QEC START GUIDE

QEC-PPC-M-090T-S Dual Ethernet Cross-Subnet Communication and Data Conversion

EtherCAT I/O and Modbus RTU with QEC-M-070T and QEC-R11CFFG

Devices used: QEC-PPC-M-090T-S, QEC-M-070T, QEC-R11CFFG
Example programs: QEC-PPC-M-090T-S_demo, QEC-M-070T_demo
Development tools: 86Duino IDE 502, UaExpert
Document version: v1.0

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1. Introduction

The QEC-PPC-M-090T-S has two independent Ethernet ports, so a single panel PC can handle the **operator interface**, **protocol conversion**, and **network isolation** at the same time. Using a three-tier demo system, this guide shows how to connect the machine side to the QEC-PPC-M-090T-S **LAN** port and the host PC to its **GLAN** port, and how the device converts Modbus TCP data to OPC UA internally.

On the field side, the **QEC-M-070T + QEC-R11CFFG** handle EtherCAT DI / DO / AI / AO and also act as a Modbus RTU Master through the **COM port of the QEC-R11CFFG**, bringing an RS-485 Modbus I/O board into the same system.

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2. System Architecture and Operation

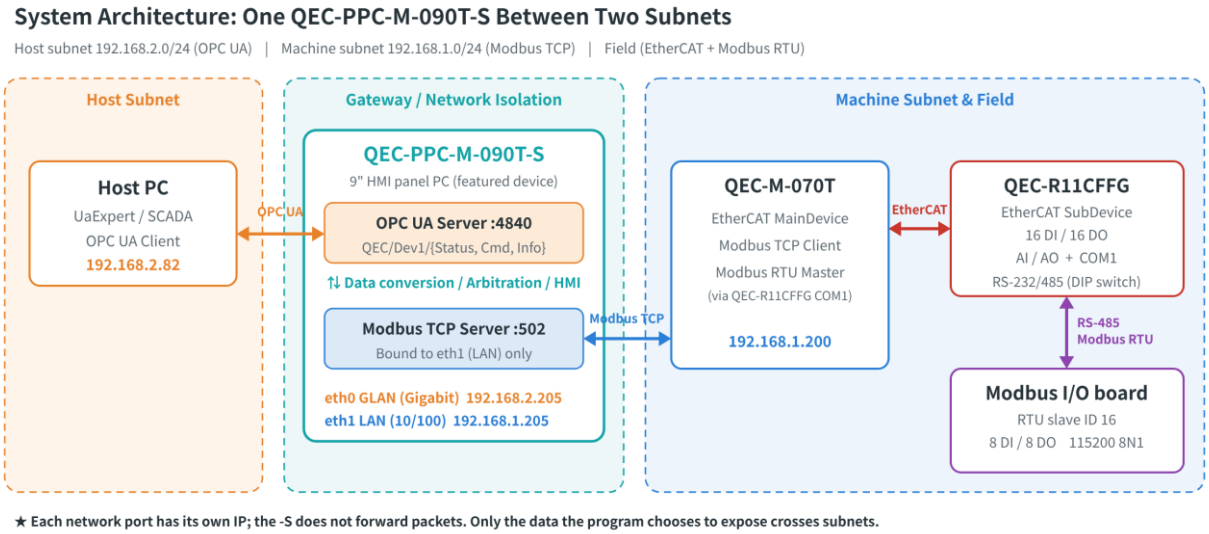


Figure 1: System architecture. The QEC-PPC-M-090T-S sits between the host subnet (192.168.2.x) and the machine subnet (192.168.1.x).

2.1 Device roles

Device	Role	Communication
QEC-PPC-M-090T-S	Operator panel, protocol conversion, network isolation	**LAN**: Modbus TCP Server **GLAN**: OPC UA Server
QEC-M-070T	Field controller	EtherCAT MainDevice, Modbus TCP Client, Modbus RTU Master
QEC-R11CFFG	EtherCAT I/O module (16 DI / 16 DQ / AI00 / AO00)	EtherCAT SubDevice; COM1 (RS-485)
Modbus I/O board	Field serial device (for demo)	Modbus RTU Slave (ID 16, 8 DI / 8 DO)
Host PC	Monitoring	OPC UA Client (UaExpert)

2.2 GLAN and LAN responsibilities

QEC-PPC-M-090T-S port	Object in code	IP	Connected to	Purpose
GLAN	`Ethernet` (eth0)	192.168.2.205	Host PC	Runs the OPC UA Server (:4840), provides data to the host system and receives commands
LAN	`Ethernet1` (eth1)	192.168.1.205	QEC-M-070T	Runs the Modbus TCP Server (:502), exchanges data with the field controller

The two ports are on different subnets and the two network adapters have different MAC addresses. The host PC cannot connect to the QEC-M-070T directly; only the data the program chooses to expose crosses between the subnets.

In the program, the Modbus TCP Server is bound to the LAN port when it is created, and the OPC UA Server uses the GLAN IP as its endpoint:

```
mbBus.begin(MODBUS_TCP, 502, Ethernet1);   // Ethernet1 = LAN
mbNode.attach(1, mbBus);                   // unit ID 1

opcBegin("192.168.2.205", 4840);           // endpoint uses the GLAN IP
opcIterate();                              // called repeatedly in loop(), never blocks
```

> **Tip** If you need to swap the roles of the two network ports, tap **SWAP** on the QEC-PPC-M-090T-S Settings page to exchange the eth0 / eth1 settings without changing the program.

2.3 Running Modbus RTU on the QEC-R11CFFG COM port

Besides DI / DO / AI / AO, the QEC-R11CFFG has an RS-232 / RS-485 COM port. COM-port data travels over **the same EtherCAT cable**, so the QEC-M-070T can access field Modbus RTU devices without extra wiring or an RTU gateway.

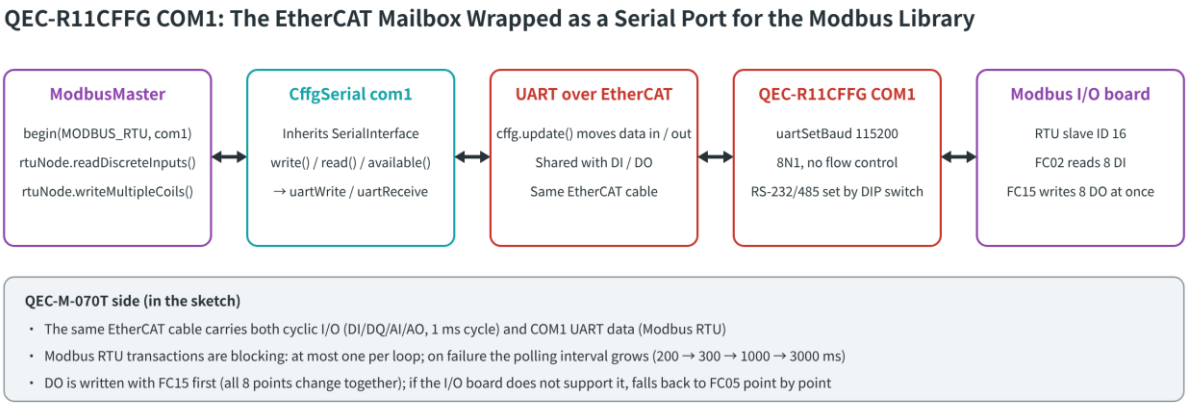


Figure 2: QEC-R11CFFG COM1 provides Modbus RTU communication over EtherCAT.

The example uses `CffgSerial.h` to wrap COM1 as a Serial interface, so the Modbus library can use it directly:

```
com1.init(&cffg, 0);               // QEC-R11CFFG COM1
com1.begin(115200);                // 8N1
rtuBus.begin(MODBUS_RTU, com1);    // used just like a regular serial port
rtuNode.attach(16, rtuBus);        // I/O board slave ID 16
```

The QEC-M-070T reads the I/O board's 8 DI with **FC02** and writes all 8 DO at once with **FC15**, while running the QEC-R11CFFG EtherCAT I/O on a 1 ms cycle. The example program also handles the following practical situations:

Situation	How the example handles it
RTU communication waits for a response; on failure it waits until the timeout expires	At most one RTU transaction per `loop()`; after consecutive failures the polling interval grows 200 → 300 → 1000 → 3000 ms, and returns to 200 ms after one success
Some I/O boards do not support FC15	On `ILLEGAL FUNCTION`, automatically falls back to FC05 (one point at a time) and records this in the Log

Situation	How the example handles it
Avoiding unnecessary writes	DO is sent only when the command changes; normally only DI is read

> **Note** Whether COM1 is RS-232 or RS-485 **is set by the DIP switch on the module**; the program can read it but cannot change it. The bottom line of the QEC-M-070T Detail page shows the current mode.

2.4 How data crosses subnets

Acting as a Modbus TCP Client, the QEC-M-070T writes field data to the QEC-PPC-M-090T-S with FC16 (**Block A**) and reads back commands with FC03 (**Block B**) **every 100 ms**. The QEC-PPC-M-090T-S only responds as a Server, and maps the data in both blocks to OPC UA nodes for the host PC.

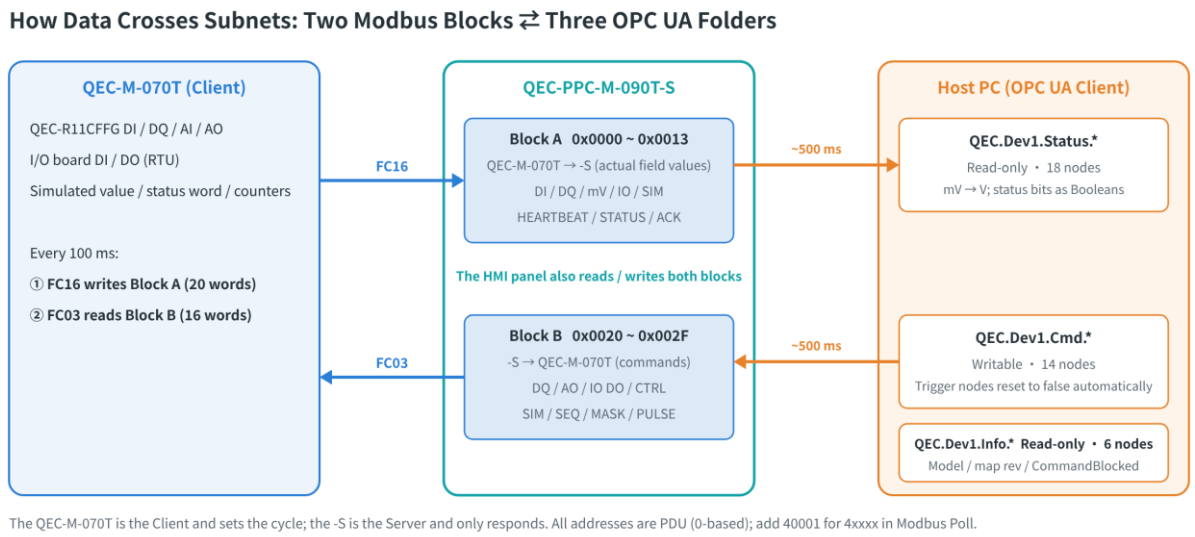


Figure 3: Mapping between Modbus Blocks A / B and OPC UA nodes.

OPC UA folder	Access	Nodes	Contents
`QEC.Dev1.Status`	Read-only	18	Actual field state: DI / DO, analog values (converted to volts), simulated value, status word, and commonly used status bits
`QEC.Dev1.Cmd`	Writable	14	Commands to the field: DQ / DO, AO, enable, pulse, reset, etc.
`QEC.Dev1.Info`	Read-only	6	Model, register map version, connection diagnostics, and `CommandBlocked` (why a command has not taken effect)

During conversion, the QEC-PPC-M-090T-S also does three things so the host side can use the data right away:

- **Engineering units**: analog values are converted from millivolts to **volts** (Double).
- **Common status bits as separate nodes**: in addition to the status word, four Boolean nodes are provided: `EcatOp`, `RtuLink`, `OutputEnabled`, and `PeerLocalMode`.
- **NodeId equals the path**: all NodeIds are strings in namespace 1, for example `QEC.Dev1.Status.CffgDi`, so you can search for them by string in UaExpert.

> **Note** The OPC UA side alternates between "push Status" and "receive Cmd" every 250 ms, so **each direction updates about every 500 ms**. This is intentionally slowed down to make sure host-side services never take processing time away from machine-side Modbus.

2.5 Three conditions for commands to take effect

The QEC-M-070T panel, the QEC-PPC-M-090T-S panel, and the host PC can all control the same outputs. To prevent outputs from jumping back and forth between multiple writers, the example uses clear conditions, visible on the panels, to manage control:

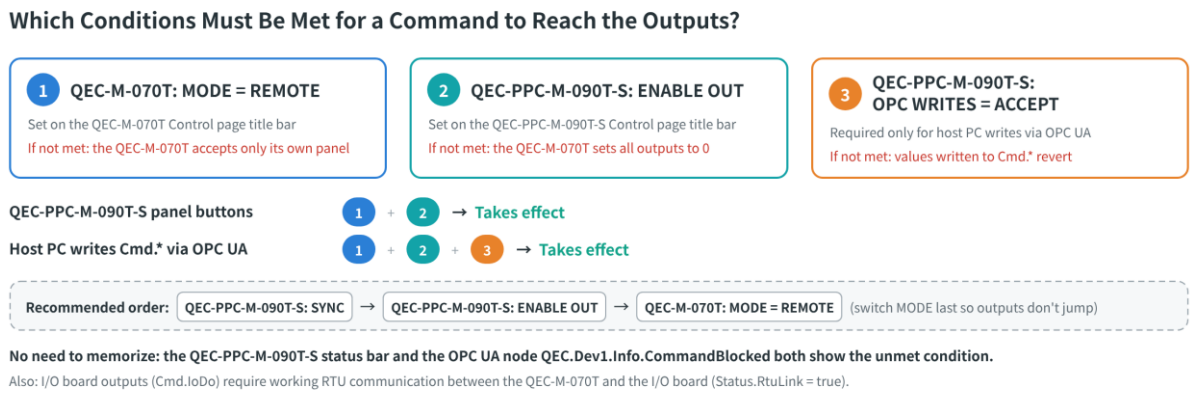


Figure 4: Conditions for commands to take effect.

Condition	Where to set	Controls	If not met
① QEC-M-070T **MODE = REMOTE**	QEC-M-070T Control page	Whether the QEC-M-070T accepts commands from the -S	The QEC-M-070T accepts only its own panel
(Recommended) **SYNC**	QEC-PPC-M-090T-S Control page	Copies the QEC-M-070T's current outputs into the -S command values	Still works, but outputs may jump when switching
② **ENABLE OUT**	QEC-PPC-M-090T-S Control page	Allows the QEC-M-070T to drive outputs	The QEC-M-070T holds all outputs at 0
③ **OPC WRITES = ACCEPT** (host PC only)	QEC-PPC-M-090T-S Control page	Whether the -S accepts OPC UA writes	Values written by the host PC revert to their previous values

> **Caution** **Recommended order**: **SYNC** on the -S → **ENABLE OUT** on the -S → finally switch the QEC-M-070T **MODE** to REMOTE. If you switch to REMOTE before enabling outputs, the QEC-M-070T resets all outputs to 0 at the moment of switching.
>
> **The QEC-M-070T MODE and the -S OPC WRITES are two separate things**: for the -S panel to control the field, only MODE = REMOTE and ENABLE OUT are needed. OPC WRITES only governs the "host PC writes via OPC UA" path.

3. Preparation

3.1 Hardware

Item	Qty
QEC-PPC-M-090T-S	1
QEC-M-070T	1
QEC-R11CFFG	1
Modbus RTU I/O board (8 DI / 8 DO, slave ID 16, 115200 bps 8N1, RS-485)	1

3.2 Software

Item	Description
86Duino IDE 502	Available from QEC Software Download (currently in beta). Version 501 does not include the OPC UA (open62541) library or the `PPCM090 (None-EtherCAT)` board option
open62541 library	In the IDE menu, go to **Sketch → Include Library → Manage Libraries…**, search for `OPC`, and install **open62541** (used by the QEC-PPC-M-090T-S)
PL2303 driver	When a QEC is connected to the PC via USB Type-C, Device Manager should show `Prolific PL2303GC USB Serial COM Port (COMx)`. If it does not, install the driver ("Set up the QEC for 86Duino")
UaExpert	OPC UA Client installed on the host PC
Example programs	`QEC-M-070T_demo` (QEC-M-070T) `QEC-PPC-M-090T-S_demo` (QEC-PPC-M-090T-S)

3.3 Example program folder structure

```
QEC-M-070T_demo/
├─ QEC-M-070T_demo.ino
├─ CffgSerial.h          QEC-R11CFFG COM1 → Serial interface
├─ QEC_DemoMap.h         Register map (shared; must be identical on both)
├─ myhmi.h / myhmi.cpp   Generated by 86HMI Editor; do not edit by hand
└─ data/_project.hpj     HMI project (800×480, 5 pages)

QEC-PPC-M-090T-S_demo/
├─ QEC-PPC-M-090T-S_demo.ino
├─ OpcUaBridge.h / .cpp  Interface layer for open62541
├─ QEC_DemoMap.h         Identical to the QEC-M-070T copy
├─ myhmi.h / myhmi.cpp
└─ data/_project.hpj     HMI project (1024×600, 5 pages)
```

3.4 Wiring

From	To	Purpose
QEC-PPC-M-090T-S **GLAN** port	Host PC	OPC UA (host subnet 192.168.2.x)
QEC-PPC-M-090T-S **LAN** port	QEC-M-070T **Giga LAN port (blue)**	Modbus TCP (machine subnet 192.168.1.x)

From	To	Purpose
QEC-M-070T **EtherCAT port (EC IN / EC OUT)**	QEC-R11CFFG	EtherCAT
QEC-R11CFFG **COM1**	Modbus I/O board	RS-485 (A to A, B to B, common GND); set the QEC-R11CFFG DIP switch to **RS-485**

Tip The two 10/100 Mbps ports on the QEC-M-070T are for EtherCAT only. Be sure to connect the QEC-PPC-M-090T-S to the blue Giga LAN port. The QEC-R11CFFG must be the first device in the EtherCAT chain (index 0).

3.5 Network settings

The example programs use the following factory defaults. If your subnets are the same, no changes are needed:

Device	IP	Mask	Gateway
Host PC	192.168.2.82	255.255.255.0	**Leave blank**
QEC-PPC-M-090T-S GLAN (eth0)	192.168.2.205	255.255.255.0	192.168.2.1
QEC-PPC-M-090T-S LAN (eth1)	192.168.1.205	255.255.255.0	192.168.1.1
QEC-M-070T	192.168.1.200	255.255.255.0	192.168.1.1

Caution **Do not set a gateway** on the host PC network adapter connected to GLAN, or it may override the PC's existing default route and cut off access to other networks.

To change a QEC IP address, edit it on the device's **SETTINGS** page, tap **CONFIRM** to save, and **restart** the device for the change to take effect. The Modbus TCP target address (SERVER) on the QEC-M-070T must match the LAN IP of the QEC-PPC-M-090T-S.

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4. Uploading the Programs

Upload each device separately. We recommend connecting only one device via USB at a time to avoid selecting the wrong port.

1. Connect the QEC's **USB Type-C port** to the PC with a USB Type-C cable, and power on the QEC.
2. Open the example sketch in 86Duino IDE 502.
3. Click the **86HMI** button in the IDE to open 86HMI Editor. Make sure the loaded project is `data/_project.hpj` inside the sketch folder, then click **Code Generation** to generate `myhmi.h` / `myhmi.cpp`.
4. Select the model under **Tools** → **Board**, and the device's COM port under **Tools** → **Port** (shown as `COMx (QEC)`).

Device	Sketch	Board	HMI resolution
QEC-M-070T	`QEC-M-070T_demo.ino`	**QEC M070T**	800×480
QEC-PPC-M-090T-S	`QEC-PPC-M-090T-S_demo.ino`	**PPCM090 (None-EtherCAT)**	1024×600

5. Click ✓ on the toolbar to compile. If there are no errors, click → to upload.
6. After uploading, check the settings on the panel's **SETTINGS** page and tap **CONFIRM** to save (network settings take effect after a restart).

> **Tip** For the QEC-PPC-M-090T-S, do not select `QEC PPCM090` (that option is for the EtherCAT version). If the wrong board is selected, compilation fails with `Select Tools > Board > "PPCM090 (None-EtherCAT)" …`.
>
> If open62541 fails to compile, uncomment `/* #define OPCUA_DISABLED */` at the top of `OpcUaBridge.cpp`. The QEC-PPC-M-090T-S will then run without OPC UA (the panel shows `disabled at build`), and you can still complete Exercises A and B.
>
> If you modify `QEC_DemoMap.h`, update both sketches and re-upload both devices; otherwise `map rev` on the Detail page shows `MISMATCH`.

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5. Exercise A: Standalone Test of the QEC-M-070T

In this step, only the QEC-M-070T is powered on, to confirm that EtherCAT I/O and COM-port Modbus RTU are working.

1. Power on the QEC-M-070T and check the Main page:
   - The **ETHERCAT** indicator is lit and shows `R11CFFG OP`
   - The **MODBUS RTU** indicator is lit and shows `I/O board ID 16`
   - The **HOST (-S)** indicator is off and shows `unreachable`, and the bottom line shows `Modbus TCP: 192.168.1.205:502 unreachable ...`: this is normal, as the QEC-PPC-M-090T-S is not connected yet
   - The top-right corner shows `LOCAL` (default at power-up; outputs are controlled from the QEC-M-070T panel)

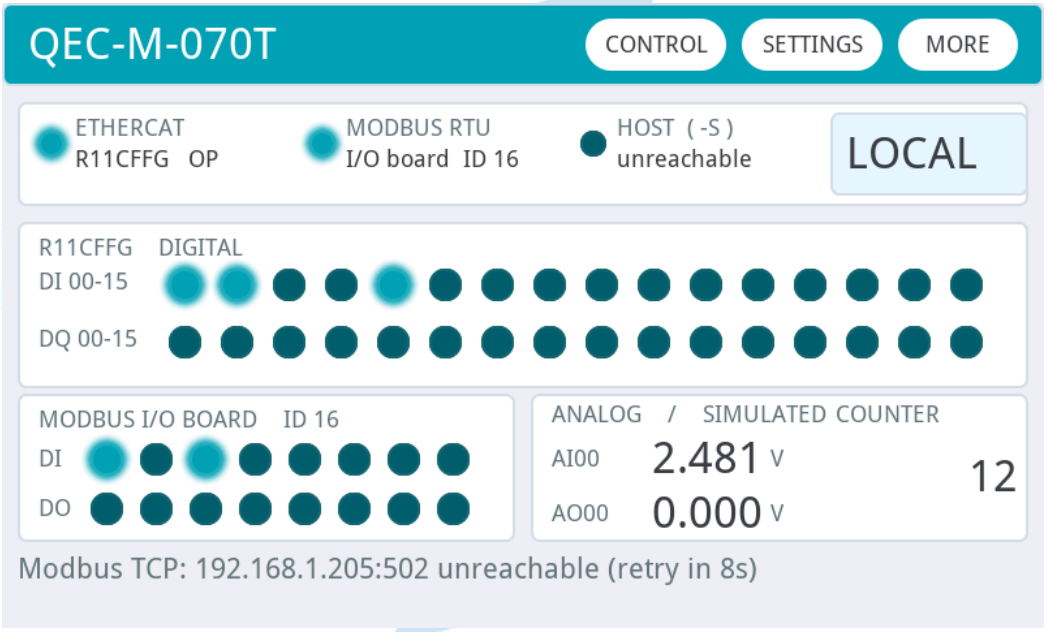


Figure 5: Main page with only the QEC-M-070T powered on (signals applied to DI terminals).

2. Apply a signal to a DI terminal on the QEC-R11CFFG or I/O board. The corresponding DI indicator on the Main page should light up.
3. Tap **CONTROL** to open the Control page, enter `5` in the AO field, and tap **SET**. AO00 should output 5 V.
4. Tap **ALL ON**. All 16 DQ on the QEC-R11CFFG and all 8 DO on the I/O board should turn on together. Then tap **ALL OFF** to turn off all outputs (AO00 also returns to 0 V).
5. Tap DQ `00` and DO `0`. QEC-R11CFFG DQ00 and I/O board DO0 turn on, and the status bar shows `I/O board DO0 = 1`. **Leave these two outputs on**; you will check them in Exercise B.

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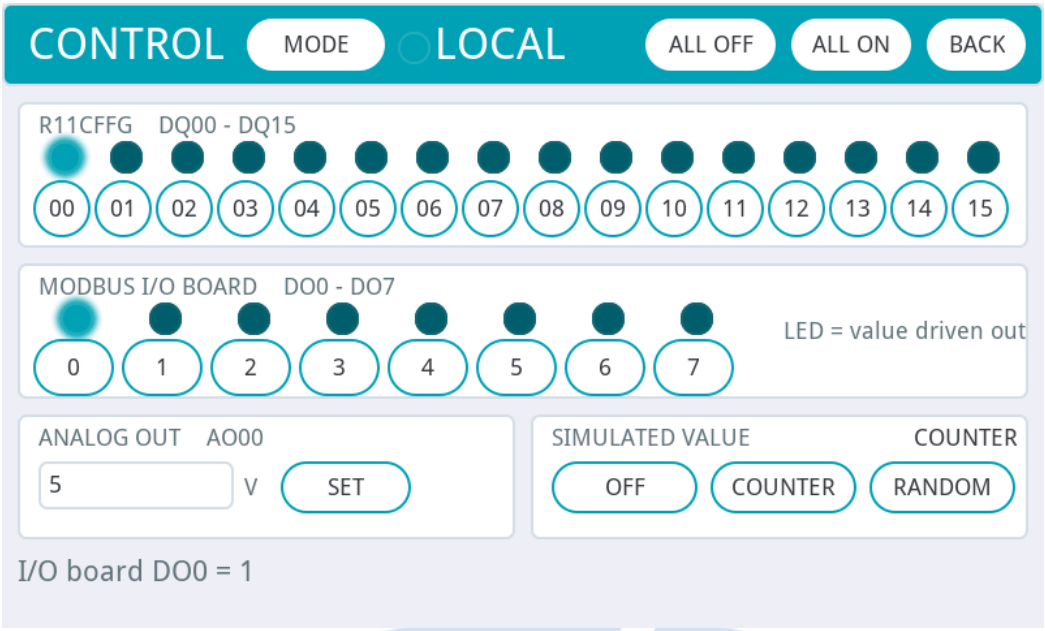


Figure 6: Control page after Step 5. Only DQ00 and DO0 are lit. The AO field still shows the 5 entered in Step 3, but AO00 was reset to 0 by ALL OFF in Step 4. The indicator to the right of MODE is lit in LOCAL (same color as the title bar).

Tip If the MODBUS RTU indicator is not lit, check whether RS-485 A / B are swapped, whether the DIP switch is set to RS-485, and the I/O board's slave ID and baud rate. If the I/O board is not slave ID 16 / 115200 bps, change **BAUD** and **SLAVE** in the COM1 section of the SETTINGS page, tap **CONFIRM**, then tap **RECONNECT**.

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6. Exercise B: Controlling Field I/O from the QEC-PPC-M-090T-S (LAN)

6.1 Connect and check the data

1. Connect the QEC-PPC-M-090T-S **LAN** port to the QEC-M-070T Giga LAN port with an Ethernet cable, and power on the QEC-PPC-M-090T-S. The QEC-M-070T reconnects automatically (retry interval up to 15 seconds).
2. Check the QEC-PPC-M-090T-S Main page:
   - **MODBUS TCP SERVER**: indicator lit, shows `listening`
   - **QEC-M-070T**: indicator lit, shows `connected`, `heartbeat` keeps increasing, `mode LOCAL`
   - The bottom line shows `070T is in LOCAL - it ignores commands from here`, meaning the QEC-M-070T is still in LOCAL; you will switch it in Section 6.2
   - The DI / DQ, I/O board, and AI / AO / SIM values below match the QEC-M-070T panel (the lit DQ00 and DO0 in the figure are the two outputs turned on in Exercise A)

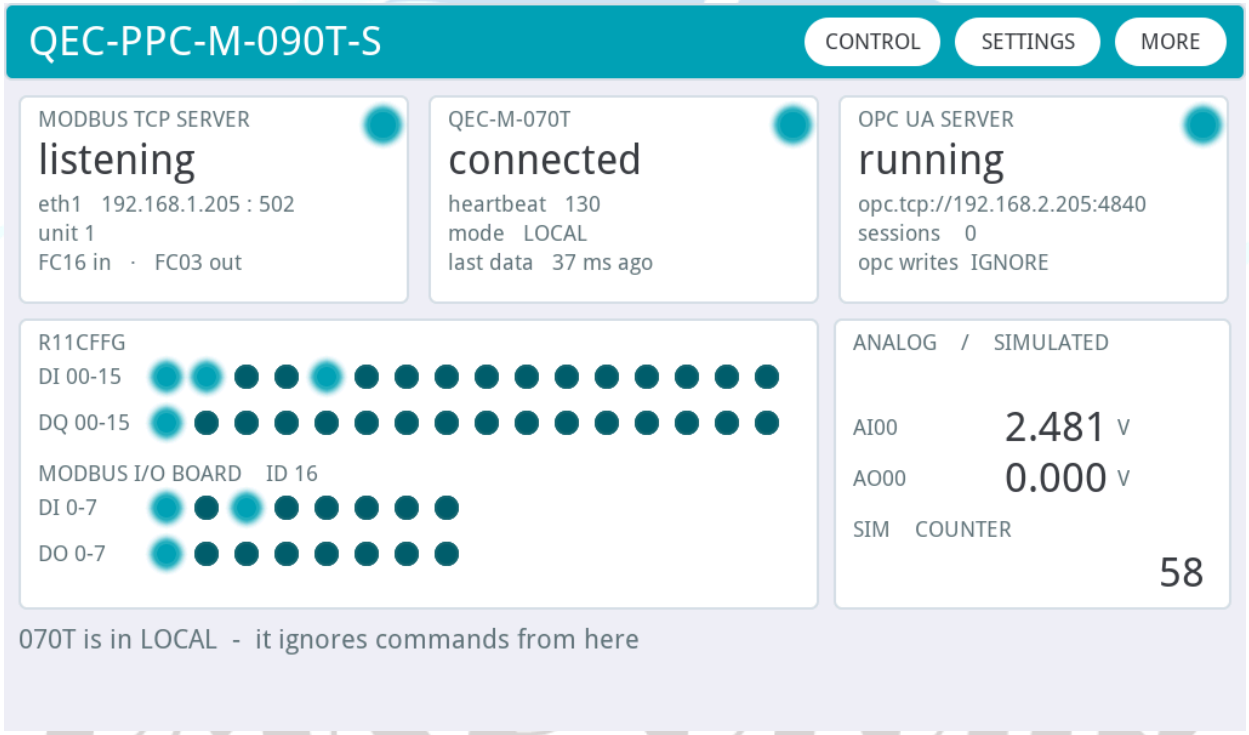


Figure 7: QEC-PPC-M-090T-S Main page after connecting, with the QEC-M-070T still in LOCAL.

3. Check the QEC-M-070T Main page: the **HOST (-S)** indicator is lit and shows `connected`.

> **Tip** The quickest way to confirm the "field → -S" data path is to check whether the `heartbeat` on the second card and the `SIM` value at the bottom right keep changing. If the second card keeps showing `no data`, check the LAN cable and make sure PORT (502) and UNIT (1) match on both devices.

6.2 Send commands

1. On the **QEC-PPC-M-090T-S**, tap **CONTROL**, then tap **SYNC** to copy the QEC-M-070T's current actual outputs into this panel's command values.
2. Tap **ENABLE OUT** to allow the QEC-M-070T to drive its outputs.

3. On the **QEC-M-070T** Control page, tap **MODE** to switch to `REMOTE`. Because SYNC and ENABLE OUT were done first, the existing outputs (DQ00, DO0) stay unchanged during the switch.
4. Back on the QEC-PPC-M-090T-S, tap any DQ / DO button. The corresponding field output switches, and the indicator above the button lights up. In this example, tap DO `3` of the I/O board; the status bar shows `I/O board DO3 = 1`.

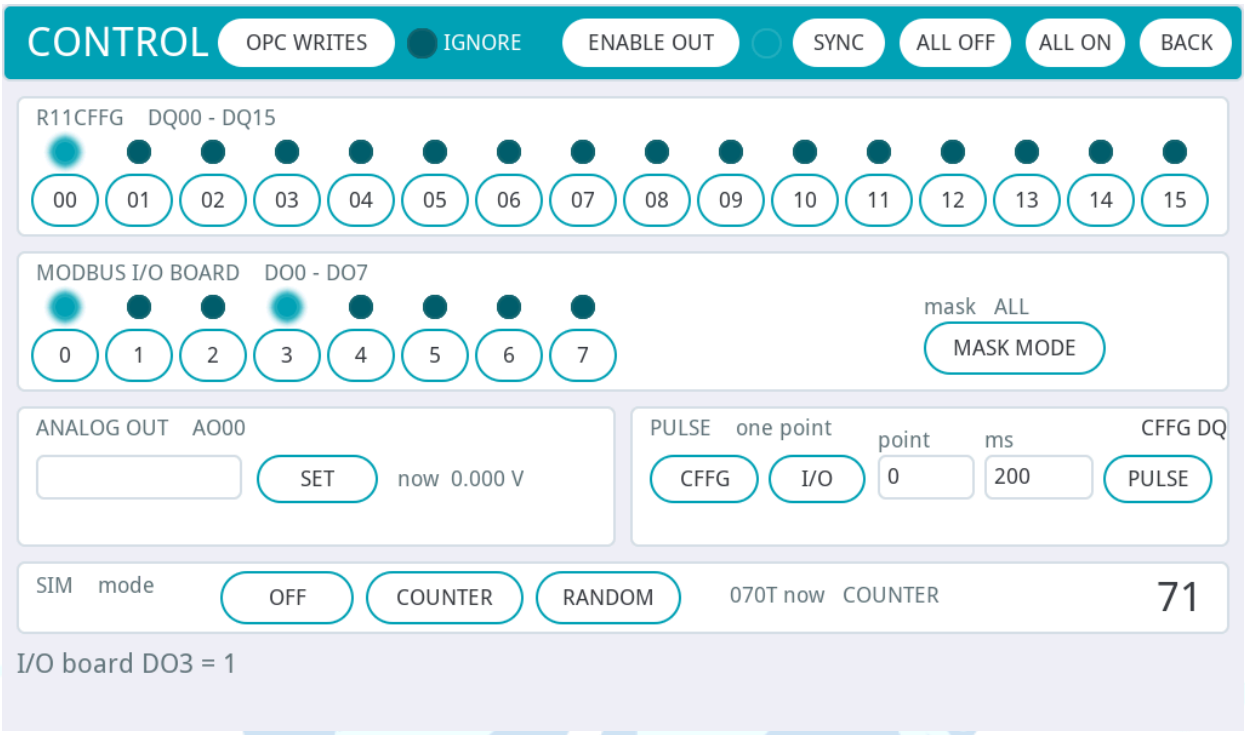


Figure 8: After SYNC, ENABLE OUT, switching the QEC-M-070T to REMOTE, and then tapping DO 3. DO0 was turned on in Exercise A and kept by SYNC; DO3 was turned on from the QEC-PPC-M-090T-S.

5. You can also try **ALL ON / ALL OFF**, **PULSE** (select `I/O`, point `0`, ms `500`), and **AO** SET.

Caution Follow the order above. If you switch the QEC-M-070T to REMOTE before pressing ENABLE OUT, the QEC-M-070T resets all outputs to 0 at the moment of switching, and SYNC will then only copy all-zero values. After SYNC, do not change outputs on the QEC-M-070T panel.

Tip The indicator to the right of ENABLE OUT shows the "outputs enabled" state reported by the QEC-M-070T. When enabled, it is the same color as the title bar and can be hard to see (when not enabled, it is a dark dot). After switching to REMOTE, go back to the Main page and check that the bottom line shows `070T is in REMOTE - outputs enabled`.

When a command does not take effect, the status bar shows which condition is not met, for example `I/O board DO3 = 1 -- 070T is in LOCAL - press MODE on the 070T panel`.

While the QEC-M-070T is in REMOTE, the output buttons on its own panel (DQ, DO, AO, ALL ON / OFF) do nothing, and the status bar shows `switch to LOCAL first`.

7. Exercise C: Accessing Data from the Host PC with UaExpert (GLAN)

7.1 Connect and read

1. Connect the host PC to the QEC-PPC-M-090T-S **GLAN** port, set the PC's IP to `192.168.2.82` (leave the gateway blank), and confirm the connection with `ping 192.168.2.205`.
2. Check that the **OPC UA SERVER** card on the QEC-PPC-M-090T-S Main page is lit and shows `running` and `opc.tcp://192.168.2.205:4840`.
3. In UaExpert, choose **Add Server**, enter `opc.tcp://192.168.2.205:4840`, select **None** for Security Policy, and connect.
4. Expand `Objects > QEC > Dev1`. You will see three folders: Status, Cmd, and Info:

```
Objects
  └ QEC
      └ Dev1
          ├ Status   Read-only: actual field state (18 nodes)
          ├ Cmd      Writable: commands to the field (14 nodes)
          └ Info     Read-only: model, version, diagnostics (6 nodes)
```

5. Drag the nodes under `Status` into the Data Access View:
   - `Status.SimValue` keeps changing → data is flowing (a simulated value built into the QEC-M-070T, incrementing by 1 every second by default)
   - `Status.IoDi` is the I/O board DI received via RS-485
   - `Status.CffgAi` is already converted to volts (V)

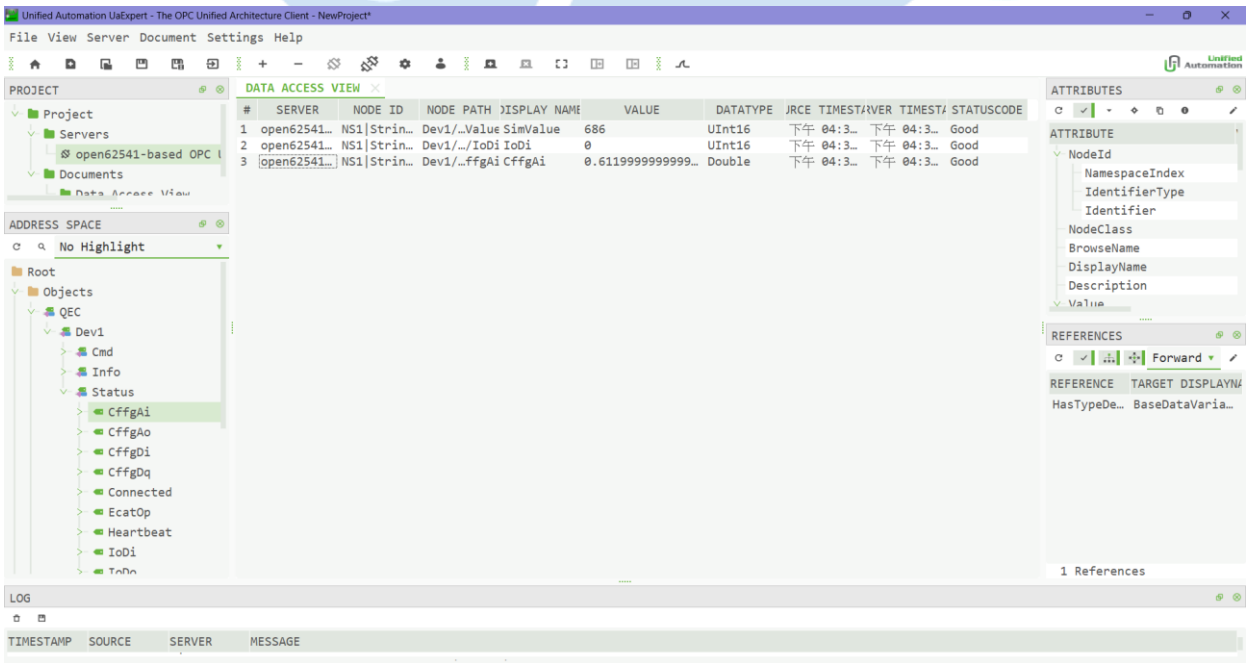


Figure 9: UaExpert address space and Data Access View. Status.SimValue, Status.IoDi, and Status.CffgAi (in volts) can be read directly.

The host PC is on the 192.168.2.x subnet and cannot connect directly to the QEC-M-070T on 192.168.1.x, yet it can still get all of its I/O data. This is the result of the QEC-PPC-M-090T-S converting data between GLAN and LAN.

7.2 Send commands

1. On the QEC-PPC-M-090T-S Control page, tap **OPC WRITES**. The text next to it changes from `IGNORE` to `ACCEPT` (REMOTE and ENABLE OUT from Exercise B must remain in place).
2. Write the following nodes in UaExpert:

Purpose	Node	Value
All 8 I/O board outputs on / off	`QEC.Dev1.Cmd.IoDo`	`255` / `0`
Turn on only QEC-R11CFFG DQ00	`QEC.Dev1.Cmd.CffgDq`	`1`
All 16 QEC-R11CFFG outputs on	`QEC.Dev1.Cmd.CffgDq`	`65535`
AO output 5 V	`QEC.Dev1.Cmd.CffgAo`	`5.0`
0.5-second pulse on I/O board DO0	Write in order: `Cmd.PulseTarget` = `2`, `Cmd.PulsePoint` = `0`, `Cmd.PulseMs` = `500`, then write `Cmd.PulseTrigger` = `true`	—

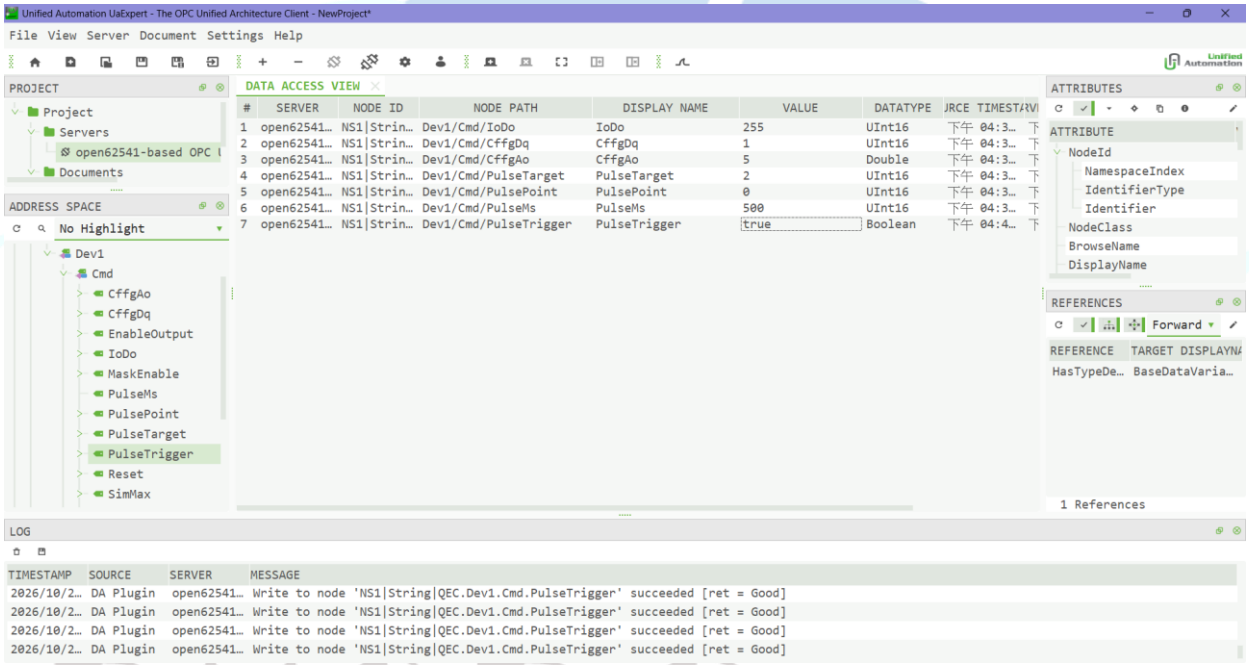


Figure 10: Writing Cmd.* nodes in the Data Access View; the Log below shows the writes succeeded. PulseTrigger automatically returns to false after true is written.

Within about 0.5 seconds of writing, the field outputs switch, and `Status.*` and the QEC-PPC-M-090T-S panel indicators update accordingly.

> **Tip** If a command does not take effect, read `QEC.Dev1.Info.CommandBlocked`; it states which condition is not met (an empty string means all conditions are met). If a written value reverts to its previous value, OPC WRITES is still set to `IGNORE`. See Section 10.4 for the complete list of messages.

8. Panel Reference: QEC-M-070T

The QEC-M-070T panel has three main navigation buttons: **CONTROL / SETTINGS / MORE**. The Detail and Log pages are reached through MORE and are used for troubleshooting.

8.1 Main

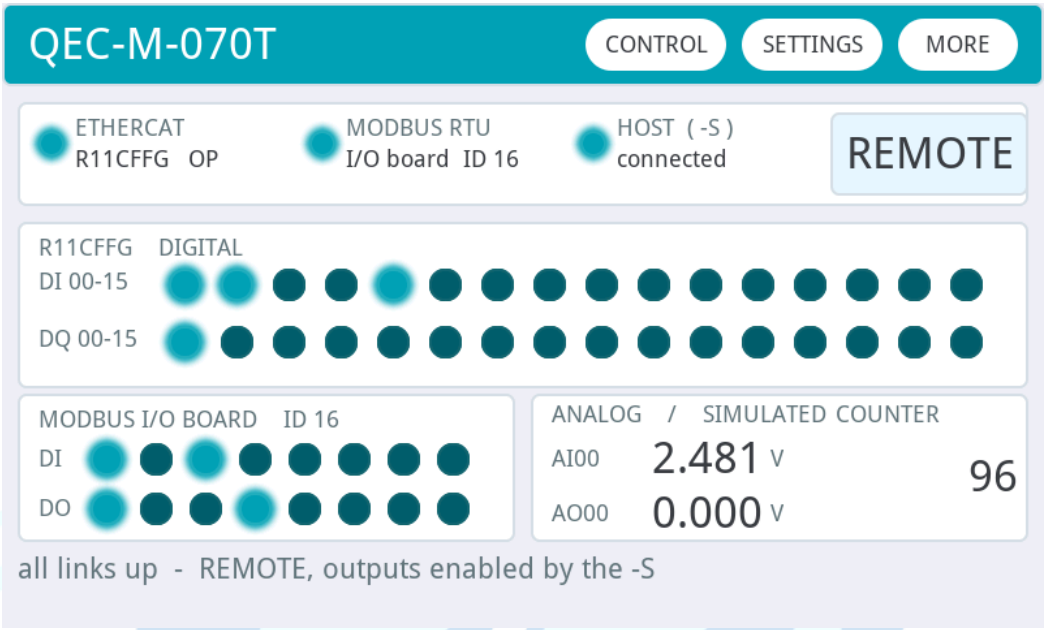


Figure 11: QEC-M-070T Main page (connected to the QEC-PPC-M-090T-S, REMOTE mode).

Section	What to look for
ETHERCAT	Indicator lit and `R11CFFG OP` shown = EtherCAT has reached OP
MODBUS RTU	Indicator lit and `I/O board ID 16` shown = RTU communication between COM1 and the I/O board is working; `no answer - retrying` = no response
HOST (-S)	Indicator lit and `connected` shown = connected to the QEC-PPC-M-090T-S via Modbus TCP
LOCAL / REMOTE (top right)	Who has control: `LOCAL` (this panel, default at power-up) or `REMOTE` (accepts commands from the -S)
R11CFFG DIGITAL	DI00–15 input indicators and DQ00–15 **actual output** indicators
MODBUS I/O BOARD	DI0–7 read via COM1 and DO0–7 actually sent
ANALOG / SIMULATED	AI00, AO00 (volts), simulated value and mode

The bottom line is a one-line status summary, for example `all links up - REMOTE, outputs enabled by the -S`.

8.2 Control

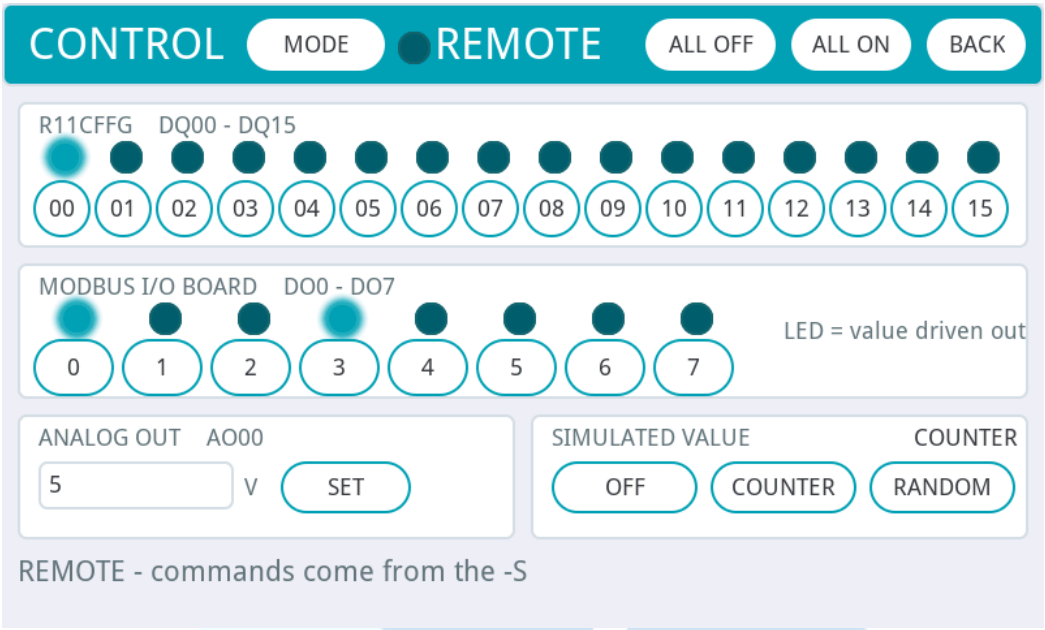


Figure 12: QEC-M-070T Control page.

Element	Function
MODE + indicator + text	Switches between LOCAL / REMOTE; this is condition ① in Section 2.5
DQ00–DQ15	Tap to toggle that point ON / OFF; the indicator above = actual output
DO0–DO7	Same as above, for the Modbus I/O board (via COM1)
ALL ON / ALL OFF	Turns all outputs on / off (ALL OFF also resets AO00 to 0)
AO00 + SET	Analog output (volts)
Simulated value mode	OFF / COUNTER / RANDOM

> **Note** In **REMOTE**, the output buttons on the QEC-M-070T panel (DQ, DO, AO, ALL ON / OFF) do nothing, and the status bar shows `switch to LOCAL first`.

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8.3 Settings

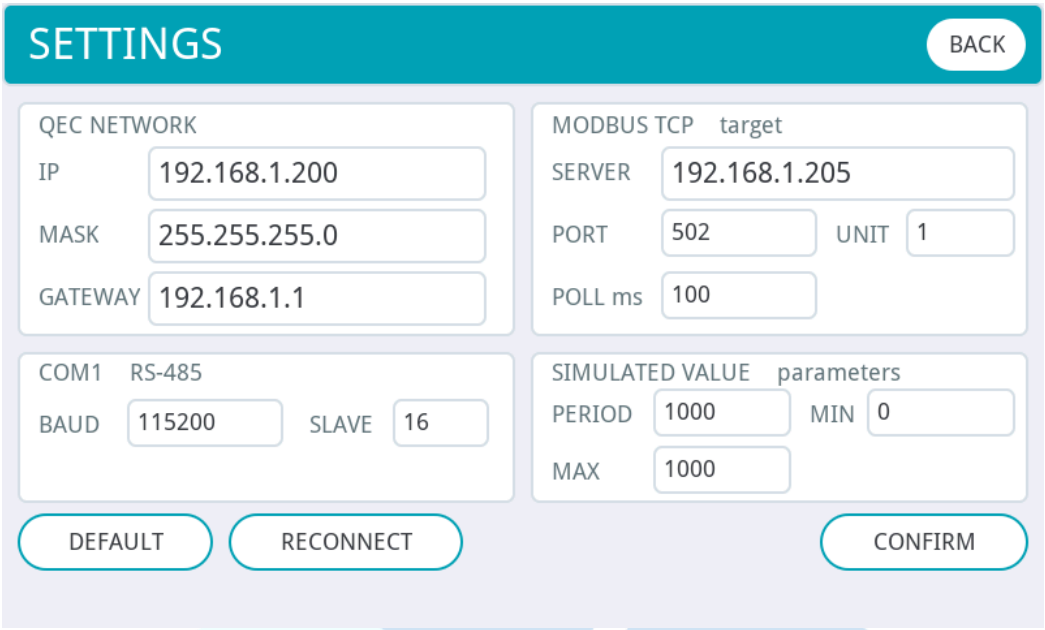


Figure 13: QEC-M-070T Settings page.

Section	Fields
QEC NETWORK	IP / MASK / GATEWAY of the QEC-M-070T itself
MODBUS TCP target	IP of the QEC-PPC-M-090T-S (`192.168.1.205`), PORT, UNIT, POLL ms
COM1	BAUD, SLAVE (I/O board slave ID). "RS-485" in the heading is fixed text; see the Detail page for the actual mode
SIMULATED VALUE	PERIOD (≥ 50 ms), MIN, MAX (must be greater than MIN)

Button	Function
DEFAULT	Restores factory defaults (tap CONFIRM to save)
RECONNECT	Reconnects Modbus TCP and COM1
CONFIRM	Validates the input and saves it to EEPROM (network settings take effect after a restart)

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8.4 Detail

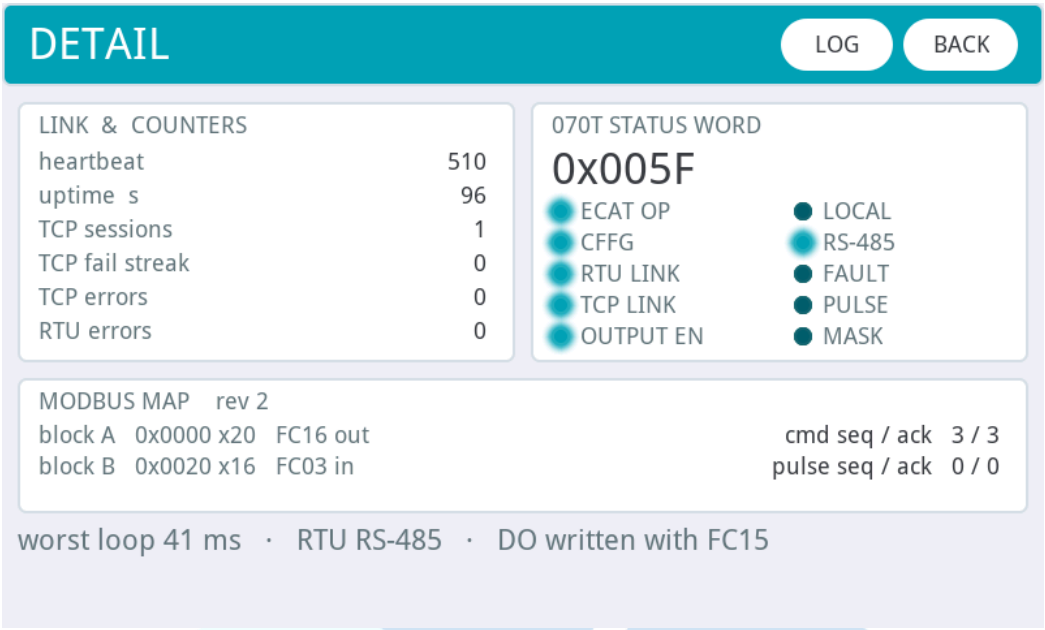


Figure 14: QEC-M-070T Detail page.

Field	Normal value / description
heartbeat	Keeps increasing
TCP sessions	**Stays at 1** (a rising value means the connection keeps reconnecting)
TCP fail streak / errors, RTU errors	Mostly 0
070T STATUS WORD	One indicator per status-word bit (see Appendix A.3)
Bottom line	worst loop, whether COM1 is RS-485 or RS-232, and whether DO is written with FC15 or FC05

8.5 Log

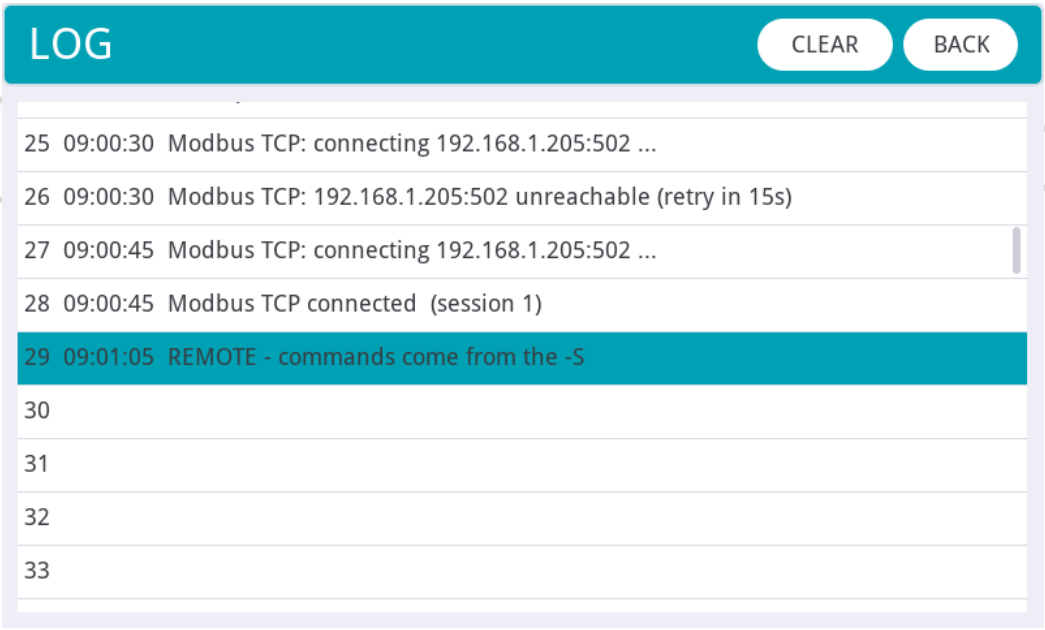


Figure 15: QEC-M-070T Log page.

The Log page keeps 99 lines of events and records only state changes and errors (single DQ / DO toggles appear only in the status bar, not in the Log). The figure shows the QEC-M-070T powering up → waiting for the -S (`unreachable` retries at intervals of 1, 2, 4, 8, and 15 seconds) → connecting at 09:00:45 → switching to REMOTE at 09:01:05. Scroll up to see EtherCAT, COM1, and the `all digital outputs ON` / `all outputs OFF` events from Exercise A.

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9. Panel Reference: QEC-PPC-M-090T-S

9.1 Main: Status of the three services and field data

The top of the Main page shows three cards for the machine-side, field-controller, and host-side connections. Below them is the field data reported by the QEC-M-070T.

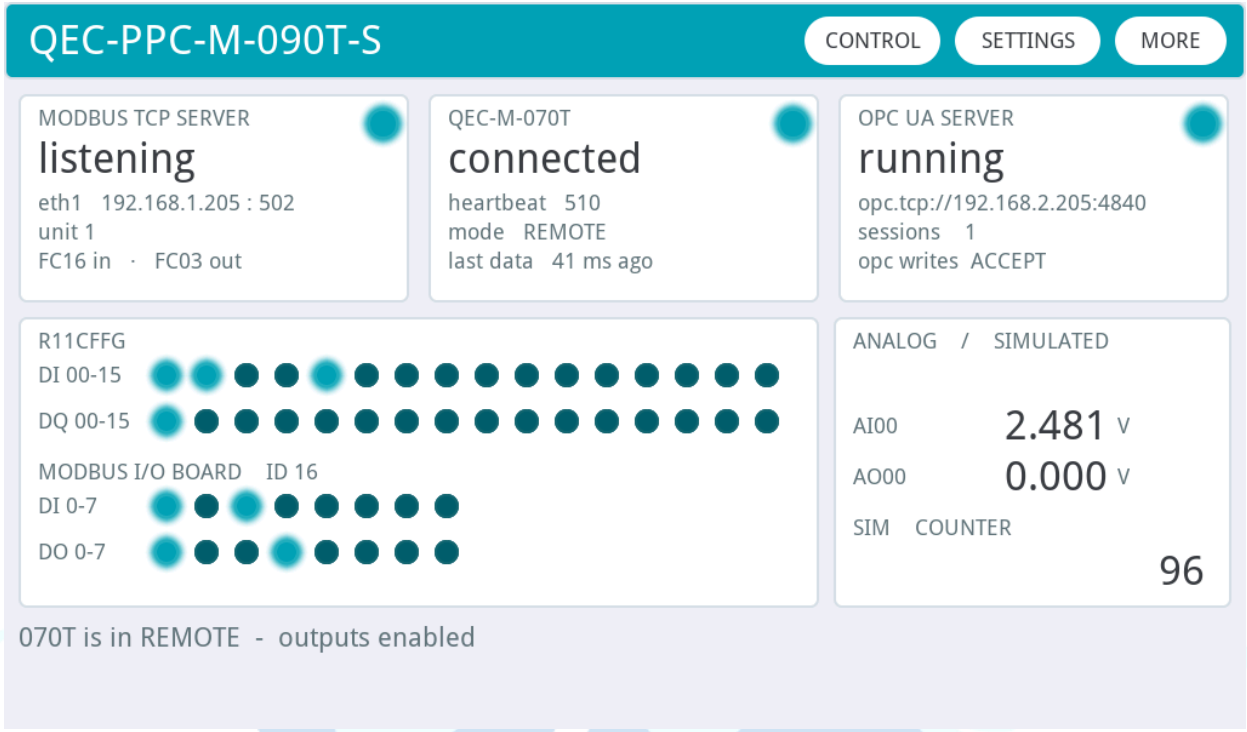


Figure 16: QEC-PPC-M-090T-S Main page (all three connected, QEC-M-070T in REMOTE, OPC WRITES set to ACCEPT). The lit DQ00, DO0, and DO3 are the outputs turned on in Exercises A and B.

Card / section	Indicator lit means	Status text
MODBUS TCP SERVER	The Modbus TCP Server on the LAN side is running	`listening`, `eth1 192.168.1.205 : 502`, `unit 1`, `FC16 in · FC03 out`
QEC-M-070T	Up-to-date data has been received from the QEC-M-070T	`connected`, `heartbeat` (keeps increasing), `mode LOCAL / REMOTE`, `last data N ms ago`
OPC UA SERVER	The OPC UA Server on the GLAN side has started	`running`, `opc.tcp://192.168.2.205:4840`, `sessions N`, `opc writes ACCEPT / IGNORE`
R11CFFG / MODBUS I/O BOARD	—	DI / DQ and I/O board DI / DO reported by the QEC-M-070T
ANALOG / SIMULATED	—	AI00, AO00 (volts), simulated value

The status bar at the bottom summarizes the current state in one line, for example `070T is in REMOTE - outputs enabled`.

9.2 Control

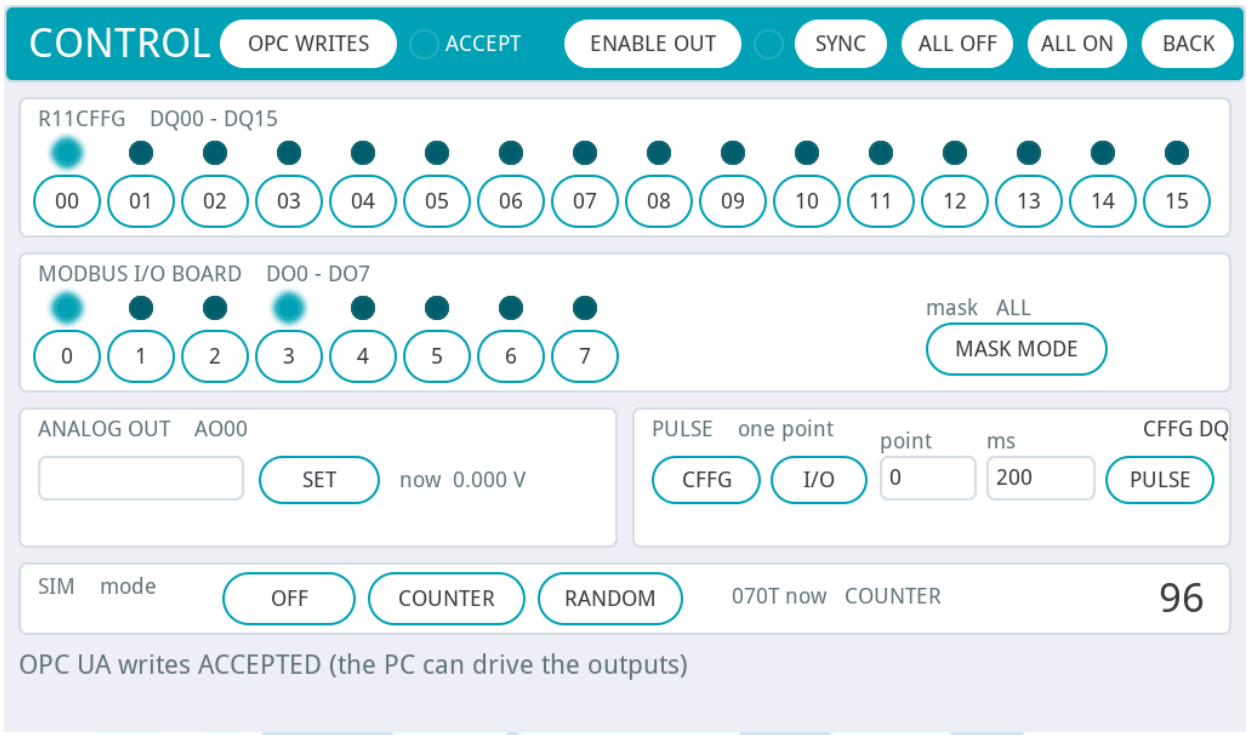


Figure 17: QEC-PPC-M-090T-S Control page.

Element	Function
OPC WRITES + indicator + text	Whether OPC UA writes from the host PC are accepted (`ACCEPT` / `IGNORE`, IGNORE at power-up); this is condition ③
ENABLE OUT + indicator	Allows the QEC-M-070T to drive outputs; the indicator is `OUTPUT_ENABLED` as reported by the QEC-M-070T; this is condition ②
SYNC	Copies the QEC-M-070T's actual outputs into this panel's command values (press once **before** switching the QEC-M-070T to REMOTE)
ALL OFF / ALL ON	Turns all outputs off / on
DQ00–DQ15, DO0–DO7	Tap to toggle that point ON / OFF; the indicator shows the actual output reported by the QEC-M-070T
MASK MODE	`ALL` = writes the whole set of outputs every cycle (normal use); `LAST point only` = writes only the point just tapped
AO00 + SET	Analog output (volts); `now` on the right is the actual value reported by the QEC-M-070T
PULSE	Select `CFFG` or `I/O`, enter point and ms (20–5000), then tap PULSE: the point turns ON and returns to OFF after the set time
SIM mode	Changes the mode of the QEC-M-070T simulated value

The status bar is at the bottom; **when a command does not take effect, the reason is shown here**.

9.3 Settings

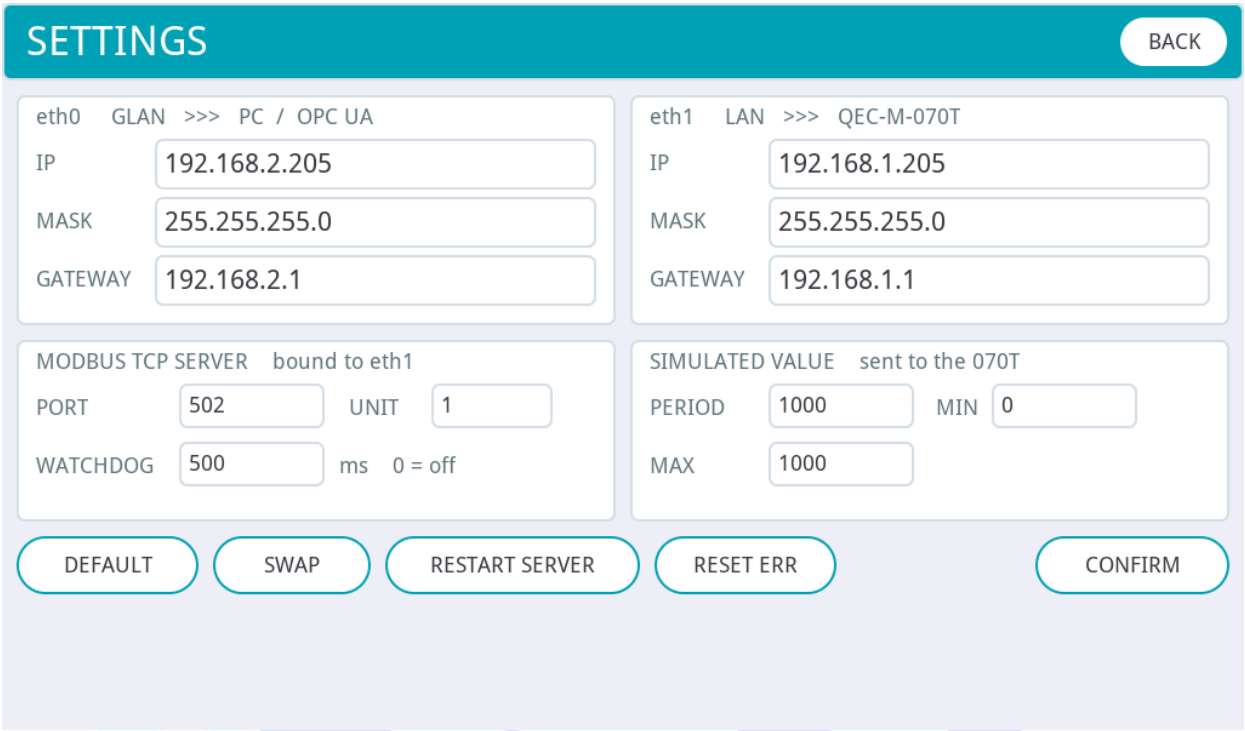


Figure 18: QEC-PPC-M-090T-S Settings page.

Section	Description
eth0 GLAN >>> PC / OPC UA	IP / MASK / GATEWAY of the host-side adapter
eth1 LAN >>> QEC-M-070T	IP / MASK / GATEWAY of the machine-side adapter
MODBUS TCP SERVER	PORT, UNIT (**must match the QEC-M-070T**), WATCHDOG (ms, 0 = off)
SIMULATED VALUE	Simulated value PERIOD / MIN / MAX sent to the QEC-M-070T

Button	Function
DEFAULT	Restores factory defaults (tap CONFIRM to save)
SWAP	Swaps the eth0 / eth1 settings (use when the roles of the two ports need to be swapped)
RESTART SERVER	Restarts the Modbus TCP Server without restarting the device
RESET ERR	Tells the QEC-M-070T to clear its error counters
CONFIRM	Saves to EEPROM (network settings take effect after a restart)

9.4 Detail: Connection quality and diagnostics

Tap **MORE** on the Main page to open the Detail page, which shows connection quality and communication counters. Check this page first when something goes wrong.

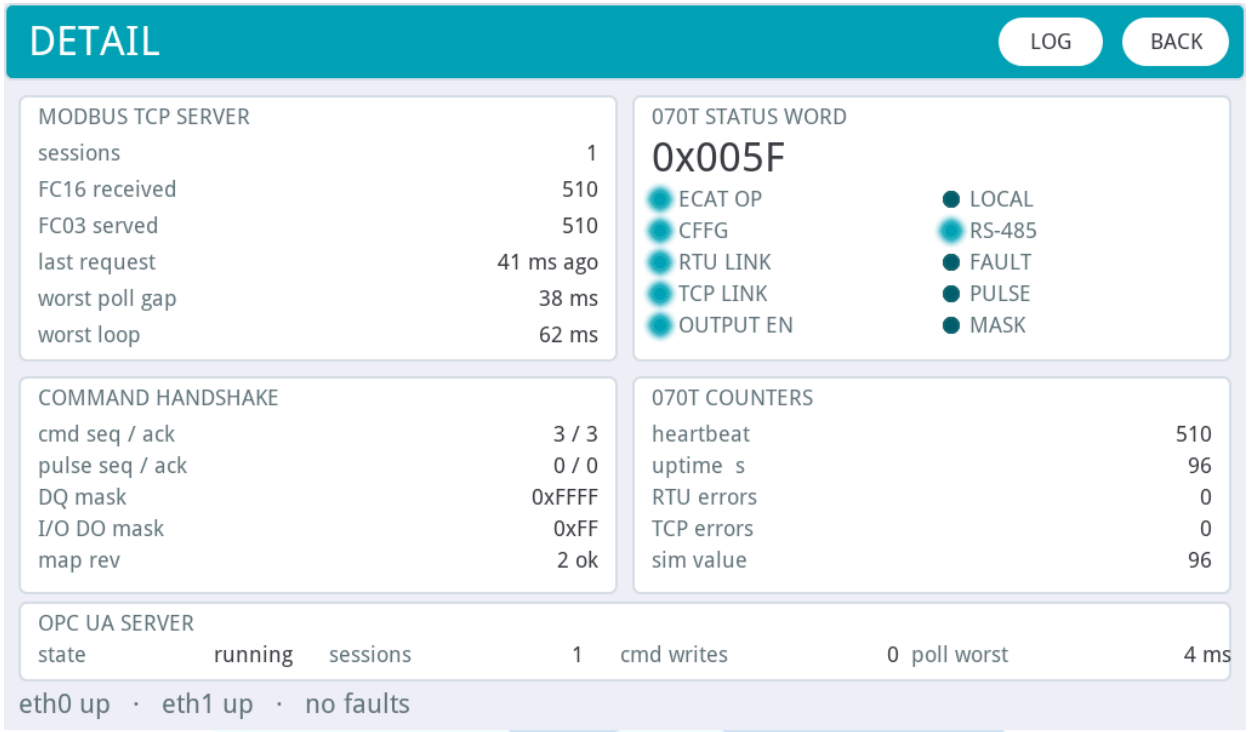


Figure 19: QEC-PPC-M-090T-S Detail page. sessions is 1, the two cmd seq / ack values match, and the bottom line shows no faults.

Section	Field	Normal value	If abnormal
MODBUS TCP SERVER	`sessions`	Stays at **1**	A rising value means the connection keeps dropping and reconnecting
	FC16 received / FC03 served	Keeps increasing	If it stops, the QEC-M-070T has stopped exchanging data
	`worst poll gap`	Tens of ms	Hundreds of ms or more means processing time is being taken by other tasks
	`worst loop`	< 100 ms	Something in the program is taking too long
070T STATUS WORD	Hex value + 10 indicators	Depends on actual state	See Appendix A.3
COMMAND HANDSHAKE	`cmd seq / ack`, `pulse seq / ack`	The two values match	If they differ, the QEC-M-070T has not read the latest command yet
	`map rev`	`2 ok`	`MISMATCH` = the two devices use different register map versions
070T COUNTERS	heartbeat / uptime / RTU / TCP errors / sim value	—	—
OPC UA SERVER	`state` / `sessions` / `poll worst`	`running` / 1 / a few ms to a little over 10 ms	If `poll worst` is high, reduce the number of nodes or lengthen the sync interval
Bottom line	Network interfaces	`eth0 up · eth1 up · no faults`	—

9.5 Log

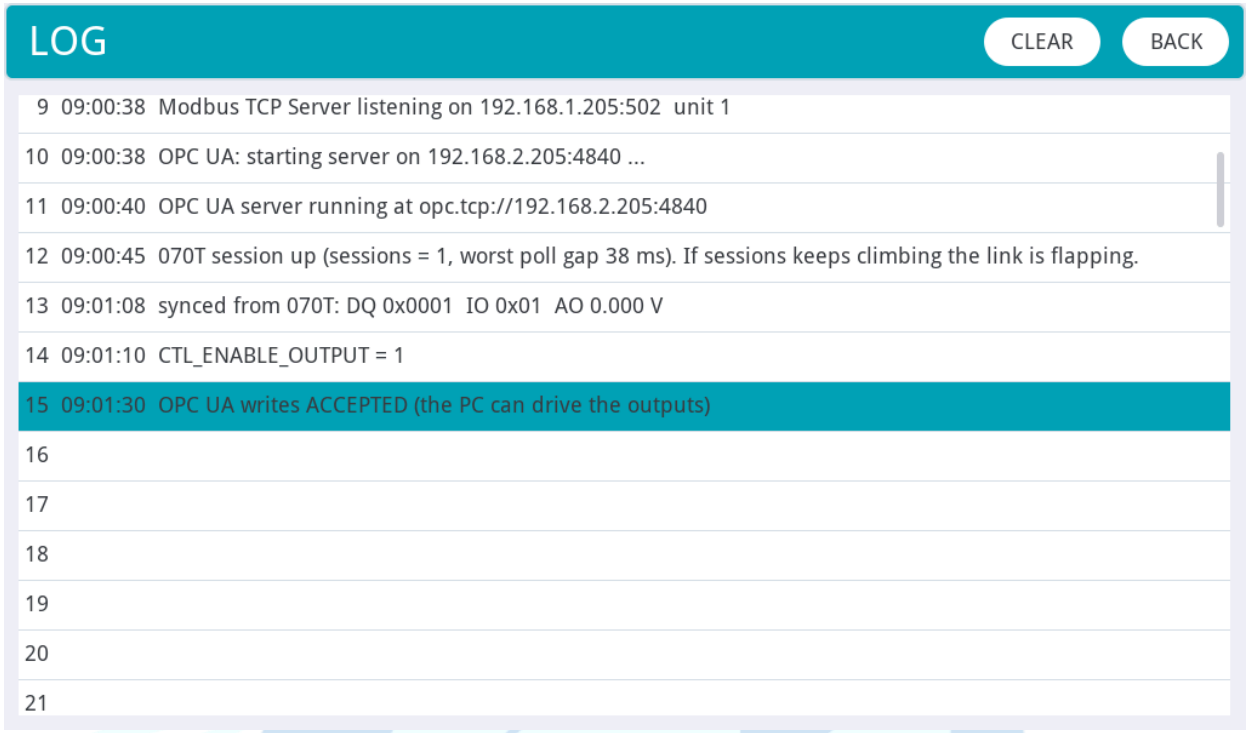


Figure 20: QEC-PPC-M-090T-S Log page.

The figure shows the -S powering up → eth0 / eth1 coming up → the Modbus TCP Server (eth1) and OPC UA Server (eth0) starting → the QEC-M-070T connecting at 09:00:45 → SYNC at 09:01:08 → ENABLE OUT at 09:01:10 → OPC WRITES switched to ACCEPT at 09:01:30. Single DQ / DO toggles on the panel (such as DO3 in Exercise B) appear only in the status bar, not in the Log.

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10. OPC UA Node Reference

Endpoint: `opc.tcp://192.168.2.205:4840`. All NodeIds are **strings in ns=1**, identical to the path, for example `ns=1;s=QEC.Dev1.Status.CffgDi`.

10.1 QEC.Dev1.Status.* (read-only, actual field state)

Node	Type	Description
`CffgDi`	UInt16	QEC-R11CFFG DI00–DI15, bit0 = DI00
`CffgDq`	UInt16	QEC-R11CFFG DQ00–DQ15 **actual output** (differs from `Cmd.CffgDq` when the QEC-M-070T is in LOCAL or outputs are not enabled)
`CffgAi`	Double	AI00, **volts**
`CffgAo`	Double	AO00 actual output, **volts**
`IoDi`	UInt16	Modbus I/O board DI0–DI7 (via QEC-R11CFFG COM1)
`IoDo`	UInt16	Modbus I/O board DO0–DO7 actual output
`SimValue`	UInt16	Simulated value; **the best way to check that data keeps updating**
`SimMode`	UInt16	0 OFF / 1 COUNTER / 2 RANDOM
`Heartbeat`	UInt16	+1 on every QEC-M-070T exchange; if it stops increasing, the data path is down
`StatusWord`	UInt16	Status word (Appendix A.3)
`RtuErrors`	UInt16	Accumulated COM1 errors
`TcpErrors`	UInt16	Accumulated Modbus TCP failures on the QEC-M-070T side
`UptimeSeconds`	UInt16	QEC-M-070T uptime in seconds (wraps to 0 after 65535)
`Connected`	Boolean	Whether the QEC-M-070T is connected (becomes false if no Block A is received for more than 3 seconds). **When false, I/O, analog, simulated value, and status word are reset to zero**; Heartbeat, error counts, and uptime keep the last received values
`EcatOp`	Boolean	= StatusWord bit0
`RtuLink`	Boolean	= bit2. **When false, writes to `Cmd.IoDo` have no effect**
`OutputEnabled`	Boolean	= bit4. When false, no output command takes effect
`PeerLocalMode`	Boolean	= bit5. **true = the QEC-M-070T is in LOCAL, the most common reason a write has no effect**

10.2 QEC.Dev1.Cmd.* (writable, commands to the field)

Node	Type	Description
`CffgDq`	UInt16	DQ bitmap (`1` = DQ00 only, `65535` = all on)
`IoDo`	UInt16	I/O board DO bitmap (`255` = all on); the upper 8 bits are not used
`CffgAo`	Double	AO00 in volts; rounded to 1 mV and limited by `CFFG_AO_LIMIT_V`
`EnableOutput`	Boolean	Same as ENABLE OUT on the -S panel
`MaskEnable`	Boolean	Same as MASK MODE (true = write only the last changed point)
`SimMode`	UInt16	0 / 1 / 2

Node	Type	Description
`SimPeriod`	UInt16	ms; values below 50 are ignored
`SimMin` / `SimMax`	UInt16	Max must be greater than Min, otherwise both are ignored
`PulseTarget`	UInt16	1 = QEC-R11CFFG DQ, 2 = I/O board DO
`PulsePoint`	UInt16	CFFG 0–15, I/O board 0–7
`PulseMs`	UInt16	20 to 5000
`PulseTrigger`	Boolean	Write true to fire one pulse; **automatically returns to false**
`Reset`	Boolean	Write true to clear the QEC-M-070T error counters; **automatically returns to false**

10.3 QEC.Dev1.Info.* (read-only, -S information)

Node	Type	Description
`Model`	String	`QEC-PPC-M-090T-S`
`MapRev` / `PeerMapRev`	UInt16	Register map version of this device / the QEC-M-070T; different values mean the two do not match
`ModbusSessions`	UInt16	Number of times the -S ↔ QEC-M-070T data path has been restored; normally 1
`OpcWritesAccepted`	Boolean	true = OPC WRITES is set to ACCEPT
`CommandBlocked`	String	Why a command has not taken effect; empty string = all conditions met

10.4 CommandBlocked messages

Conditions are checked in the following order, and only the first unmet condition is shown:

Message	Meaning / what to do
`Modbus server is not listening yet`	The -S Modbus TCP Server has not started; wait or tap RESTART SERVER
`070T offline - no block A received`	The QEC-M-070T is not connected; check the LAN cable, IP, PORT, and UNIT
`070T is in LOCAL - press MODE on the 070T panel`	Condition ①: switch the QEC-M-070T to REMOTE
`output not enabled - press ENABLE OUT here`	Condition ②: tap ENABLE OUT, or write `Cmd.EnableOutput = true`
`070T has not enabled outputs yet - wait one poll`	The command is on its way; please wait
`070T EtherCAT is not in OP`	Check the QEC-R11CFFG wiring and power
`OPC writes IGNORED - press OPC WRITES on the -S panel`	Condition ③: switch OPC WRITES on the -S to ACCEPT
`COM1 RTU link to the I/O board is down (I/O board DO only)`	Affects only `Cmd.IoDo`; QEC-R11CFFG DQ / AO still work normally

11. Isolation and Disconnection Tests

After completing Exercises A–C, you can use the following tests to confirm that the two subnets are truly isolated and that a disconnection on one side does not affect the other:

Test	Expected result
`ping 192.168.1.200` (QEC-M-070T) from the host PC	**No reply** (the PC is connected only to the GLAN side)
Unplug LAN (-S ↔ QEC-M-070T)	OPC UA stays connected; after about 3 seconds `Status.Connected` becomes false and field data resets to zero; the second card on the -S shows `no data`
Unplug GLAN (-S ↔ host PC)	Modbus keeps running; the QEC-M-070T and -S panels are unaffected
Unplug RS-485	The QEC-M-070T MODBUS RTU indicator goes off; `Status.RtuLink` = false; QEC-R11CFFG EtherCAT I/O keeps running
Reconnect each cable	Recovers automatically; no restart needed
Stress test: subscribe to all `Status.*` in UaExpert while repeatedly tapping DO buttons on the -S and writing `Cmd.IoDo` from UaExpert	`sessions` on the -S Detail page **stays at 1**, `worst poll gap` is tens of ms, and OPC UA `poll worst` is a few ms to a little over 10 ms

> **Note** The last test is the most important: **after adding OPC UA, the machine-side Modbus `sessions` should not increase**. If it stays the same, host-side services are not taking processing time away from the machine side.

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12. Troubleshooting

12.1 Symptom table

Symptom	Check first	Possible cause
QEC-M-070T ETHERCAT indicator not lit	QEC-M-070T Main page status bar	QEC-R11CFFG not powered, cable not connected to the EtherCAT port, or the QEC-R11CFFG is not the first device in the EtherCAT chain (index 0)
QEC-M-070T MODBUS RTU indicator not lit	Bottom line of the QEC-M-070T Detail page (RS-485 / RS-232)	RS-485 A / B swapped, DIP switch not set to RS-485, or mismatched slave ID or baud rate
First -S card (MODBUS TCP SERVER) not lit	Status text on the card	The server has not started; wait or tap RESTART SERVER
Second -S card shows `no data`	LAN cable, IP of both devices	QEC-M-070T not connected; make sure it is on the Giga LAN port and that PORT (502) and UNIT (1) match
`heartbeat` stops increasing	Same as above	The data path from the QEC-M-070T is down
Output buttons have no effect	**-S status bar**	A condition is not met; the status bar shows which one (Section 10.4)
UaExpert cannot connect	PC IP and gateway	The PC must be on 192.168.2.x with no gateway; ping 192.168.2.205 first
Values written in UaExpert revert	OPC WRITES on the -S	Still set to IGNORE; switch it to ACCEPT
Writes from UaExpert have no effect	`Info.CommandBlocked`	The node states which condition is not met
`sessions` on the -S Detail page keeps increasing	LAN cable, Log page	The Modbus connection keeps reconnecting; note messages such as `!! modbus poll starved` and `slow loop` in the Log
`map rev` on the Detail page shows `MISMATCH`	Program version on both devices	`QEC_DemoMap.h` must be identical on both devices; re-upload both
Reading the -S with Modbus Poll from the machine subnet gives odd data	—	The -S Modbus Server serves only one client at a time; stop the QEC-M-070T connection first
Compile error `Select Tools > Board > "PPCM090 (None-EtherCAT)"`	Tools → Board	Select PPCM090 (None-EtherCAT) for the QEC-PPC-M-090T-S

12.2 General recovery steps

1. On the Main page, find which card or indicator is not lit and start checking from there.
2. Open the Detail page and compare against the normal values in Sections 8.4 and 9.4.
3. Check the last few events on the Log page.
4. Tap RESTART SERVER on the -S Settings page.
5. Power-cycle both devices (start the QEC-M-070T first, then the QEC-PPC-M-090T-S).

12.3 Further use: changing the host protocol

This example uses OPC UA on the host side because it has the most complete information model and is the most common requirement for SCADA and IT systems. You can change the host protocol to suit your application:

Host protocol	How to implement on 86Duino
MQTT, Web Server, MySQL	Supported directly by libraries
OPC UA	open62541 (wrapped by `OpcUaBridge` in this example)
Other TCP protocols	Write your own in C/C++, or use a third-party protocol stack

Whichever protocol you choose, the code that binds each service to a network port stays exactly the same, and the register map, control management, and panels need no changes; only the host-side implementation changes. **The host protocol is your choice; what really matters is having two independent Ethernet interfaces.**

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Appendix A: Modbus Register Map

Both devices share the same `QEC_DemoMap.h` (**map rev 2**) and cross-check the version number stored in a reserved register. All addresses are **PDU addresses (0-based)**; when viewing 4xxxx registers in Modbus Poll, add 40001.

A.1 Block A: QEC-M-070T → -S (from 0x0000, 20 words, FC16)

PDU	Name	Contents
0x0000	`CFFG_DI`	QEC-R11CFFG DI00–DI15 bitmap
0x0001	`CFFG_AI_MV`	AI00, millivolts (INT16)
0x0002	`CFFG_DO`	DQ00–DQ15 **actual** output
0x0003	`CFFG_AO_MV`	AO00 actual output, millivolts (INT16)
0x0004	`IO_DI`	I/O board DI0–DI7
0x0005	`IO_DO`	I/O board DO0–DO7 **actual** output
0x0006	`SIM_VALUE`	Simulated value
0x0007	`SIM_MODE`	0 OFF / 1 COUNTER / 2 RANDOM
0x0008	`HEARTBEAT`	+1 on every exchange
0x0009	`STATUS`	Status word (A.3)
0x000A	`RTU_ERR`	Accumulated COM1 errors
0x000B	`UPTIME_S`	QEC-M-070T uptime in seconds
0x000C–0x000E	`SIM_PERIOD / MIN / MAX`	Simulated value parameters
0x000F	`CMD_ACK`	Echoes the received `CMD_SEQ` (acknowledgment)
0x0010	`PULSE_ACK`	Echoes the received `PULSE_SEQ` (acknowledgment)
0x0011	`PULSE_STATE`	bit0 `BUSY`, bit1 `REJECTED`, bit8–11 target, bit12–15 point
0x0012	`TCP_ERR`	Accumulated TCP failures on the QEC-M-070T side
0x0013	Reserved	Holds the map version number

A.2 Block B: -S → QEC-M-070T (from 0x0020, 16 words, FC03)

PDU	Name	Contents
0x0020	`CFFG_DO`	DQ command
0x0021	`CFFG_AO_MV`	AO command (millivolts)
0x0022	`IO_DO`	I/O board DO command
0x0023	`CTRL`	bit0 `ENABLE_OUTPUT`, bit1 `RESET`, bit2 `MASK_ENABLE`, bit15 `WATCHDOG`
0x0024–0x0027	`SIM_MODE / PERIOD / MIN / MAX`	Simulated value commands
0x0028	`CMD_SEQ`	Command sequence number
0x0029 / 0x002A	`CFFG_DO_MASK / IO_DO_MASK`	Masks (effective only when `MASK_ENABLE` is set)

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PDU	Name	Contents
0x002B–0x002D	`PULSE_TARGET / POINT / MS`	Single-point pulse parameters
0x002E	`PULSE_SEQ`	Fires one pulse whenever the value **changes** (edge-triggered)
0x002F	Reserved	—

A.3 Status word (Block A 0x0009)

bit	Name	bit	Name
0	`ECAT_OP`	5	`LOCAL_MODE`
1	`CFFG_ONLINE`	6	`RTU_IS485`
2	`RTU_LINK`	7	`FAULT`
3	`TCP_LINK`	8	`PULSE_ACTIVE`
4	`OUTPUT_ENABLED`	9	`MASK_PARTIAL`

> **Caution** The -S Modbus TCP Server **serves only one client at a time** (a library limitation). To read port 502 of the -S with a third-party tool from the machine subnet, stop the QEC-M-070T connection first.

DM&P Group