Development Board EPC9147A Quick Start Guide

Motor Drive Controller Interface board – Microchip DSP

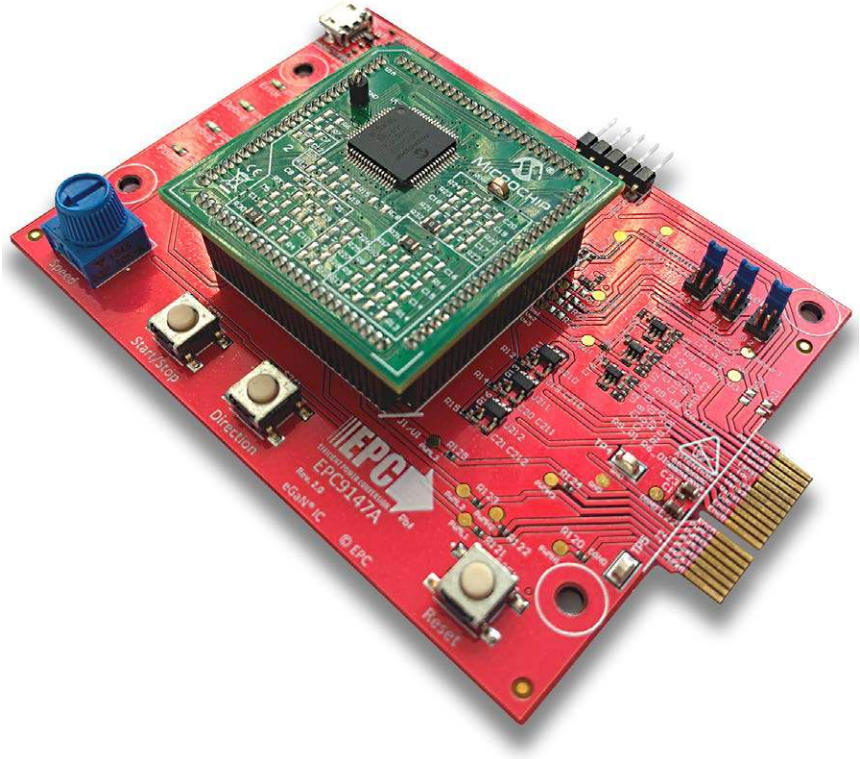
Revision 2.0

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9147A board is an interface board that accepts the Microchip MA330031-2 Plug-In-Module (PIM), that is fitted with the dsPIC33EP256MC506 Digital Signal Processor (DSP), and interfaces to a 3-phase eGaN® FET/IC motor drive inverter board. This interface board allows users to utilize the existing Microchip motorBench® Development Suite resources to program the PIM that controls a motor powered by an eGaN FET/IC 3-phase inverter using sensorless field orientation control with space vector pulse width modulation.

Figure 1 shows an overview of the EPC9147A board detailing connections and various human interfaces that measures 99.3 mm x 68 mm (L x W). It is provided with a fully isolated micro-USB communications interface that is powered by the host computer on the isolated side and by the motor inverter on the non-isolated side.



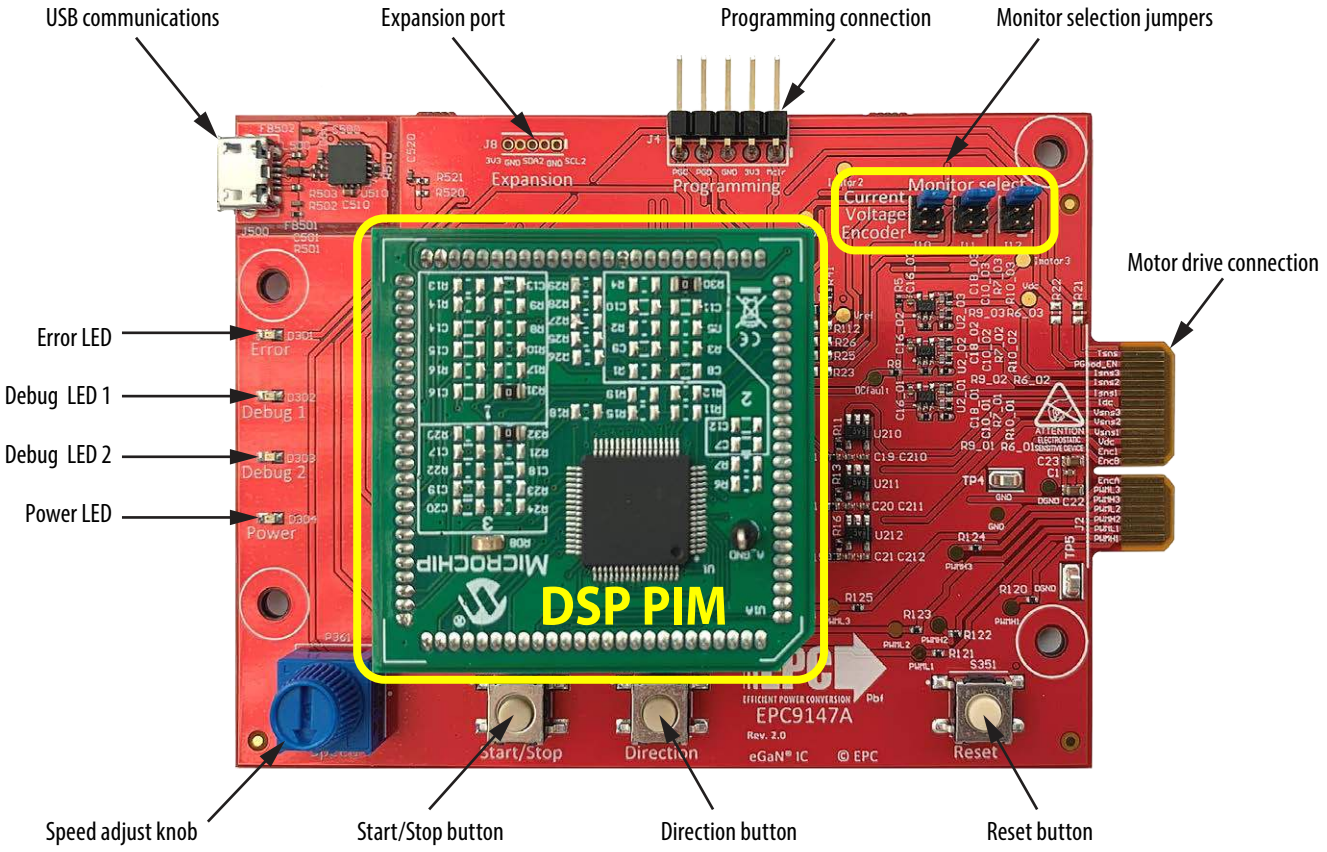
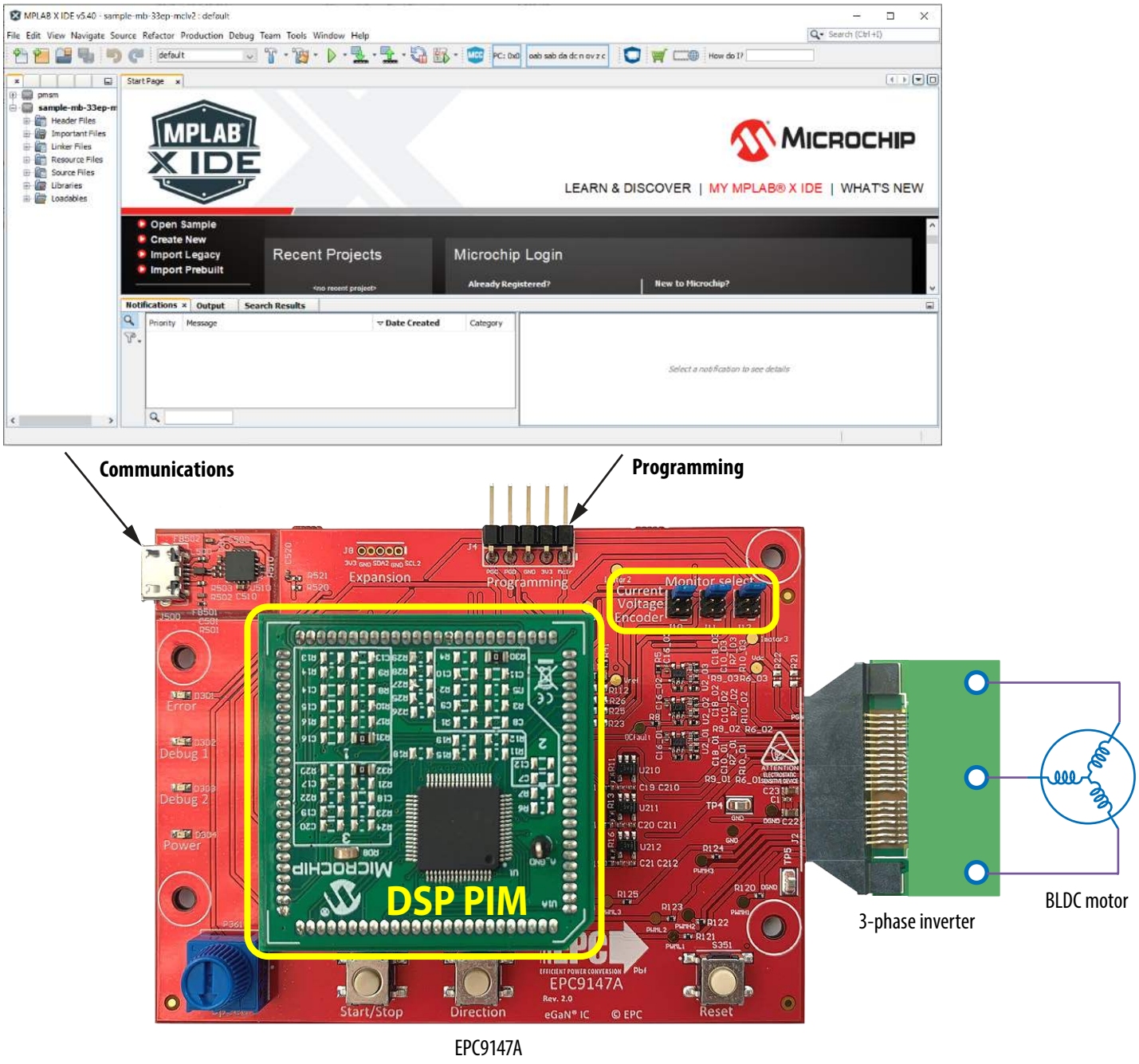


Figure 1. Overview of the EPC9147A board

The EPC9147A is includes a standard Microchip compatible programming port (J4), I2C expansion port (J8) and, a 40-pin card edge connector (J2) that interfaces the PWM, analog feedback signal, errors states and 3.3 V power to the motor drive inverter board as shown in figure 2.



EPC9147A

Figure 2. Application overview of the EPC9147A control interface board

The USB communication port is used to communicate with the PIM module that monitors various inverter operating conditions using X2C-Scope. The programming port is used to program the controller using MPLAB® X IDE or IPE and compatible programming devices.

HUMAN INTERFACE CONTROLS AND INDICATORS

The EPC9147A has various human interface controls and indicators as shown in figure 1.

To operate the motor the following controls are available as push button or knob:

- **Start/Stop** – Starts and stops the motor from spinning toggle.
- **Direction** – This button toggles the motor spin direction.
- **Speed** – This knob changes the rotation speed of the motor.

There are also 4 LED indicators the help provide information on the status of the controller:

- Power LED (**green**) – The board has power. Power is provided by the motor drive inverter.
- Error LED (**red**)- Indicates some error has occurred. The operator can read the error based on the flashing codes of the debug LED or using motorBench® Development Suite.
- Debug LEDs (**yellow** and **blue**) - Indicates the code by a series of encoded flashes. Please refer to the Microchip manual for MCLV-2 for details on the codes.

There is a reset button that can be used to reset the processor to the power up state.

Warning: The human interface controls and knob, as well as the entire EPC9147A, are not isolated. The EPC9147A is referenced to Power Ground and extreme caution has to be observed when operating at high voltage.

Test Points

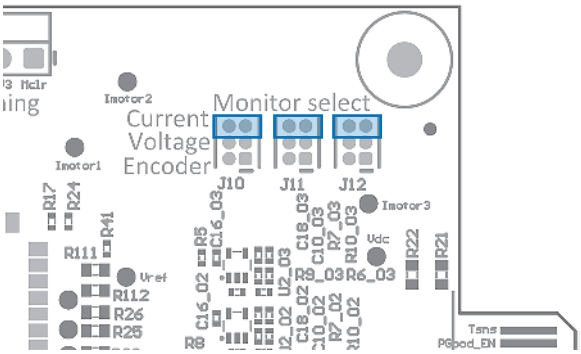
A number of test-points are available for measurement of various analog, error and PWM signals. Analog signals include voltage and current readings, input DC voltage to the drive, and current sense amplifier voltage reference. The operator is encouraged to read the motor drive inverter drive QSG carefully to determine the correct scaling factors. All three phases of the PWM signals are available as test points. An over-current error signal is also available as a test point. Two locations for ground connections for measurement purposes are available at TP4 and TP5.

Over-Current detect

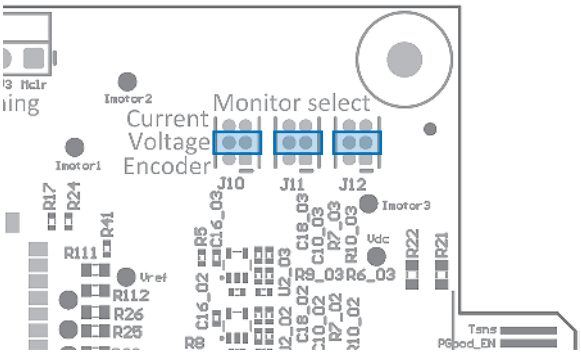
The EPC9147A includes and overcurrent detect that is fed to the controller as a fault signal (OC_FLT). This signal will trigger if any motor current phase exceeds the preset voltage of 3.25 V. Refer to the motor drive inverter for the correct conversion of the current sense circuit to determine the correct current magnitude that will generate an over-current trip. Once an over-current is triggered, the OC_FLT signal will remain low for a short period of time, determined by the RC time constant of R5+R8 and C17. The behavior when the OC_FLT is asserted depends on the specific program that has been programmed in the PIM.

Monitoring Jumper Settings

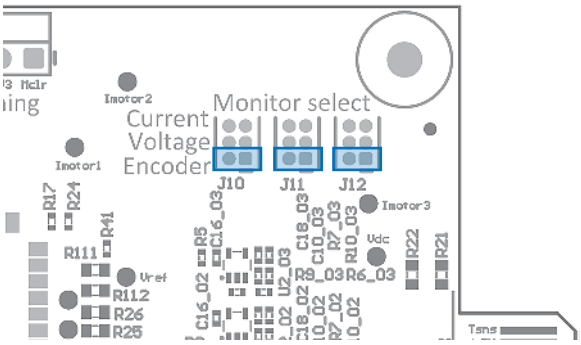
The EPC9147A is provided with a set of jumpers that can be used to change the monitoring connections. Table 1 provides a detailed list of the settings mapping and figure 3 shows this graphically.



(a)



(b)



(c)

Figure 3. Monitoring jumper settings (a) All phases Current, (b) All phases voltage, (c) Shaft encoder

Any combination of valid position settings may be selected.

Table 1: Monitoring jumper settings mapping

Jumper	Phase	Position 5-6	Position 4-3	Position 1-2
J10	1	Motor Phase Current 1	Motor Phase Voltage 1	Shaft Encoder A
J11	2	Motor Phase Current 2	Motor Phase Voltage 2	Shaft Encoder B
J12	3	Motor Phase Current 3	Motor Phase Voltage 3	Shaft Encoder Index

Compatible Motor Drive Inverters

A list of compatible motor drive inverter to the EPC9147A is given in table 2. Check EPC9147A web page for updates on additional compatible converters.

Table 2: Compatible eGaN FET/IC motor driver inverters to the EPC9147A

Board Number	Basic specifications	Web link
EPC9146 Rev. 2.1	400 W, 3-phase BLDC motor drive inverter using EPC2152	https://epc-co.com/epc/Products/DemoBoards/EPC9146.aspx

EPC9147A Electrical Specifications

Table 3: Performance Summary (T_A = 25°C) EPC9147A

Symbol	Parameter	Conditions	Min	Nominal	Max	Units
V_{DD}	Operating voltage		3.1	3.3	3.5	V
V_{IN}	PWM voltage			3.3		
V_{PWM}	Analog feedback voltage		-0.1		3.4	V
V_{IN}	Digital feedback voltages		-0.1		3.4	

CONNECTION DETAILS

Inverter

A 40 pin connector is used to interface power, PWM signals and analog feedback signals between the interface board and the motor drive inverter. Table 4 gives the map (J2) for each signal.

Table 4: Motor interface connection (J2) pin allocation map

Symbol	Nominal	Max	Units
2	PWMH1	GND	1
4	PWML1	GND	3
6	PWMH2	GND	5
8	PWML2	GND	7
10	PWMH3	3V3	9
12	PWML3	3V3	11
14	EncA	3V3	13
Index Slot			
18	EncB	GND	17
20	Encl	GND	19
22	Vin	GND	21
24	V1	GND	23
26	V2	GND	25
28	V3	GND	27
30	Iin	GND	29
32	I1	GND	31
34	I2	GND	33
36	I3	GND	35
38	EN/Pgood	LEDerr	37
40	Tsns	LEDact	39

Programming

The PIM module can be programmed using compatible programmers connected to Programming port (J4). The pin allocation map is shown in table 5.

Table 5: Programming port (J4) pin allocation map

Pin#	Connector
1	MCLR
2	3V3
3	GND
4	PGD
5	PGC

The programming port (J4) supports all of Microchip's in-circuit programmers/debuggers, such as MPLAB® ICD4, MPLAB® REAL ICE or MPLAB® PICkit4 and previous derivatives.

Development tools: https://www.microchip.com/development-tools

Expansion

The EPC9147A is provided with an I2C expansion port (J8) that can be used to expand functionality to the board. Table 6 provides the pin allocation map for the expansion port.

Table 6: Expansion port (J8) pin allocation map

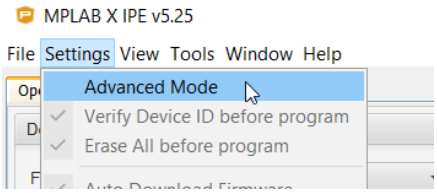
Pin#	Connector
1	SCL
2	GND
3	SDA
4	GND
5	3V3

Programming with HEX file

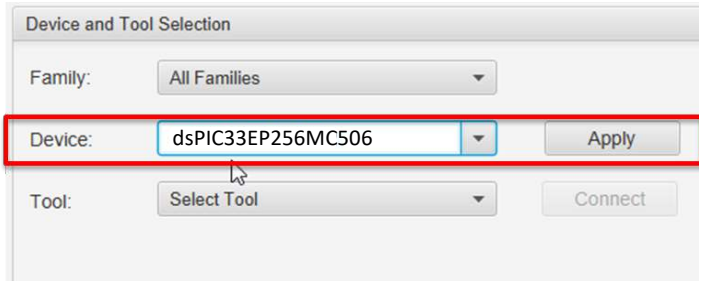
Download the latest MPLAB® X IPE from Microchip website and follow the five steps below:

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

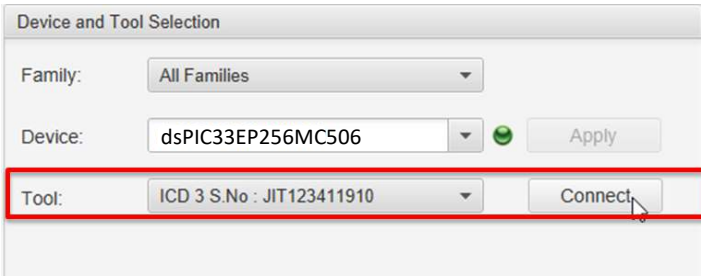
1. Enable Advanced Mode:



2. Select Device: dsPIC33EP256MC506 and then apply:

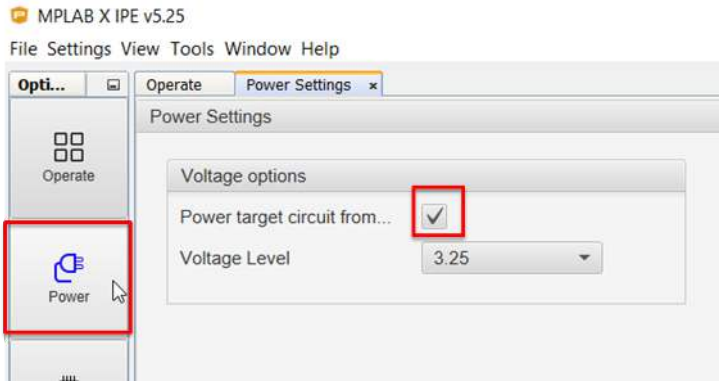


3. Select programming tool and then connect:

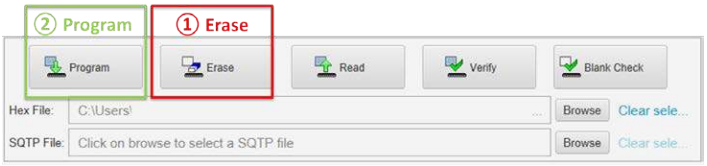


4. Click 'Browse' to select the provided .hex file:

Optional:



5. Erase device, and then program device:



QUICK START PROCEDURE

Please check the following:
https://epc-co.com/epc/Products/eGaNDriversandControllers.aspx
for updates on compatible eGaN FET/IC inverters with reference settings for specific motors.

Motor Commissioning Procedure

It is recommended to follow the detailed motor commissioning process for MCLV-2, provided by Microchip MotorBench® Development Suite when using the EPC9147A in conjunction with and compatible eGaN FET/IC 3-phase motor drive inverter. The procedure documented here provided as simple guide and example only.

1) Start **MPLAB X**, then select **MCC** to load the MPLAB X Code Configurator (MCC).

2) On MCC tree view in the left panel, scroll down until you **find motor Bench® development** and select it.

3) Once motor Bench development suite has loaded, select the **Configure** Tab and chose **Board** and expand it, then select the **MCLV-2 board**. **The MCLV-2 settings can be used to configure the eGaN FET/IC based inverter to the motor selected**.

4) An example is given in Table 7. **Pay careful attention to the deadtime field as it tends to revert to 2µs, which is too long for GaN FET inverters**. **A dead time setting of 21 ns is recommended.**

5) Customizable settings can be changed by selecting the "Show advanced parameters" checkbox. Customizable settings include: minimum velocity, maximum acceleration/deceleration, startup current, minimum acceleration time and, active damping (recommend using zero here).

6) After entering all the parameters, check that you get "Ready to Generate" on the tab above "Configure". If not, recheck the parameter settings. If you get the "Ready to Generate" tab then proceed to select the Generate tab and allow MCC to generate the code. Once the code is generated, connect the ICD programmer to the EPC9147A board programming port (JX) and select the Program Icon. Make sure that the ICD can power up the EPC9147A and that the EPC9147A is not connected to other power supply.

Note: Every time you change Motor or load (e.g. from no load to dynamometer bench) it is important to regenerate the code with proper values. If you change motor section parameter, double check the board parameters. MPLAB X occasionally reverts them back to the default values of MCLV-2 that are not suitable for the GaN FET/IC inverter.

Warning: The motor parameters **measurement feature** of motorBench® Development Suite does not work by default on the EPC9147A.

Table 7: Example settings for EPC9146 Inverter paired with Teknic M-3411P-LN-08D Motor

General Parameters	
ID	mclv2
Name	EPC9146 Development Board
Board Part Number	DM330021-2
PIM Part Number	dspic33ep256mc506-external-opamp
Processor Clock	70.0×10^{6} Hz
Sampling Time Current	50.0×10^{-6} s
Sampling Time Velocity	1.00×10^{-3} s
Minimum Operating Velocity	524 rad/s
PWM	
Switching frequency minimum	1000 Hz
Switching frequency maximum	100×10^{3} Hz
Switching frequency	100×10^{3} Hz
Deadtime minimum	21.0×10^{-9} s
Deadtime maximum	6.00×10^{-6} s
Deadtime	21.0×10^{-9} s
Voltage Source	
Output	48.0 V
Max Current	12.0 A
Inverter	
Maximum duty cycle	95
Minimum duty cycle	0.500
Minimum DC link voltage	16.0 V
Maximum DC link voltage	72.0 V
Maximum current	22.0 A
Voltage Sensor	
Full scale reading	81.5 V
Equivalent time constant	188×10^{-6} s
Current Sensor	
Full scale reading	22.0 A
Equivalent time constant	1.50×10^{-6} s
Compensation Gains	[1.0 0.0] [0.0 1.0]
Motor Definition	
ID	Teknic
Company Name	Teknic
Motor Name	Dummy
Part Number	Dummy
Additional Info	rshunt=1.5
MicrochipDIRECT Part Number	
Number of Pole Pairs	4
Rated Current : Continuous	14.0 A
Rated Current : Peak	14.0 A
Rated Voltage	48.0 V
Nominal Speed	1300 RPM
Maximum Speed	1300 RPM
Electrical And Mechanical Parameters	
Rs	0.800 Ω line to line
Ld	1.00 mH line to line
Lq	1.00 mH line to line
Ke	10.2 Vrms/kRPM (l-l)
B	301×10^{-6} N·m/(rad/s)
Tf	0.0746 N·m
J	867×10^{-6} N·m/(rad/s^2)
Time Constant	2.19×10^{-3} s
Current Phase Margin	80.0
Current Phase Lag	45.0
Velocity Phase Margin	85.0
Velocity Phase Lag	1.00

Table 1: Bill of Materials

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	2	C5, C7	33 pF	Yageo	CC0603JRNPO9BN330
2	3	C13, C14, C15	10 µF	Murata	GRM188R61C106MA73D
3	2	C22, C23	10 µF	Murata Electronics	GRM188R61E106MA73J
4	1	C4	56 pF	TDK	C1005C0G1H560J050BA
5	26	C1, C2, C3, C6, C8, C10, C11, C12, C16_O1, C16_O2, C16_O3, C19, C20, C21, C41, C42, C210, C211, C212, C331, C341, C351, C361, C500, C501, C520	100 nF	Yageo	CC0402KRX7R8BB104 04023C104JAT2A
6	10	C10_O1, C10_O2, C10_O3, C17, C18_O1, C18_O2, C18_O3, C38, C39, C40	1 nF	KEMET	C0402C102J5GACTU
7	2	C502, C503	47 pF	Yageo	CC0402JRNPO9BN470
8	1	C510	1 µF	TDK	GCM155C71A105KE380
9	1	C511	470 nF	TDK	C1005X5R1E474K050BB
10	1	D301	Red LED 0603	Lite-On	LTST-C193KRKT-5A
11	1	D302	Yellow LED 0603	Lite-On	LTST-C193KSKT-5A
12	1	D303	Blue LED 0603	Lite-On	LTST-C193TBKT-5A
13	1	D304	Green LED 0603	Lite-On	LTST-C193KGKT-5A
14	1	D500	USB TVS array	Wurth	82400152
15	3	FB1, FB501, FB502	600 Ω @ 100MHz	Murata	BLM15PX601SN1D
16	1	J1	100-pin PIM Header, Pitch 1.27mm		TMS-125-01-G-S
17	3	J10, J11, J12	2-pin 100 mil male header	Sullins	GRPB032VWVN-RC
18	1	J500	Micro USB connector	Amphenol	10118194-0001LF
19	3	JP8, JP9, JP10	50 mil blue jumper	Harwin Inc	M50-2030005
20	1	L500	9 Ω @ 100MHz	Wurth	744230900
21	1	P361	10 k	Vishay	M63P103KB30T607
22	4	R4, R551,R20,R111	0 Ω	Panasonic	ERJ-3GEY0R00V
23	7	R2, R12, R14, R15, R50, R51, R510	10 k	Yageo	RC0402FR-0710KL
24	2	R3, R361	100 Ω	Yageo	RC0402FR-07100RL RC0402JR-07100RL
25	1	R5	10 k	Yageo	RC0402JR-0710KL
26	3	R6_O1, R6_O2, R6_O3	470 Ω	Yageo	RC0402FR-07470RL, PFR05S-471-FNH
27	6	R7_O1, R7_O2, R7_O3, R17, R24, R41	1 k	Yageo	RC0402FR-071KL RC0402FR-071KL RJ-2RKF1001X
28	4	R8, R11, R13, R16	300 Ω	Yageo	RC0402FR-07300RL RC0402JR-07300RL
29	3	R9_O1, R9_O2, R9_O3	1M	Yageo	RC0402FR-071ML
30	3	R10_O1, R10_O2, R10_O3	30 k	Yageo	RC0402FR-0730KL ERA-2AEB303X
31	6	R120, R121, R122, R123, R124, R125	10	Panasonic	ERJ-2RKF10R0X
32	6	R301, R302, R303, R304, R530, R531	270 Ω	Panasonic	ERJ-2RKF2700X
33	7	R331, R332, R341, R342, R351, R352, R501	4.7 k	Panasonic	ERJ-2RKF4701X
34	2	R502, R503	15	Panasonic	ERJ-2RKF15R0X
35	3	S331, S341, S351	SPST-NO 50 mA 24 V	Omron	B3S-1000
36	2	TP4, TP5	SMD Test hookup	Keystone	5015
37	1	U1	PIM Controller	Microchip	MA330031-2
38	3	U2_O1, U2_O2, U2_O3	IC COMPARATOR R-R INPUT SC-70-5 Open Drain	Texas Instruments	LMV7235M7/NOPB
39	4	U12, U210, U211, U212	Op Amp	Texas Instruments	OPA320AIDBVT
40	1	U510	USB to UART IC	MicroChip	MCP2221A-I/ML
41	1	U520	UART isolator	Analog Devices	ADuM1201CR
42	1	X1	Crystal oscillator	ECS	ECS-80-20-4X
43	1	J4	CONN HEADER R/A 5POS 2.54 MM	Wurth	61300511021

Table 2: Optional Components

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	4	SO1, SO2, SO3, SO4	Stand off	Keystone	4810
2	1	J8	50 mil male header 5 position	Samtec	TMS-105-02-L-S
3	9	R21, R22, R23, R25, R26, R112, R532, R533, R552	0 Ω	Yageo	RC0603JR-070RL
4	1	R110	10 k	Yageo	RC0402FR-0710KL
5	4	R520, R521, R534, R535	4.7 k	Panasonic	ERJ-2RKF4701X

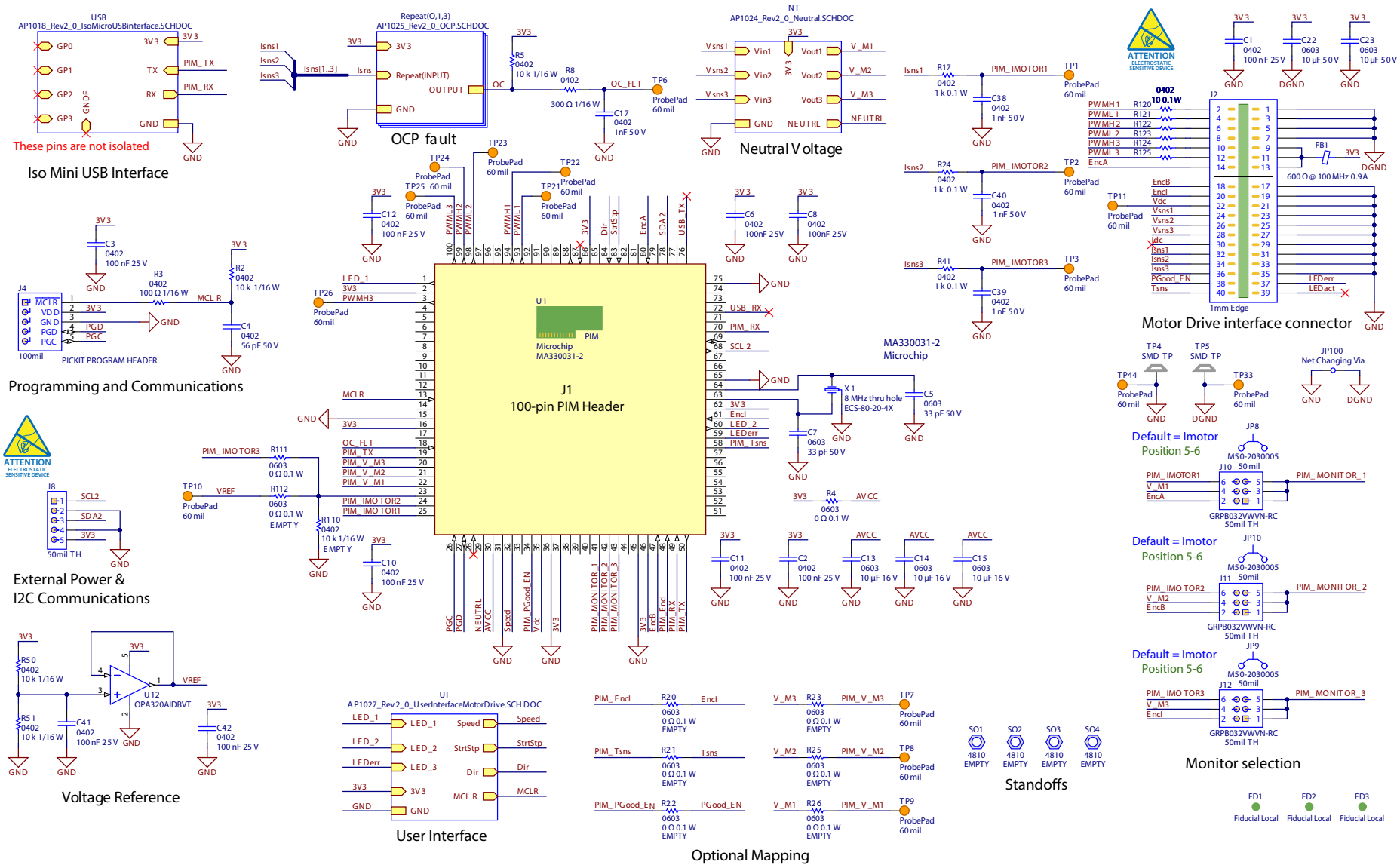


Figure 4: EPC9147A Main schematic

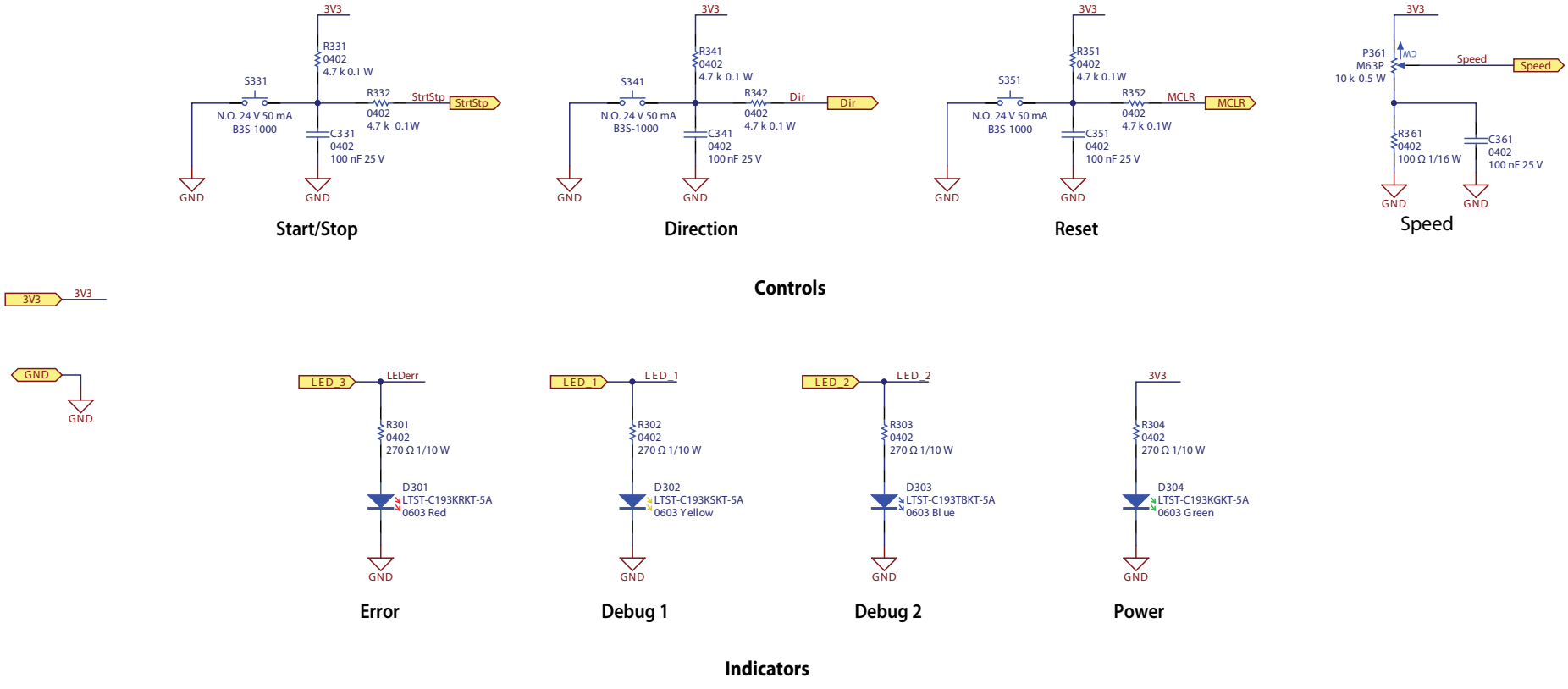


Figure 5: EPC9147A Human Interface schematic

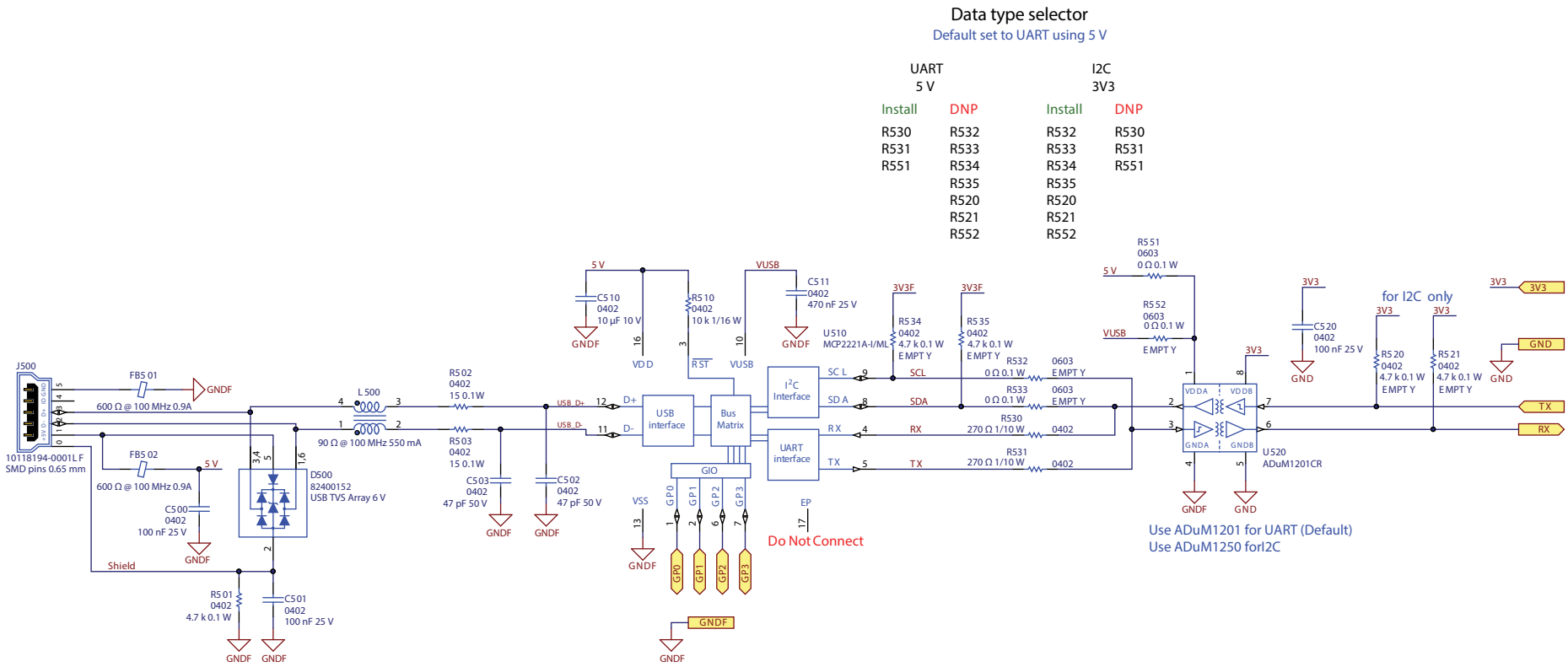


Figure 6: EPC9147A USB schematic

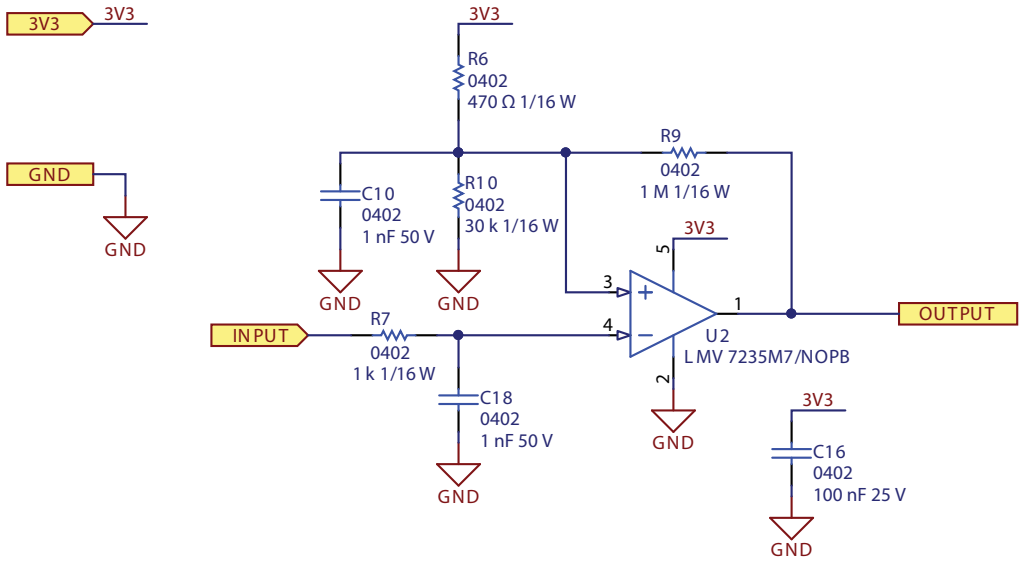


Figure 7: EPC9147A Over-current Detect schematic

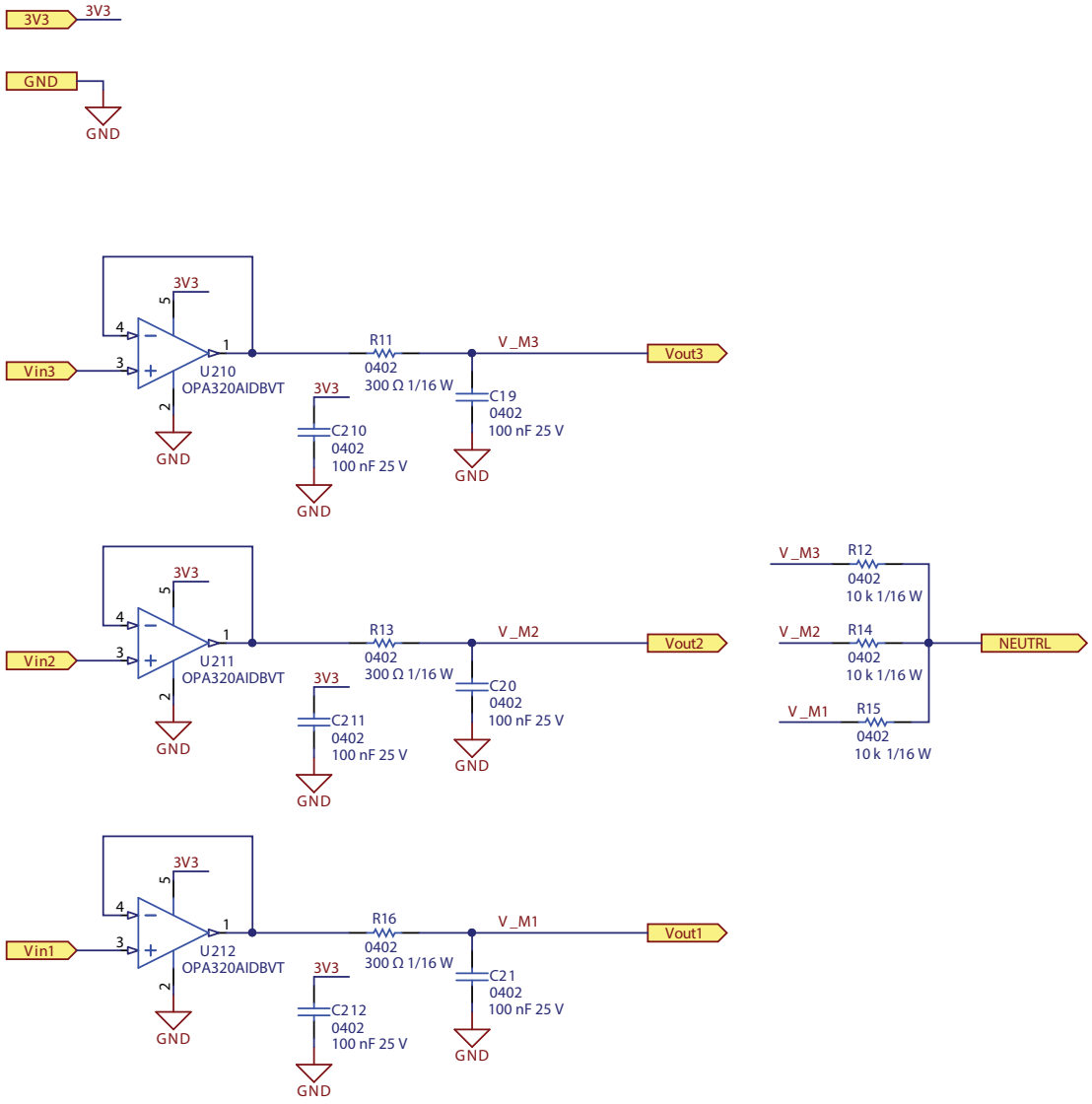


Figure 8: EPC9147A Phases and Neutral Voltage Feedback schematic

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