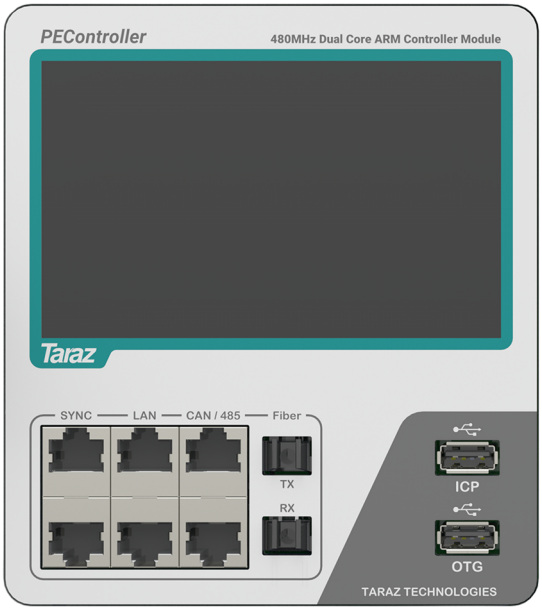
PEController

480MHz Dual-Core ARM Controller Module with 5" Touch Display

OVERVIEW

The PEController is an industrial-grade controller module that is specially designed for power electronics applications. It features dual high accuracy 16-bit ADCs that can perform simultaneous sampling at 250 ksps for all the available 16 channels. It also includes the most common industrial communication protocols and a 5" touch display for the user interface. The isolated Sync/Fiber-optic communication enables fast module to module communication and can be used to develop distributed control system or master-slave operation of multiple controllers. The PEController is built using the ST Microelectronics ARM® Cortex® M7 and M4 dual-core STM32H745BI microcontroller.

This module is supported by open-source embedded C libraries 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 & Control Systems
- ✓ High-Performance Data Acquisition
- ✓ Automatic Testing Systems (ATS)
- ✓ Customized Product Development

Features

- ✓ Dual-Core ARM Cortex M7/M4 STM32H745BI Controller
- ✓ 16 Channels, ±10V Inputs, 250KSps @ 16-Bit, Simultaneous Sampling Dedicated ADC Chips
- ✓ Up to 24 PWM Outputs & 18 Analog Inputs
- ✓ eMMC slot for SD Card
- ✓ USB In Circuit Programming & Debugging
- ✓ Open-Source Embedded C Libraries & Application Examples
- ✓ 5" IPS 800x480 Capacitive Touch Display
- ✓ Multiple Industrial Communication Protocols such as Isolated CAN, Isolated RS-485, LAN, Sync, Fiber Optics & USB 2.0 HS
- ✓ Up to 50 (3.3V/5V) Digital I/Os
- ✓ Quadrature Encoder, SPI, UART & I2C Interfaces
- ✓ Optional intelliSENS Monitoring & DAQ Software Integration
- ✓ Designed for High Reliability & High Temperature Operation

IDE Software Requirements

The PEController is intended to be programmed using embedded C language, and does not support graphical programming such as MATLAB as of yet. The programming and debugging is done through the ICP USB port, following are some of the IDE software that can be used:

- STM32CubeIDE (Free & Recommended)
- STM32CubeMX (Free)
- Keil MDK-ARM
- IAR Embedded Workbench for ARM

Our application examples are built using the STM32CubeIDE, and therefore compete project files will be provided in that format.

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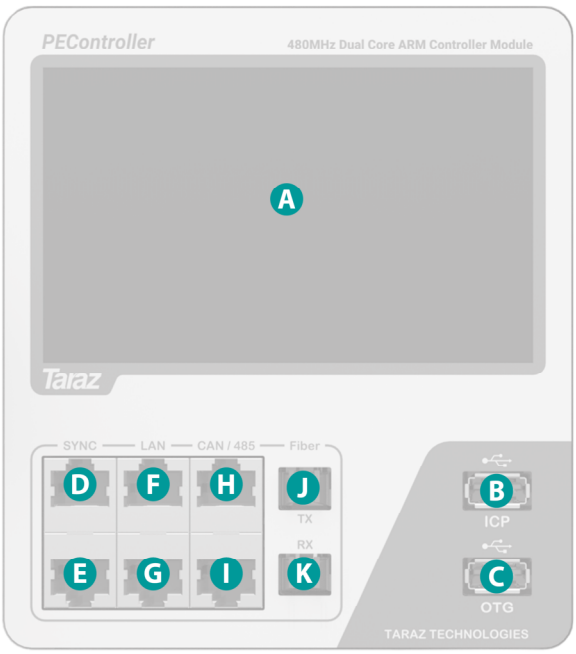
REVISION HISTORY

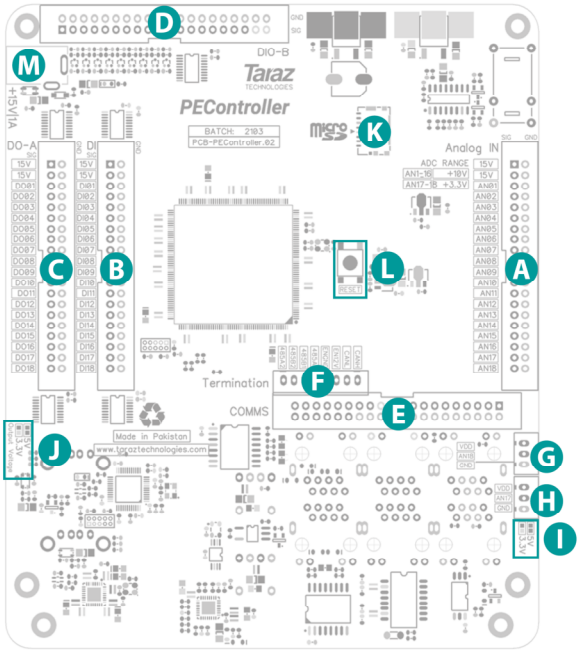
Revision	Date	Changes Description
1.0	22-05-2021	Initial release
2.0	10-04-2022	Second release with major changes and more details

DETAILED DESCRIPTION

Connections and Interface



FRONT

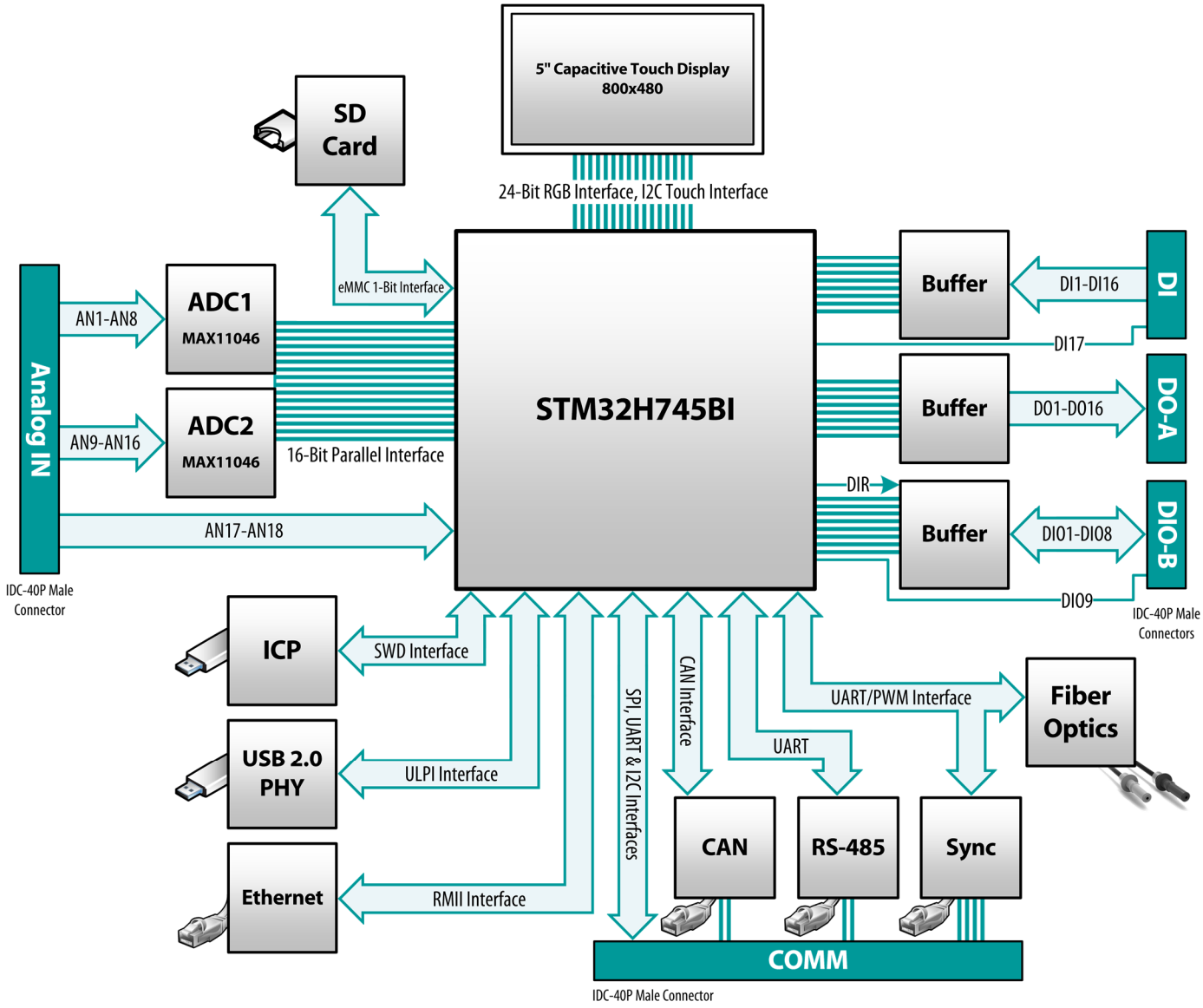


REAR

- A 5" IPS 800x480 Capacitive Touch Display
- B USB for In Circuit Programming & Debugging
- C USB 2.0 HS OTG for Data
- D Isolated Sync (A) RJ-45 Connector
- E Isolated Sync (B) RJ-45 Connector
- F Ethernet LAN (A) RJ-45 Connector
- G Ethernet LAN (B) RJ-45 Connector
- H Isolated CAN/RS-485 (A) RJ-45 Connector
- I Isolated CAN/RS-485 (B) RJ-45 Connector
- J Fiber Optics Transmitter
- K Fiber Optics Receiver

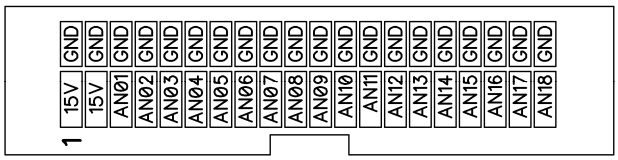
- A Analog Input IDC-40 Male Connector
- B Digital Input IDC-40 Male Connector
- C Digital Output (DO-A) IDC-40 Male Connector
- D Digital I/O (DIO-B) IDC-40 Male Connector
- E Communications IDC-40 Male Connector
- F Termination Resistors Header/Pins
- G AN17 Analog Input Header (Plug Model: XHP-3)
- H AN18 Analog Input Header (Plug Model: XHP-3)
- I 3.3V/5V Configuration SMD Jumpers to AN17-18 Connectors
- J 3.3V/5V Configuration SMD Jumpers to Digital Outputs
- K eMMC slot for SD Card
- L Microcontroller Reset Pushbutton
- M +15VDC, 2A Power Supply Jack

Functional Block Diagram



Pin Mapping

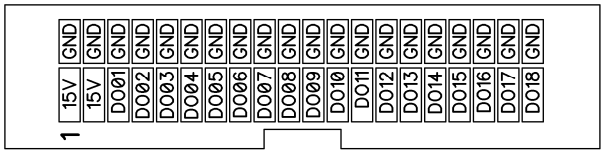
Analog Input IDC-40 Male Connector



Pin Name	Pin No	Description	Alternate Use
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	CH0 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN2	7	CH1 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN3	9	CH2 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN4	11	CH3 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN5	13	CH4 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN6	15	CH5 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN7	17	CH6 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN8	19	CH7 of External ADC1 (MAX11046), ±10V Range, 250 ksps	-
AN9	21	CH0 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN10	23	CH1 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN11	25	CH2 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN12	27	CH3 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN13	29	CH4 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN14	31	CH5 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN15	33	CH6 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN16	35	CH7 of External ADC2 (MAX11046), ±10V Range, 250 ksps	-
AN17	37	ADC12_INP3 (Pin 59) of Internal ADC, 0-3.3V Range, 1Msps	Digital I/O (PA6)*
AN18	39	ADC12_INP18 (Pin 57) of Internal ADC, 0-3.3V Range, 1Msps	Digital I/O (PA4)*

* Check electrical specifications for current rating.

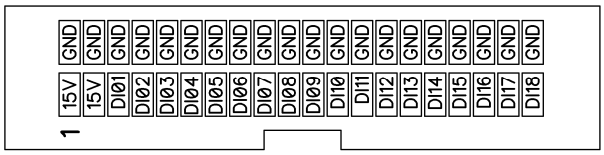
Digital Output Connector (DO-A)



				STM32H745BI Controller	
Pin Name	Pin No.	Description	Alternate Usage	Controller 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	PWM1	PC6 / HRTIM_A1	142
DO2	7	Digital Output, 3.3V/5V Configurable	PWM2 or PWM1B*	PC7 / HRTIM_A2	143
DO3	9	Digital Output, 3.3V/5V Configurable	PWM3	PC8 / HRTIM_B1	144
DO4	11	Digital Output, 3.3V/5V Configurable	PWM4 or PWM3B*	PA8 / HRTIM_B2	146
DO5	13	Digital Output, 3.3V/5V Configurable	PWM5	PA9 / HRTIM_C1	147
DO6	15	Digital Output, 3.3V/5V Configurable	PWM6 or PWM5B*	PA10 / HRTIM_C2	148
DO7	17	Digital Output, 3.3V/5V Configurable	PWM7	PA11 / HRTIM_D1	149
DO8	19	Digital Output, 3.3V/5V Configurable	PWM8 or PWM7B*	PA12 / HRTIM_D2	150
DO9	21	Digital Output, 3.3V/5V Configurable	PWM9	PG6 / HRTIM_E1	136
DO10	23	Digital Output, 3.3V/5V Configurable	PWM10 or PWM9B*	PG7 / HRTIM_E2	137
DO11	25	Digital Output, 3.3V/5V Configurable	PWM11A	PE9 / TIM1_CH1+	77
DO12	27	Digital Output, 3.3V/5V Configurable	PWM11B*	PE8 / TIM1_CH1-	78
DO13	29	Digital Output, 3.3V/5V Configurable	PWM12A	PJ11 / TIM1_CH2+	124
DO14	31	Digital Output, 3.3V/5V Configurable	PWM12B*	PJ10 / TIM1_CH2-	123
DO15	33	Digital Output, 3.3V/5V Configurable	PWM13A	PJ9 / TIM1_CH3+	122
DO16	35	Digital Output, 3.3V/5V Configurable	PWM13B*	PE12 / TIM1_CH3-	83
DO17	37	Not Connected	-	-	-
DO18	39	Not Connected	-	-	-

* Complementary output of another PWM, e.g., PWM1B is the complementary output of PWM1 or PWM1A.

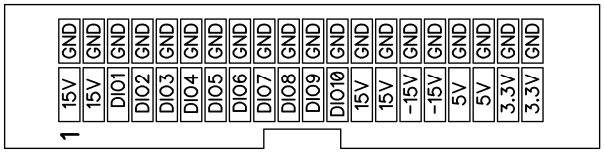
Digital Input Connector (DI)



				STM32H745BI Controller	
Pin Name	Pin No.	Description	Alternate Usage	Controller 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	-	PG1	75
DI2	7	Digital Input, 3.3V~5V	-	PG4	134
DI3	9	Digital Input, 3.3V~5V	-	PG5	135
DI4	11	Digital Input, 3.3V~5V	-	PG8	138
DI5	13	Digital Input, 3.3V~5V	-	PI1	162
DI6	15	Digital Input, 3.3V~5V	-	PI3	164
DI7	17	Digital Input, 3.3V~5V	-	PD4	174
DI8	19	Digital Input, 3.3V~5V	-	PD5	175
DI9	21	Digital Input, 3.3V~5V	-	PG9	180
DI10	23	Digital Input, 3.3V~5V	-	PG15	188
DI11	25	Digital Input, 3.3V~5V	Encoder A	PD12	111
DI12	27	Digital Input, 3.3V~5V	Encoder B	PD11	110
DI13	29	Digital Input, 3.3V~5V	PWMIN1*	PD13 / TIM4_CH2_PWMIN	112
DI14	31	Digital Input, 3.3V~5V	PWMIN2*	PA0 / TIM5_CH1_PWMIN	45
DI15	33	Digital Input, 3.3V~5V	Sigma Delta Channel 0	PE7	76
DI16	35	Digital Input, 3.3V~5V	Sigma Delta Channel 1	PE10	81
DI17	37	Digital Input, 3.3V~5V	Comparator 2 Input	PE11	82
DI18	39	Not Connected	-	-	-

* PWMIN pins can be used as PWM capture and compare modules

Digital Input / Output Connector (DIO-B)



				STM32H745BI Controller	
Pin Name	Pin No.	Description	Alternate Usage	Controller 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/5V Configurable	PWM14A or PWMIN3**	PJ8 / TIM8_CH1+	121
DIO2	7	Digital I/O*, 3.3V/5V Configurable	PWM14B*** or PWMIN4**	PH13 / TIM8_CH1-	156
DIO3	9	Digital I/O*, 3.3V/5V Configurable	PWM15A or PWMIN5**	PJ6 / TIM8_CH2+	117
DIO4	11	Digital I/O*, 3.3V/5V Configurable	PWM15B*** or PWMIN6**	PJ7 / TIM8_CH2-	118
DIO5	13	Digital I/O*, 3.3V/5V Configurable	PWM16A or PWMIN7**	PK0 / TIM8_CH3+	127
DIO6	15	Digital I/O*, 3.3V/5V Configurable	PWM16B*** or PWMIN8**	PK1 / TIM8_CH3-	128
DIO7	17	Digital I/O*, 3.3V/5V Configurable	PWM17A or PWMIN9**	PB8 / TIM16_CH1+	195
DIO8	19	Digital I/O*, 3.3V/5V Configurable	PWM17B*** or PWMIN10**	PB6 / TIM16_CH1-	192
DIO9****	21	Digital Output, 3.3V/5V Configurable	Output Clock for Sigma Delta	PD3 / SIGDEL_CLKOUT	173
DIO10	23	Not Connected	-	-	-
-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. 115 (PD14) of the microcontroller:

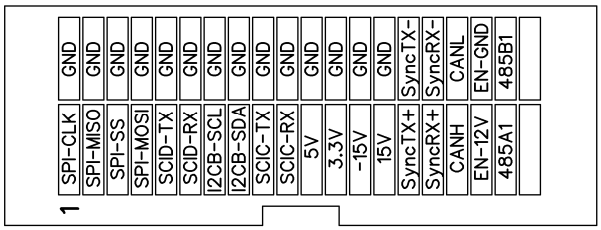
- PD14 (Low): DIO-B configured as output.
- PD14 (High): DIO-B configured as input.

** PWMIN pins can be used as PWM capture and compare modules.

*** Complementary output of another PWM, e.g., PWM1B is the complementary output of PWM1 or PWM1A.

**** DIO9 is unidirectional. DIO9 will always be configured as output irrespective of the state of PD14.

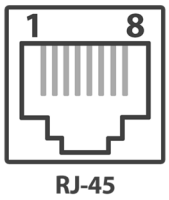
Communications Connector (COMMS)

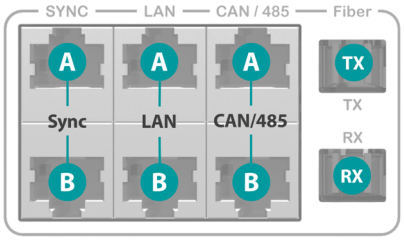


				STM32H745BI Controller	
Pin Name	Pin No.	Description	Alternate Usage	Controller Pin Name	Pin No.
SPI-CLK	1	Clock Pin of SPI3	I2S3_CK	PC10 / I2S3_CK	167
SPI-MISO	3	MISO Pin of SPI3	I2S3_SDI or PWM_FLT1	PC11 / HRTIM_FLT2 / I2S3_SDI	168
SPI-SS	5	SS Pin of SPI3	PWMIN11 or PWM18 or PWM_FLT2	PA15 / TIM2_CH1+ / HRTIM_FLT1	166
SPI-MOSI	7	MOSI Pin of SPI3	Comparator 1 IN+	PB2 / COMP2_INP	65
SCID-TX	9	TX Pin of UART5	I2S3_SDO	PC12 / UART5_TX / I2S3_SDO	169
SCID-RX	11	RX Pin of UART5	-	PD2 / UART5_RX	172
I2CB-SCL	13	Clock Pin of I2C3	-	PH7 / I2C3_SCL	93
I2CB-SDA	15	Data Pin of I2C3	PWMIN12 or PWM19	PC9 / I2C3_SDA / TIM3_CH4+ / TIM8_CH4+	145
SCIC-TX	17	TX Pin of UART7 (Fiber Optics TX)	PWM20	PB4 / UART7_TX / TIM3_CH1+	190
SCIC-RX	19	RX Pin of UART7 (Fiber Optics RX)	PWMIN13	PB3 / UART7_RX / TIM2_CH2+ / HRTIM_FLT4	189
+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	-	-	-
Rs485A1	37	RS-485 Transceiver Non-Inverting I/O	-	-	-
Rs485B1	38	RS-485 Transceiver Inverting I/O	-	-	-
NC	39, 40	Not Connected	-	-	-
GND	2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28	Logic Power Ground	-	-	-

Communication Protocols

Pin Mapping





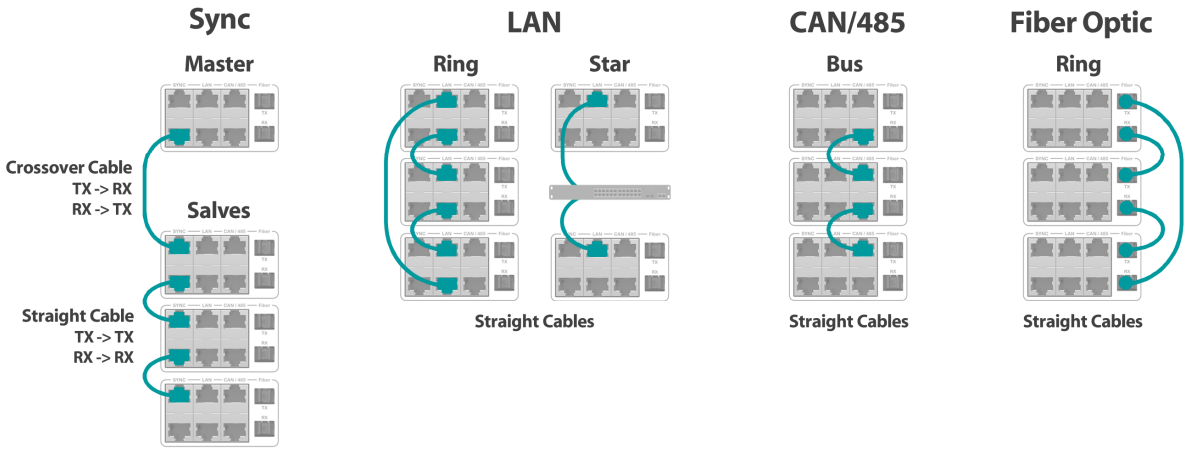
RJ-45	Sync (A&B)		LAN (A)		LAN (B)		CAN / 485 (A&B)	
Pin	Name	Description	Name	Description	Name	Description	Name	Description
1	SYNC-TX+	Sync Transmitter Positive	TX+	Ethernet Transmitter Positive	RX+	Ethernet Receiver Positive	CANH	High-Level CAN Bus Line
2	SYNC-TX-	Sync Transmitter Negative	TX-	Ethernet Transmitter Negative	RX-	Ethernet Receiver Negative	CANL	Low-Level CAN Bus Line
3	GND		RX+	Ethernet Receiver Positive			EN-12V	Enable +
4	GND						EN-GND	Enable -
5	GND						Rs485_A	Transceiver Non-Inverting I/O
6	GND		RX-	Ethernet Receiver Negative			Rs485_B	Transceiver Inverting I/O
7	SYNC-RX-	Sync Receiver Negative						
8	SYNC-RX+	Sync Receiver Positive						
Shield Connected to GND								

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 PEController.

Connection Guide

The PEController 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 PEController uses on-board ICP (STLINK-V2) for programming and debugging using the ICP USB connector. The STLINK-V2 programs the microcontroller via the SWD debug port. To be able to use the on-board ICP, required drivers must be installed on Windows® which can be downloaded using below link:

https://www.st.com/en/development-tools/stsw-link009.html

Connections with Microcontroller

STLINK Function	Controller Pin Name	Controller Pin
SWD_DIO	PA13 / JTMS / SW_DIO	151
SWD_CLK	PA14 / JTCK / SW_CLK	165
Virtual Com Port Rx	PD9 / USART3_RX (Not available in all versions*)	106
Virtual Com Port Tx	PD8 / USART3_TX (Not available in all versions*)	105
MCU Reset	NRST	37

*Note: Some features are lost due to chip shortage, which replacement chip do not support.

Clock & Reset

Clock Sources

Following clock sources are available on the PEController module:

- 24MHz External Crystal
- 50MHz shared oscillator between microcontroller and Ethernet PHY

Connections with Microcontroller

Function	Controller Pin	Controller Pin Name
24MHz OSC_IN	35	PH0 / OSC_IN
24MHz OSC_OUT	36	PH1 / OSC_OUT
50MHz Clock	46	PA1 / ETH_CLK

Reset

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

- Reset button
- STLINK-V2

Analog to Digital Conversion

The PEController incorporates dual, high performance, 16-bit, high precision ADCs (MAX11046), each converting 8 channels with simultaneous sampling capability. Each ADC channel has a pre-buffer stage which sets high impedance to the input, while increasing the input voltage range to ±10V commonly used by most HIL simulators and high accuracy sensors. In addition, 2 channels of internal ADCs with 0-3.3V range are left for low accuracy measurements such as temperature sensors. Following are details of the ADCs:

External ADC1 & ADC2 (MAX11046)

The microcontroller is interfaced with two parallel 16-bit ADCs (MAX11046) each converting 8 channels simultaneously. The data lines for these ADCs are shared, therefore both ADCs can either be used in ping-pong fashion or a single ADC maybe used at a time. Care must be taken so that $\overline{CS}$ pins for both ADCs should never be driven low at the same time as it may damage the ADCs.

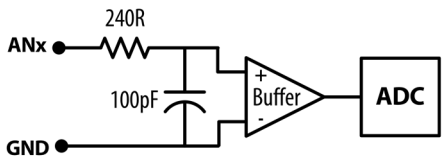
MAX11046 Operation Brief

A Falling Edge on CONVST initiates conversion. $\overline{EOC}$ remains high until the conversion is completed. A falling edge on $\overline{EOC}$ indicates the conversion completion. After EOC transitions low, read the conversion data by driving $\overline{CS}$ and $\overline{RD}$ low. Each low period of $\overline{RD}$ presents the next channel's result. When $\overline{CS}$ or $\overline{RD}$ are high, the data bus is high impedance. $\overline{CS}$ may be driven high between individual channel readouts or left low during the entire 8-channel readout. More details about the ADCs may be acquired from the ADC datasheet.

MAX11046 Connections with Microcontroller

		STM32H745BI Mapping	
MAX11046	Description	ADC1	ADC2
D0-D15	16-bit data lines	PF0- PF15 (22-27, 30-34, 67-71)	PF0- PF15 (22-27, 30-34, 67-71)
$\overline{EOC}$	ADC conversion completion flag	PC14 (11)	PC15 (12)
$\overline{RD}$	Used to acquire data	PC13 (10)	PC13 (10)
$\overline{WR}$	Used to configure the ADC	PI8 (9)	PI8 (9)
$\overline{CS}$	Used to select ADC for data acquisition	PE2 (1)	PE3 (2)
CONVST	Used to start conversion	PH6 / TIM12_CH1 (92)	Pb15 / TIM12_CH2 (104)

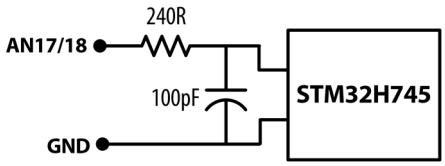
Input Equivalent Circuit



Internal ADC

This ADC is internal to the microcontroller with up to 16-bit resolution at 1Msps. ENOB of internal ADC depends on other modules that are used, which cause higher noise in the ADC, therefore, these channels are not suited for high precision measurements. In addition, no pre-buffer stage is available for this ADC, therefore, analog input impedance must be kept below 3kOhm to achieve good transient response.

Input Equivalent Circuit



RGB LCD Display

The PEController incorporates a 5" display with 800 x 480 resolution and integrated capacitive touch panel. It is connected to the microcontroller using the LCD-TFT module interface. One of the following LCD modules are used in the PEController:

- A0: AFY800480A0-5.0INTH-C, TFT IPS with high brightness 900cd/m2. (Default)
- B0: AFY800480B0-5.0N12NTM-C, TFT with high brightness 427cd/m2.

The touch controller used in both LCD modules is MXT336T which has 10 point touch tracking capability. However, the controllers used in the display modules are different. The A0 uses ST7262 while the B0 uses ILI5960 or ILI6122. Please refer to the modules datasheets for more information.

Operation Overview

The microcontroller's LTDC module is used to control the LCD display. Since the display resolution is 800x480, a 24-bit frame buffer requires 1125Kbytes of memory, which is neither available in RAM or Flash of the microcontroller. To overcome this limitation, following solutions are recommended:

- Use of pallete color formats such as L8/AL88/AL44; this solution is preferred for dynamic window creations such as buttons, measurements, etc. However, only 256 user selected colors can be used on the display at the same time.
- Use of 16-bit static images in the flash; this option does not allow dynamic window creation on the display such as measurements, button, etc. However, it can be used to display static images with high color depths such as logos, etc.
- Use of SD Card memory to store large 24-bit data; this solution will requires significant processing time since it cannot use the available LTDC module of the microcontroller. However, large number of images can be displayed using this solution.

To control the display brightness, a PWM signal is given to directly control the backlight LED current, which in turn changes the brightness as required. The recommended PWM frequency is 1 KHz.

Connections with Microcontroller

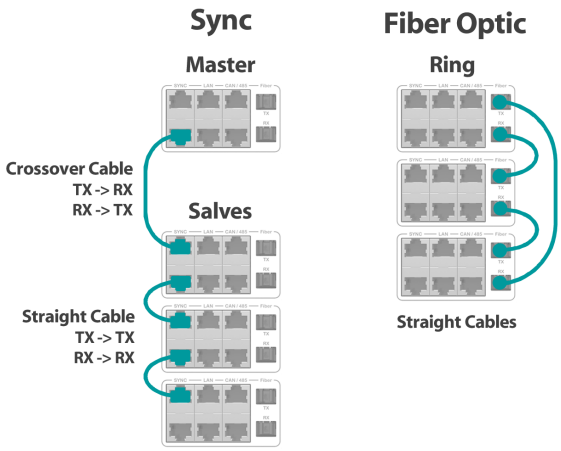
LCD Functionality	Controller Pin Name	Controller Pin
Brightness Control / LED_PWM	PB9 / TIM17_CH1	196
R0	PH2 / LTDC_R0	48
R1	PH3 / LTDC_R1	51
R2	PH8 / LTDC_R2	94
R3	PH9 / LTDC_R3	95
R4	PH10 / LTDC_R4	96
R5	PH11 / LTDC_R5	97
R6	PH12 / LTDC_R6	98
R7	PE15 / LTDC_R7	86
G0	PE5 / LTDC_G0	4
G1	PE6 / LTDC_G1	5
G2	PI15 / LTDC_G2	66
G3	PH14 / LTDC_G3	157
G4	PH15 / LTDC_G4	158
G5	PI0 / LTDC_G5	159
G6	PI11 / LTDC_G6	15
G7	PK2 / LTDC_G7	129
B0	PE4 / LTDC_B0	3
B1	PG12 / LTDC_B1	183
B2	PG10 / LTDC_B2	181
B3	PD10 / LTDC_B3	107

B4	PI4 / LTDC_B4	203
B5	PI5 / LTDC_B5	204
B6	PI6 / LTDC_B6	205
B7	PI7 / LTDC_B7	206
CLK	PE14 / LTDC_CLOCK	85
DISP	PI2 / LCD_DISP	163
HSYNC	PI10 / LTDC_HSYNC	14
VSYNC	PI9 / LTDC_VSYNC	13
DE	PE13 / LTDC_DE	84
CTP_RST	PG3 / CTP_RST	131
CTP_INT	PG2 / CTP_INT	130
CTP_SCL	PH4 / I2C2_SCL	52
CTP_SDA	PH5 / I2C2_SDA	53

Sync & Fiber Optics

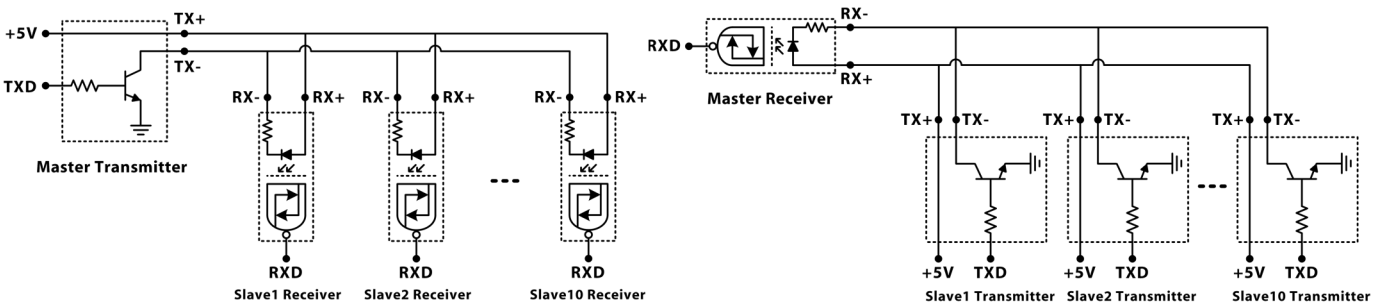
The PEController incorporated a specially designed isolated Sync communication protocol to enable master-slave control and distributed control systems between multiple PEControllers. In this protocol, the master controller can transmit reference signals to all the slave controllers (up to 10 slaves) 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.

Alternatively, fiber optic communication 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.



It is important to note that **either Sync or Fiber Optics can be used at the same time, since both use the same pins** on the microcontroller. Additionally, the TX and RX pins can also operate in PWM and PWMIN modes respectively to enable very high speed reference signal communications. For Sync wiring, we recommend using twisted pair, shielded cable such as Belden 3109A for best performance.

Sync Communication Equivalent Circuit



Connections with Microcontroller

Fiber Optics / Sync	Fiber Optic Model	Controller Pin Name	Controller Pin
TXD	AFBR-1634Z	PB4 / UART7_TX / TIM3_CH1	190
$\overline{\text{RXD}}$	AFBR-2634Z	PB3 / UART7_RX / TIM2_CH2	189

CAN, RS-485 & Battery Enable

The PEController has CAN and RS-485 communication protocols which are standard protocols widely used in industrial equipment. In addition, many commercially available battery packs require 12V enable signal to turn on the battery. The PEController 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 PEController uses an isolated CAN Transceiver IC ISO1042 from Texas Instruments as a bridge to connect the microcontroller FDCAN1 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	PD1 / FDCAN1_TX	171
RXD	PD0 / FDCAN1_RX	170

RS-485 (Half-Duplex) Bus Interface

The PEController uses an isolated RS-485 Transceiver IC ISO1450 from Texas Instruments as a bridge to connect the microcontroller UART to the RS-485 bus. Following are details of the connections between the transceiver IC and the microcontroller:

ISO1450 Pin Name	Controller Pin Name	Controller Pin
R	PE0 / UART8_RX	197
$\overline{\text{RE}}$	GND	-
DE	PD15 / UART8_RTS	116
D	PE1 / UART8_TX	198

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	PB7	193

Termination & Wiring

Both RS-485 and CAN bus requires a 120R termination resistors 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.

Ethernet

The PEController includes a 10M/100M Ethernet communications via an Ethernet PHY (KSZ8041NLI), which supports IEEE 802.3u. The Ethernet PHY is connected to the microcontroller via an RMII interface. The RMII interface is clocked by a 50MHz crystal which is buffered to both the microcontroller and the Ethernet PHY for synchronization. Following are the connection details with the microcontroller.

KSZ8041NLI Pin Name	Controller Pin Name	Controller Pin
MDIO	PA2	47
RX_D1	PC5	62
RX_D0	PC4	61
TX_D1	PG14	185
TX_D0	PG13	184
TX_EN	PG11	182
CRS_DV	PA7	60
MDC	PC1	39
50MHz Clock	PA1 / ETH_REF_CLK	46

USB 2.0 HS OTG

The PEController supports a USB 2.0 high speed communications via a USB-A connector. The controller uses a ULPI interface IC (USB3300) to act as a USB PHY. The PEController 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 PEController is a mass storage, HID or other such device

USB3300 Connections with Microcontroller

USB3300 Pin Name	Controller Pin Name	Controller Pin
D0	PA3	54
D1	PB0	63
D2	PB1	64
D3	PB10	87
D4	PB11	88
D5	PB12	101
D6	PB13	102
D7	PB5	191
DIR	PC2	40
NXT	PC3	41
STP	PC0	38
CLK	PA5	58

SD Card

The PEController has a micro SD card slot, which enables communication between the microcontroller and the micro SD card via 1-Bit eMMC interface. Following are the connections with the microcontroller.

Signal	Controller Pin Name	Controller Pin
D0	PB14	103
INT/DET	PG0	72
CMD	PD7	177
CLK	PD6	176

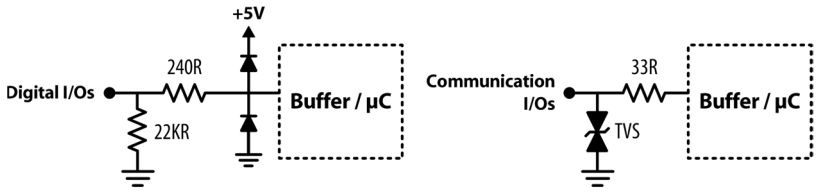
SPECIFICATIONS

Electrical Characteristics

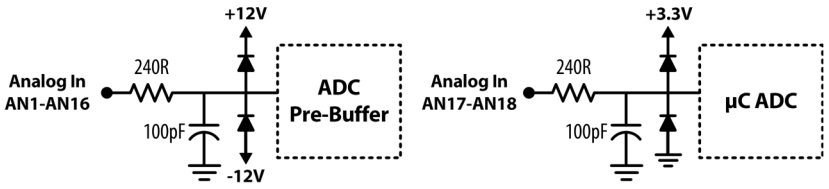
*All ratings are given at 15V power supply and 25°C ambient temperature unless otherwise specified.

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 (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 (AN1-16)		-10	-	10	V
Analog Input Voltage (AN17-18)		0	-	3.3	V

Analog & Digital Electrical Equivalent Circuits



Digital I/Os Equivalent Circuit



Analog Inputs Equivalent Circuit

Communications Characteristics

Protocol	Version/Speed
RS-485	500 kbps ~ 12.5 Mbps
CAN	1 Mbps ~ 5 Mbps
Ethernet	10/100 Mbps
Sync	UART Mode: 12.5 Mbps | PWM Mode: 50 Mbps (20ns Resolution)
Fiber Optics	UART Mode: 12.5 Mbps | PWM Mode: 50 Mbps (20ns Resolution)
OTG USB	2.0 High Speed, 480 Mbps

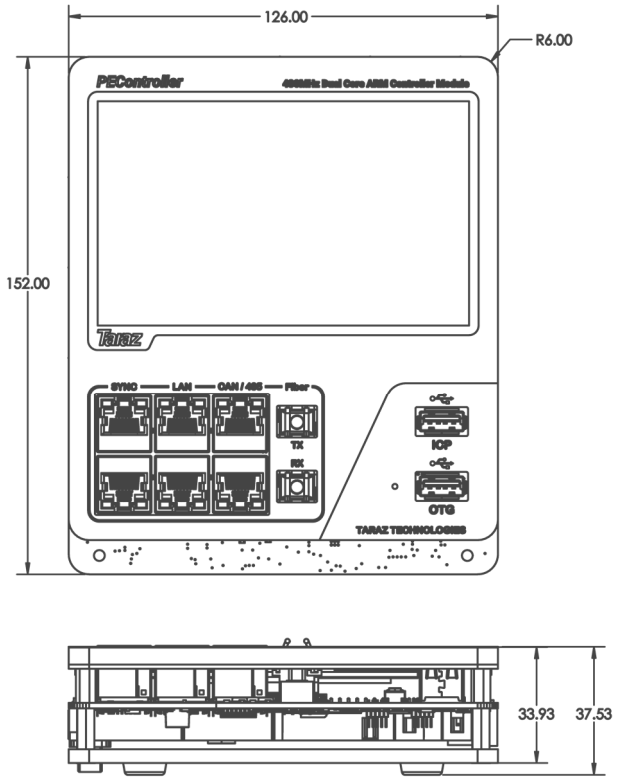
* RS-485, CAN, Sync speed can differ due to chip shortage, lower speed models may be used if originally intended chips are not available.

General Specifications

Parameter	Test Conditions/Notes	Minimum	Typical	Maximum	Unit
Operating Temperature		-20	-	50	℃
Storage Temperature		-40	-	70	℃
Sync, CAN & RS-485 Isolation	AC Voltage, 1 Minute	-	-	1500	V

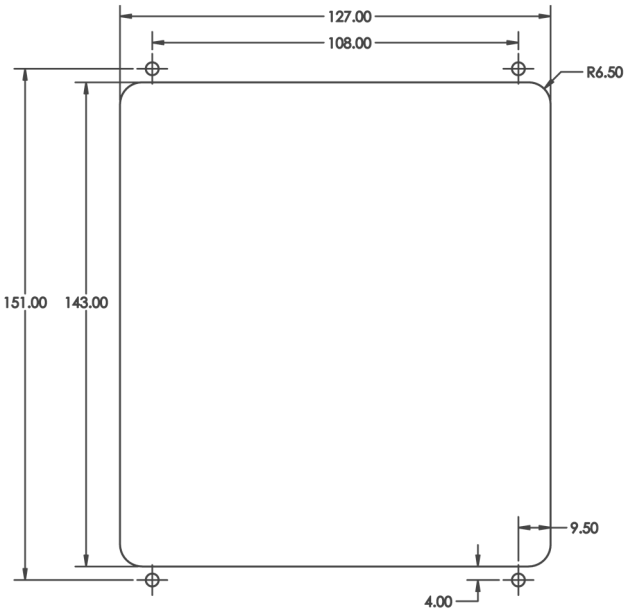
MECHANICAL

Dimensions



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

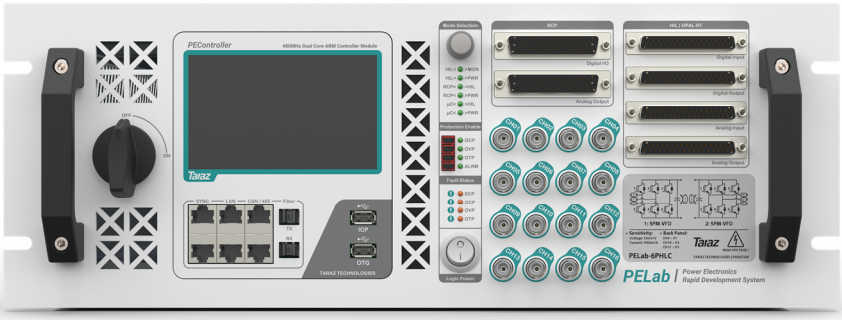
Panel Mount Cutout



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

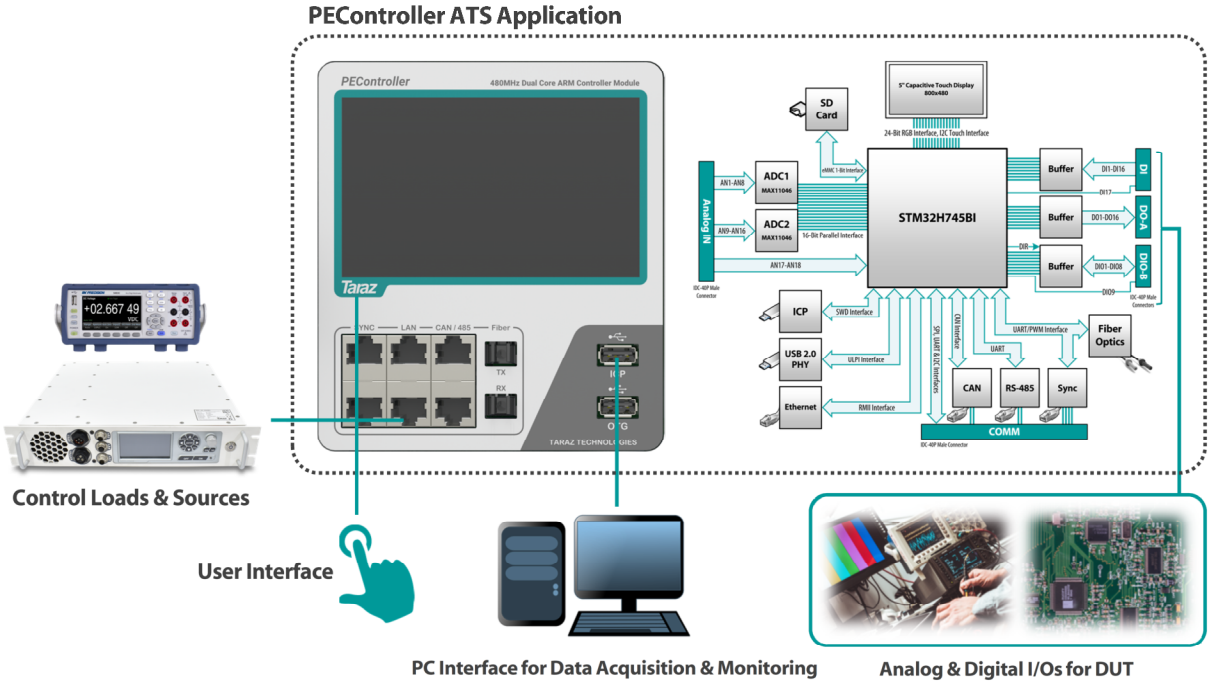
APPLICATION EXAMPLES

Power Electronics Applications



The PEController is ideal for power electronics inverters and converters control system implementation due to its high performance architecture. It is considered a complete control, communication and user interface solution without need for any additional controllers. In addition, the open-source embedded C libraries will greatly accelerate the development cycle of power electronics converters due to the available application examples. Due to its integration in the PELab systems, complete R&D development is possible prior to its integration in the final industrial products.

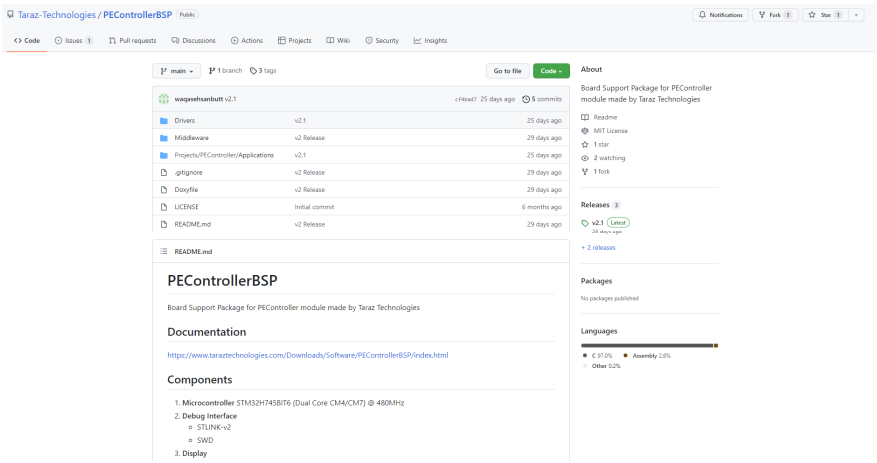
Automatic Testing Systems



The PEController is also particularly suitable for ATS application due to the availability of large number of I/Os, high accuracy measurements, wide range of communications and 5" touch display for user interface. The available communication protocols can directly command programmable power supplies and loads to perform automatic complex testing sequences, while the high accuracy measurements and digital I/Os interface with the Device under Test (DUT). In addition, the user can enter testing information on the touch screen while the USB PC interface can send the testing data and measurements to make automatic reports or integrate with manufacturing systems.

SOFTWARE SUPPORT

Embedded C Libraries & Application Examples



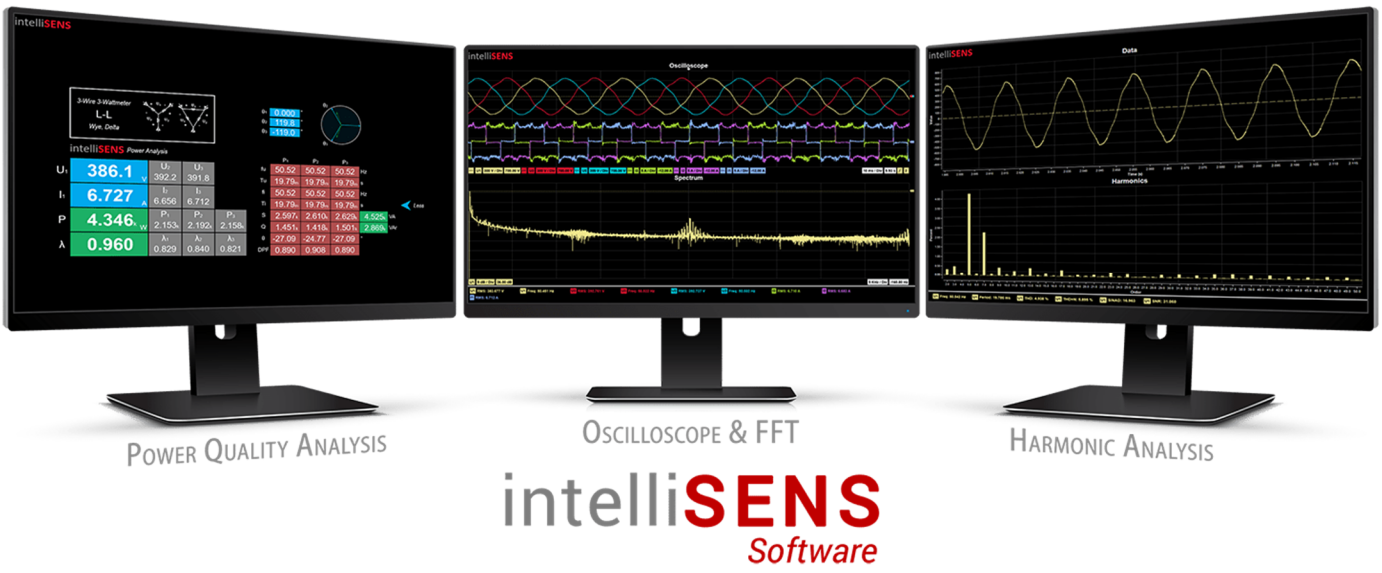
The PEController is supported by open-source embedded C libraries on GitHub. These libraries also includes sample application examples which can accelerate the development. The libraries can be accessed using below link:

- https://github.com/Taraz-Technologies/PEControllerBSP

Optional IntelliSENS Software Integration

The PEController can be purchased with additional intelliSENS software integration license which enables data acquisition at 100 ksps/Channel on the 16-bit ±10V analog inputs. The intelliSENS software is a ready-to-use application software designed to assist students, researchers and engineers in the field of power electronics to develop, monitor & test power electronics systems by replacing multiple lab equipment, such as, oscilloscopes, spectrum analyzers, power analyzers and recorders. It can perform the following:

- The intelliSENS software includes oscilloscope with wide array of measurements, math functions and FFT, enabling both frequency and time domain analysis.
- The intelliSENS software enable harmonic analysis that can calculate THD+N and THD up-to the 100th harmonic and display them in bar or table format similar to traditional power analyzers.
- The intelliSENS software can perform power quality analysis of single and 3 phase power systems determining Real & Reactive Power, Power Factor (PF) and Phase Angle values.
- The Recorder functionality can be achieved using intelliSENS software. In addition, the recorded files retain complete analysis capabilities to enable further analysis by colleagues and collaborators.

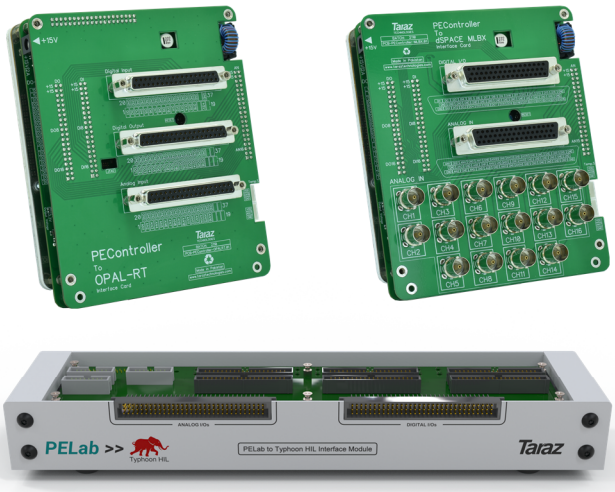


PLUGINS & ACCESSORIES

Real-Time HIL Simulators Interface Daughter Cards & Modules

The PEController 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

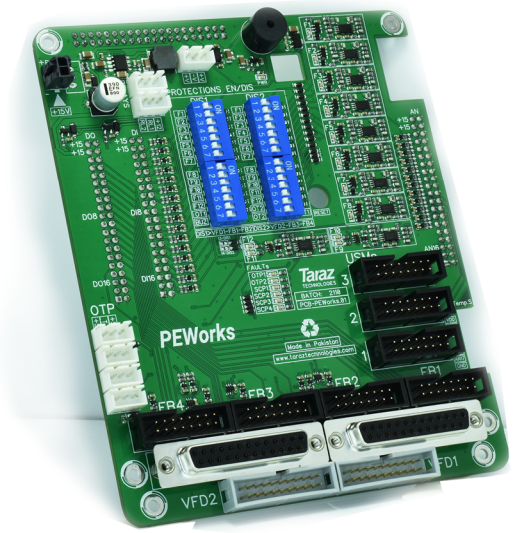
OPAL-RT TECHNOLOGIES
Typhoon HIL
speedgoat real-time simulation and testing
dSPACE
plecs

Power Electronics Interface Daughter Card (PEWorks)

The PEController 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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