# UM11298 EV-INVERTER Enablement kit user guide Rev. 1 – 4 October 2019

**User manual** 



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# 1 Finding kit resources and information on the NXP web site

The NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. The boards support a range of analog, mixed-signal and power solutions. They incorporate monolithic integrated circuits and system-in-package devices that use proven high-volume technology. NXP products offer longer battery life, a smaller form factor, reduced component counts, lower cost and improved performance in powering state-of-the-art systems. NXP Semiconductors provides online resources for this reference design and its supported device(s) on <a href="http://www.nxp.com">http://www.nxp.com</a>. The information page for EV traction motor reference design is at <a href="http://www.nxp.com">EV Power Inverter Reference Platform</a>. The information page provides overview information, specifications, ordering information, documentation and software. The Documents and Software tab provides quick-reference information applicable to using the EV-INVERTER Enablement Kit, including the downloadable assets referenced in this document.

## 1.1 Collaborate in the NXP Community

The NXP Community is for sharing ideas and tips, ask and answer technical questions, and receive input on just about any embedded design topic.

The NXP Community is at https://community.nxp.com/community/s32.

# 2 Getting started

The NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. These development boards support a range of analog, mixed-signal, and power solutions. These boards incorporate monolithic integrated circuits and system-in-package devices that use proven high-volume technology. NXP products offer longer battery life, a smaller form factor, reduced component counts, lower cost, and improved performance in powering state-of-the-art systems.

### Note:

Read this manual in its entirety before connecting the Power Inverter Module (PIM) to any power source. When operating in a lab environment, make sure all high-voltage connections are secured. and the operator is properly protected from any shock hazard.

## 2.1 Kit contents

The enablement kit (EV-INVERTER) kit includes:

- MCU control board (EV-CONTROLEVM)
- Driver control board (EV-POWEREVB)
- Sensor board (EV-SENSOREVB)
- Interface Board (EV-INTERFACEVB)
- PCB Interconnect cables (EV-HW-INVERTER)

## 2.2 Additional hardware

In addition to the kit contents, the following hardware is necessary or beneficial when working with this kit. As a service to customers to speed development, a complete EV Inverter Platform can be purchased from our development partner Vepco Technologies.

- Fuji IGBT M653 Module: Available for purchase from Fuji Electric, Inc. by authorized customers of the NXP EV Inverter Enablement Kit. <u>https://www.fujielectric.com/</u> products/semiconductor/model/igbt/ev\_hev\_module.html
- Cooling plate or water jacket for IGBT Fuji IGBT M653 Module: The cold plate serves as the cooling structure interface for the IGBT module and it functions as mechanical support to the Power Inverter Module (PIM) electronics and accessory components. Provide a cooling plate of your own design or purchase the complete platform from our inverter partner Vepco Technologies. <a href="http://www.vepcotech.com/">http://www.vepcotech.com/</a>
- **DC link capacitor:** Four EZP-E50117MTA 500 V 110 μF film capacitors connected in parallel are used for inverter baseline performance measurements. Selected capacitor must be compatible with the IGBT listed above and intended operating voltages.
- **Bus bar:** Provide your own design or available when purchasing the complete platform from Vepco Technologies: <u>http://www.vepcotech.com/</u>
- **High-voltage cabling:** Provide your own or available when purchasing the complete platform from Vepco Technologies: <u>http://www.vepcotech.com/</u>
- 23-position signal connector: (Ampseal® PN 770680-1) TE Connectivity-770680-1
- **Mounting hardware:** Provide your own or available when purchasing the complete platform from Vepco Technologies: <u>http://www.vepcotech.com/</u>
- Power supply: Up to 500 V, 400 A
- CAN Interface link
- Motor: Provide your own or available from Vepco Technologies: <a href="http://www.vepcotech.com/">http://</a>
   www.vepcotech.com/

## 2.3 Interface connections

**High-voltage interface:** Must be 8 mm away from any other terminals and between each terminal:

- Two terminal DC connection inputs V+ and V– from high voltage power supply connected via bus bar to IGBT module.
- Three terminal AC connection outputs are U, V, W phase from IGBT module.

## 2.4 Windows PC workstation

This evaluation board requires a Windows PC workstation. Meeting these minimum specifications should produce great results when working with this evaluation kit.

• Windows 10, 8 or 7 compatible PC with an available USB port

## 2.5 Software

Installing software is necessary to work with this reference design. All listed software is available on the reference design's information page at <u>http://www.nxp.com/HV-</u><u>INVERTER</u>. The software bundle includes the actual application software that runs on the Inverter Kit. This will also be available as a download on the Inverter page.

- S32S Design Studio IDE for power architecture
- Automotive Math and Motor Control Library (AMMCL)
- FreeMaster 2.0 runtime debugging tool
- Motor Control Application Tuning (MCAT)
- Example code, GD3100 Device Driver notes and GD3100 Device Driver Reference notes

# 3 Getting to know the hardware

## 3.1 Enablement kit overview

The EV-INVERTER is a reference design enablement kit containing NXP content to develop an EV three-phase traction motor inverter. The system is designed to drive the Fuji M653 IGBT module. This kit includes four PCBs as described above, three cables used to interconnect the PCBs and basic configuration and drive software. PCB board layout and schematics and gerber files are available on the NXP website <a href="http://www.nxp.com/HV-INVERTER">http://www.nxp.com/HV-INVERTER</a>.

It is your responsibility to obtain the additional inverter components. These components include the IGBT module, link capacitor, bus bar, cooling plate, mounting hardware, etc. You can design, select and assemble your own components and use the NXP PCBs to complete a PIM. As a service to our customers, a complete pre-assembled reference PIM platform is available through our partner Vepco Technologies. The IGBT module is available from our partner Fuji Electric.

## 3.2 EV-INVERTER enablement kit features

## Benefits:

- Increases speed of development
- Full platform solution
- · Provides functional safety options
- Optimizes performance

### Featured products:

- GD3100 isolated IGBT ASIL-D gate driver
- MPC5775E advanced motor control ASIL-D MCU
- FS65XX robust ASIL-D SBC
- TJA1042 redundant CAN bus interface
- Capability to connect to Fuji M653 IGBT module for three-phase evaluations



## 3.3 EV-INVERTER Enablement kit block diagram

## 3.4 Board descriptions

## 3.4.1 EV-CONTROLEVM board connectors

The center of the PIM unit is the controller board. This section describes the internal signals connecting to the control board. An MPC5775E is shown in Figure 2.



### 3.4.1.1 Vehicle Interface connector pinout

### Table 1. Vehicle interface 30-pin connector definitions

Connector: Samtec 2 mm, 2 x 15

Pin	Function	Туре	Range	Memo	
1	Resolver COS_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. +	
2	Resolver COS_N	Analog Input	0 to 5 V	2.5 V Centered; differential sig	
3	Resolver SIN_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. +	
4	Resolver COS_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. –	
5	Resolver Shield	AGND			
6	Resolver Shield	AGND			
7	Resolver VREX_P	Analog Output	0 to 5 V	Excitation; differential sig. +	
8	Resolver VREX_ N	Analog Output	0 to 5 V	Excitation; differential sig. –	
9	RTD_RTN	AGND			
10	RTD2_Sig	Resistive Input	0 to ∞ ohm	1 k RTD expected	
11	RTD_RTN	—	—	—	
12	RTD1_Sig	Resistive Input	0 to ∞ ohm	1 k RTD expected	
13	CANB_L	Digital IO	0 to 5 V		
14	CANB_H	Digital IO	0 to 5 V		
15	GND_12V_RTN	—			
16	GND_12V_RTN	—			
17	NC	—		For clearance	
18	NC			For clearance	
19	12 V	Power	8 to 16 V		
20	12 V	Power	8 to 16 V		
21	NC	—		For clearance	
22	NC	—		For clearance	
23	IGNITION	Digital Input	0 to 16 V	Threshold 4.5 V	
24	CANF_H	Digital IO	0 to 5 V		
25	FS_IND	Digital Output	0 to 5 V	Fault Indicator	
26	CANF_L	Digital IO	0 to 5 V		
27	DGND	DGND		—	
28	CANA_H	Digital IO	0 to 5 V	—	
29	DGND	DGND		—	
30	CANA_L	Digital IO	0 to 5 V	_	

### 3.4.1.2 Driver signals connector pinout

### Table 2. Driver signals 40-pin connector definitions

Connector: Samtec 2 mm, 2 x 20

Pin	Function	Туре	Range	Memo	
1	12 V	Power	8 to 16 V	Bypass	
2	12 V	Power	8 to 16 V	Bypass	
3	NC	NC	_	For clearance	
4	NC		_	—	
5	GND_12V_RTN		_	—	
6	GND_12V_RTN	—	_	—	
7	SCLK_GD_HS	Digital output	0 to 5 V	SPI_HS clock	
8	DGND	—	—	—	
9	MISO_GD_HS	Digital input	0 to 5 V	SPI_HS MISO	
10	SCLK_GD_LS	Digital output	0 to 5 V	SPI_LS Clock	
11	MOSI_GD_HS	Digital output	0 to 5 V	SPI_HS MOSI	
12	MISO_GD_LS	Digital input	0 to 5 V	SPI_LS MISO	
13	CS_HS	Digital output	0 to 5 V	SPI_HS CS	
14	MOSI_GD_LS	Digital output	0 to 5 V	SPI_LS MOSI	
15	FSS_HS	Digital output	0 to 5 V	Fail safe state high-side; active low	
16	CS_GD_LS	Digital output	0 to 5 V	SPI_LS CS	
17	EN_FLYBK_HS	Digital output	0 to 5 V	Enables flyback for high side	
18	EN_FLYBK_LS	Digital output	0 to 5 V	Enables flyback for low side	
19	VDDA	Power	5 V	Analog supply for Vdc measurement	
20	FSENB	Digital output	0 to 5 V	Enables safe state; active low	
21	VbusDivByX	Analog input	0 to 5 V	Bus voltage measurement	
22	FSS_LS	—	_	Fail-safe state low side; active low	
23	AGND	—	_		
24	VGD_LDO	Power	5 V	Power supply for LS Logic	
25	INTB_GD_HS	Digital input	0 to 5 V	Fault Indicator HS	
26	INTB_GD_LS	Digital input	0 to 5 V	Fault Indicator LS	
27	DGND				
28	VDDIO	Power	5 V	Power supply for HS Logic	
29	AOUT_UH	Digital input	0 to 5 V		
30	AOUT_UL	Digital input	0 to 5 V		
31	AOUT_VH	Digital input	0 to 5 V	-	
32	AOUT_VL	Digital input	0 to 5 V	—	
33	AOUT_WH	Digital input	0 to 5 V	—	
34	AOUT_WL	Digital input	0 to 5 V	—	

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Pin	Function	Туре	Range	Memo
35	PWM_UH	Digital output	0 to 5 V	
36	PWM_UL	Digital output	0 to 5 V	
37	PWM_VH	Digital output	0 to 5 V	_
38	PWM_VL	Digital output	0 to 5 V	_
39	PWM_WH	Digital output	0 to 5 V	-
40	PWM_WL	Digital output	0 to 5 V	

### 3.4.1.3 Phase currents connector pinout

#### Table 3. Phase currents 10-pin connector definitions

Connector: Samtec 2 mm, 2 x 5

Pin	Function	Туре	Range	Memo
1, 2	SHLD_GND	AGND	0	_
4, 6	VDDA	Power	5 V	50 mA max
3	VMID	Analog Input	0 to 5 V	Mid point of the supply voltage
5	la	Analog Input	0 to 5 V	
7	lb	Analog Input	0 to 5 V	
9	lc	Analog Input	0 to 5 V	
8, 10	AGND	AGND	_	_

## 3.4.1.4 Phase extra debug GPIOs connector pinout

### Table 4. Phase extra debug GPIOs 14-pin connector definitions

Connector: Samtec 2 mm, 2 x 7

Pin	Function	Туре	Range	Memo
1, 3,5, 7, 9	AGND			
2, 4, 6	Extra Digital IO	Digital IO	0 to 5 V	
8, 10, 12	Extra Analog Inputs	Analog Input	0 to 5 V	
11	IL_N	Resistive Input	0 to ∞ ohm	Loop back from IL_P
12	IL_P	Resistive Input	0 to ∞ ohm	

### 3.4.1.5 JTAG connector pinout

JTAG connector is compatible with PE Micro Multilink Debugger 0.1' 2x7 connector. Implemented signals as shown:

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# Table 5. Phase extra debug GPIOs 14-pin connector definitionsConnector: Samtec 2 mm, 2 x 7

Pin	Function	Туре	Range	Memo
1	TDI_R_PPC			
2				Puts SBC input Debug mode upon power up
3	TDO_R_PPC			
4				
5				
6				
7				
8				
9	RSTB_JTAG			
10	TMS_R_PPC			
11				
12				
13				
14	JCOMP_R_PPC			

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## 3.4.2 EV-POWEREVB board connector

### 3.4.2.1 Driver signals connector pinout

### Table 6. Driver signals 40-pin connector definitions

Connector: Samtec 2 mm, 2 x 20

Pin	Function	Туре	Range	Memo	
1	12 V	Power	8 to 16 V	Bypass	
2	12 V	Power	8 to 16 V	Bypass	
3	NC	NC	—	For clearance	
4	NC	—	—		
5	GND_12V_RTN	—	—		
6	GND_12V_RTN	—	—	_	
7	SCLK_GD_HS	Digital output	0 to 5 V	SPI_HS clock	
8	DGND	—	—		
9	MISO_GD_HS	Digital input	0 to 5 V	SPI_HS MISO	
10	SCLK_GD_LS	Digital output	0 to 5 V	SPI_LS Clock	
11	MOSI_GD_HS	Digital output	0 to 5 V	SPI_HS MOSI	
12	MISO_GD_LS	Digital input	0 to 5 V	SPI_LS MISO	
13	CS_HS	Digital output	0 to 5 V	SPI_HS CS	
14	MOSI_GD_LS	Digital output	0 to 5 V	SPI_LS MOSI	
15	FSS_HS	Digital output	0 to 5 V	Fail-safe state high side; active low	
16	CS_GD_LS	Digital output	0 to 5 V	SPI_LS CS	
17	EN_FLYBK_HS	Digital output	0 to 5 V	Enables flyback for high side	
18	EN_FLYBK_LS	Digital output	0 to 5 V	Enables flyback for low side	
19	VDDA	Power	5 V	Analog supply for Vdc measurement	
20	FSENB	Digital output	0 to 5 V	Enables safe state; active low	
21	VbusDivByX	Analog Input	0 to 5 V	Bus voltage measurement	

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Pin	Function	Туре	Range	Memo
22	FSS_LS			Fail-safe state low side; active Low
23	AGND	—		
24	VGD_LDO	Power	5 V	Power supply for LS logic
25	INTB_GD_HS	Digital input	0 to 5 V	Fault indicator HS
26	INTB_GD_LS	Digital input	0 to 5 V	Fault indicator LS
27	DGND			
28	VDDIO	Power	5 V	Power supply for HS Logic
29	AOUT_UH	Digital input	0 to 5 V	
30	AOUT_UL	Digital input	0 to 5 V	—
31	AOUT_VH	Digital input	0 to 5 V	
32	AOUT_VL	Digital input	0 to 5 V	
33	AOUT_WH	Digital input	0 to 5 V	
34	AOUT_WL	Digital input	0 to 5 V	
35	PWM_UH	Digital output	0 to 5 V	—
36	PWM_UL	Digital output	0 to 5 V	—
37	PWM_VH	Digital output	0 to 5 V	
38	PWM_VL	Digital output	0 to 5 V	
39	PWM_WH	Digital output	0 to 5 V	—
40	PWM_WL	Digital output	0 to 5 V	-

## 3.4.3 EV-SENSOREVB board connectors



#### 3.4.3.1 EV-SENSOREVB connector pinout

### Table 7. Phase currents 10-pin connector definitions

Connector: Samtec 2 mm, 2 x 5

Pin	Function	Туре	Range	Memo
1, 2	SHLD_GND	AGND	0	
4, 6	VDDA	Power	5 V	50 mA max
3	VMID	Analog Input	0 to 5 V	Mid point of the supply voltage
5	la	Analog Input	0 to 5 V	
7	lb	Analog Input	0 to 5 V	
9	lc	Analog Input	0 to 5 V	
8, 10	AGND	AGND	_	—

## 3.4.4 EV-INTERFACEVB board connectors



Figure 6. EV-SENSOREVB connector

### 3.4.4.1 EV-INTERFACEVB connector pinout

### Table 8. EV-INTERFACEVB 30-pin connector definitions

Connector: Samtec 2 mm, 2 x 15

Pin	Function	Туре	Range	Memo
1	Resolver COS_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. +
2	Resolver COS_N	Analog Input	0 to 5 V	2.5 V Centered; differential sig. –
3	Resolver SIN_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. +
4	Resolver COS_P	Analog Input	0 to 5 V	2.5 V Centered; differential sig. –
5	Resolver Shield	AGND	—	
6	Resolver Shield	AGND	—	

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Pin	Function	Туре	Range	Memo
7	Resolver VREX_P	Analog Output	0 to 5 V	Excitation; differential sig. +
8	Resolver VREX_ N	Analog Output	0 to 5 V	Excitation; differential sig. –
9	RTD_RTN	AGND	—	
10	RTD2_Sig	Resistive Input	0 to ∞ ohm	1k RTD expected
11	RTD_RTN	_	—	
12	RTD1_Sig	Resistive Input	0 to ∞ ohm	1k RTD expected
13	CANB_L	Digital IO	0 to 5 V	
14	CANB_H	Digital IO	0 to 5 V	
15	GND_12V_RTN	—	—	—
16	GND_12V_RTN	—	—	
17	NC		—	For clearance
18	NC	—	—	For clearance
19	12V	Power	8 to 16 V	—
20	12V	Power	8 to 16 V	—
21	NC	—	—	For clearance
22	NC	—	—	For clearance
23	IGNITION	Digital Input	0 to 16 V	Threshold 4.5 V
24	CANF_H	Digital IO	0 to 5 V	
25	FS_IND	Digital Output	0 to 5 V	Fault Indicator
26	CANF_L	Digital IO	0 to 5 V	
27	DGND	DGND	—	
28	CANA_H	Digital IO	0 to 5 V	—
29	DGND	DGND	—	-
30	CANA_L	Digital IO	0 to 5 V	

# 4 Assembling the hardware

The following hardware, described in <u>Section 3 "Getting to know the hardware"</u>, is required to build an inverter assembly.

- The enablement kit (EV-INVERTER)
- Fuji IGBT M653 Module
- Cooling plate
- DC link capacitor
- Bus bar
- High-voltage cabling for inverter supply (2-wire)
- High-voltage cabling for motor connection (3-wire)
- 23-position signal connector
- · Mounting hardware
- 12 V power supply (inverter)

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- High-voltage power supply (motor)
- CAN Interface link
- Motor



Figure 7. Vepco Technologies EV inverter platform used as an illustration of a completed inverter

- 1. Attach the IGBT module to the cooling plate.
- 2. Attach the DC link capacitor tabs to the IGBT terminals.
- Attach the EV-POWEREVB to the IGBT module. Ensure that all board socket connection pins are properly seated onto the IGBT pin connections. Fasten the gate driver board to the IGBT with screws and other hardware for a secure fitment.
- 4. Connect the 3-phase motor cable to the IGBT module, ensuring the U, V, and W connections match. If available, latch the handle to ensure a secure connection.
- 5. For running a motor in a closed loop motor control, connect the EV-SENSOREVB board to the EV-CONTROLEVM with the 10-pin harness. See Figure 8.
- 6. Connect the EV-POWEREVB to the EV-CONTROLEVM with the 40-pin harness. See Figure 8.
- 7. Connect the EV-INTERFACEVB to the EV-CONTROLEVM with the 30-pin harness. See Figure 8.
- 8. Connect the low-voltage DC power supply (12 V) to the EV-CONTROLEVM board.
- 9. Connect the high voltage/high current DC supply positive and negative connections (2-wire) to the DC Link capacitor to supply high voltage to the IGBT and motor.
  - a. Before applying high voltage (>300 V) to the DC connection, use a current limited (1 A) power supply and apply 15 to 30 V to the DC to make sure there is no excessive leakage current.
  - b. Unlatch the handle, insert the cable assembly to the header and relatch the handle for a secure connection.
- 10.Connect the EXT DGND to 12 V GND.
- 11.Open the PIM by removing the plastic protection cover.

- 12.Connect the 14-pin debugger header on the EV-CONTROLEVM with pin 1 mark aligned.
- 13.Connect the PEMicro Multilink to the host PC. Both led lights on the PEmicro Multilink should be on, indicating that the CAN bus is live and ready to communicate.



## 4.1 Using a motor not from Vepco Tehnologies

The application software in the PIM was developed for a 4-pole pair, 3-phase permanent magnet synchronous motor. The PIM expects a 4-lobe 6-wire position resolver sensor to provide the rotor position information. If the custom motor is the same configuration, then the speed and position information in the software are correct.

In the case of a different number of pole pair or resolver configuration, it is necessary to reconfigure or rewrite the PCS.c API void Get\_RotorPos(T\_S16\* Pos) to calculate the position (0 to 4095) based on the resolver configuration.

The connectors shown in <u>Figure 9</u> and <u>Figure 10</u> are used to bring in signals from CAN, resolver, and motor.

Please note that depending on how the motor is wound the positive direction of the motor may be different from the definition from the PIM.

#### Calibration table

It is often required to use a custom motor table for optimization. The format of the table is presented in LookupTable.c. The lookup tables are two-dimensional (2D) tables. These tables request torque (Tq\_cmd) and rpm/Vdc ratio (rpm\_Vdc) inputs. The outputs are Id, Iq, Ld, Lq, and Lambda; each output having its own table. It is possible to bypass the lookup tables by operating the motor in the Id Iq reference mode instead of Torque reference mode.

#### • Faults and Warnings

The faults and warnings are handled in the FTM module. A few examples are provided in the module.

### Speed mode

The speed reference mode is implemented as an outer loop of the torque reference mode. Depending on the inertia and other characteristics of the motor, it may require

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some tuning to the speed loop parameters. These parameters can be found in the MSC module.

23-position signal connector Ampseal® PN 770680-1



Figure 9. EV-INTERFACEVB connections

The EV-Interface 23 pin connector is used to bring in signals from the CAN, resolver, and motor. The 23-position signal connector on the backside of the EV-INTERFACEEVB connections are described in Table 9.

- 1. Unlatch the handle, insert the cable assembly into the header and relatch the handle. **Note:** depending on how the motor is wound the positive direction of the motor may be different from the definition from the PIM.
- 2. The PIM rB is preloaded with demo software that does not require motor signals to be connected. The demo software runs open-loop controls once the logic power is supplied.
- 3. The following are required connections for the demo software:
  - Ground: EXT\_DGND must be connected to 12 V GND
  - Power supply: unswitched 12 V and ignition may be tied together.
  - In the supplied harness, the red/white wire is connected to the supply. The redblack/white-black is connected to the logic ground.



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Pin	Name	Description	Value
1	EXT_CANH_A	CANA Low	TTL 0 to 5 V
2	EXT_DGND	Digital Ground	0 V, 100 mA
3	EXT_DGND	Digital Ground	0 V, 100 mA
4	EXT_12V_IGNIT	Ignition	0 to 16 V, 100 mA
5	EXT_MTRTD1_RTN	Motor RTD 1 Return	Resistor –
6	EXT RSLVR_DRV_SHIELD	Resolver Excitation Shield	0 V
7	EXT_RSLVR_SNS_SHIELD	Resolver Sense Shield	0 V
8	EXT_RSLVR_S1	Resolver sense S1	Analog 100 mA
9	EXT_CANL_A	CANA High	TTL 0 to 5 V
10	EXT_FLT_OUT	Fsb1	TTL
11	NC		
12	EXT_MTRRTD1_SIG	Motor RTD 1 Signal	Resistor +
13	EXT_MTRRTD2_SIG	Motor RTD 2 Signal	Resistor +
14	EXT_RSLVR_R1	Resolver excitation R1	Analog 100 mA
15	EXT_RSLVR_S3	Resolver sense S3	Analog 100 mA
16	NC	—	—
17	NC	—	
18	EXT_12V_UNSWTCHD	Unswitched 12 V	10 to 16 V, 2 A
19	EXT_12V_RETURN_GND	12 V GND	0 V, 2 A
20	EXT_MTRRTD2_RTN	Motor RTD 2 Return	Resistor –
21	EXT_RSLVR_R2	Resolver excitation R2	Analog 100 mA
22	EXT_RSLVR_S2	Resolver sense S2	Analog 100 mA
23	EXT_RSLVR_S4	Resolver sense S4	Analog 100 mA

#### Table 9. EV-INTERFACEVB connections

Connecting CANA\_H to CANA\_L in the supplied harness is optional. The green wire is CANH and the green-black wire is CANL. Refer to <u>Table 10</u> for connections. For advanced operation of the PIM, it is required to have a motor with a resolver and RTD temperature sensing connections. Connect CANA\_H CANA\_L Resolver signals to x6 RTD1 signals x2 for proper operation of the PIM.

РСВ	Device	Color	Molex 33472-1206
P1	RTD1 +	RD	1
P2	RTD –	RD-BK	2
P3	RTD2 +	YL	3
P4	RTD2 –	YL-BK	4
P10	RSLV S1	BL	7
P6	RSLV S3	BL-BK	8
P5	RSLV S2	GN	9

#### Table 10. Optional connections

РСВ	Device	Color	Molex 33472-1206
P9	RSLV S4	GN-BK	10
P8	RSLV R1	WT	11
P7	RSLV R2	WT-BK	12
n.a.	n.a.	n.a.	5
n.a.	n.a.	n.a.	6

# 5 Software requirements and installation

Table 11. Software descriptions				
Name	Source	Use		
S32 Design Studio for Power Architecture 2017.R1	nxp.com	Debugger toolchain		
Ginkgo CAN-USB driver set		GUI toolchain		
Python 3.6, 32-bit		GUI toolchain		
Pyqt5 (supporting package for the Gui)		GUI toolchain		
Csv (supporting package for the Gui)		GUI toolchain		

## 5.1 S32 Design Studio for Power Architecture 2017.R1

The S32 Design Studio IDE is a complimentary integrated development environment for Automotive and Ultra-Reliable MCUs that enables editing, compiling and debugging of designs.

- 1. Go to <u>https://www.nxp.com/design/software/embedded-software/s32-design-studio-ide/s32-design-studio-ide-for-power-architecture-based-mcus:S32DS-PA</u> and click User Guide.
- 2. Follow the instructions within the S32 Design Studio for Power Architecture 2.1 Installation Guide.
- 3. Run the S32 Design Studio by clicking the S32 Design Studio for Power Architecture Version 2017.R1 icon.
- 4. Click Run > Flash from file...
- 5. Double-click the **GDB PEmicro Interface Debugging** icon
- 6. Change the name of the new configuration to MPC5775E.

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🗋 🗎 🗧 🐡 🕶	Name: MPC5775E					
type filter text	🕒 Main 🔅 Debugger 🗭 Startup 💱 Source 🔳 Corr	mon 🍠 OS Awareness				
> C/C++ Application	Project:					
CUC++ Kemote Application     COB Hardware Debugging     CoB PErMark Debugging     CM PCT75     Lauch Group     Lauch Group     Laucebach TRACE32 Debugger	PIM-R_MPC5775E_SDK_080819					
	Specify the number of additional object files you wish to pr	ogram: 0 Generate Object File Fields			^	
	C/C++ Application:				~	
	Debug_FLASH\PIMrB_MPC5775E_SDK.elf					
			Variables	Search Project	Browse	
	Build (if required) before launching					
	Build Configuration: Select Automatically				~	
	O Enable auto build	<ul> <li>Disable auto build</li> </ul>				
	Use workspace settings	Configure Workspace Settings				
Filter matched 8 of 10 items				Revert	Apply	
0	n.			Debug	Close	

## 7. Click the **Debugger** tab

C 🗎 🗶 🖻 🐡 🕶	Name: MPC5775E
type filter text > C/C++ Application C/C++ Remote Application C ODB Hardware Debugging V C GDB PEMicro Interface Debugging	Main (\$ Debugger > Setup \$ Source ] Common # 05 Awareness Software Registration      Registration
€ UsurGF Korp Laurtebach TRACE32 Debugger	PEMicro Interface     USB Multilink, USB Multilink, FX, Embedded OSBDM/OS/TAG - USB Port     Compatible Hardware       Port     USB I - Multilink, Universal FX Rev 8 (PEMA541EB)      Refresh       Device Name     MPC5775E     Core     ZZ_0
	Specify IP Specify IP Additional Options Additional Options Hardware Unitaria Power Control (Voltage → Power-Out Jack) Provide power to target Regulator Output Voltage 250 ms
	Power off target upon software exit 20'     Power Up Delay 1000 ms      Target Communication Speed Debug Shift Freq (1941; 5000 Delay after reset and before communicating to target for 0 ms      GDE Server Settinas
Filter matched 8 of 10 items	Revent Apply
0	Debug Close

8. Click the Device Name drop-down menu and select MPC5775E

C 🗎 🗶 🖻 🏇 •	Name: MPC5775E
type filter text	📔 Main (参 Debugger 💊 Startup) 🤤 Source) 🖂 Common 🖉 OS Awareness
C/C++ Application     C/C++ Remote Application     GDB Hardware Debugging     GDB PEMicro Interface Debugging     GDB VEMicro Interface Debugging     GDB VEMicro Interface Debugging	Software Registration Please register your software to remove this message. Register now
Launch Group	PEMicro Interface Settings
Lauterbach TRACE32 Debugger	Interface: USB Multilink, USB Multilink, EX, Embedded OSBDM/OSJTAG - USB Port V Compatible Hardware
	Port: USB1 - Multilink Universal FX Rev B (PEMA541EB) V Refresh
	Device Name: MPC5775E V Core: Z7.0 V
	Specify IP Specify Network Card IP
	Additional Options
	Advanced Options
	Hardware Interface Power Control (Voltage> Power-Out Jack)       Provide power to target     Regulator Output Voltage       Power off target upon software exit     ZV       Power Up Delay     1000
	Target Communication Speed
	Debug Shift Freq (KHz) 5000
	Delay after reset and before communicating to target for ms
	GDB Server Settings
Filter matched 8 of 10 items	Revert Apply
()	Debug Close

×

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Manced Ontions

reate, manage, and run configurations			
Plugin has not been registered. Some functional	Flash Algorithm Selection Use the following flash algorithm when programming flash data:		
] ⊞ 🗶   🖻 斗? ▼	Name: MPC5775E	nxp_mpc5775e_1x32x1024k_cflash_highspeed.pcp	
yee filter text C/C++ Application C/C++ Application	Common      Software Registration	Use Alternative Algorithm Browse	
€       C/C++ Remote Application         C GOB Hardware Debugging       €         C GOB PENIcro Interface Debugging       €         C MERCIFIC Interface Debugging       €         L Mutch Group       €         Lauterbach TRACE32 Debugger	Register your software to remove this message. Register now PEMicro Interface Settings	Initialization Script Selection Specify a .mac script to run after connecting to the device. Enable initialization script	
	Interface USB Multilink, USB Multilink FX, Embedded OSBDM/OS1TAG - USB Port V Compatible Hardware Port USB I - Multilink Universal FX Rev 8 (PEMA541EB) V Refresh Device Name (MPCS775E Core 27.0 V Specify IP Specify Network Card IP Additional Metions	Brows. Variables. Non-Volatile Memory Preservation Data that reside in a preserved range of memory will be maintained through	
	Advanced Options.           Hardware Interface Power Control (Voltage> Power-Out Jack)           Provide power to target           Regulator Output Voltage           Power off target upon software exit           2V           Power Up Delay           1000	masked to match the row size of the memory. Preserve this range (Memory Range 0) From: 0 To: 3 Preserve this range (Memory Range 1)	
	Target Communication Speed Debug Shift Freq (RHz) 5000 Debug Shift Freq RHz 5000 Debug Shift Freq RHz 5000 Reserve Settings 008 Server Settings	From: 0 To: 3 Preseve this range (Memory Range 2) From: 0 To: 3 OK	
Filter matched 8 of 10 items			

9. Click the Advanced Options button

10.Under the Flash Algorithm Selection, check the Use Alternative Algorithm checkbox.

		Use the following flash algorithm when programming flash data:	
	Name: MPC5775E	nxp_mpc5775e_1x32x1024k_cflash_highspeed.pcp	
/pe filter text	📄 Main 🏇 Debugger 🔪 🗭 Startup 🦃 Source 🔲 Common 🖑 OS Awareness	Use Alternative Algorithm Browse	
C C/C++ Application C C/C++ Remote Application G GDB Hardware Debugging F GDB PEMicro Interface Debugging C MPC5775E Launch Group	Software Registration Please register your software to remove this message. Register now PDFNers leafers Astronom	Initialization Script Selection Specify a .mac script to run after connecting to the device.	
Lauterbach TRACE32 Debugger	Interface: IISB Multilink IISB Multilink EX Embedded OSBDM/OSITAG - IISB Port	Enable initialization script	
	Port:         USB1 - Multilink Universal FX Rev B (PEMA541EB)         Refresh	Browse Variables	
	Device Name: MPC5775E V Core: Z7_0 V	Non-Volatile Memory Preservation	
	Specify IP Specify Network Card IP	Data that reside in a preserved range of	
	Additional Options Advanced Options	erse/prograwilibe erse/prograwilibe masked to match the row size of the memory. Preserve this range (Memory Range 0) From: 0 To: 3	
	Hardware Interface Power Control (Voltage> Power-Out Jack)		
	Provide power to target Regulator Output Voltage Power Down Delay 250 ms		
	Power off target upon software exit 2V V Power Up Delay 1000 ms	Preserve this range (Memory Range 1)	
	Target Communication Speed	From: 0 To: 3	
	Debug Shift Freq (KHz) 5000	Preserve this range (Memory Bange 2)	
	Delay after reset and before communicating to target for 0 ms	From: 0 To: 3	
	GDB Server Settings		
	L	OK	
as matched 8 of 10 items		UK	

11.Browse to select NXP\_MPC5775E\_1x32x64k\_EEPROM\_highspeed.pcp Note This file may reside in different locations, depending on the PE micro plugin installation. Search the file name under the Design Studio installation directory or PE micro installation directory to locate the .pcp file.

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°	Numer MDC 5775E	Use the following flash algorithm when programming flash data:		
hanne filtere text		nxp_mpc5775e_1x32x1024k_cflash_highspeed.pcp		
<ul> <li>CC++ Application</li> <li>CC++ Remote Application</li> <li>COB Hardware Debugging</li> <li>COB PEMicro Interface Debugging</li> <li>MPCS775E</li> <li>Launch Group</li> </ul>	Main So Decuging Source Common (See OS Awareness)     Software Registration     Please register your software to remove this message.     Register now     PEMicro Interface Settings	Use Alternative Algorithm Browse mp_mpc5775c_1ts22644_exprom_highspeed.pcp Initialization Script Selection Specify a max script or un after connecting to the device.		
Lauteroach I KALES2 Debugger	Interface         USB Multilinik, USB Multilinik, FX, Exheckdad OSBDM/OSTAG - USB Pot         Compatible Handware           Port:         USB 1 - Multilinik, USB Multilinik, FX Rev 8 (PEMASHIER)         Refresh           Device Name:         IMDCST75E         Create         Refresh           Additional Options         Additional Options         Additional Options         Refresh           Hardware Interface Power Control (Voltage -> Power-Out Jack)         Provide power for target         Regulator Output Voltage         Power Up Delay         220 ms           Power off target upon software exit         RV         Power Up Delay         1000 ms         Target Communication Speed           Debug shift-Frag (CHL)         Stol	Brown         Watables           Non-Volatile Memory Preservation         Data that reside in a preserved range of enserving range of the marked to marked to mark the row size of the marked to mark the tow size of the memory.         Image: Comparison of the marked to mark the row size of the marked to mark the row size of the memory.           Image: Comparison of the marked to mark the row size of the memory.         Image: Comparison of the marked to mark the row size of the marked to mark the row size of the memory.           Image: Comparison of the marked to mark the row size of the marked to mark the row size of the marked to mark the row size of the marked to mar		
ilter matched 8 of 10 items		UK		

- 12.Flash the .elf file once.
- 13.Uncheck the **Use Alternative Algorithm** checkbox and flash the .elf a second time using the default flash algorithm for MPC5775E.

eate, manage, and run configurations		Advanced Options		
Plugin has not been registered. Some functionali	ty may not be available.	Use the following flash algorithm when programming flash data:		
3 📾 🗶   🖻 ⊉ ▾	Name: MPC5775E	nxp mpc5775e 1x32x1024k cflash highspeed.pcp		
ype filter text	📄 Main 🕸 Debugger 🕟 Startup 🤯 Source 🔲 Common 🕮 OS Awareness	Dure Alternative Algorithm		
C/C++ Application C/C++ Remote Application	Software Registration Please register your software to remove this message.	Distriction of the second seco		
GDB Hardware Debugging     GDB PEMicro Interface Debugging     MPC 5775E	Register now	Initialization Script Selection Specify a .mac script to run after connecting to the		
Launch Group	PEMicro Interface Settings	Enable initialization script		
👠 Lauterbach TRACE32 Debugger	Interface: USB Multilink, USB Multilink FX, Embedded OSBDM/OSJTAG - USB Port V Compatible Hardware			
	Port: USB1 - Multilink Universal FX Rev B (PEMA541EB) V	Browse Variables		
	Device Name: MPC5775E V Core: Z7_0 V	Non-Volatile Memory Preservation		
	Specify IP Specify Network Card IP	Data that reside in a preserved range of		
	Additional Options	memory will be maintained through erase/program cycles, Values will be		
	Advanced Options	masked to match the row size of the memory. Preserve this range (Memory Range 0)		
	Hardware Interface Power Control (Voltage> Power-Out Jack)			
	Provide power to target Regulator Output Voltage Power Down Delay 250 ms	From: 0 To: 3		
	Power off target upon software exit 2V V Power Up Delay 1000 ms	Preserve this range (Memory Range 1)		
	Target Communication Speed	From: 0 To: 3		
	Debug Shift Freq (KHz) 5000	Preserve this range (Memory Range 2)		
	Delay after reset and before communicating to target for 0 ms	From: 0 To: 3		
	GDB Server Settings			
		ОК		
ter matched 8 of 10 items				

# 5.2 Installing the USB – CAN interface adapter

- 1. Browse to: <u>http://www.viewtool.com/index.php/en/20-2016-07-29-02-10-12/16-ginkgo-series-drivers</u>.
- 2. Download the v1.0.0 driver and install it. The driver page is shown in <u>#topic\_b94d254c-c3f7-4e60-b3ab-263f1303d04c/fig\_07659ffb-2fff-4376-a313-a77030033a83</u>.

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HOME	S.V.I	BUS ADAPTER	SNIFFER	SENSOR	EVB	BBS
Ginkgo Series Driv	res					
Vindows						
inkgo Series Drivers is suitable for both 32-bit 3.0.0: The windows driver indows system. It's been 2.0.0: The windows driver indows system. But for s usue will be fixed in 2019,	and 64-bit Windows sy of Ginkgo series produc verified on the latest W of Ginkgo series produc ome updated version of for more info about driv	rstem. It has passed microsoft driv indows 10 (version: 1809). It has passed microsoft driv windows 10 or some other er installation please have a	ver signature on July, 201 er signature certificate, it windows version, it may : look at article: <b>Windows</b>	6, it's not necessary to us 's not necessary to use " still need to manually disa 10 driver installation	se "Disable driver signatur Disable driver signature er able driver signature enforc	e enforcement" in all nforcement" in all cement once,and this

If the driver does not install correctly, please complete the following steps to boot Windows 10 in **Disable driver signature enforcement** mode and then install the driver.

3. Connect the USB-CAN Interface Adapter to a USB port on the computer.



### 5.2.1 Steps to disable the driver signature enforcement in Windows 10

- 1. Click the Windows Start button, then click the Settings gear icon.
- 2. Select Update & Security.
- 3. On the left, click the **Recovery** option.
- 4. Once selected, you will see an advanced startup section appear on the right hand side. You will need to click on the **Restart now** button.
- 5. Once your Computer has rebooted you will need to choose the Troubleshoot option.
- 6. Click Advanced options.
- 7. Click Startup Settings.
- 8. Because you are modifying the boot time configuration settings, you will need to restart your computer one last time.
- 9. Here you will be given a list of startup settings that you can change. Press the F7 key to choose the **Disable driver signature enforcement** setting.

## 5.3 Python setup

- 1. Download Python 3.6.8 from: <u>https://www.python.org/ftp/python/3.6.8/</u> python-3.6.8.exe
- 2. Run the installer and follow the prompts to install it.
- 3. Open a command window and navigate to the install directory. CD to the Scripts directory.
- 4. Install PYQT5 by typing "pip install pyqt5" and pressing Enter.

	^
C:\Python36-32\Scripts>pip install pyqt5	
Collecting pyqt5	
Using cached https://files.pythonhosted.org/packages/5a/6f/e2510c7d11183fbb41c11bf50b6c3248f5e3defc10326756a51321bea6f	2
8/PyQt5-5.12.1-5.12.2-cp35.cp36.cp37.cp38-none-win32.whl	
Collecting PyQt5_sip<4.20,>=4.19.14 (from pyqt5)	
Using cached https://files.pythonhosted.org/packages/79/8c/3fed3fb79a629a80544e5e0cc8467706a5fa1f56e3027e034d1530ca2e0	
8/PyQt5_sip-4.19.15-cp36-none-win32.wh1	
Installing collected packages: PyQt5-sip, pyqt5	
Successfully installed PyQt5-sip-4.19.15 pyqt5-5.12.1	
You are using pip version 18.1, however version 19.0.3 is available.	
You should consider upgrading via the 'python -m pip installupgrade pip' command.	
2월 1월 2011년 1월 2012년 1월 2012년 1월 2012년 1월 2012년 1월 1일 2012년 1월 2012년 1월 2012년 1월 2012년 1월 2012년 1월 2012년 1월 201	

5. Install PYQTGraph by typing "pip install pyqtgraph" and pressing Enter.



- 6. Download the PIM GUI using the following link: <u>https://nxp1.sharepoint.com/:u:/</u> <u>t/ext330/ETZLgn\_fSy9HvOi46pMOEWEBX2AktvAtmQVSnH8oqVy2gw?</u> <u>e=4:ECaWcy:origemail&at=9</u>
- 7. Unzip c55\_gui.zip to a folder that you want to run it from.
- 8. Right click on app\_mpc55term.py and select "Open with".
- 9. Select "Choose another app".
- 10.Scroll down and click on "More apps"

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How do y	ou want to open this file?								
Other optic	ons	^							
idle.t	bat								
Micro	osoft Visual Studio 2019 Preview								
Note	pad								
More Wore	dPad								
i Look	for an app in the Store								
More apps	L Contraction of the second seco	~							
Always u	Always use this app to open .py files								
	ОК								
	ок								

11.If Python is not shown, scroll down and click on "Look for another app on this PC".

12.Navigate the Python.exe file that was installed earlier and select it.

13. Check the box labeled "Always use this app to open .py files" and click on OK.

## 5.4 Running the PIM GUI

- 1. Double click on app\_mpc55term.py to run the PIM GUI.
- 2. Click on CANBus  $\rightarrow$  Connect to connect to the USB\_CAN interface adapter.
- 3. The GUI should now be connected to the PIM.

Diagnostics	SignalView							
Id*	0.0	• Ref mode • Ø Idq	Send	Params ROS 125	2	Update	Parameters	
Iq*	0.0	•		Status1	Status2	Status3		
Torque*	0.0	• O Torque	Soft STOP	0	0	0	UL	
Speed*	0.0	• O Speed	STOP PWM	0	0	0	VL	
				0	0	0	WL	
GOTO S	STATE	PowerUP	~	0	0	0	UH	
			Record	0	0	0	VH	
Sensed Measu	rements			0	0	0	WH	
Speed(rpm)	0.0	Vbus (Vdc)	0.0	Terration Terration		Mater Terror	Chalter	
Id(A)	0.0	Ud (norm)	0.000	Inverter Tempe	ratures	Motor Temps	States	_
Iq(A)	0.0	Uq (norm)	0.000	0.0	0.0	0.0	State 0	
Torque (N)	0.0	Mod Index	0.000	0.0	0.0	0.0	Fault 0	
reated event log file	.\c55data\\20190403153	1152.log		Readme: ROS: Resolver Offset - correct PM motor initial when the motor is in	should be calculated if in angle. The valid range is motion.	nown or be used as a calibra 0-4095 corresponding to 0-3	ton variable to seek the 360deg. <b>Do NOT modify</b>	• • • • • • • • • • • • • • • • • • •

# 6 Operation of the Power Inverter Module (PIM)

After completing the steps in <u>Section 4 "Assembling the hardware"</u> and <u>Section 5</u> <u>"Software requirements and installation"</u>, you are now ready to operate the Power Inverter Module (PIM).

## 6.1 Demo software

- The Inverter control board is preloaded with DEMO software that does not require motor signals to be connected. The Demo software is running open loop controls once the logic power is supplied.
- 2. Required connection for demo software:
  - Ground: EXT\_DGND must be connected to 12 V GND
  - Power Supply: Unswitched 12 V and Ignition may be tied together.
  - In the supplied harness, the red/white wire is connected to the supply. The red-blak/ white-black is connected to the logic ground.
  - · Optional connection:
  - CANA\_H CANA\_L
  - In the supplied harness, the green is CANH and green-black is the CANL.
  - Refer to <u>Table 10</u> for connection:
  - For advanced operation of PIM, it is required to have a motor with resolver and RTD temperature sensing connections: The following signals need to be connected for proper operation of the PIM.
  - CANA\_H CANA\_L
  - Resolver signals x6
  - RTD1 signals x2
- 3. Apply 30 Vdc on the TE DC connector
- 4. Apply 12 V logic power supply and observe the motor starting to slowly spin with a speed ramp up until it is stable

## 6.2 BSW software

- 1. Once the DC connection, Motor 3 phase connection and the signal connections are in place, turn on the logic power
- 2. Apply DC voltage (recommend or lower on the bench)
- 3. Start the Python based UI program named app\_mpc55term.py

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us							
Diagnostics S	lignalView						
Id*	0.0	• Ref mode	Send	Params			
T-*	0.0	◎ Idq		ROS 400		Update	Parameters
Id.	0.0	•		Status1	Status2	Status3	
Torque*	0.0	• Torque	Soft STOP	0	0	38	UL
Speed*	500.0	<ul> <li>Speed</li> </ul>	STOP PWM	0	0	22	VL
	500.0			0	0	22	WL
GOTO S	TATE	Torque	•	0	0	22	UH
#136 : ID: 0x777 D	ata: FE 00 00 00 40 01	31 88	Record	0	0	38	VH
Sensed Measur	ements			0	0	38	WH
Speed(rpm)	499.7	Vbus (Vdc)	51.7				<b>C</b> 1.1
Id(A)	-1.0	Ud (norm)	-0.356	Inverter Tempe	eratures	Motor Temps	States
Iq(A)	2.0	Uq (norm)	0.413	2.0 1.0	) 2.0	29.0	State 4
Torque (N)	0.8	Mod Index	0.545	2.0 2.0	0.0	0.0	Fault 0
.09140653908252716 .12391692399978638 .16106219589710236 .1991332471370697, .23329469561576843 .2684099078178406,	, 0.112610921 , 0.145933538 , 0.179129421 0.219375118 , 0.247981667 0.283313810	16369476 17530823 1096802 132431 1861572 253479	^	Readme: ROS: Resolver Offset - correct PM motor initial. when the motor is in	should be calculated if kno angle. The valid range is 0 1 <b>motion.</b>	own or be used as a calibra -4095 corresponding to 0-	tion variable to seek the 360deg. <b>Do NOT modify</b>

- 4. Once started, click on the **CANBus** > **Connect** menu to initialize the CAN connection to the PIM.
- 5. Once the CAN communication is established, Sensed Measurements, Inverter Temperatures and Motor Temps (only top one is implemented), States, GD Statuses are updated regularly.
- 6. The motor parameters ROS is the initial angle of the resolver, its value should be predetermined or calibrated. The valid range is 0 to 4096 corresponding to 0 to 360°. The speed parameters are not implemented.

To enable the Pulse Width Modulation (PWM):

- 1. Click the drop down menu and select Torque
- 2. Click the GOTO STATE button
- 3. Once in the Torque mode, select a desired reference mode and apply the proper command value
- 4. Click Send button to execute the command

To stop, either by clicking the Soft STOP button to automatically reduce the commands to 0 but remain in the Torque mode; or, click the STOP PWM button to disable the PWM directly (equivalent to GOTO STATE PowerDown). The State display should change accordingly to the actual state the PIM is in. The numerical relationship between state text and state number is

#### Table 12. Inverter control states

Description	State number	Fault number
PowerUp	0	
Init	1	
SelfTest	2	
Ready	3	

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Description	State number	Fault number
Torque	4	
LimitedOp	5	
Fault	6	
Discharge	7	
PowerDown	8	

During operation, the Status registers of each GD is read periodically. The values are in decimal format display.

In case of Fault, the current behavior is that the PIM will report the Fault number and stays in Fault mode until the next reset (by power cycle or debugger reset)

Faults and the fault codes In the current software are listed in <u>Table 13</u>.

Fault	Bit	Condition	PWM	Warning level
Over voltage	1	> 450 V	6 Off	400
Over current la	2	> 700 A	6 Off	500
Over current lb	3	> 700 A	6 Off	500
Over current Ic	4	> 700 A	6 Off	500
MT Over temperature	5	120 °C	6 Off	110
GD INTB fault	6	GD INTB = 0	6 Off	any
IGBT OT	7	150 °C	6 Off	135
Scheduler	8	Over run	6 Off	any
Resolver fault	9	Init Fault	6 Off	any

#### Table 13. Fault codes

**Diagnostics:** 

Diagnostics functions are available to trace instantaneous values of key variables when fault occurs or when requested.

There are total 6 records stored in the RAM and FLASH. Record 0 is the Statistical Result. Current Record is the latest Signal results. Records 1 to 4 are the stored (in flash) the last 4 records.

## 6.3 Diagnostics

The records are either triggered by a fault condition except CurrentRecord, which can be triggered by Manual Trigger.

To retrieve the records, click the Grab Button. Then choose the desired signal after the record is 100% uploaded.

The record contains 64 data points each sampled at the 100uS task. When triggered by Fault, 50 data points are before the triggering, 14 are after.

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Figure 13. Resolver position data

The software provides the graphical view of arbitrary signal when requested. It records 2048 data at T0 rate. To retrieve a desired signal, first lookup the map file. For example, the output duty of the C phase pwm is shown in

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	Free	scale	Code	Warri	or																		2	Z
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### Figure 14. Variable address in map file

Fill the Addr(hex) fields according to the map address, then choose the right format of the variable before click the **Dump** button.

## **EV-INVERTER Enablement kit user guide**



Figure 15. Output variable graph

Too zoom in and out the graph, use the right mouse button. To reset, click the **A** button at lower left corner of the display area.



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# 7 Software development tools

NXP has software development tools available for use with the NXP MPC5777C development board (DEVB). The development board is intended to provide a platform for easy customer evaluation of the MPC5777C microcontroller and to facilitate hardware and software development. The development board can be used for powertrain/ inverters/Battery Management Systems (BMS)/automotive Ethernet, etc. The latest product information is available at www.nxp.com/MPC5777C.

Development software, available at http://www.nxp.com:

- S32S Design Studio IDE for power architecture: The S32S design studio for power architecture IDE installed on a Windows PC workstation enables editing, compiling and debugging of source code designs. SDK supports several devices including MPC5777C.
- Automotive Math and Motor Control Library (AMMCL): The AMMCL is a precompiled software library containing the building blocks for a wide range of motor control and general mathematical applications.
- FreeMaster 2.0 runtime debugging tool: FreeMASTER runtime debugging tool is a separate download and can also be used in conjunction with the MCU code developed with S32DS as a user-friendly realtime debug monitor, graphical control panel, and data visualization tool for application development and information management.
- Motor Control Application Tuning (MCAT): The MCAT is a FreeMASTER plug-in tool intended for the development of PMSM FOC and BLDC motor control applications.
- Example code, GD3100 Device Driver notes and GD3100 Device Driver Reference notes:

GD3100 Device Driver example code REV1.1, or later, provides a basis to get started and begin software development for the desired motor control.

# 8 Schematics, board layout and bill of materials

The board schematics, board layout and bill of materials are available at <u>http://www.nxp.com/HV-INVERTER</u>.

## 9 References

- [1] Tool summary page for HV-INVERTER <u>http://www.nxp.com/HV-INVERTER</u>
- [2] Product summary page for GD3100 <u>http://www.nxp.com/GD3100</u>
- [3] Product summary page for MC5775E <u>http://www.nxp.com/MC5775E</u>
- [4] Product summary page for FS6523 <u>http://www.nxp.com/FS6523</u>
- [5] Product summary page for TJA1042 <u>http://www.nxp.com/TJA1042</u>
- [6] Product summary page for Fuji M653 <u>http://www.nxp.com/Fuji\_M653</u>
- [7] Vepco Technologies <u>http://www.vepcotech.com/</u>

# **10 Revision history**

Revision history								
Rev	Date	Description						
1	20191004	Initial version						

### EV-INVERTER Enablement kit user guide

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