased board is 100% RoHS compliant.

The Evaluation board (or kit) is for demonstration purposes only and neither the Board nor this Quick Start Guide constitute a sales contract or create any kind of warranty, whether express or implied, as to the applications or products involved.