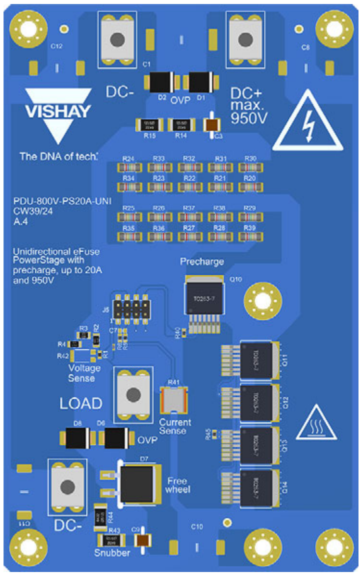
Reference Design
SiC MOSFET-Based 800 V, 20 A Unidirectional eFuse



FEATURES

- Low TCR shunt for precise current measurement
- Low tracking error voltage divider
- Robust I/O port providing ESD protection and freewheel capabilities
- Fast switching speed

KEY COMPONENTS

- CMB0207 high pulse load carbon film MELF resistor
- MXP120A045FE SiC MOSFET

LINKS TO ADDITIONAL RESOURCES

- EFUSE-800V20AUNI

DESCRIPTION

Electronic fuses (eFuses) are crucial in modern applications, especially in automotives. They are used to enhance overall vehicle safety by protecting against overcurrent, voltage spikes, and temperature rise. eFuses often comprise a control board and a power board. Here we focus on providing a complete power board design example that is based on Vishay SiC's MOSFETs.

This power board is capable of handling voltages up to 950 V and 20 A current. The circuit can be easily scaled up for high current ratings. In addition to the eFuse functionality, the circuit benefits from a pre-charge circuit connected in parallel with the main eFuse switch, which avoids inrush currents into external uncharged capacitors. The power circuit is fully equipped with all the required feedback signals, including circuit current - which is measured by a Vishay low TCR shunt resistor - and the circuit voltage, which is measured by a low tracking error voltage divider.

OVERALL SYSTEM BLOCK DIAGRAM

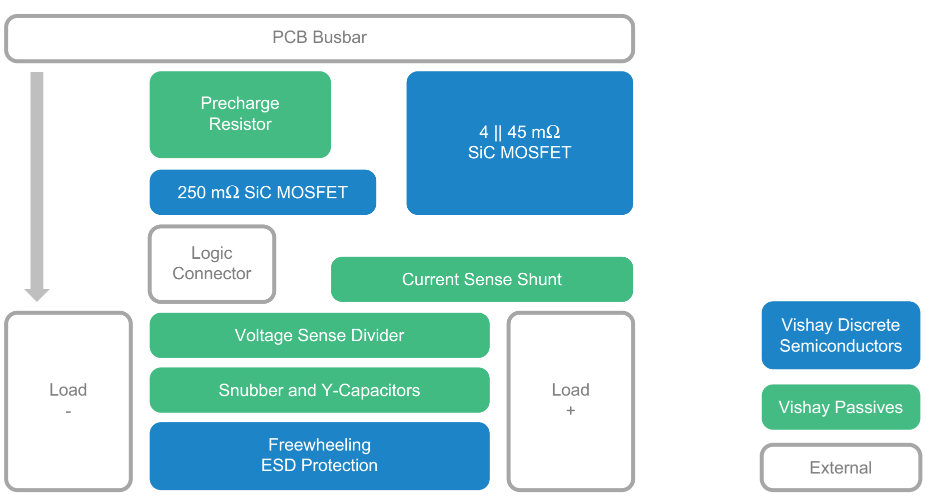


Fig. 1 - Overall System Block Diagram

APPLICATION DESCRIPTION

The eFuse circuit should be able to supply and disconnect the current from the source side to the load side. It also provides a separate pre-charge path to avoid inrush currents when operating with capacitive loads.

Pre-Charging

During the pre-charge, Q10 should be turned on and (Q11 - Q15) should be turned off.

The DC-Link capacitor should be pre-charged first before the main switch is tuned on. In this design the effective pre-charge resistance is 10 kΩ. This is achieved by using two parallel 10 series connection of 2 kΩ/0.4 W resistors.

These resistors can be adjusted by the user to achieve the required pre-charge time according to the specific application.

Considering the existing setup, a 10 kΩ pre-charge resistor and 800 V supply voltage, the initial peak current of the circuit will be about 80 mA ($\frac{800}{10\ k\Omega}$).

$$P_R = I^2 \times R = (0.08\ A)^2 \times 10\ k\Omega = 64\ W\ \text{(peak power)}$$

Each resistor should withstand ($\frac{64}{20} \sim 3.2$) peak power for a duration equal to

$$5\tau = 5 \times R \times C = 5 \times 10\ k\Omega \times C$$

where C is the capacitance connected to the output of the eFuse.

For the SiC MOSFET

Assuming $R_{DS(on)}$ = 250 mΩ at 80 °C and V_{GS} = 20 V:

$P = I^2R = (0.08\ A)^2 \times 250\ m\Omega = 1.6\ mW$.

Considering the maximum junction to ambient thermal resistance R_{thJA} = 43 °C/W, the following simple thermal equation provides the temperature rise:

$$T_J = T_{amb} + dT \quad (1)$$

Where;

T_J is the junction temperature

T_{amb} is the ambient temperature

dT is the temperature rise due to the energy dissipation. This can be calculated by applying P_{loss} x R_{th}, or from the graphs provided in the datasheet

P_{loss} is the power loss within the component

R_{th} is the internal thermal resistance of the component.

$$T_J = T_{80\ °C} + 1.6\ mW \times 43\frac{°C}{W} \sim 80.7\ °C$$

(it indicates that no active cooling is required in this case)

Normal Operation

During normal operation, (Q11 - Q15) should be turned on and Q10 should be turned off.

For the MOSFET, considering $R_{DS(on)}$ = 45 mW at 80 °C and V_{GS} = 20 V, for 20 A divided by four MOSFETs in parallel, each MOSFET will have 5 A:

$$P = I^2R = (5\ A)^2 \times 45\ m\Omega = 1.125\ W$$

Considering the maximum junction to ambient thermal resistance R_{thJA} = 42 °C/W, the following simple thermal equation provides the temperature rise:

$$T_J = T_{80\ °C} + 1.125\ W \times 42\frac{°C}{W} \sim 127.25\ °C < T_{J\ max.}\ (150\ °C)$$

It indicates that no active cooling is required in this case as well. The user should take care in calculating the actual temperature rise in the final application.

PIN CONFIGURATION

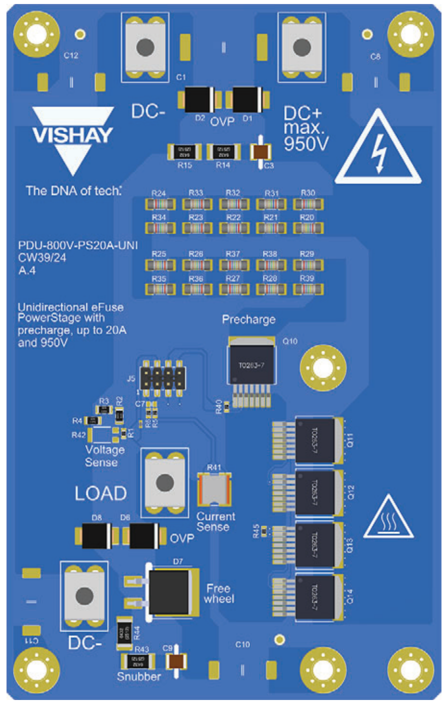


Fig. 2 - Pin Configuration

PIN DESCRIPTION		
PIN NUMBER	**SYMBOL**	**DESCRIPTION**
DC+	DC+	Connect with HV DC voltage input; max. 950 V
DC-	DC-	Connect with reference point for DC input
LOAD	DC+	Connect with load; max. 950 V
DC-	DC-	Connect with reference point for LOAD
J5 / 1	+DC_SH+	Output load shunt positive
J5 / 3	+DC_SH-	Output load shunt negative
J5 / 5	GATE_SW_ON	Input gate switch fuse active high
J5 / 7	KS_SW_ON	Reference for GATE_SW_ON
J5 / 2	CD_LOAD_SNS_REF	Reference for DC_LOAD_SNS
J5 / 4	DC_LOAD_SNS	Output voltage divider for load voltage (950:1)
J5 / 6	GATE_PRECHARGE	Input for gate signal of pre-charge MOSFET- active high
J5 / 8	KS_PRECHARGE	Reference for gate signal of pre-charge MOSFET

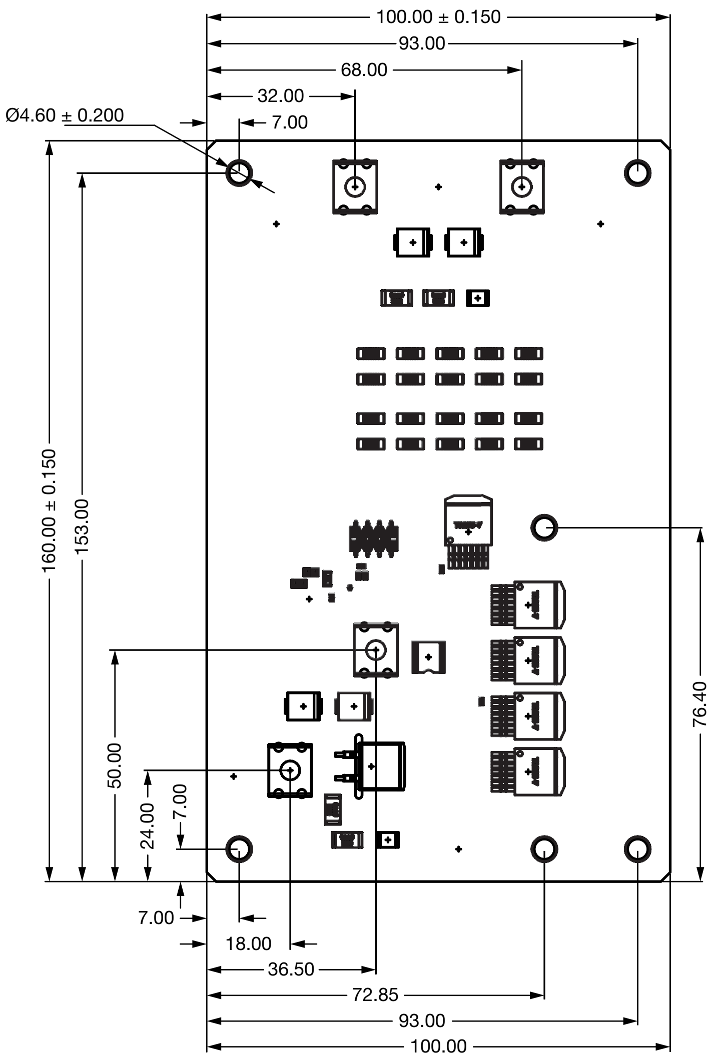
RECOMMENDED OPERATING RANGE			
PARAMETER	**MIN.**	**MAX.**	**UNIT**
DCLINK+ to DCLINK-	25	950	V

ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS (T_{amb} = 25 °C, unless otherwise specified)		
ELECTRICAL PARAMETER	**LIMITS**	**UNIT**
HV U_{DC} to ref.	950	V
Ambient temperature	-40 to +125	°C
Storage temperature	-40 to +150	°C
Max. power consumption	1500	mW
Max. current consumption	300	mA
Isolation voltage	5	kV_{RMS}

DIMENSIONS in millimeters

EFUSE-800V20AUNI



Tolerances if not other defined: ± 0.1

Fig. 3

PACKAGE LIST OF THE REFERENCE KIT

- EFUSE-800V20AUNI

ADDITIONAL RESOURCES

[1] Thermal Management in Surface-Mounted Resistor Applications

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