PE-RCP Box

TI C2000 F28379D Based Controller

OVERVIEW

The PE-RCP Box 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
- ✓ Rapid Control Prototyping

Features

- ✓ Dual-Core C2000 TMS320F28379D 200MHz Controller
- ✓ Up to 16 PWM Outputs & 16 Analog Inputs
- ✓ Up to 16 Channel, ±10V Input ADC with 8 Channels (16-Bit) @ 360ksps & 8 Channels (12-Bit) @ 430ksps
- ✓ Multiple Communication Protocols such as Isolated CAN, Sync, Fiber Optics & USB 2.0 FS
- ✓ Isolated USB In Circuit Emulator for Programming & Debugging
- ✓ MicroSD Card Support (On the ControlCARD)
- ✓ Open-Source MATLAB Simulink Models
- ✓ 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

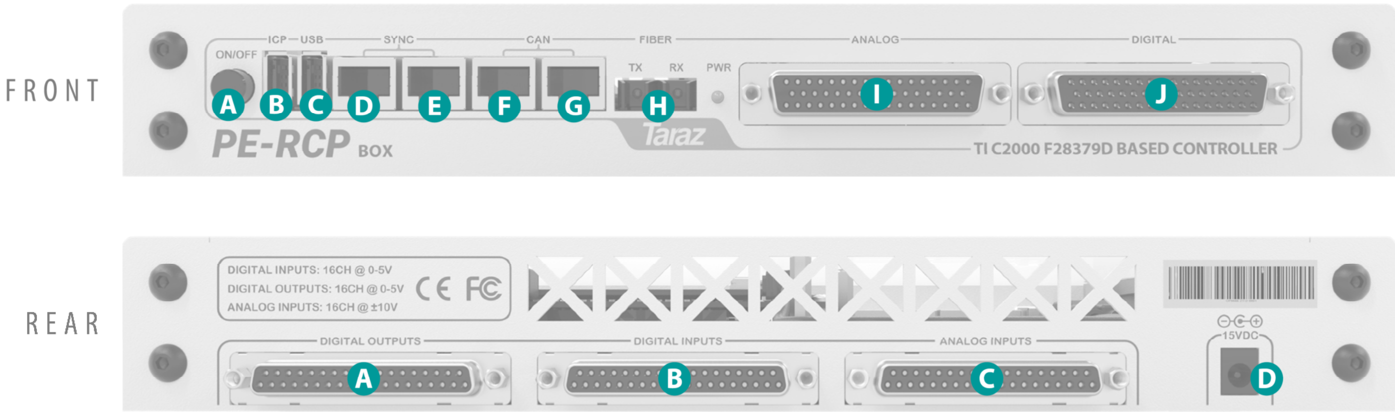
TABLE OF CONTENTS

REVISION HISTORY

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

DETAILED DESCRIPTION

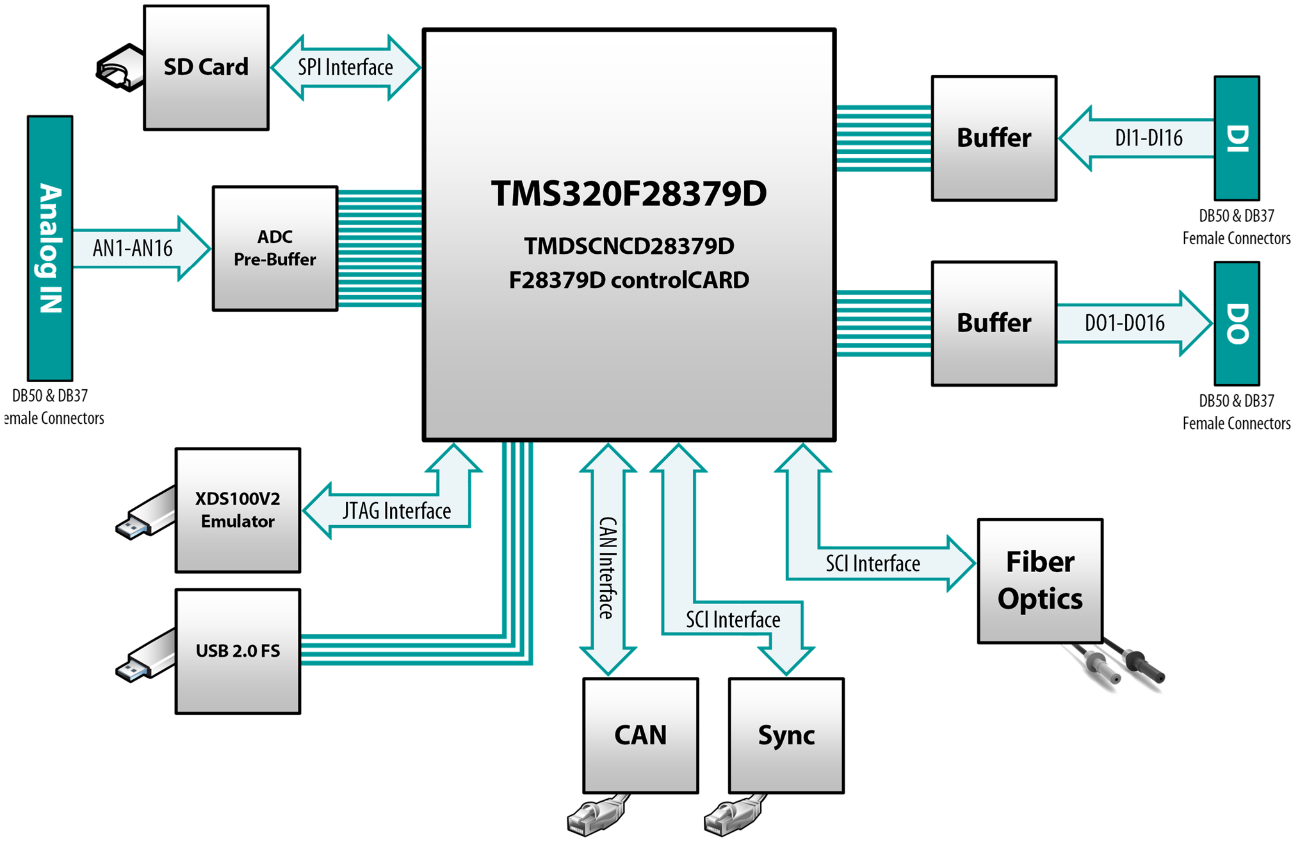
Connections and Interface



FRONT		REAR	
A	Power ON/OFF Connector	A	Digital Outputs DB37 Female Connector
B	Isolated USB for In Circuit Programming & Debugging	B	Digital Inputs DB37 Female Connector
C	USB 2.0 FS for Data	C	Analog Inputs DB37 Female Connector
D	Isolated Sync (A) RJ-45 Connector	D	+15 V DC, 1.5 A Power Supply Jack
E	Isolated Sync (B) RJ-45 Connector		
F	Isolated CAN (A) RJ-45 Connector		
G	Isolated CAN (B) RJ-45 Connector		
H	Fiber Optic Ports		
I	Analog Inputs DB50 Female Connector		
J	Digital I/Os DB50 Female Connector		

*Note: MicroSD card connector is on the F28379D controlCARD, which is accessible when the top acrylic cover is removed.

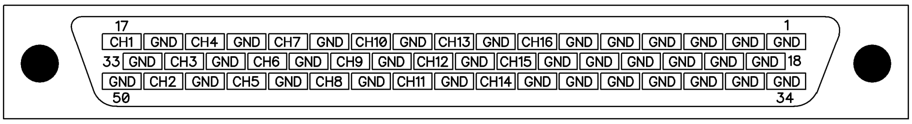
Functional Block Diagram



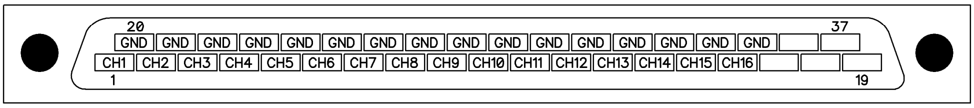
Pin Mapping

Analog Input Connectors

DB50 | ANALOG INPUTS



DB37 | ANALOG INPUTS

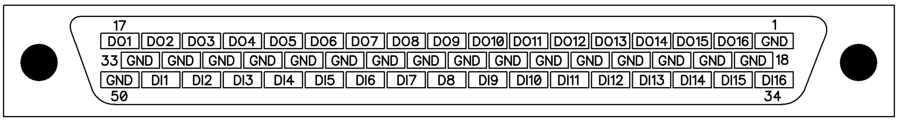


	Pin Number			TMS320F28379D	
Pin Name	DB50	DB37	Description	ADC Channel	Pin No.
CH1	17	1	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A0 / ADC-A1	U1 – T1
CH2	49	2	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A2 / ADC-A3	U2 – T2
CH3	32	3	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-A4 / ADC-A5	U3 – T3
CH4	15	4	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B0 / ADC-B1	V2 – W2
CH5	47	5	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D0	T5
CH6	30	6	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D1	U5
CH7	13	7	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D2	T6
CH8	45	8	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D3	U6
CH9	28	9	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B2 / ADC-B3	V3 – W3
CH10	11	10	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-B4 / ADC-B5	V4 – W4
CH11	43	11	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-C2 / ADC-C3	R3 – P3
CH12	26	12	16-Bit Differential Input ADC, ±10V Range, 360 ksps	ADC-C4 / ADC-C5	R4 – P4
CH13	9	13	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D4	T7
CH14	41	14	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADC-D5	U7
CH15	24	15	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADCIN14	T4
CH16	7	16	12-Bit Single Ended Input ADC, ±10V Range, 430 ksps	ADCIN15	U4
GND	1-6, 8, 10, 12, 14, 16, 18-23, 25, 27, 29, 31, 33-40, 42, 44, 46, 48, 50	20-35	Analog Ground	-	-

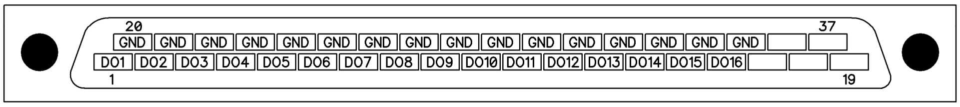
*Note: Both DB37 and DB50 connectors have the same electrical connection, therefore inputs can only be connected to either of them at the same time.

Digital Output Connectors

DB50 | DIGITAL I/Os



DB37 | DIGITAL OUTPUTS

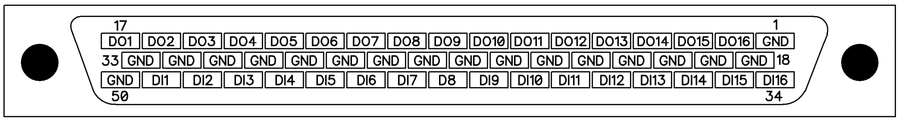


	Pin Number				TMS320F28379D	
Pin Name	DB50	DB37	Description	Alternate Usage	Pin Name	Pin No.
DO1	17	1	Digital Output, 0-5V	ePWM1A	GPIO0	C8
DO2	16	2	Digital Output, 0-5V	ePWM1B*	GPIO1	D8
DO3	15	3	Digital Output, 0-5V	ePWM2A	GPIO2	A7
DO4	14	4	Digital Output, 0-5V	ePWM2B*	GPIO3	B7
DO5	13	5	Digital Output, 0-5V	ePWM3A	GPIO4	C7
DO6	12	6	Digital Output, 0-5V	ePWM3B*	GPIO5	D7
DO7	11	7	Digital Output, 0-5V	ePWM4A	GPIO6	A6
DO8	10	8	Digital Output, 0-5V	ePWM4B*	GPIO7	B6
DO9	9	9	Digital Output, 0-5V	ePWM5A	GPIO8	G2
DO10	8	10	Digital Output, 0-5V	ePWM5B*	GPIO9	G3
DO11	7	11	Digital Output, 0-5V	ePWM6A	GPIO10	B2
DO12	6	12	Digital Output, 0-5V	ePWM6B*	GPIO11	C1
DO13	5	13	Digital Output, 0-5V	ePWM7A	GPIO12	C2
DO14	4	14	Digital Output, 0-5V	ePWM7B*	GPIO13	D1
DO15	3	15	Digital Output, 0-5V	ePWM8A	GPIO14	D2
DO16	2	16	Digital Output, 0-5V	ePWM8B*	GPIO15	D3
GND	1, 18-33, 50	20-35	Logic Ground	-	-	-

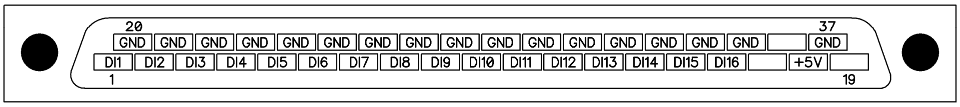
*Note: Complementary output of another PWM, e.g., PWM1B is the complementary output of PWM1A.

Digital Input Connectors

DB50 | DIGITAL I/Os



DB37 | DIGITAL INPUTS

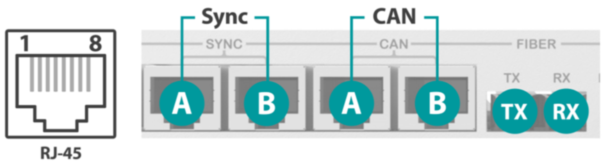


	Pin Number				TMS320F28379D	
Pin Name	DB50	DB37	Description	Alternate Usage	Pin Name	Pin No.
DI1	49	1	Digital Input, 3.3V~5V	CAP1	GPIO24	K3
DI2	48	2	Digital Input, 3.3V~5V	CAP2	GPIO25	K2
DI3	47	3	Digital Input, 3.3V~5V	CAP3	GPIO26	K1
DI4	46	4	Digital Input, 3.3V~5V	CAP4	GPIO27	L1
DI5	45	5	Digital Input, 3.3V~5V	XINT4	GPIO44	K18
DI6	44	6	Digital Input, 3.3V~5V	XINT5	GPIO133	G18
DI7	43	7	Digital Input, 3.3V~5V	QEP3A	GPIO62	J17
DI8	42	8	Digital Input, 3.3V~5V	QEP3B	GPIO63	J16
DI9	41	9	Digital Input, 3.3V~5V	QEP2A	GPIO54	P18
DI10	40	10	Digital Input, 3.3V~5V	QEP2B	GPIO55	P19
DI11	39	11	Digital Input, 3.3V~5V	SD1-D1	GPIO48	R16
DI12	38	12	Digital Input, 3.3V~5V	SD1-C1	GPIO49	R17
DI13	37	13	Digital Input, 3.3V~5V	SD1-D2	GPIO50	R18
DI14	36	14	Digital Input, 3.3V~5V	SD1-C2	GPIO51	R19
DI15	35	15	Digital Input, 3.3V~5V	INXBAR5	GPIO32	U13
DI16	34	16	Digital Input, 3.3V~5V	INXBAR6	GPIO33	T13
GND	1, 18-33, 50	20-35	Logic Ground	-	-	-

*Note: Both DB37 and DB50 connectors have the same electrical connection, therefore inputs can only be connected to either of them at the same time.

Communication Protocols

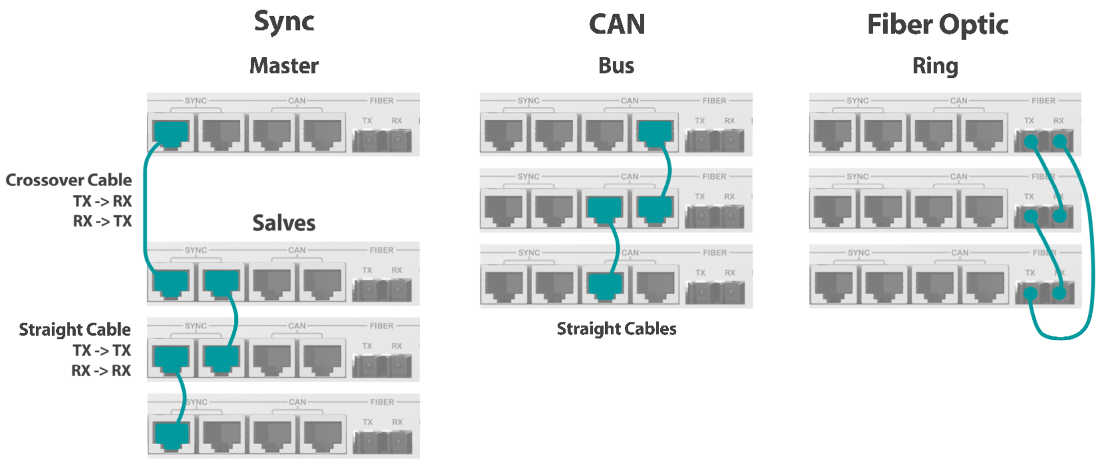
Pin Mapping



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		

Connection Guide

The PE-RCP Box 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:



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 Box.

OPEATIONAL INFORMATION

Programming & Debugging

The PE-RCP Box 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 Box 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

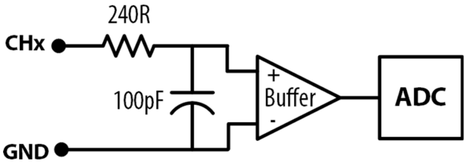
Analog to Digital Conversion

The PE-RCP Box uses four microcontroller's internal ADC units, responsible for the conversion of 16 analog channels. The PE-RCP Box 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.

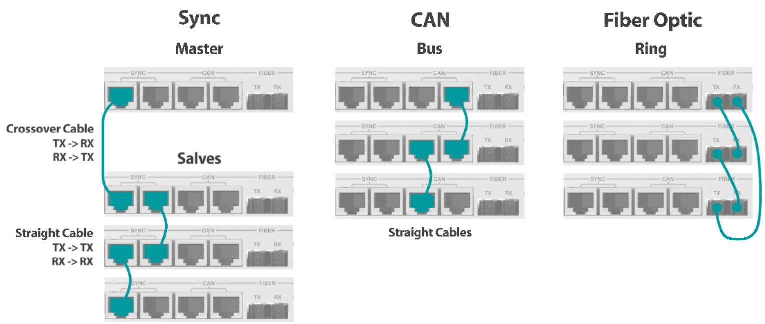
ADC Units	Channel Count	Configuration	Min Acquisition Time (ns)	Min Sample Hold Time
ADC-A	3	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-B	3	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-C	2	16-Bit Differential	320	29.5 ADC Clock Cycles
ADC-D	8	12-Bit Single Ended	75	10.5 ADC Clock Cycles

Input Equivalent Circuit

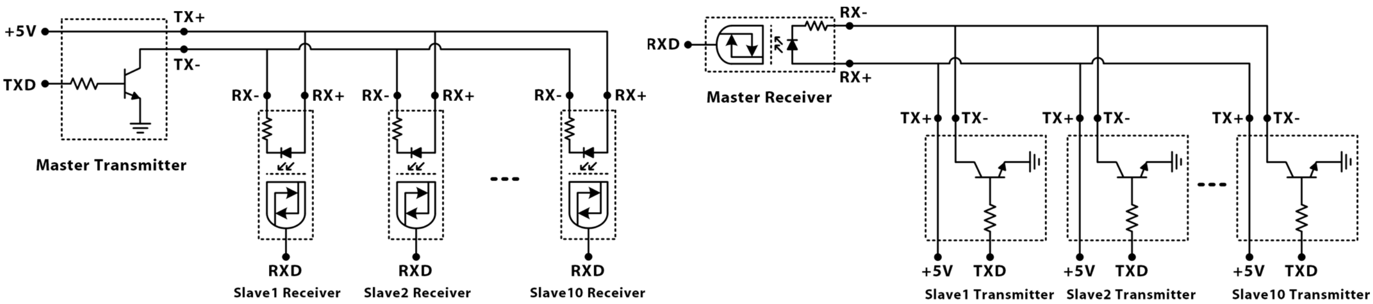


Sync

The PE-RCP Box 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 Box 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 Box have a CAN Bus communication protocol as well, 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 Box 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 Box 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 unused RJ45 connectors. 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 Box supports a USB 2.0 full speed communications via a USB-A connector. The microcontroller has an internal USB 2.0 Full Speed PHY for communication over the USB protocol. The PE-RCP Box 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 Box 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
$\overline{\text{CS}}$	GPIO125	T9
DI	GPIO122	T8
CLK	GPIO124	V8
DO	GPIO123	U8

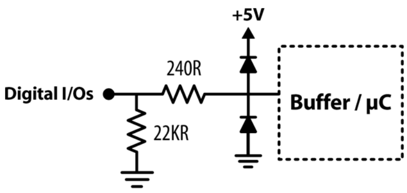
SPECIFICATIONS

Electrical Characteristics

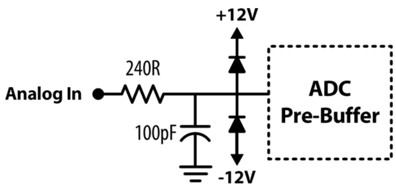
*All ratings are given at 15V power supply and 25°C ambient temperature unless otherwise specified.

Parameter	Test Conditions/Notes	Minimum	Typical	Maximum	Unit
Power Supply Voltage		14.5	15	17	V
Power Supply Current		-	-	2	A
Logic Input Voltage		0	-	5.5	V
Logic High Input Threshold		2.0	-	-	V
Logic Low Input Threshold		-	-	0.8	V
Logic High Output		4.5	5	5.5	V
Logic Low Output		0	-	0.55	V
Output Current		-20	-	20	mA
Analog Input Voltage		-10	-	10	V

Digital I/Os & Analog Inputs 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

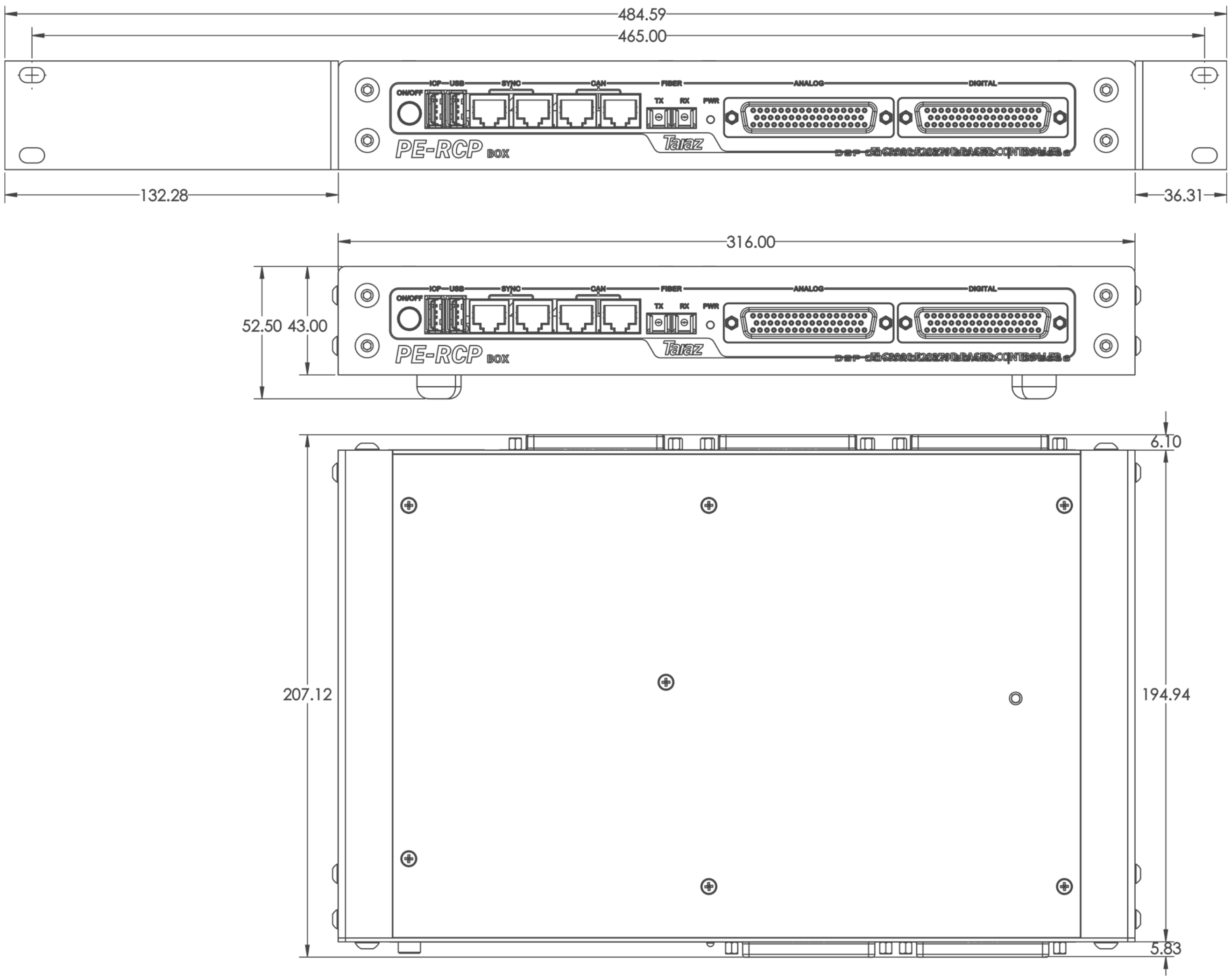
*Note: CAN & Sync speed can differ due to chip shortage, lower speed models may be used if originally intended chips are not available.

General Specifications

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

MECHANICAL

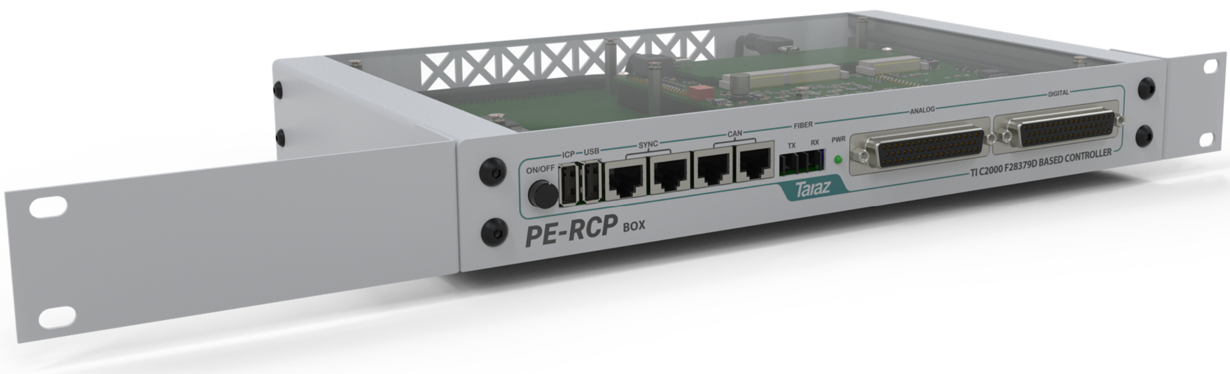
Dimensions



* Note: All dimensions are in mm.

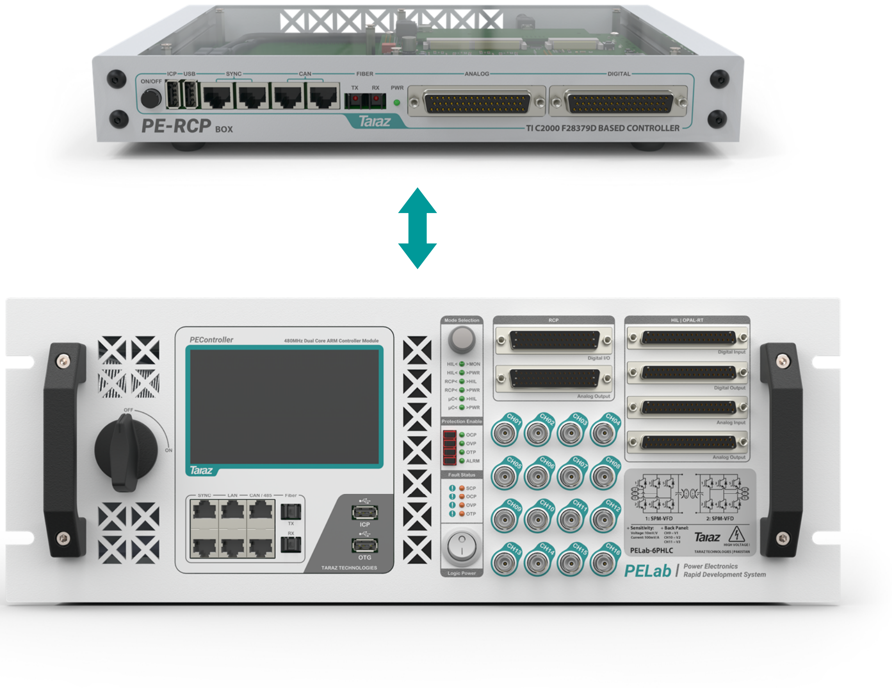
19” Rack Mount Accessories

The PE-RCP Box can be fitted on a 19” standard rack cabinet using the supplies accessories, note that the module is shifted from the middle of the rack in order to align the DB50 connectors between the PE-RCP Box and the PELab in a combined solution.



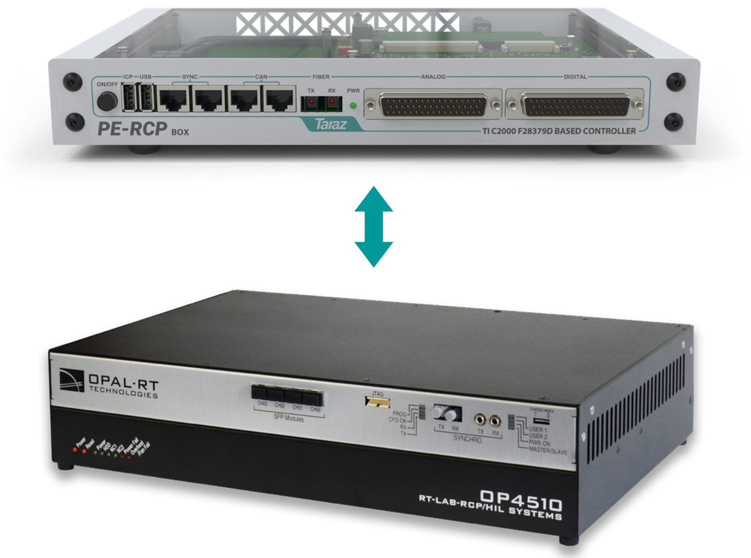
APPLICATION EXAMPLES

Power Electronics Applications



The PE-RCP Box 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 direct interface with the PELab through the DB50 connectors, rapid development of power electronics systems is possible.

Controller Hardware-In-The-Loop Applications



The PE-RCP Box also interfaces directly to OPAL-RT real-time simulators through the DB37 connectors on the rear panel. This enables a low cost RCP controller HIL solution, which can reduce the development time and increase flexibility without investing on the hardware prior to finalizing the control system.

SOFTWARE SUPPORT

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

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

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.

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