EA Control Tech

Modular PLC System

System Manual

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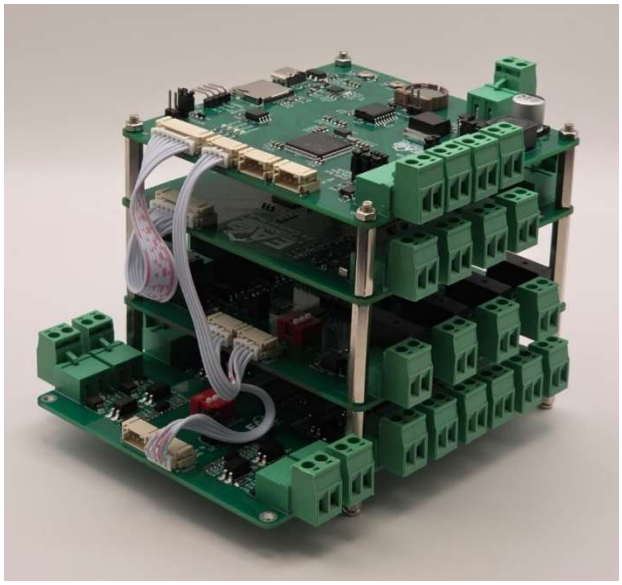
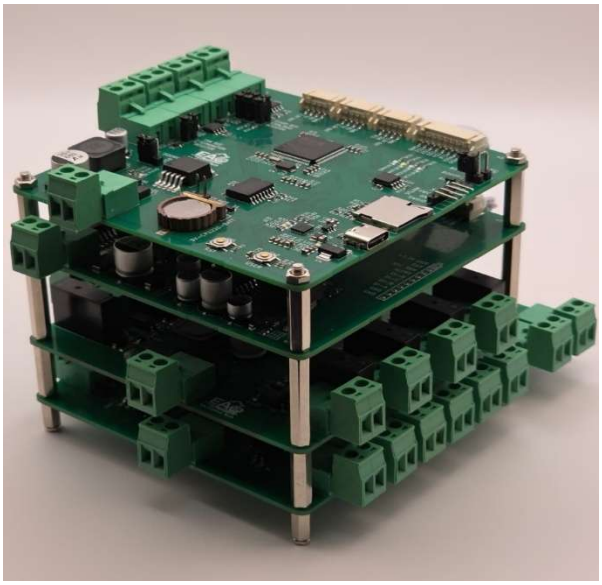
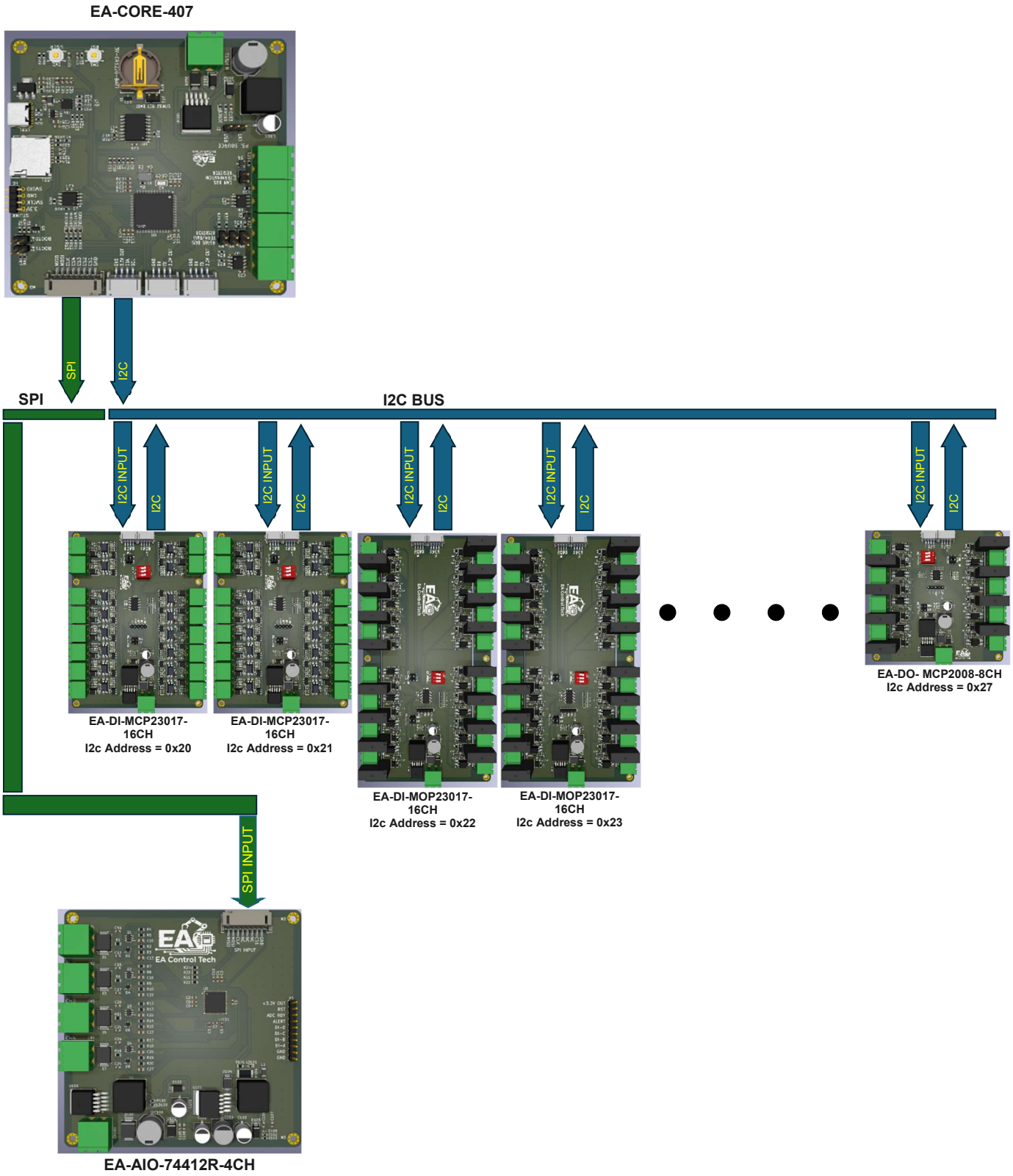




Example System Configuration



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1. Product Overview

The Modular PLC System is a flexible, industrial-grade programmable logic controller platform designed and manufactured by EA Control Tech. The system is built from a set of plug-and-play PCB modules that share common 24 VDC power, I²C, and SPI buses. A customer can assemble any supported configuration to match the I/O requirements of their application without requiring custom hardware.

The central processing unit is the EA-CORE-407, an STM32F407-based industrial CPU board. All I/O expansion modules attach to the shared I²C bus (for digital I/O) or SPI bus (for analog I/O) originating from that CPU.

1.1 Intended Applications

- Industrial automation and machine control
- Process monitoring and discrete I/O acquisition
- PLC replacement and embedded controller expansion
- Relay and contactor control systems
- Alarm, signaling, and remote I/O nodes
- Mixed analog/digital industrial control panels

1.2 Available Modules

The system is composed of the following PCB boards:

Model	Description	Communication	PCB Size
EA-CORE-407	STM32F407 Industrial CPU Board	SPI + I²C + RS485 + CAN	100 × 100 mm
EA-AIO-74412R-4CH	4-Channel Configurable Analog I/O (AD74412R)	SPI	100 × 100 mm
EA-DI-MCP23017-16CH	16-Channel 24 VDC Opto-Isolated Digital Input	I²C	100 × 135 mm
EA-DO-MCP23008-8CH	8-Channel 24 VDC Relay Output w/ Optocouplers	I²C	100 × 100 mm
EA-DO-MCP23017-16CH	16-Channel 24 VDC Relay Output w/ Optocouplers	I²C	100 × 193.5 mm

2. System Configuration Rules

Each Modular PLC System must include exactly one EA-CORE-407 CPU board. Additional I/O expansion modules are added based on the application requirements. The following rules govern which modules and how many can be present in a single system.

2.1 Module Slot Rules

Module	Maximum Quantity per System	Notes
EA-CORE-407 (CPU)	1	Mandatory. Only one CPU allowed per system.
EA-AIO-74412R-4CH (Analog I/O)	1	Only one analog board per system.
EA-DI-MCP23017-16CH (16 DI)	Up to 8 total DI/DO boards (see rules below)	Shares the I²C bus with DO boards.
EA-DO-MCP23008-8CH (8 DO)	Up to 8 total DI/DO boards (see rules below)	Shares the I²C bus with DI boards.
EA-DO-MCP23017-16CH (16 DO)	Up to 8 total DI/DO boards (see rules below)	Shares the I²C bus with DI boards.

2.2 I²C Digital I/O Expansion Rules

All digital I/O modules (EA-DI-MCP23017-16CH, EA-DO-MCP23008-8CH, EA-DO-MCP23017-16CH) share the same I²C bus originating from the EA-CORE-407. Because the MCP23008 and MCP23017 I²C GPIO expanders support a maximum of 8 unique addresses (0x20 through 0x27), the total number of digital I/O boards across all types must not exceed 8.

The allowed combinations are:

16 DI Boards	8 DO Boards	16 DO Boards	Total Boards	Valid?
0–8	0	0	0–8	Yes
0–8	0	0–8	0–8	Yes (mixed DI + 16 DO, sum ≤ 8)
0–8	0–8	0	0–8	Yes (mixed DI + 8 DO, sum ≤ 8)
0–8	0–8	0–8	0–8	Yes (any mix, sum ≤ 8)
any	any	any	> 8	No — exceeds I²C address limit

NOTE: *Each digital I/O board must be assigned a unique I²C address via its DIP switch (A0, A1, A2). Two boards with the same address on the same bus will cause communication errors.*

2.3 SPI Analog I/O Rule

The EA-AIO-74412R-4CH connects to the EA-CORE-407 via the SPI-OUT bus. The AD74412R supports up to 4 chip-select addresses; however, only one analog I/O board is permitted per system in this revision.

2.4 Power Supply Requirements

All modules in the system require 24 VDC supply. Each module includes its own on-board 24 V to 3.3 V buck regulator. Each board must be powered independently from the 24 VDC panel supply, or the 3.3 V logic rail can be sourced from the I²C bus (see Power Source Selection in each module section).

Module	Power Input	On-board Regulation
EA-CORE-407	24 VDC (18–30 V range)	LM2596 → 3.3 V for MCU and peripherals
EA-AIO-74412R-4CH	24 VDC	Buck → 3.3 V digital + VDDA analog rail
EA-DI-MCP23017-16CH	24 VDC	LM2596-3.3V → 3.3 V logic rail
EA-DO-MCP23008-8CH	24 VDC	Buck (LM2596) → 3.3 V logic rail
EA-DO-MCP23017-16CH	24 VDC	Buck (LM2596) → 3.3 V logic rail

3. Configuration Examples

The following examples illustrate typical system builds. Any combination that satisfies the rules in Section 2 is valid.

3.1 Minimum Configuration (CPU Only)

Board	Qty	I²C Address	Notes
EA-CORE-407	1	—	CPU + RS485 + CAN + SPI + I²C master

3.2 Digital I/O System — Small (16 DI + 8 DO)

Board	Qty	I²C Address	Notes
EA-CORE-407	1	—	CPU
EA-DI-MCP23017-16CH	1	0x20	16 digital inputs
EA-DO-MCP23008-8CH	1	0x21	8 relay outputs

3.3 Digital I/O System — Medium (32 DI + 16 DO)

Board	Qty	I²C Address	Notes
EA-CORE-407	1	—	CPU
EA-DI-MCP23017-16CH	2	0x20, 0x21	32 digital inputs
EA-DO-MCP23017-16CH	1	0x22	16 relay outputs

3.4 Digital I/O System — Large (128 DI)

Board	Qty	I²C Addresses	Notes
EA-CORE-407	1	—	CPU
EA-DI-MCP23017-16CH	8	0x20 – 0x27	128 digital inputs (maximum I²C capacity)

3.5 Full Mixed Configuration (CPU + Analog + Mixed DI/DO)

This is the configuration illustrated in the interconnection diagram on the cover page.

Board	Qty	Bus / Address	Notes
EA-CORE-407	1	SPI-OUT + I²C-OUT	CPU
EA-AIO-74412R-4CH	1	SPI	4 analog channels (V in/out, I in/out, RTD)
EA-DI-MCP23017-16CH	2	I²C: 0x20, 0x21	32 digital inputs
EA-DO-MCP23017-16CH	2	I²C: 0x22, 0x23	32 relay outputs
EA-DO-MCP23008-8CH	1	I²C: 0x27	8 relay outputs

NOTE: *Total I²C devices: 5 (0x20, 0x21, 0x22, 0x23, 0x27). Total DI/DO boards: 5. Remaining available I²C addresses: 0x24, 0x25, 0x26.*

3.6 Analog + Digital Mixed

Board	Qty	Bus / Address	Notes
EA-CORE-407	1	SPI-OUT + I²C-OUT	CPU
EA-AIO-74412R-4CH	1	SPI	4 analog I/O channels
EA-DI-MCP23017-16CH	4	I²C: 0x20–0x23	64 digital inputs
EA-DO-MCP23017-16CH	2	I²C: 0x24, 0x25	32 relay outputs

4. CPU Board — EA-CORE-407

4.1 Product Overview

The EA-CORE-407 is an industrial microcontroller board built around the STM32F407VGT6 ARM Cortex-M4 MCU. It serves as the central controller for the Modular PLC System, providing processing, communication, storage, and timing resources. It exposes SPI and I²C expansion buses to drive all I/O modules.

4.2 Key Features

- STM32F407VGT6 — ARM Cortex-M4 at up to 168 MHz, 1 MB Flash, 192 KB SRAM
- RS485 industrial communication interface (USART2, half-duplex, with bias/termination jumpers)
- CAN Bus interface (CAN1, with 120 Ω termination jumper)
- USB-C to UART bridge (CP2102) for debug and firmware programming
- SPI-OUT expansion bus — drives the analog I/O board (CS1–CS4 available)
- I²C-OUT expansion bus — drives all digital I/O modules
- W25Q128 128 Mbit SPI Flash for firmware storage and data logging
- MicroSD card slot (SPI2) for large-capacity storage
- DS3231SN precision RTC with CR1220 battery backup
- ST-LINK SWD debug header (SWCLK / SWDIO)
- Four status LEDs (Green, White, Red, Blue)
- 24 VDC industrial power input (18–30 V supported), LM2596 3.3 V regulator
- 100 × 100 mm, 4-layer PCB, 4 × M3 mounting holes

4.3 Electrical Characteristics

Microcontroller

Feature	Specification
Part	STM32F407VGT6
Core	ARM Cortex-M4
Clock Frequency	Up to 168 MHz (8 MHz HSE crystal, X1)
Flash	1 MB internal
SRAM	192 KB
Operating Voltage	3.3 V
Peripherals	UART, SPI, I²C, CAN, USB, ADC, Timers

Power System

Parameter	Value
Input Voltage	24 VDC nominal (18–30 V range)
Input Protection	Reverse polarity diode + TVS suppressor + bulk filtering
On-board Regulator	LM2596 switching buck → 3.3 V
3.3 V Load	STM32F407 + all on-board peripherals
Power Source Jumper	Selects external 24 V supply or USB power

4.4 Communication Interfaces Summary

Interface	Standard	STM32 Peripheral	Typical Use
USB-UART	USB / Virtual COM	USART1 (PA9, PA10)	Debug terminal, firmware upload
RS485	Industrial bus	USART2 (PA2, PA3)	PLC / Modbus RTU communication
CAN Bus	CAN 2.0	CAN1 (PA11, PA12)	Field device network
SPI-OUT	4-wire SPI	SPI3 (PB3–PB5)	Analog I/O module expansion
I²C-OUT	I²C	I²C1 (PB8, PB9)	Digital I/O module expansion
UART1	Serial	USART6 (PC6, PC7)	Auxiliary serial device
UART2	Serial	UART3 (PC10, PC11)	Auxiliary serial device

4.5 Real-Time Clock

The DS3231SN RTC provides temperature-compensated, battery-backed timekeeping over I²C2 (PB10 / PB11). A CR1220 coin-cell battery maintains the RTC and STM32 backup registers when main power is removed. A jumper enables or disables the backup battery connection.

4.6 External Memory

Device	Interface	Capacity	STM32 Peripheral	Typical Use
W25Q128 Flash	SPI1 (PA4–PA7)	128 Mbit	SPI1	Firmware, configuration, data logging
MicroSD Card	SPI2 (PB12–PB15)	User card	SPI2	Large-capacity data and file storage

4.7 Programming and Debugging

ST-LINK SWD Header

Pin	Signal	STM32 Pin	Description
1	3.3V	—	Target reference voltage
2	SWCLK	PA14	Debug clock
3	GND	—	Ground
4	SWDIO	PA13	Debug data

Boot Mode Jumpers

BOOT1	BOOT0	Mode
0	0	Flash (normal run)
0	1	System Bootloader (UART firmware upload)
1	1	SRAM (for test)

> **NOTE:** *The CP2102 USB-UART bridge auto-controls BOOT0 (via RTS) and NRST (via DTR), allowing firmware tools to automatically enter and exit bootloader mode.*

4.8 Connector Pinouts

RS485 Connector

Pin	Signal	Description
1	RS485-B	Differential line B
2	GND	Signal ground
3	VBUS	Optional bus power
4	RS485-A	Differential line A

CAN Bus Connector

Pin	Signal	Description
1	CANL	CAN Low
2	GND	Signal ground
3	VBUS	Optional bus power
4	CANH	CAN High

SPI Expansion Connector (SPI-OUT)

Pin	Signal	STM32 Pin	Description
1	MOSI	PB5 (SPI3)	SPI master output
2	MISO	PB4 (SPI3)	SPI master input
3	SCLK	PB3 (SPI3)	SPI clock
4	CS1	PD0	Chip select 1
5	CS2	PD1	Chip select 2
6	CS3	PD2	Chip select 3
7	CS4	PD3	Chip select 4
8	GND	—	Ground

I²C Connector (I²C-OUT)

Pin	Signal	STM32 Pin	Description
1	3.3V	—	Power reference
2	GND	—	Ground
3	SDA	PB9 (I²C1)	I²C data
4	SCL	PB8 (I²C1)	I²C clock

4.9 GPIO Map Summary

Key peripheral-to-pin assignments on the STM32F407VGT6:

Signal	STM32 Pin	Pin #	Function
RS485_TX	PA2	25	RS485 UART transmit
RS485_RX	PA3	26	RS485 UART receive
RS485_DE	PA1	24	RS485 driver enable
CAN_RX	PA11	70	CAN1 receive
CAN_TX	PA12	71	CAN1 transmit
SPI_FLASH_CS	PA4	29	W25Q128 chip select (SPI1)
SPI_MISO (OUT)	PB4	90	SPI3 MISO — expansion bus
SPI_MOSI (OUT)	PB5	91	SPI3 MOSI — expansion bus
SPI_CLK (OUT)	PB3	89	SPI3 CLK — expansion bus
CS1–CS4	PD0–PD3	81–84	Analog I/O chip selects

Signal	STM32 Pin	Pin #	Function
I2C_SDA	PB9	96	I²C1 data — digital I/O bus
I2C_SCL	PB8	95	I²C1 clock — digital I/O bus
RTC_SDA	PB11	48	I²C2 data — DS3231 RTC
RTC_SCL	PB10	47	I²C2 clock — DS3231 RTC
uSD_CS	PB12	51	MicroSD chip select (SPI2)
UART1_TX	PC6	63	Auxiliary UART1 transmit
UART1_RX	PC7	64	Auxiliary UART1 receive
UART2_TX	PC10	78	Auxiliary UART2 transmit
UART2_RX	PC11	79	Auxiliary UART2 receive
LED_GRN	PD12	59	Green status LED
LED_WHT	PD13	60	White status LED
LED_RED	PD14	61	Red status LED
LED_BLU	PD15	62	Blue status LED

4.10 Mechanical Specifications

Parameter	Value
PCB Dimensions	100 mm × 100 mm
Mounting	4 × M3 holes
PCB Type	4-layer PCB
Form Factor	Square industrial PCB

5. Analog I/O Board — EA-AIO-74412R-4CH

5.1 Product Overview

The EA-AIO-74412R-4CH is a 4-channel configurable analog input/output board built around the Analog Devices AD74412R software-configurable I/O platform. Each of the four channels can be independently configured in firmware to operate in any of five modes. It connects to the EA-CORE-407 via the SPI-OUT bus and is the only analog module permitted per system.

5.2 Key Features

- 4 independently software-configurable analog channels
- Based on the Analog Devices AD74412R configurable analog I/O IC
- 24 VDC industrial power input with TVS surge protection and reverse polarity protection
- Integrated buck DC/DC regulators (3.3 V digital rail + VDDA analog rail)
- SPI daisy-chain input and output connectors for multi-board expansion
- Hardware chip-select address jumpers (CS1–CS4)
- Auxiliary header exposing RESET, ALERT, ADC_READY, DI-A through DI-D
- 100 × 100 mm PCB, 4 × M3 mounting holes
- Non-isolated shared-ground architecture

5.3 Channel Operating Modes

Each channel is independently configured via SPI. The following modes are supported per channel:

Mode	Range	Description
Voltage Input	0 – 10 V	Measures an external 0–10 V signal
Current Input	0 – 25 mA	Measures loop current (externally or board-powered)
Voltage Output	0 – 11 V	Sources a programmable voltage to a load
Current Output	0 – 25 mA	Sources a programmable current to a loop
RTD Input	PT100 / PT1000 (2-wire)	Temperature measurement via resistance sensing

NOTE: *Mode selection is entirely firmware controlled. Applying a signal outside the configured mode range may produce incorrect readings or damage the channel. Always verify the channel mode in firmware before connecting field signals.*

5.4 Electrical Characteristics

Power Input

Parameter	Value
Nominal Supply	24 VDC
Input Protection	Reverse polarity diode + TVS suppression
On-board Regulation	Buck → 3.3 V digital + VDDA analog rail
VDDA Purpose	Analog output drivers, current outputs, RTD excitation

SPI Interface

Parameter	Specification
Interface Type	4-wire SPI
SPI Mode	Mode 1 (CPOL = 0, CPHA = 1)
Logic Level	3.3 V
Max SPI Clock	Per AD74412R datasheet
Multi-board	SPI daisy-chain via SPI IN / SPI OUT connectors

5.5 Auxiliary Control Header (H5)

Pin	Label	Direction	Description
1	+3.3V OUT	Output	Regulated 3.3 V reference (light auxiliary use only)
2	RST	Input	Hardware reset for AD74412R — useful during startup or fault recovery
3	ADC_RDY	Output	ADC conversion ready — enables deterministic sampling without polling
4	ALERT	Output	Device fault/diagnostic output — interrupt-driven error handling
5	DI-D	Input	AD74412R Digital Input D
6	DI-C	Input	AD74412R Digital Input C
7	DI-B	Input	AD74412R Digital Input B
8	DI-A	Input	AD74412R Digital Input A
9	GND	—	Ground
10	GND	—	Ground

NOTE: *DI-A through DI-D are directly connected to the AD74412R digital input pins and must be driven with 3.3 V logic referenced to board GND.*

5.6 SPI Connector Pinout

Pin	Label	Description
1	MISO	Master In Slave Out
2	MOSI	Master Out Slave In
3	CLK	SPI Clock
4	CS4	Chip Select 4
5	CS3	Chip Select 3
6	CS2	Chip Select 2
7	CS1	Chip Select 1
8	GND	Ground reference

5.7 Wiring Guidelines

Power

- Connect 24 VDC to the +24VDC terminal and 0 V to GND.
- Use a stable, regulated industrial 24 VDC supply.

Voltage Input (0–10 V)

- Signal positive → CHx+
- Signal return → CHx−
- Do not exceed 10 VDC on CHx+ in voltage input mode.

Current Input (0–25 mA)

Two wiring methods are supported:

  - Externally powered source: current source positive → CHx+, return → CHx−. The board measures loop current without sourcing excitation.
  - Loop-powered (board-sourced): CHx+ → transmitter +, transmitter − → CHx−. The channel provides loop drive and measures return current.

Voltage Output (0–11 V)

- CHx+ → load input, CHx− → load return.

Current Output (0–25 mA)

- CHx+ → load, load return → CHx−.
- Ensure total loop resistance does not exceed device compliance limits (set by VDDA level).

RTD (2-Wire PT100 / PT1000)

- RTD lead 1 → CHx+, RTD lead 2 → CHx−.
- Only 2-wire RTD configuration is supported in hardware revision V1.0.
- Accuracy depends on lead resistance — apply calibration offsets in firmware if required.

Grounding

The EA-AIO-74412R-4CH is non-isolated. All I/O share a common system ground. Avoid connecting to field devices with different ground potentials. In high-noise environments, use shielded cables and single-point grounding.

5.8 Operating Limits

Mode	Max Input / Output	Safety Note
Voltage Input	10 VDC max on CHx+	Do not apply voltage exceeding 10 V.
Current Input	25 mA max through channel	Do not exceed 25 mA.
Voltage Output	0–11 V range	Do not short-circuit the output.
Current Output	25 mA max	Ensure loop resistance stays within compliance window.
RTD Mode	PT100 / PT1000 only	Do not connect external voltages to RTD terminals in RTD mode.

5.9 Mechanical Specifications

Parameter	Value
PCB Dimensions	100 mm × 100 mm
Mounting	4 × M3 holes
Form Factor	Square industrial PCB

6. 16-Channel Digital Input Board — EA-DI-MCP23017-16CH

6.1 Product Overview

The EA-DI-MCP23017-16CH is a 16-channel 24 VDC digital input module based on the MCP23017 I²C GPIO expander. It provides robust industrial input conditioning with per-channel opto-isolation, surge protection, and RC filtering. Digital input state is read by the host controller via I²C at 3.3 V logic level.

6.2 Key Features

- 16 × 24 VDC digital inputs (sourcing / PNP-style)
- Per-channel opto-isolation (EL817) — field side isolated from logic side
- Per-channel protection: reverse polarity diode + TVS clamp + series resistor
- Per-channel RC filtering for transient/noise reduction
- MCP23017 I²C GPIO expander — 3.3 V logic interface
- I²C address selection via A0/A1/A2 DIP switch (8 addresses: 0x20–0x27)
- Optional I²C pull-up enable jumpers (JP3/JP4) for SDA and SCL
- Separate INTA and INTB interrupt outputs exposed
- RESET signal exposed
- I²C IN and I²C OUT connectors for bus daisy-chaining
- On-board 24V → 3.3V buck regulator (LM2596-3.3V)
- Power source selection: on-board regulator or external 3.3V from I²C bus
- 100 × 135 mm PCB, M3 mounting holes

6.3 Electrical Characteristics

Power Input

Parameter	Value
Nominal Supply	24 VDC
Input Protection	Reverse polarity diode + TVS suppression
On-board Regulation	LM2596-3.3V buck regulator
3.3V Source Selection	On-board regulator or external 3.3V via I²C bus (PS SOURCE jumper)

Digital Inputs (Per Channel)

Parameter	Value
Input Type	24 VDC sourcing (PNP-style)
Isolation	Opto-isolated — EL817 optocoupler
Input Polarity	Active HIGH at MCP23017 when 24 V applied to IN+
Input Current	~6.8 mA per channel at 24 V (typical)
All-inputs ON	~108 mA total field-side current (worst case)
ON Threshold	≥ 12 VDC recommended for reliable detection
OFF Threshold	≤ 5 VDC recommended
Protection	Reverse polarity diode + TVS + series resistance + RC filter

I²C Interface

Parameter	Value
Communication	I²C
Logic Level	3.3 V
Device	MCP23017 GPIO expander
Interrupts	INTA, INTB exposed on Control Header J1
Reset	RESET exposed on Control Header J1

6.4 Signal Behavior

Field Condition	Optocoupler	MCP23017 Input
24 V applied to IN+	ON (conducting)	Logic HIGH
No voltage / < 5 V	OFF	Logic LOW

6.5 Connector Pinouts

Digital Input Terminals — PORT A (IN1–IN8)

Channel	Terminal	Wiring
IN1–IN8	IN x+ (positive)	Connect 24 VDC signal
IN1–IN8	IN x− (return)	Connect field return / 0 V

NOTE: *PORT B (IN9–IN16) has identical electrical behavior. Apply 24 V to the '+' terminal of each channel for a logic HIGH reading at the MCP23017.*

I²C IN Connector

Pin (Top→Bottom)	Signal	Description
1	SCL	I²C clock from host
2	SDA	I²C data from host
3	3.3V IN	3.3V power (optional)
4	GND	Ground

I²C OUT Connector (Daisy-Chain)

Pin (Top→Bottom)	Signal	Description
1	GND	Ground
2	3.3V OUT	3.3V power to next module
3	SDA	I²C data
4	SCL	I²C clock

Control / Interrupt Header (J1)

Pin (Top→Bottom)	Signal	Description
1	3.3V OUT	3.3V reference output
2	INTB	MCP23017 Port B interrupt
3	INTA	MCP23017 Port A interrupt
4	RESET	Hardware reset
5	GND	Ground

6.6 I²C Address Selection

Address	A2	A1	A0
0x20	OFF	OFF	OFF
0x21	OFF	OFF	ON
0x22	OFF	ON	OFF
0x23	OFF	ON	ON
0x24	ON	OFF	OFF
0x25	ON	OFF	ON
0x26	ON	ON	OFF
0x27	ON	ON	ON

NOTE: *Set jumpers JP3/JP4 to enable on-board I²C pull-up resistors (3.3 V) for SDA and SCL only if no other pull-ups exist on the bus. When daisy-chaining multiple modules, enable pull-ups on only one board.*

6.7 Operating Limits and Safety

- Inputs are designed for 24 VDC sourcing (PNP) signals only.
- Do not exceed nominal 24 VDC system levels on the input terminals.
- Verify wiring polarity per terminal marking (+ / −) before powering.
- Field ground is isolated from logic ground — do not intentionally connect them.
- Disconnect power before making wiring changes.

6.8 Mechanical Specifications

Parameter	Value
PCB Dimensions	100 mm × 135 mm
Mounting	M3 holes
Input Count	16 channels

7. 8-Channel Digital Output Board — EA-DO-MCP23008-8CH

7.1 Product Overview

The EA-DO-MCP23008-8CH is an 8-channel relay output module designed for industrial 24 VDC control systems. It is based on the MCP23008 I²C GPIO expander and drives eight relay output contacts through optocoupler-isolated driver stages. Each output channel is independently controllable via the I²C bus.

7.2 Key Features

- 8 × SPST normally open relay outputs
- MCP23008 I²C GPIO expander — 3.3 V logic interface
- Optocoupler-driven relay control (EL817) for signal isolation
- MOSFET/transistor driver stage per output
- Flyback diode protection for relay coils
- Per-output status LEDs
- I²C address selection via DIP switch (A0, A1, A2) — 8 addresses
- Interrupt output (INT) and hardware RESET exposed on control header
- I²C IN and I²C OUT connectors for bus expansion
- On-board 24V → 3.3V buck regulator (LM2596)
- Power source selection: on-board regulator or I²C bus 3.3V
- 100 × 100 mm PCB, M3 mounting holes

7.3 Output Operation

Output activation is controlled by the MCP23008 GPIO output register:

GPIO Pin State	Optocoupler	MOSFET/Transistor	Relay Coil	External Load
HIGH (logic 1)	ON	ON (conducting)	Energized	Connected (relay closed)
LOW (logic 0)	OFF	OFF	De-energized	Disconnected (relay open)

7.4 Electrical Characteristics

Power Supply

Parameter	Value
Nominal Supply	24 VDC
Input Protection	Reverse polarity diode + TVS suppression
On-board Regulation	LM2596 buck → 3.3 V logic rail
3.3V Source Selection	On-board regulator (EXT) or I²C bus (BUS) via PS SOURCE jumper

Logic Interface

Parameter	Value
Communication	I²C
Logic Level	3.3 V
Device	MCP23008
Interrupts	INT exposed
Reset	RESET exposed

Relay Output Specifications

Parameter	Value
Number of Outputs	8 channels
Relay Type	SPST Normally Open — G5NB-1A-E-24VDC
Contact Rating	5 A
Maximum Load Voltage	30 VDC / 250 VAC
Coil Voltage	24 VDC
Coil Resistance	2.88 kΩ
Coil Power	~200 mW
Coil Current	~8.3 mA
Operating Temperature	−40°C to +85°C
Contact Material	Silver Alloy, Cd-Free
Output Connector	WJ2EDGRC-5.08-2P (~15 A contact rating)

7.5 Inductive Load Protection

Each output channel includes a flyback diode across the relay coil driver stage. This protects the switching transistor when the relay de-energizes and the stored magnetic energy collapses. Suitable for driving relay coils, solenoids, and contactors.

7.6 I²C Address Selection

Address	A2	A1	A0
0x20	OFF	OFF	OFF
0x21	OFF	OFF	ON
0x22	OFF	ON	OFF
0x23	OFF	ON	ON
0x24	ON	OFF	OFF
0x25	ON	OFF	ON
0x26	ON	ON	OFF
0x27	ON	ON	ON

NOTE: *Up to 8 modules may share the same I²C bus as long as each has a unique address. Total count across all DI and DO board types must not exceed 8.*

7.7 Connector Pinouts

I²C IN

Pin	Signal	Description
1	SCL	I²C clock
2	SDA	I²C data
3	3.3V IN	Power input
4	GND	Ground

I²C OUT

Pin	Signal	Description
1	GND	Ground
2	3.3V OUT	Power output to next module
3	SDA	I²C data
4	SCL	I²C clock

Control Header

Signal	Description
3.3V OUT	3.3V reference output
INT	MCP23008 interrupt output
RESET	Hardware reset
GND	Ground
GND	Ground

7.8 Mechanical Specifications

Parameter	Value
PCB Dimensions	100 mm × 100 mm
Mounting	M3 holes
Output Count	8 channels

8. 16-Channel Digital Output Board — EA-DO-MCP23017-16CH

8.1 Product Overview

The EA-DO-MCP23017-16CH is a 16-channel relay output module designed for industrial 24 VDC control systems. It is based on the MCP23017 I²C GPIO expander and drives sixteen relay output contacts through optocoupler-isolated driver stages divided across Port A (OUT1–OUT8) and Port B (OUT9–OUT16).

8.2 Key Features

- 16 × SPST normally open relay outputs
- MCP23017 I²C GPIO expander — 3.3 V logic interface
- Optocoupler-driven relay control for improved signal integrity
- MOSFET/transistor driver stage + flyback protection per output
- Per-output status LEDs
- I²C address selection via DIP switch (A0, A1, A2)
- INTA / INTB interrupt outputs and hardware RESET exposed
- I²C IN and I²C OUT connectors for bus daisy-chaining
- On-board 24V → 3.3V buck regulator; optional external 3.3V
- 100 × 193.5 mm PCB, M3 mounting holes

8.3 Output Operation

GPIO Pin State	Optocoupler	MOSFET/Transistor	Relay Coil	External Load
HIGH (logic 1)	ON	ON (conducting)	Energized	Connected (relay closed)
LOW (logic 0)	OFF	OFF	De-energized	Disconnected (relay open)

8.4 Electrical Characteristics

Power Supply

Parameter	Value
Nominal Supply	24 VDC
Input Protection	Reverse polarity diode + TVS suppression
On-board Regulation	LM2596 buck → 3.3 V logic rail
3.3V Source Selection	On-board (EXT) or I²C bus (BUS) via PS SOURCE jumper

Relay Output Specifications

Parameter	Value
Number of Outputs	16 channels (Port A: OUT1–OUT8, Port B: OUT9–OUT16)
Relay Type	SPST Normally Open — G5NB-1A-E-24VDC
Contact Rating	5 A
Maximum Load Voltage	30 VDC / 250 VAC
Coil Voltage	24 VDC
Coil Resistance	2.88 kΩ
Coil Power	~200 mW
Coil Current	~8.3 mA
Operating Temperature	−40°C to +85°C
Contact Material	Silver Alloy, Cd-Free
Output Connector	WJ2EDGRC-5.08-2P (~15 A contact rating)

8.5 Output Terminals

Outputs are organized into two ports corresponding to the MCP23017 Port A and Port B GPIO banks:

Port	Channels	MCP23017 Bank
Port A	OUT1 – OUT8	Port A (GPA0–GPA7)
Port B	OUT9 – OUT16	Port B (GPB0–GPB7)

8.6 I²C Interface and Address Selection

Identical to the EA-DO-MCP23008-8CH. See the address table in Section 7.6. The MCP23017 exposes INTA and INTB (one per port) rather than a single INT pin.

Control Header

Signal	Description
3.3V OUT	3.3V reference
INTB	Port B interrupt
INTA	Port A interrupt
RESET	Hardware reset
GND	Ground

8.7 Mechanical Specifications

Parameter	Value
PCB Dimensions	100 mm × 193.5 mm
Mounting	M3 holes
Output Count	16 channels

9. Bus Interconnection and Wiring

9.1 System Bus Architecture

The Modular PLC System uses two independent expansion buses originating from the EA-CORE-407:

Bus	Protocol	CPU Connector	Connected Modules	Max Modules
SPI-OUT	4-wire SPI (SPI3)	SPI-OUT header (PB3–PB5, PD0–PD3)	EA-AIO-74412R-4CH (analog I/O)	1
I²C-OUT	I²C (I²C1)	I²C-OUT header (PB8, PB9)	All digital I/O boards (DI + DO)	8 total (address limited)

9.2 I²C Bus Daisy-Chain Wiring

Digital I/O modules connect in a daisy-chain topology using the I²C IN and I²C OUT connectors on each module:

- EA-CORE-407 I²C-OUT → first module I²C IN
- First module I²C OUT → second module I²C IN
- Continue for each additional module in sequence
- Last module I²C OUT is left unconnected (or may be used for future expansion)

NOTE: *Enable I²C pull-up resistors (JP3/JP4) on only one module in the chain. **If** the EA-CORE-407 already provides bus pull-ups, disable all module pull-ups.*

9.3 SPI Bus Wiring

The EA-AIO-74412R-4CH connects to the EA-CORE-407 SPI-OUT connector. Connect the SPI-OUT header of the CPU board to the SPI INPUT connector on the analog board. Ensure CS1 through CS4 signals are routed to the correct chip-select jumper on the analog board.

9.4 Power Wiring

Each module must be powered from the panel 24 VDC supply independently. Connect +24 VDC and GND to each module's power input connector. Do not rely on power drawn through the I²C or SPI bus cables for the 24 V supply — those cables carry 3.3 V logic only.

- Use appropriately rated wire for 24 VDC and relay load circuits.
- Observe polarity at each module's power input terminal.
- Power down the entire system before making wiring changes.
- Use a common ground reference across all modules to prevent ground loops.

9.5 General Safety Notes

- Always disconnect power before wiring any module.
- Verify correct polarity on all power connections before energizing.
- The EA-AIO-74412R-4CH is non-isolated — all analog I/O share system ground.
- The EA-DI-MCP23017-16CH digital inputs are opto-isolated — do not connect field ground to logic ground.
- Relay contact ratings: 5 A at 30 VDC / 250 VAC. Do not exceed these limits.
- Use appropriate industrial wiring practices and ensure enclosure/grounding meet site safety requirements.

10. Document Control

Item	Description
System	Modular PLC System
Manufacturer	EA Control Tech
Website	eacontroltech.com
Hardware Revision	V1.0
Document Revision	1.0
Designed In	USA

10.1 Included Boards

Model	Document
EA-CORE-407	STM32F407 Industrial CPU Board — HW Rev V1.0
EA-AIO-74412R-4CH	4-Channel Analog I/O Board — HW Rev V1.0
EA-DI-MCP23017-16CH	16-Channel 24VDC Digital Input Module — HW Rev V1.0
EA-DO-MCP23008-8CH	8-Channel 24VDC Relay Output Module — HW Rev V1.0
EA-DO-MCP23017-16CH	16-Channel 24VDC Relay Output Module — HW Rev V1.0