Evaluation System EPC9153 Quick Start Guide

44–60 V Input, 12-20 V, 12.5 A Output
up to 250 W High Efficiency, Thin Power Module

January 13, 2021

Version 1.0

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9153 evaluation board is a synchronous buck converter with 60 V maximum input voltage, 12.5 A maximum output current, and 12-20 V (default set to 20 V) regulated output voltage. The simplified schematic diagram is shown in Figure 1. It features the 100 V EPC2218 and EPC2038 GaN FETs. Other features include:

- High efficiency: 98.2% @ 20 V/12.5 A output
- Low profile: 6.5 mm component height
- Temperature rise: < 40 °C @ 20 V with 12.5 A output
- Constant switching frequency: 400 kHz
- Re-programmable
- 150% over current for 10 ms
- 200% over current for 1 ms
- Fault protection:
  - Input undervoltage
  - Input overvoltage
  - Output over voltage
  - Short circuit
  - Over current

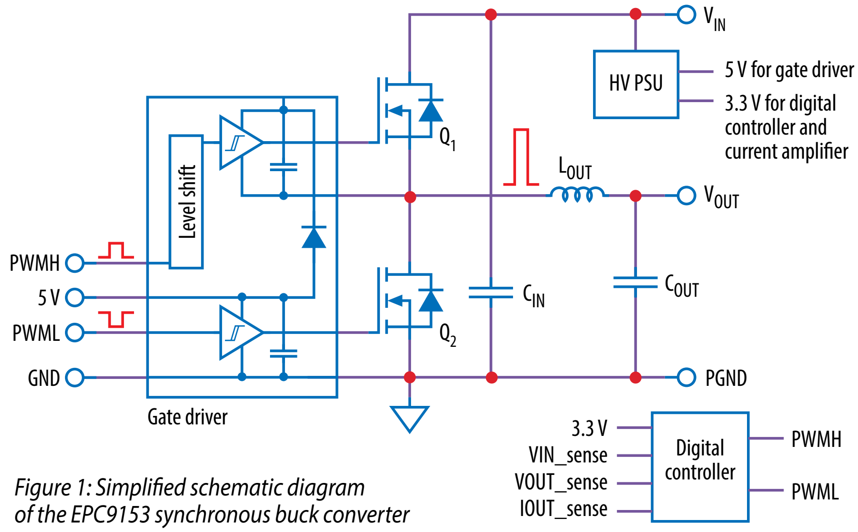


Figure 1: Simplified schematic diagram of the EPC9153 synchronous buck converter

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 and Microchip websites for the latest firmware updates.

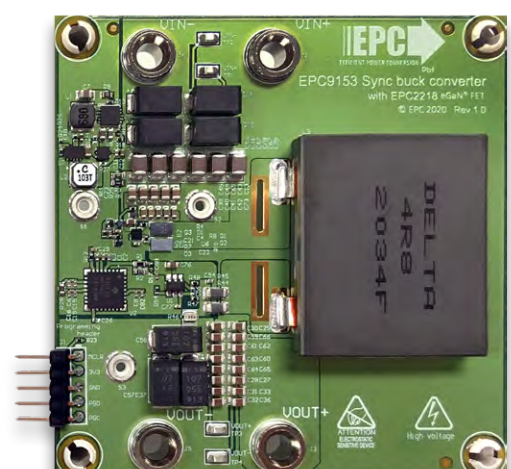
Table 1: Absolute Maximum Ratings

Symbol	Parameter	Conditions	Min	Max	Units
V_{IN}	Input voltage			80	V

Table 2: Electrical Characteristics (T_A = 25°C unless specified otherwise)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{IN}	Input Voltage		44	56	60	
$V_{IN,on}$	Input UVLO Turn on Voltage		42		44	
$V_{IN,off}$	Input UVLO Turn off Voltage		40		42	V
V_{IN_OVP}	Input Over Voltage Protection		59.5		60	
V_{OUT}	Output Voltage			20		
$t_{OUT,rise}$	Output Voltage Rise Time	V_{IN} = 56 V, I_{OUT} = 0 A		6		ms
ΔV_{OUT}	Output Voltage Ripple	I_{OUT} = 12.5 A		40		mV
V_{OUT_OVP}	Output Over Voltage Protection		21.7		25.5	
$V_{OUT\_150\%}$	Output Voltage at 150% Transient Overcurrent	I_{OUT} = 18.75 A, over current period = 10 ms	18.5			
$V_{OUT\_200\%}$	Output Voltage at 200% Transient Overcurrent	I_{OUT} = 25 A, over current period = 1 ms	18.5			V
V_{OUT_OS}	Output Voltage Overshoot at Load Step	Load step = 11.25 A to 0 A, V_{IN} = 56 V			21.5	
V_{OUT_US}	Output Voltage Undershoot at Load Step	Load step = 0 A to 11.25 A, V_{IN} = 56 V	18.5			
I_{OUT}	Output Current		0		12.5	A
$I_{OUT,limit}$	Overcurrent Limit Threshold		14		17	
f_s	Switching Frequency			400		kHz
T_{rise}	Temperature Rise	V_{IN} = 56 V, I_{OUT} = 12.5 A, heat-spreader installed, no forced air, measured at heat-spreader	33		38	°C

EPC9153 board - Variant 1, Wurth inductor



EPC9153 board - Variant 2, Delta/Cyntec inductor

ELECTRICAL PERFORMANCE

Typical efficiency and power loss

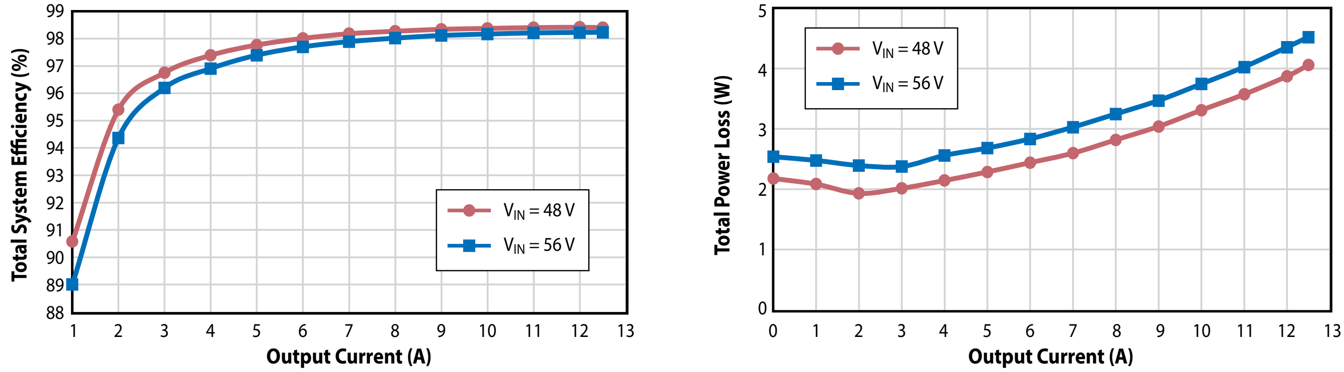


Figure 2: 20 V output, different input voltages

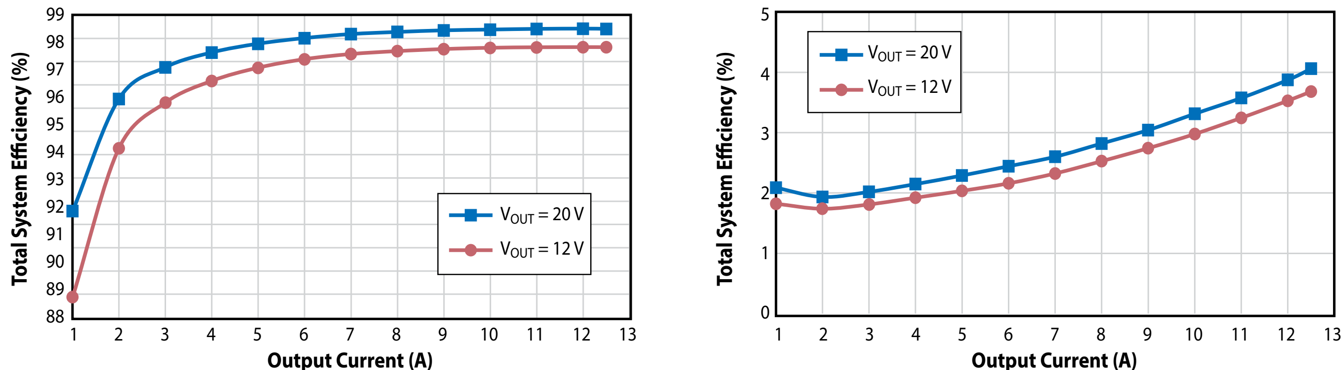


Figure 3: 12.5 A output, different ouput voltages

Typical output voltage ripple

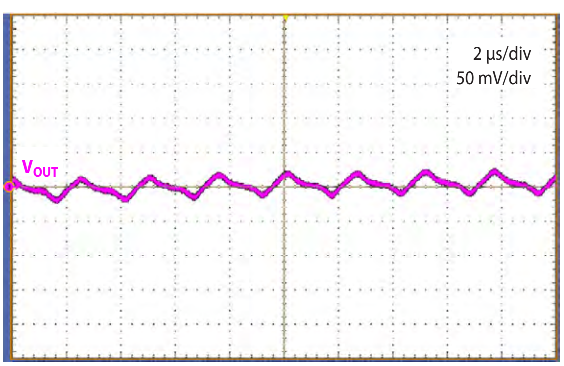


Figure 4: V_{IN} = 56 V, V_{OUT} = 20 V, I_{OUT} = 12.5 A

Typical transient response

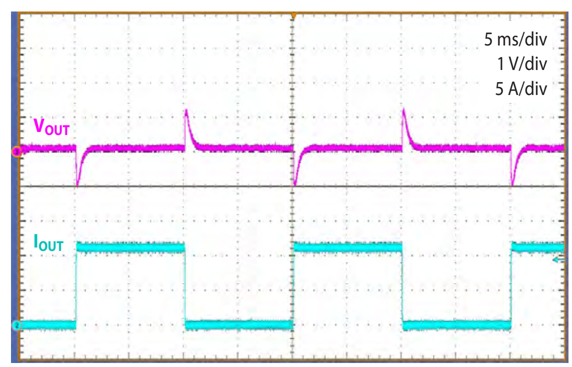


Figure 5: V_{IN} = 56 V, V_{OUT} = 20 V, 10% (1.25 A) to 100% (12.5 A)

Startup

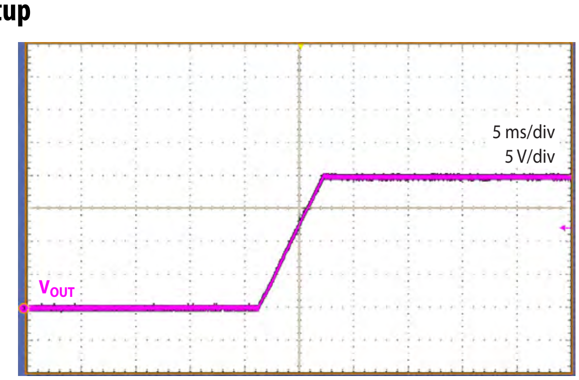


Figure 6: Start-up at V_{IN} = 56 V, V_{OUT} = 20 V, I_{OUT} = 12.5 A

Typical switching waveform

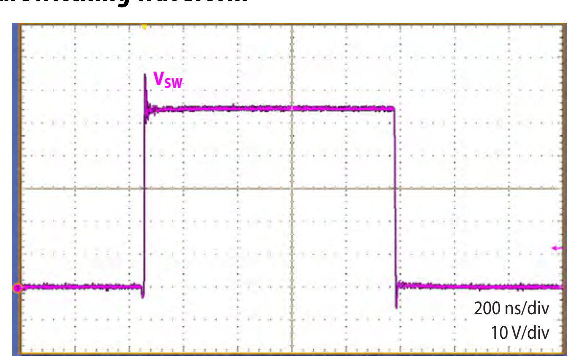


Figure 7: Measured switch-node voltage at V_{IN} = 56 V, V_{OUT} = 20 V, I_{OUT} = 12.5 A

ELECTRICAL PERFORMANCE *(continued)*

Overcurrent protection

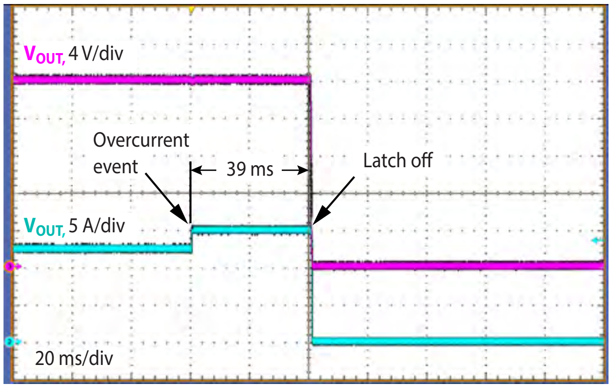


Figure 8: Output voltage and current waveforms at overcurrent protection

OPERATING CONSIDERATIONS

Controller

The EPC9153 synchronous buck power module features a Microchip Technology 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.

Control loop

The EPC9153 synchronous buck 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.

Soft start-up

The start-up of the EPC9153 output voltage is programmed to be a soft start-up: Once the input voltage passes the input UVLO threshold, the output voltage rises monotonously from 0 to its final value without overshoot in 6 ms. The rise time can be changed through a re-program of the controller.

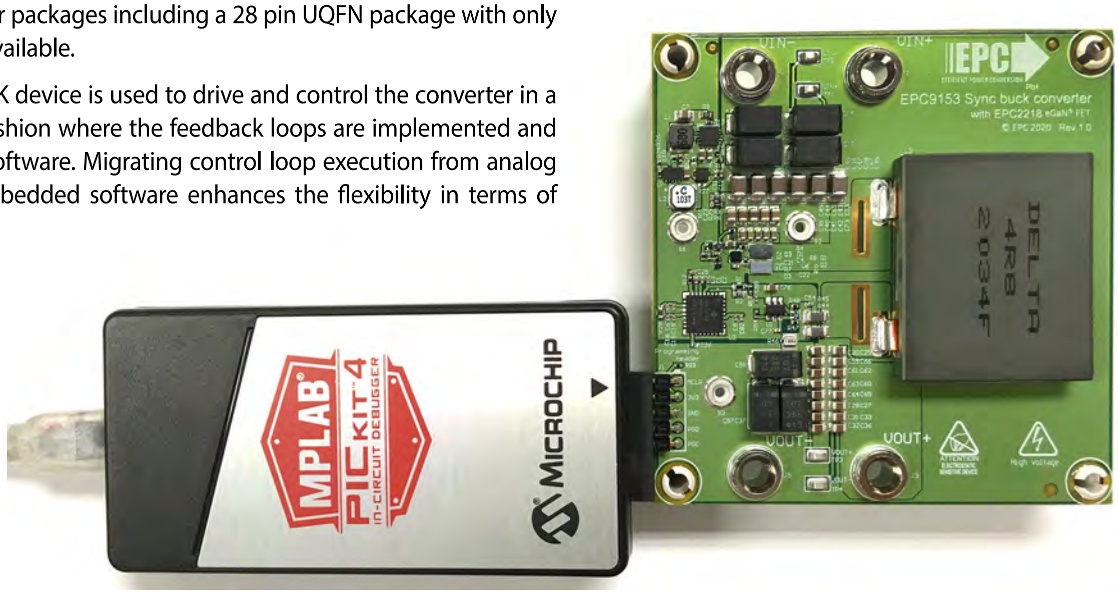


Figure 9: Programming connection

FAULT PROTECTION

Several basic fault handlers have been implemented. Whenever a fault condition is tripped, the PWM signals are switched off and the converter shuts down. And it will remain in this shut-down state. To restart, the input voltage needs to be removed, and then reapplied. Once the output voltage drops below 2.5 V, the converter will attempt to restart.

Over-Current Protection

The maximum rated continuous output current is 12.5 A. It can also handle 150% over current (12.5 A to 18.75 A) for 10 ms, and 200% over current (12.5 A to 25 A) for 1 ms. When the total duration of the over current event exceeds the time limit, the over-current fault will trip.

In addition, if the output current is higher than 15 A for longer than 30 ms, the over-current fault will trip as well.

Short-Circuit Protection

The short-circuit fault will trip when the output is shorted to ground. If the short is present before powering up, the converter will not start.

Output Over-Voltage Protection

If the output voltage is 3.5 V above the set point, the PWM signals are switched off.

THERMAL MANAGEMENT

Thermal management is very important to ensure proper and reliable operation. The EPC9153 is intended for bench evaluation at normal ambient temperature. The addition of a heat-spreader or heatsink and forced air cooling can significantly increase the current rating of the power devices, but care must be taken to not exceed the absolute maximum die temperature of 150°C.

The EPC9153 board is designed with three mechanical spacers that accept M2 x 0.4 mm thread screws and can be used to easily attach a heat-spreader/heatsink as shown in Figure 10. It only requires a thermal interface material (TIM), a custom shape heat-spreader/heatsink, a thin insulation layer for the components with exposed conductors such as capacitors and resistors and screws. The EPC9153 with the heat-spreader installed is shown in Figure 11.

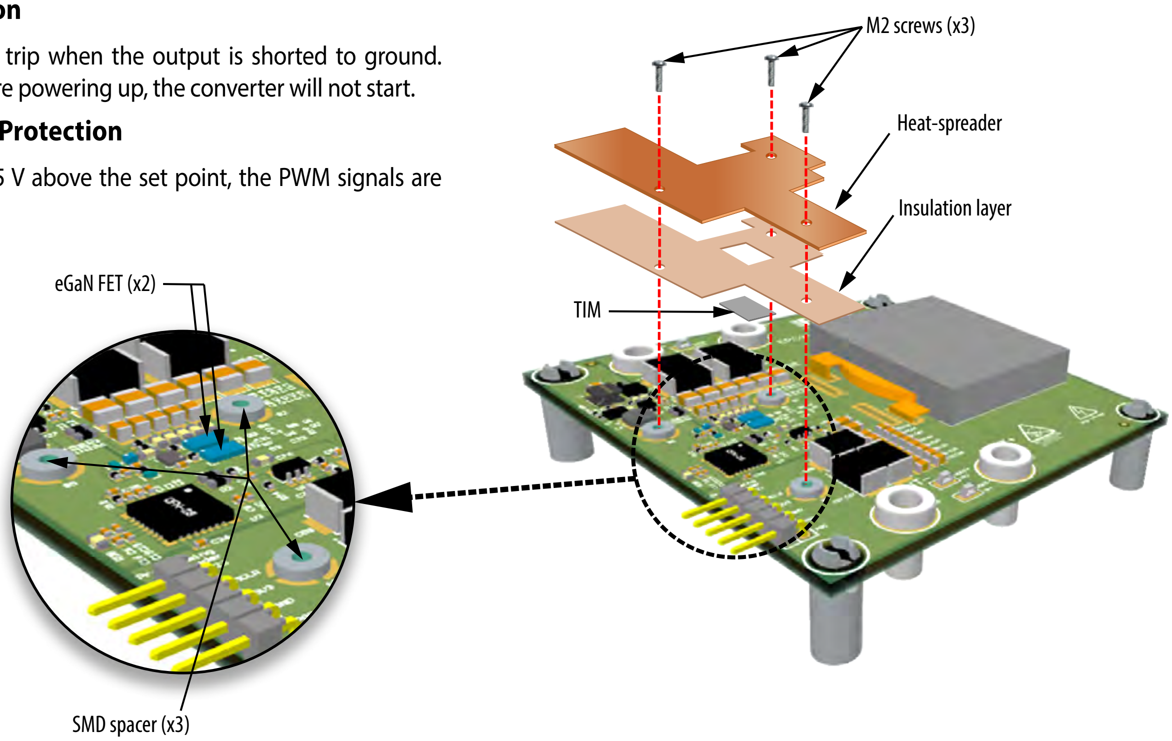


Figure 10: Illustration of the heat-spreader assembly

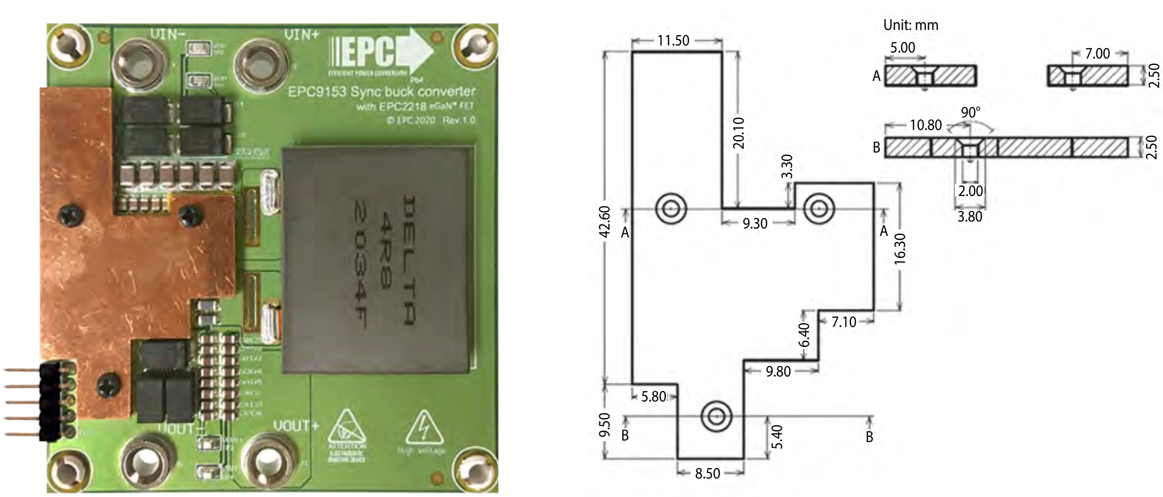


Figure 11: (left) EPC9153 with heat-spreader assembled (right) Dimensions of the heat-spreader

THERMAL MANAGEMENT *(continued)*

The choice of TIM needs to consider the following characteristics:

- **Mechanical compliance** – The TIM becomes compressed during heatsink attached and exerts a force on the FETs. A maximum compression of 2:1 is recommended for maximum thermal performance and to constrain the mechanical force that maximizes thermal mechanical reliability.
- **Electrical insulation** – The backside of the eGaN® FETs are substrate that are connected to source and the upper FET will thus be connected to the switch-node. The TIM must therefore provide insulation to prevent short-circuiting the upper FET to the ground.
- **Thermal performance** – The choice of thermal material will affect the thermal performance. Higher thermal conductivity materials will result in higher thermal performance.

EPC recommends t-Global P/N: TG-X 500 µm for the thermal interface material.

As shown in Figure 12, the EPC9153 board with the heat-spreader installed measures a temperature rise of less than 40 °C at full load operation without any forced air.

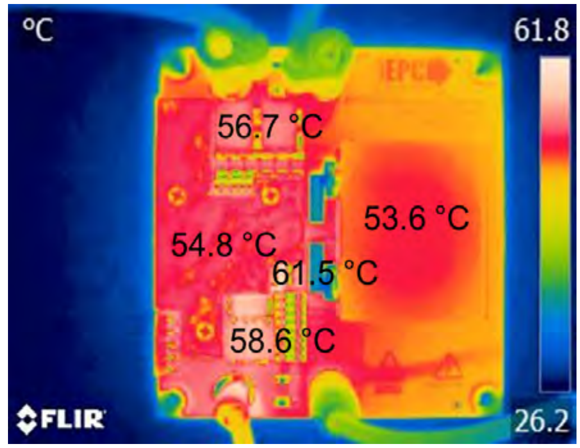


Figure 12: Thermal image of the EPC9153 operating at 56 V_{IN}, 20 V and 12.5 A output, thermal steady state

Thermal derating

Without sufficient thermal management, the output current capability is reduced. If the user decides to uninstall the heatsink, the module temperature should be monitored to ensure the maximum temperature does not exceed the rating.

QUICK START OPERATING PROCEDURE

The EPC9153 synchronous buck converter module is easy to set up for evaluation. Refer to Figures 13-14 and follow the procedure below for proper connection and measurement setup:

1. With power off, connect the input power supply to VIN+ and VIN- as shown in Figure 13.
2. With power off, connect the load to VOUT+ and VOUT- as in Figure 12.
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 60 V). Output voltage regulation begins at 44 V input voltage.
4. Once operational, adjust the load within the operating range and observe the switching behavior, efficiency, transient response and other parameters as in Figure 14.
5. For shutdown, please follow the above steps in reverse.

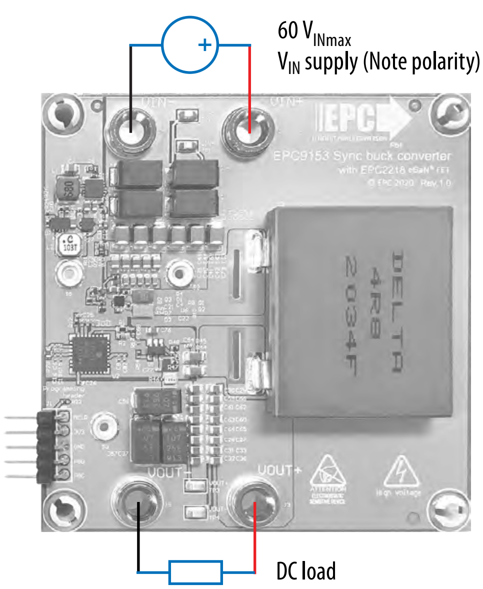


Figure 13: Input and output connection

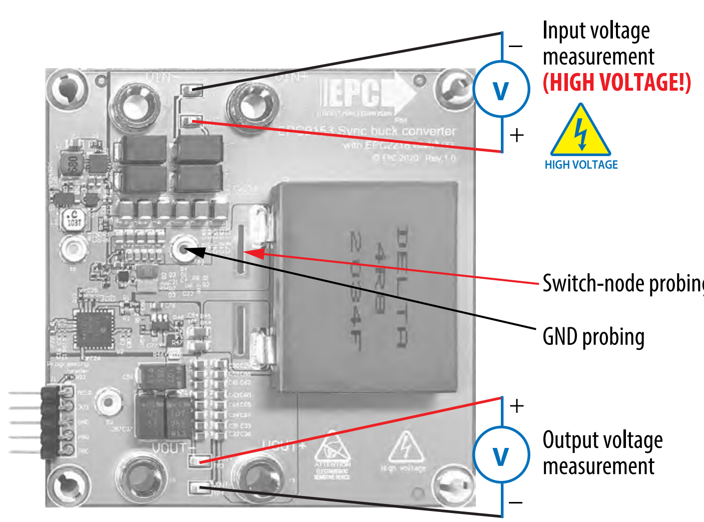


Figure 14: Measurement connection

MECHNICAL SPECIFICATIONS

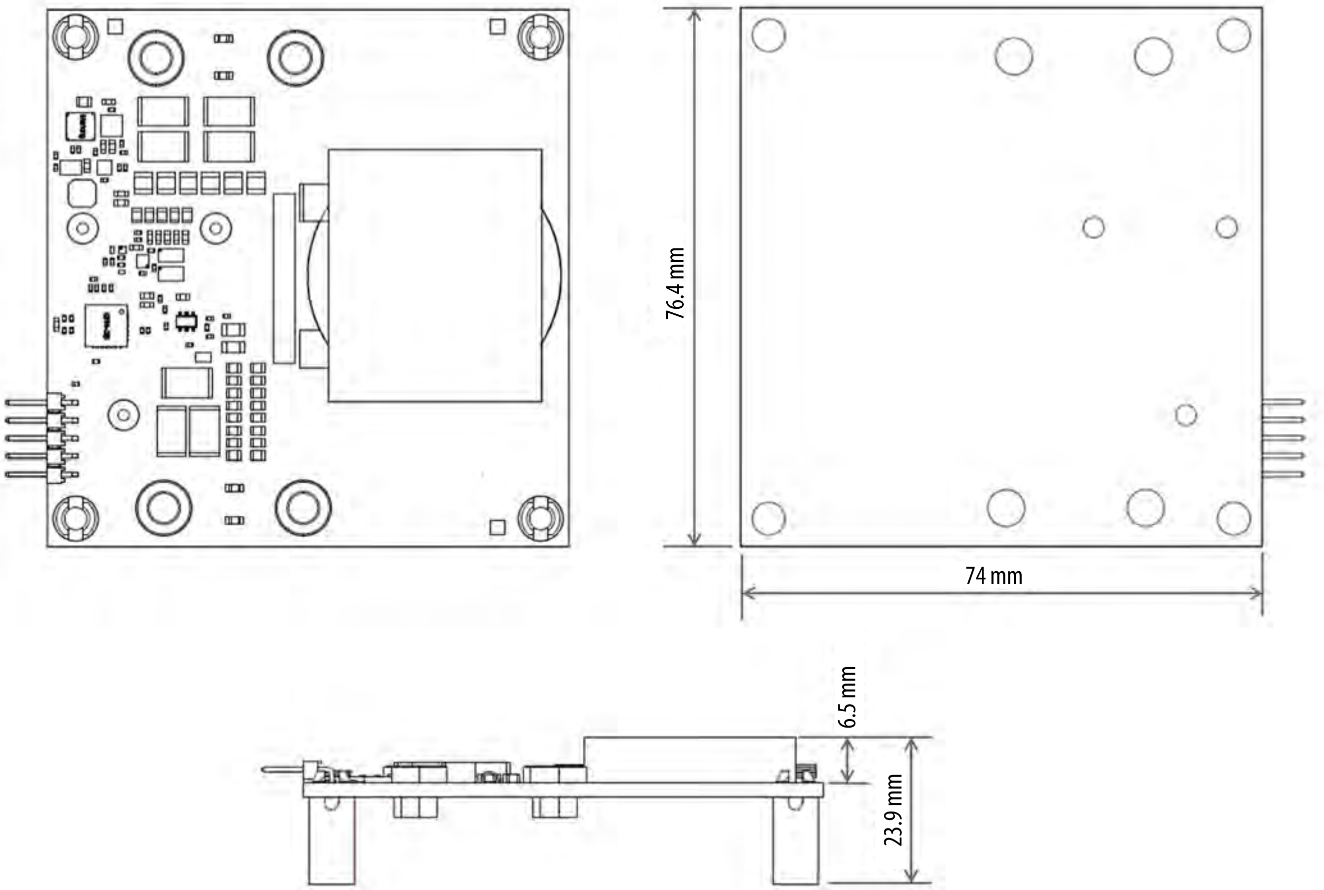


Figure 15: EPC9153 mechanical dimensions

For support files including schematic, Bill of Materials (BOM), and gerber files please visit the EPC9153 landing page at: https://epc-co.com/epc/products/demo-boards/epc9153

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

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The EPC9153 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**.

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EFFICIENT POWER CONVERSION

Evaluation Board Notification

The EPC9153 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.

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