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Demonstration System EPC9130 Quick Start Guide

48 V to 12 V 5-Phase Regulated IBC Using EPC2045

Revision 1.0

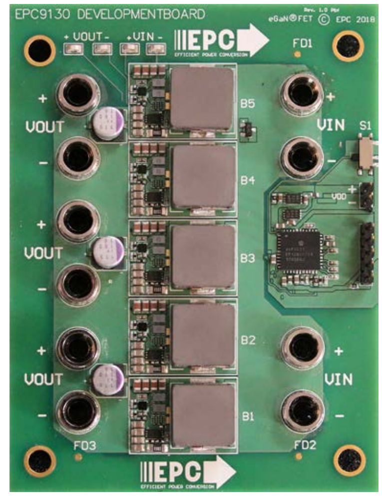
EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9130 development board is a 500 kHz switching frequency, 48 V nominal input voltage, 60 A maximum output current, 5-phase intermediate bus converter (IBC) with onboard microcontroller and gate drives, featuring the 100 V EPC2045 enhancement mode (eGaN®) field effect transistor (FET). The purpose of this development board is to provide a regulated 12 V power supply for high performance applications showcasing the superior performance of the EPC2045 eGaN® FET.

The EPC9130 development board has five phases of two EPC2045 eGaN FETs in a half bridge configuration using a uPI semiconductor up1966A gate driver with supply and bypass capacitors. The PWM signals to the gate drivers are fed by an onboard dsPIC33 microcontroller from Microchip®. The output voltage is regulated to 12 V. The board contains all critical components and layout for optimal switching performance. There are also various probe points to facilitate simple waveform measurement and efficiency calculation.

A complete block diagram of the circuit is given in Figure 1. The converter uses five interleaved half-bridges built from EPC2045 as power switches, and the uPI1966A as the gate driver. Basic voltage mode control of output is done with the microcontroller. Current sharing among the phases, under-voltage lockout as well as overcurrent, over-voltage, and over-temperature protection is available. To allow more flexible operation for this evaluation board, only current sharing and under-voltage lockout are implemented for this EPC9130 demo board.



EPC9130 Top View

For more information on the EPC2045 eGaN FETs please refer to the datasheet available from EPC at www.epc-co.com. The datasheets should be read in conjunction with this quick start guide.

QUICK START PROCEDURE

Development board EPC9130 is easy to set up to evaluate the performance of the EPC2045 eGaN FET and uPI1966A driver, as well as the transient response due to the dsPIC33 microcontroller. Refer to Figures 2 and 3 for proper connect and measurement setup and follow the procedure below:

1. With power off, connect the input power supply bus to $+V_{IN}$ banana sockets (red) and ground / return to $-V_{IN}$ banana sockets (black) as shown.
2. With power off, connect a/multiple DC load(s) to the output $+V_{OUT}$ (red) and $-V_{OUT}$ (black) return to your circuit as required.
3. With power off, connect the gate drive and controller input supply to $+V_{DD}$ (red) and ground return to $-V_{DD}$ (black).
4. Turn on the gate drive supply – make sure the supply is within the 7.5 V and 12 V range.
5. Turn on the bus voltage to the required value (do not exceed the absolute maximum voltage of 60 V on V_{IN}) and probe switching node to observe switching operation.
6. Once operational, turn on the load current and adjust the bus voltage within the operating range and observe the output switching behavior, efficiency, and other parameters.
7. For shutdown, please follow steps in reverse.

NOTE. When measuring the high frequency content switch node, care must be taken to avoid long ground leads. Measure the switch node by using a probe jig with the oscilloscope probe tip. Refer to figure 3 for proper scope probe technique.

Table 1: Performance Summary (T_A = 25°C) EPC9130

Symbol	Parameter	Min	Typ	Max	Units
V_{DD}	Gate Drive and Controller Input Supply	7.5	10	12	V
V_{IN}	Bus Input Voltage	36	48	60	V
V_{OUT}	Output Voltage		12		V
I_{OUT}	Output Current		50*		A
f_{sw}	Switching Frequency		500		kHz

** Maximum output current depends on die temperature – actual maximum current with be subject to bus voltage, ambient temperature, and thermal design considerations, i.e. air flow and heat sinking.*

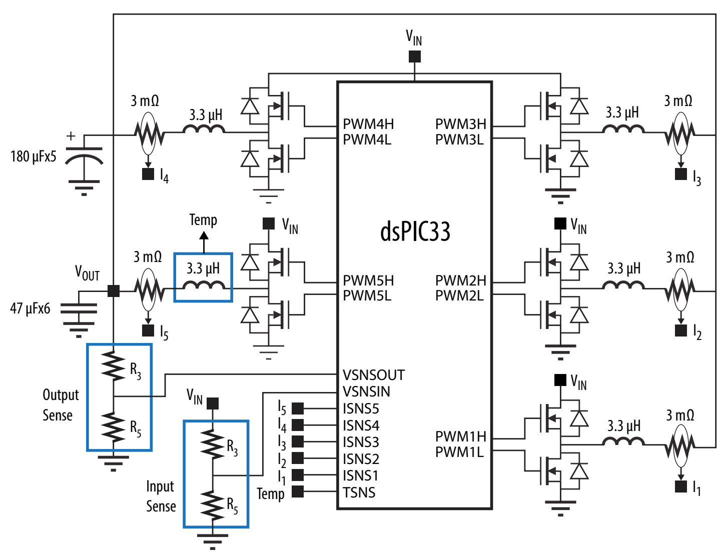


Figure 1. Block Diagram of EPC9130 Development Board.

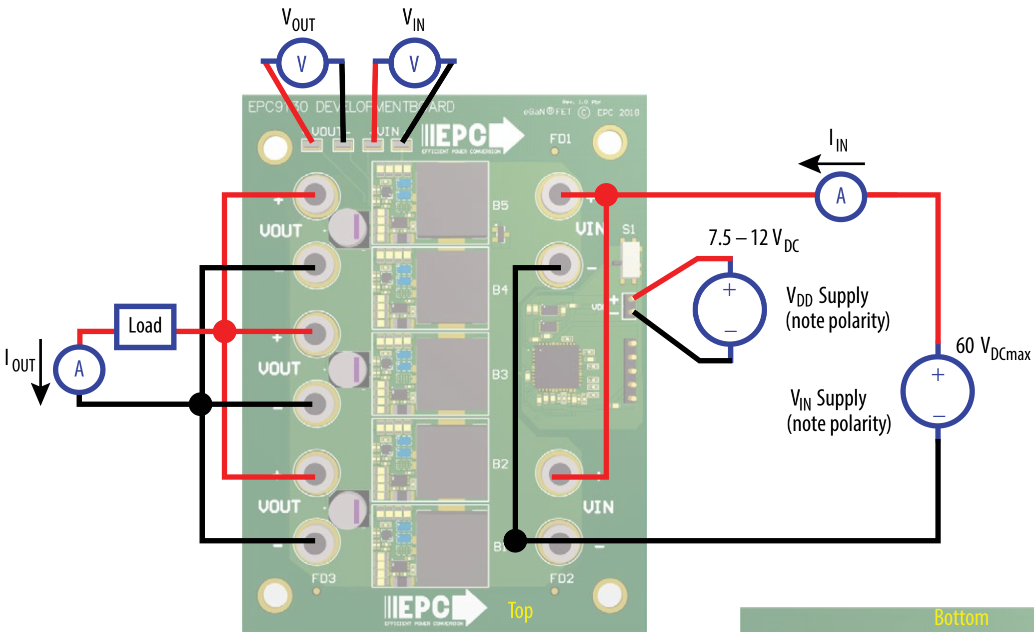


Figure 2: Proper Connection and Measurement Setup for efficiency/transient characterization (Top)

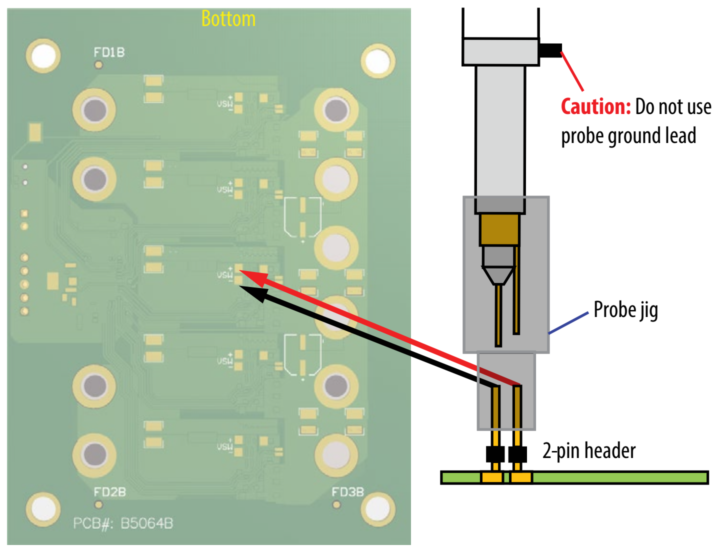


Figure 3: Optional Switch Node Measurement (Bottom)

CIRCUIT PERFORMANCE

The EPC9130 demonstration circuit was designed to showcase the size and performance that can readily achieved using eGaN FETs. Figure 4 shows typical full-load waveforms under 400 LFM (2 m/s) for a 48 V input voltage, unless otherwise noted, using probe tip adapters as shown in Figure 3. Figure 5 shows efficiency plots for 48 V input voltage at 25°C.

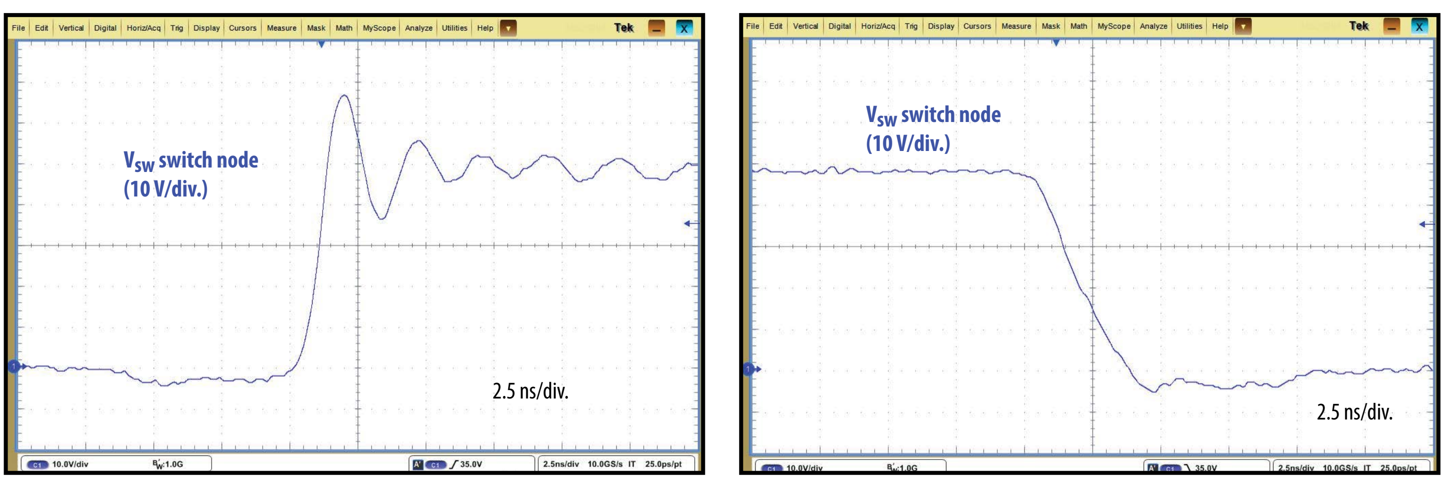


Figure 4: Typical switch node waveforms taken at 48 V_{IN} to 12 V_{OUT}/50 A_{OUT}

OPERATING CONSIDERATIONS

The EPC9130 is a demonstration platform intended to show the capabilities of eGaN FETs in a multiphase IBC application. The transient response has been optimized for a 25 A transient with a slew rate of 1 A/µs and voltage overshoot/undershoot of ~1 V. See figure 6.

Source and Load

It is recommended that the converter be driven from a source with both low dc and ac impedance. Additional input capacitance may be added as necessary.

Thermal Management

The EPC9130 demo board has no on-board thermal protection. Thermal images for steady state full-load operation are shown in Figure 7. The EPC9130 is intended for bench evaluation with nominal room ambient temperature and forced air cooling. Operation without forced air cooling is possible for limited power operation. It is recommended that the maximum temperature on the EPC9130 not exceed 125°C.

Electrical Protection

The EPC9130 has under-voltage lockout and will not operate below input voltage of 16 V. For flexible operation of this evaluation board, designed features such as over-current, over-temperature, and over-voltage protection were not enabled, so the user is encouraged to operate in the ranges specified on Table I.

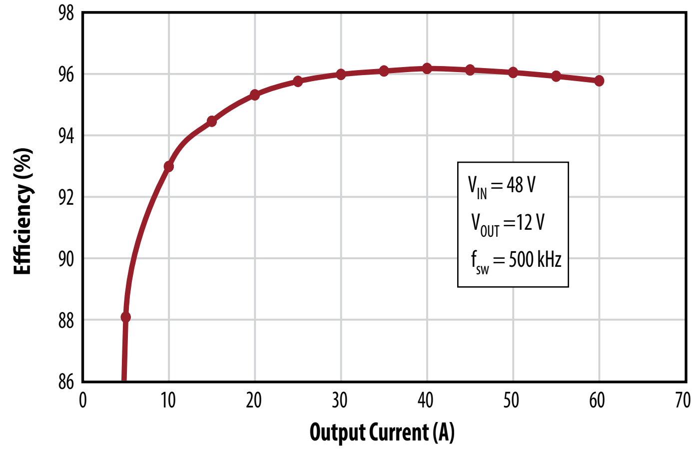


Figure 5: Typical efficiency curve. 48 V to 12 V.

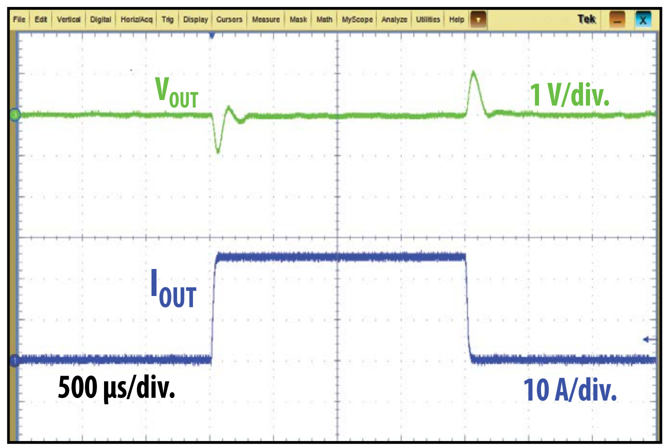


Figure 6: Typical load transient-12.5 A to 37.5 A to 12.5 A over a period of 2 ms

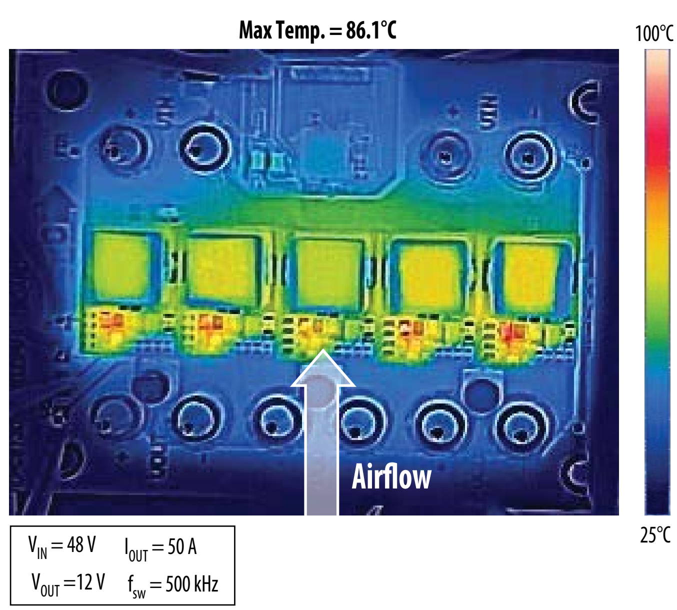


Figure 7: Thermal image of EPC9130. Operating Conditions : 400 LFM (2 m/s) forced convection, ambient temperature 25°C, thermal steady state.

Table 2: Bill of Materials

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	4 per phase	CINA, CINB, CINC, CIND	Capacitor, 1 µF, 20%, 100 V, X7S, 0805	TDK	C2012X7S2A105M125AB
2	2 per phase	Q1, Q2	100 V 5.6 mΩ eGaN FET	EPC	EPC2045
3	1 per phase	CB1	Capacitor, 0.1 µF, 10%, 25 V, X5R, 0402	TDK	C1005X5R1E104K050BC
4	1 per phase	CDEC1	Capacitor, 1 µF, 10%, 25 V, X5R, 0402	TDK	C1005X5R1E105K050BC
5	1 per phase	U4	UPI, UP1966A, USMD, BGA	UPI	UP1966A
6	4 per phase	COUT1, COUT2, COUT3, COUT4	Capacitor, 22 µF, 20% 25 V, X5R, 0805	TDK	C2012X5R1E226M125AC
7	1 per phase	L3B	Fixed Inductor, 3.3 uH, 15 A, 9.2 mΩ	Vishay	IHLP5050EZER3R3M01
8	1 per phase	RVDD	Resistor, 4.7 Ω, 1% ,1/16 W, 0402	Stackpole	RMCF0402FT4R70
9	1 per phase	R9	Resistor, 10 kΩ, 1% ,1/16 W, 0402	Stackpole	RMCF0402FT10K0
10	1 per phase	R10	Resistor, 10 kΩ, 1% ,1/16 W, 0402	Stackpole	RMCF0402FT10K0
11	1 per phase	CL	Capacitor, 22 pF, 1%, 50 V, C0G/NP0, 0402	Kemet	CBR04C220F5GAC
12	1 per phase	CH	Capacitor, 22 pF, 1%, 50 V, C0G/NP0, 0402	Kemet	CBR04C220F5GAC
13	1 per phase	R11	Resistor, 750 Ω, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT750R
14	1 per phase	C18	Capacitor, 220 pF, 10%, 50 V, X7R, 0402	Kemet	C0402C221K5RACTU
15	1 per phase	R6	Resistor, 3 mΩ, 1%, 1 W, 1206	Stackpole	CSNL1206FT3L00
16	1 per phase	R7	Resistor, 10 Ω, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT10R0
17	1 per phase	R8	Resistor, 10 Ω, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT10R0
18	4	E1, E2, E3, E4	Test Point, SMT	Keystone Electronics	Keystone Elect, 5015
19	1 per phase	U5	IC OpAmp Current Sense 100 kHz, 6DFN	Linear Technology	LT6105
20	10	B1, B2, B3, B4, B5, B6, B7, B8, B9, B10	Jack, Non-Insulated, .218"	Stackpole	Keystone Elect, 575-4
21	1	R2	Resistor, 4.99 kΩ, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT4K99
22	1	R4	Resistor, 1 kΩ, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT1K00
23	1	C16	Capacitor, 220 pF, 10%, 50 V, X7R, 0402	Kemet	C0402C221K5RACTU
24	1	R3	Resistor, 30 kΩ, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT30K0
25	1	R5	Resistor, 1 kΩ, 1%, 1/16 W, 0402	Stackpole	RMCF0402FT1K00
26	1	C17	Capacitor, 220 pF, 10%, 50 V, X7R, 0402	Kemet	C0402C221K5RACTU
27	5	CS1, CS2, CS3, CS4, CS5	Capacitor, 220 pF, 10%, 50 V, X7R, 0402	Kemet	C0402C221K5RACTU
28	1	L1	Ferrite Bead, 180 Ω, 0603, 1LN	Murata	BLM18PG181SN1D
29	1	L2	Ferrite Bead, 180 Ω, 0603, 1LN	Murata	BLM18PG181SN1D
30	5	C1, C2, C3, C4, C5	Capacitor, 10 µF, 6.3 V, X6S, 0603	Taiyo Yuden	JMK107BC6106MA-T
31	1	U6	Temp Sensor, Analog Voltage, SOT 23-3	Microchip	TC1047AVNBTR
32	1	C26	Capacitor, 220 pF, 10%, 50 V, X7R, 0402	Kemet	C0402C221K5RACTU
33	1	S1	Sliding Switch, SPDT, 300 mA, 4 V	APEM	MA12RTR
34	1	R1	Resistor, 0 Ω, 1%, 1/8 W, 0603	Panasonic	ERJ-3GEY0R00V
35	3	C6, C7, C8	Capacitor, 1 µF, 10%, 25 V, X5R, 0603	Murata	GRM188R61E105KA12D
36	1	U1	IC Regulator, LDO, 5 V, 0.25 A, 8DFN	Microchip	MCP1703T-5002E/MC
37	1	U2	IC Regulator, LDO, 3.3 V, 0.25 A, 8DFN	Microchip	MCP1703T-3302E/MC
38	1	U3	Microcontroller, dsPIC33, 44-pin QFN	Microchip	DSPIC33EP128GS704-E/ML
39	1	J1	2 pins of Tyco, 4-103185-0	Tyco	4-103185-0
40	1	J4	5 pins of Tyco, 4-103185-0	Tyco	4-103185-0
41	3	CBULK1, CBULK2, CBULK3	Aluminium Capacitor, 180 µF, 16 V, 20%, OSCON	Panasonic	16SVPF180M
42	1	RMCLR	Resistor, 10 kΩ, 1%, 1/10 W, 0603	Stackpole	RMCF0603FT10K0

Table 3: Optional Components

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	1 per phase	Q3	100 V 5.6 mΩ eGaN FET	EPC	EPC2045
2	6	C19, C20, C21, C22, C23, C24	Capacitor, 47 µF, 20%, 25 V, X5R, 1210	TDK	TMK325ABJ476MM-P
3	1 per phase	CINE	Capacitor, 4.7 µF, 10%, 100 V, X7S, 1210	TDK	CGA6M3X7S2A475K200AB
4	2	CBULK4, CBULK5	Aluminium Capacitor, 180 µF, 16 V, 20%, OSCON	Panasonic	16SVPF180M

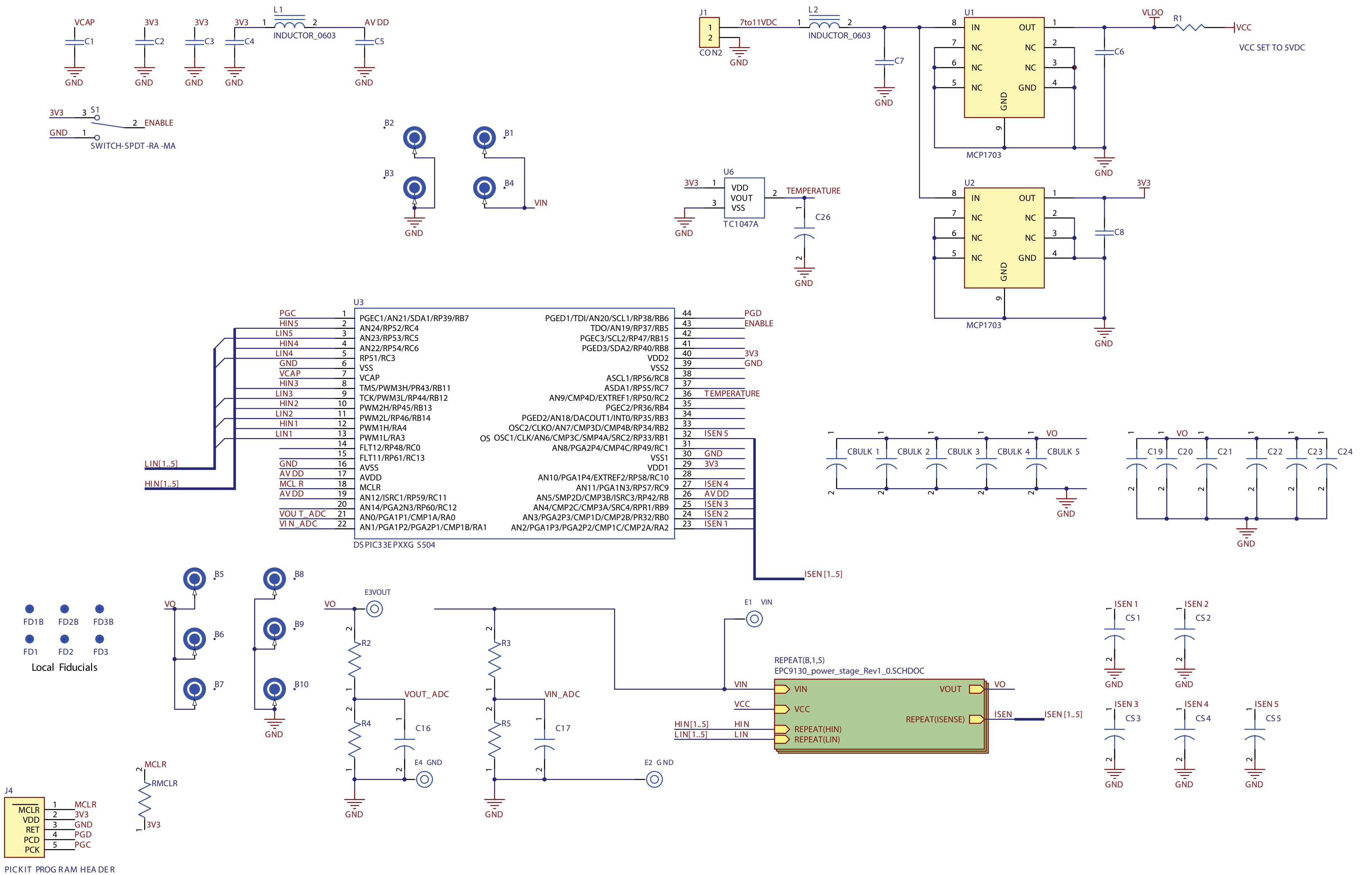


Figure 8: EPC9130 Controller schematic

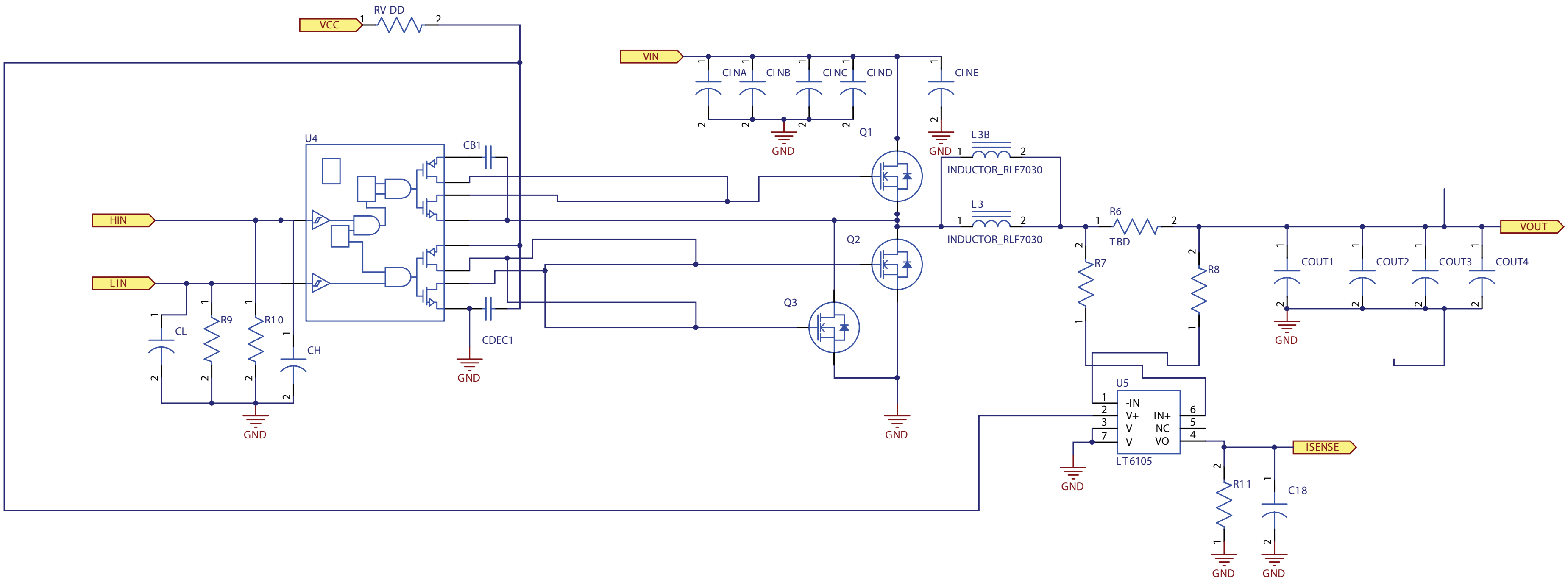


Figure 9: EPC9130 Power Stage schematic

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EFFICIENT POWER CONVERSION

Demonstration Board Notification

The EPC9130 board is intended for product evaluation purposes only and is not intended for commercial use. 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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