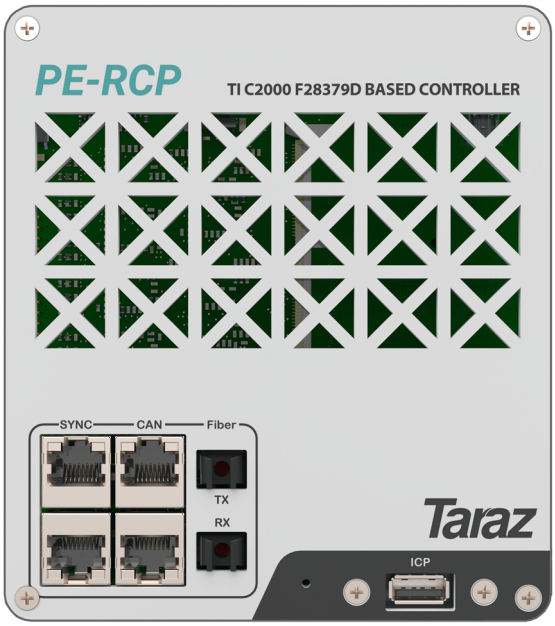
PE-RCP

TI C2000 F28379D Based Controller

OVERVIEW

The PE-RCP controller module is based on the popular TI C2000 series of microcontrollers that support direct programming from MATLAB Simulink, PSIM as well as embedded C. This versatility is especially powerful for power electronics applications, where the PE-RCP can be used for Rapid Control Prototyping (RCP) and conventional embedded development. Keeping that in mind, the PE-RCP was designed to benefit fully from the RCP functionality while providing maximum integration and communication options. The microcontroller ADC capabilities are extended further by providing pre-buffer stage, which increases the input voltage range to ±10V, thus making it suitable to interface to most sensors and HIL real-time simulators directly. In addition, isolated Sync communication is added to enables fast module to module communication and can be used to develop distributed control system or master-slave operation of multiple controllers. Finally, the fiber optic and CAN communications are added as well to allow application versatility. The PE-RCP is made using Texas Instruments TMDSCNCD28379D controlCARD to benefit from the available resources.



This module is also supported by MATLAB Simulink models and application examples that can accelerate development and reduce time to the market. It can also be used as a part of a final product since it can be panel mounted without additional accessories.

Applications

- ✓ Power Electronics Applications
- ✓ Customized Product Development
- ✓ Rapid Control Prototyping

Features

- ✓ Dual-Core C2000 TMS320F28379D 200MHz Controller
- ✓ Up to 16 Channel, ±10V Input ADC with 8 Channels (16-Bit) @ 360ksps & 8 Channels (12-Bit) @ 430ksps
- ✓ Up to 2 Quadrature Encoder Inputs, SPI, SCI & I2C Interfaces
- ✓ Isolated USB In Circuit Emulator for Programming & Debugging
- ✓ Open-Source MATLAB Simulink Models
- ✓ Up to 24 PWM Outputs & 16 Analog Inputs
- ✓ Multiple Communication Protocols such as Isolated CAN, Sync, Fiber Optics & USB 2.0 FS
- ✓ Up to 58 (3.3V/5V) Digital I/Os
- ✓ MicroSD Card Support
- ✓ Open-Source Application Examples

Software Requirements

The PE-RCP can be programmed using embedded C language as well as graphical programming. The programming and debugging is done through the ICP USB port. The following software can be used for programming:

- Code Composer Studio (Embedded C, Free)
- MATLAB Simulink
- PSIM

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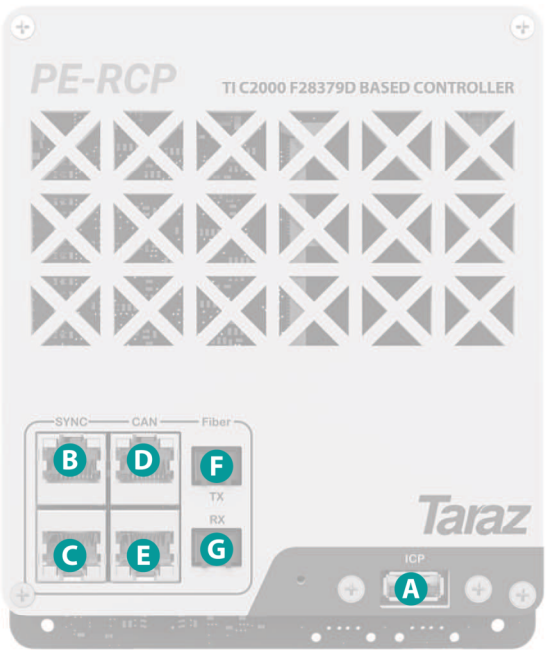
REVISION HISTORY

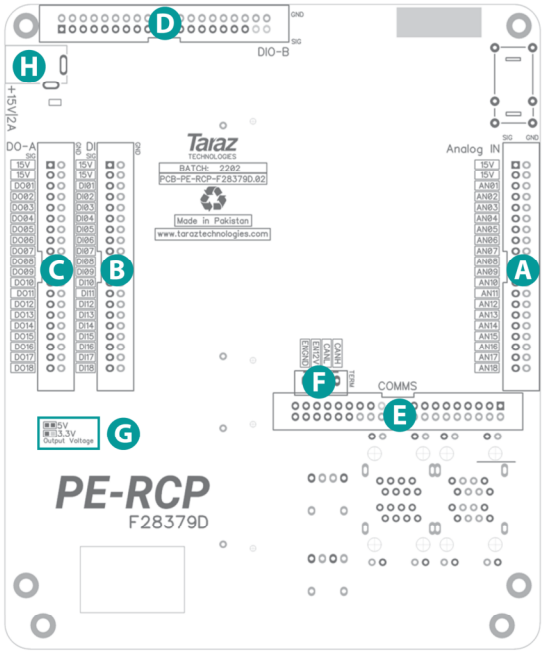
Revision	Date	Changes Description
1.0	10-04-2022	Initial release

DETAILED DESCRIPTION

Connections and Interface



FRONT



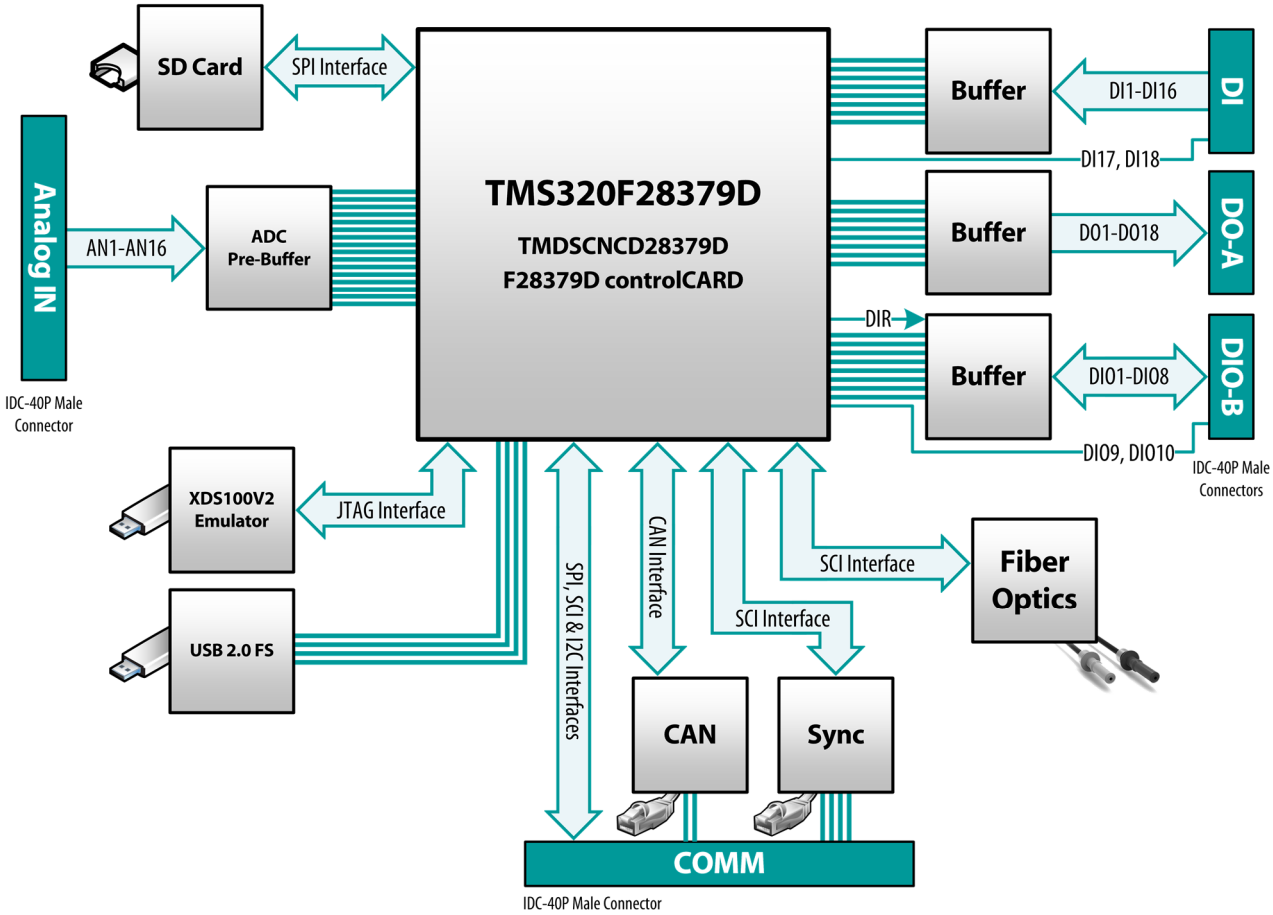
REAR

- **A** USB for In Circuit Programming & Debugging
- **B** Isolated Sync (A) RJ-45 Connector
- **C** Isolated Sync (B) RJ-45 Connector
- **D** Isolated CAN (A) RJ-45 Connector
- **E** Isolated CAN (B) RJ-45 Connector
- **F** Fiber Optics Transmitter
- **G** Fiber Optics Receiver

- **A** Analog Input IDC-40 Male Connector
- **B** Digital Input IDC-40 Male Connector
- **C** Digital Output (DO-A) IDC-40 Male Connector
- **D** Digital I/O (DIO-B) IDC-40 Male Connector
- **E** Communications IDC-40 Male Connector
- **F** Termination Resistors Header/Pins
- **G** 3.3V/5V Configuration SMD Jumpers to Digital Outputs
- **H** +15VDC, 2A Power Supply Jack

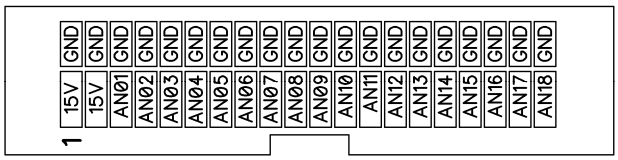
*Note: USB 2.0 FS OTG & MicroSD Card are accessible on the F28379D controlCARD only, therefore not accessible from the front panel when installed inside the PELab.

Functional Block Diagram



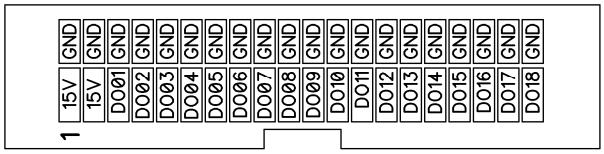
Pin Mapping

Analog Input IDC-40 Male Connector



			TMS320F28379D	
Pin Name	Pin No	Description	ADC Channel	Pin No.
15V	1, 3	+15VDC Power Supply	-	-
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40	Logic Power Ground	-	-
AN1	5	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A0 / ADC-A1	U1 – T1
AN2	7	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A2 / ADC-A3	U2 – T2
AN3	9	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A4 / ADC-A5	U3 – T3
AN4	11	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B0 / ADC-B1	V2 – W2
AN5	13	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D0	T5
AN6	15	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D1	U5
AN7	17	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D2	T6
AN8	19	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D3	U6
AN9	21	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B2 / ADC-B3	V3 – W3
AN10	23	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B4 / ADC-B5	V4 – W4
AN11	25	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-C2 / ADC-C3	R3 – P3
AN12	27	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-C4 / ADC-C5	R4 – P4
AN13	29	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D4	T7
AN14	31	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D5	U7
AN15	33	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADCIN14	T4
AN16	35	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADCIN15	U4
AN17	37	Not Connected	-	-
AN18	39	Not Connected	-	-

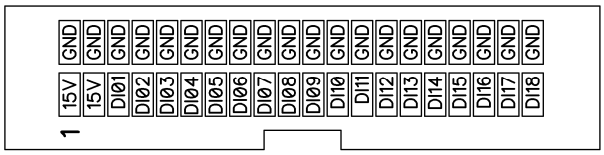
Digital Output Connector (DO-A)



				TMS320F28379D	
Pin Name	Pin No.	Description	Alternate Usage	Pin Name	Pin No.
15V	1, 3	+15VDC Power Supply	-	-	-
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40	Logic Power Ground	-	-	-
DO1	5	Digital Output, 3.3V/5V Configurable	ePWM1A	GPIO0	C8
DO2	7	Digital Output, 3.3V/5V Configurable	ePWM1B*	GPIO1	D8
DO3	9	Digital Output, 3.3V/5V Configurable	ePWM2A	GPIO2	A7
DO4	11	Digital Output, 3.3V/5V Configurable	ePWM2B*	GPIO3	B7
DO5	13	Digital Output, 3.3V/5V Configurable	ePWM3A	GPIO4	C7
DO6	15	Digital Output, 3.3V/5V Configurable	ePWM3B*	GPIO5	D7
DO7	17	Digital Output, 3.3V/5V Configurable	ePWM4A	GPIO6	A6
DO8	19	Digital Output, 3.3V/5V Configurable	ePWM4B*	GPIO7	B6
DO9	21	Digital Output, 3.3V/5V Configurable	ePWM5A	GPIO8	G2
DO10	23	Digital Output, 3.3V/5V Configurable	ePWM5B*	GPIO9	G3
DO11	25	Digital Output, 3.3V/5V Configurable	ePWM6A	GPIO10	B2
DO12	27	Digital Output, 3.3V/5V Configurable	ePWM6B*	GPIO11	C1
DO13	29	Digital Output, 3.3V/5V Configurable	ePWM7A	GPIO12	C2
DO14	31	Digital Output, 3.3V/5V Configurable	ePWM7B*	GPIO13	D1
DO15	33	Digital Output, 3.3V/5V Configurable	ePWM8A	GPIO14	D2
DO16	35	Digital Output, 3.3V/5V Configurable	ePWM8B*	GPIO15	D3
DO17	37	Digital Output, 3.3V/5V Configurable	XCLKOUT	GPIO73	A16
DO18	39	Digital Output, 3.3V/5V Configurable	OUTXBAR1	GPIO58	N17

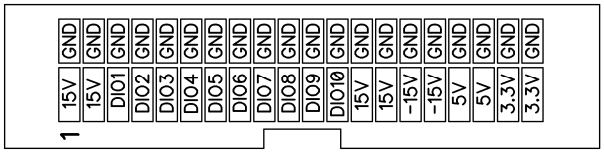
*Note: Complementary output of another PWM, e.g., PWM1B is the complementary output of PWM1A.

Digital Input Connector (DI)



				TMS320F28379D	
Pin Name	Pin No.	Description	Alternate Usage	Pin Name	Pin No.
15V	1, 3	+15VDC Power Supply	-	-	-
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40	Logic Power Ground	-	-	-
DI1	5	Digital Input, 3.3V~5V	CAP1	GPIO24	K3
DI2	7	Digital Input, 3.3V~5V	CAP2	GPIO25	K2
DI3	9	Digital Input, 3.3V~5V	CAP3	GPIO26	K1
DI4	11	Digital Input, 3.3V~5V	CAP4	GPIO27	L1
DI5	13	Digital Input, 3.3V~5V	XINT4	GPIO44	K18
DI6	15	Digital Input, 3.3V~5V	XINT5	GPIO133	G18
DI7	17	Digital Input, 3.3V~5V	QEP3A	GPIO62	J17
DI8	19	Digital Input, 3.3V~5V	QEP3B	GPIO63	J16
DI9	21	Digital Input, 3.3V~5V	QEP2A	GPIO54	P18
DI10	23	Digital Input, 3.3V~5V	QEP2B	GPIO55	P19
DI11	25	Digital Input, 3.3V~5V	SD1-D1	GPIO48	R16
DI12	27	Digital Input, 3.3V~5V	SD1-C1	GPIO49	R17
DI13	29	Digital Input, 3.3V~5V	SD1-D2	GPIO50	R18
DI14	31	Digital Input, 3.3V~5V	SD1-C2	GPIO51	R19
DI15	33	Digital Input, 3.3V~5V	INXBAR5	GPIO32	U13
DI16	35	Digital Input, 3.3V~5V	INXBAR6	GPIO33	T13
DI17	37	Digital Input, 3.3V	SD1-D3	GPIO52	P16
DI18	39	Digital Input, 3.3V	SD1-C3	GPIO53	P17

Digital Input / Output Connector (DIO-B)



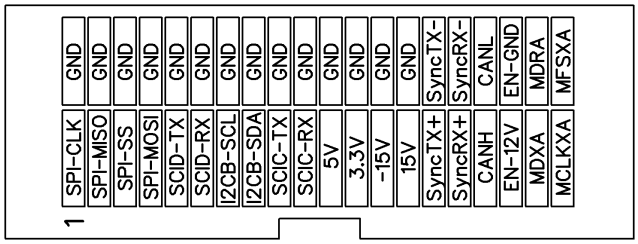
				TMS320F28379D	
Pin Name	Pin No.	Description	Alternate Usage	Pin Name	Pin No.
15V	1, 3, 25, 27	+15VDC Power Supply	-	-	-
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40	Logic Power Ground	-	-	-
DIO1	5	Digital I/O*, 3.3V	ePWM9A	GPIO161	C9
DIO2	7	Digital I/O*, 3.3V	ePWM9B	GPIO162	D9
DIO3	9	Digital I/O*, 3.3V	ePWM10A	GPIO163	A8
DIO4	11	Digital I/O*, 3.3V	ePWM10B	GPIO164	B8
DIO5	13	Digital I/O*, 3.3V	ePWM11A	GPIO20	F2
DIO6	15	Digital I/O*, 3.3V	ePWM11B	GPIO21	F3
DIO7	17	Digital I/O*, 3.3V	ePWM12A	GPIO22	J5
DIO8	19	Digital I/O*, 3.3V	ePWM12B	GPIO23	K4
DIO9 **	21	Digital Output, 3.3V	OUTXBAR2	GPIO59	M16
DIO10 **	23	Digital Output, 3.3V	OUTXBAR3	GPIO60	M17
-15V	29, 31	Unregulated -15VDC Power Output	-	-	-
5V	33, 35	5V Logic Power Output	-	-	-
3.3V	37, 39	3.3V Logic Power Output	-	-	-

* Direction of DIOs can be controlled using Pin No. V16 (GPIO36) of the microcontroller:

- GPIO36 (Low): DIO-B configured as output.
- GPIO36 (High): DIO-B configured as input.

** DIO9-10 is output irrespective of the state of GPIO36.

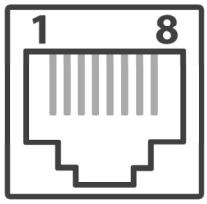
Communications Connector (COMMS)

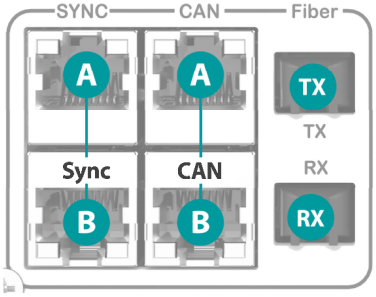


				TMS320F28379D	
Pin Name	Pin No.	Description	Alternate Usage	Pin Name	Pin No.
SPI-CLK	1	Clock Pin of SPIA	-	GPIO18	E3
SPI-MISO	3	MISO Pin of SPIA	OUTXBAR8	GPIO17	E2
SPI-SS	5	SS Pin of SPIA	-	GPIO19	E4
SPI-MOSI	7	MOSI Pin of SPIA	OUTXBAR7	GPIO16	E1
SCID-TX	9	TX Pin of SCID	-	GPIO76	C16
SCID-RX	11	RX Pin of SCID	-	GPIO77	A15
I2CB-SCL	13	Clock Pin of I2CB	-	GPIO41	U17
I2CB-SDA	15	Data Pin of I2CB	-	GPIO40	V17
SCIC-TX	17	TX Pin of SCIC (Fiber Optics TX)	CANB-TX	GPIO38	T16
SCIC-RX	19	RX Pin of SCIC (Fiber Optics RX)	CANB-RX	GPIO39	W17
+5V	21	5V Logic Power Output	-	-	-
+3.3V	23	3.3V Logic Power Output	-	-	-
-15V	25	Unregulated -15VDC Power Output	-	-	-
+15V	27	+15VDC Power Supply	-	-	-
Sync-TX+	29	Sync Transmitter Positive	-	-	-
Sync-TX-	30	Sync Transmitter Negative	-	-	-
Sync-RX+	31	Sync Receiver Positive	-	-	-
Sync-RX-	32	Sync Receiver Negative	-	-	-
CANH	33	High-Level CAN Bus Line	-	-	-
CANL	34	Low-Level CAN Bus Line	-	-	-
EN-12V	35	12V Enable Signal Positive	-	-	-
EN-GND	36	12V Enable Signal Ground	-	-	-
MDXA	37	McBSP-A Transmit Serial Data	-	GPIO84	A11
MDRA	38	McBSP-A Receive Serial Data	-	GPIO85	B11
MCLKXA	39	McBSP-A Transmit Clock	-	GPIO86	C11
MFSXA	40	McBSP-A Transmit Frame Sync	-	GPIO87	D11
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28	Logic Power Ground	-	-	-

Communication Protocols

Pin Mapping





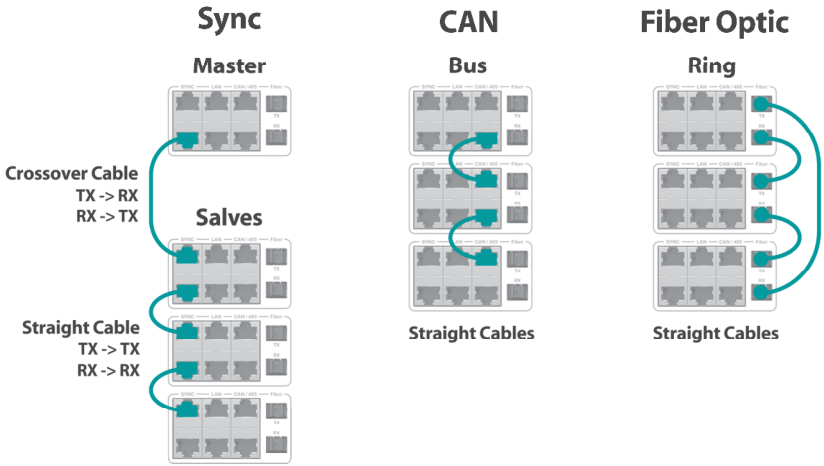
RJ-45	Sync (A&B)		CAN (A&B)	
Pin	Name	Description	Name	Description
1	SYNC-TX+	Sync Transmitter Positive	CANH	High-Level CAN Bus Line
2	SYNC-TX-	Sync Transmitter Negative	CANL	Low-Level CAN Bus Line
3	GND		EN-12V	Enable +
4	GND		EN-GND	Enable -
5	GND			
6	GND			
7	SYNC-RX-	Sync Receiver Negative		
8	SYNC-RX+	Sync Receiver Positive		

WARNING!

Use the communication ports only as intended, using wrong wiring or connection can result in permanent damage to the communication port and/or the PE-RCP.

Connection Guide

The PE-RCP communications are intended with certain architectures in mind, which can help in achieving the optimum utilization of the communication port in specific applications. Following are the possible connection architectures:



OPEATIONAL INFORMATION

Programming & Debugging

The PE-RCP uses on-board ICP (XDS100V2 Emulator) for programming and debugging using the ICP USB connector. The XDS100V2 programs the microcontroller via the JTAG debug port. The emulator also provides a USB to UART adapter functionality to use as Virtual Com Port for monitoring purposes.

Connections with Microcontroller

STLINK Function	Controller Pin Name	Controller Pin
JTAG_TRSTN	TRSTN	V14
JTAG_TCK	TCK	V15
JTAG_TDI	TDI	W13
JTAG_TMS	TMS	W14
JTAG_TDO	TDO	W15
Virtual Com Port RX	GPIO28 / SCIA_RXD	V11
Virtual Com Port TX	GPIO29 / SCIA_TXD	W11

Clock & Reset

Clock Sources

The PE-RCP uses an on-board 20MHz oscillator as controller clock source, which has the following connections with the microcontroller.

Function	Controller Pin Name	Controller Pin
MCU_X1	X1	G19
MCU_X2	X2	J19

Reset

The reset signal is active low. The reset sources include:

- Reset button
- XDS100V2 Emulator

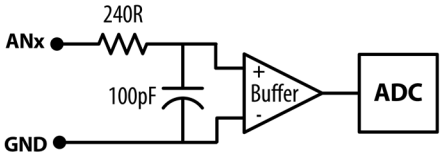
Analog to Digital Conversion

The PE-RCP uses four microcontroller's internal ADC units, responsible for the conversion of 16 analog channels. The PE-RCP provides eight 16-bit differential mode channels and eight 12-bit single ended channels. Each ADC channel has a pre-buffer stage, which sets high impedance to the input, while increasing the input voltage range to ±10V which is commonly used by most HIL simulators and high accuracy sensors. Simultaneous sampling is possible only on channels belonging to different ADC units. The 16-bit channels can convert at 1.1Msps, while the 12-bit channels can convert at 3.5Msps, when only a single channel of a particular ADC unit is used.

The following table provides essential information regarding the possible configurations of the ADC units.

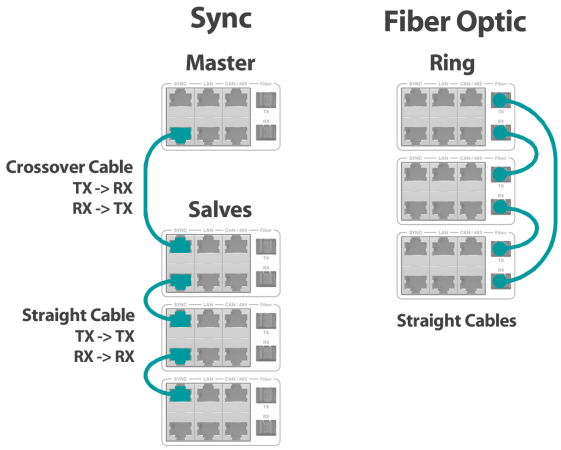
ADC Units	Channel Count	Configuration	Min Acquisition Time (ns)	Min Sample Hold Time
ADC-A	3	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-B	3	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-C	2	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-D	8	12-Bit Single Ended	75	10.5 ADC Clock Cycles

Input Equivalent Circuit

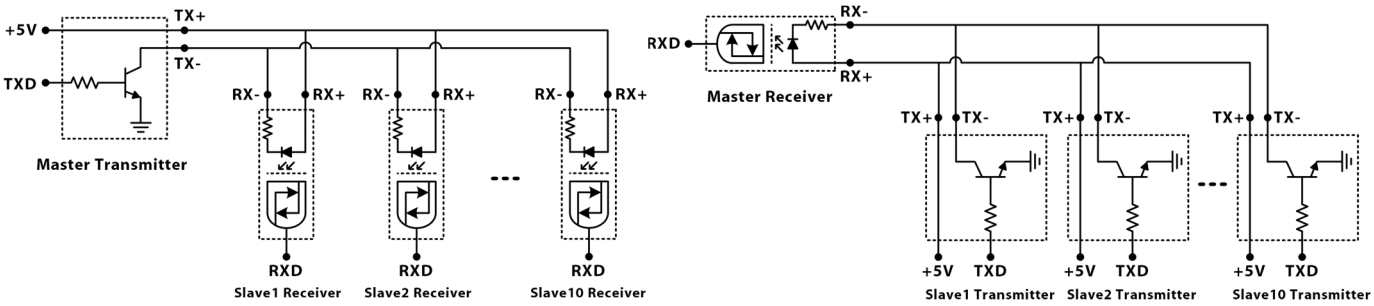


Sync

The PE-RCP incorporates a specially designed isolated Sync communication protocol to enable master-slave control and distributed control systems between multiple controllers. In this protocol, the master controller can transmit reference signals to all the slave controllers (up to 10 slaves) at the same time, while the slave controllers can give feedback signals to the master controller one at a time. This architecture enables lowest latency in communication between the master controller and slave controllers, and it is especially suited for common power electronics applications such as parallel power supplies, multi-cell inverters and converters, etc.



Sync Communication Equivalent Circuit



Connections with Microcontroller

Sync	Controller Pin Name	Controller Pin
TXD	GPIO70 / SCIB_TXD	A17
RXD	GPIO71 / SCIB_RXD	B17

Fiber Optics

The PE-RCP also incorporates fiber optic communication that can be used in daisy chain, which has its own applications such as distributed control systems but without master-slave controllers. It is also particularly suited for longer range and noisy environment operation. Following are the connections with the microcontroller.

Fiber Optics	Fiber Optic Model	Controller Pin Name	Controller Pin
TXD	AFBR-1634Z	GPIO38 / SCIC_TX	T16
RXD	AFBR-2634Z	GPIO39 / SCIC_RX	W17

CAN & Battery Enable

The PE-RCP has CAN Bus communication protocol, which is the standard protocol widely used in industrial equipment. In addition, many commercially available battery packs require 12V enable signal to turn on the battery. The PE-RCP added this additional Battery Enable signals to enable interface to such battery packs. Note that the output of these protocols is isolated from the main controller, however they share the same ground among them.

CAN Bus Interface

The PE-RCP uses an isolated CAN Transceiver IC ISO1042 from Texas Instruments as a bridge to connect the microcontroller CAN-A to a CAN bus. Following are details of the connections between the transceiver IC and the microcontroller:

ISO1042 Pin Name	Controller Pin Name	Controller Pin
TXD	GPIO31 / CANA_TX	U11
RXD	GPIO30 / CANA_RX	T11

Battery Enable

The battery enable signal is achieved through isolated optocoupler IC, which turns ON and OFF the output accordingly. Following are the connection details with the microcontroller.

Signal Name	Controller Pin Name	Controller Pin
Battery Enable	GPIO35	193

Termination & Wiring

The CAN bus requires a 120R termination resistor at far ends of the bus. These resistors can be installed easily on the termination header/pins (see page 4, connections & interface, rear view, point F). In addition, it is recommended to use a twisted pair, shielded cable with 100R-120R characteristic impedance such as Belden 3109A for best performance.

USB 2.0 FS OTG

The PE-RCP supports a USB 2.0 full speed communications via a USB-A connector. The controller has an internal USB 2.0 Full Speed PHY for communication over the USB protocol. The PE-RCP can be configured as:

- USB Host: To connect to other devices such as USB Mass Storage devices for data storage.
- USB Device: To connect to a host system, where the PE-RCP is a mass storage, HID or other such device

Connections with Microcontroller

USB Signal	Controller Pin Name	Controller Pin
USB-DM	GPIO42	D19
USB-DP	GPIO43	C19
USB_ID	GPIO47	E18
USB_VBUS	GPIO46	E19
USB_EPEN	GPIO121	W16
USB_PFLT	GPIO120	U15

SD Card

The PE-RCP provides a micro SD card slot (on the ControlCARD), which enables communication between the microcontroller and the micro SD card via SPI interface. Following are the connections with the microcontroller.

Signal	Controller Pin Name	Controller Pin
$\overline{CS}$	GPIO125	T9
DI	GPIO122	T8
CLK	GPIO124	V8
DO	GPIO123	U8

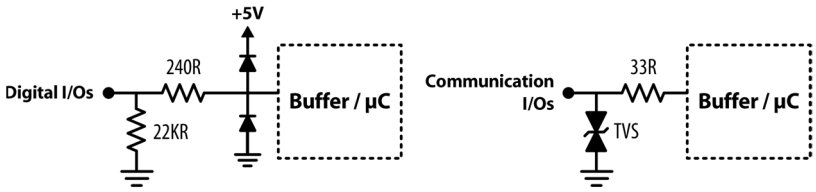
SPECIFICATIONS

Electrical Characteristics

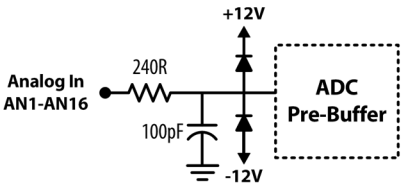
*All ratings are given at 15V power supply and 25°C ambient temperature unless otherwise specified.

Parameter	Test Conditions/Notes	Minimum	Typical	Maximum	Unit
Power Supply Voltage		14.5	15	17	V
Power Supply Current		-	-	2	A
Logic Input Voltage (Buffered)		0	-	5.5	V
Logic Input Voltage (Non-buffered)		0	-	3.45	V
Logic High Input Threshold		2.0	-	-	V
Logic Low Input Threshold		-	-	0.8	V
Logic High Output (Buffered Outputs)	3.3V/5V Selectable	3	-	5	V
Logic High Output (Non-buffered Outputs)		3	-	3.3	V
Logic Low Output		0	-	0.55	V
Output Current (Buffered Outputs)		-20	-	20	mA
Output Current (Non-buffered Outputs)		-10	-	10	mA
Analog Input Voltage		-10	-	10	V

Analog & Digital Electrical Equivalent Circuits



Digital I/Os Equivalent Circuit



Analog Inputs Equivalent Circuit

Communications Characteristics

Protocol	Version/Speed
CAN	Up to 1 Mbps
Sync	UART Mode: 6.25 Mbps
Fiber Optics	UART Mode: 6.25 Mbps
OTG USB	2.0 Full Speed, 12 Mbps

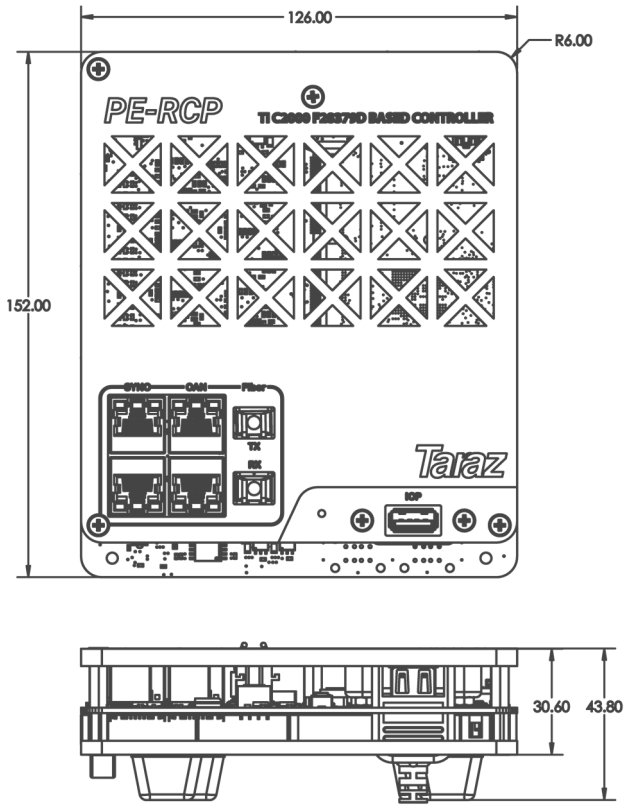
*Note: CAN & Sync speed can differ due to chip shortage, lower speed models may be used if originally intended chips are not available.

General Specifications

Parameter	Test Conditions/Notes	Minimum	Typical	Maximum	Unit
Operating Temperature		-20	-	50	℃
Storage Temperature		-40	-	70	℃
Sync & CAN Isolation	AC Voltage, 1 Minute	-	-	1500	V

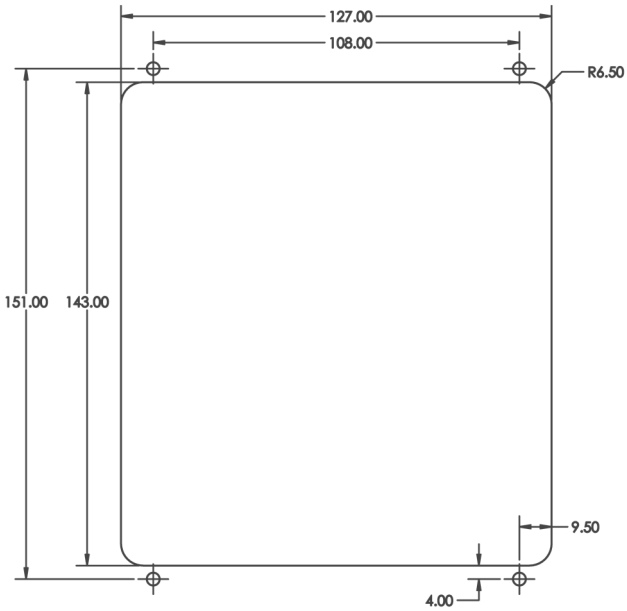
MECHANICAL

Dimensions



* Note: PE-RCP panel mount application is possible with additional accessories. All dimensions are in mm.

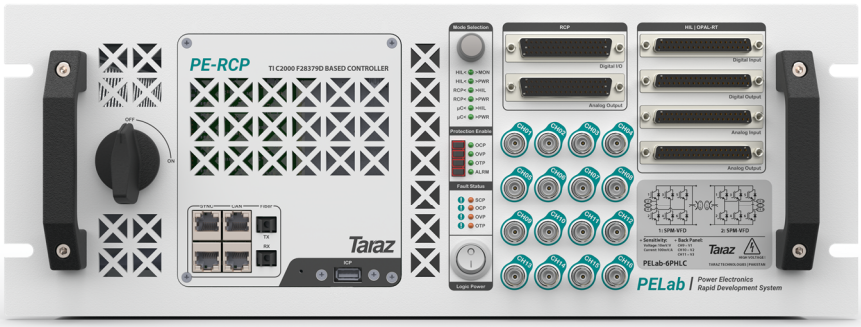
Panel Mount Cutout



* Note: PE-RCP panel mount application is possible with additional accessories. Panel mount holes are M3. All dimensions are in mm.

APPLICATION EXAMPLES

Power Electronics Applications



The PE-RCP is ideal for power electronics inverters and converters control system implementation due to its Rapid Control Prototyping capability and high performance. Therefore, it's quite popular for research and prototyping. In addition, the open-source MATLAB Simulink models will greatly accelerate the development cycle of power electronics converters with the help of available application examples. Furthermore, large resources are available from Texas Instruments that support the development of the F28379D ControlCARD. Finally, Due to its integration in the PELab systems, a complete R&D development is possible prior to its integration in the final industrial product.

SOFTWARE SUPPORT

The PE-RCP is supported by open-source MATLAB Simulink application examples, which can be found on the following page:

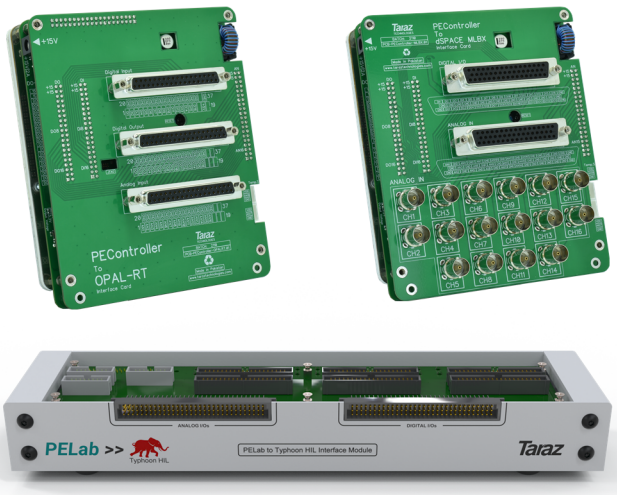
- https://www.taraztechnologies.com/help/

PLUGINS & ACCESSORIES

Real-Time HIL Simulators Interface Daughter Cards & Modules

The PE-RCP can be interfaced with HIL real-time simulators using plugin daughter cards or interface modules. Following are the available cards and modules:

- OPAL-RT Interface Daughter Card
- Typhoon HIL Interface Module
- dSPACE MLBX Interface Daughter Card
- Speedgoat Interface Daughter Card
- RT-Box Interface Daughter Card



Supported HIL Simulators

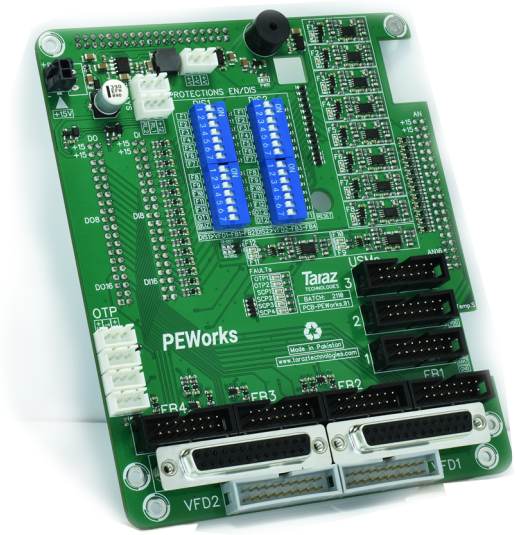
OPAL-RT TECHNOLOGIES
Typhoon HIL
speedgoat real-time simulation and testing
dSPACE
plecs

Power Electronics Interface Daughter Card (PEWorks)

The PE-RCP can be easily interfaced to Taraz Technologies' power modules and measurement modules. The PEWorks daughter card can interface to the following:

- Up to 2 SPM-VFD / SPM-VFDHP Three Phase Inverter Modules.
- Or, Up to 4 SPM-FB / SPM-MMC / SPM-NPC / SPM-TNPC Power Modules.
- Up to 3 USM-3IV Isolated Voltage & Current Measurement Modules (Total 8 Voltage & 8 Current Channels).
- Up to 4 Relays, 12V Fan Power Supply and Thermostats.

More information available in the PEWorks datasheet.



ABOUT TARAZ TECHNOLOGIES

Taraz Technologies has been providing research-oriented power electronics solutions to customers in more than 30 countries. Our products include DC/DC Converters, Gate Drivers, Power Modules, Embedded Controllers, Isolated Sensors, Smart Probes, Data Acquisition devices as well as fully integrated Power Electronics Systems. Our product design philosophy focuses on easy-to-use, research-friendly, and modular solutions that can accelerate the research and development cycle while providing maximum versatility for research. Furthermore, our finished product portfolio includes Programmable Power Supplies and Solar Inverters for the domestic market.

Founded in 2012, Taraz was nominated among the top most innovative technology startups in Pakistan. Our research and manufacturing facility is located in Islamabad, the green capital city of Pakistan.

TARAZ WARRANTY

Taraz Technologies warrants it's Products against defects in material, workmanship, and design for a period of twelve (12) months. The defective Products will be repaired or replaced, free of charge, as per our standard terms and conditions. For more information on warranty and terms, please visit our website at www.taraztechnologies.com.

SAFETY NOTICE

This Device is ESD Sensitive and Needs to be Handled with Care. High Voltage Condition May Occur During Operation of the Device, and Hence User is Solely Responsible for Equipment and Personnel Safety. Taraz Technologies Shall Not be Hold Liable for any Damage to Personnel and/or Properties as a Result of Using this Device. User Must Take Adequate Steps to Ensure Electrical and Mechanical Safety of the Device in Use.

WARNING & DISCLAIMER

The Information Herein is Given to Describe Certain Components and Shall Not be Considered as a Guarantee of Characteristics. Terms of Delivery and Rights to Technical Change Reserved. We Hereby Disclaim any and All Warranties, Including But Not Limited to Warranties of Non-Infringement, Regarding Circuits, Descriptions, and Charts Stated Herein. Customer is Solely Responsible for Proper and Legal Use of all Products Offered by Taraz Technologies.

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