CAE專家教室 T1S1001 課程

10BASE-T1S Ethernet

SPE (Single Pair Ethernet)

T1S1001 v1.00

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

CAE Taiwan
Microchip Technology Inc.

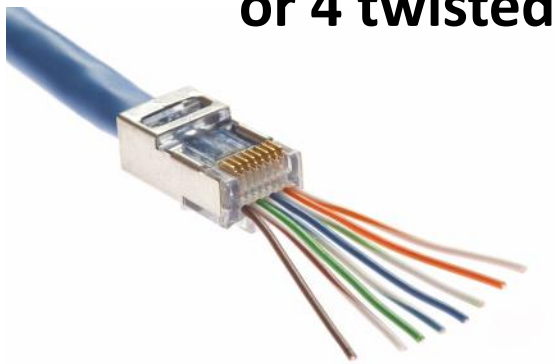
May 21, 2026

CAE Expert Classroom : T1S1001 Index

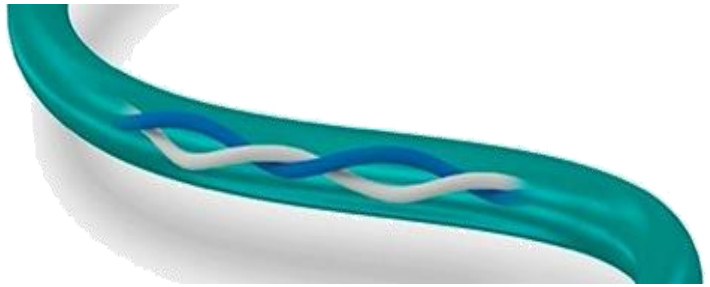
Single Pair Technology

What is Single Pair Ethernet (SPE)?

- Traditional ethernet uses 2 or 4 twisted pairs



- SPE = Single Pair Ethernet
- T1 = 1-Twisted Pair



- Just a new ethernet transceiver (PHY)
- Network layers 2-7 remain the same
- Independent of speed; 10BASE-T1, 100BASE-T1, NGBASE-T1…

Why Single Pair Ethernet?

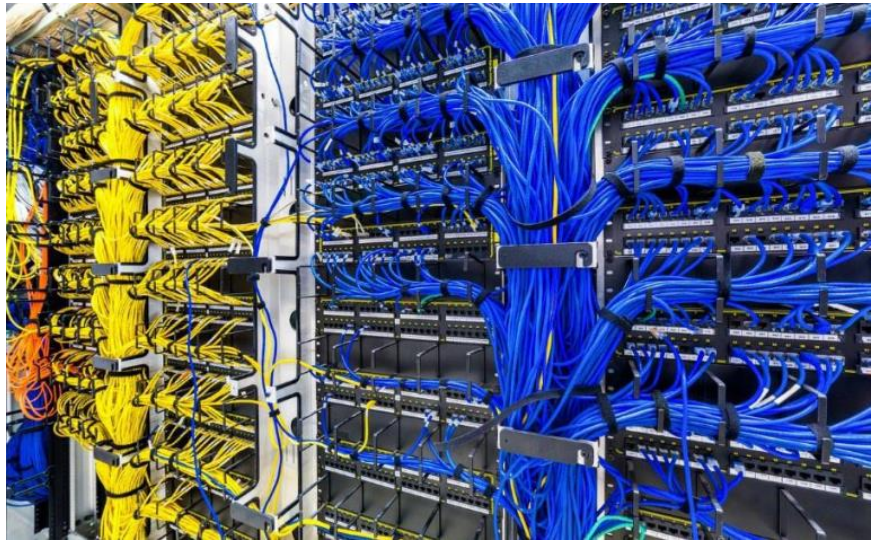
- Single Pair Ethernet reduces system cost, weight and wiring complexity

- **IEEE 802.3cg - 10BASE-T1S and 10BASE-T1L**
  - 10 Mbit/s connection over a single two-conductor cable
    - 10BASE-T1S: Short Reach (25m), multi-drop bus line or point-to-point connection
    - 10BASE-T1L: Long Reach (1 km), point-to-point connection

- **IEEE 802.3bw - 100BASE-T1**
  - 100 Mbit/s over single pair

- **IEEE 802.3bp - 1000BASE-T1**
  - 1000 Mbit/s over single pair cable

- **IEEE 802.3ch – NGBASE-T1**
  - 2.5Gbit/s, 5Gbit/s, 10Gbit/s over single pair cable



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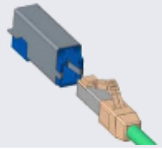
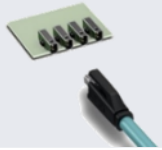
SPE Connector Standard – Current Status

- **ISO/IEC 63171 CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT**

	IEC 63171	IEC 63171-1	IEC 63171-2	IEC 63171-3	IEC 63171-4	IEC 63171-5	IEC 63171-6	IEC 63171-7
Initiator	N/A	Commscope	R&M	SIEMON	BKS	Phoenix Contact	Harting	TE
Picture								
Type		LC-Style	Rectangle	TERA 1P	Square-shaped	M8 / M12	Rectangle / M8 / M8 Hybrid/ M12	M12 Hybrid
Variants		1	1		1	2	4	7
IP-class		IP20	IP20	IP20	IP20	IP67	IP20 / IP67	IP67
Status Norm	**published**	ED1 published ED2 in progress	**published**	-	CDV	**2. CDV** publish in 2022	ED1 published ED2 in progress	CD
Target markets	N/A	Building	Building / Industry	-	Building / Data Center	Industry	Industry	Industry
Available products		-	**Sockets, Patchcables**	-	-	**M8 sockets, M8 Patchcable**	IP20 sockets, Patchcables	-

Longer reach application

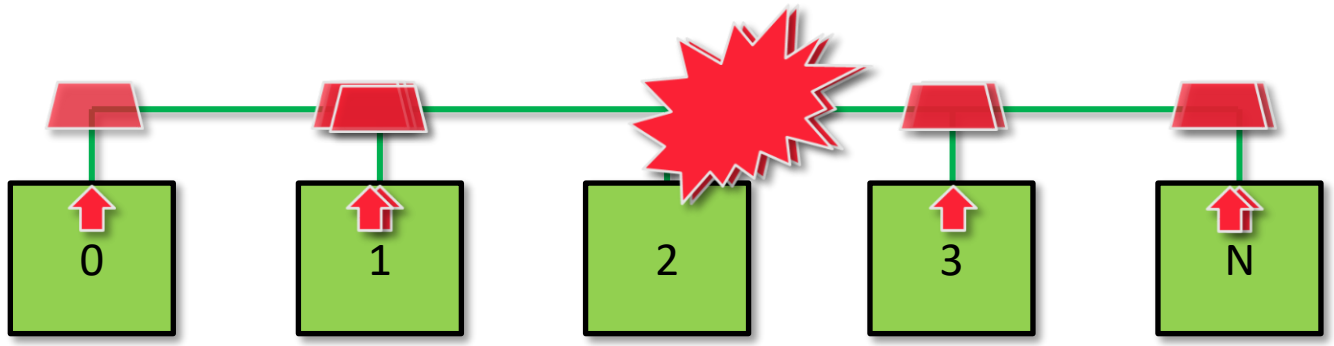
- AN1829 - Understanding System Intrinsic Noise: Enabling Longer Reach and More Nodes on 10BASE-T1S Systems
- Total 100M, 50 nodes , each node spacing for 2M

Introduction to T1S

What is 10BASE-T1S ?

- **Ethernet on a UTP bus line**
  - 10 Mbps shared
  - Half-duplex
  - 2-50 nodes, depending on the environment
  - Up to 25m bus length
  - IEEE 802.3cg standard
  - Low power
  - No collisions (PLCA)

10 Mbps shared,
without PLCA, Collisions occur



What is 10BASE-T1S ?

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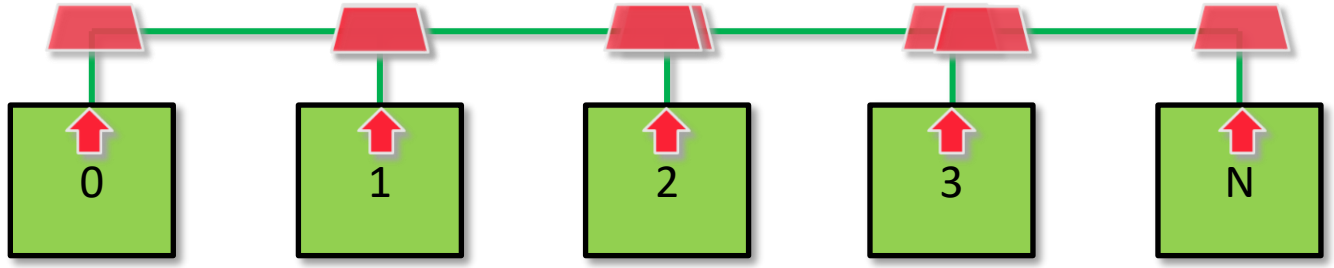
  - Half-duplex
  - 2-50 nodes, depending on the environment
  - Up to 25m bus length
  - IEEE 802.3cg standard
  - Low power
  - No collisions (PLCA)
- **Benefits**
  - No switch required
  - Inexpensive UTP cabling
  - Inexpensive analog front end
  - Less PHYs and cabling than with star topology
  - Supports Functional Safety

10 Mbps shared,
PLCA switched ON, avoids collisions

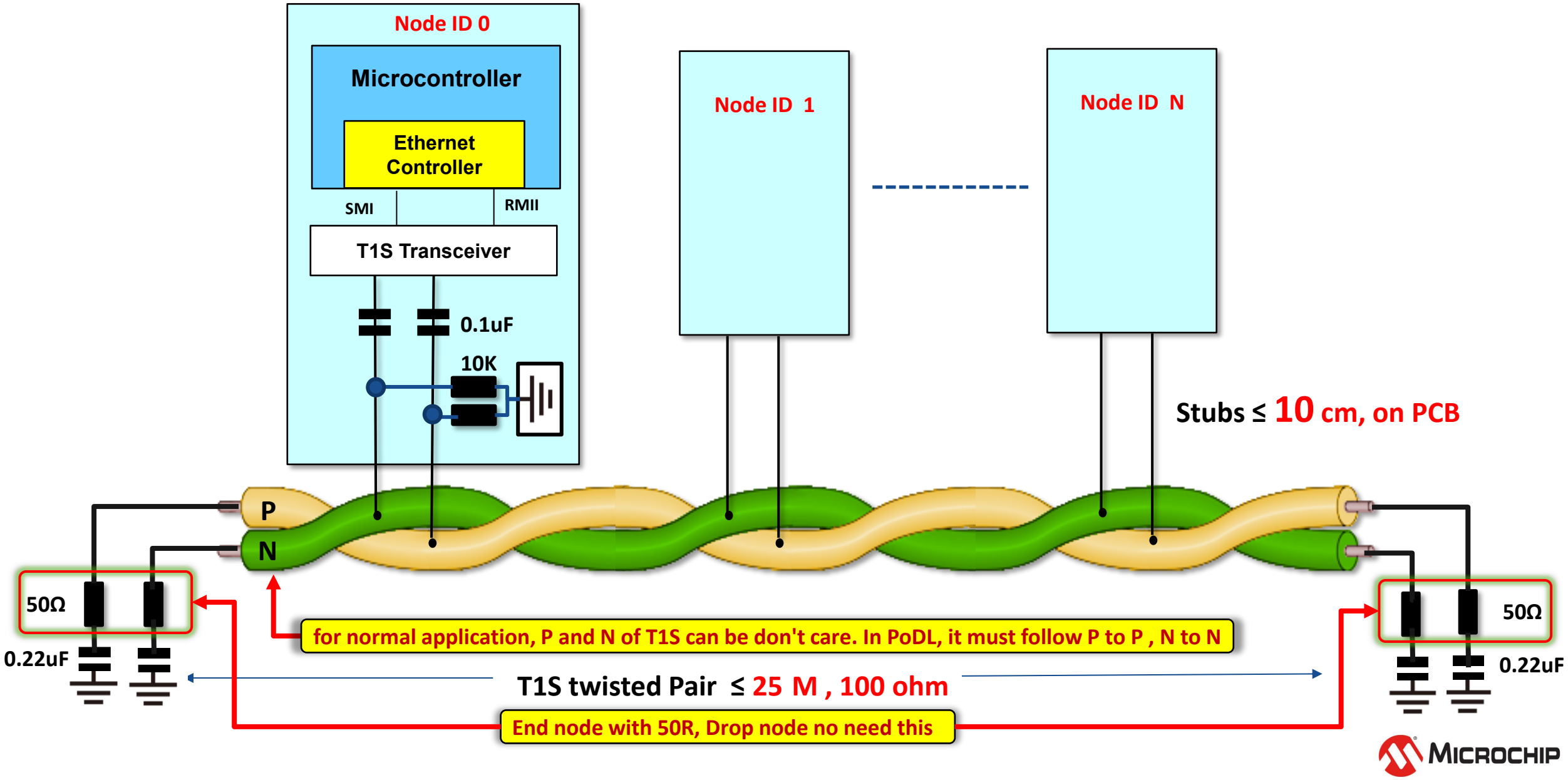


PLCA in IEEE 802.3 Ethernet Model

OSI Reference Model Layers	IEEE 802.3 Ethernet Model Layers
Application	Higher Layers
Presentation	
Session	
Transport	
Network	
Data Link	LLC = Logical Link Control (or other MAC client)
	MAC Control
	MAC = Media Access Control
Physical	MII = Media Independent Interface
	PLCA Reconciliation
	MII
	PCS = Physical Coding Sublayer
	PMA = Physical Medium Attachment
	AN = Auto-Negotiation
	MDI = Medium Dependent Interface

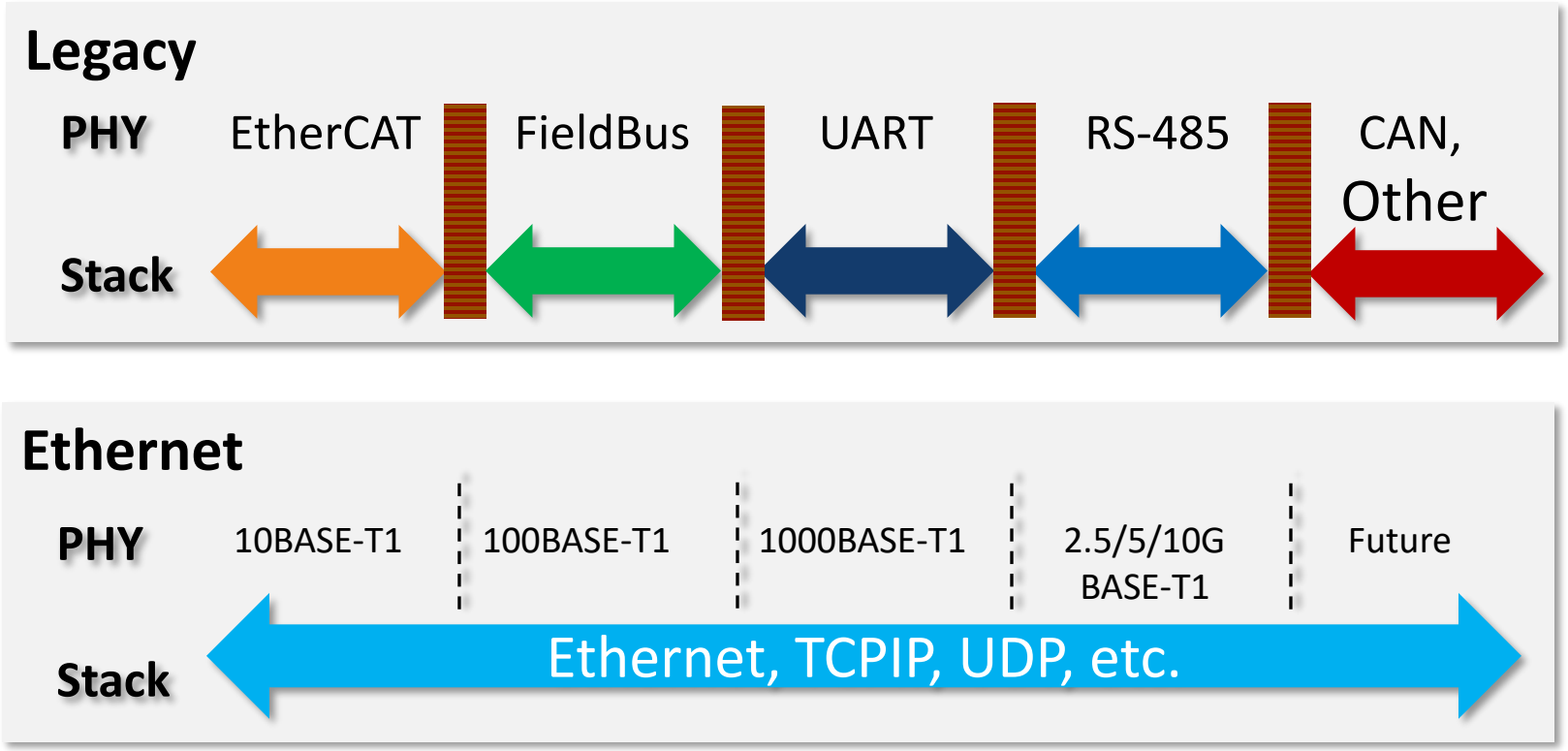
PHY

T1S cabling example



Scalable from Low to High Bandwidths

- **Common network software stacks**
- **Physical layer independent**

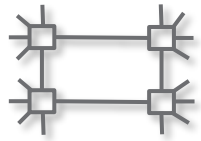


Motivation

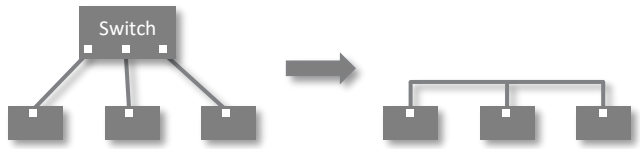
Ethernet, a success story

- **Security**
  - Offering reliable standards (MACsec, IPsec)
- **Safety**
  - Preventing nodes from flooding network
  - Deterministic behavior
- **Synchronization**
  - Single time base for all nodes
- **Software defined system**
  - Sensors, actuators just offering a service
  - Independent applications operating on services

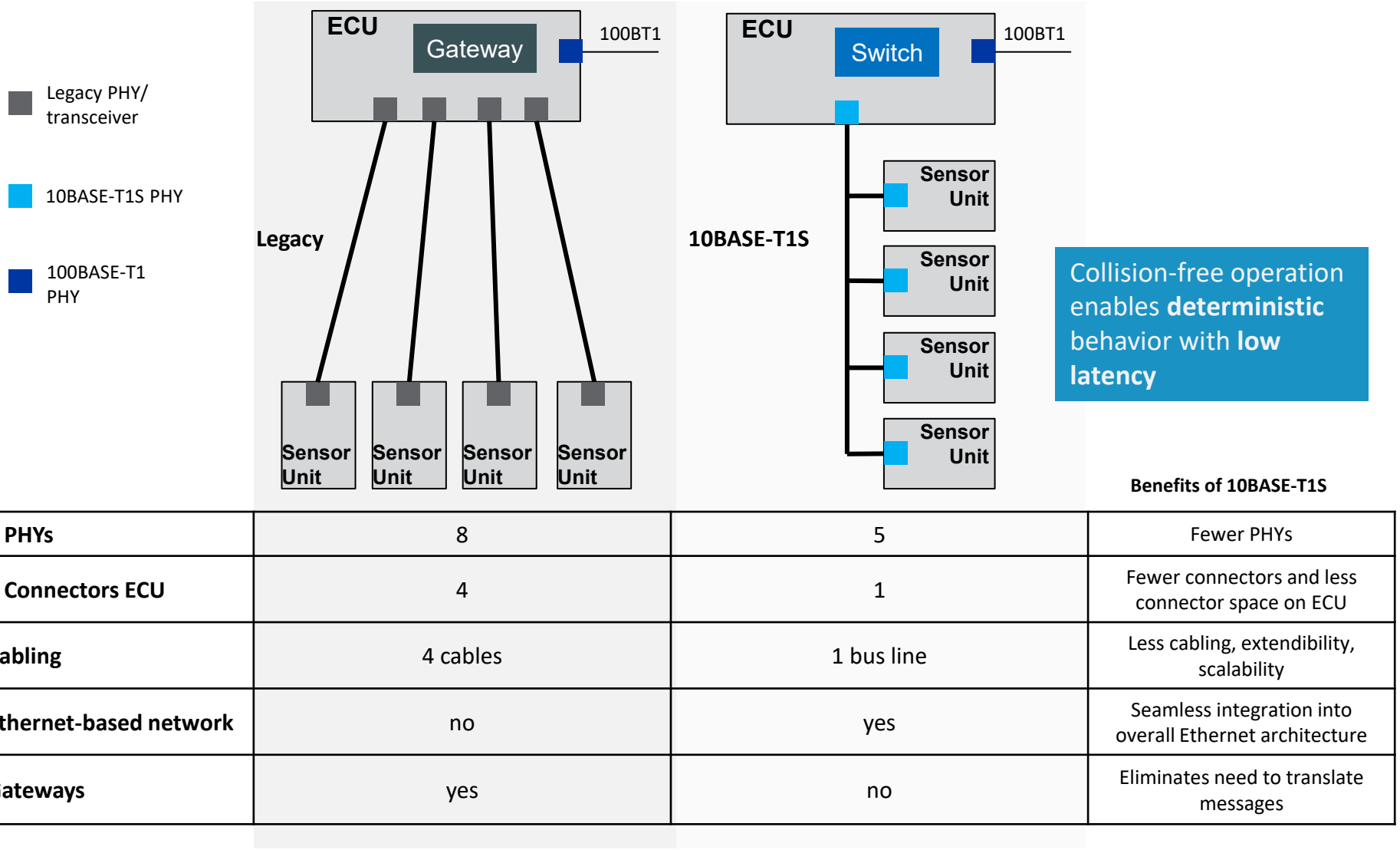
- **Wiring**
  - Shorter cables through zone architecture
  - Enabling machine-made wire-harness



- **No Gateways**
  - Using switches instead of gateways
- **Multidrop**
  - Fewer PHYs
  - Less cables
  - Fewer switch ports
  - Simple UTP cabling



No Gateway, Less Phys and Cables， Reduce Costs



			Benefits of 10BASE-T1S
# PHYs	8	5	Fewer PHYs
# Connectors ECU	4	1	Fewer connectors and less connector space on ECU
Cabling	4 cables	1 bus line	Less cabling, extendibility, scalability
Ethernet-based network	no	yes	Seamless integration into overall Ethernet architecture
Gateways	yes	no	Eliminates need to translate messages

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Introduction to OPEN Alliance

Standardization OPEN Alliance

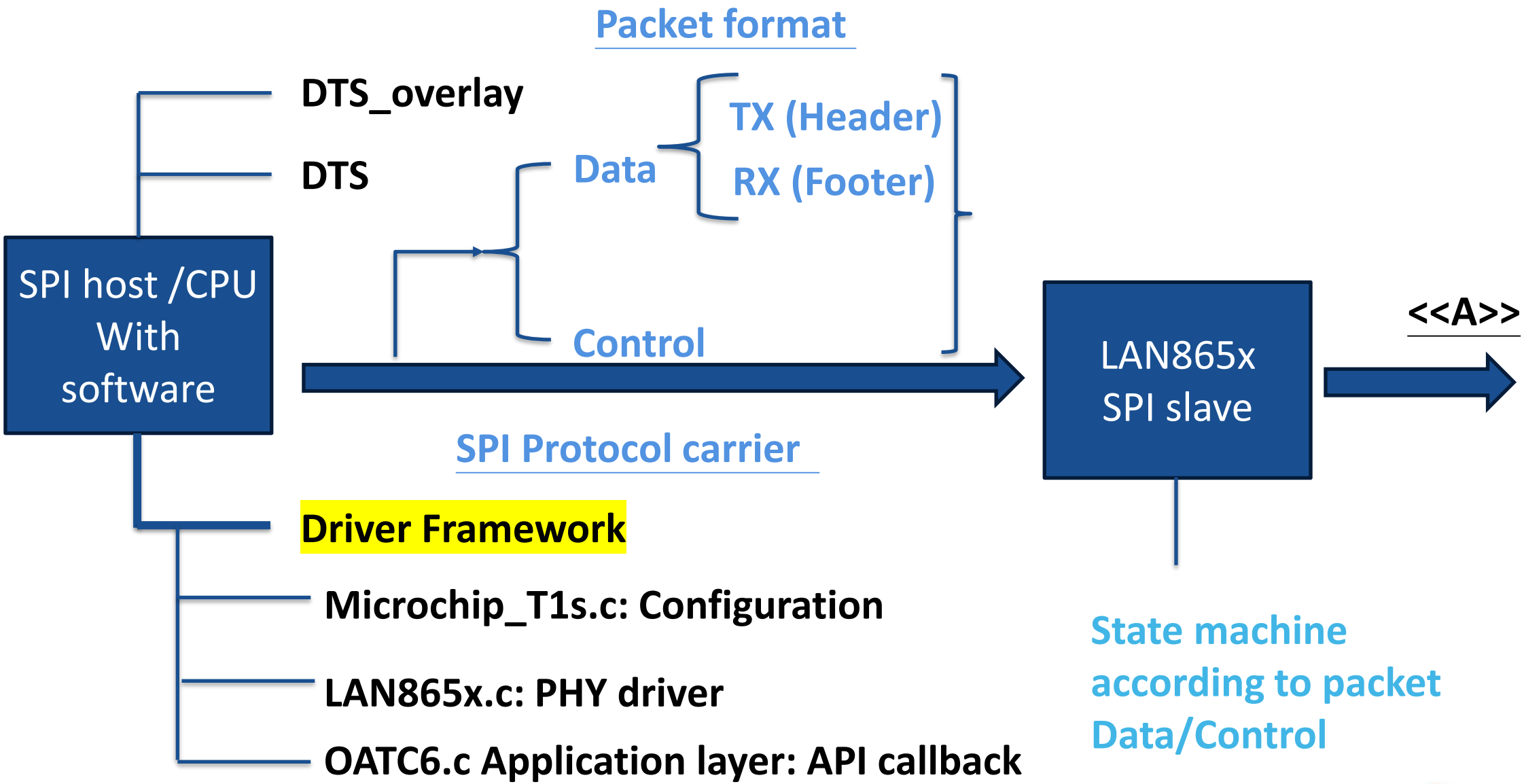
- **TC6 (Technical Committee):**
  - SPI Protocol for MAC-PHY
  - Low pin count interface for Transceiver
- **TC10:**
  - Sleep/Wake-up
- **TC14:**
  - Compliance
  - Interoperability
  - EMC
  - Diagnosis
- **TC17:**
  - MACsec

Founded in 2011, OPEN Alliance emerged with the idea of collaboration in the blossoming automotive Ethernet landscape. There was a gap in the industry that propelled its formation: a transparent space, governed by clear rules, for anyone to join and participate. Knowledge exchange, market development, and industrialization of the technology were its pillars. But the true cornerstone was the desire to break free from single-company specifications. OPEN Alliance envisioned a world where access to these crucial specifications wouldn't depend on favoritism or opaque promises, but on an open, fair, and universally accessible framework. By fostering transparent peer review and non-discriminatory access, OPEN Alliance aimed to pave the way for a collaborative future where innovation in Ethernet could truly thrive.

OPEN: One Pair Ethernet

小组	名称	Status
TC 1	Interoperability & Compliance Tests for 100BASE-T1 PHYs 100BASE-T1 PHY的物理层互操作性和一致性测试	on hold
TC 2	100BASE-T1 Ethernet Channel & Components 100BASE-T1 PHY的以太网通道和组件测试	on hold
TC 3	1000BASE-T1 CMC Requirements 1000BASE-T1 PHY CMC要求	rescoped
TC 4	Tools 工具	completed
TC 5	Gap Identification 差距识别	on hold
TC 6	Common Media Independent Interface Definitions for Automotive Purposes 车用通用媒体独立接口定义	in progress
TC 7	Gigabit Ethernet over Optical Fiber 千兆光纤以太网	in progress
TC 8	Automotive Ethernet ECU Test Specification 车载以太网ECU测试规范	on hold
TC 9	Automotive Ethernet Channel & Components 车载以太网通道和组件	in progress
TC 10	Automotive Ethernet Sleep/Wake-Up 车载以太网睡眠/唤醒	in progress
TC 11	Ethernet switch requirements and qualification 以太网交换机要求和资格	in progress
TC 12	Test specifications for the compliance testing of IEEE 1000BASE-T1(IEEE802.3bp, Cause 97) Physical Interface (PHY) devices 1000BASE-T1 PHY设备一致性测试规范	in progress
TC 13	New Test House Qualification Requirements 测试机构资格新要求	in progress
TC 14	Interoperability & Compliance Tests for 10BASE-T1S PHYs 10BASE-T1 PHY互操作性和一致性测试	in progress
TC 15	Multi Gig Interoperability and Compliance Tests 多千兆互操作性和一致性测试	in progress
TC 16	EEE Interoperability and Compliance EEE互操作性和一致性	in progress
TC 17	MACsec Automotive Profile MACsec汽车行业配置	in progress

TC6 - Overview



TC10 - Key goal

- new service primitives provided by the ISO/OSI layer 1 (PHY) and supporting a controlled link shutdown and a fast global wake-up within an Ethernet network, The sleep and wake up process in a PHY shall fulfill SPEC'S timing requirement (next page
- Power consumption The following guidelines on the device power consumption in sleep mode target typical Ethernet products such as single and multiport PHYs and switches. A single-port PHY product should have a quiescence current of 35µA. A multi-port PHY or switch product should have a quiescence current of 25µA plus 10µA for each port4 .

Pins and command about TC10

- **Pins**

Pin Name	Description
VBAT	This pin powers the sleep or wake management block.
INH	This is an open-drain output pin that goes low to disable power. During normal operation, an external resistor pulls it hight to enable power.
WAKE_IN	This is an input pin that can be used to wake up the PHY from Sleep state.
WAKE_OUT	This is an output pin that is asserted when the PHY receives a wake-up request.

- **Command**

Command Name	Description
Wake-Up Request (WUR)	This is the MDI wake-up request command sent on an active link.
Wake-Up Pulse (WUP)	This is the MDI wake-up request command sent on an inactive link.
Low-Power Sleep (LPS)	This is the MDI sleep request and acknowledge command.

TC10 Specification / Terminology

- **Low Power Sleep (LPS)**
  - Command to indicate a sleep request to the link partner. Request transition to SLEEP state.
  - 100BASE-T1: Encoded in the IDLE scrambler stream. Sent for a minimum of 64 bits.
  - 1000BASE-T1: Sent in OAM (Operations, Administration, Maintenance) Frame.

- **Wake-Up Request (WUR), for PHY is link up case**
  - Command indicating a wake-up request to the link partner.
  - Can be sent by a node PHY or switch PHY to distribute the wake-up request over a link, which is already active.
  - 100BASE-T1: Encoded in the IDLE scrambler stream. Sent for a minimum of 64 bits.
  - 1000BASE-T1: Sent in OAM (Operations, Administration, Maintenance) Frame.

- **Wake-Up Pulse (WUP): for PHY is link down case**
  - Command indicating wake-up request to link partner. Sent when link is not active.
  - Transmitted using link training (idle) codes over the network, for a duration of 1 ms (+/- 0.3ms)

Result (both 100 and 1000 mode are PASS)

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C&S OPEN ALLIANCE

Preliminary

P24_0286_LAN8870_1000B_TC10_Test_Report_00D_00

Date of Release: 2024-Nov-29

Test Report

Device Under Test

Device Name	LAN8870
Manufacturer	Microchip
Type / Version	-
Sample marking	LAN8870v VB000e3 241146Q

Customer

Order No.	P24_0286
Name	Microchip Technology Inc.
Address	80 Arkay Dr, Ste 100 11788 Hauppauge NY USA

Number of Pages	38
Test Period	from 2024-Nov-19 until 2024-Nov-28
Test Method / Test Requirement	1000BASE-T1 Interoperability Test Suite
Performed Tests and References	1000BASE-T1 Interoperability Test Suite v1.9.1 (2024-Feb-13) - TC10 Sleep/Wake-up functionality
Interoperability Test Results	The test results refer to the delivered device and the applicable test cases.
1 1000BASE-T1 Interoperability Test Suite[1]	**PHY Sleep/Wale-up Functionality: PASS**

	Link Partners		
Chapter	**RTK RTL9010AA**	**BCM 89884**	**MIC LAN8870[2]**
Group 5: Wake-up reception and signalizing	PASS	PASS	PASS
Group 6: Wake-up transmission	PASS	PASS	PASS
Group 7: Wake-up forwarding	NOT APPLICABLE[3]	NOT APPLICABLE[3]	NOT APPLICABLE[3]
Group 8: Sleep	PASS	PASS	PASS

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C&S OPEN ALLIANCE

Preliminary

P24_0286_LAN8870_100B_TC10_Test_Report_00D_02

Date of Release: 2024-Nov-29

Test Report

Device Under Test

Device Name	LAN8870
Manufacturer	Microchip
Type / Version	-
Sample marking	LAN8870v VB000e3 241146Q

Customer

Order No.	P24_0286
Name	Microchip Technology Inc.
Address	80 Arkay Dr, Ste 100 11788 Hauppauge NY USA

Number of Pages	40
Test Period	from 2024-Nov-6 until 2024-Nov-15
Test Method / Test Requirement	100BASE-T1 Interoperability Test Suite
Performed Tests and References	100BASE-T1 Interoperability Test Suite v1.2 (2024-Feb-13) - TC10 Sleep/Wake-up functionality
Interoperability Test Results	The test results refer to the delivered device and the applicable test cases.
1 100BASE-T1 Interoperability Test Suite[1]	**PHY Sleep/Wale-up Functionality: PASS**

	Link Partners			
Chapter	**RTK RTL9000AA**	**MVL 88Q1110**	**NXP TJA1101B**	**MIC LAN8870[2]**
Group 5: Wake-up reception and signalizing	PASS	PASS	PASS	PASS
Group 6: Wake-up transmission	PASS	PASS	PASS	PASS
Group 7: Wake-up forwarding	NOT APPLICABLE[3]	NOT APPLICABLE[3]	NOT APPLICABLE[3]	NOT APPLICABLE[3]
Group 8: Sleep	PASS	PASS	PASS	PASS

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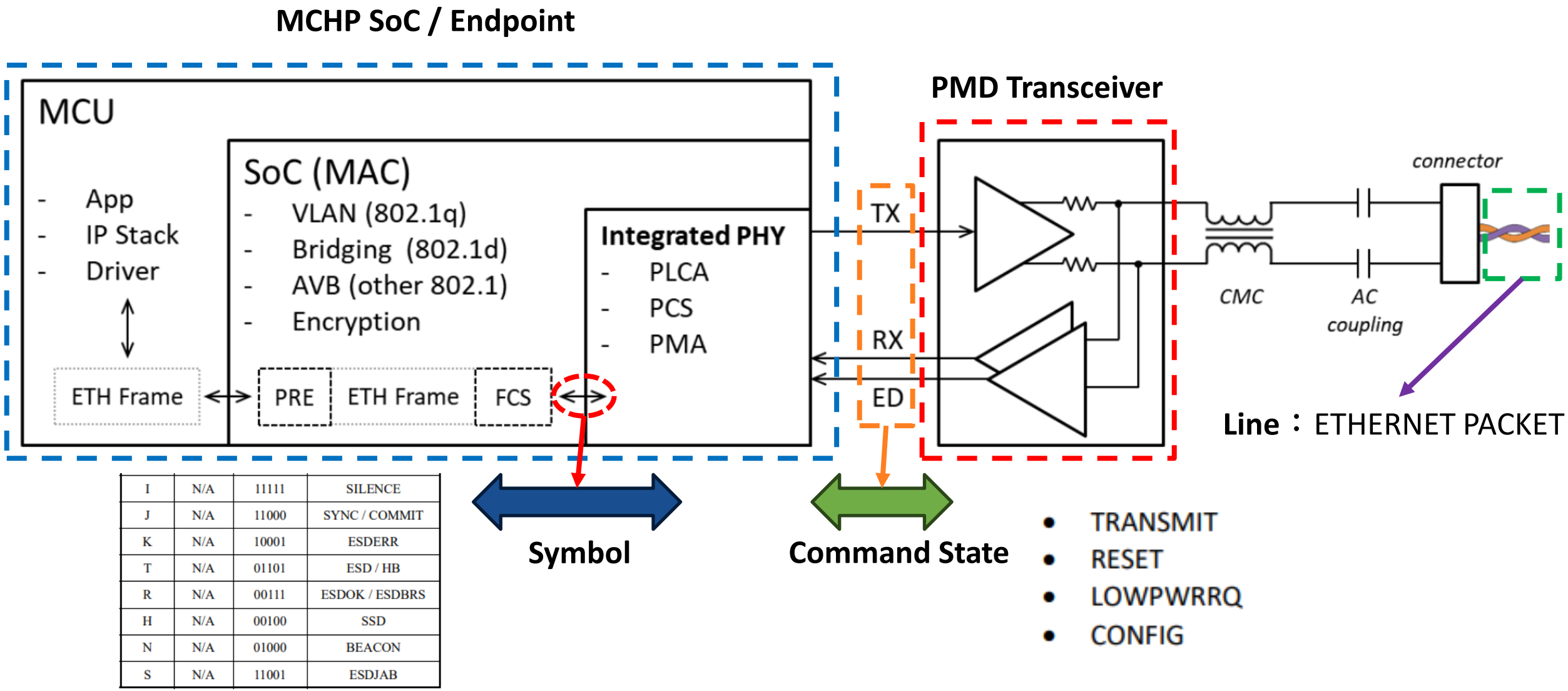
TC14 - OA3P (open alliance 3 pins)



I	N/A	11111	SILENCE
J	N/A	11000	SYNC / COMMIT
K	N/A	10001	ESDERR
T	N/A	01101	ESD / HB
R	N/A	00111	ESDOK / ESDBRS
H	N/A	00100	SSD
N	N/A	01000	BEACON
S	N/A	11001	ESDJAB

MCHP solution (SoC / Endpoint)

- **LAN8660 , LAN8661 : IO to OA3p**
  - **Control**
    - Sensors
    - Actuators
  - **Audio**
    - Microphones
    - Speakers
  - **Light**
    - Interior lights
    - Exterior lights
    - Small displays

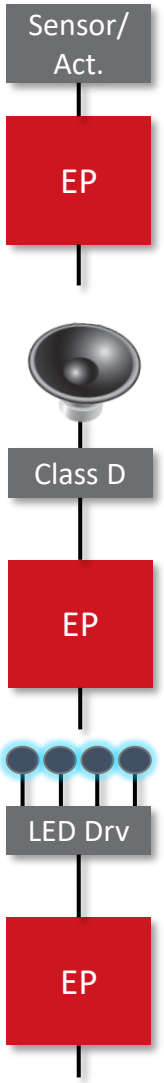
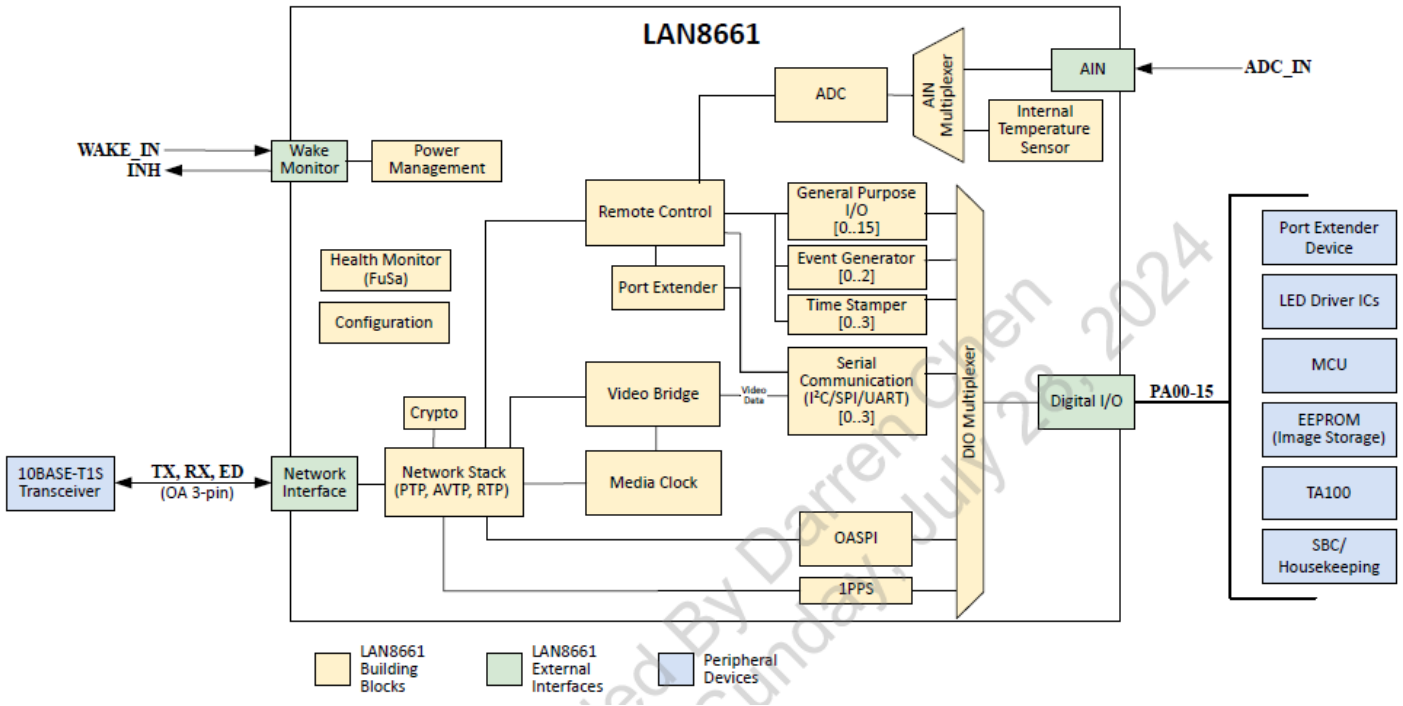


Figure 1-1. LAN8661 Block Diagram



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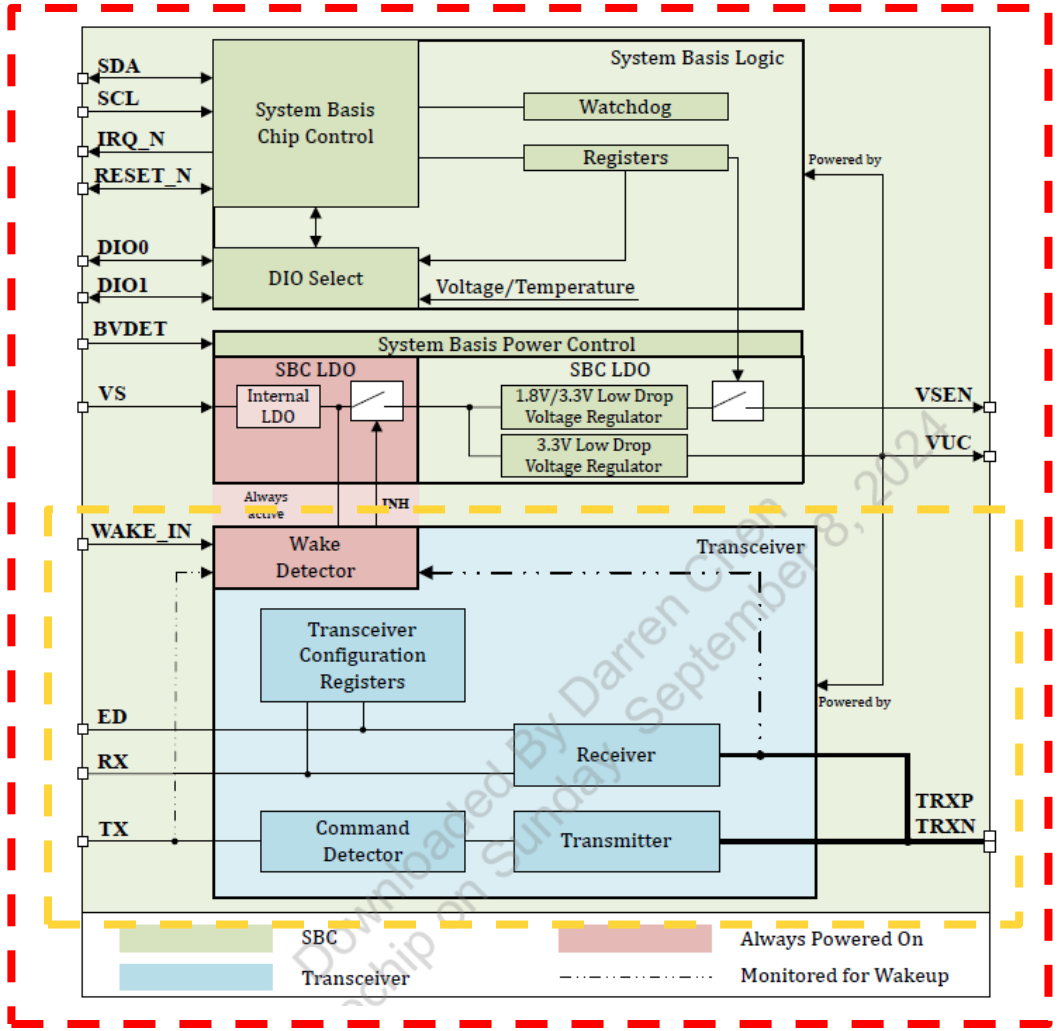
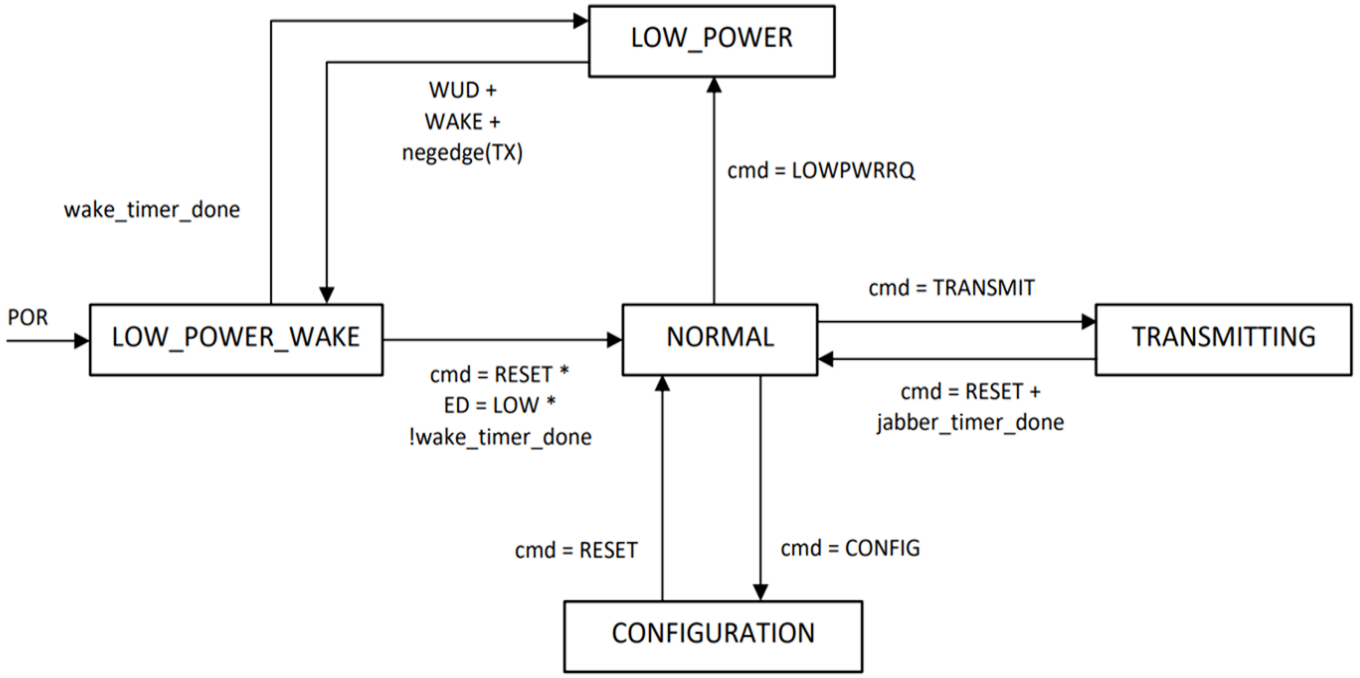
MCHP solution (PMD Transceiver)

- LAN8679：OA3p to T1S
- LAN8680：OA3p to T1S >> TC14 and I2C interface (SBC)



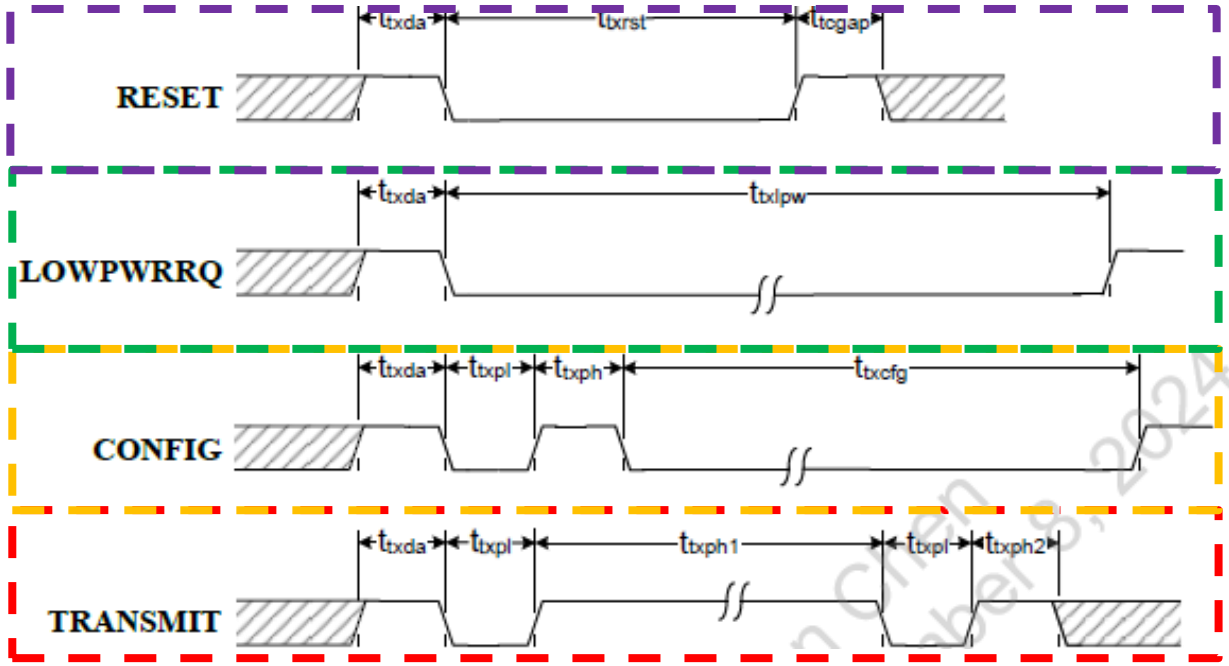
Functional States available in Transceiver

- The host controller uses the TX pin to send commands and activate the different function states of the transceiver. These states include the TRANSMITTING state, NORMAL state, LOW-POWER state, and CONFIGURATION state.
- Instead of using a data line with a clock to transmit data and activate the functions in the transceiver, the TX pin instead sends pulses of defined length. This is done to reduce electromagnetic emissions.



Command timing on TX pin

- **The TX pin is a high-speed low-voltage 3.3V output to an external PMD transceiver. It encodes the transmit data and controls the PMD reset, configuration, and entering/exiting low-power states.**

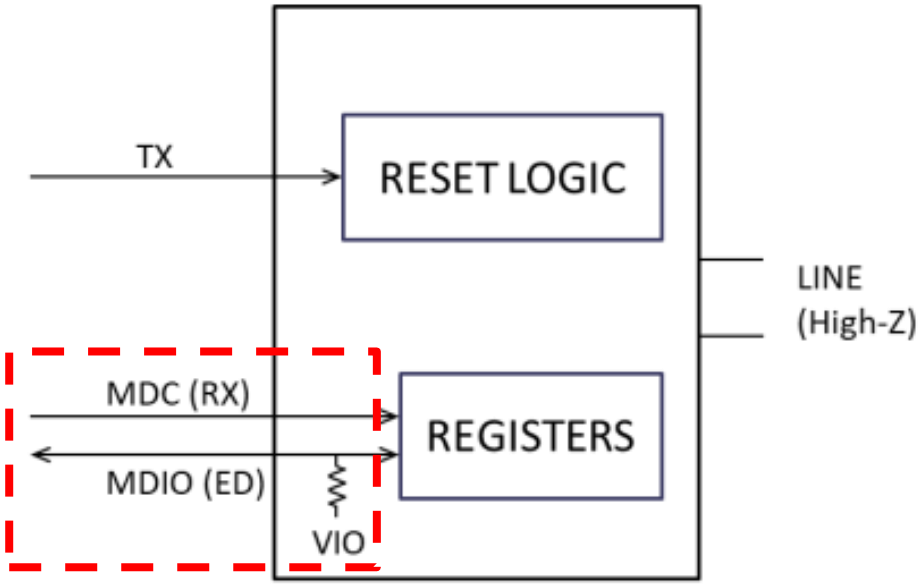


Parameter	Symbol	Min	Typ	Max	Units
Multiple Commands					
Deassertion time before a command	t_{txda}	TBD	20	-	ns
Low pulse duration	t_{txpl}	TBD	20	TBD	ns
RESET Command					
RESET command assertion time	t_{txrst}	TBD	80	TBD	ns
Gap between commands	t_{tcgap}	TBD	20		ns
LOWPWRRQ Command					
LOWPWRRQ command assertion time	t_{txlpw}	TBD	16	-	µs
CONFIG Command					
High pulse duration	t_{txph}	TBD	20	TBD	ns
CONFIG command assertion time	t_{txcfg}	TBD	16	-	µs
TRANSMIT Command					
TRANSMIT command high pulse duration	t_{txph1}	TBD	180	TBD	ns
TRANSMIT end high pulse duration	t_{txph2}	TBD	20	TBD	ns

Functional States available in Configuration

- When the PMD transceiver is set to configuration mode, the RX and ED pins are used as MII management interface (MIIM). pins are used as the MDC and MDIO pins to access configuration registers.

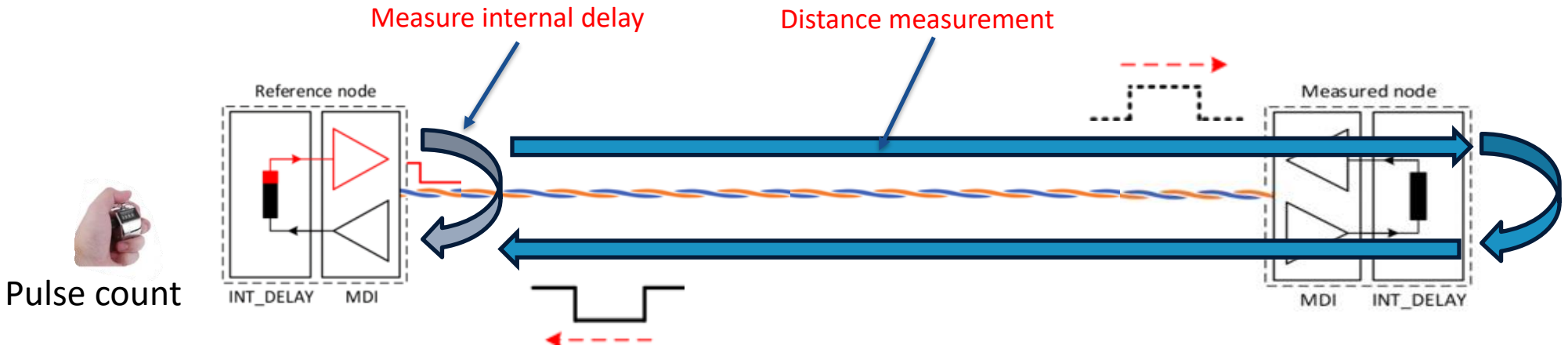
- During configuration mode, the transceiver does not drive any differential voltage at the line interface with low impedance, regardless of any activity on the TX pin.



Topology Discovery

- **TC14's topology discovery function :**
  - Automatically identify network topology:
    - In automotive Ethernet, 10BASE-T1S supports bus topology with multi-point connections. Topology discovery can help identify the physical connection relationship between nodes.
  - Diagnosis and troubleshooting:
    - Through topology discovery, the system can monitor the network structure in real time and detect and locate fault points early.
  - Improve system reliability:
    - Accurate topology information helps optimize data transmission paths, reduce latency and packet loss, and improve overall network performance.

Topology Discovery



- **Procedure**
  - Only one Reference /Measure pair operating per time (topology configuration phase) , the rest nodes keep “listening/receive “ and PLCA suggestion to turn off during this phase
  - Enter CONFIGURATION mode by set the TPEN bit and configure the TPREFN bit in register CTRL0 and leave CONFIGURATION mode using a RESET command (for both reference (host) and measured node)
  - TX will keep generating Generate TP_pulse , this pulse will keep cycling within the loop. The refence node need keep counting how many pulse has been counted
  - “**unfiltered**” ED signal (Filtered signal will introduce delay) to calculate the pulse traveling time (Tp) between reference node and measure node at ED pin’s MEAS FSM period
  - Counting the # of “local count” as the reference (reference node loop back) : **Blue**
  - Counting the # of “remote count” as the measured node : **Orange**
  - Longer distance will get more count
  - Program convert the counting # to distance
  - Normally , cable propagation delay about 5ns/m

Enabling TD in the LAN8680

Bit 1 – TPREFN Topology Discovery Reference Node select

When the PMD is configured for topology discovery operation, this bit will select which topology discovery mode the PMD operates in. When set, the PMD will function as a topology discovery measured node. When clear, the PMD will function as a topology discovery reference node. This configures the PMD topology discovery internal scrambler for the correct operation as a measured or reference topology discovery node.

Note: This bit has no effect when the Topology Discovery Enable (TPEN) bit is clear.

Value	Description
0	PMD operates as a topology discovery measured node
1	PMD operates as a topology discovery reference node

Bit 0 – TPEN Topology Discovery Enable

When set, the PMD operates in topology discovery mode.

Value	Description
0	Normal operation
1	Topology discovery mode

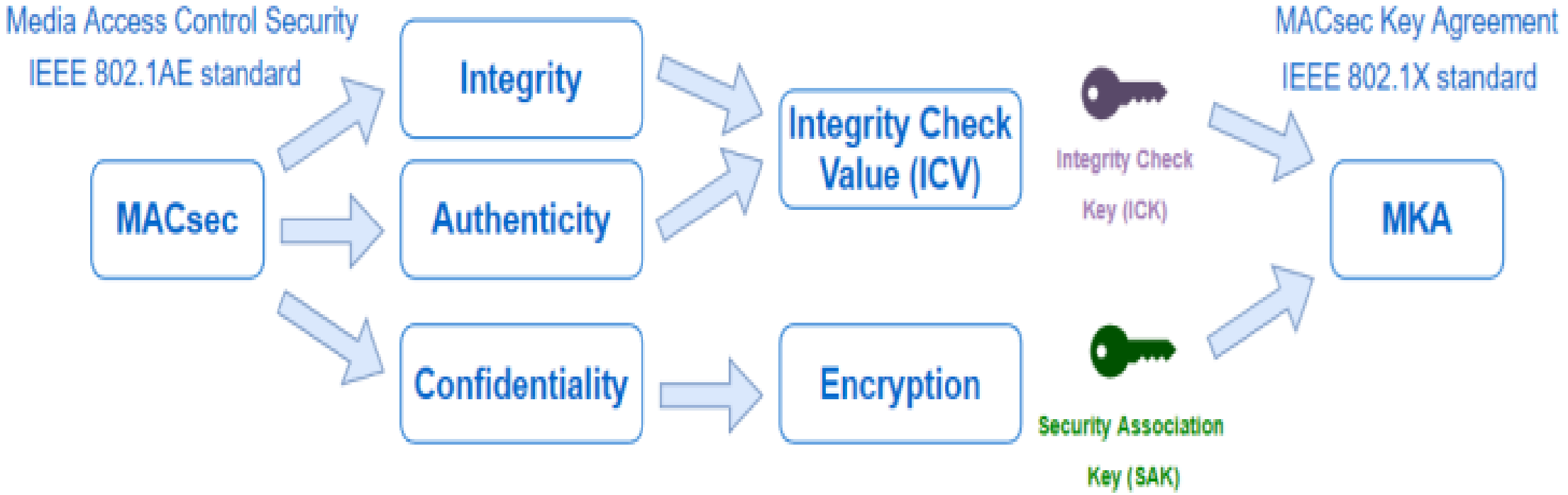
This does not include the setup and operation of the host.

Open Alliance TC17 MACsec Auto Profile

- **MACSec = Media Access Security IEEE 802.1AE**
  - Point to point security protocol with Confidentiality, Integrity and Authentication
  - Transmit side Adds Security Tag (SecTag) and Integrity Check Value (ICV) while encrypting the payload
  - Receive side identifies and decrypts packets
    - Identifies packets
    - Decrypts
    - Prevents replay
    - Removes SecTag and ICV discarding invalid packets
    - All unencrypted frames dropped other than diagnostic and key agreement
- **MKA can be cumbersome in automotive applications**
- **Some OEM's mandating keys are stored in secure elements / HSM's with tamper protection**

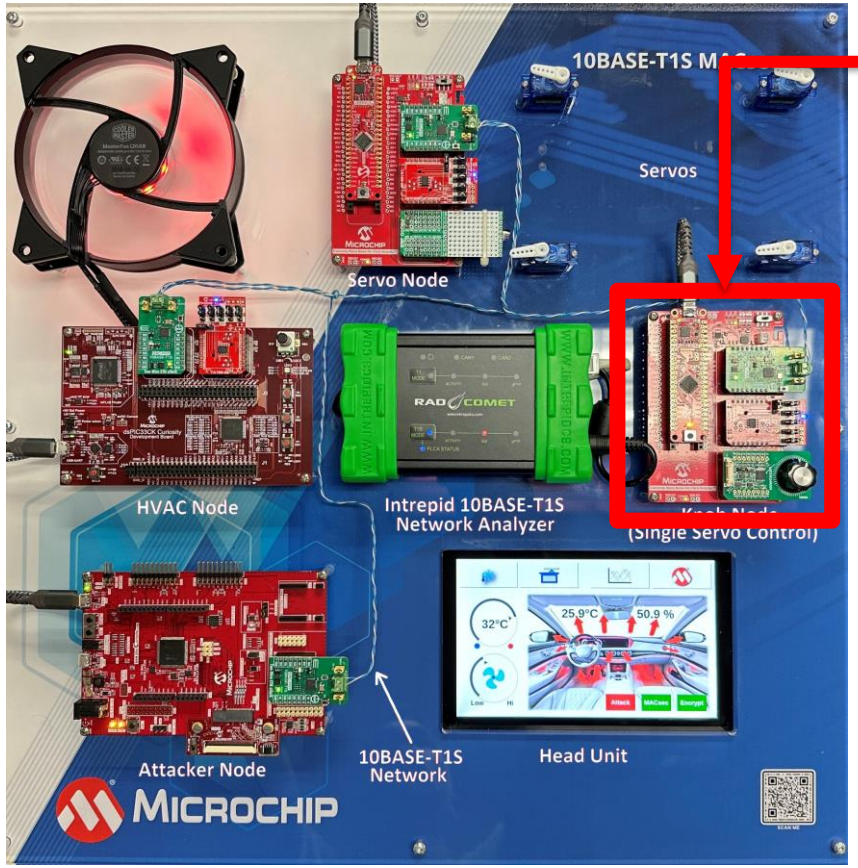
Goal

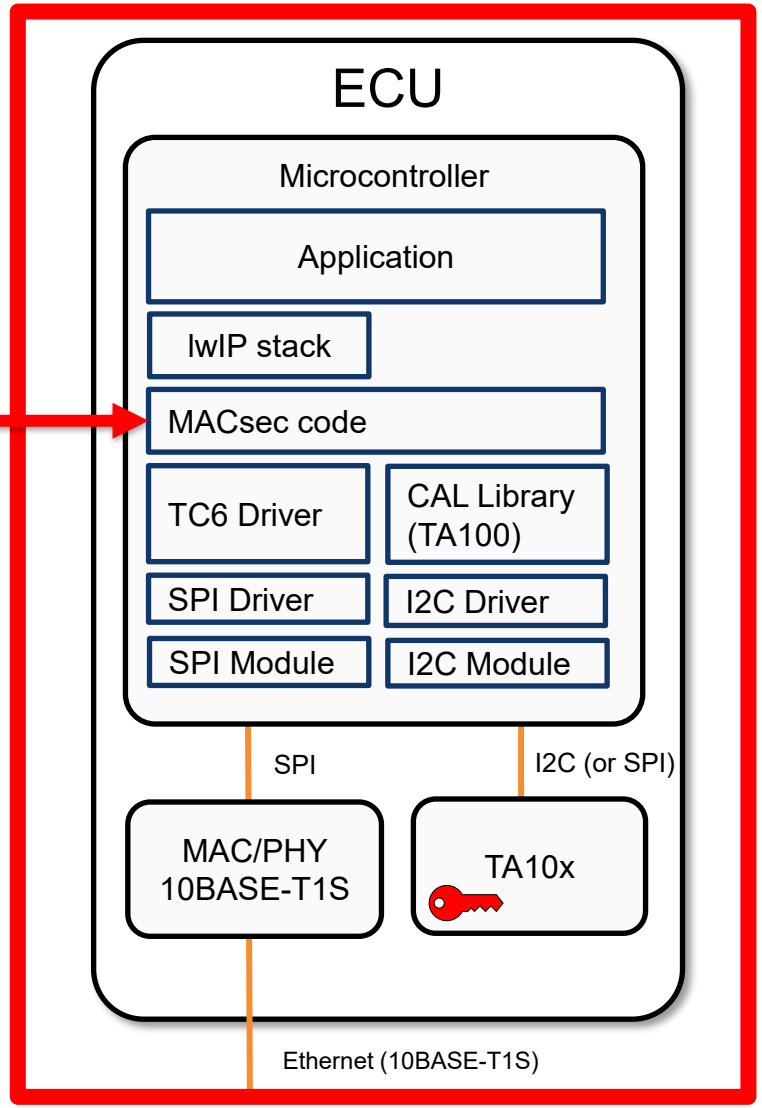
- **It ensures the security of Ethernet data frames through functions such as identity authentication, data encryption, integrity verification, and replay protection, preventing devices from processing messages that pose security threats.**



TC17 MACSEC for automotive

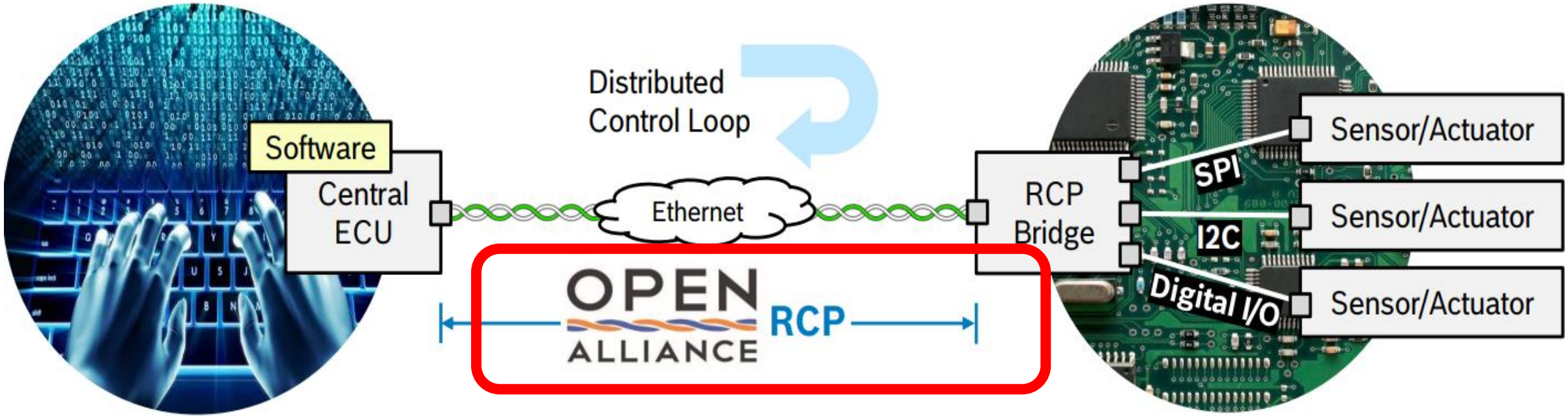
- **10M SPE :**
  - The MACSEC is implement by software suite
  - Key was loaded in the TA100
  - JIL FISP certificated

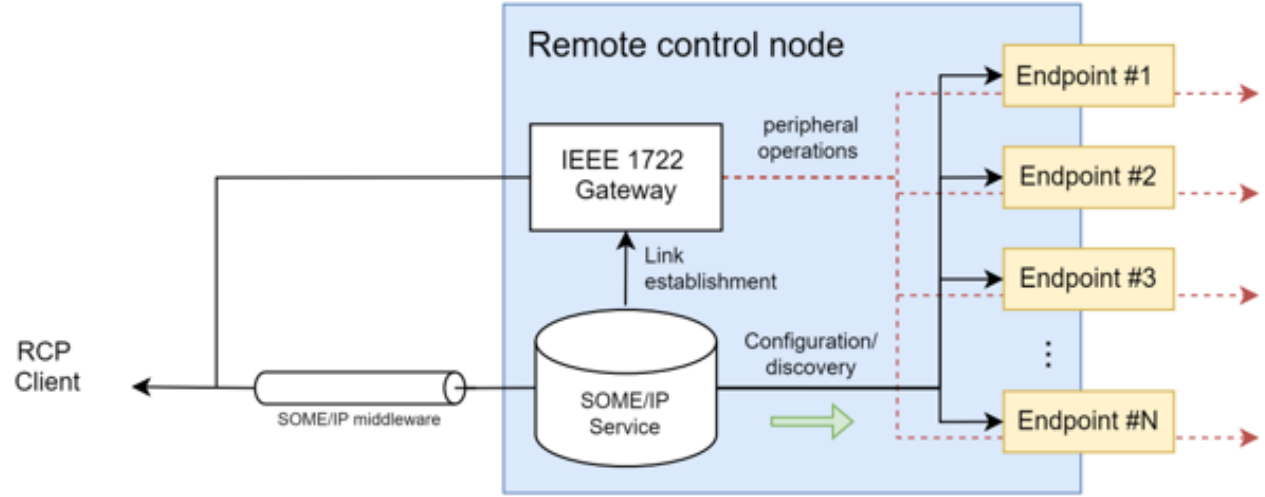




MICROCHIP

Remote Controlled Peripherals/Protocol





MICROCHIP

10BASE-T1S Control/Lighting/Audio Endpoints

Optimized for MCU-less edge devices

- **Features**
  - Control protocol
    - SOME/IP
    - TC18 RCP
  - Streaming protocol
    - AVTP
    - UDP/RTP
  - Security / Safety
    - MACsec, E2E Profile 4, SecOC
    - External HSM TA100 (opt.)
    - Secure Configuration / Firmware Update
  - Content delivery modes(LAN8661X only)
    - Video streaming
    - Edge Node Rendering (graphic commands)
    - Play pre-stored graphics, videos
  - gPTP Slave
  - PDM to PCM conversion (LAN8662X only)
  - External MCU via I2C or SPI (optional)

Control/Lighting/Audio

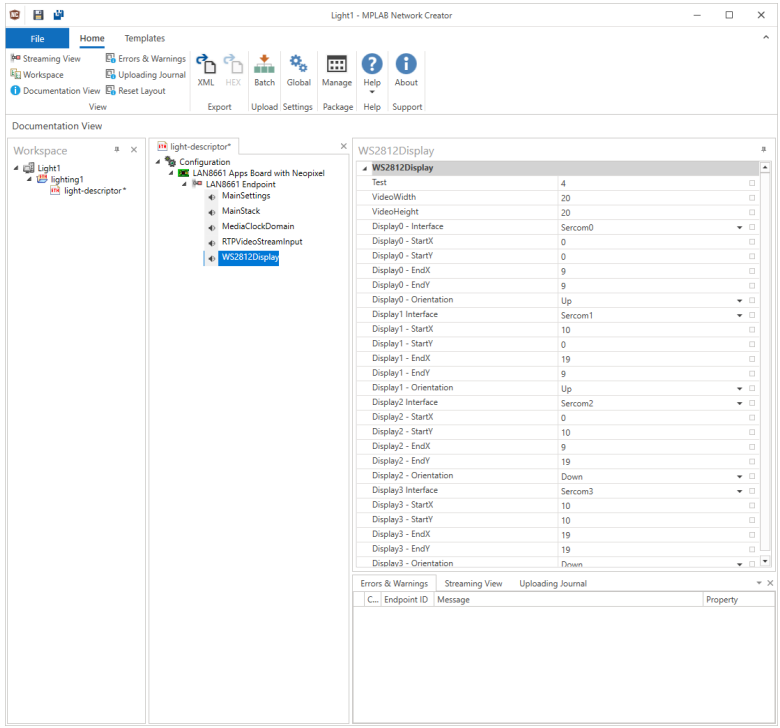
Available Features	LAN8660X	LAN8661X	LAN8662X
SOME/IP	✓	✓	✓
RCP	✓	✓	✓
OPEN Alliance TC10/14 Wake/Sleep	✓	✓	✓
gPTP	✓	✓	✓
PWM Interface	✓	✓	—
AVTP	—	✓	✓
RTP	—	✓	✓
Video Streaming and LED Driver IC Control	—	✓	—
Audio Interfaces	—	—	✓
CAN FD Controller	✓	✓	—
SERCOMs	Up to 4	Up to 4	Up to 3
GPIOs	Up to 16	Up to 16	Up to 12
ADC Channels	1	1	1

RCP

Remote-Control-Client

MCU less

End point configurator



RCP Client

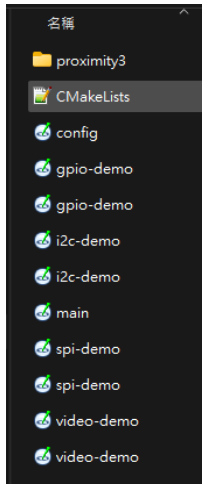
T1S

RCP Server 8680

866X

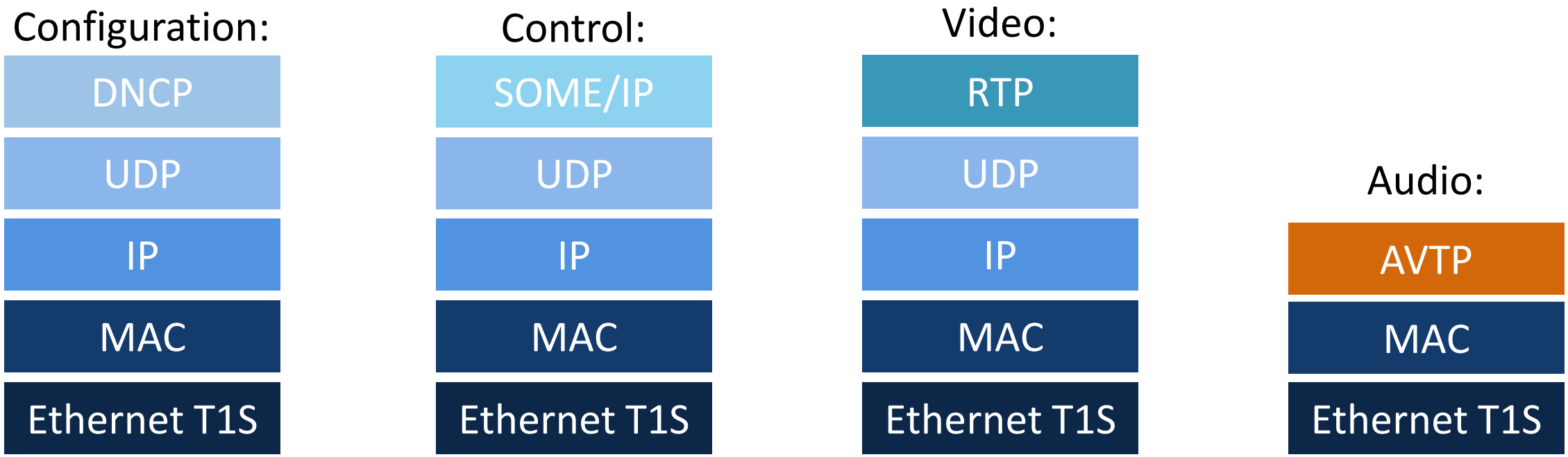
IO
Audio
LED
SPI

Software data flow

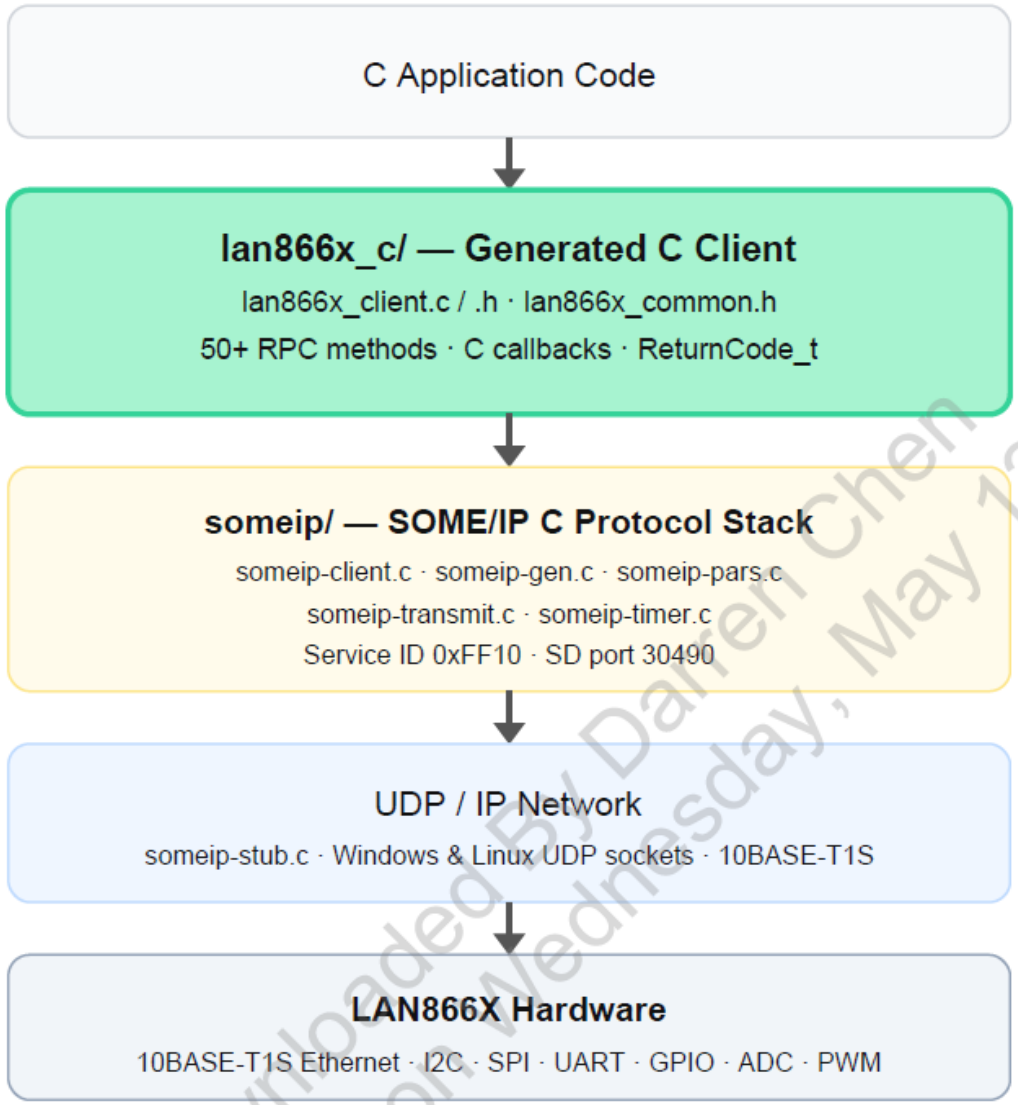


MICROCHIP

LAN866x Protocols



Client Tools

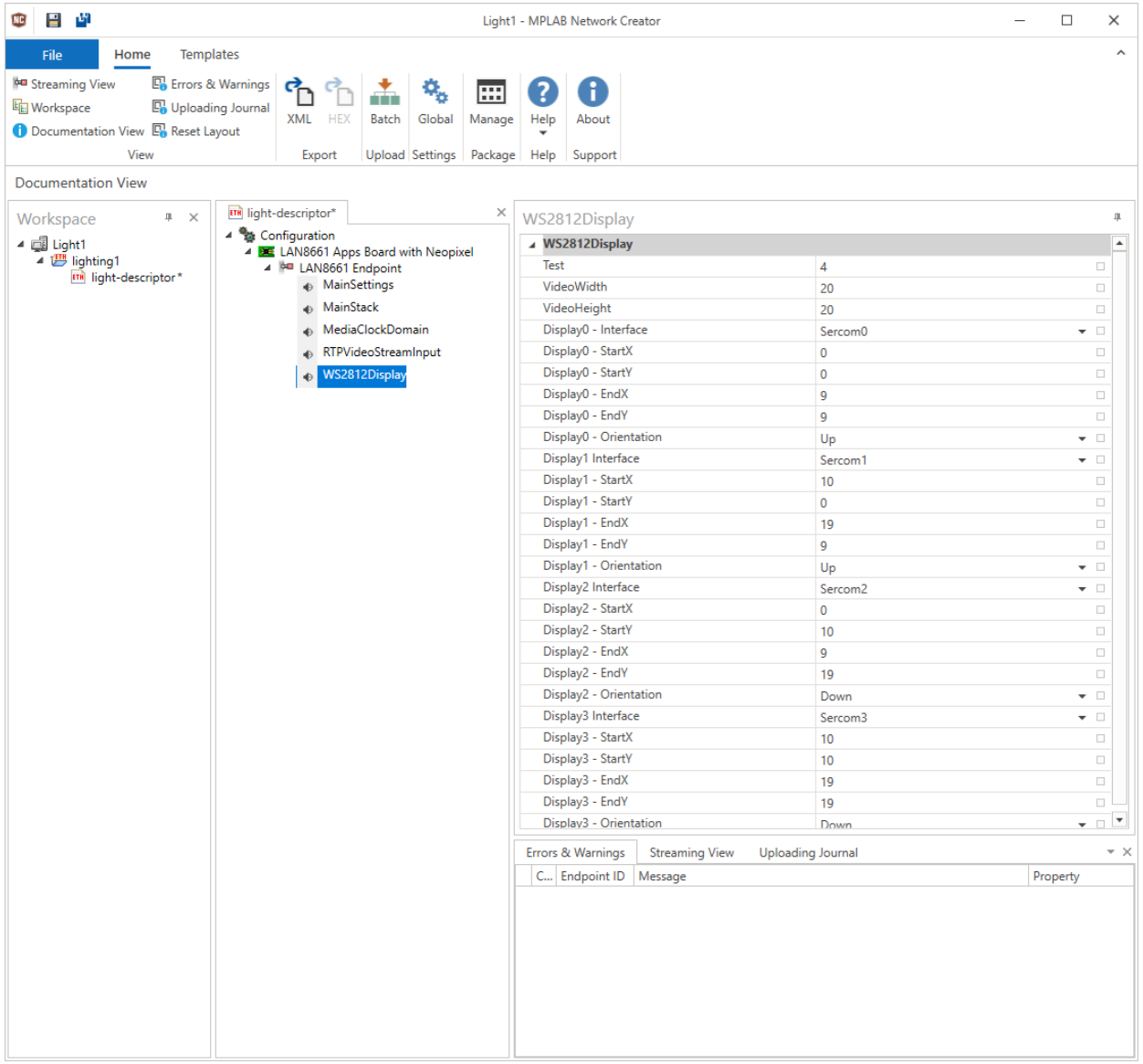


We support multiple tools

Folder	Content
`generator/`	Code generator: `lan866x.proto`, Jinja2 templates, `generate-lan866x.{bat,sh}`, Doxyfile, version-sync helper.
`lan866x_c/`	Generated C client (`lan866x_client.c/.h` + `lan866x_common.h`) with C examples.
`lan866x_cpp/`	Generated C++ client with C++20 examples.
`lan866x_python/`	Python client (pybind11 bindings + wrappers), prebuilt Windows wheels, examples.
`lan866x_csharp/`	.NET 8 C# client, NuGet package, examples.
`lan866x_java/`	Java 11 client, JNI shim, prebuilt Windows JAR, examples.
`lan866x_rust/`	Rust client, FFI bindings, prebuilt Windows DLL, examples.
`lan866x_blockly/`	Drag-and-drop Blockly frontend for the Python client.
`lan866x_arxml/`	Generated AUTOSAR XML (`lan866x.arxml`).
`lan866x_wireshark/`	Wireshark SOME/IP dissector config files.
`lan866x_doxygen-cpp/`	Generated Doxygen HTML for the C++ API.
`someip/`	Git submodule: the SOME/IP protocol stack.
`tools/`	Developer utilities (ARXML validator, CA bundle maker).
`docs/`	Architecture SVGs, design documents, specifications.

Endpoint Configuration

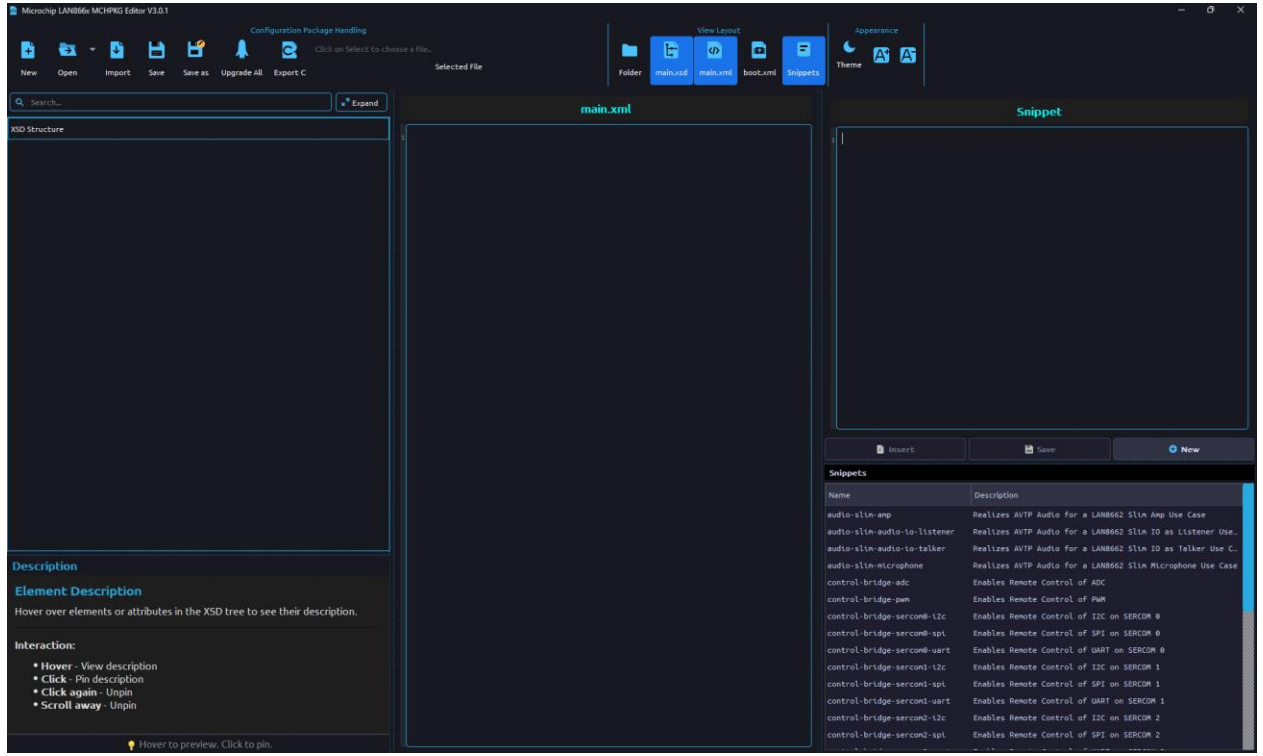
- **MPLAB Network Creator**
  - SAME GUI for config PHYs, Switches, Endpoints
  - Access to all available parameters
  - Selection of Peripheral Modules
  - Output of configuration
    - Config file for End-Of-Line programming
    - MDI/network (e.g. during OTA or in repair shop)

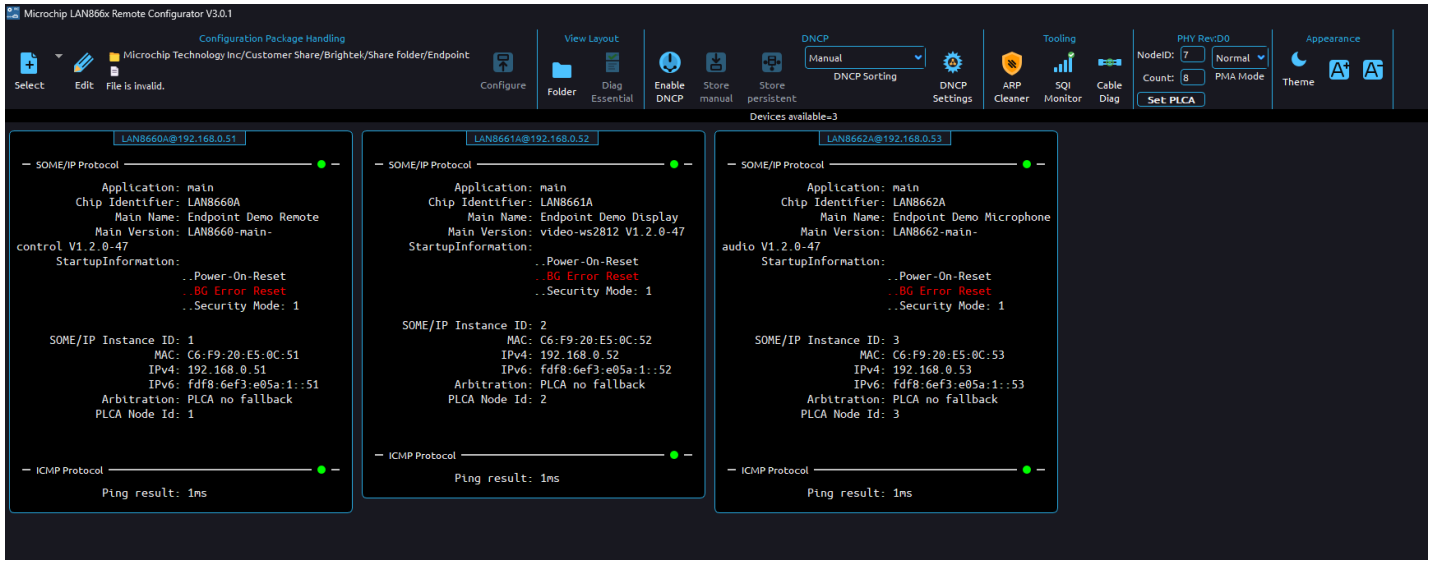


Remote Configurator

GUI:

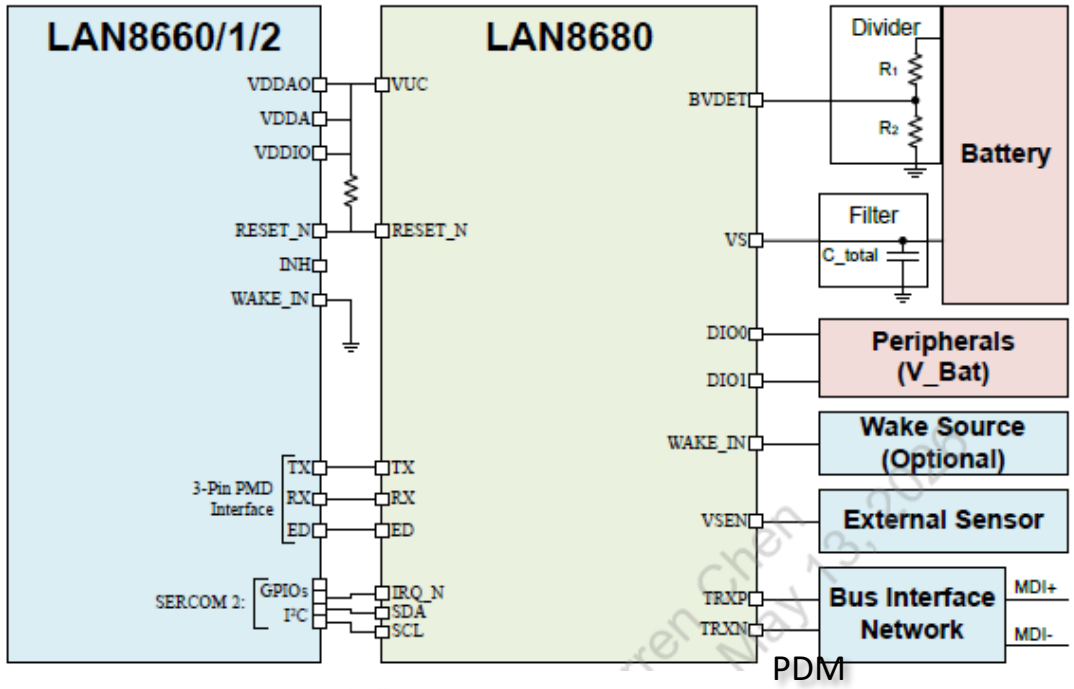
- Configure over Network
- Uses config file from
- MPLAB Network Creator
- Display found EPs at once
- List all parameters
- Send to sleep / wakeup
- Windows / Linux support



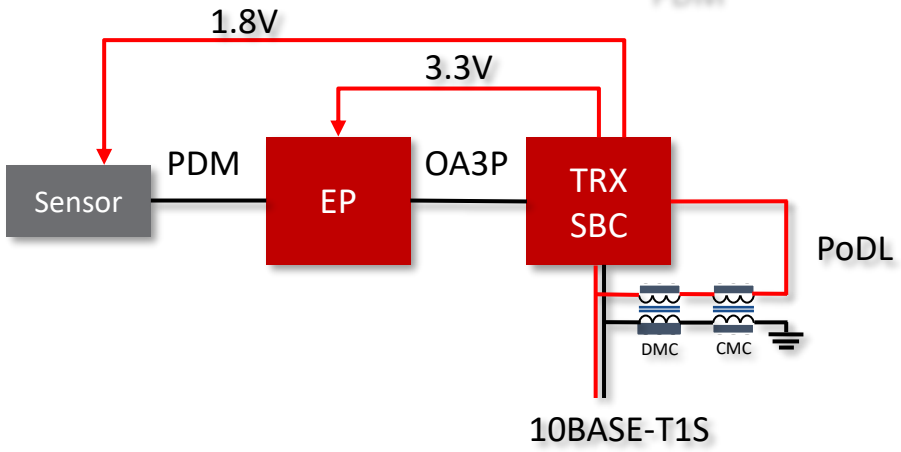


Microchip solutions

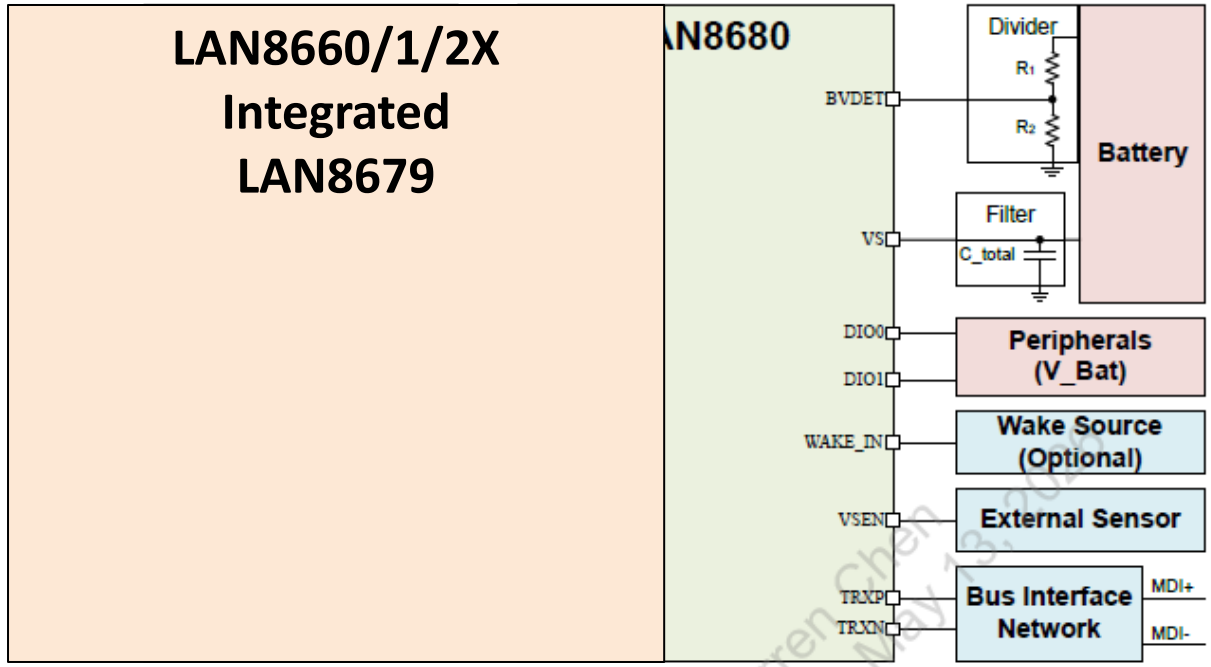
- **Endpoint + PMD Transceiver**

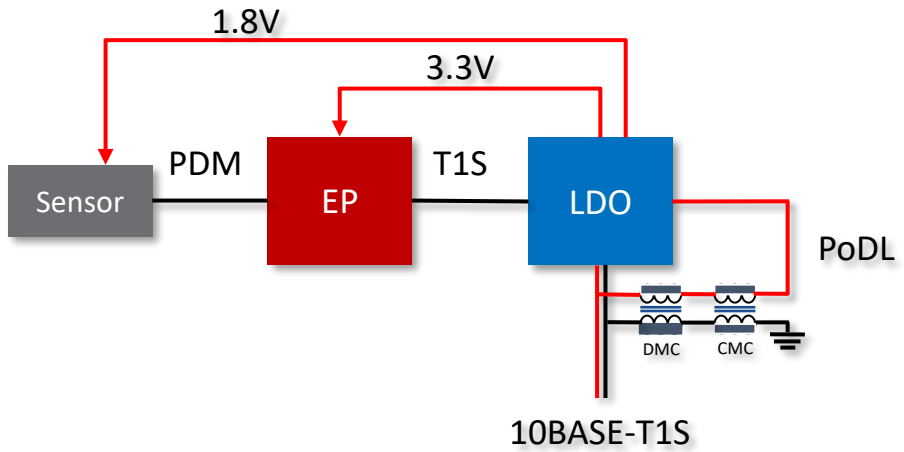


PDM



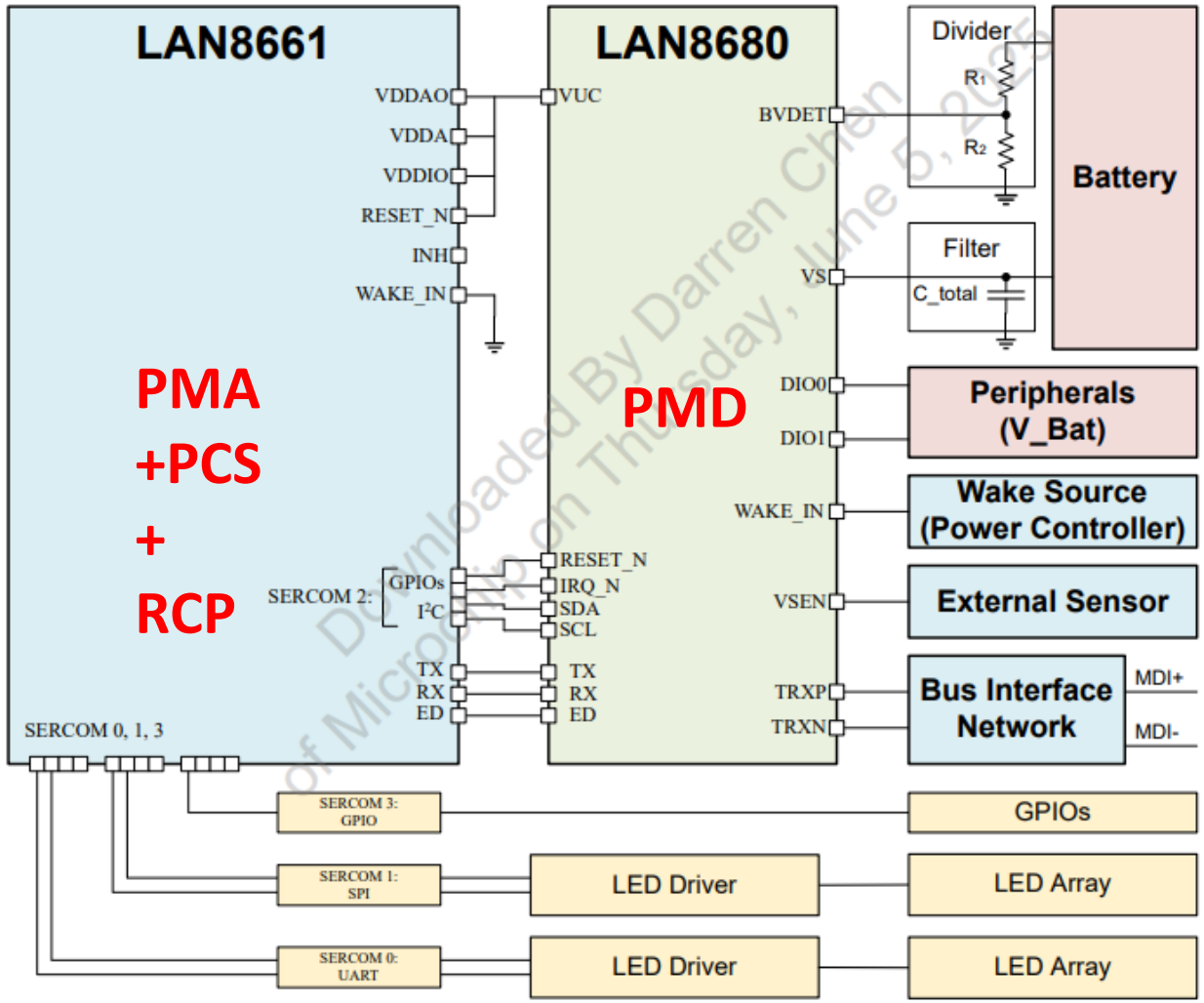
- **Endpoint Integrated PMD Transceiver**

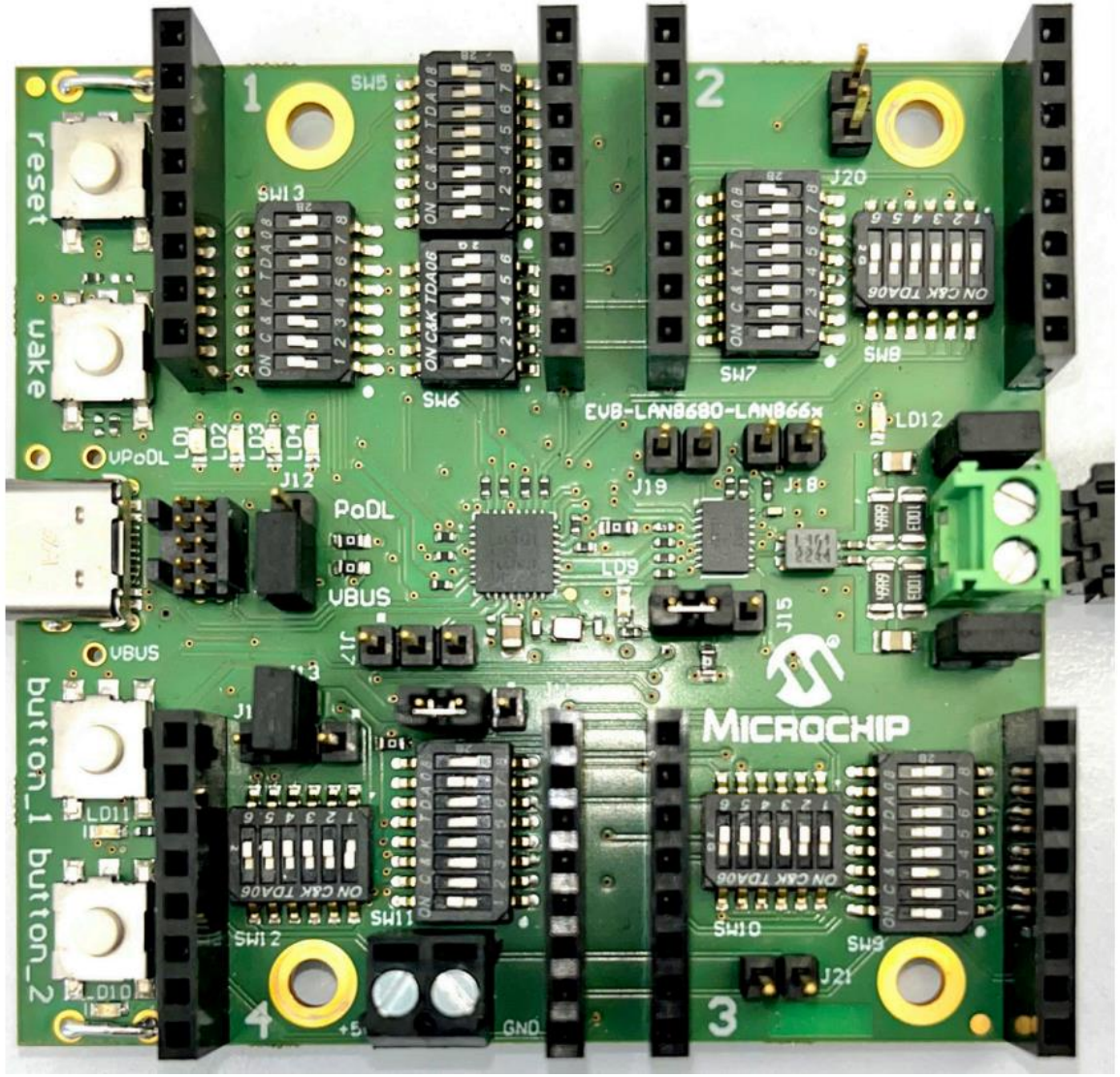




MICROCHIP

MCHP RCP solution





MICROCHIP

Introduction to T1S Application

Evolving In Vehicle networking

Microchip's Long-Term Vision for In-Vehicle Networking (IVN)

Today's Automotive Networking Landscape…

CAN

FPD LINK

APIX®

GMSL

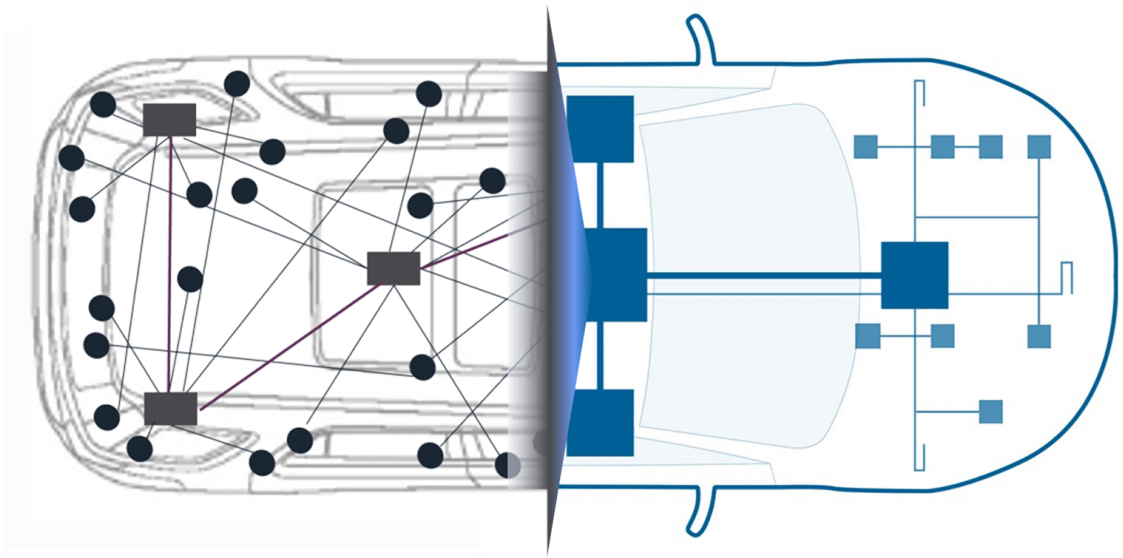
MOST®

CoaXPress®

A2B®

FlexRay™

lin LOCAL INTERCONNECT NETWORK



Future Automotive Networking Landscape…

Low Speed & Backbone

OPEN ALLIANCE *Ethernet*

HPC & Storage

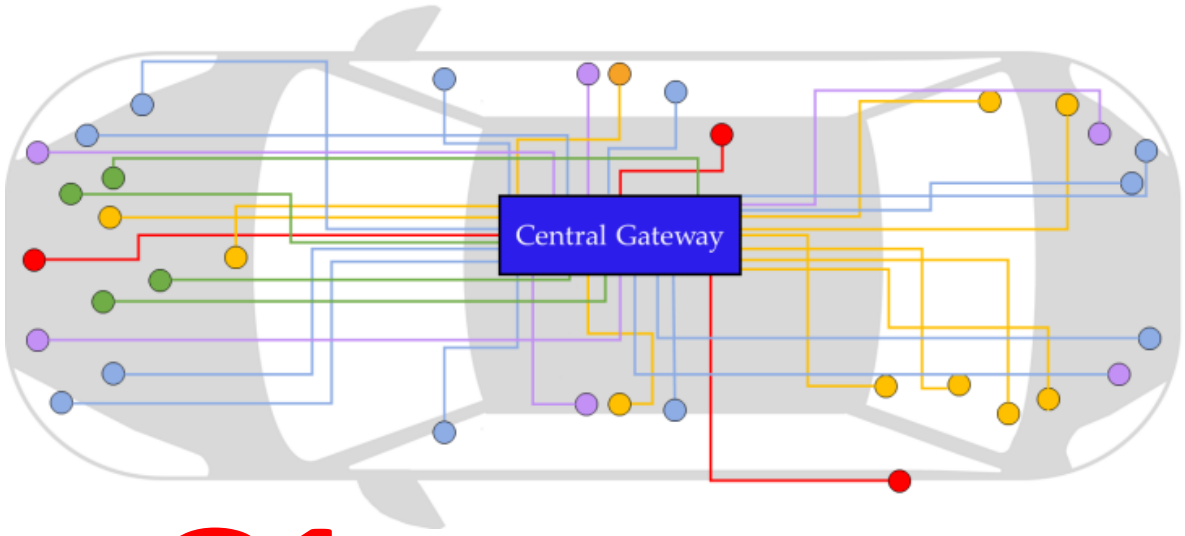
PCI EXPRESS®

Camera & Display

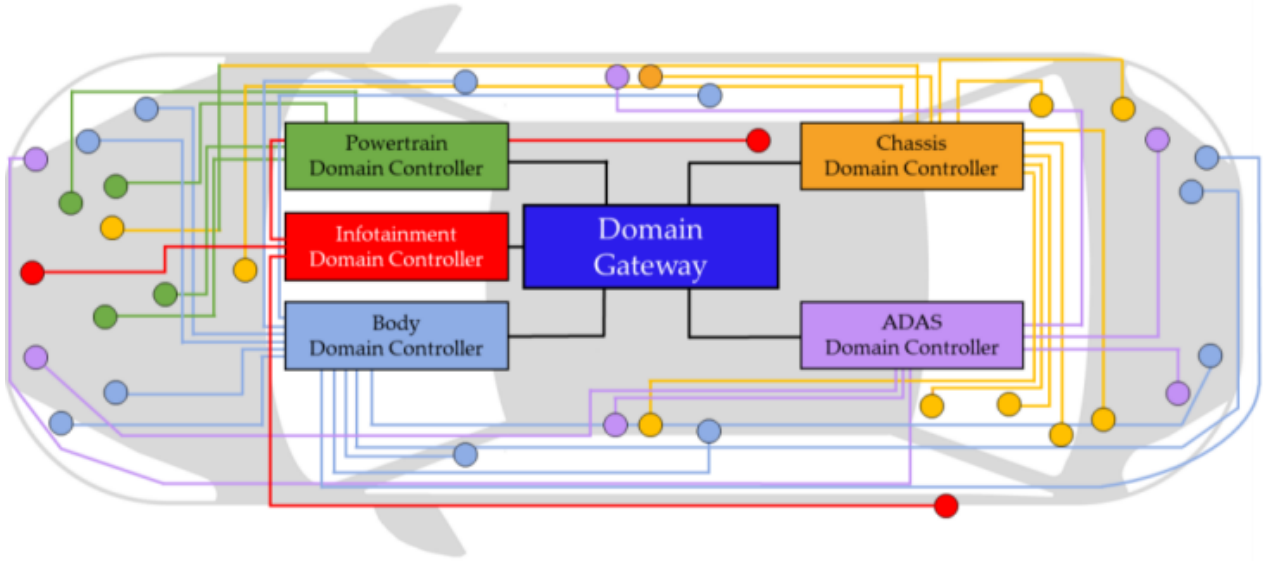
ASA

MICROCHIP

Generations of ECU connections

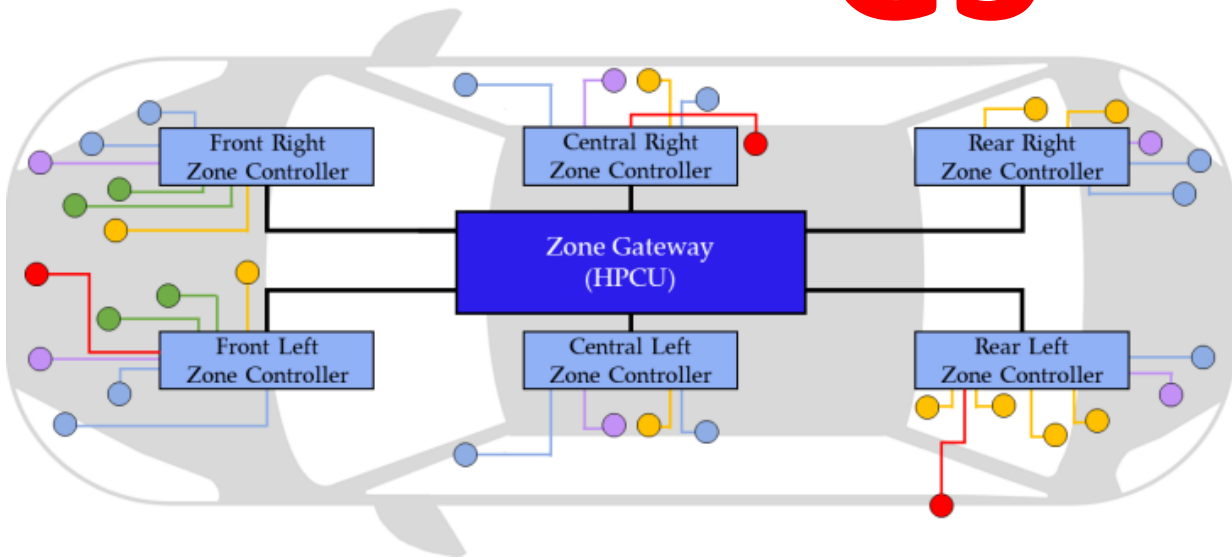


G1



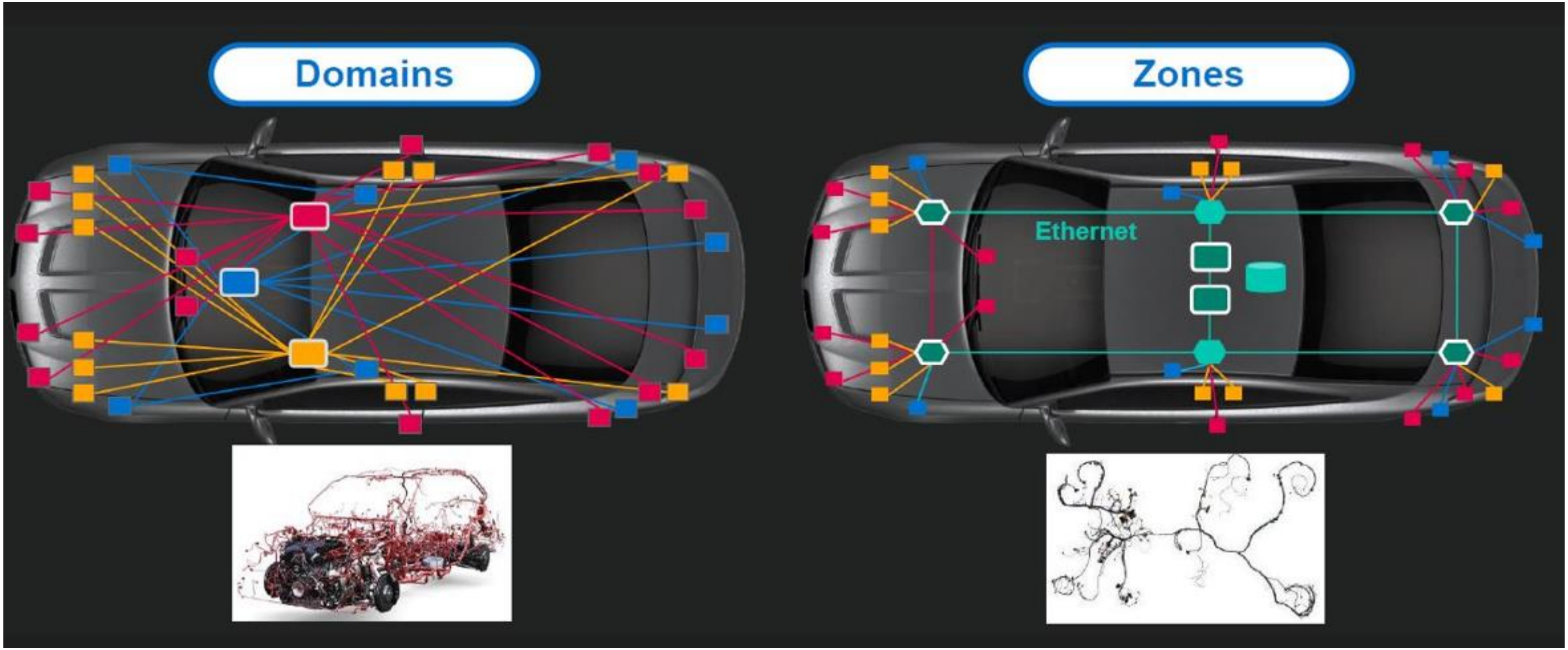
G2

G3

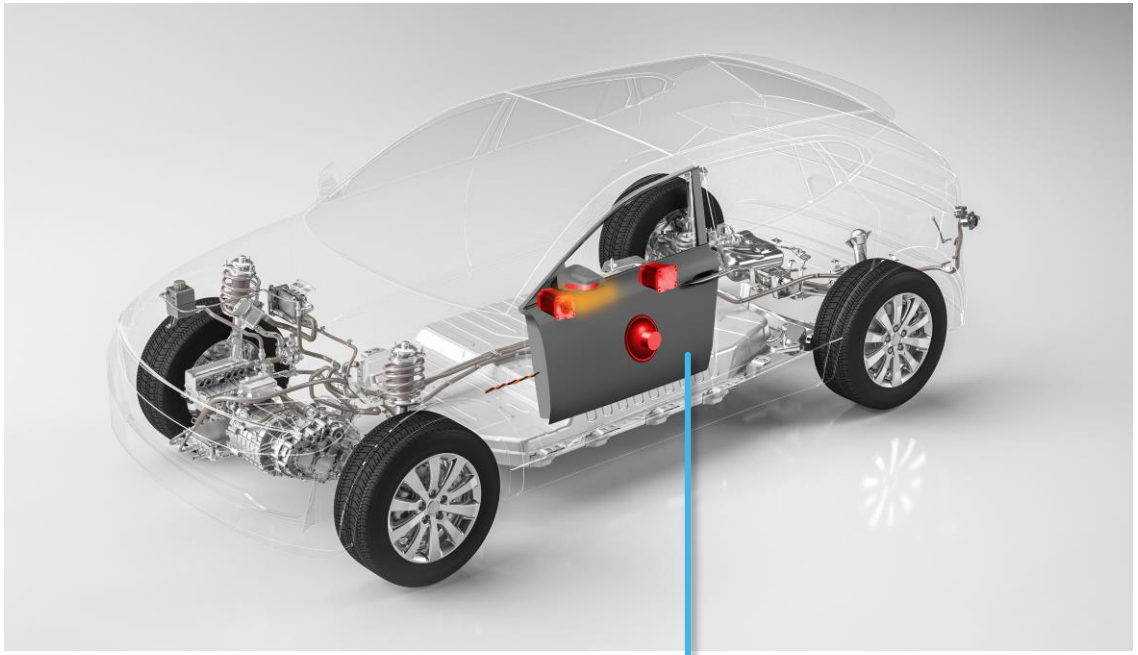


MICROCHIP

Saving in cable and harness



Automotive Zone Architecture



10BASE-T1S bus: Multiple applications on a single cable!

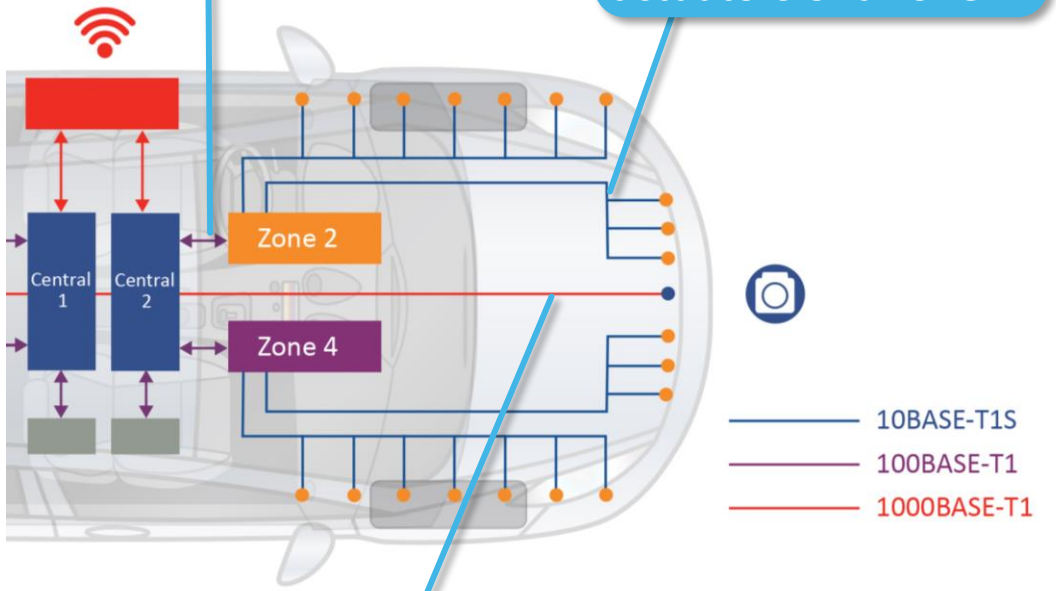
Example: Door Zone

- **Window lifter**
- **Mirror control**
- **Speakers**
- **Lock**
- **Ambient/interior light**

Typical Zone Architecture using All-Ethernet

100/1000BASE-T1 connects zone and central computer

10BASE-T1S connects sensors and actuators of a zone

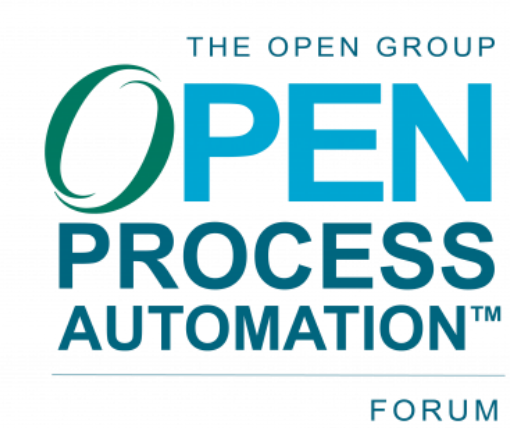


NGAUTO-T1 backbone connects several central computers and maybe cameras

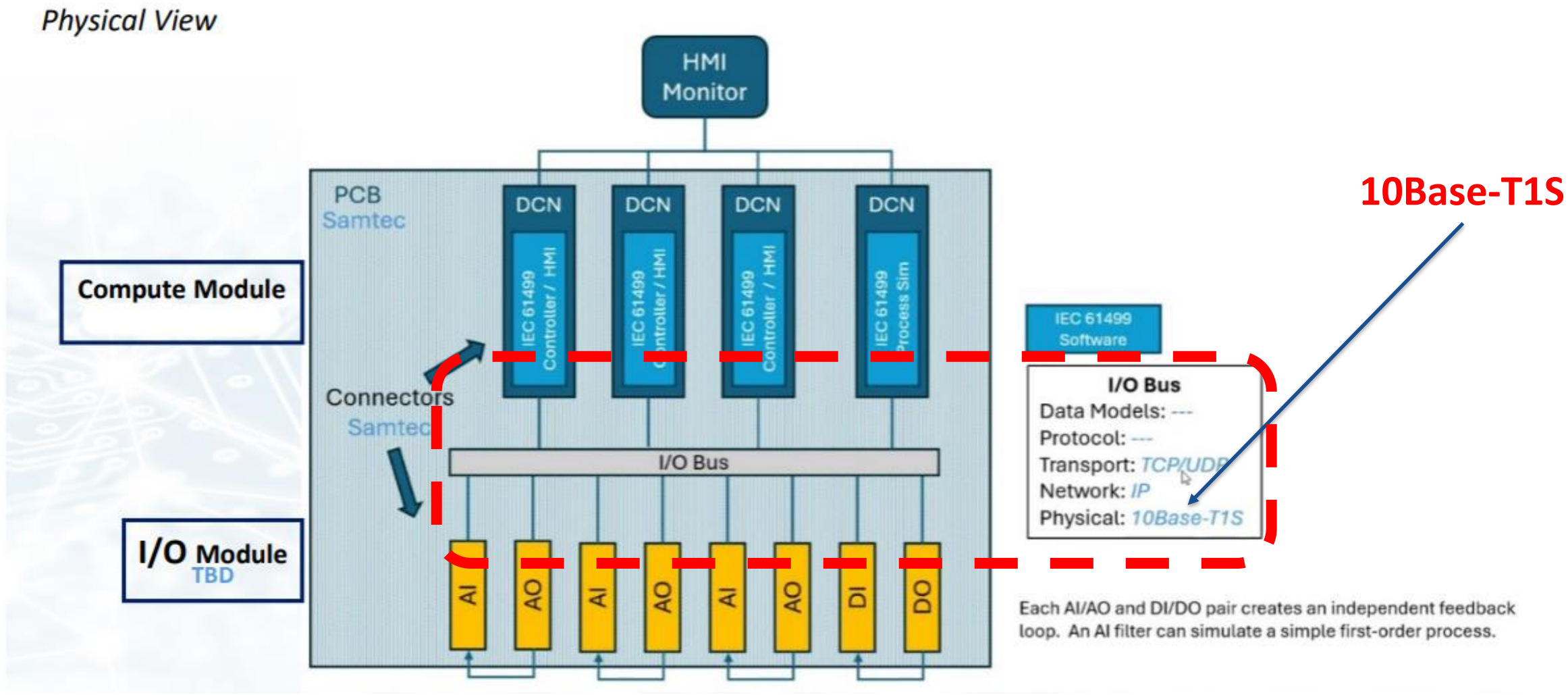
MICROCHIP

DCS (Distributed control system)

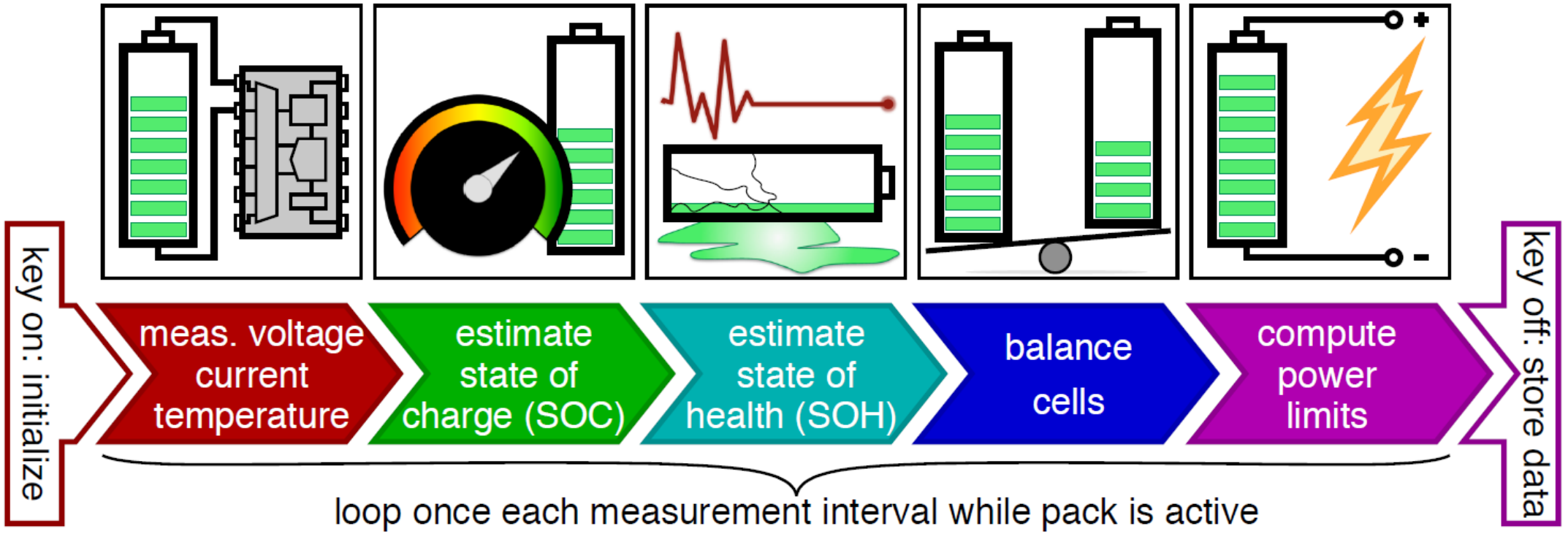
Schneider Electric, Intel, and Red Hat explore modern DCSs



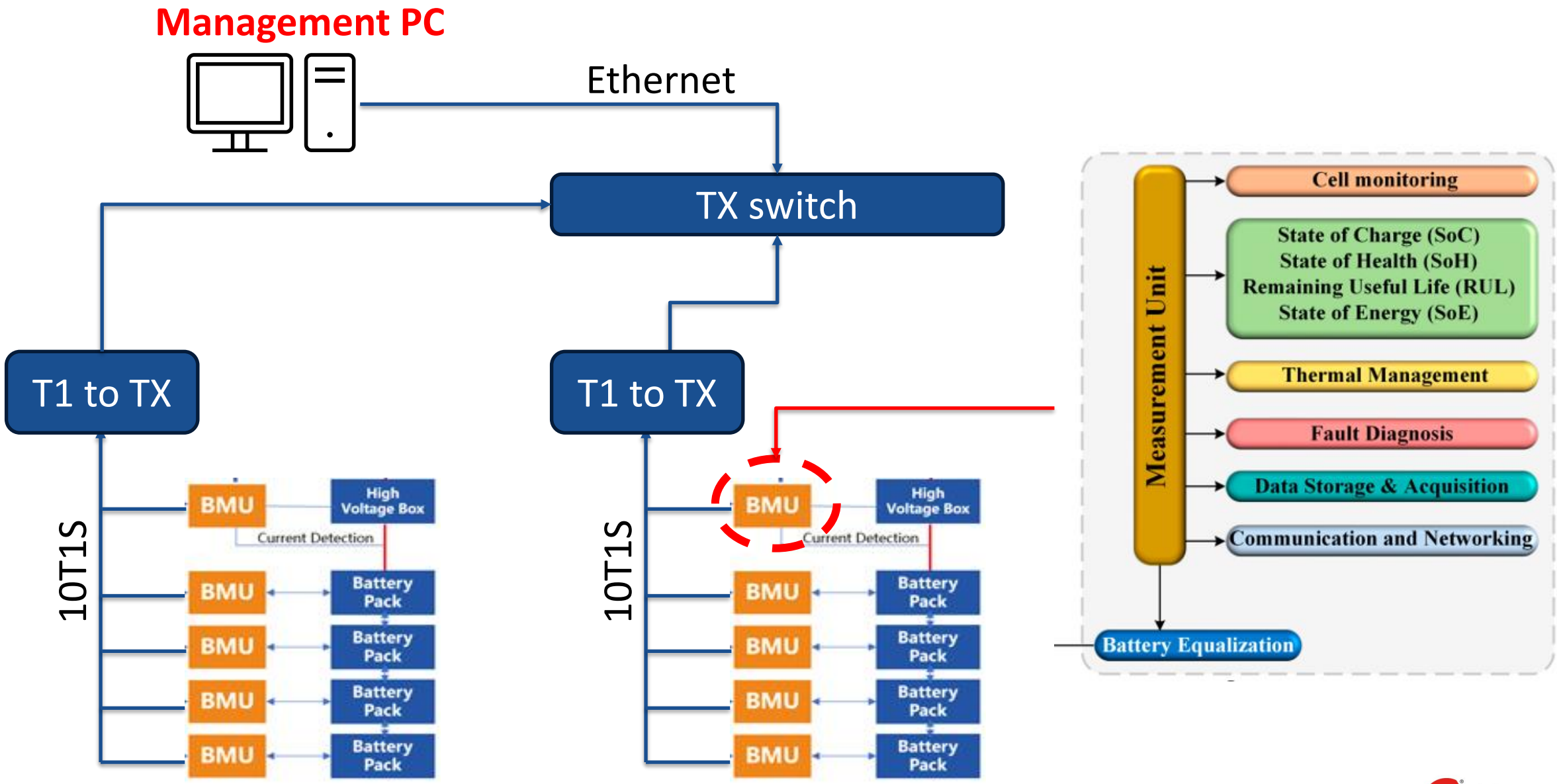
DCN : field terminal & controller connection



Software flow of a BMS

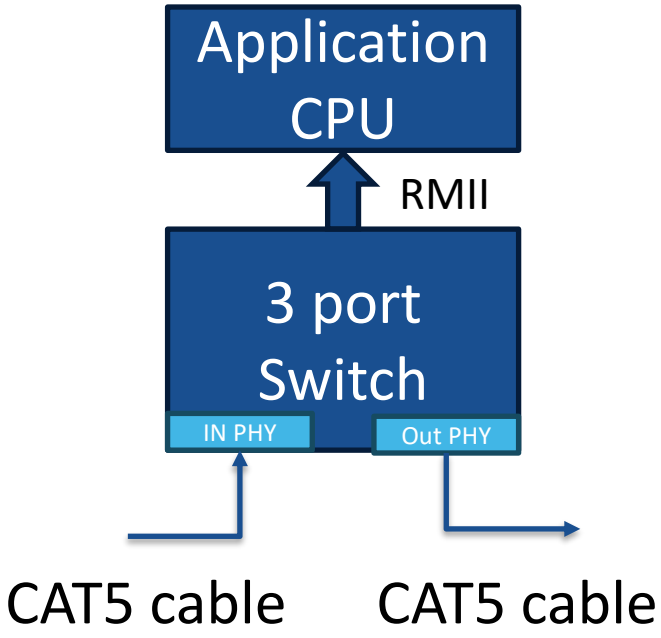


BMU based EMS (communication)

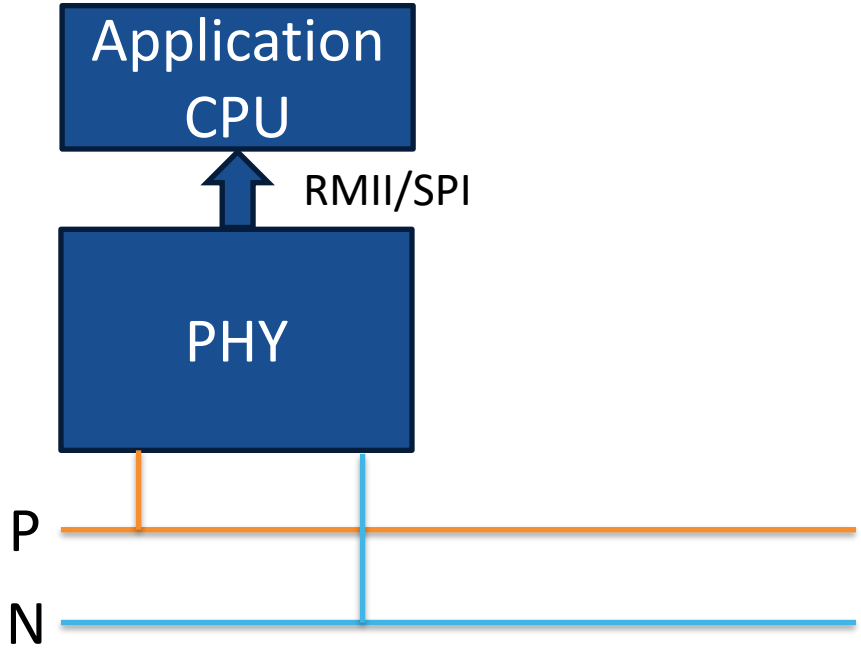


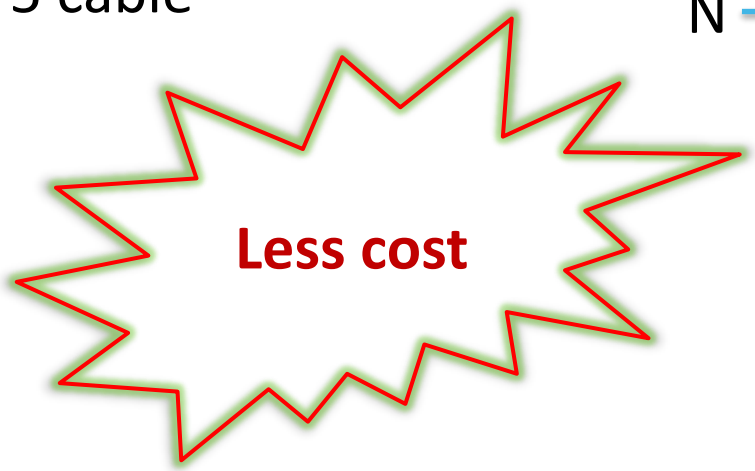
Daisy chain replacement

- 3 port switch implement

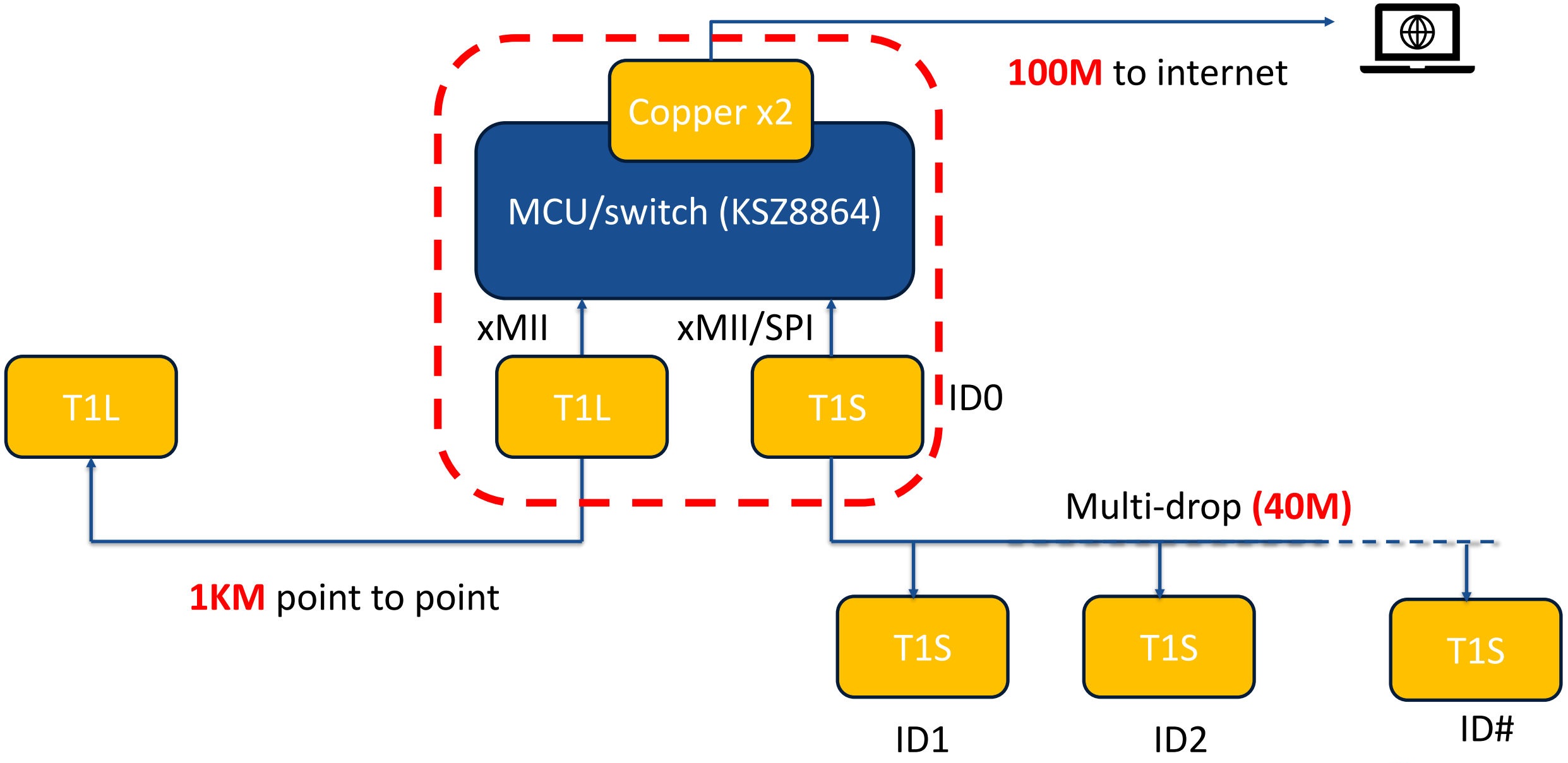


- 10Base-T1S PHY implement





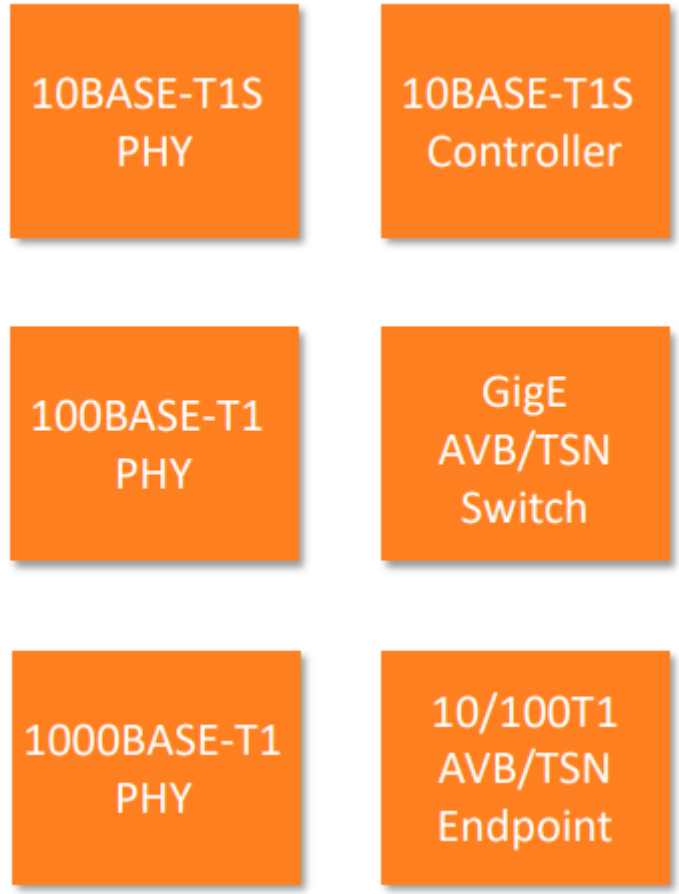
Full range process automation



SPE Product Details

Microchip SPE Solutions

- Flexible and scalable system solutions
- Extended cable reach
- Smallest packages
- Lowest power, wake/sleep
- Security support
- Functional safety ready
- Ambient temperatures up to 125 ◦C
- Comprehensive software & tool support



MICROCHIP

10BASE-T1S Roadmap

Development | Sampling | Production

PHY (MII, RMII)

- LAN8670 — 32 QFN — MII/RMII
- LAN8671 — 24 QFN — RMII

Updated to latest OA Spec Q3 2025

MAC-PHY (SPI)

- LAN8650 — 32 QFN — Ext. LDO
- LAN8651 — 32 QFN — Int. LDO
- LAN865x — Latest OA Spec — 48V

Samples Q4 2026

Transceiver SBC (OA3p)

- LAN8680 — 16 DFN — 12V LDO

RTP Q3 2026

Transceiver (OA3p)

- LAN8679 — 8 DFN

RTP Q2 2026

- LAN8681 — 14 DFN — Wake/Sleep,48V

Samples Q4 2026

Endpoint (OA3p)

- LAN8660 — 32 QFN — Control EP, RCP
- LAN8661 — 32 QFN — Lighting EP, RCP
- LAN8662 — 32 QFN — Audio EP, RCP
- LAN8660X/1X/2X — 32 QFN — integrated TRX

RTP Q3 2026

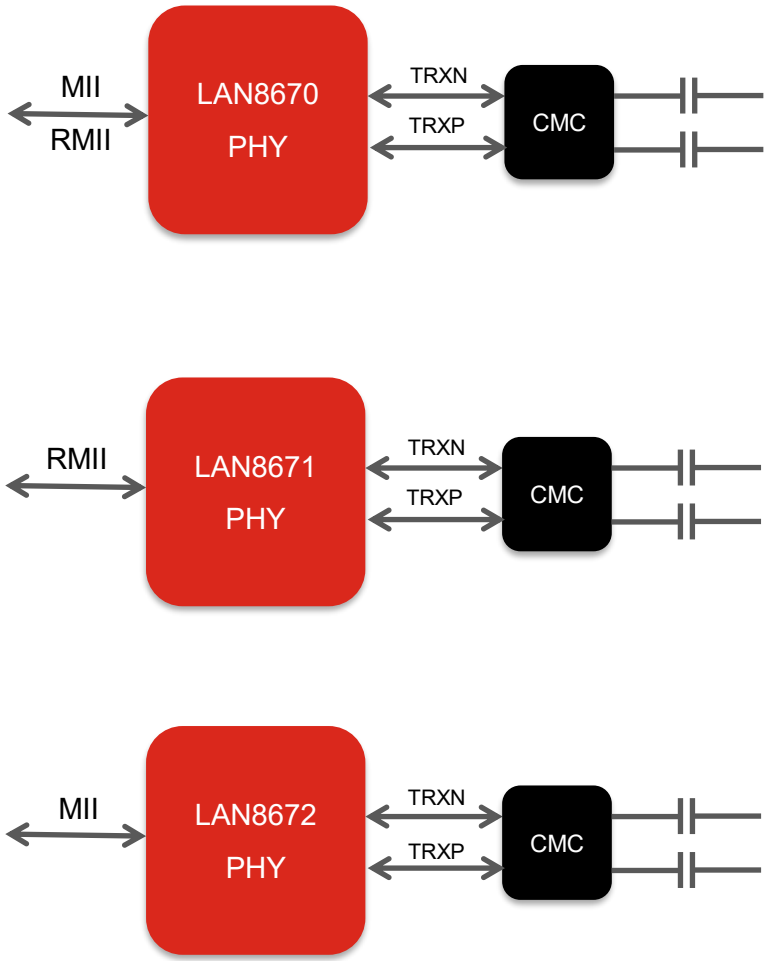
MCU, Switch (OA3p)

- PIC32CM — 32 QFN — MCU
- dsPIC33A — 48 QFN — MCU
- Hallberg — 30G, 100/1000T1 — Switch
- Buzz — 3G, 100T1/SGMII — Switch

MICROCHIP

LAN867x 10BASE-T1S PHYs

10BASE-T1S Ethernet PHY

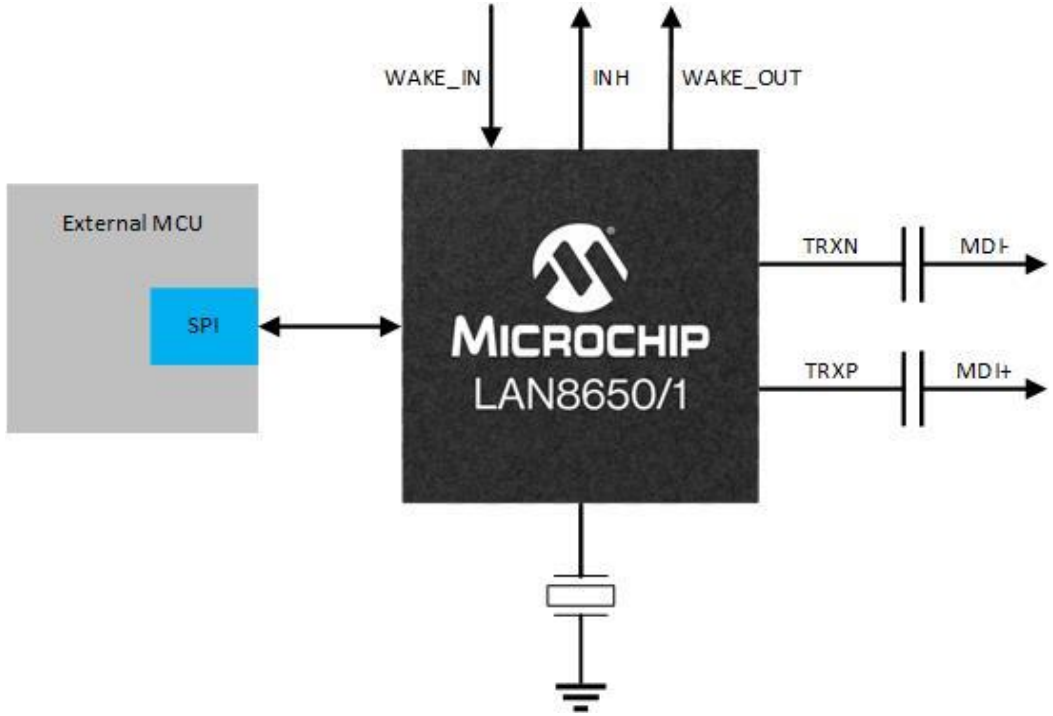


- **Designed according to IEEE Std 802.3cg-2019™**
  - 10 Mbps over single balanced pair of conductors
  - Half-duplex point-to-point segments up to at least 15 m
  - Half-duplex multidrop segments up to at least 25 m with up to at least 8 nodes
- **High bandwidth utilization and latency optimization**
  - Physical Layer Collision Avoidance (PLCA)
  - Multiple PCLA IDs per node
  - Burst mode
- **Time Sensitive Networking (TSN) support**
  - Enables high-precision clock recovery with ultra-low jitter (IEEE Std 802.1AS™ / IEEE 1588™)
- **Standard interface**
  - MII / RMII
  - SMI (MDIO, MDC) for rapid register access
- **Ultra-low power sleep mode**
  - Wake on network activity or input pin
- **Functional Safety Ready**
  - SGS TUV Certified ISO 26262 ASIL B ready
  - FMEDA, Safety Manual,
- **Small footprint**
  - 24 & 32 & 36-pin
  - VQFN package with wettable flanks
- **AEC-Q100 Grade 1 (-40 to +125C)**

MICROCHIP

LAN865x 10BASE-T1S PHYs

10BASE-T1S MAC-PHY Ethernet Controller with SPI



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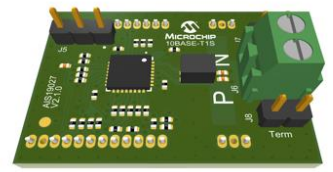
  - 10 Mbps over single balanced pair of conductors
  - Half-duplex point-to-point segments up to at least 15 m
  - Half-duplex multidrop segments up to at least 25 m with up to at least 8 nodes
- **High bandwidth utilization and latency optimization**
  - Physical Layer Collision Avoidance (PLCA)
  - Multiple PCLA IDs per node
  - Burst mode
- **Standard interface**
  - Serial Peripheral Interface (SPI)
  - Designed to the OPEN Alliance 10BASE-T1x MAC-PHY Serial Interface specification, V1.1
- **Ultra-low power sleep mode**
  - Wake on network activity or input pin
- **Functional Safety Ready**
  - SGS TUV Certified ISO 26262 ASIL B ready
  - FMEDA, Safety Manual
- **Small footprint**
  - 32-pin (5x5 mm)
  - VQFN package with wettable flanks
- **AEC-Q100 Grade 1 (-40 to +125C)**

MICROCHIP

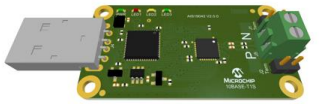
10BASE-T1S Evaluation Boards

Evaluation Boards and MPLAB® Harmony

- **10BASE-T1S PHY RMII Evaluation Board EVB-LAN8670-RMII**
  - Fits to many Microchip MCU boards
  - Small form factor
  - Available from MicrochipDirect (EV06P90A)



- **10BASE-T1S PHY USB Evaluation Board EVB-LAN8670-USB**
  - Makes every USB host a potential 10BASE-T1S node
  - Drivers for Linux and Windows
  - Available from MicrochipDirect (EV08L38A)



- **10BASE-T1S MAC-PHY SPI Evaluation Board**
  - Enables Ethernet communication for various Microchip evaluation kits that support click boardsTM and the SPI interface
  - Available from MikroE (www.mikroe.com, Two-Wire Eth Click, MIKROE-5543)

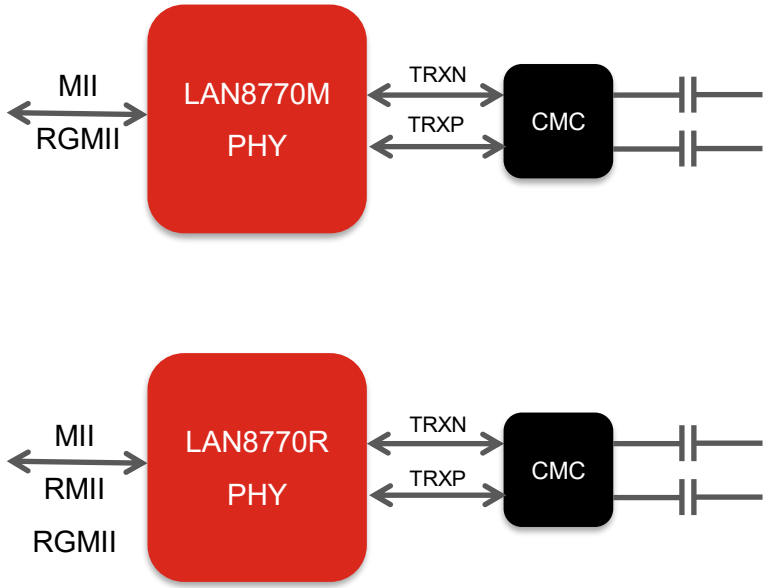
- **MPLAB® Code Configurator Development Framework**
  - Integration into development framework for Microchip microcontrollers and microprocessors

MPLAB® CODE CONFIGURATOR

MICROCHIP

LAN877x 100BASE-T1 PHY

100BASE-T1 Ethernet PHY

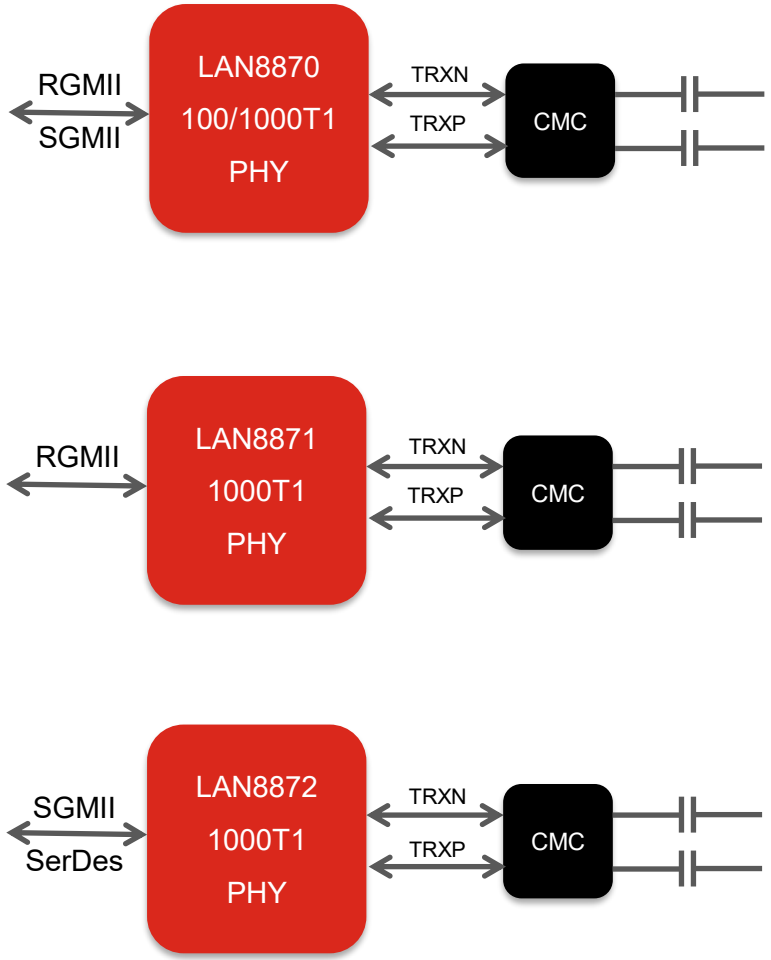


- **Fully compliant IEEE802.3bw Single-Port PHY**
- **Leading Energy Efficiency**
  - Low Power ~130mW operation
  - TC10 Wake up / Sleep (< 15uA)
- **Reduced BOM**
  - Fully integrated line termination and filtering
  - RGMII, RMII, MII w/ FlexPWR®
  - 125MHz RGMII output
- **Enhanced LinkMD™ diagnostics**
  - OPEN Alliance (TC1) Advanced diagnostics compliant
  - SQI counter w/ MSE, peak, threshold interrupt
- **Functional Safety Ready**
  - SGS TUV Certified ISO 26262 ASIL B ready
  - FMEDA, Safety Manual,
- **Smallest T1 PHY**
  - 32-Pin & 36-Pin Wettable QFN (5x5mm, 6x6mm)
- **AEC-Q100 Grade 1 (-40 to +125C)**

MICROCHIP

LAN887x 1000BASE-T1 PHY

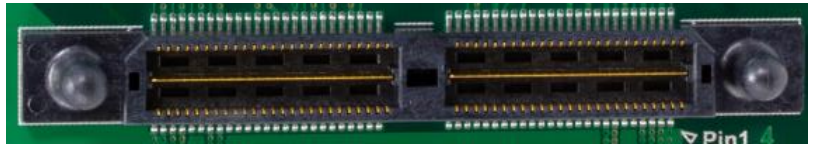
1000BASE-T1 Ethernet PHY



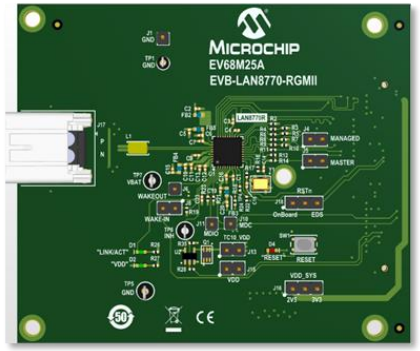
- **Fully compliant IEEE802.3bw/bp Single-Port PHY**
  - Force or auto-negotiation mode
- **IEEE 1588 / .1AS Time synchronization support**
  - 8ns jitter accuracy
- **Cable reach**
  - Type A (15m) and Type B (40m)
  - Extended reach (>40m*)
- **TC10 Sleep and Wakeup support**
  - <20uA standby power consumption
- **Enhanced Diagnostics**
  - Cable diagnostics, Signal Quality Indicator
  - BIST, link, error, temperature, voltage and clock monitoring
- **Functional Safety Ready**
- **48-Pin (7mm x 7mm) package**
- **AEC-Q100 Grade 2 (-40degC to +105degC)**

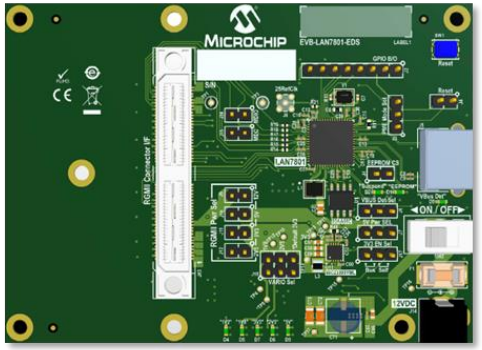
MICROCHIP

100/1000 BASE-T1 Plug-in Bridge Solutions



100BASE-T1
LAN8770

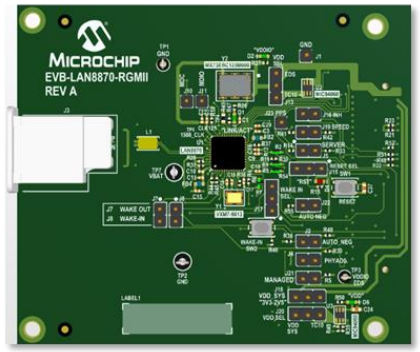


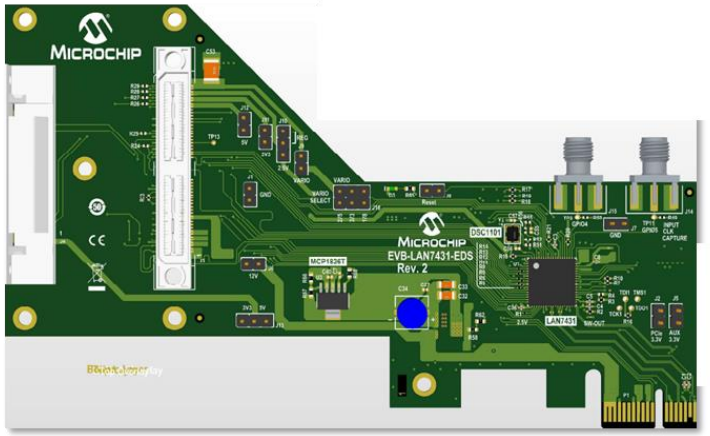


SUPERSPEED CERTIFIED USB

LAN7801 + Software

1000BASE-T1
LAN8870



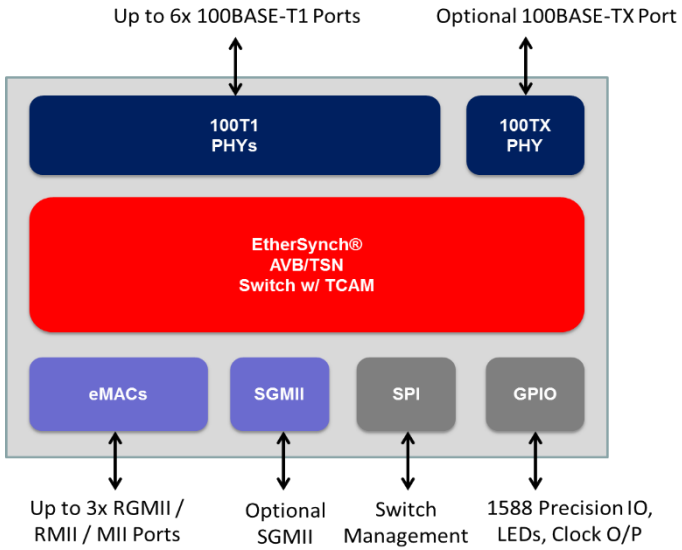


PCI EXPRESS

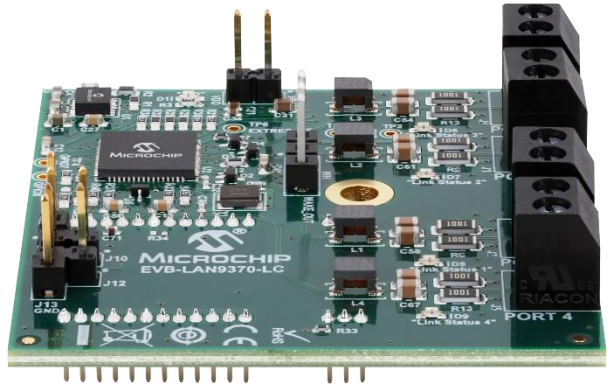
LAN7431 + Software

MICROCHIP

LAN937x 100T1 GigE Switch



Part Number	T1 PHY Ports	TX PHY Ports	RGMII/ RMII/MII Ports	SGMII Ports	Temperature	Package
LAN9370	4	0	1	0	-40°C +105°C	64-QFN
LAN9371	3	1	2	0	-40°C +105°C	128-TQFP
LAN9372	5	1	2	0	-40°C +105°C	128-TQFP
LAN9373	5	0	2	1	-40°C +105°C	128-TQFP
LAN9374	6	0	2	0	-40°C +105°C	128-TQFP



- **5 to 8-Port AVB/TSN Switch**
- **Cascade for up to 14-Ports**
- **Software and pin compatible**
- **TC11 compliant**
- **TC10 wake up and sleep**
- **AEC-Q100 Grade 2**

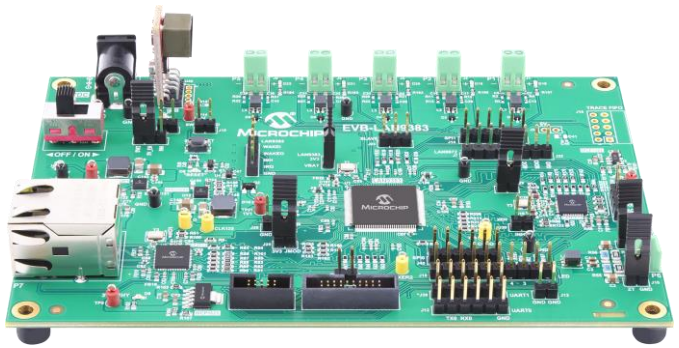
- **Advanced AVB/TSN support**
  - 802.1AS Time Sync
  - 802.1Qat Stream Reservation
  - 802.1Qav Shaper
  - 802.1Qbv Scheduler
  - 802.1Qci Ingress Policing

EVB-LAN9370

- Partner: SAME70 XULT, SAMA5D3-EDS, Audio End Point
- Software: Autosar, FreeRTOS, Linux

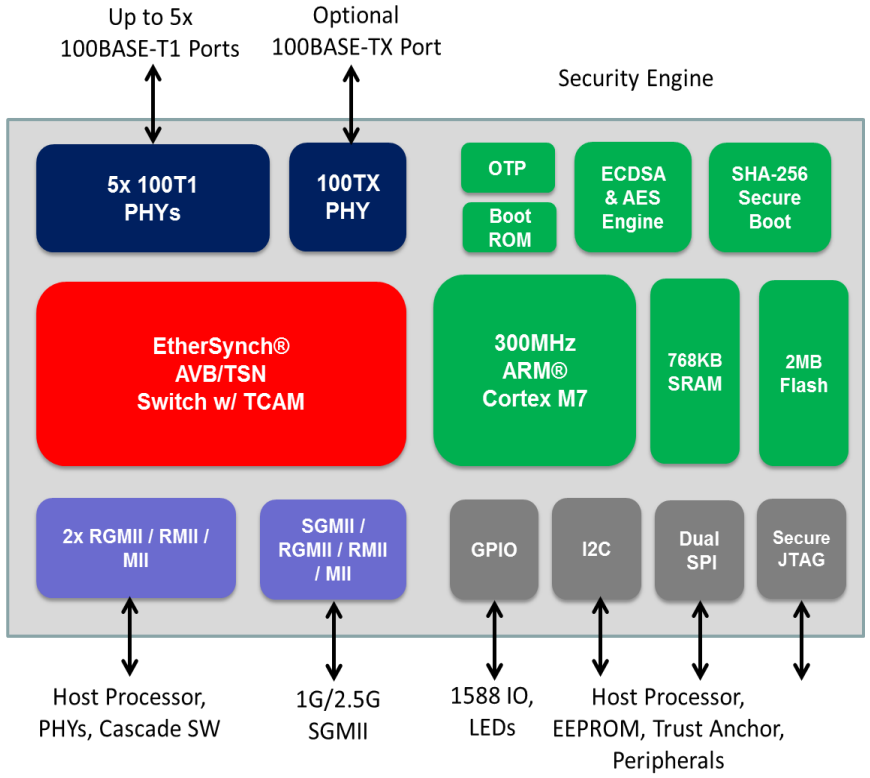
MICROCHIP

LAN938x 100T1 GigE Switch w/ CPU



Part Number	T1 PHY Ports	TX PHY Ports	RGMII / RMII / MII Ports	SGMII OR RGMII MUX Port	Temperature	Package
LAN9384	5	1	0	1	-40 +105	128-TQFP
LAN9383	5	0	1	1	-40 +105	128-TQFP
LAN9382	4	1	1	1	-40 +105	128-TQFP
LAN9381	4	0	2	1	-40 +105	128-TQFP

- **7-Port AVB/TSN Switch**
- **300MHz Cortex M7**
- **Integrated Flash & ECC RAM**
- **1G/2.5G SGMII Uplink**
- **Advanced TSN support**
  - 802.1AS-2020 Time Sync
  - 802.1Qbv Scheduler
  - 802.1Qci Ingress Policing
  - 802.1CB Redundancy
- **Advanced Security Engine**
- **TC10 wake up and sleep**
- **Functional Safety ready**
- **AEC-Q100 Grade 2**



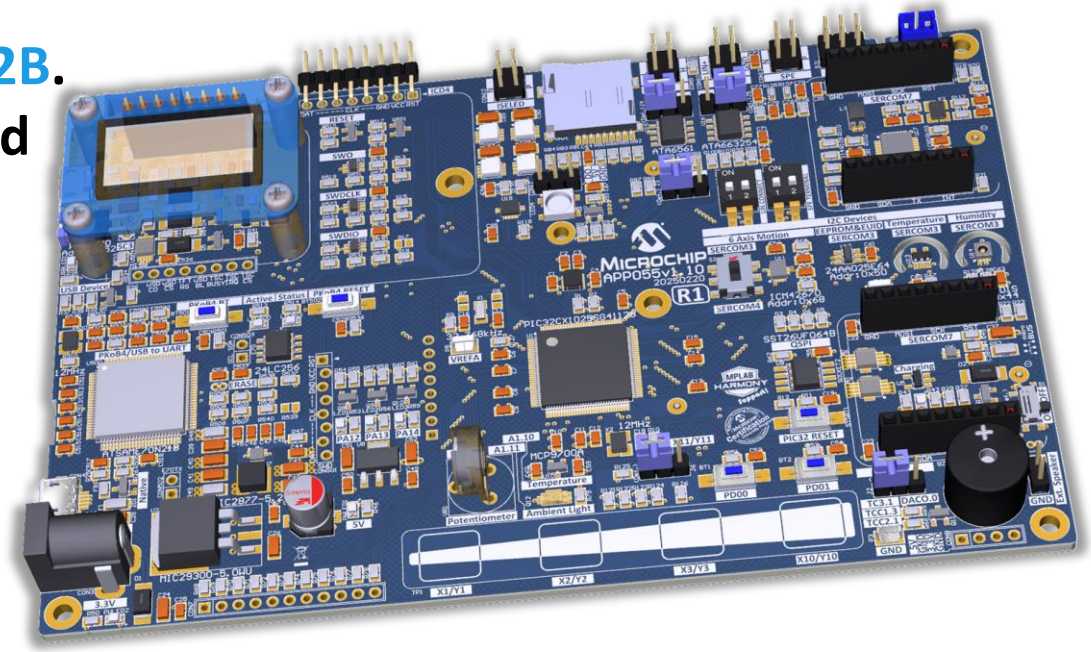
MICROCHIP

PIC32CX-SG EVB
APP055 v1.10R1 Introduction

MICROCHIP

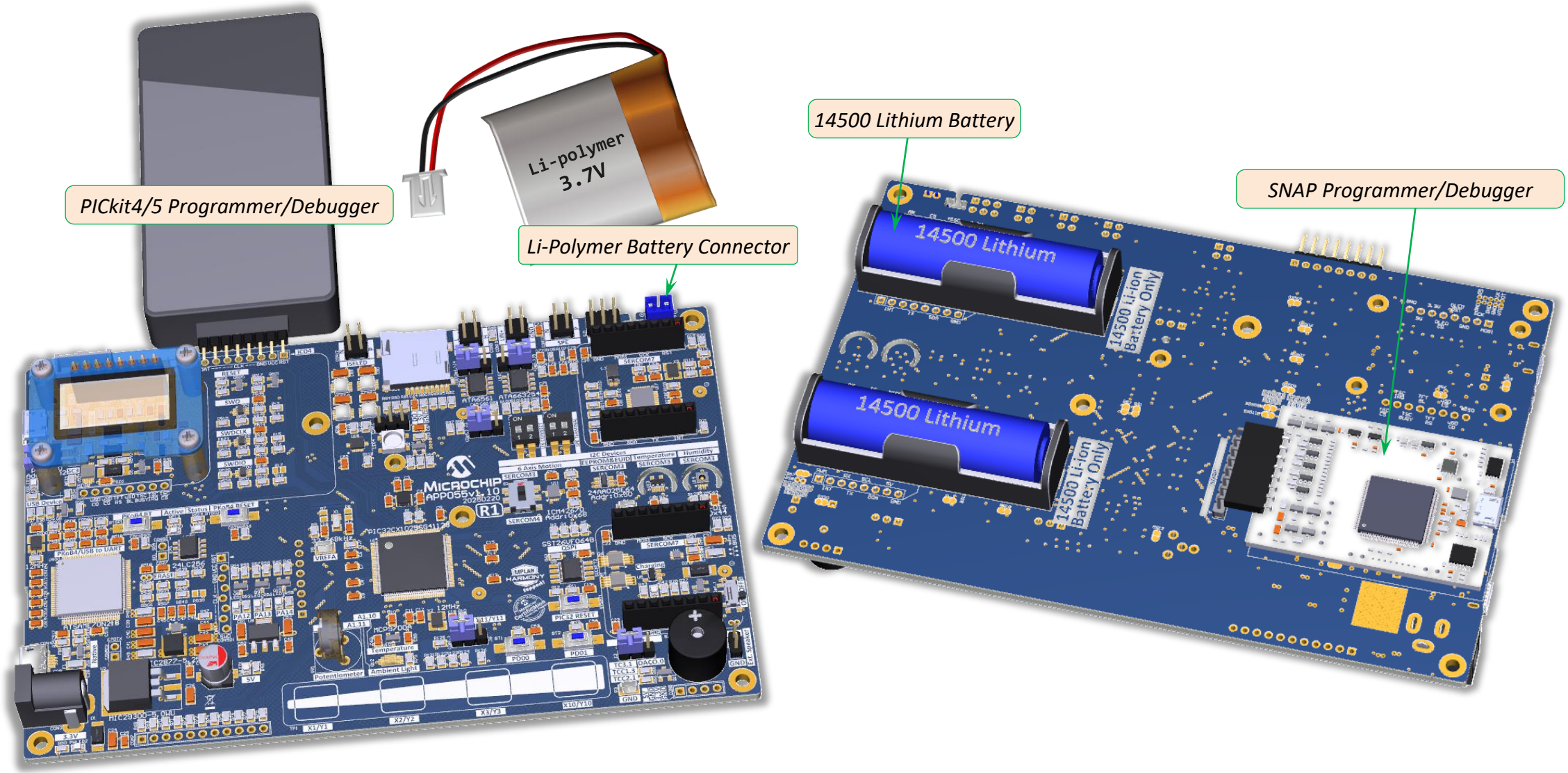
APP055 v1.10$_{R1}$ Features

- PIC32CX1025SG41128 32Bit Arm Cortex M4F Microcontroller with FPU.
- Built-in PKoB4 Programmer/Debugger with USB CDC Virtual COM.
- Multiple Power Source and support Li-on battery with battery charger.
- ISELED, Single Pair Ethernet, CAN-FD, LIN support ready.
- Capacitive QTouch® Slider & Buttons with Driven Shield.
- mikroBUS™ Click Board Socket ready.
- Digital IO : 2 x Buttons and 3 x LEDs and WS2812B.
- Analog : Potentiometer, Temperature Sensor and Ambient Light Sensor.
- I2C : Temperature, EEPROM, 6 Axis Motion and Humidity Sensor.
- SPI : OLED (128 x 64, SSD1306 Compliant)
- QSPI : Flash Memory.
- SDHC : MicroSD Socket.
- PWM, DAC : Buzzer.

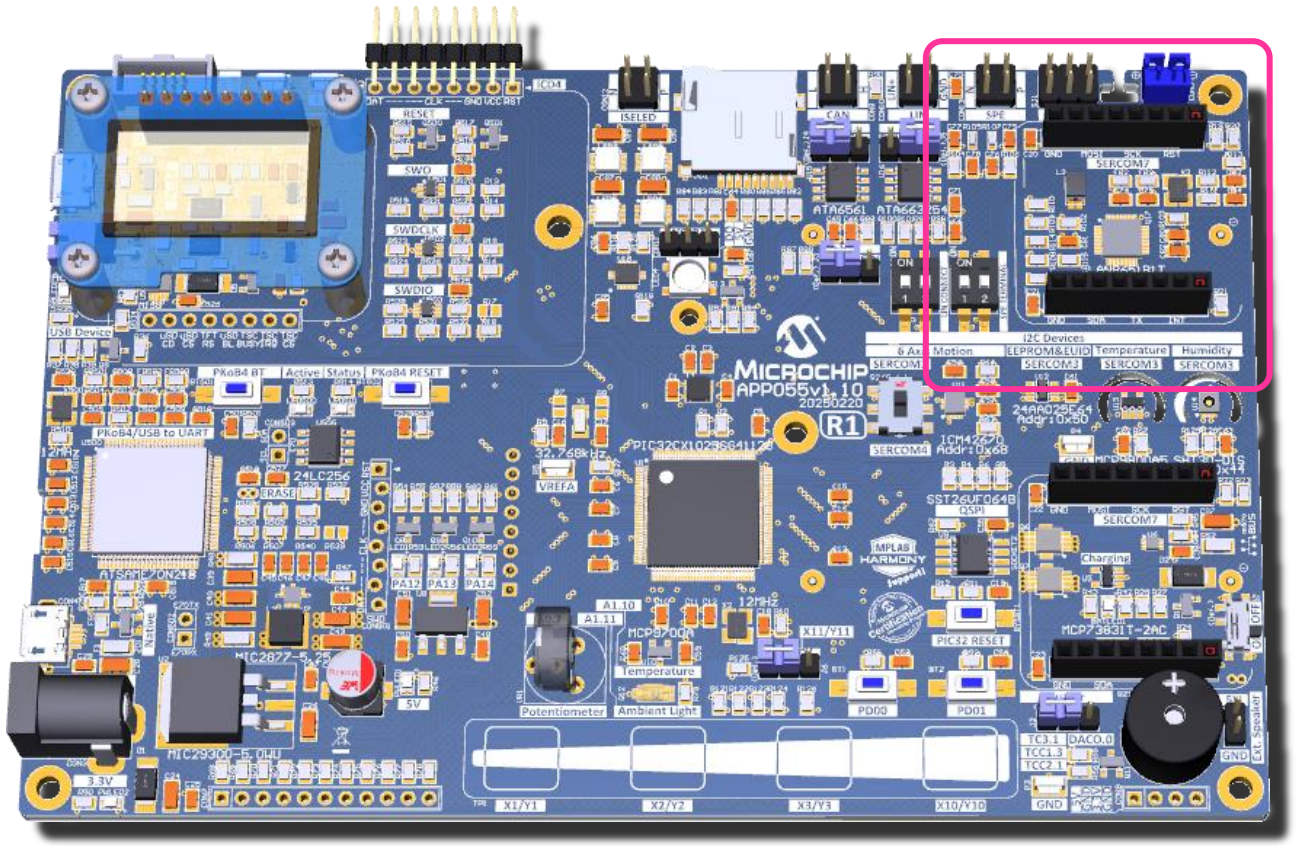


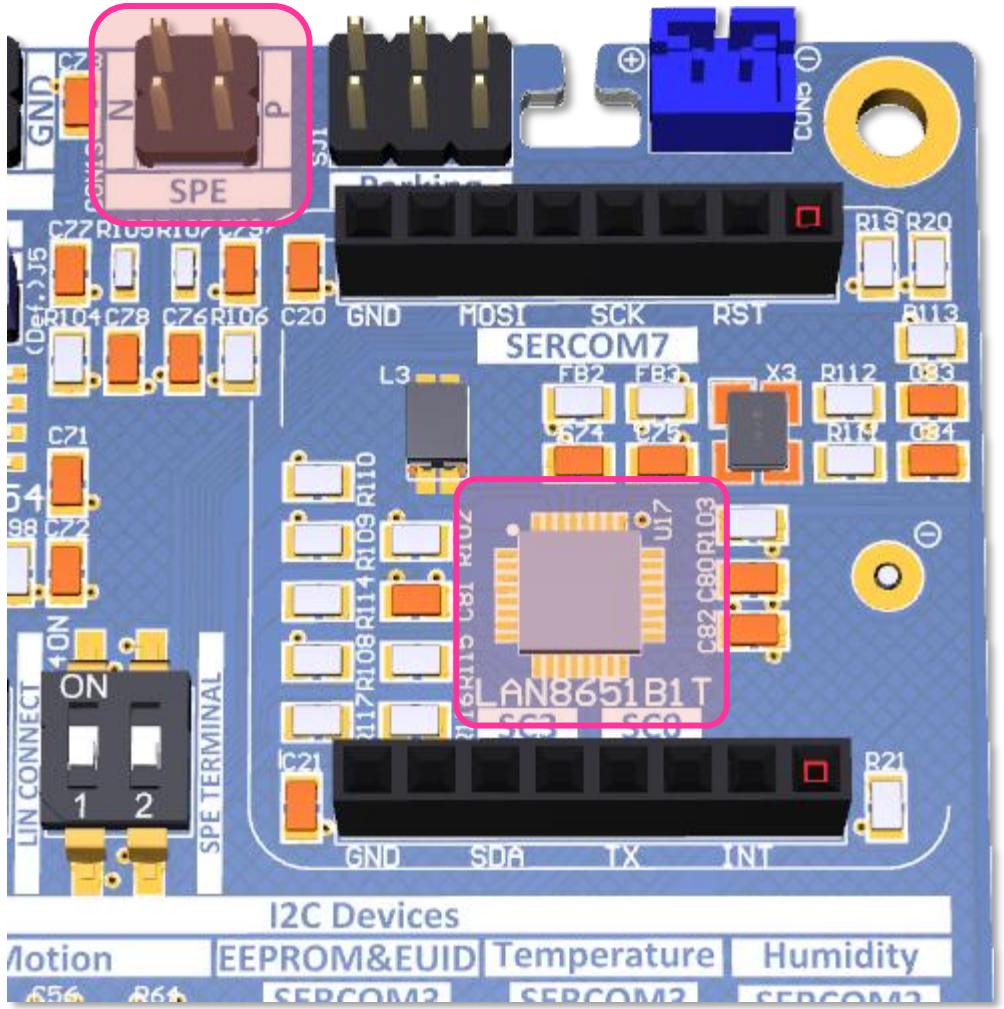
MICROCHIP

APP055 v1.10$_{R1}$ Accessories

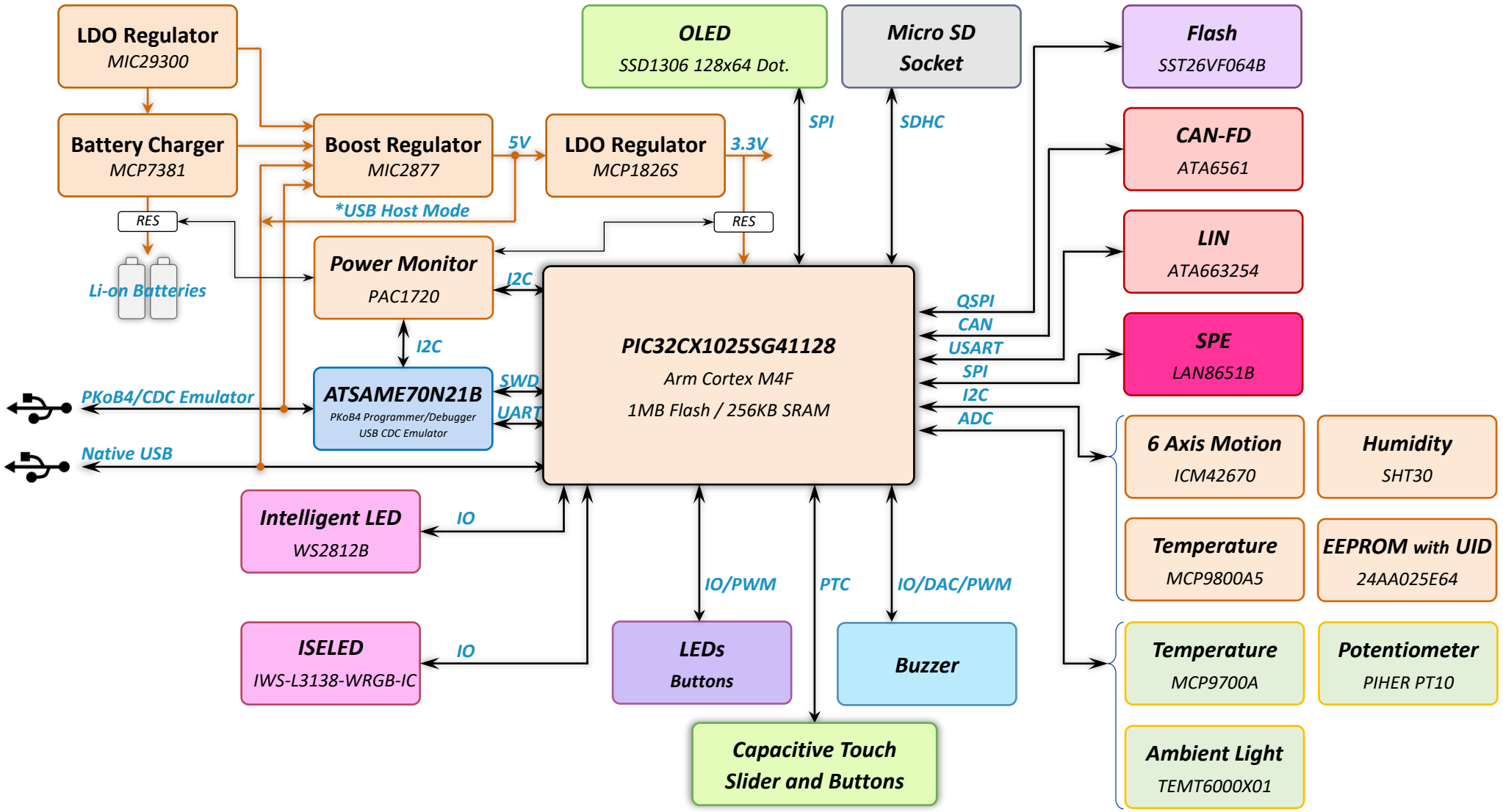


Single Pair Ethernet (SPE) LAN8651- 10BASE-T1S Ethernet



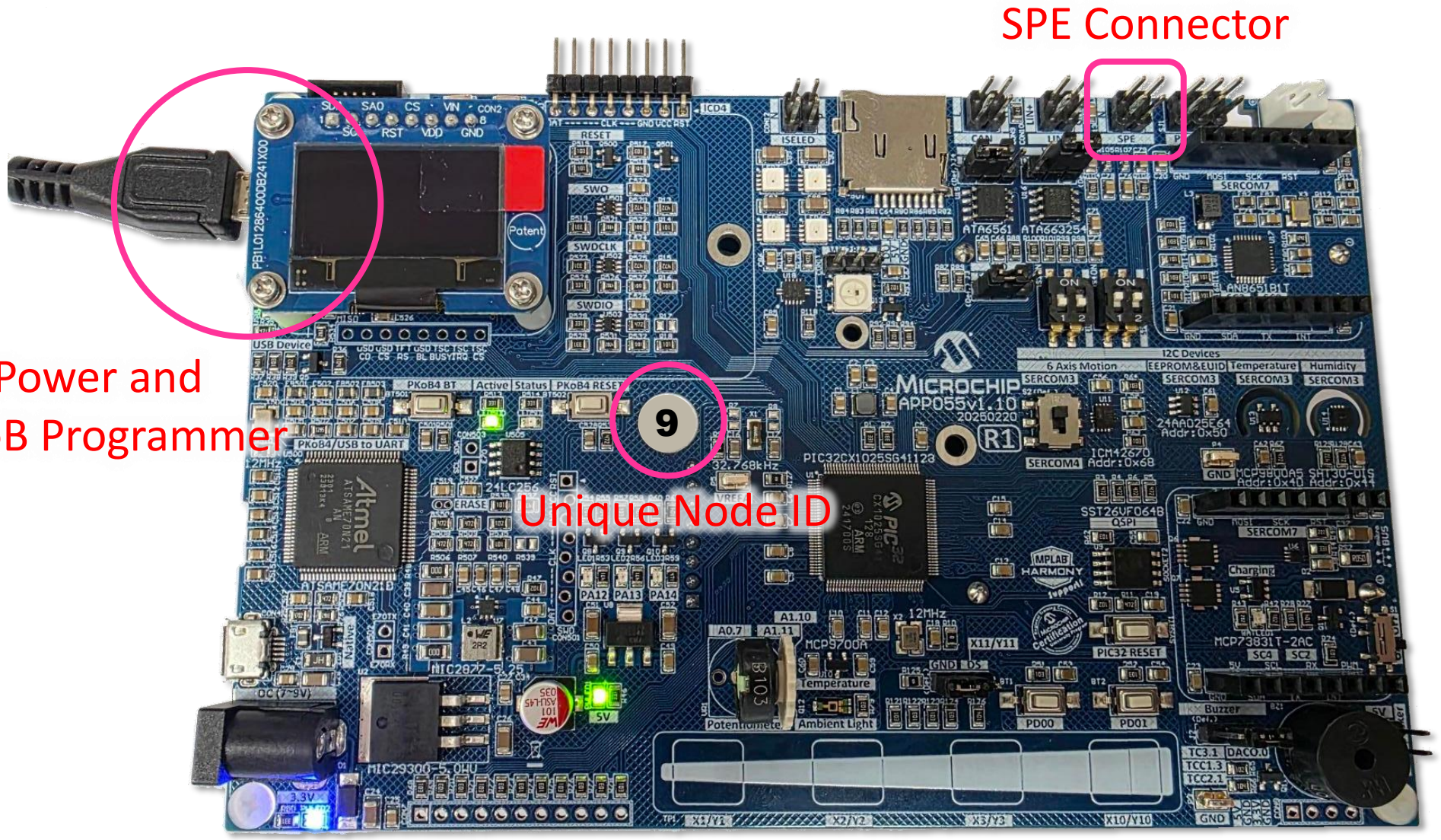


APP055 v1.10$_{R1}$ Block Diagram



MICROCHIP

APP055 v1.10$_{R1}$ Connection



MICROCHIP

MCC Harmony Framework

The Software Framework for MCC

MICROCHIP

Software Request In this Course

When the versions of the software and the framework differ from the created project, issues may occur. Therefore, it is recommended to use the following setting in this course.

- **MPLAB® X IDE v6.30** https://www.microchip.com/mplab/mplab-x-ide
- **MPLAB® XC32 Compiler v5.00** https://www.microchip.com/mplab/compilers
- **MPLAB® Code Configurator (MCC) v5.6.4.2**
- **MCC Content Manager v2.0.4.2**
- **MCC-Service-Provider-Plugin v1.2.0**
- **MCC Core v5.8.4**
- **MCC Harmony Framework (From X IDE MCC Content Manager)**
  - MCC Harmony Core (com.microchip.mcc.harmony.Harmony3Library) v1.5.5
  - Harmony 3 - Chip Support Package (**csp**) v3.25.1
  - Harmony 3 - Core (**core**) v3.16.2
  - Harmony 3 - Core (**bsp**) v3.25.0
  - Harmony 3 - Networking Stack and Solutions (**net**) v3.14.5
  - Harmony 3 - Networking Stack and Solutions (**net_10base_t1s**) v1.4.3
  - Harmony 3 - WolfSSL solutions (**wolfssl**) v5.4.0
  - Harmony 3 - Harmony Services (**harmony-services**) v1.5.0
  - arm CMSIS (**CMSIS_5**) v5.9.0
- **MPLAB® X IDE Packs**
  - PIC32CX-SG41_DFP v1.6.172 (Device Family Pack)
  - CMSIS v6.2.0 or Newest (Device Family Pack)

➢ **MCC Core and Framework Update from X IDE > MCC > Content Manager**

➢ **PIC32CX-SG41_DFP Update from X IDE > Tools > Packs**

➢ **Tera Term v5.5** https://github.com/TeraTermProject/teraterm/releases

(Lasted Update : 2026/04/22)

MICROCHIP

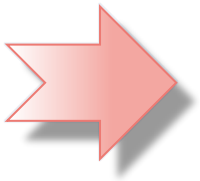
MCC Harmony Framework

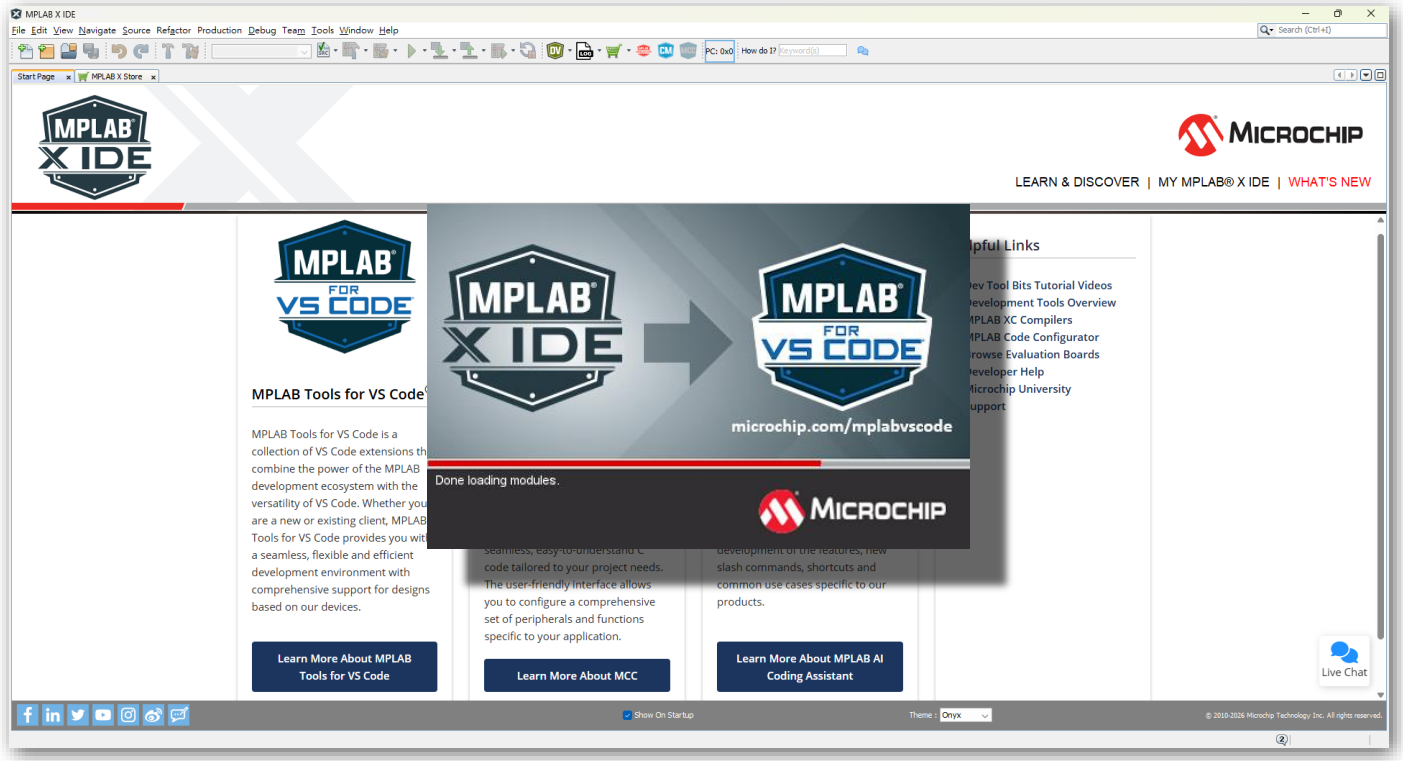
Step 1

- **Open MPLAB X IDE v6.30.**

MPLAB X IDE v6.30

Double Click!



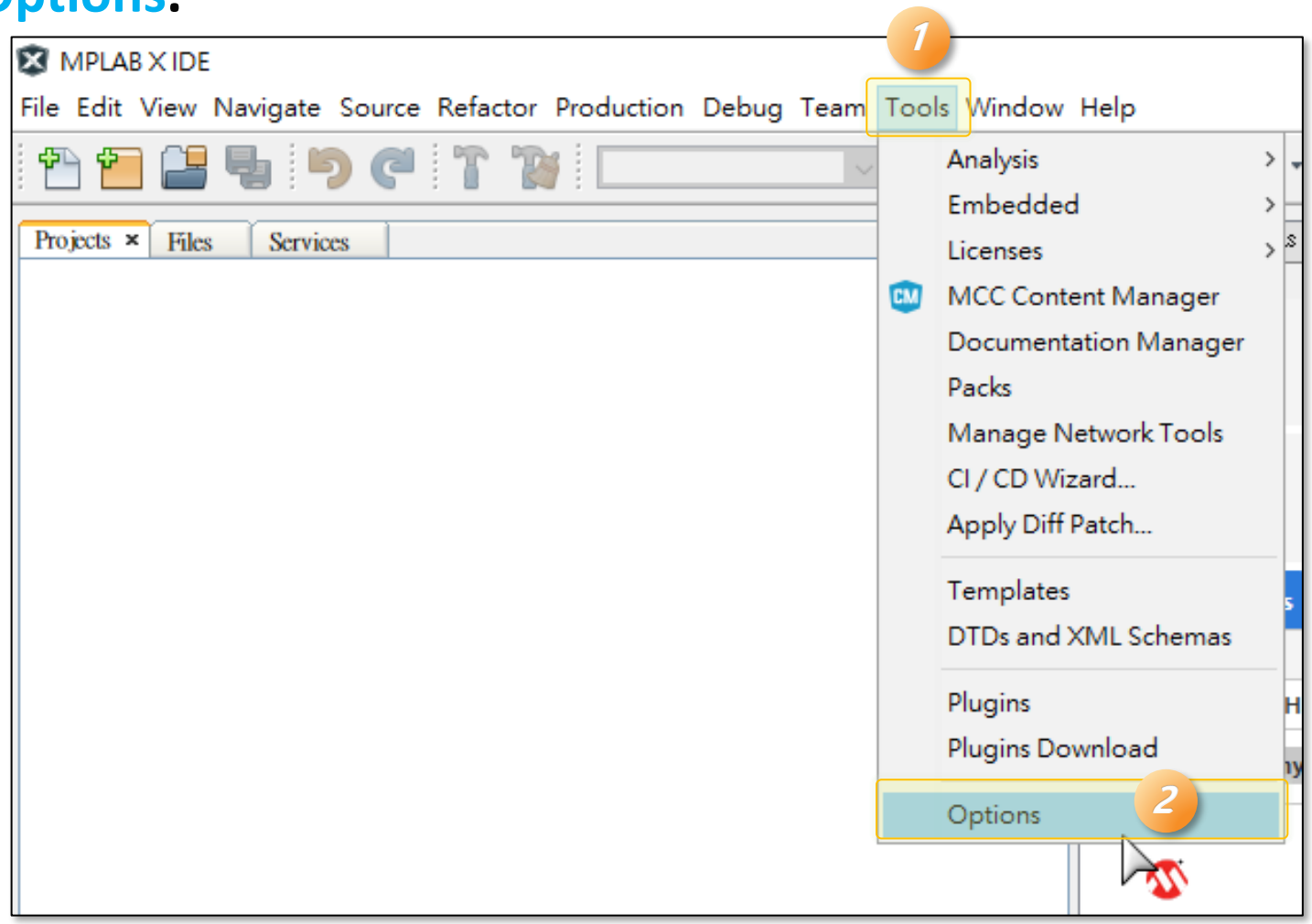


MICROCHIP

MCC Harmony Framework

Step 2

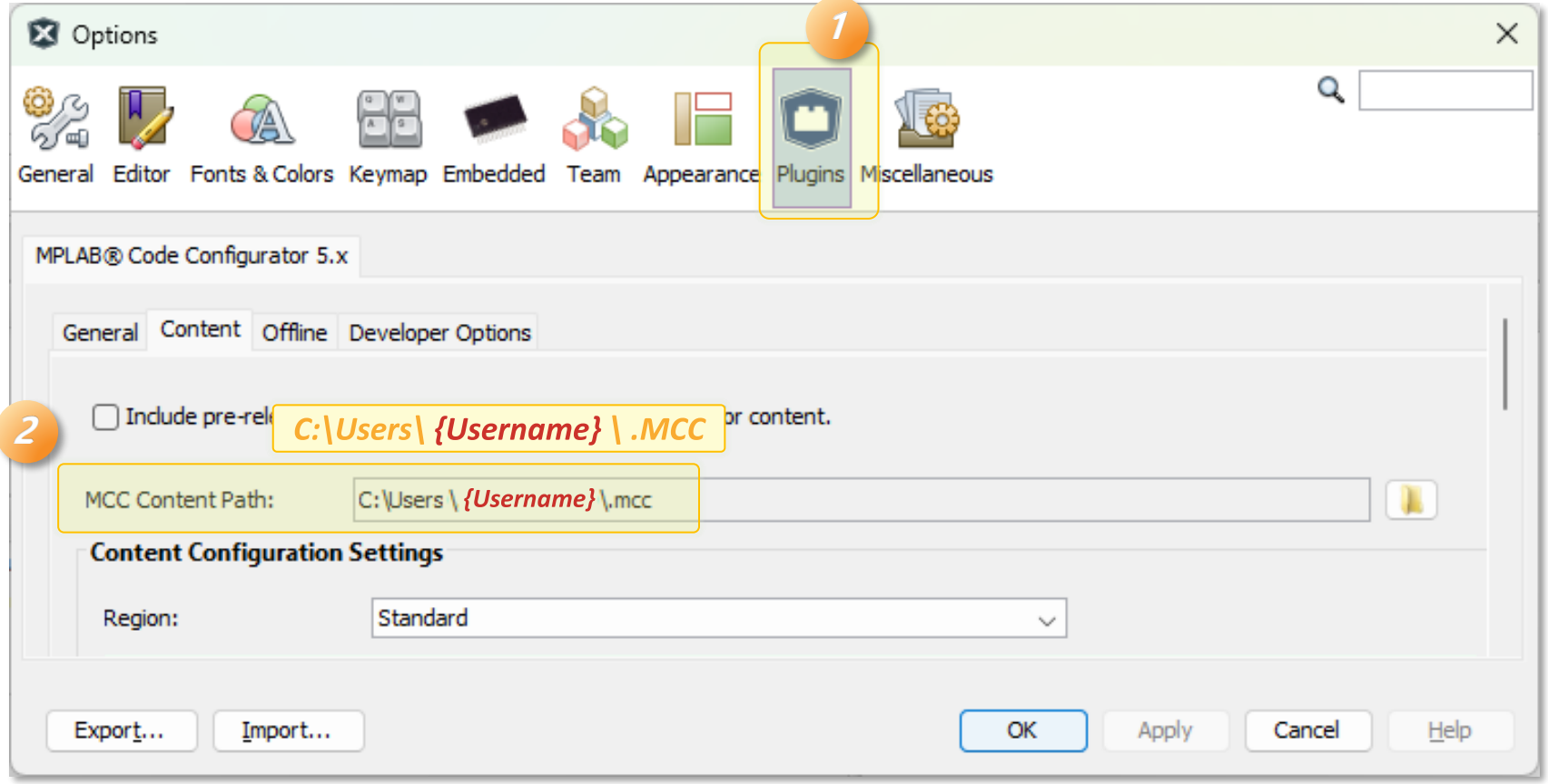
- **Click Tools > Options.**



MCC Harmony Framework

Step 3

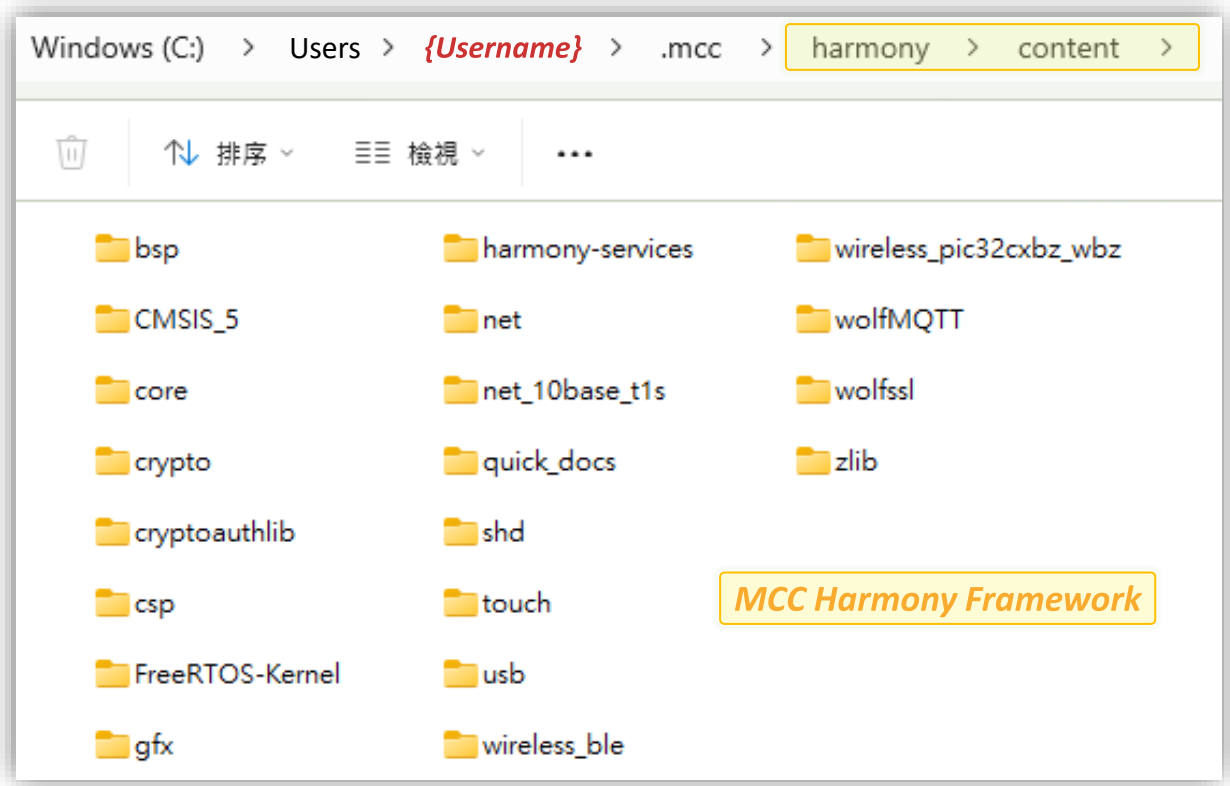
- Click Plugins and check the Harmony Content Path



MCC Harmony Framework

Step 4

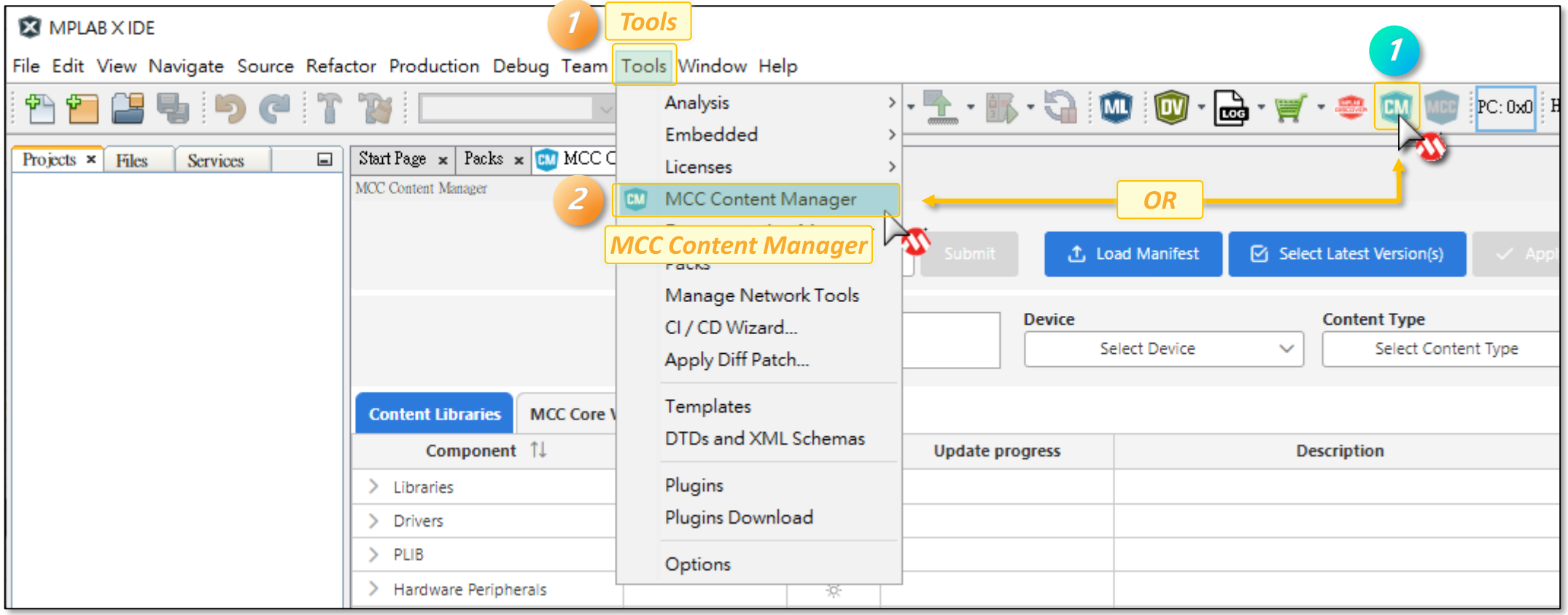
- **Locate the MCC Harmony Framework folder in your computer.**
  C:\Users\ *{Username}* \.mcc\harmony\content



MCC Harmony Framework

Step 5

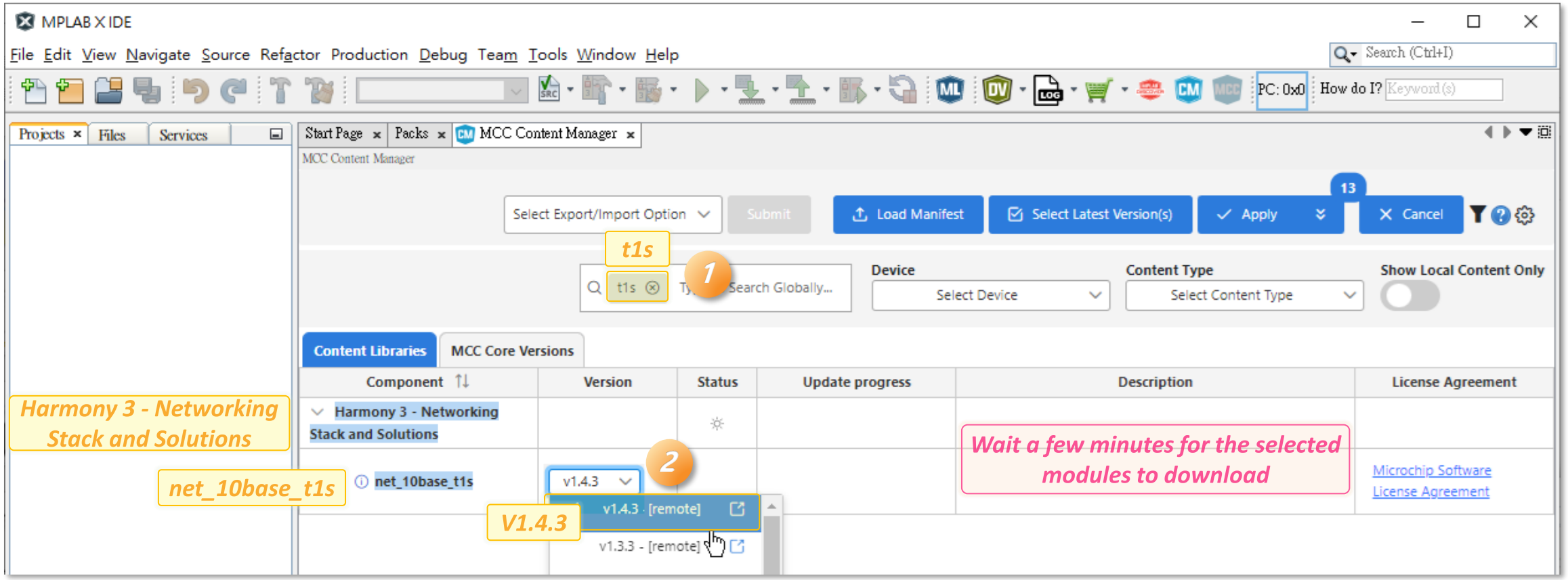
- **Click Tools > MCC Content Manager or Click icon** 



MCC Harmony Framework

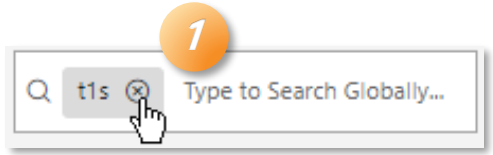
Step 6

- Type "t1s" in quick search, select to latest net_10base_t1s module then next page.

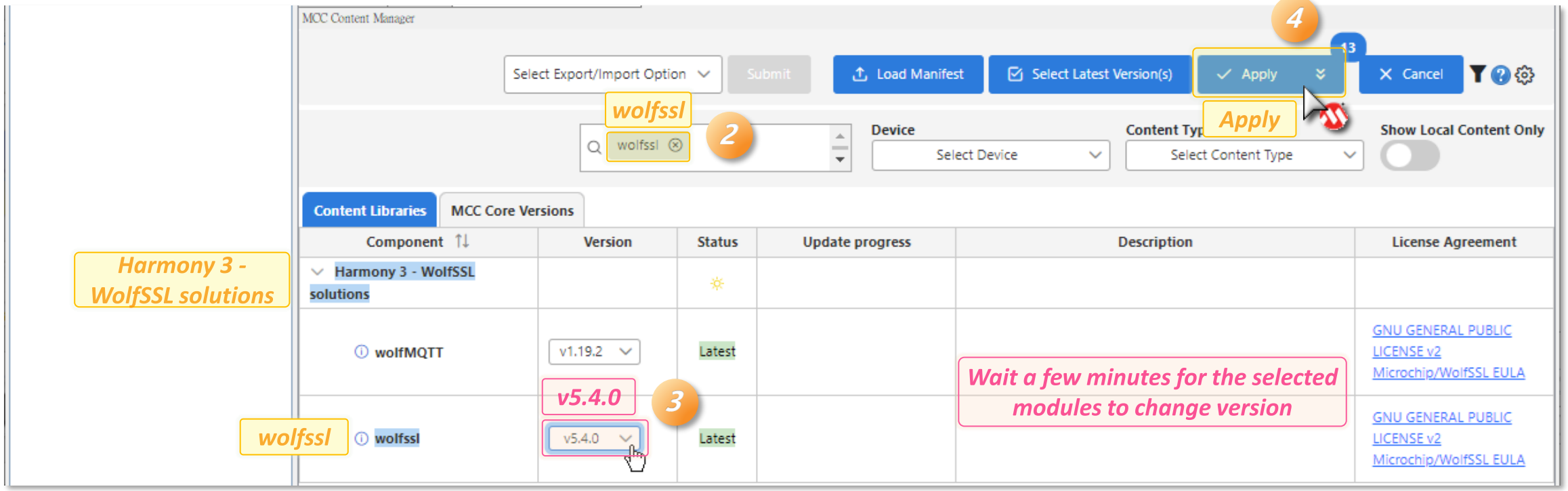


MCC Harmony Framework

Step 7

- Clean "t1s" by 

in quick search, Input "wolfssl" to find module and change the version of wolfssl to v5.4.0 and click on Apply to make changes then remember close the Content Manager before execute MCC.



Start From New Project

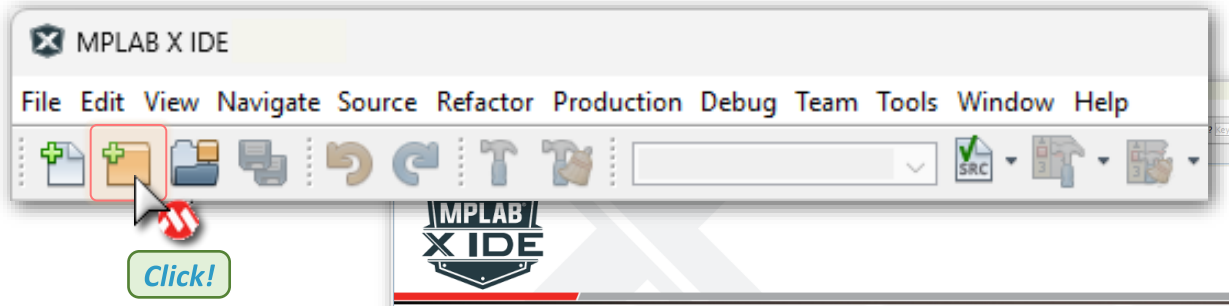
Create a New Project in MPLAB X IDE

MICROCHIP

Start From New Project

Step 1

- Select to File > New Project or Click icon 

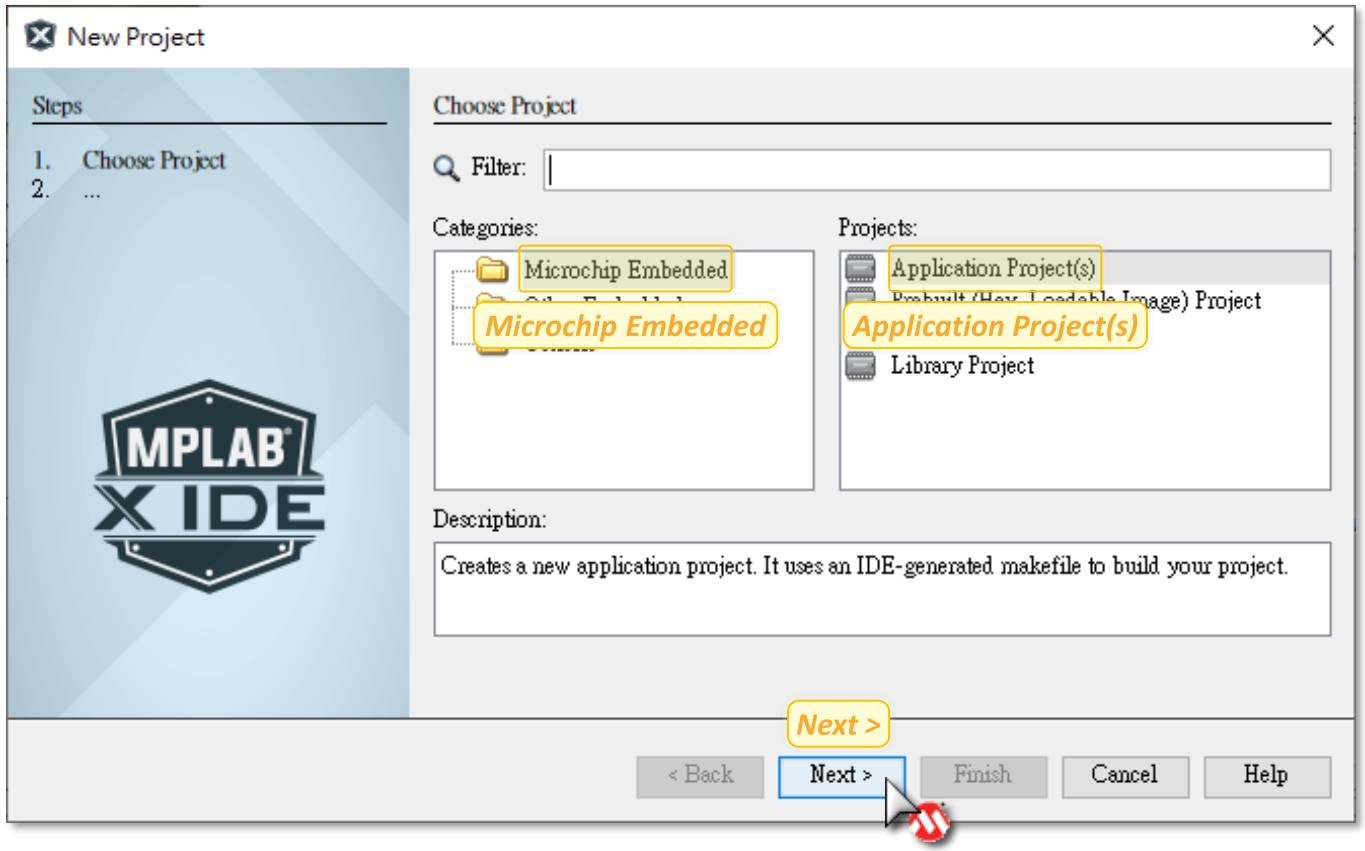


MICROCHIP

Start From New Project

Step 2

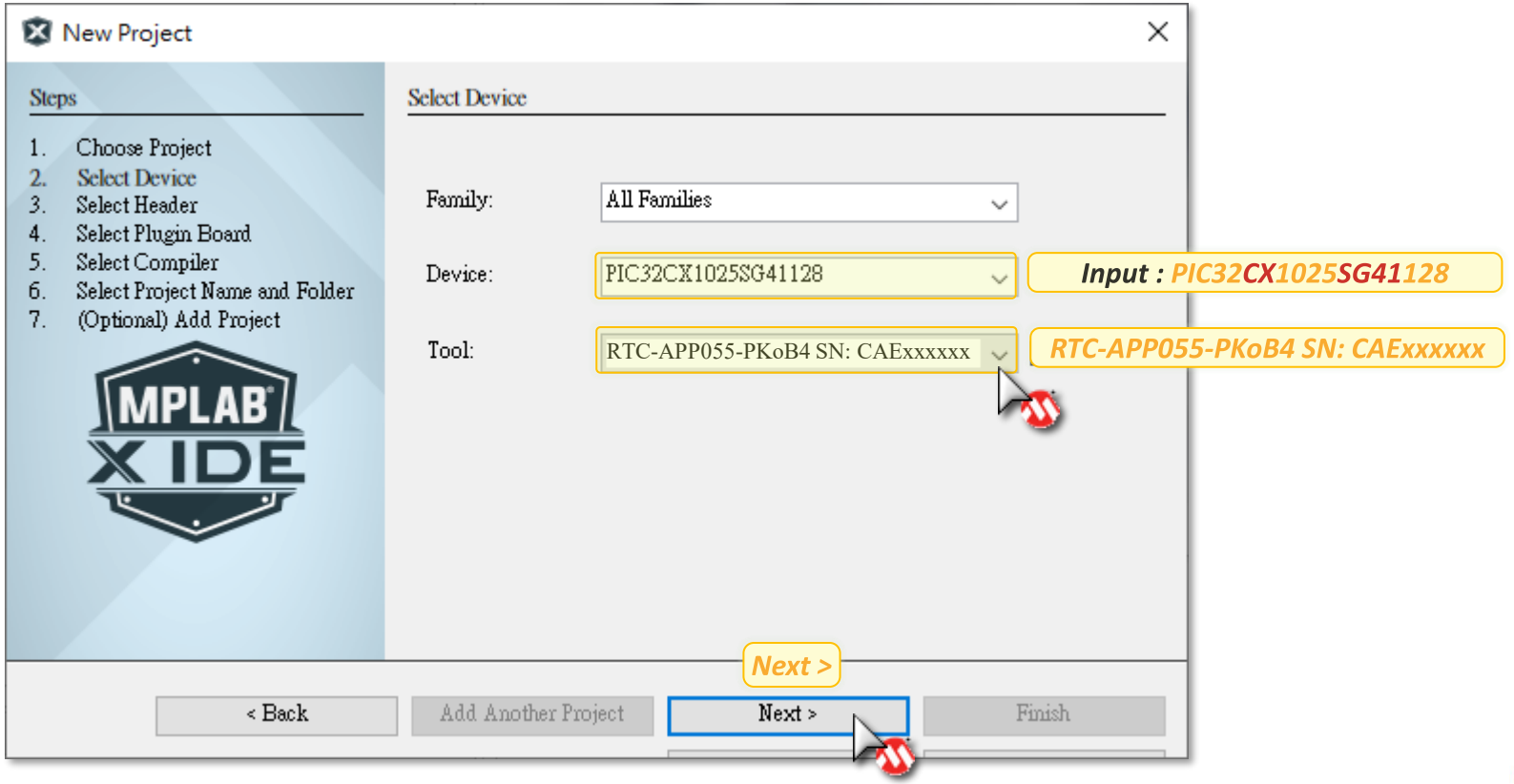
- **Categories** : **Microchip Embedded**
- **Projects** : **Application Project(s)**



Start From New Project

Step 3

- **Family** : **All Families**
- **Device** : **PIC32CX1025SG41128** ***Don't miss any character***
- **Tool** : **RTC-APP055-PKoB4 SN: CAExxxxxxxxxxxx**

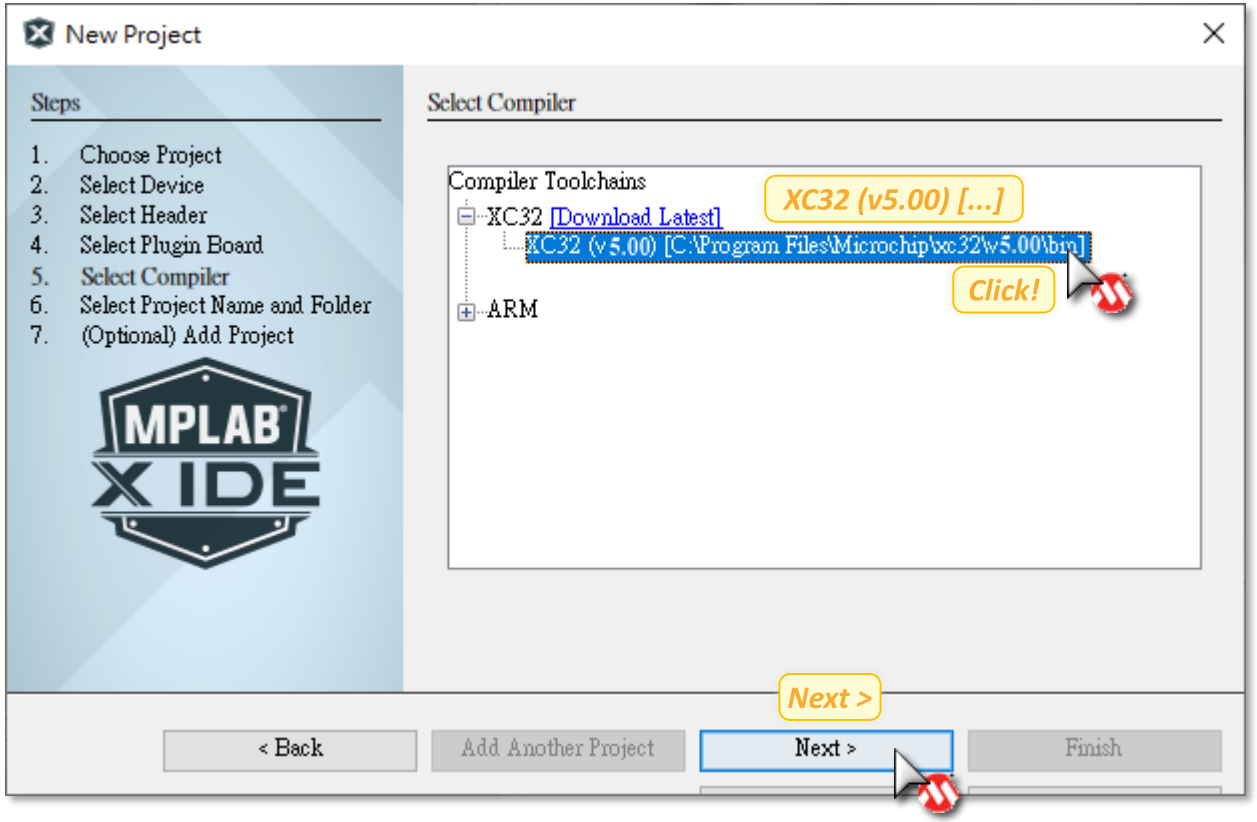


Start From New Project

Step 4

Assign Compiler Toolchains

- **XC32** : **XC32 (v5.00)[…]**

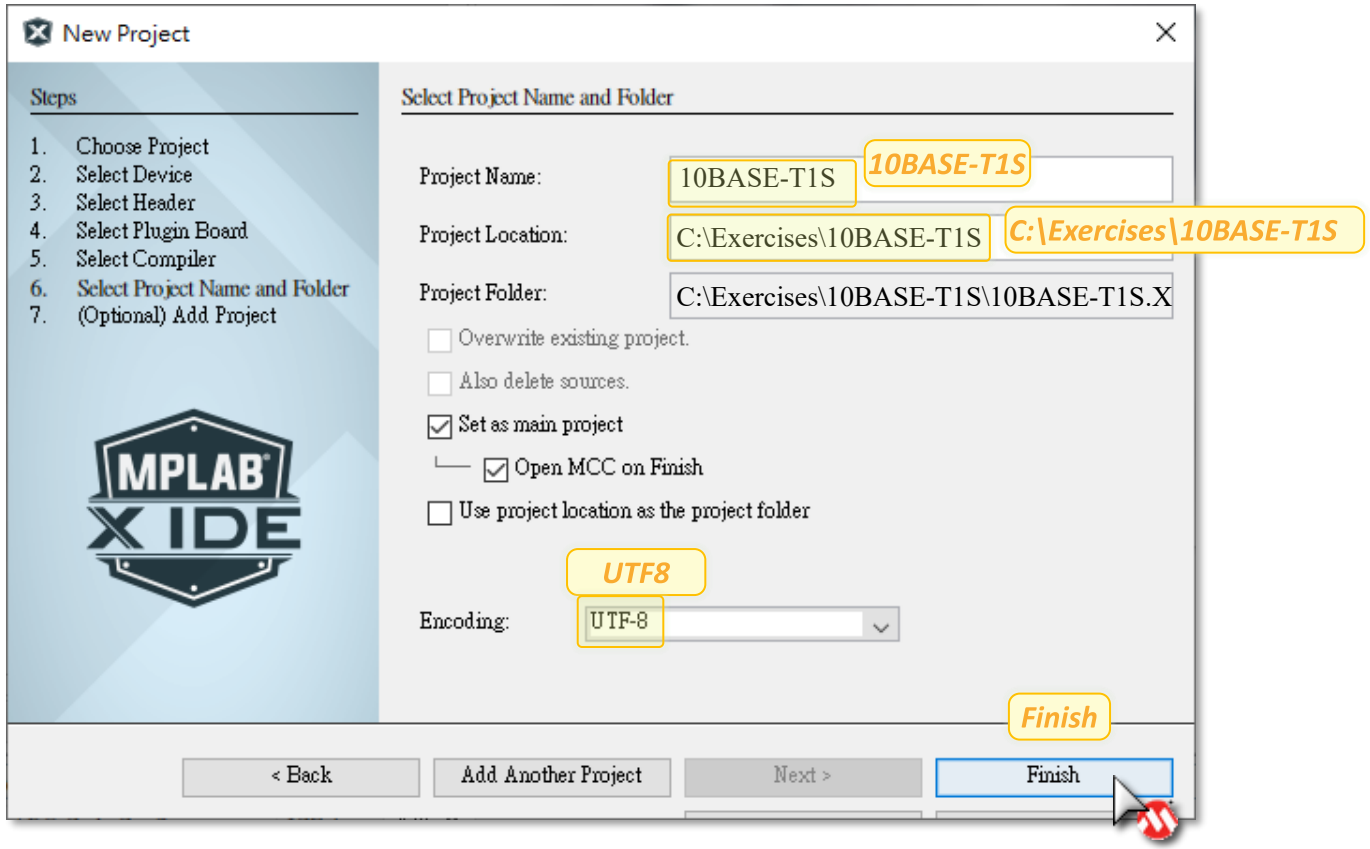


Start From New Project

Step 5

Configure the Project Location and Project Folder Name.

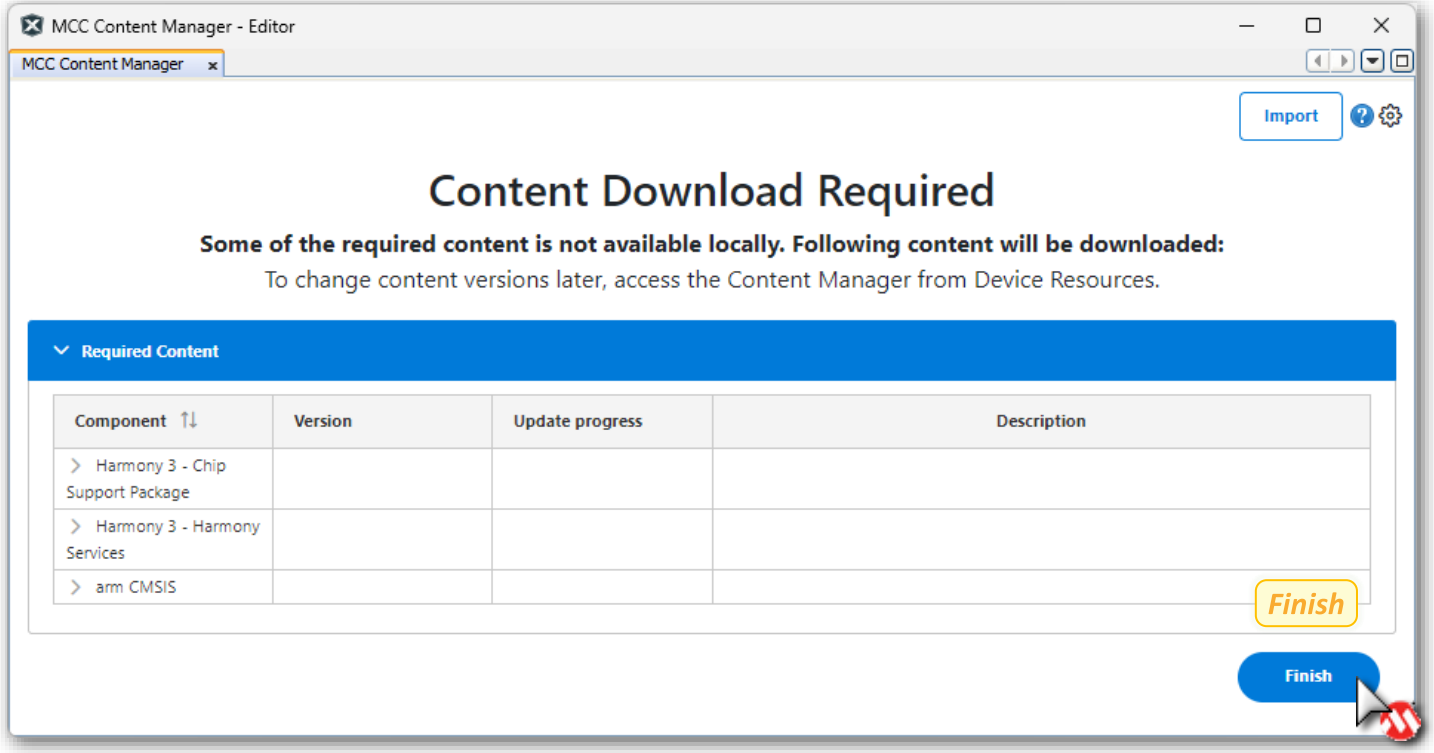
- **Project Name : 10BASE-T1S** *No white space of project name or path*
- **Project Location : C:\Exercises\10BASE-T1S**



Start From New Project

Step 6 (optional)

- **Click Finish and Waiting for automatic download MCC Framework.**



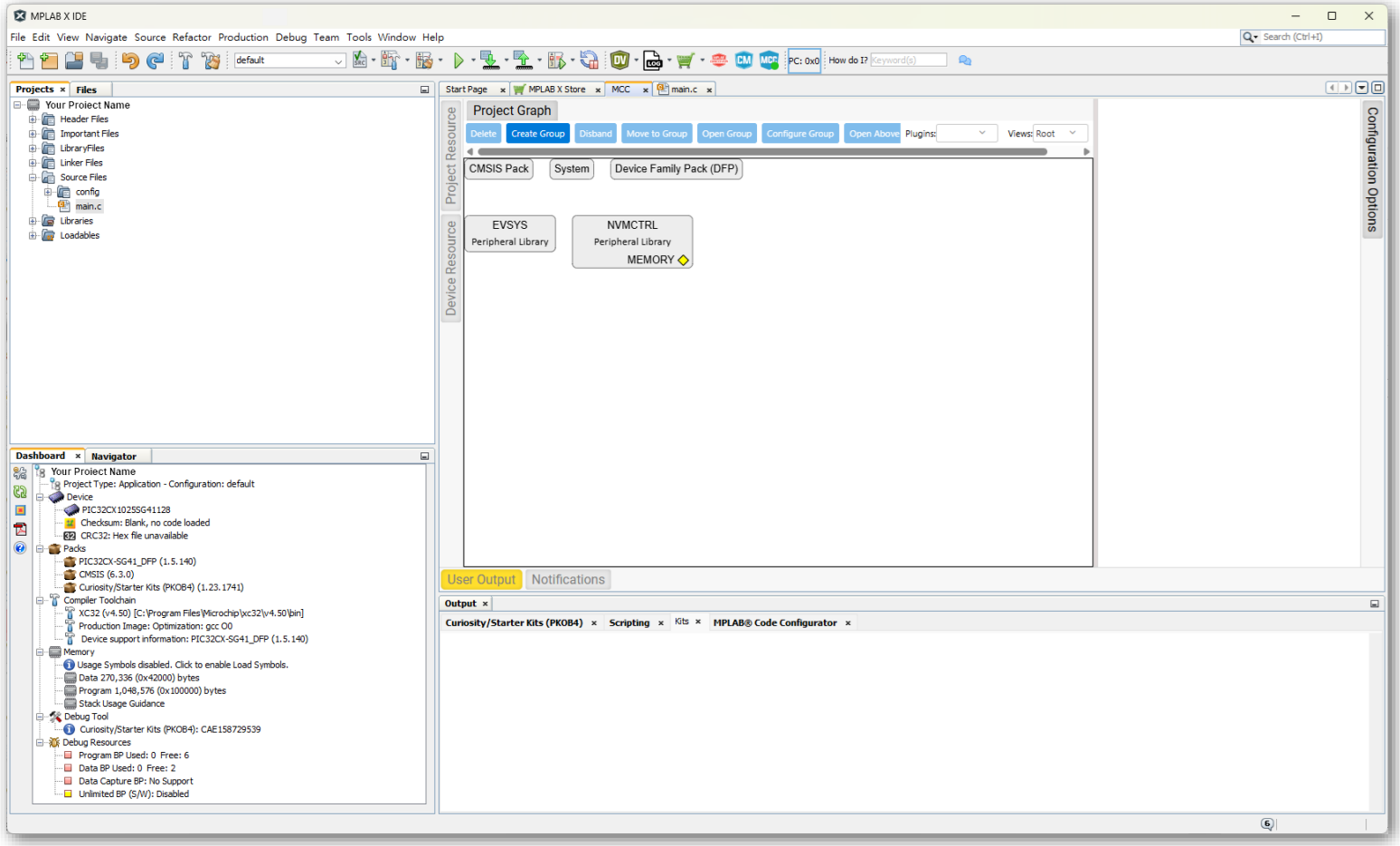
** MCC will download the latest Framework, which only needs to be performed once.*
** This step will not occur in the course because the MCC Framework is already installed on the computer.*

MICROCHIP

Start From New Project

Step 7

- **The MCC Harmony Configurator interface appears.**



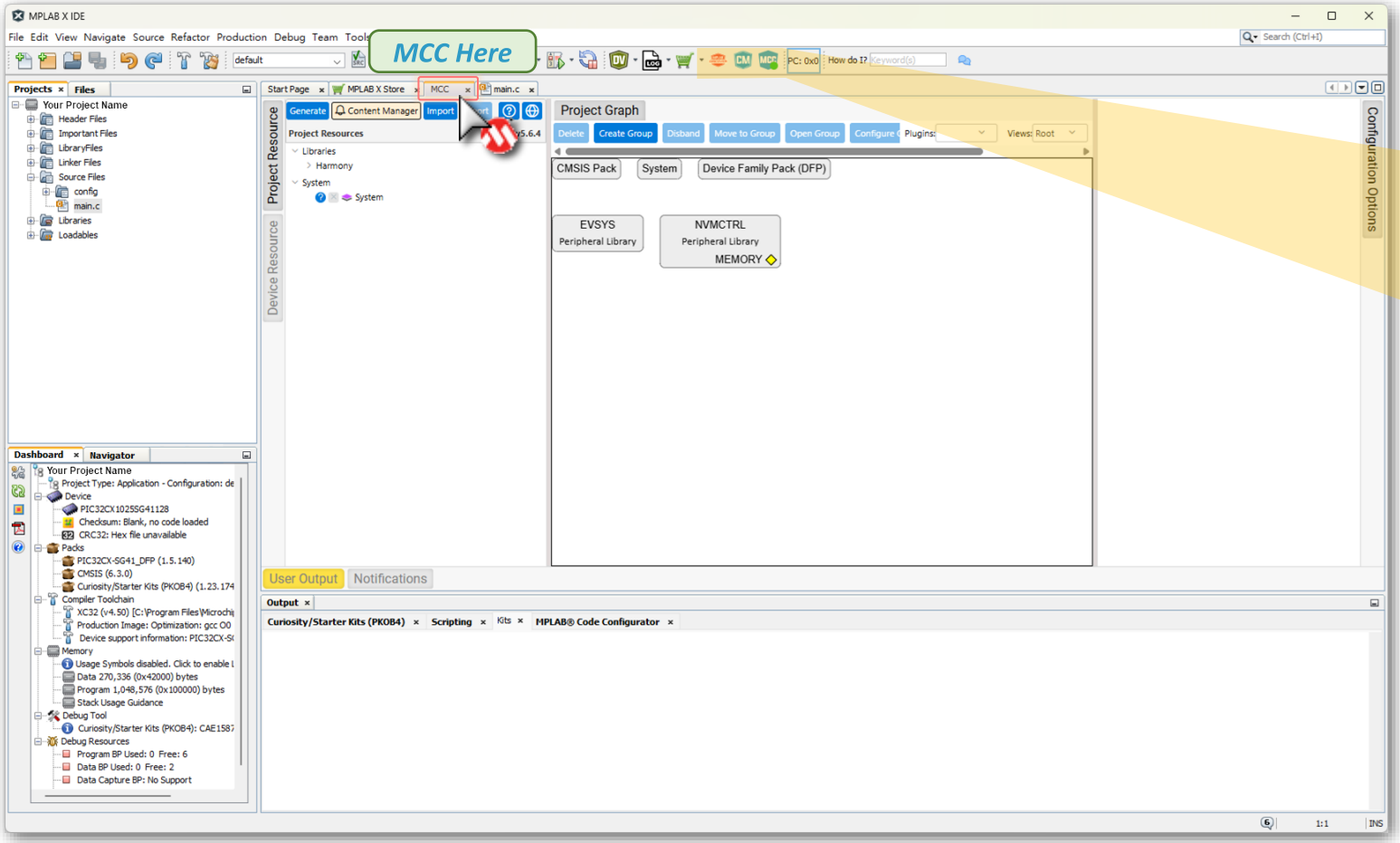
MPLAB® Code Configurator (MCC)

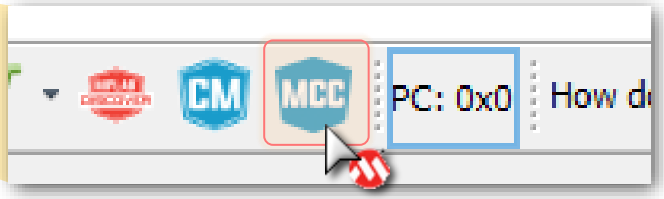
Harmony Interface Introduction

MICROCHIP

MCC Harmony Interface

- Let's take a brief look at the MCC Harmony Configurator interface.
- **Notice !** If you close MCC already , please click the MCC icon and reopen MCC.





Click on MCC only when it is not started

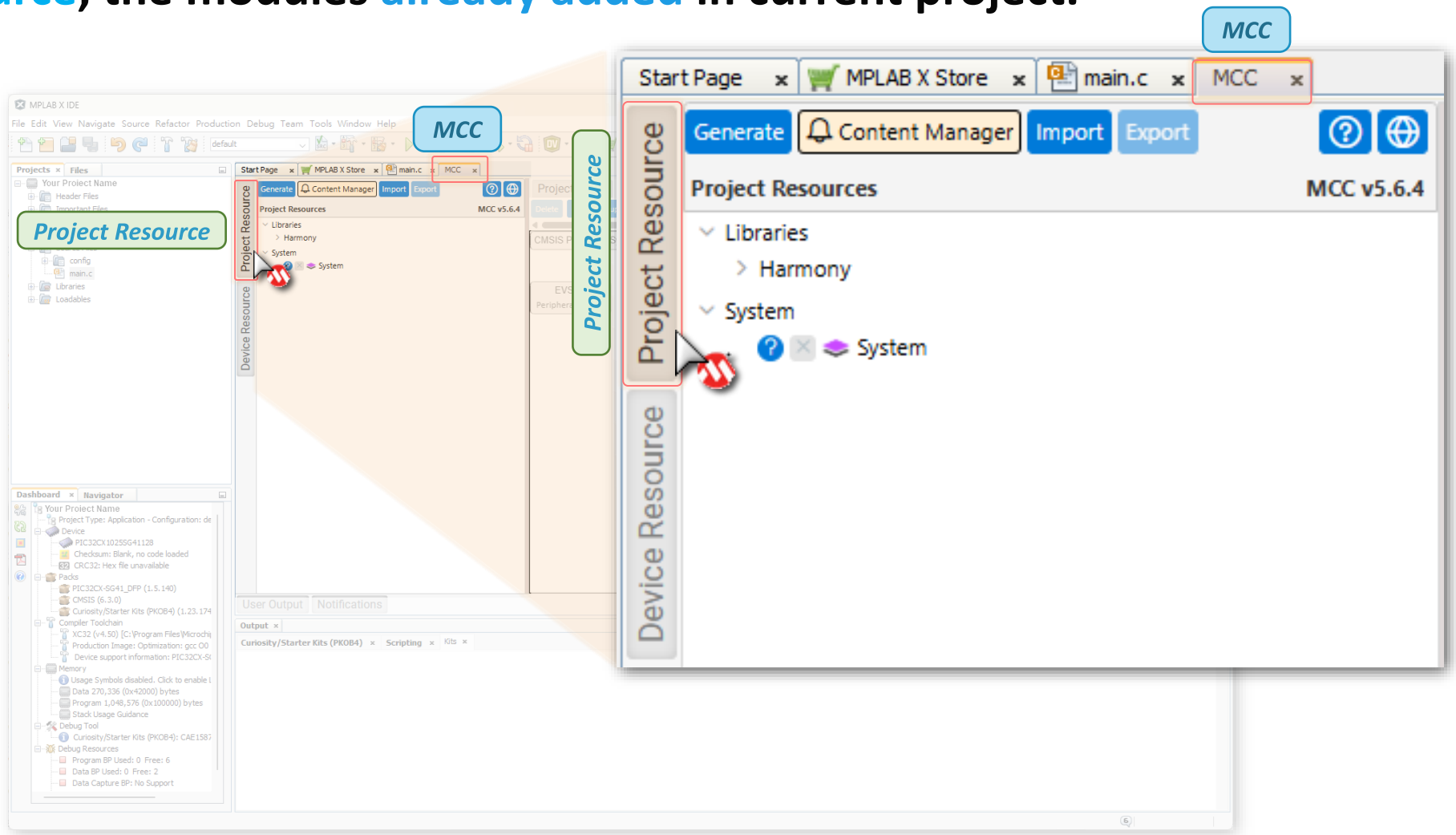
MCC started

Not Started

MICROCHIP

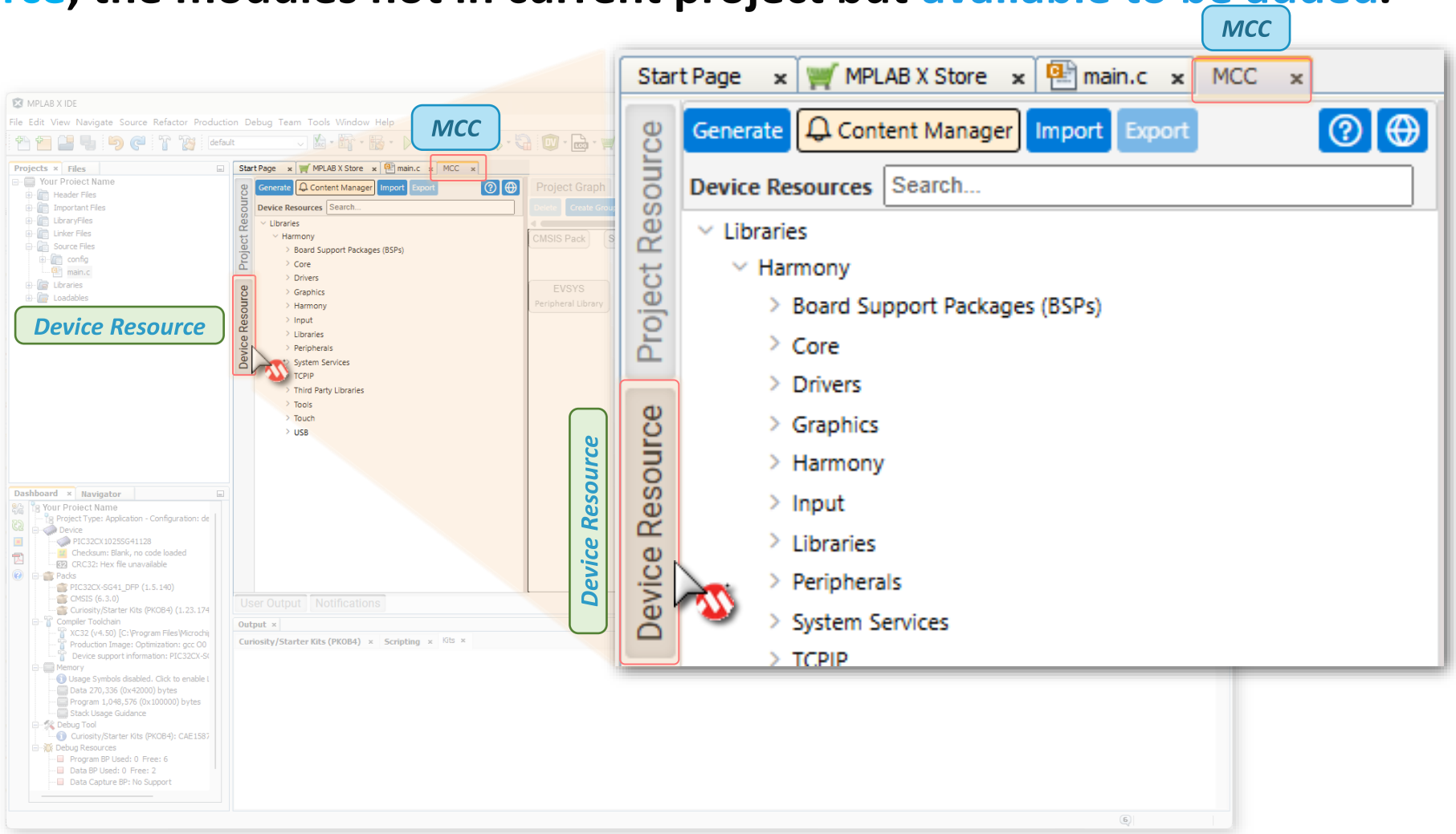
MCC Harmony Interface

- **Project Resource**, the modules **already added** in current project.



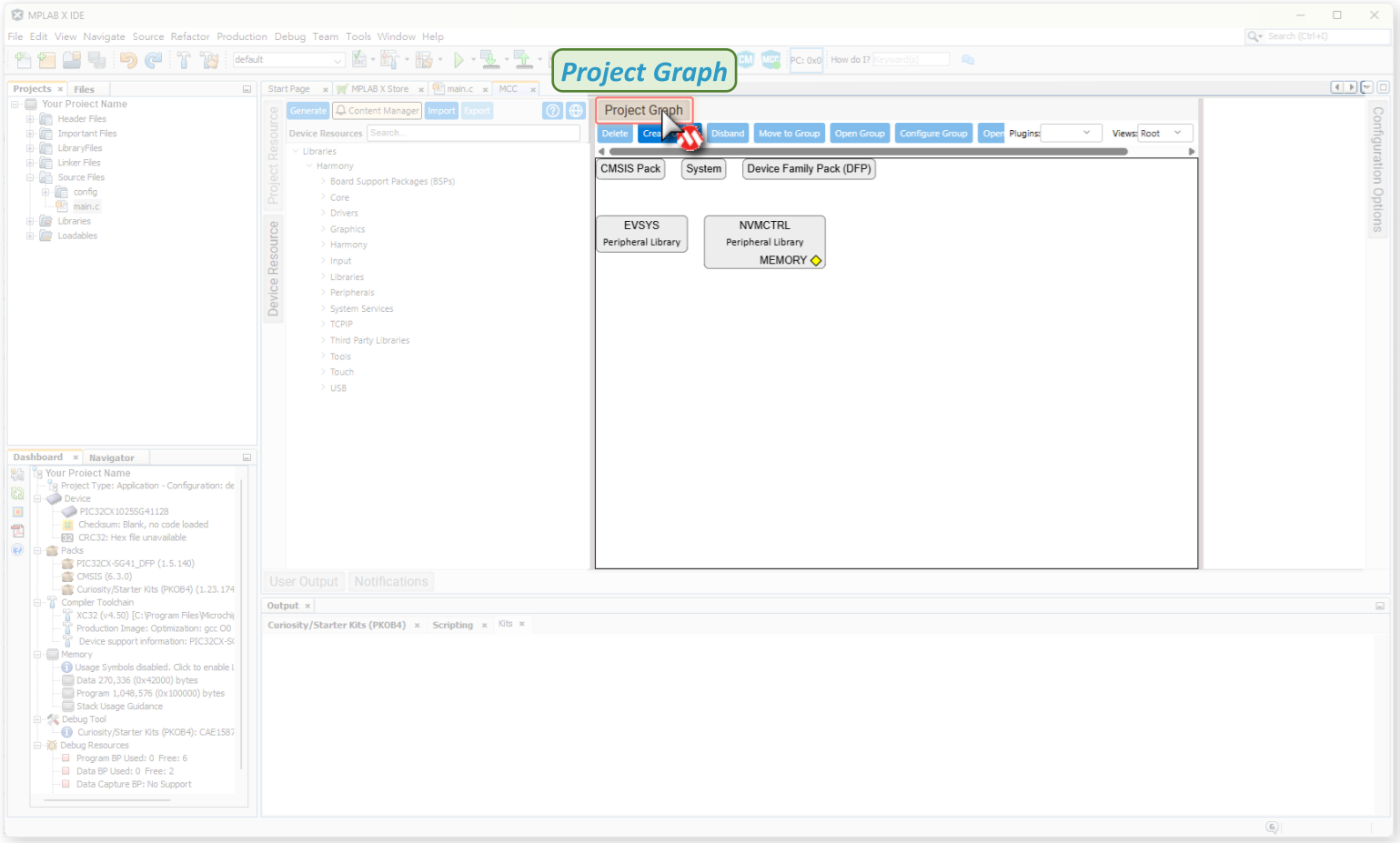
MCC Harmony Interface

- **Device Resource**, the modules not in current project but **available to be added**.



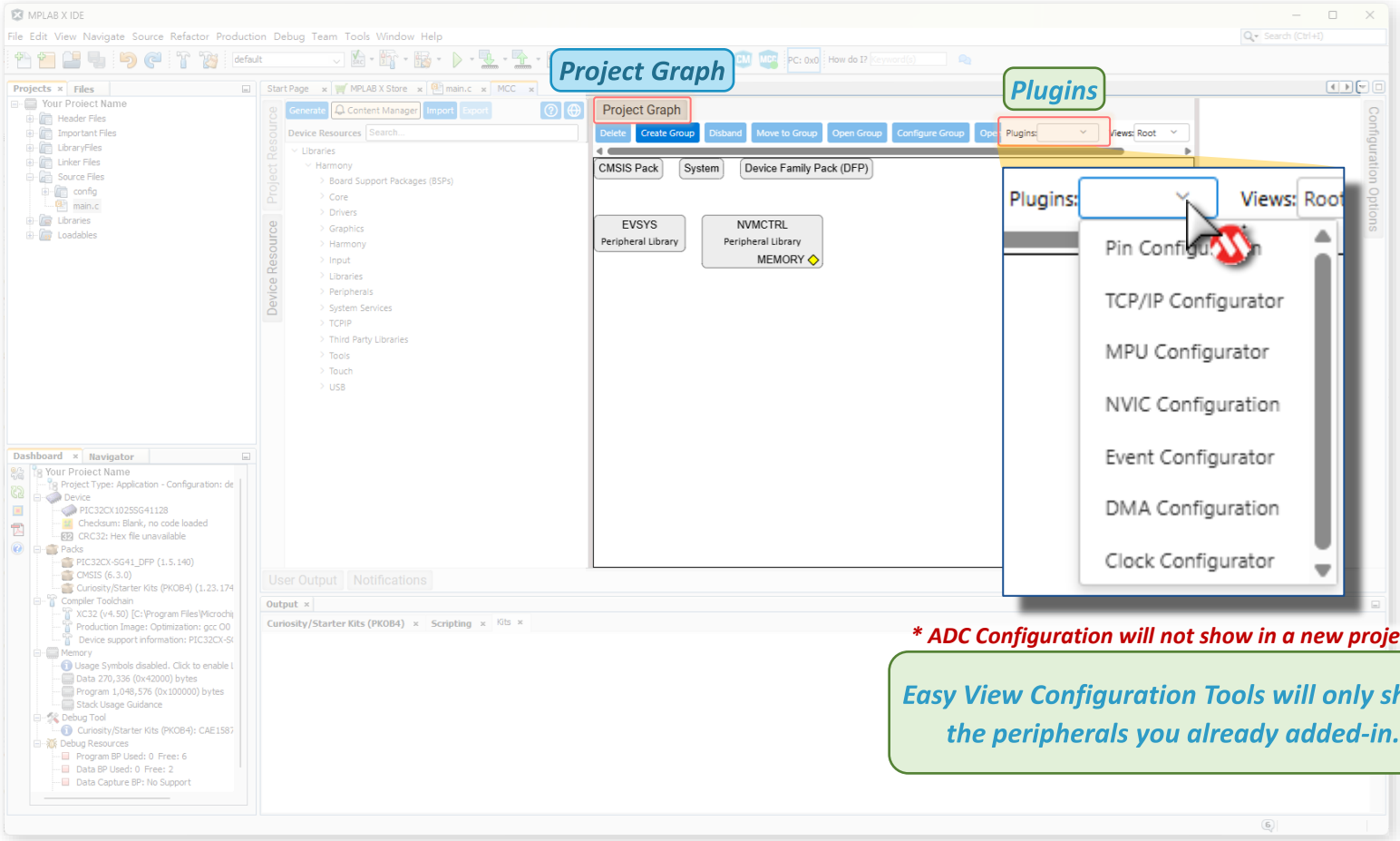
MCC Harmony Interface

- **Project Graph**, the connection diagram between modules.



MCC Harmony Interface

- **Project Graph → Plugins, the Easy View Configuration of modules.**

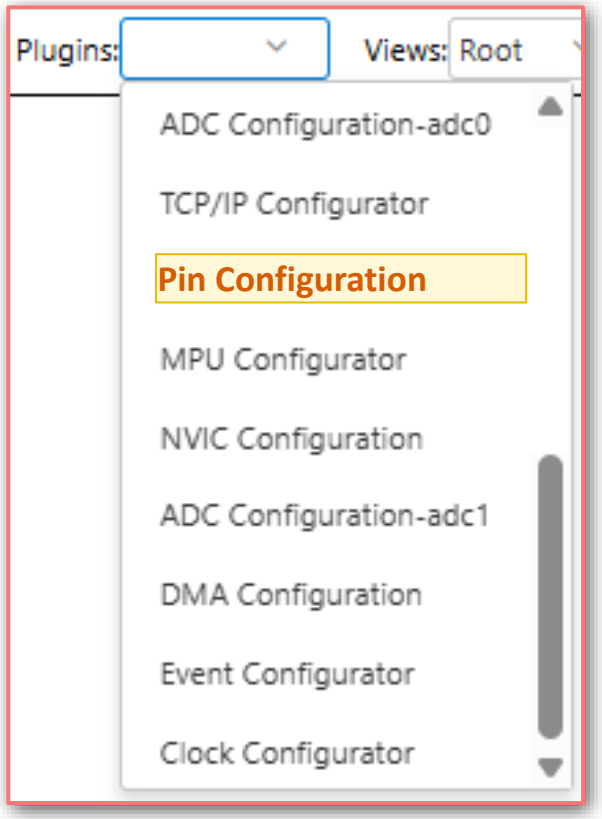


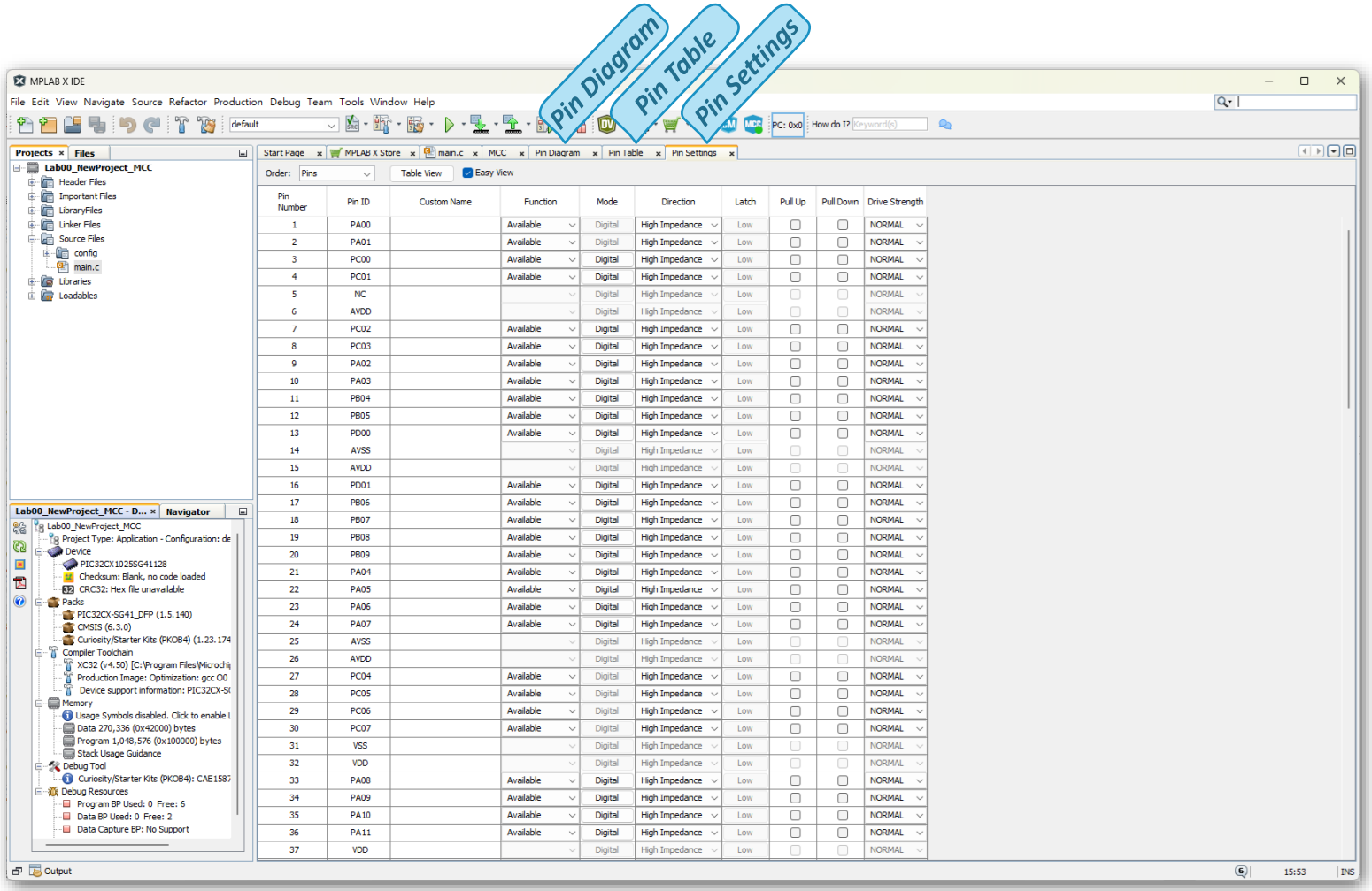
** ADC Configuration will not show in a new project*

Easy View Configuration Tools will only show the peripherals you already added-in.

MCC Harmony Interface

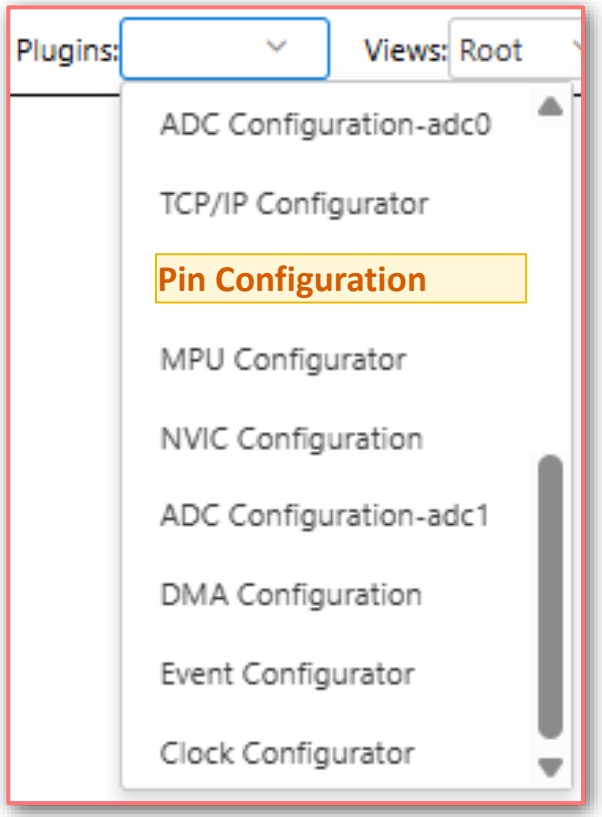
- **Project Graph → Plugins : Pin Configuration**

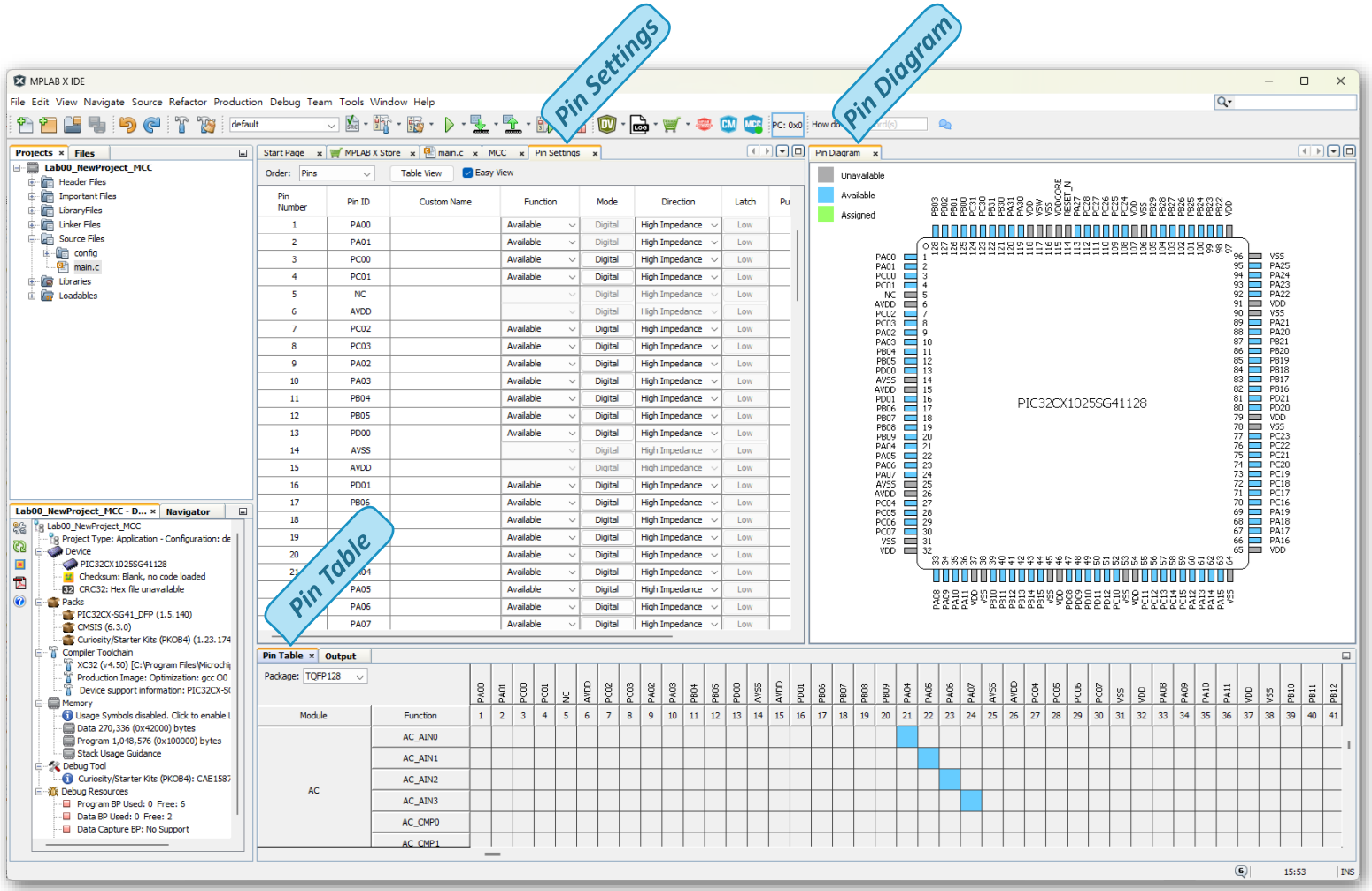




MCC Harmony Interface

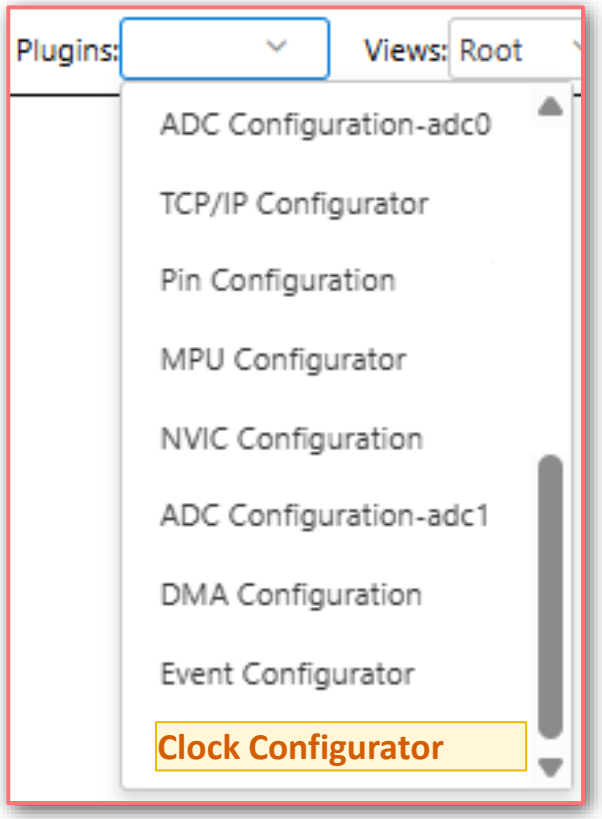
- **Project Graph → Plugins : Pin Configuration (Dock three windows to different locations)**

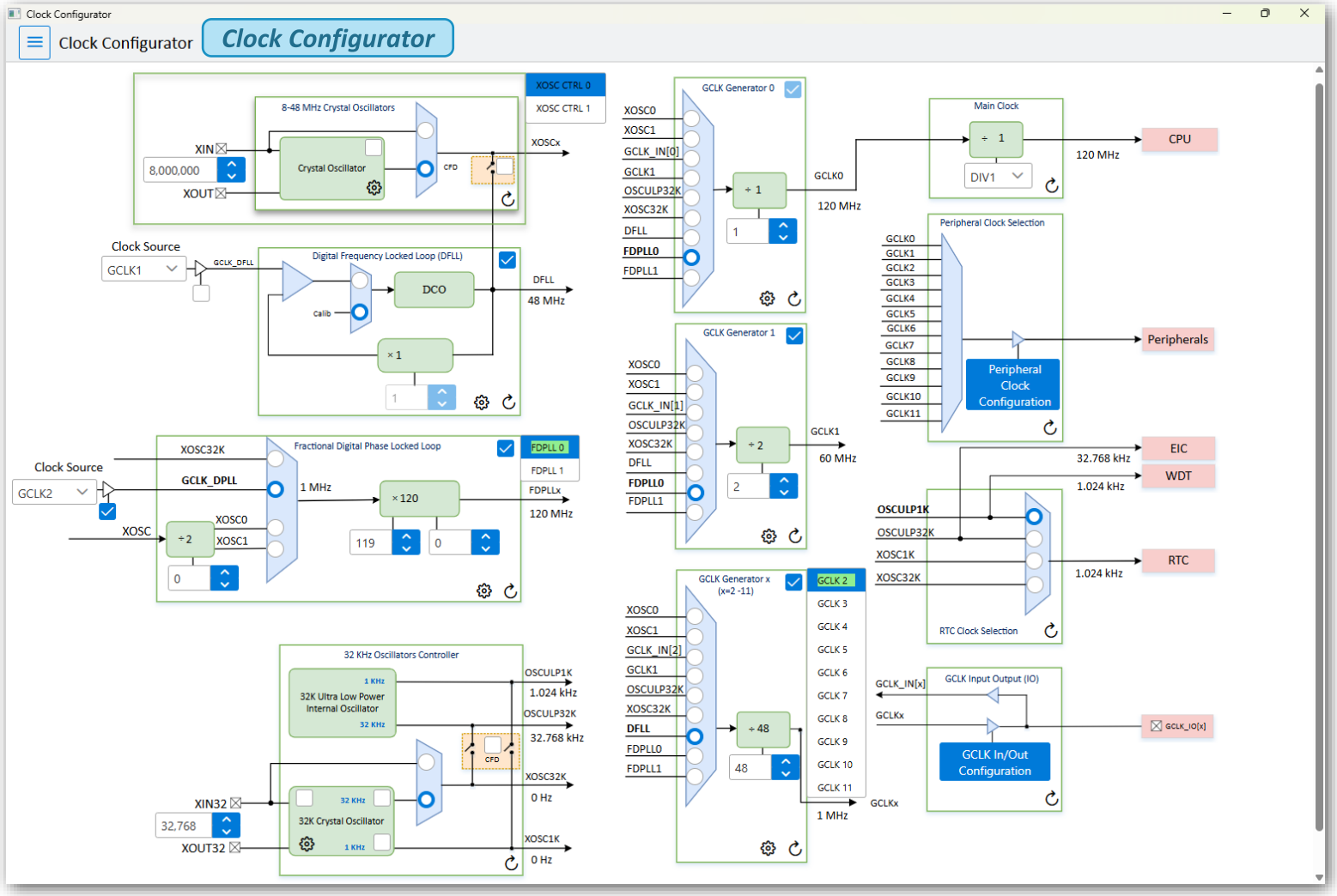




MCC Harmony Interface

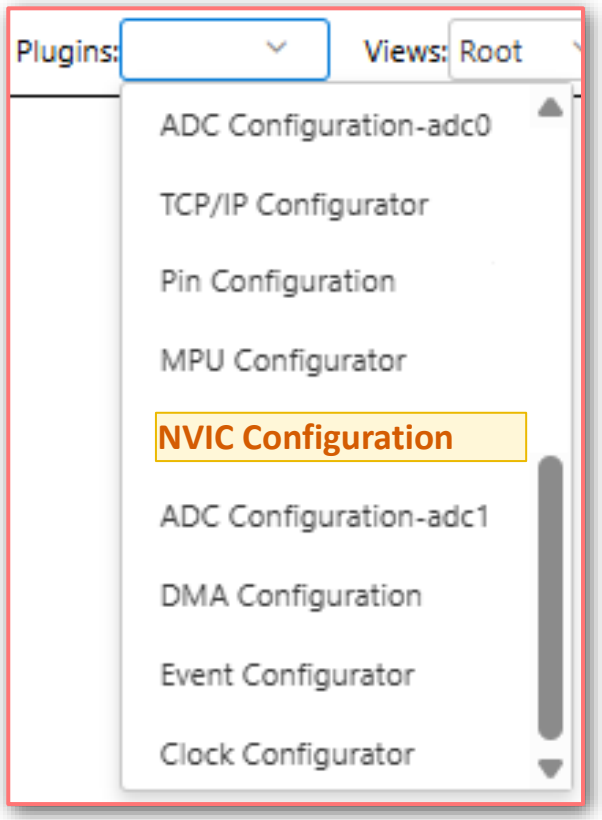
- **Project Graph → Plugins : Clock Configuration**

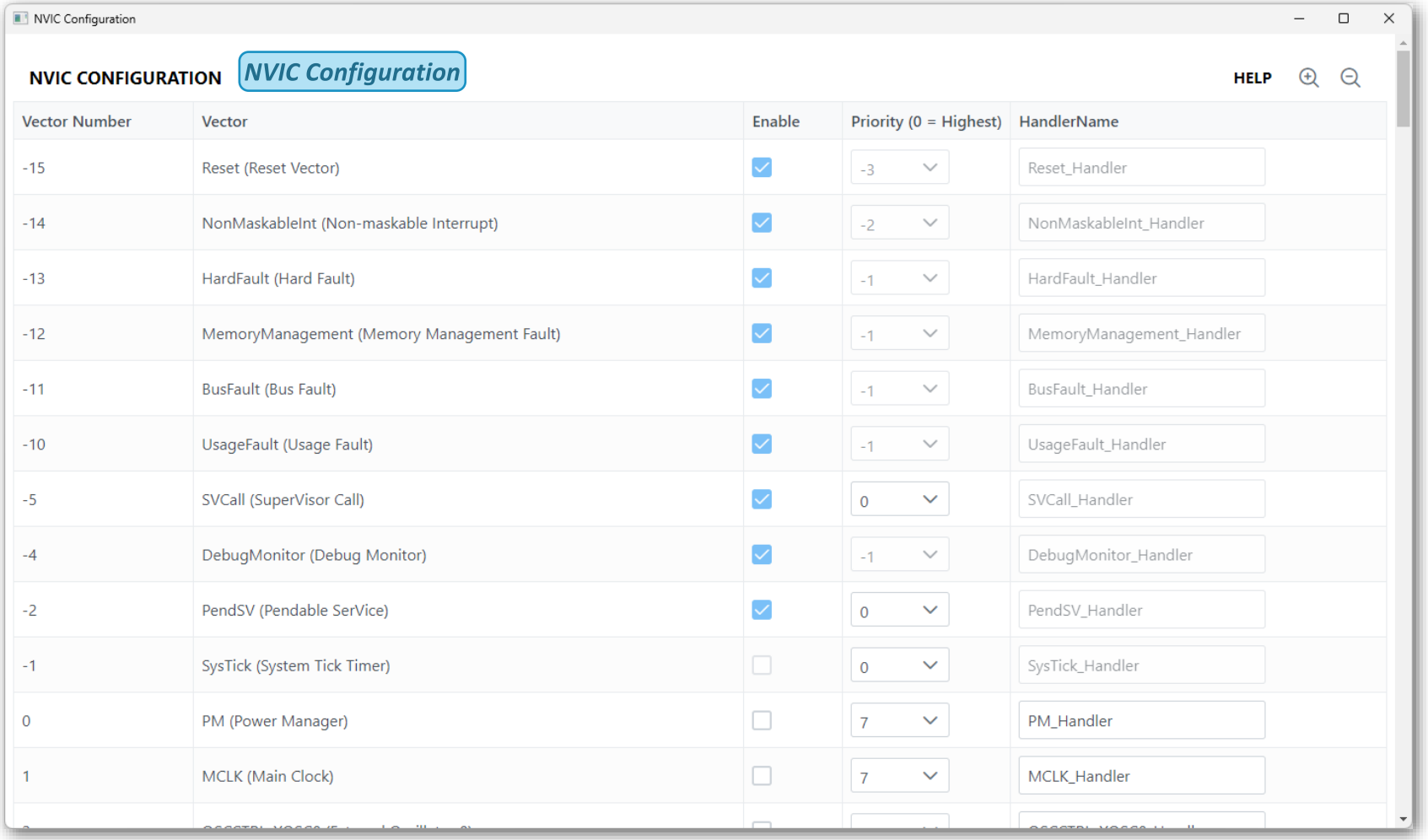




MCC Harmony Interface

- **Project Graph → Plugins : NVIC Configuration (Open a new window after clicked)**



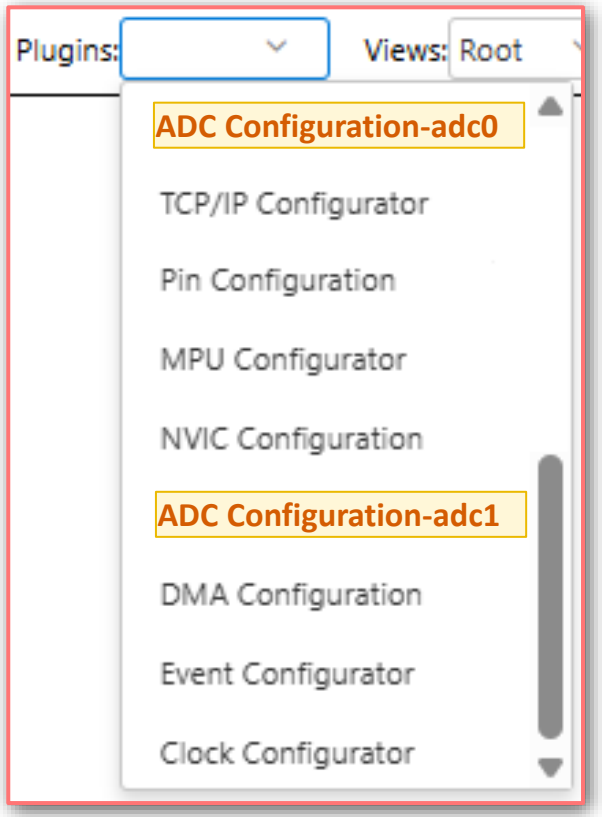


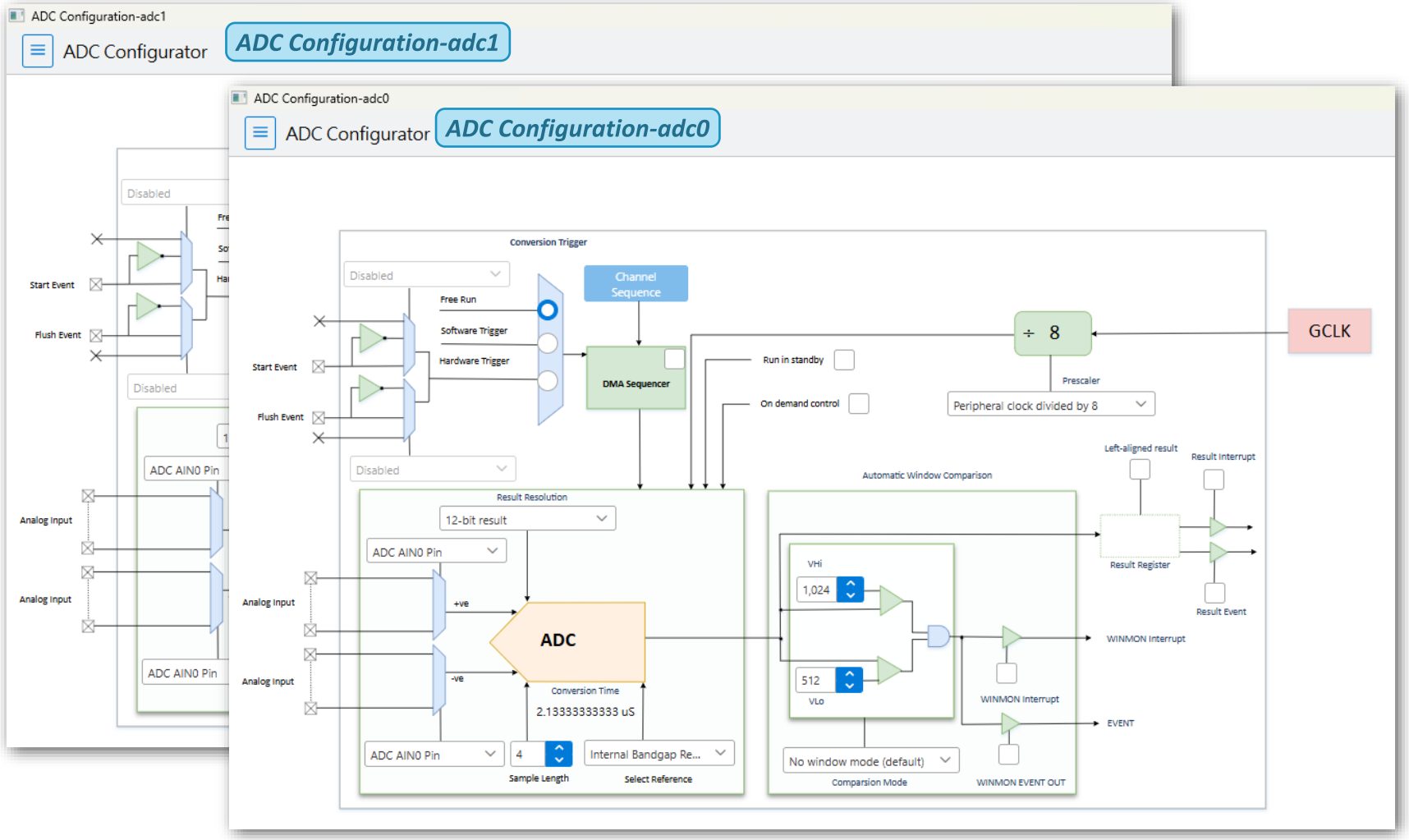
Vector Number	Vector	Enable	Priority (0 = Highest)	HandlerName
-15	Reset (Reset Vector)	☑	-3	Reset_Handler
-14	NonMaskableInt (Non-maskable Interrupt)	☑	-2	NonMaskableInt_Handler
-13	HardFault (Hard Fault)	☑	-1	HardFault_Handler
-12	MemoryManagement (Memory Management Fault)	☑	-1	MemoryManagement_Handler
-11	BusFault (Bus Fault)	☑	-1	BusFault_Handler
-10	UsageFault (Usage Fault)	☑	-1	UsageFault_Handler
-5	SVCall (SuperVisor Call)	☑	0	SVCall_Handler
-4	DebugMonitor (Debug Monitor)	☑	-1	DebugMonitor_Handler
-2	PendSV (Pendable SerVice)	☑	0	PendSV_Handler
-1	SysTick (System Tick Timer)	☐	0	SysTick_Handler
0	PM (Power Manager)	☐	7	PM_Handler
1	MCLK (Main Clock)	☐	7	MCLK_Handler

MCC Harmony Interface

- **Project Graph → Plugins : ADC Configuration (Open a new window after clicked)**

** ADC Configuration will not show in a new project*

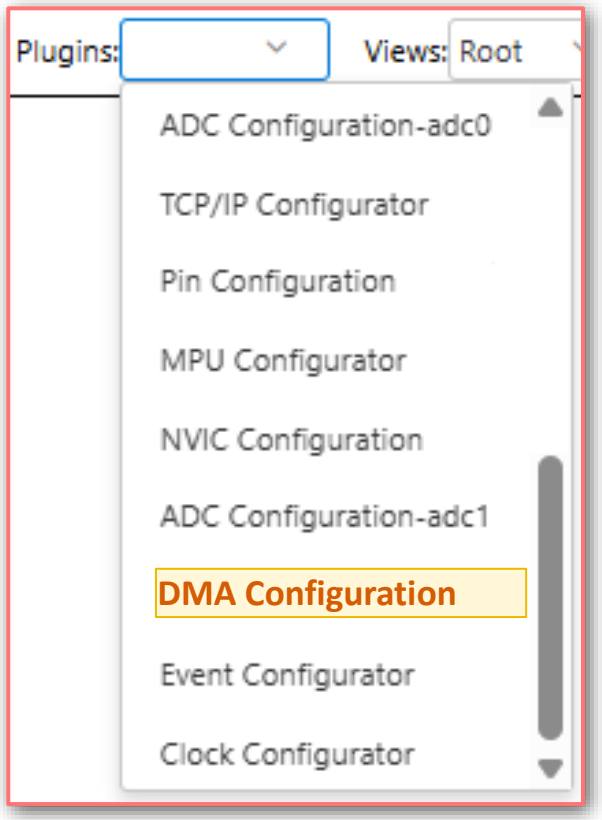




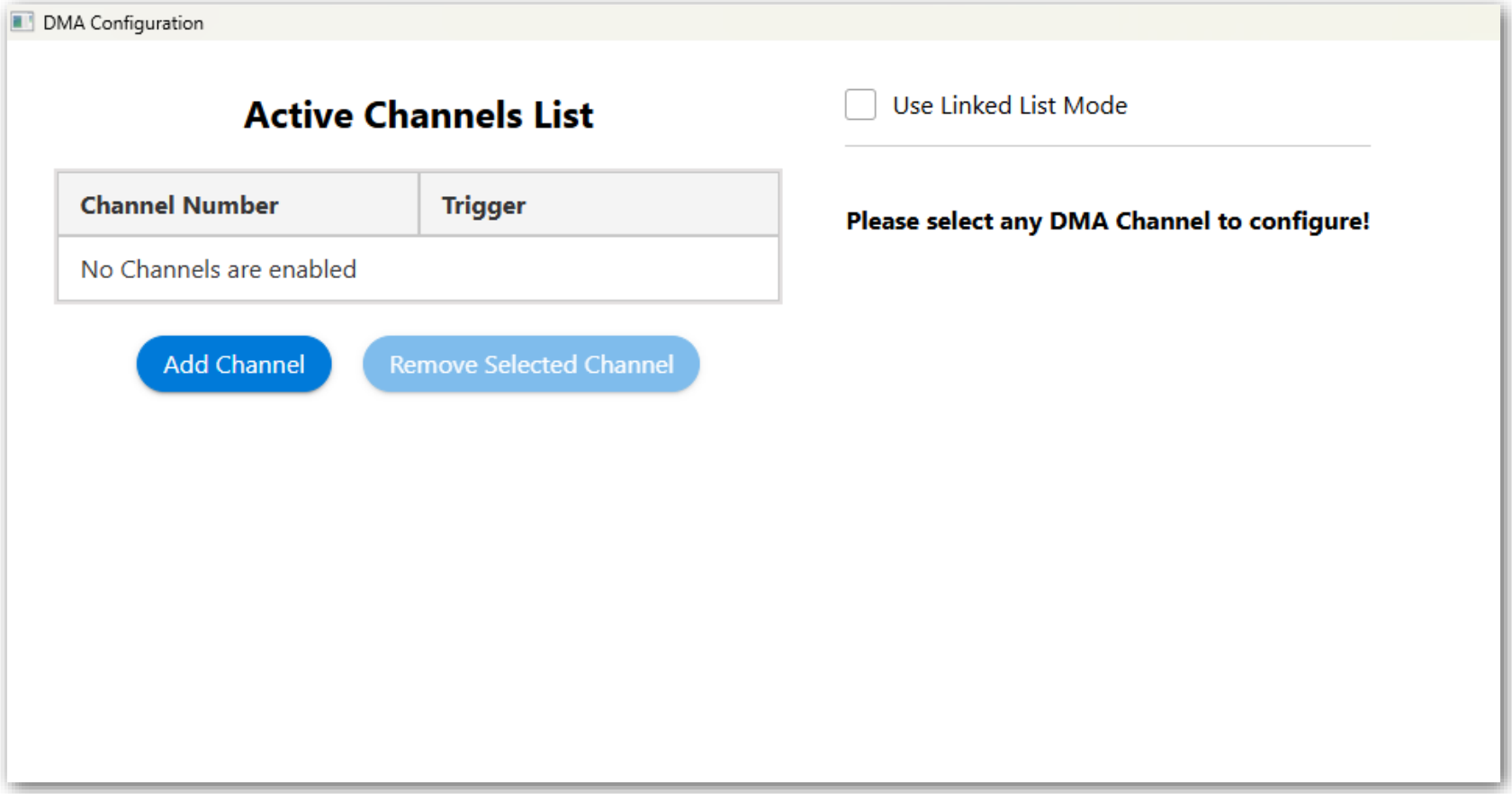
MICROCHIP

MCC Harmony Interface

- **Project Graph → Plugins : DMA Configuration (Open a new window after clicked)**

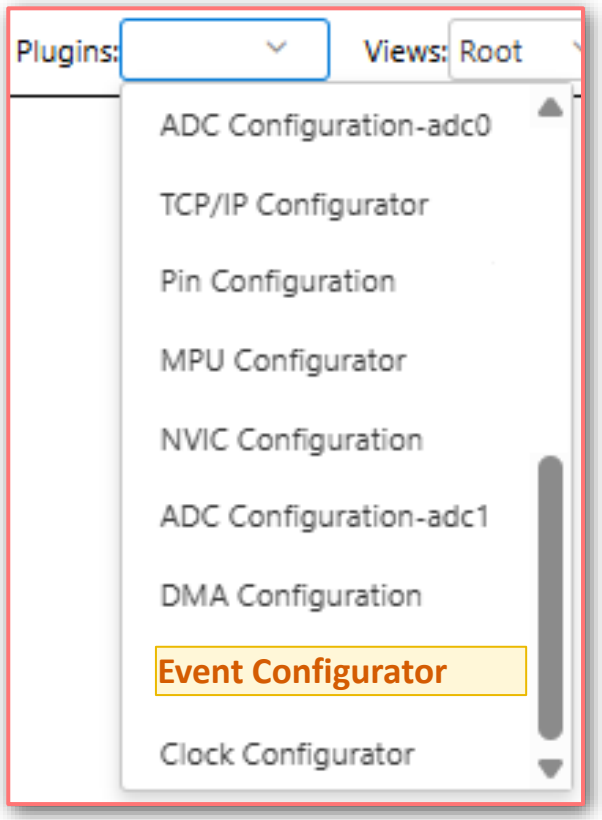


DMA Configuration

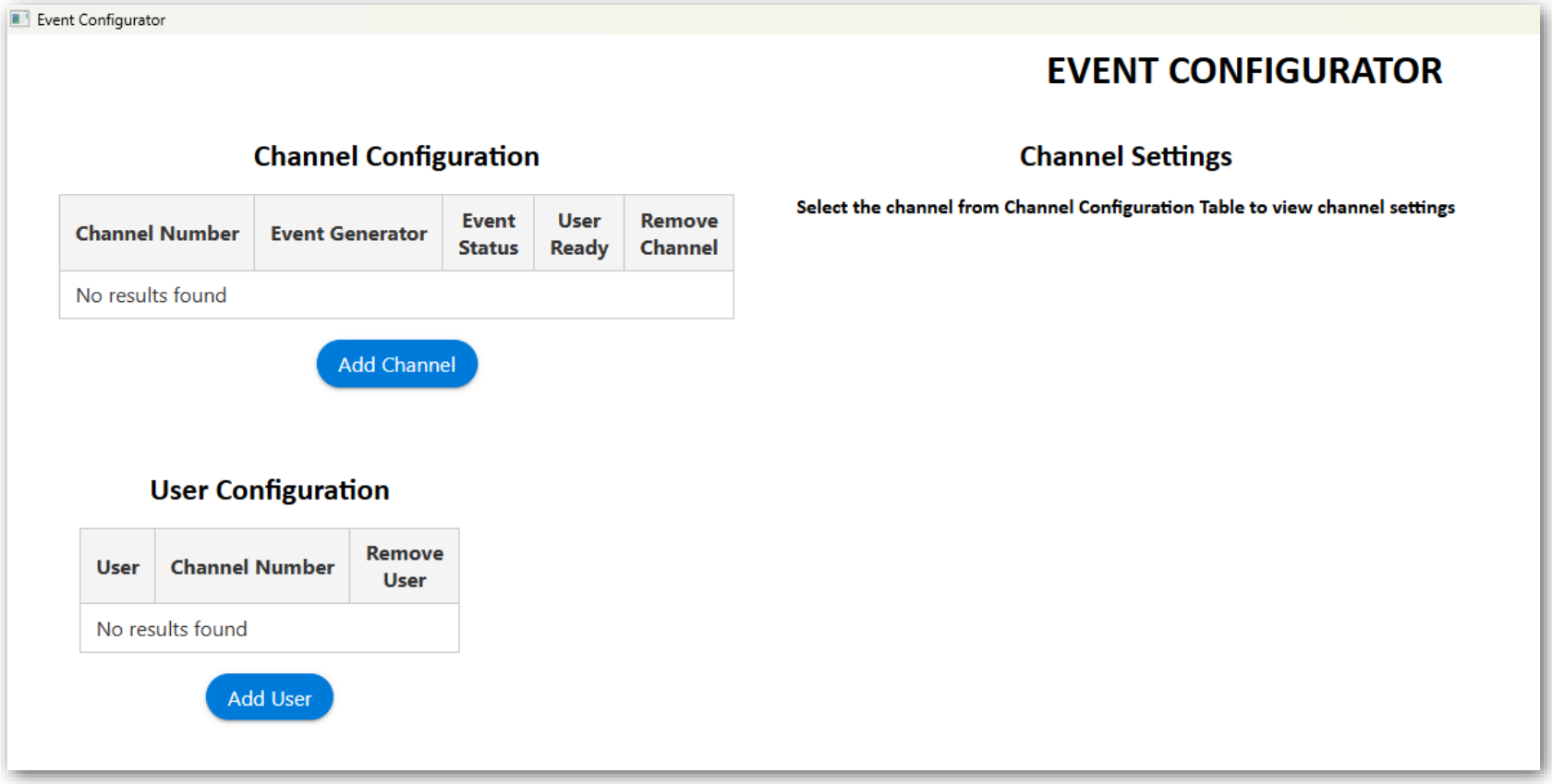


MCC Harmony Interface

- **Project Graph → Plugins : Event Configurator (Open a new window after clicked)**

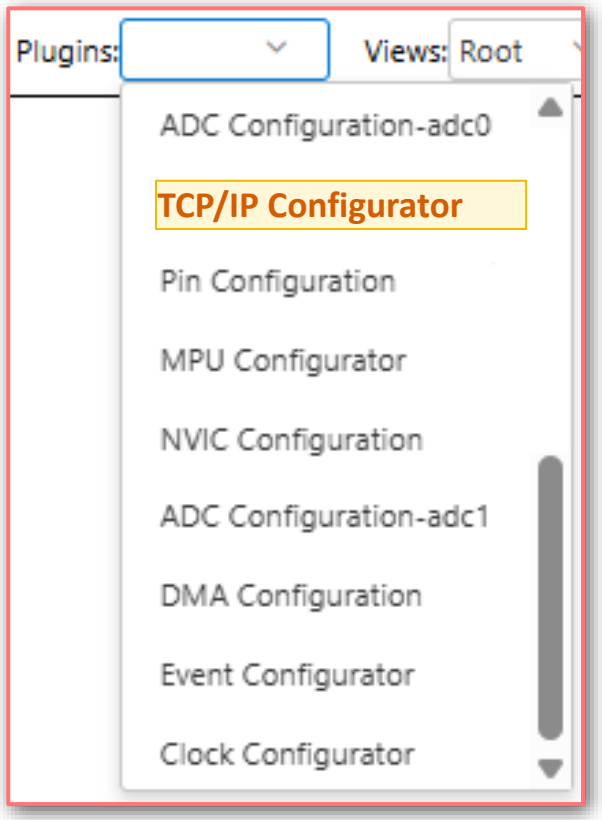


Event Configurator

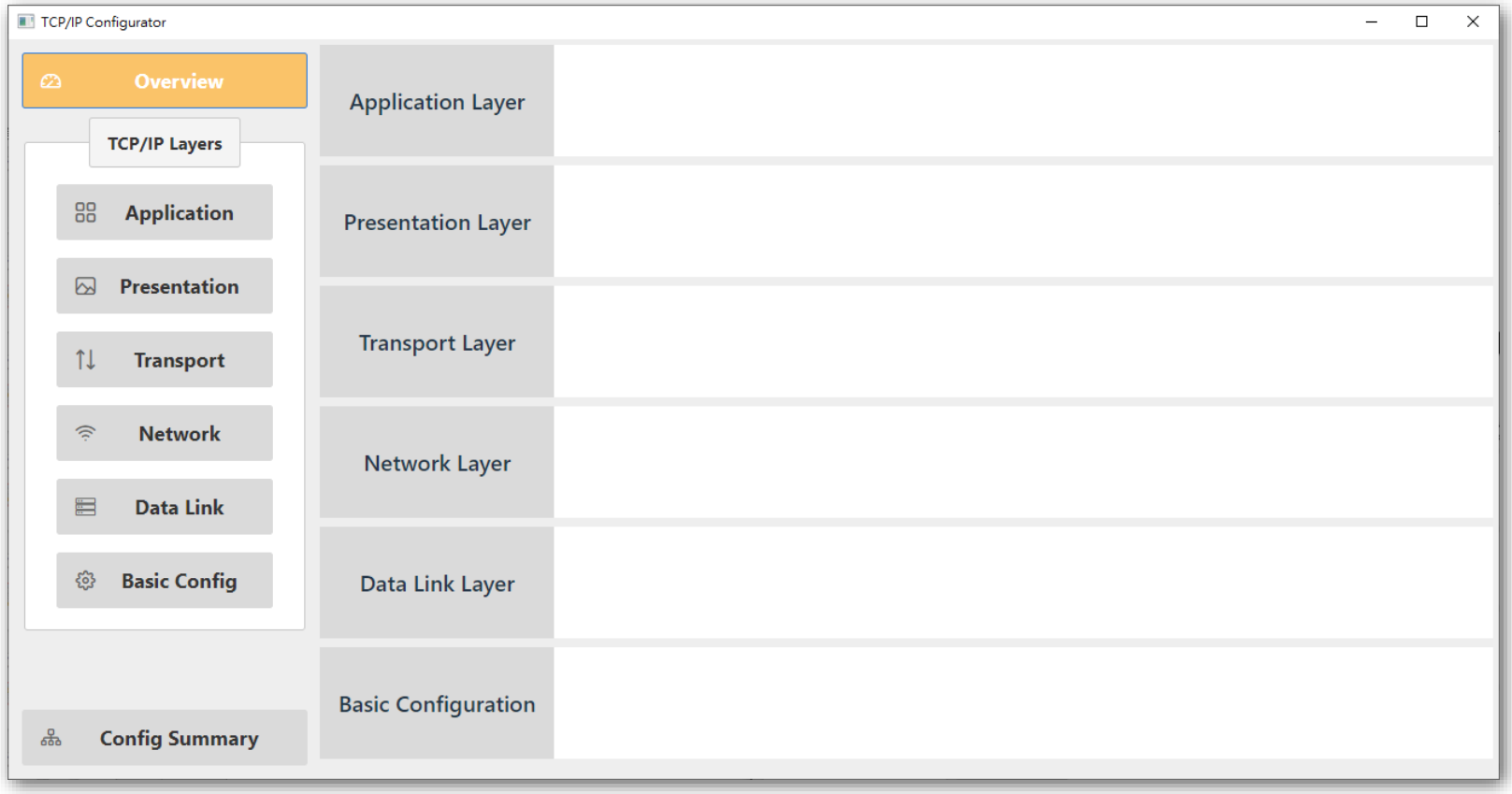


MCC Harmony Interface

- **Project Graph → Plugins : TCP/IP Configurator (Open a new window after clicked)**



TCP/IP Configurator



MPLAB® Code Configurator (MCC) TCP/IP Configurator

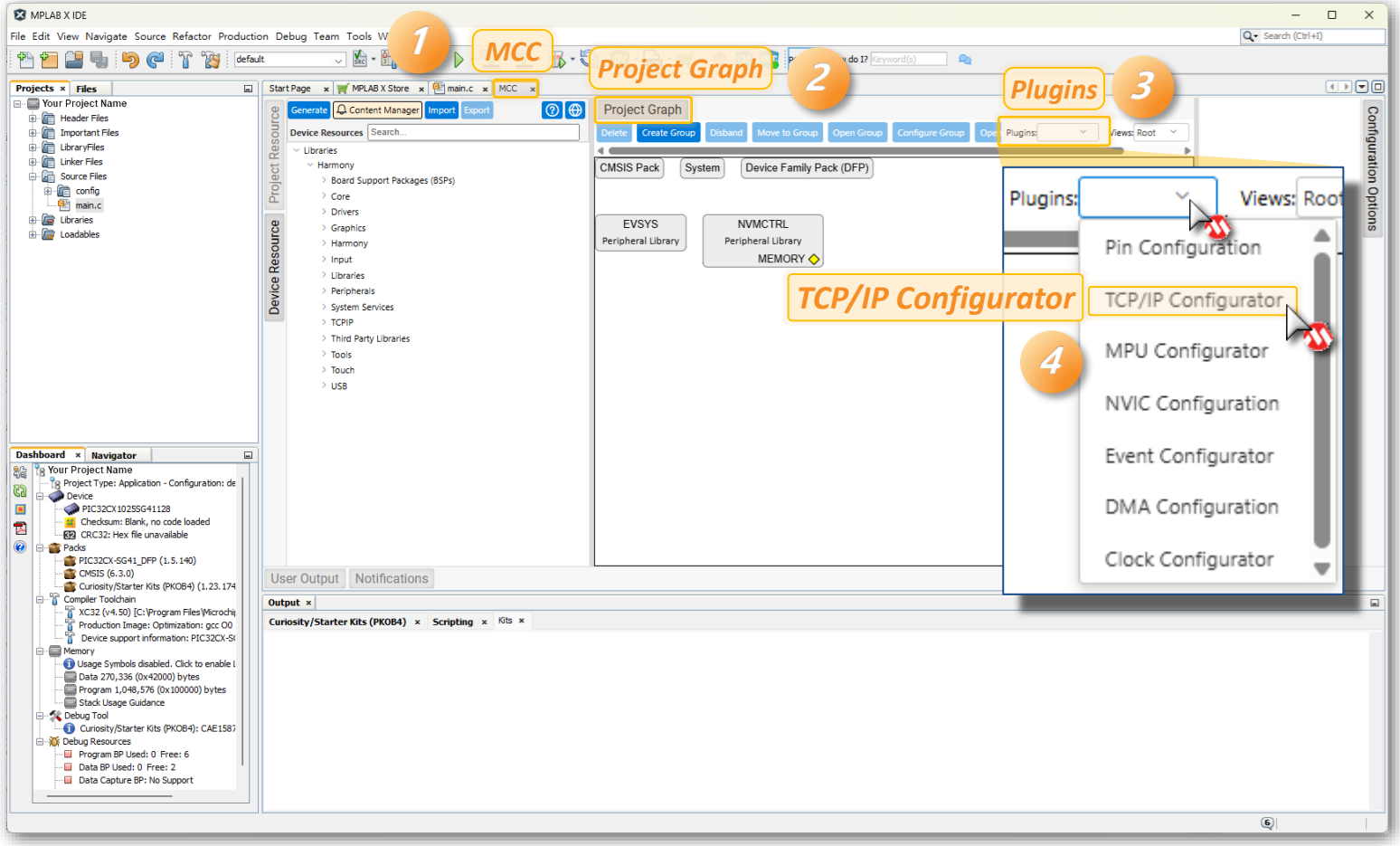
An Easy Configuration Tool for TCP/IP

MICROCHIP

MCC - TCP/IP Configurator

Step 1

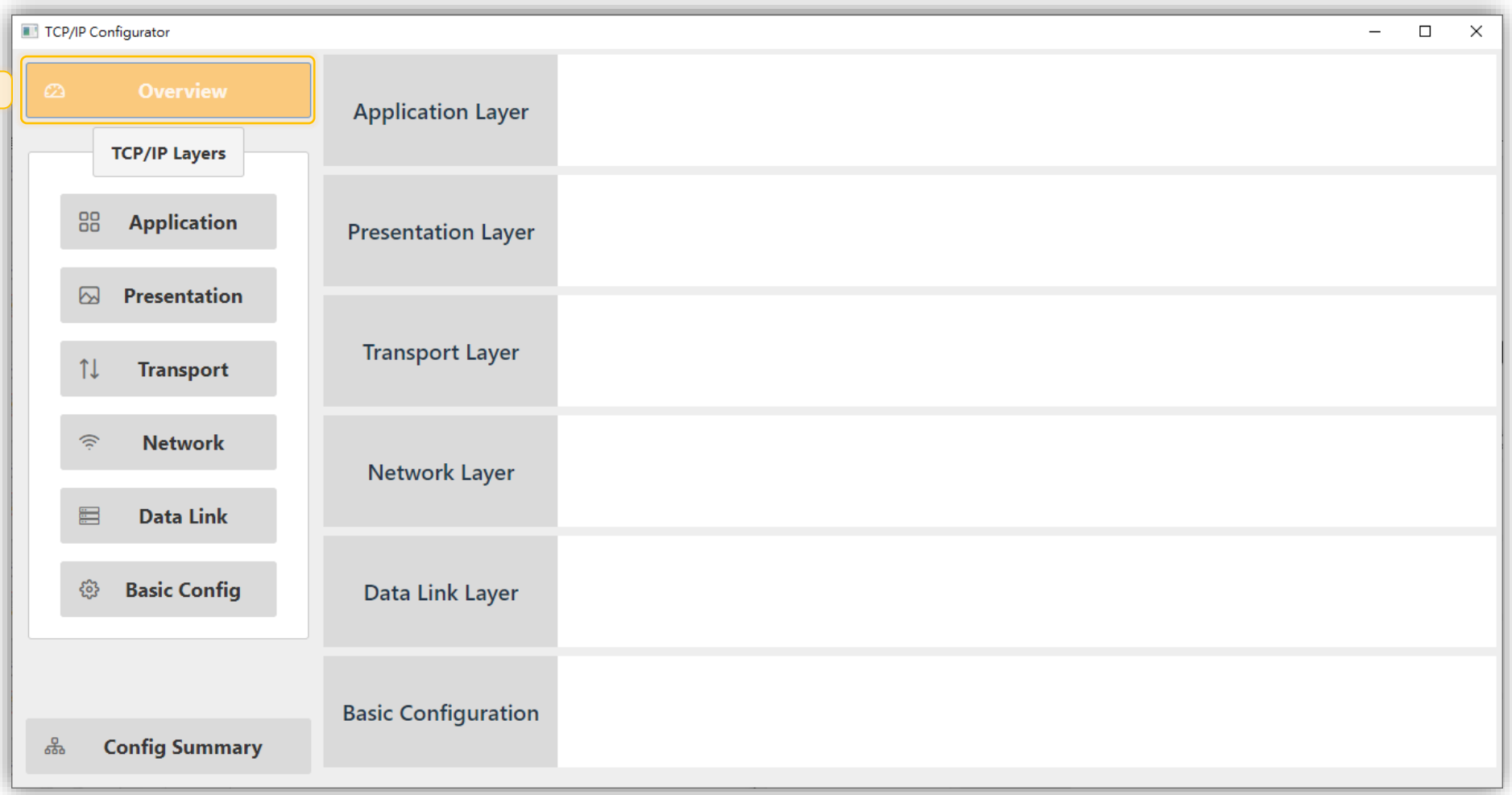
- **Under MCC, click on Project Graph > Plugins > TCP/IP Configurator.**



MCC - TCP/IP Configurator

Step 2

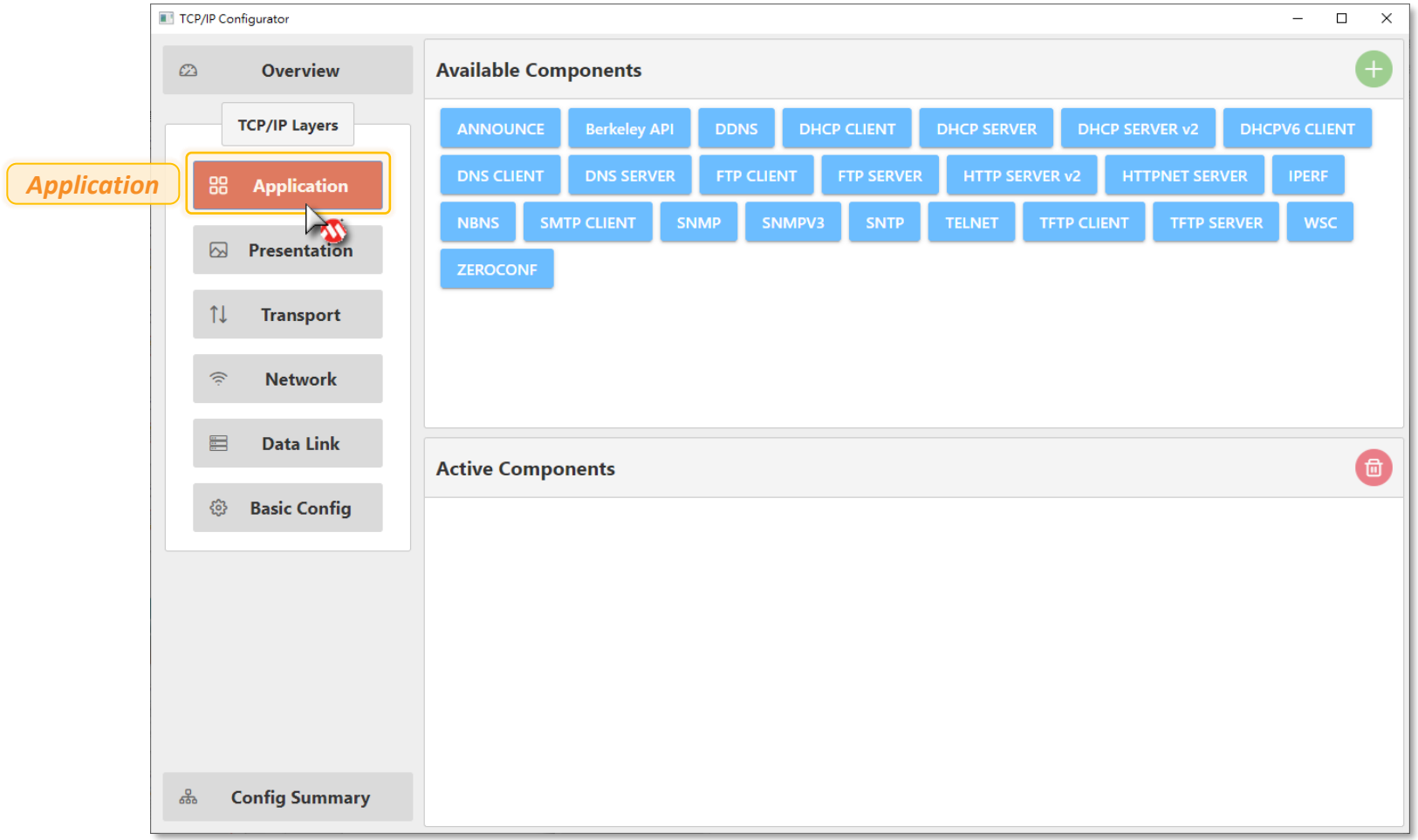
- The TCP/IP Configurator interface appears.



MCC - TCP/IP Configurator

Step 3

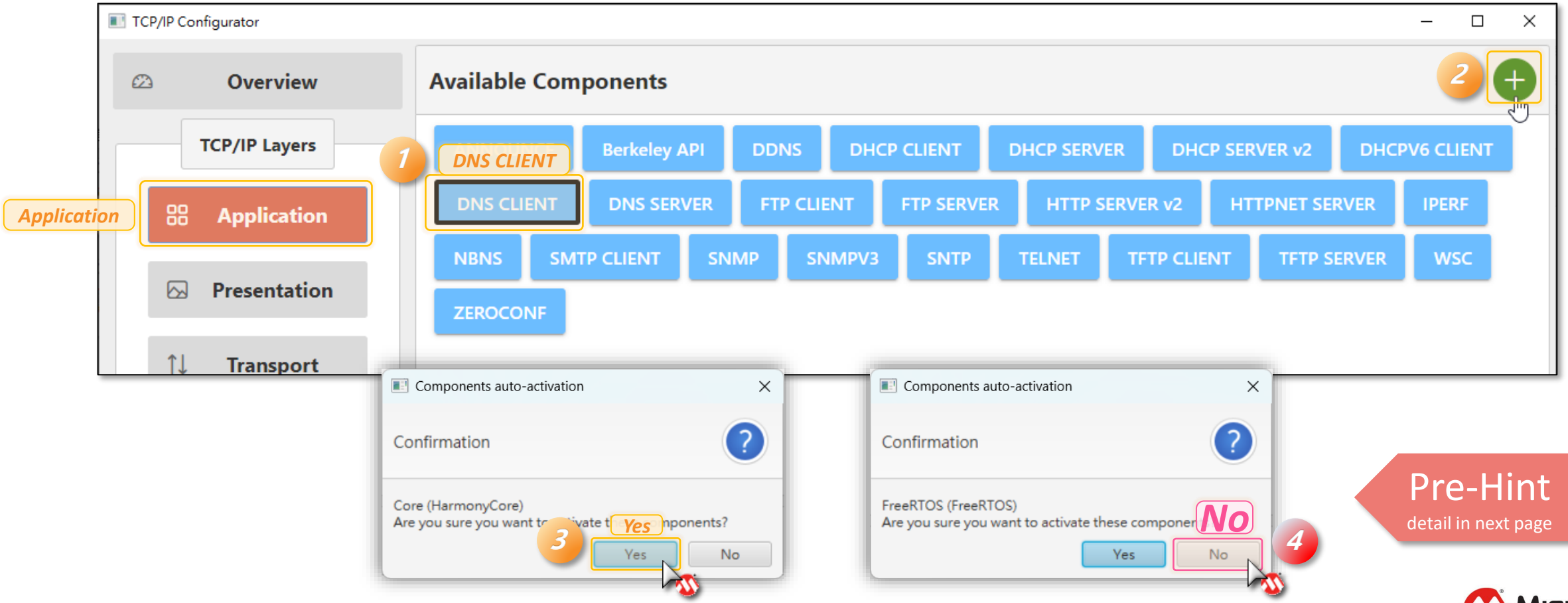
- Click the Application button to select the Application Layer.



MCC - TCP/IP Configurator

Step 4

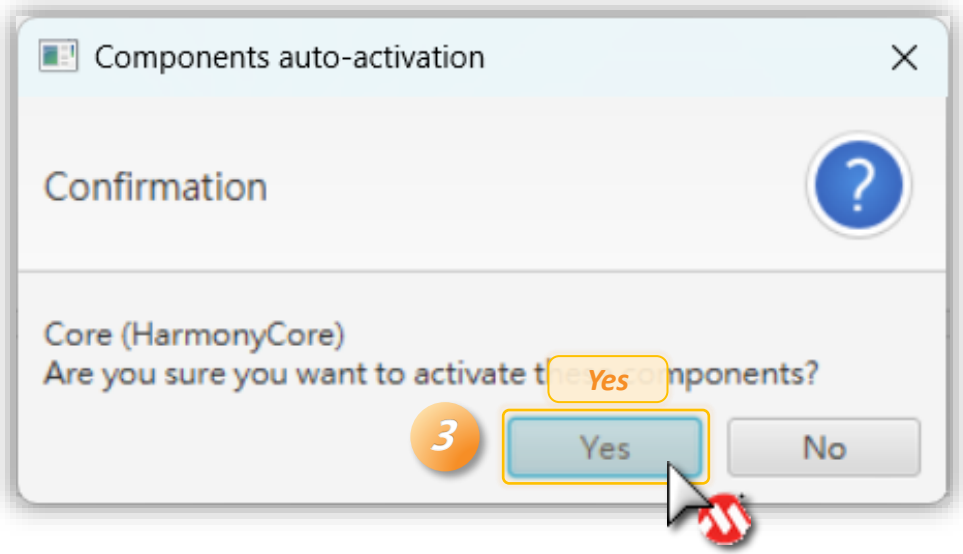
- Select "DNS Client" from the Available Components and click + to add it to the Active Components.

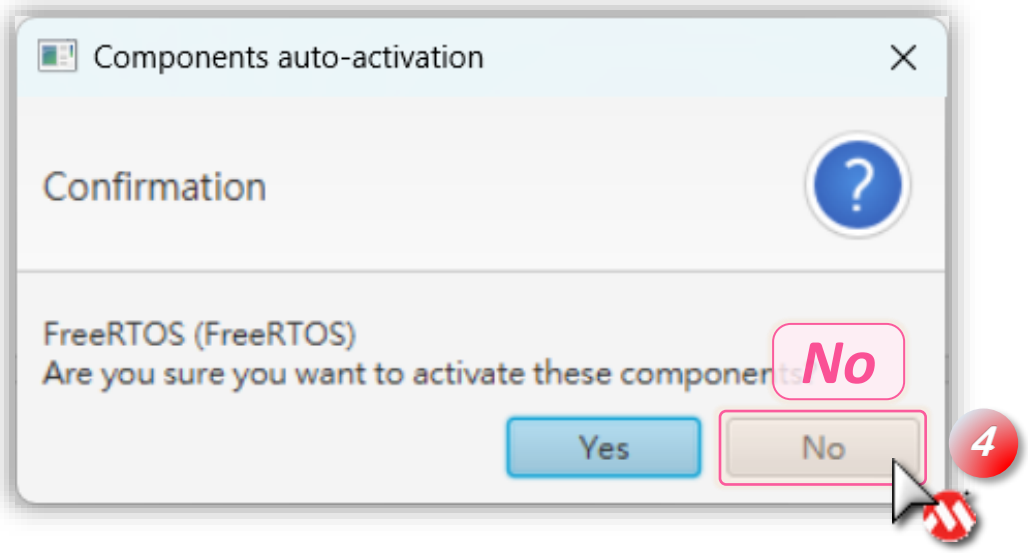


MCC - TCP/IP Configurator

Step 5

- Once you click ⊕, two dialog boxes will pop up.
- Click Yes to add the "Harmony Core" component.
- Click No to not use the "FreeRTOS". (We use bare metal to complete the project)

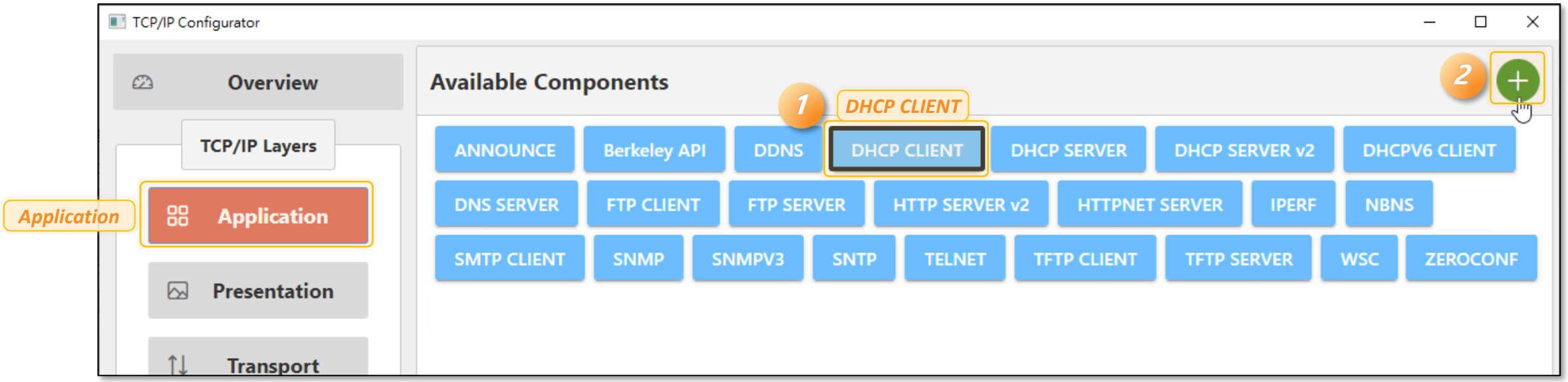




MCC - TCP/IP Configurator

Step 6

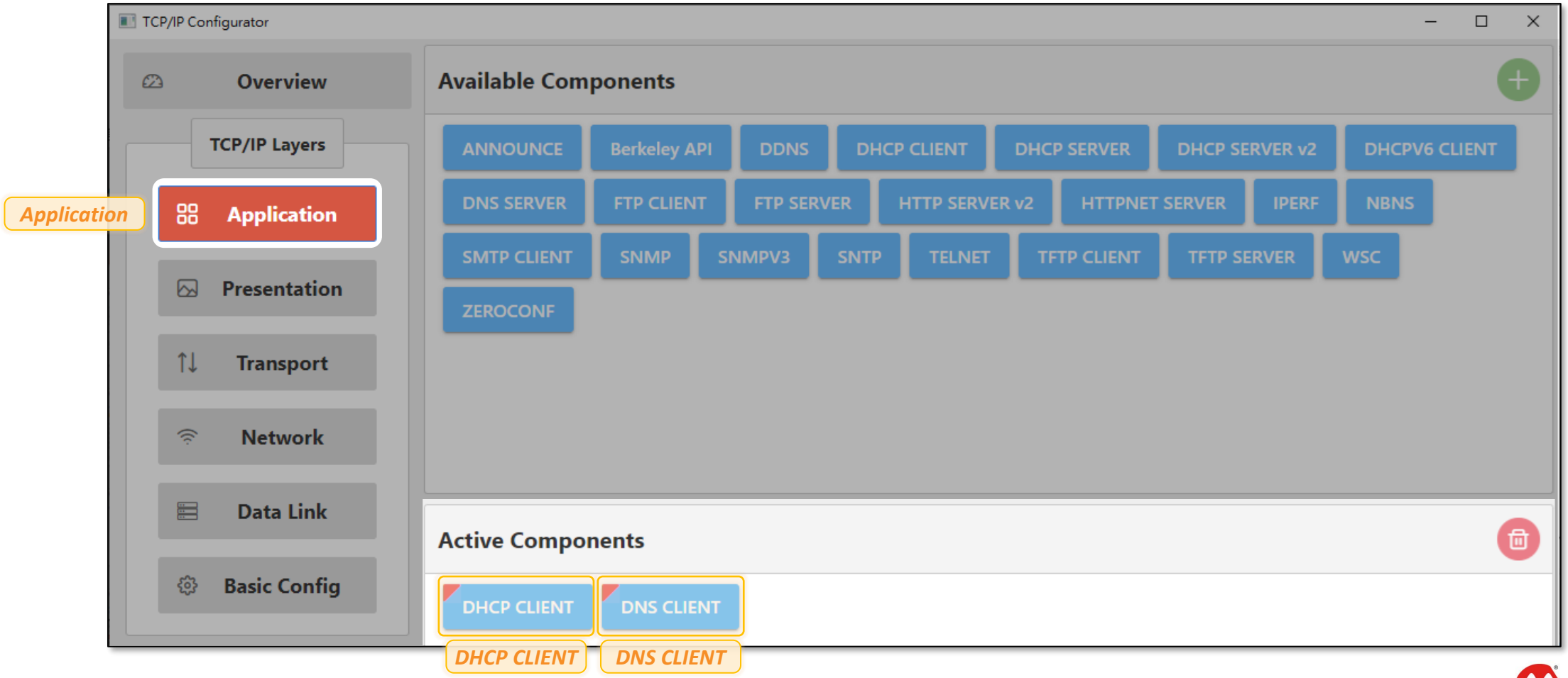
- Select another module "DHCP Client" from the Available Components and click + to add it to the Active Components.



MCC - TCP/IP Configurator

Step 7 – Result Check

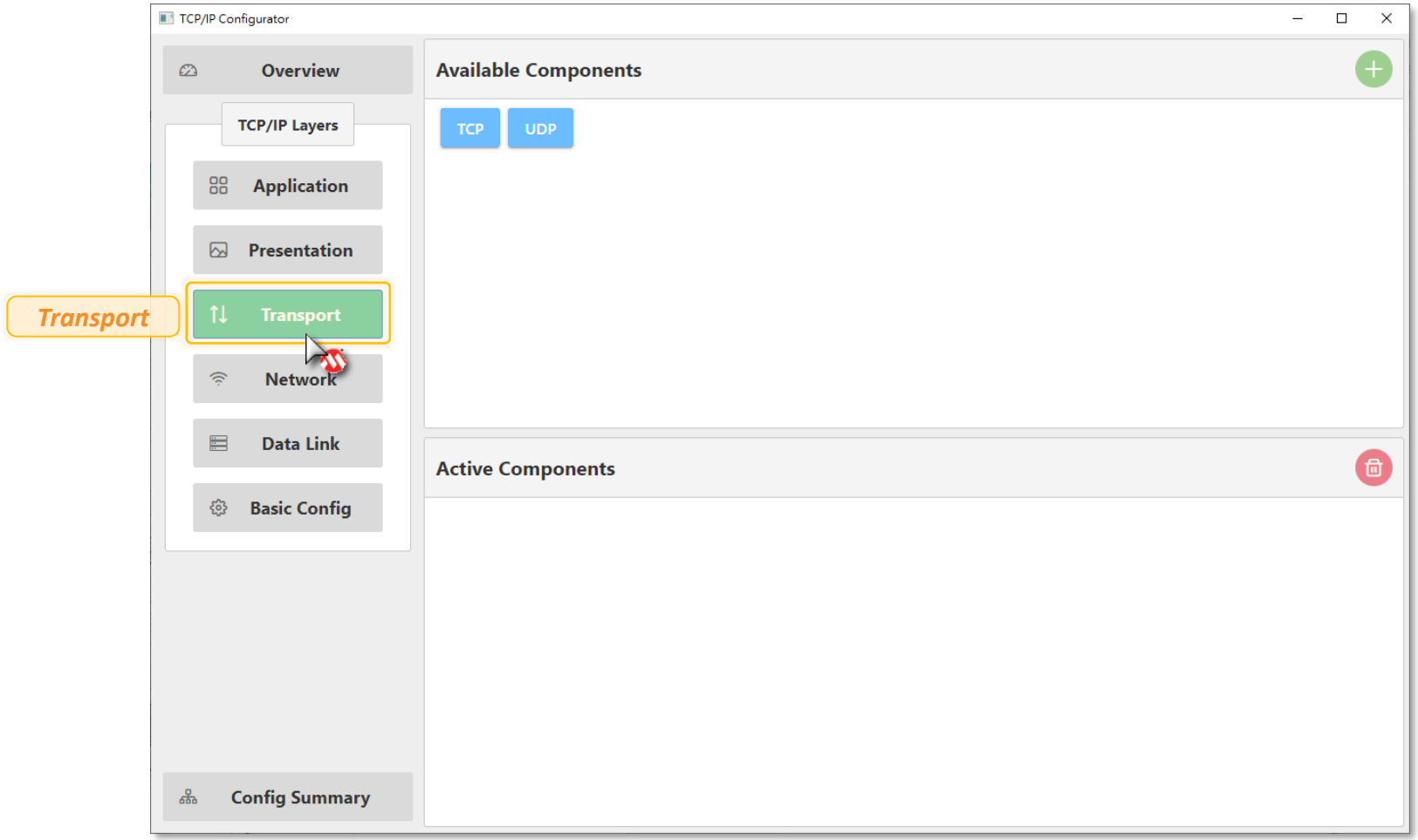
- The "DHCP Client" and "DNS Client" will be added to the Active Components.



MCC - TCP/IP Configurator

Step 8

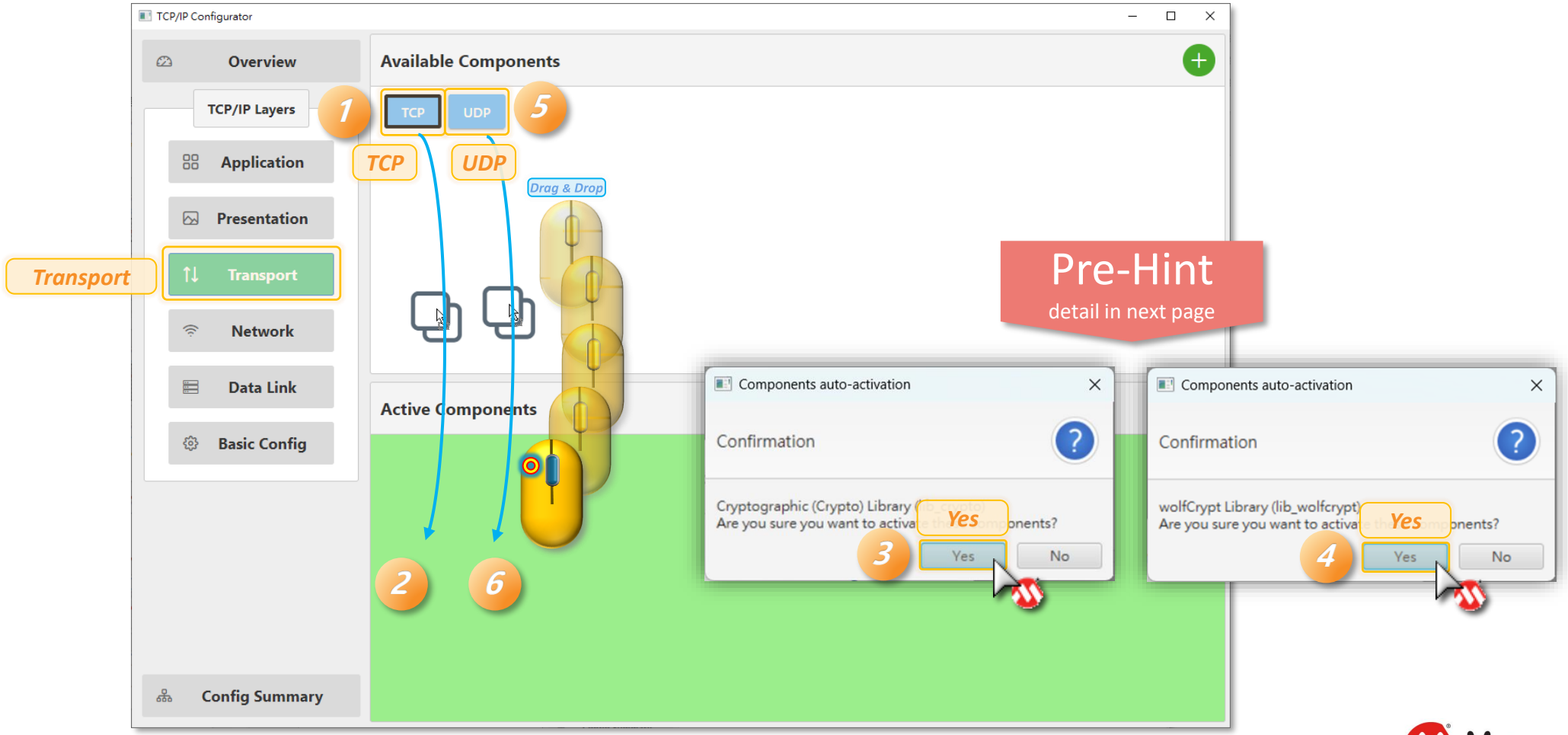
- Click the Transport button to select the Transport Layer.



MCC - TCP/IP Configurator

Step 9

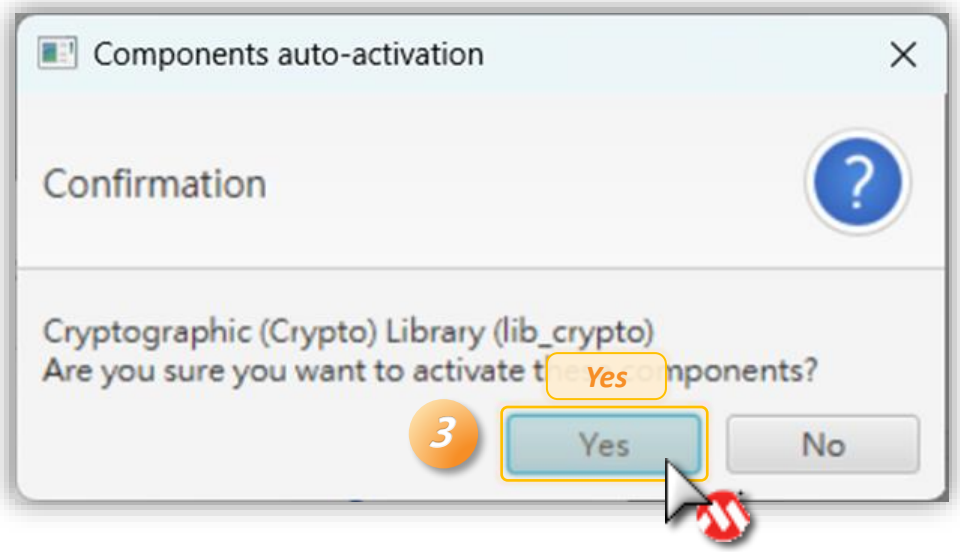
- You can also add "TCP" and "UDP" to the Active Component by dragging and dropping.

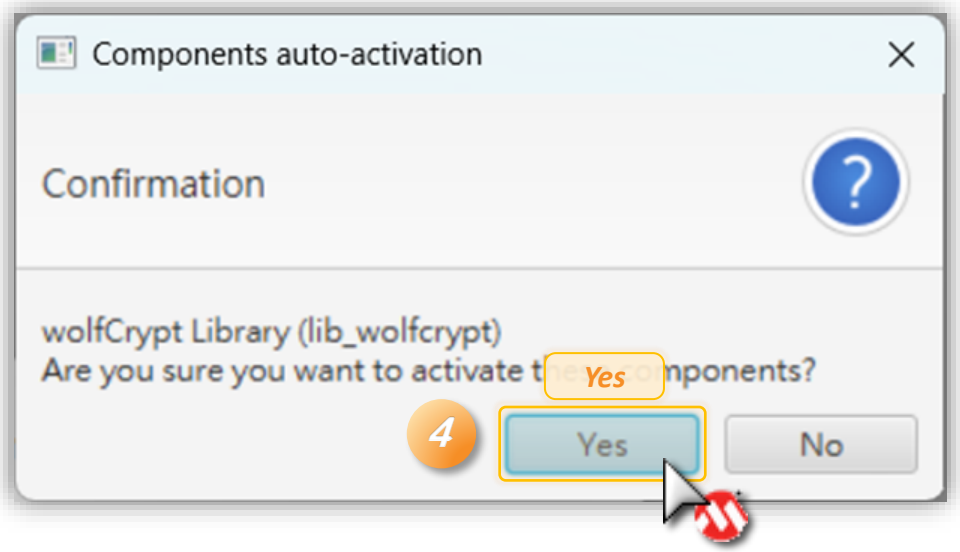


MCC - TCP/IP Configurator

Step 10

- Once you drop the component to Active Components, three dialog boxes will pop up.
- Click Yes to add the "lib_crypto" component.
- Click Yes to add the "lib_wolfcrypt" component.



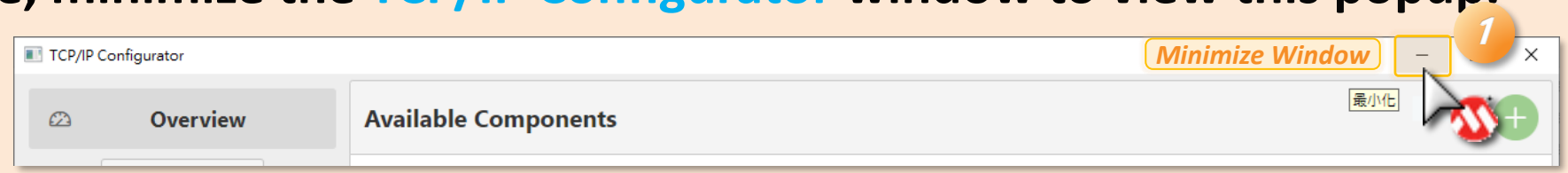


MICROCHIP

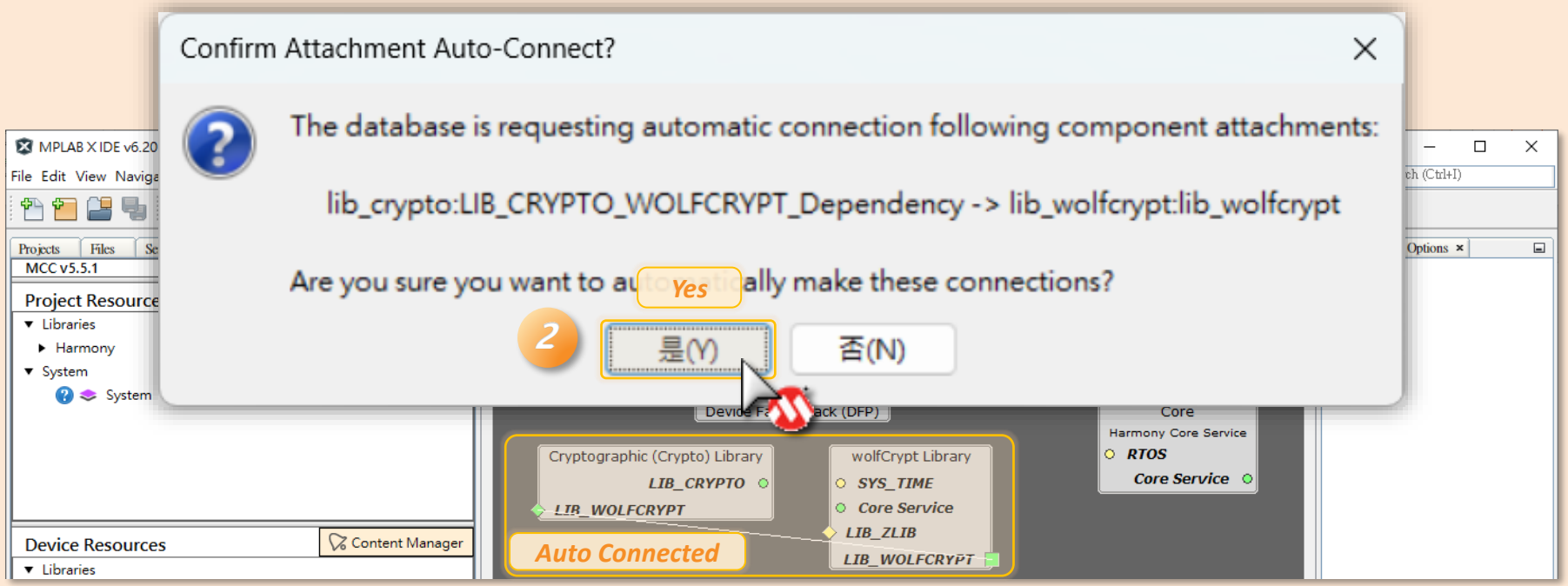
MCC - TCP/IP Configurator

Step in Older Version MCC

- The third dialog box popup appears behind the TCP/IP Configurator window. Therefore, minimize the TCP/IP Configurator window to view this popup.



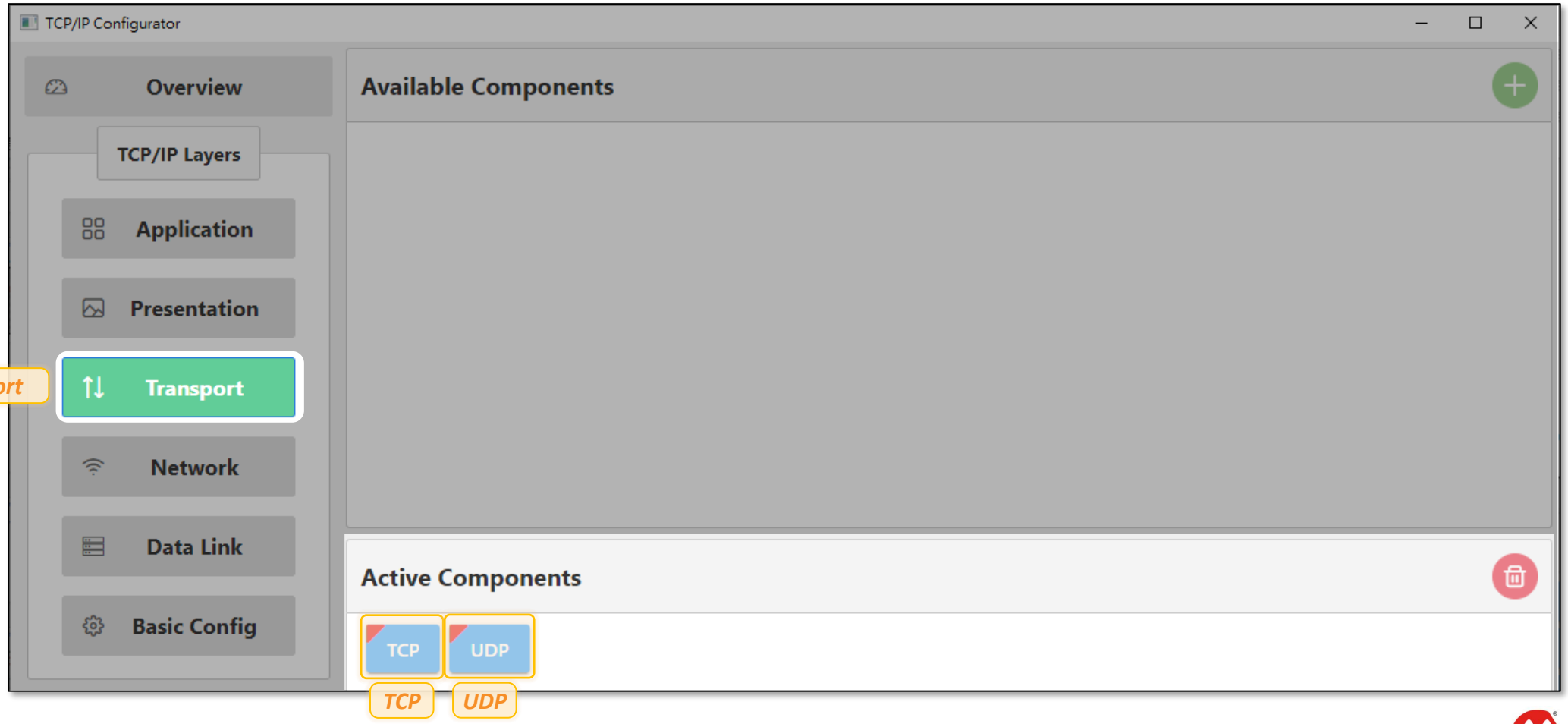
- Click Yes to Auto-Connect the "lib_crypto" and "lib_wolfcrypt".



MCC - TCP/IP Configurator

Step 11 – Result Check

- The "TCP" and "UDP" success to be added to the Active Components.

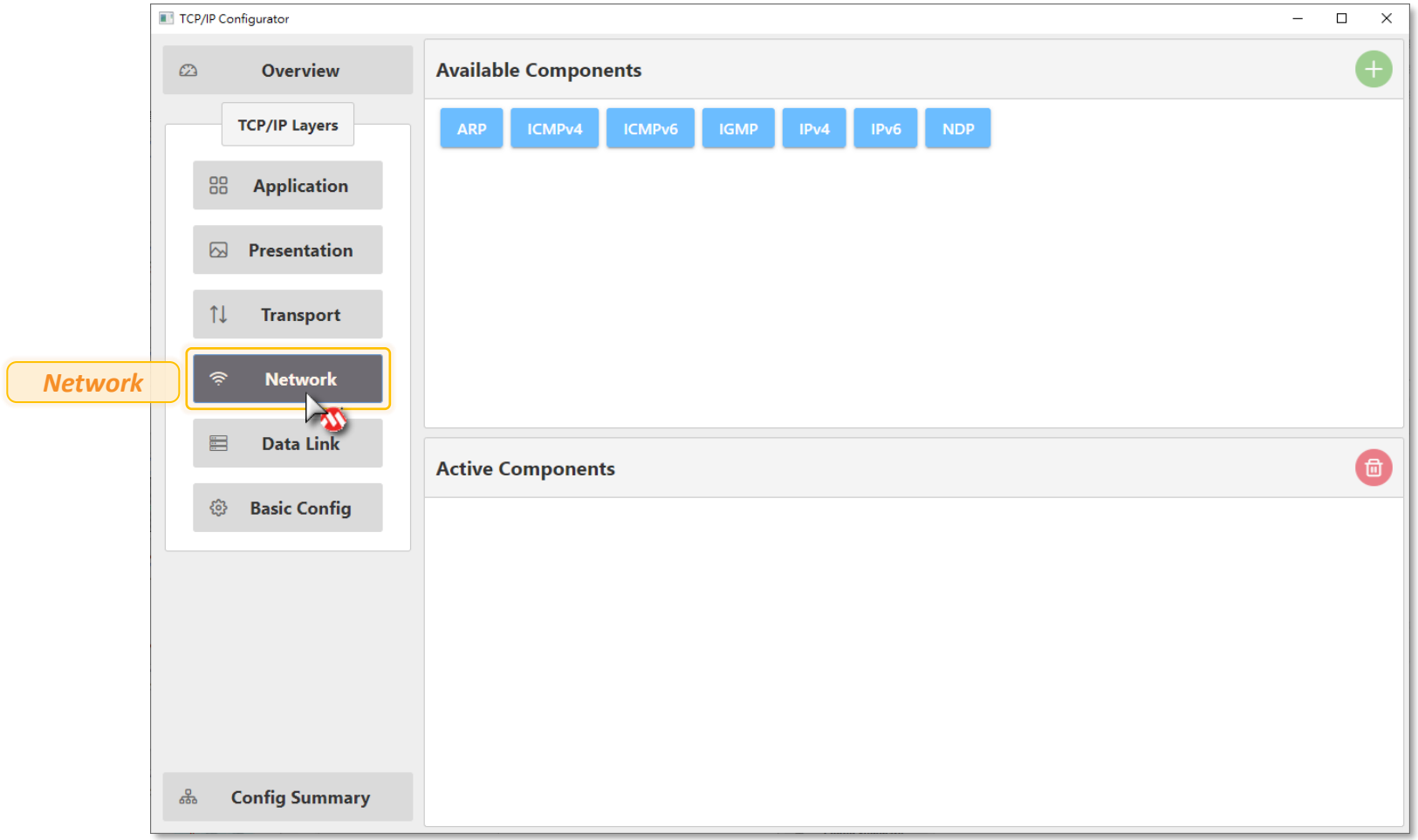


MICROCHIP

MCC - TCP/IP Configurator

Step 12

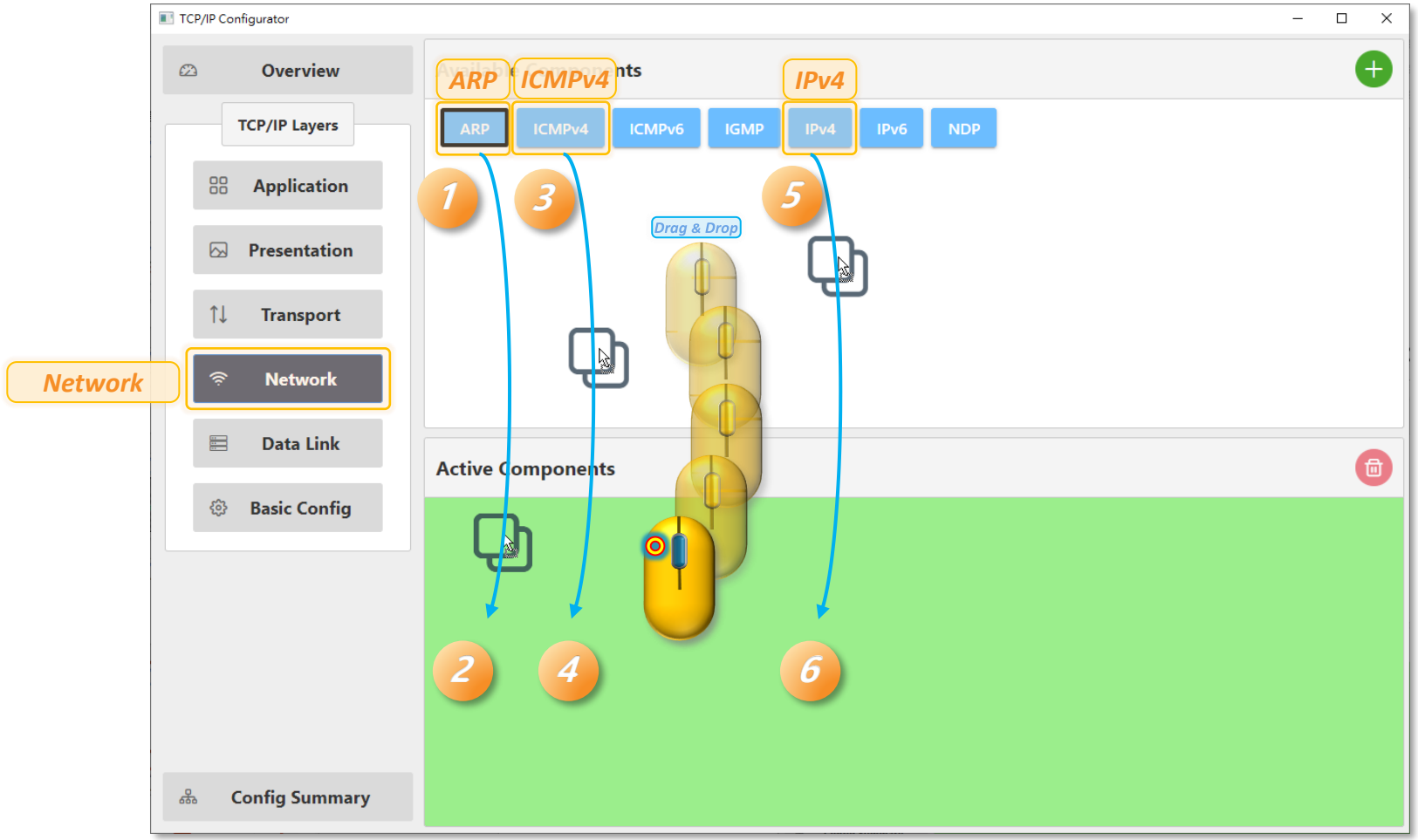
- Click the Network button to select the Network Layer.



MCC - TCP/IP Configurator

Step 13

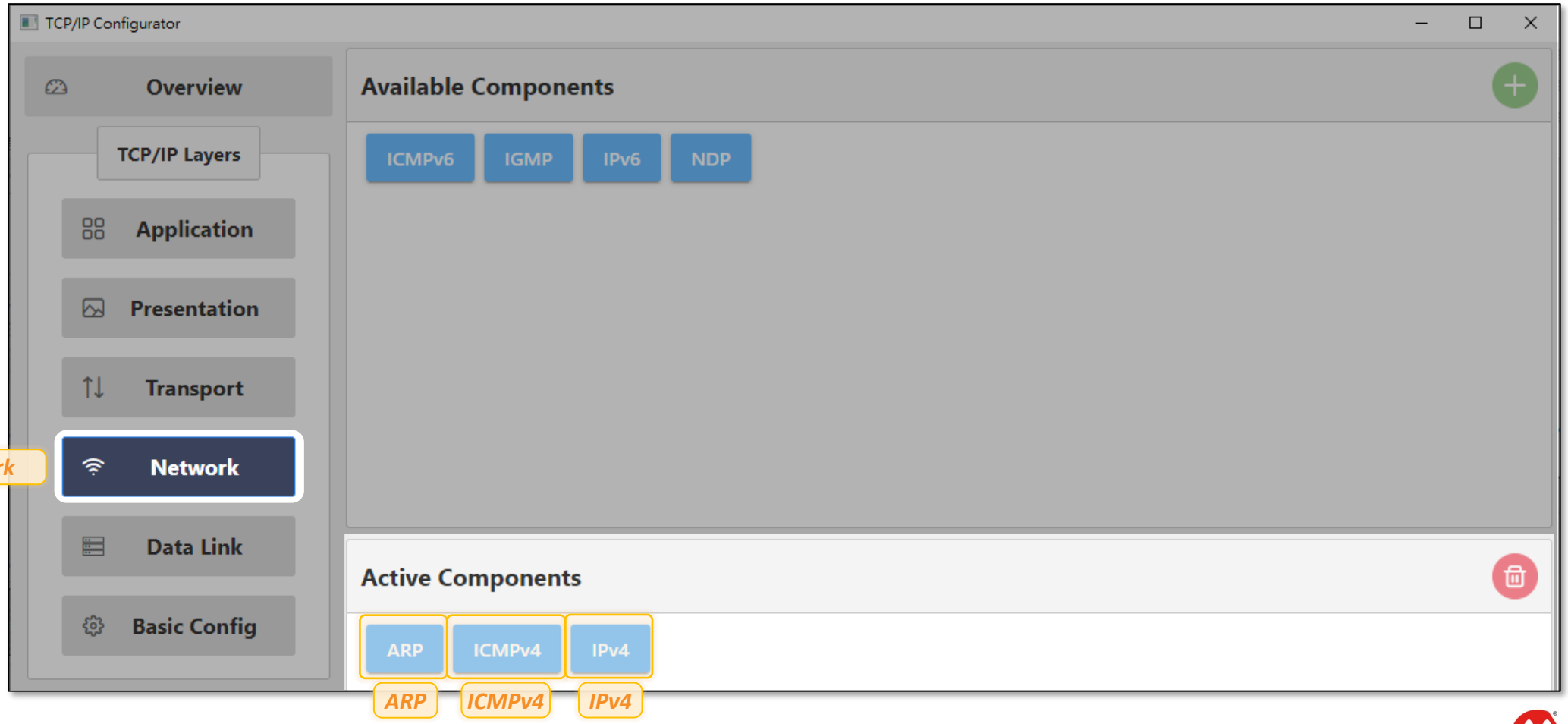
- Add "ARP", "IPv4" and "ICMPv4" to the Active Component by dragging and dropping.



MCC - TCP/IP Configurator

Step 14 – Result Check

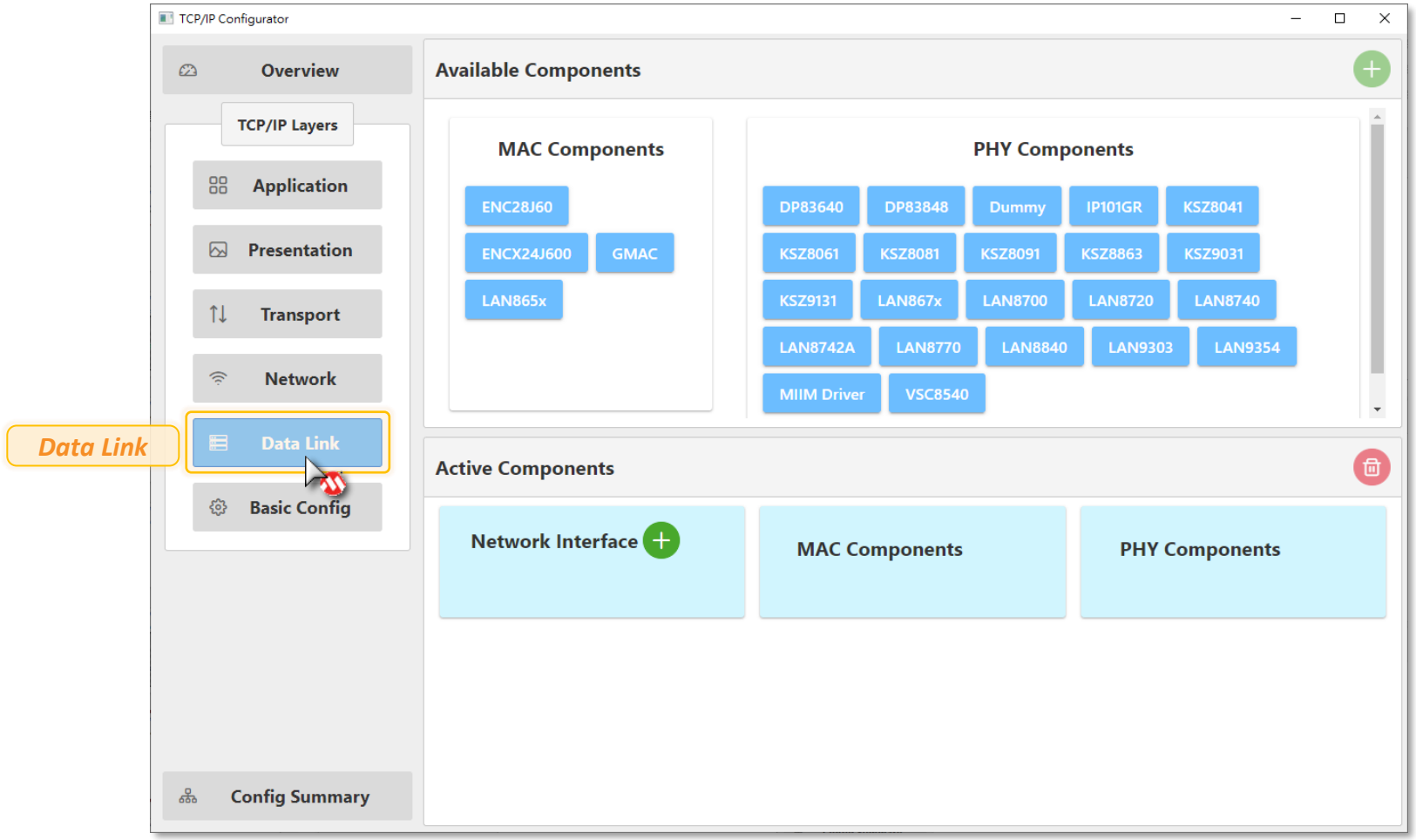
- The "ARP", "IPv4" and "ICMPv4" success to be added to the Active Components.



MCC - TCP/IP Configurator

Step 15

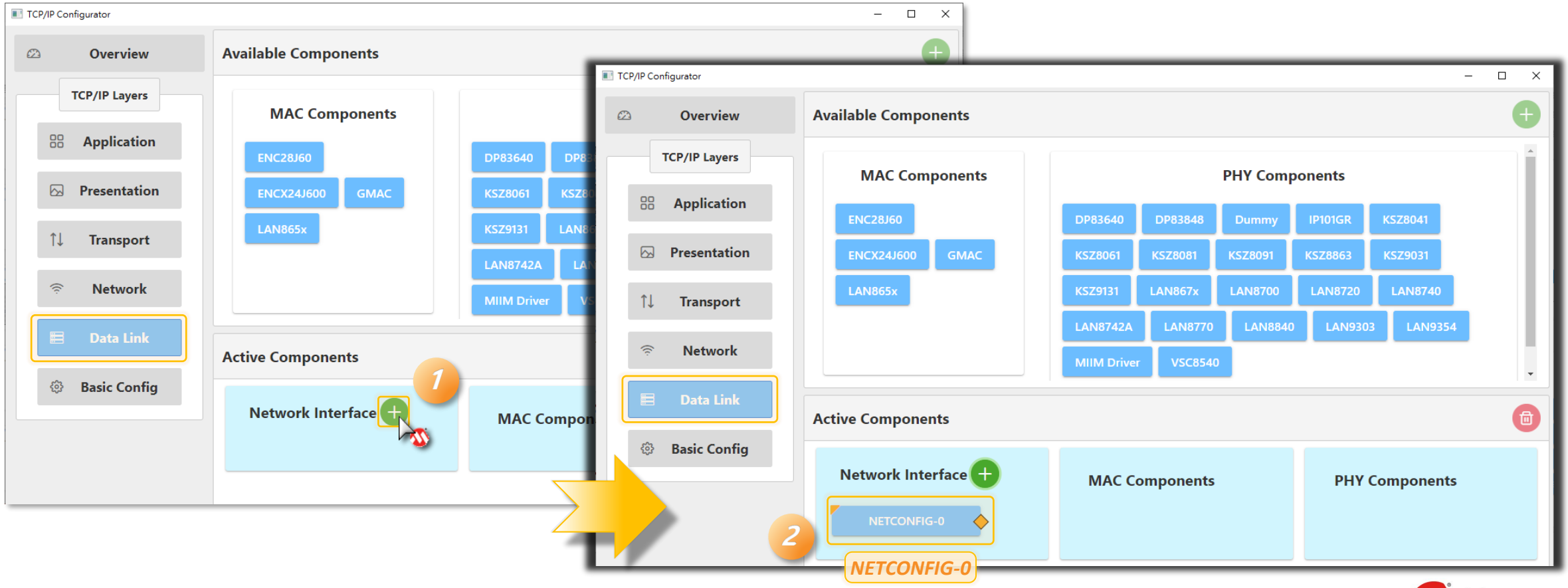
- Click the Data Link button to select the Data Link Layer.



MCC - TCP/IP Configurator

Step 16

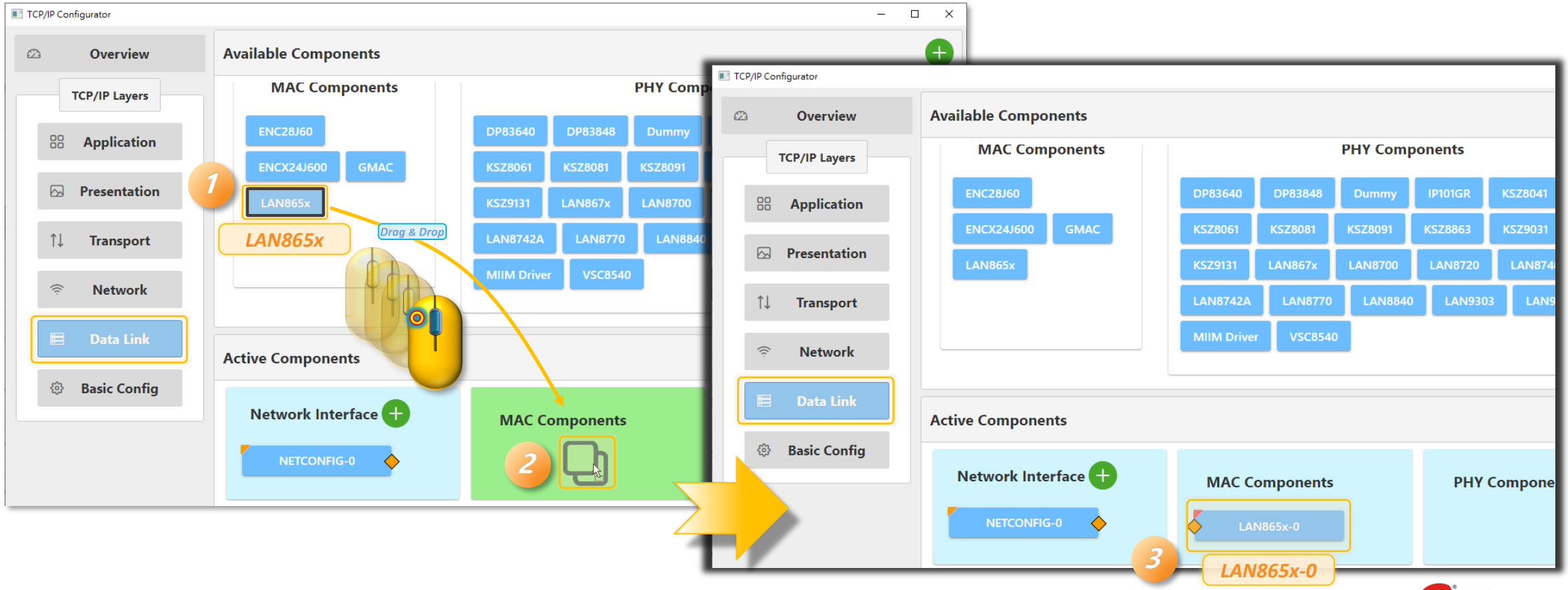
- Click the ⊕ on the "Network Interface" in the Active Components area.
- A new instance NETCONFIG-0 will be added in Network Interface.



MCC - TCP/IP Configurator

Step 17

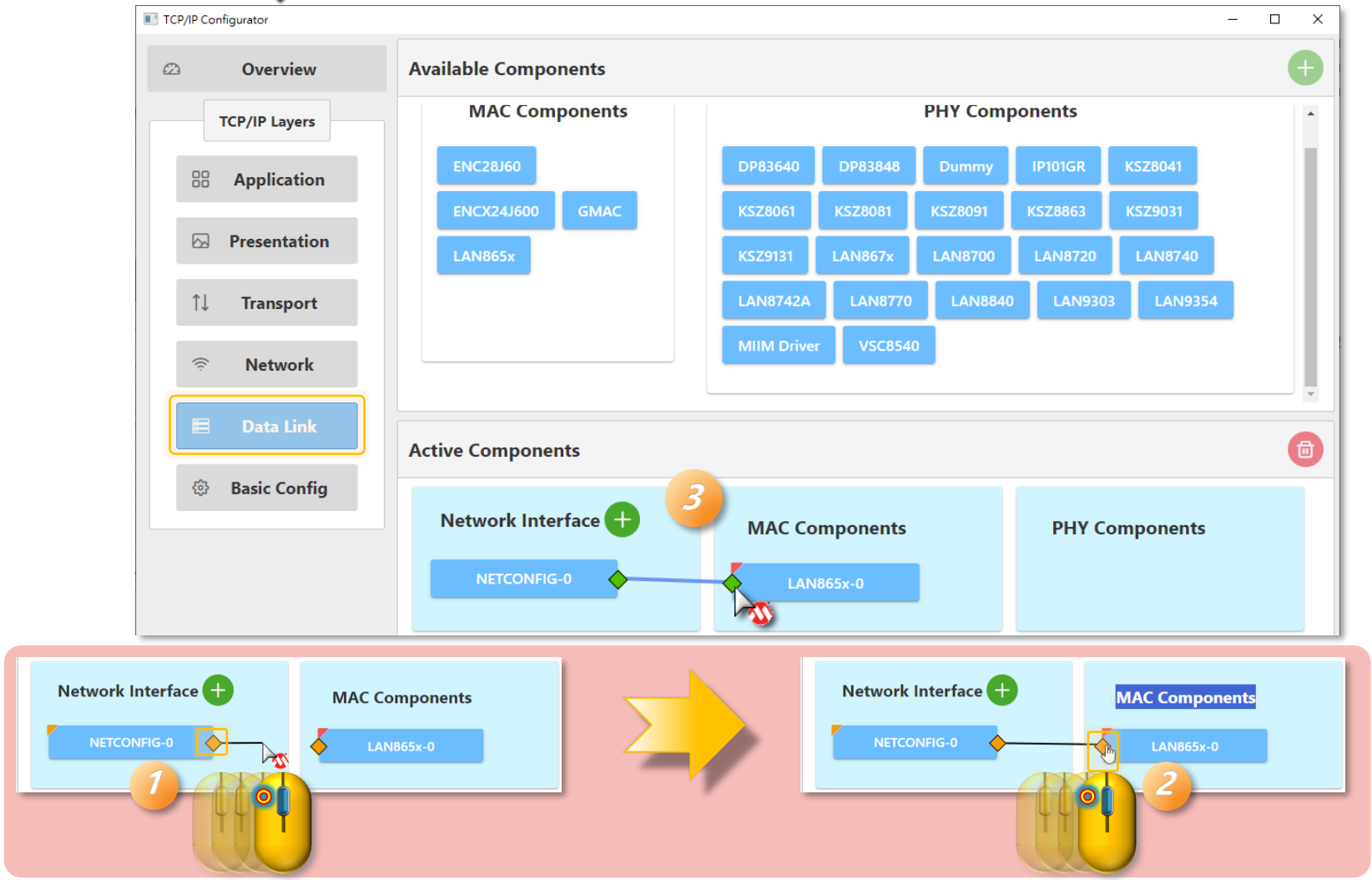
- Drag and drop "LAN865x" from MAC Components of Available Components to the Active Components area, a new instance LAN865x-0 will add to MAC Components.



MCC - TCP/IP Configurator

Step 18

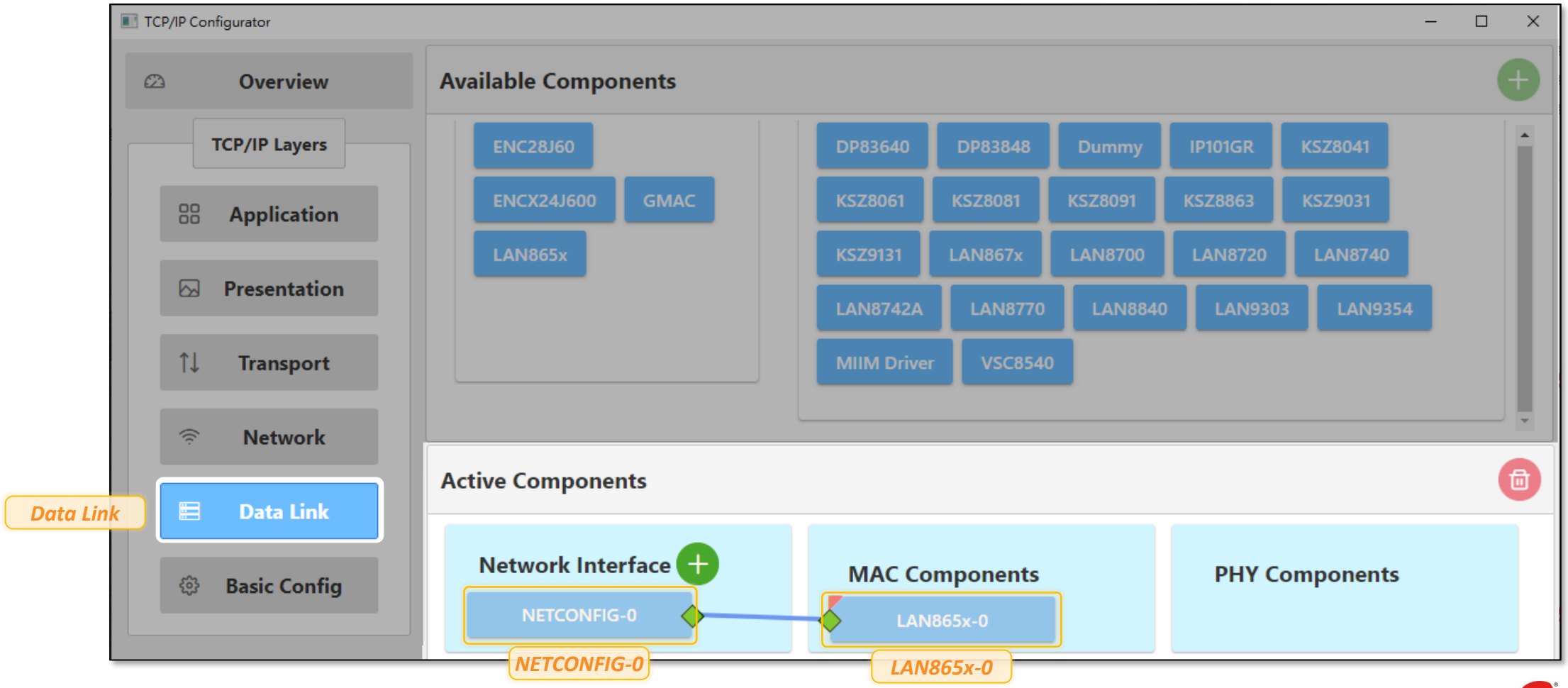
- Drag a line from the ◆ diamond to connect "NETCONFIG-0" and "LAN865x-0".



MCC - TCP/IP Configurator

Step 19 – Result Check

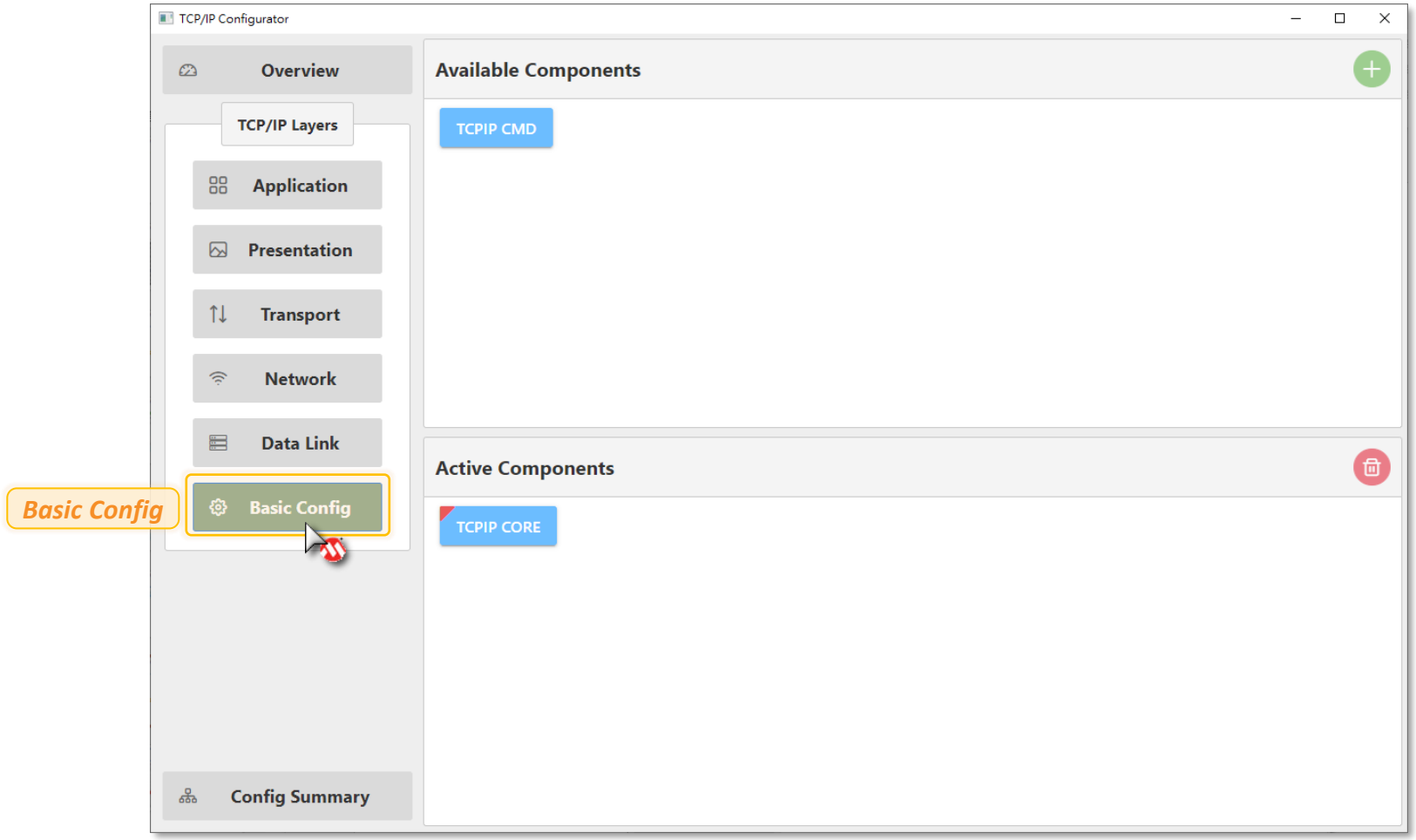
- The "NETCONFIG-0" and "LAN865x-0" success connected in Active Components.



MCC - TCP/IP Configurator

Step 20

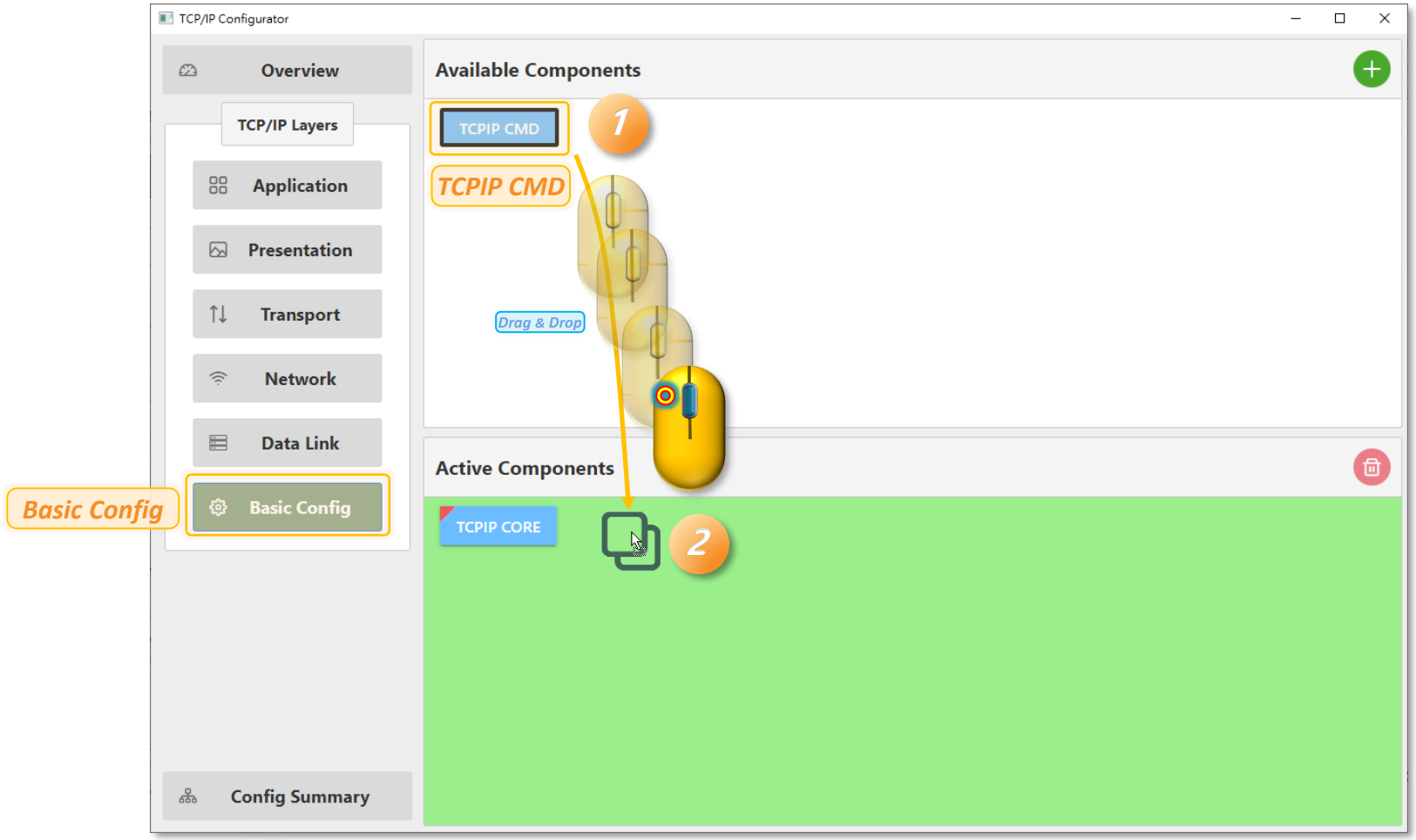
- **Click the Basic Config button to select the Basic Config Layer.**



MCC - TCP/IP Configurator

Step 21

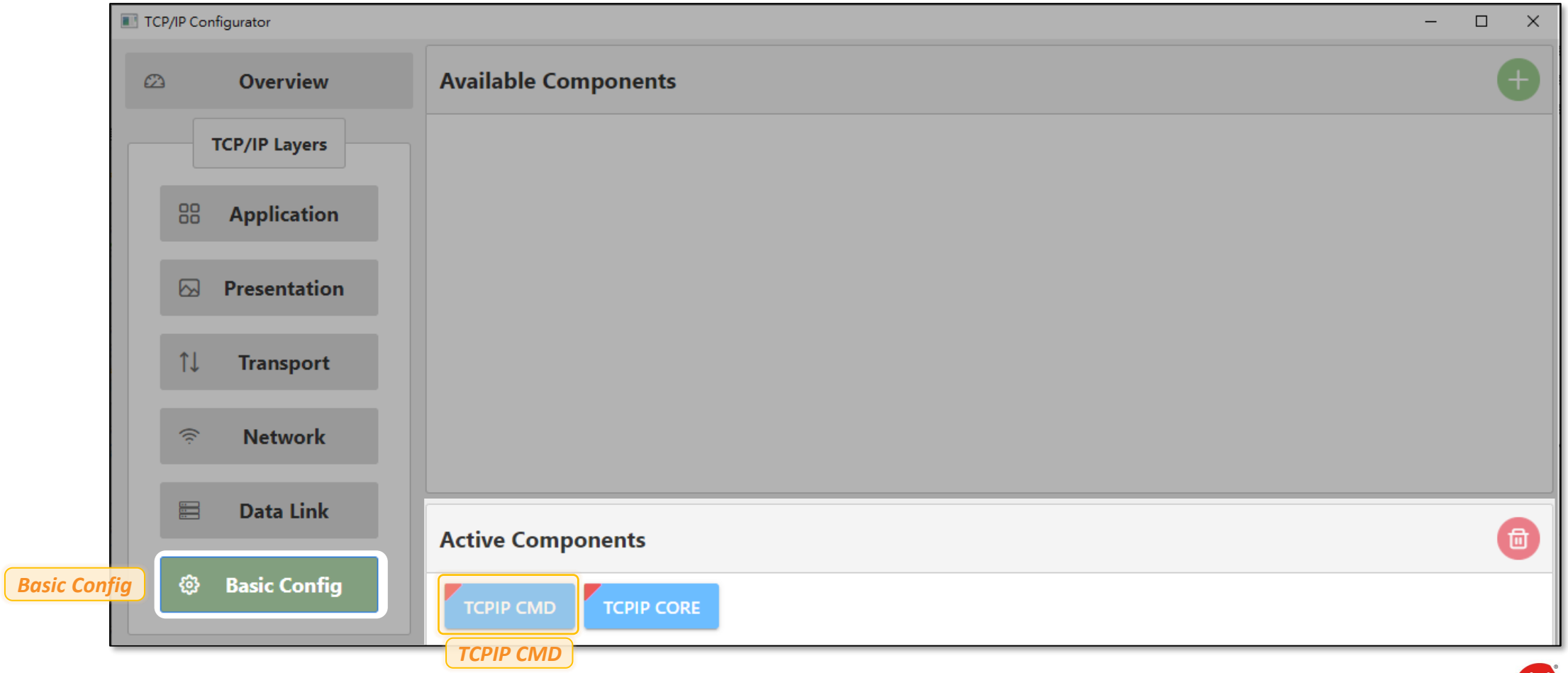
- **Drag and Drop "TCPIP CMD" into Active Components.**



MCC - TCP/IP Configurator

Step 22 – Result Check

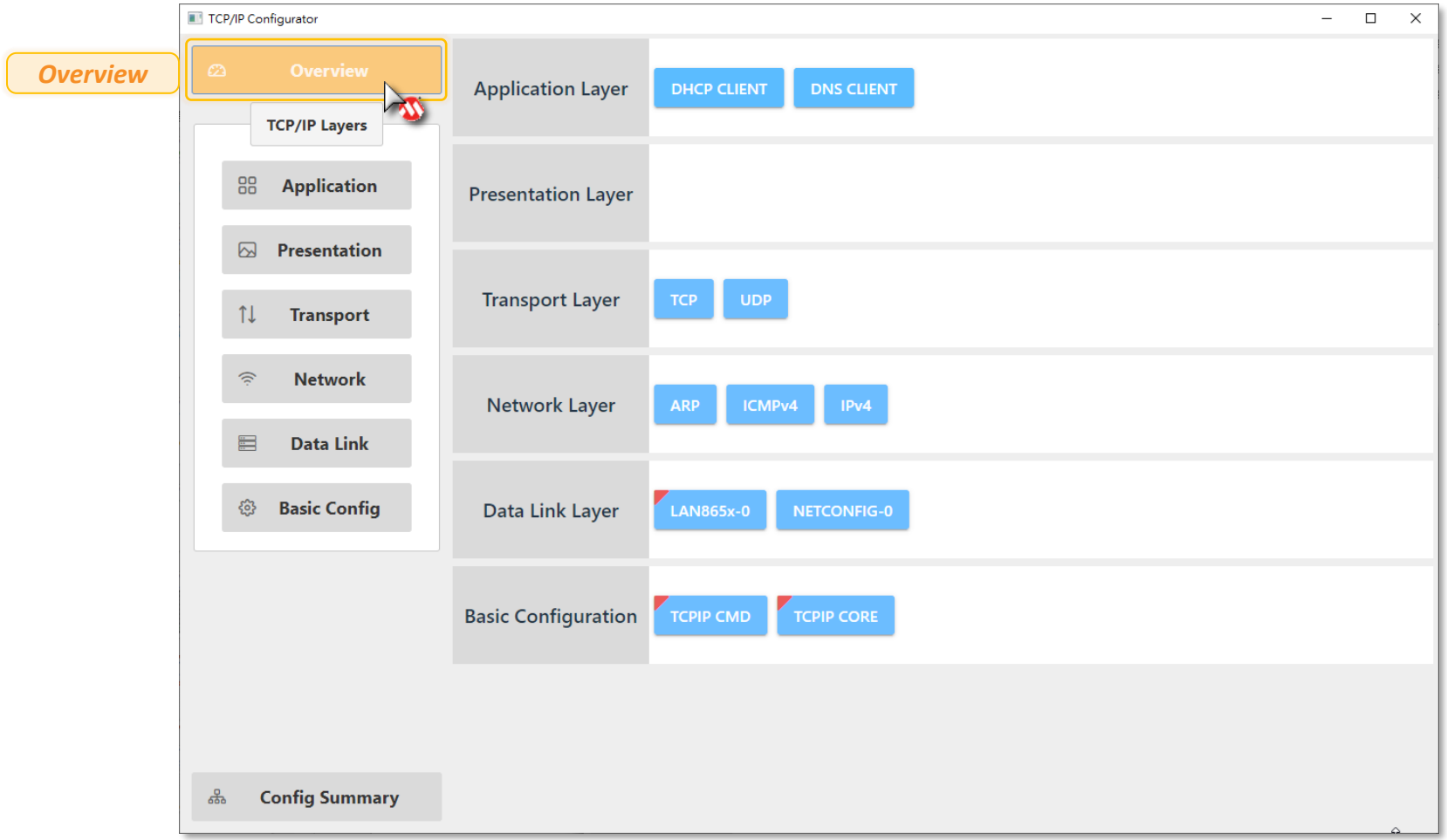
- The "TCPIP CMD" success to be added to the Active Components.



MCC - TCP/IP Configurator

Step 23

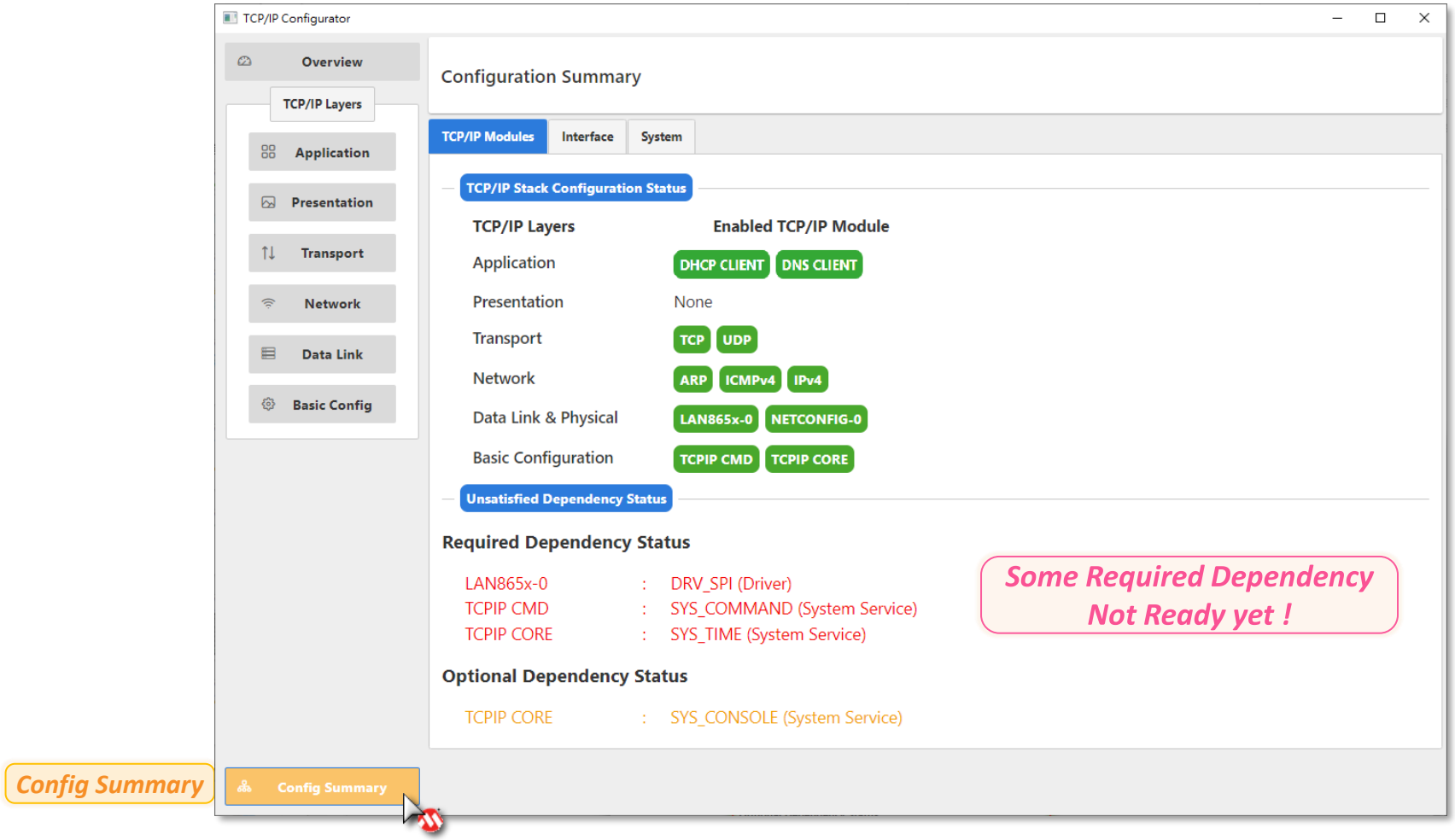
- Click the Overview button to see all added components.



MCC - TCP/IP Configurator

Step 24

- **Click the Config Summary button to view the dependency status.**



MPLAB® Code Configurator (MCC) Added TCP/IP Dependency, System Driver & Peripheral Library

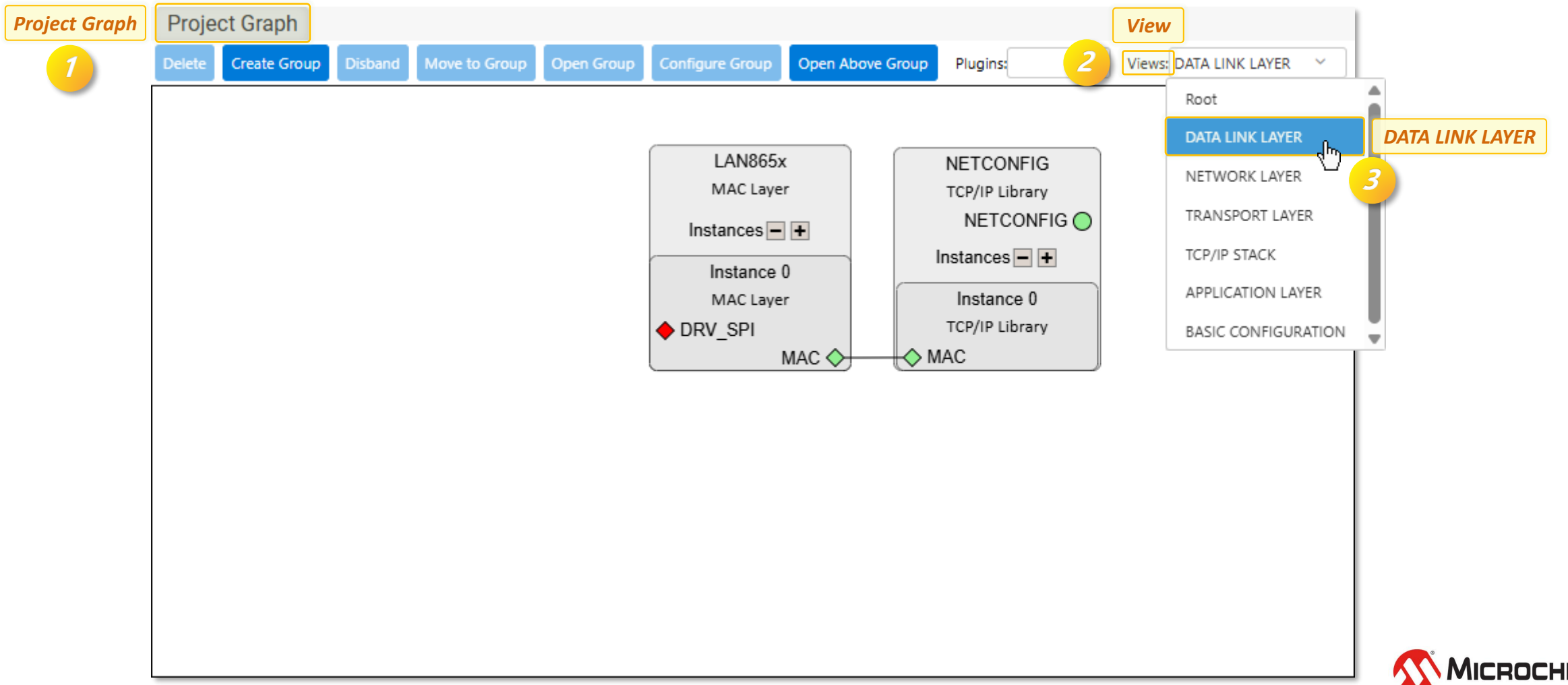
MCC Harmony Configuration

MICROCHIP

Added TCP/IP Dependency, System Driver & Peripheral Library

Step 1

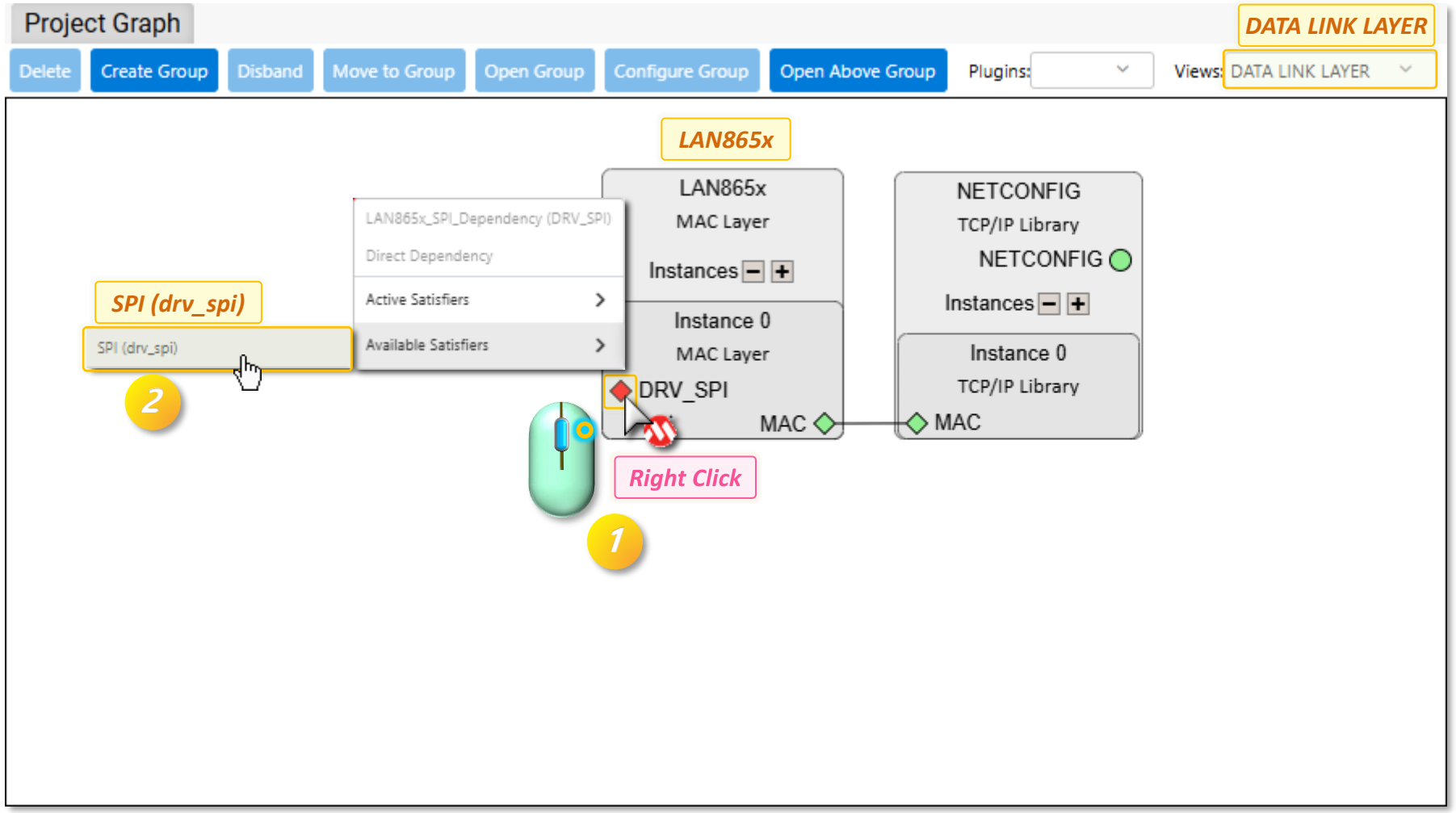
- Return "Project Graph" of MCC Harmony, Select "DATA LINK LAYER" from the "View".



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 2

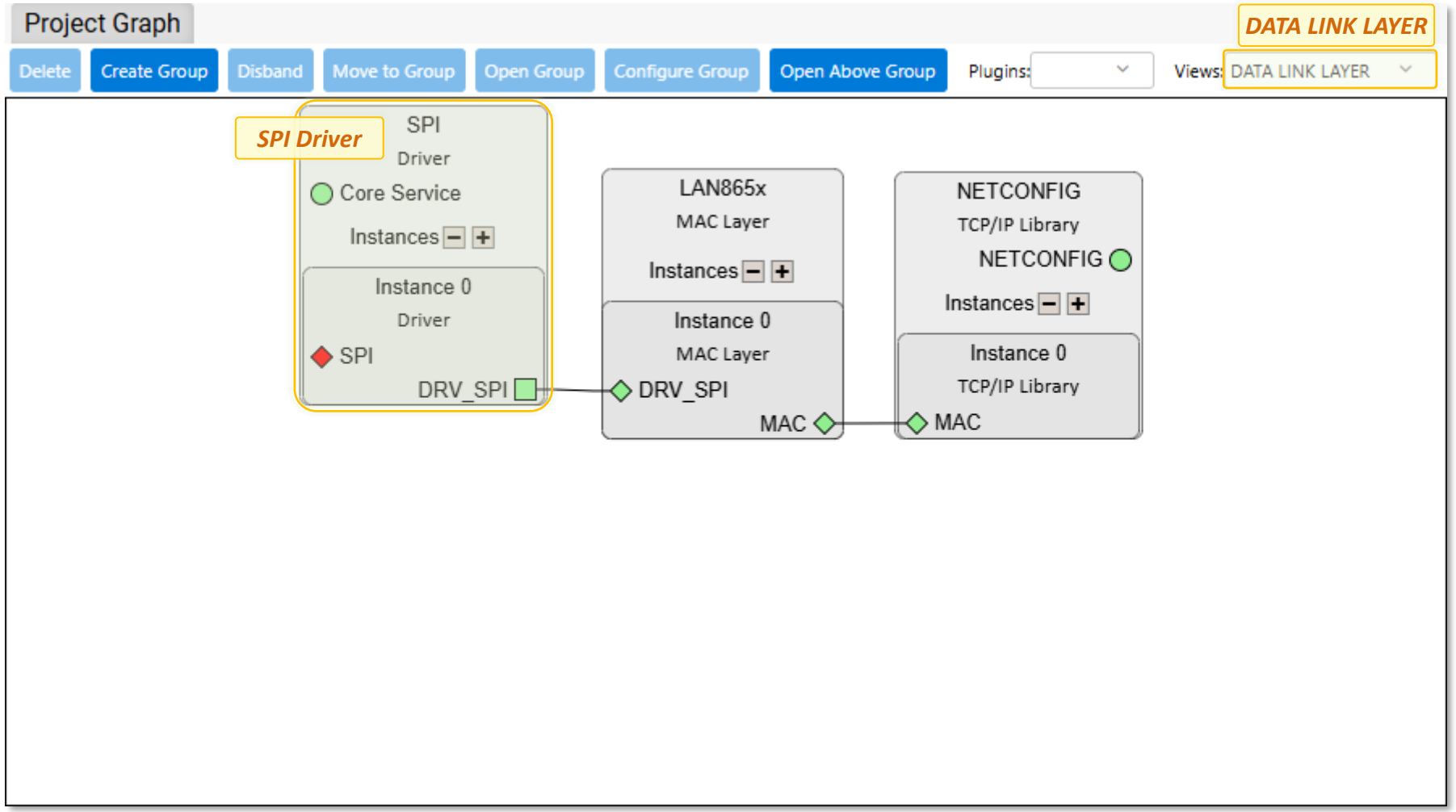
- Right click on "DRV_SPI" of LAN865x , select the "SPI (drv_spi)" as Satisfiers of it.



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 3

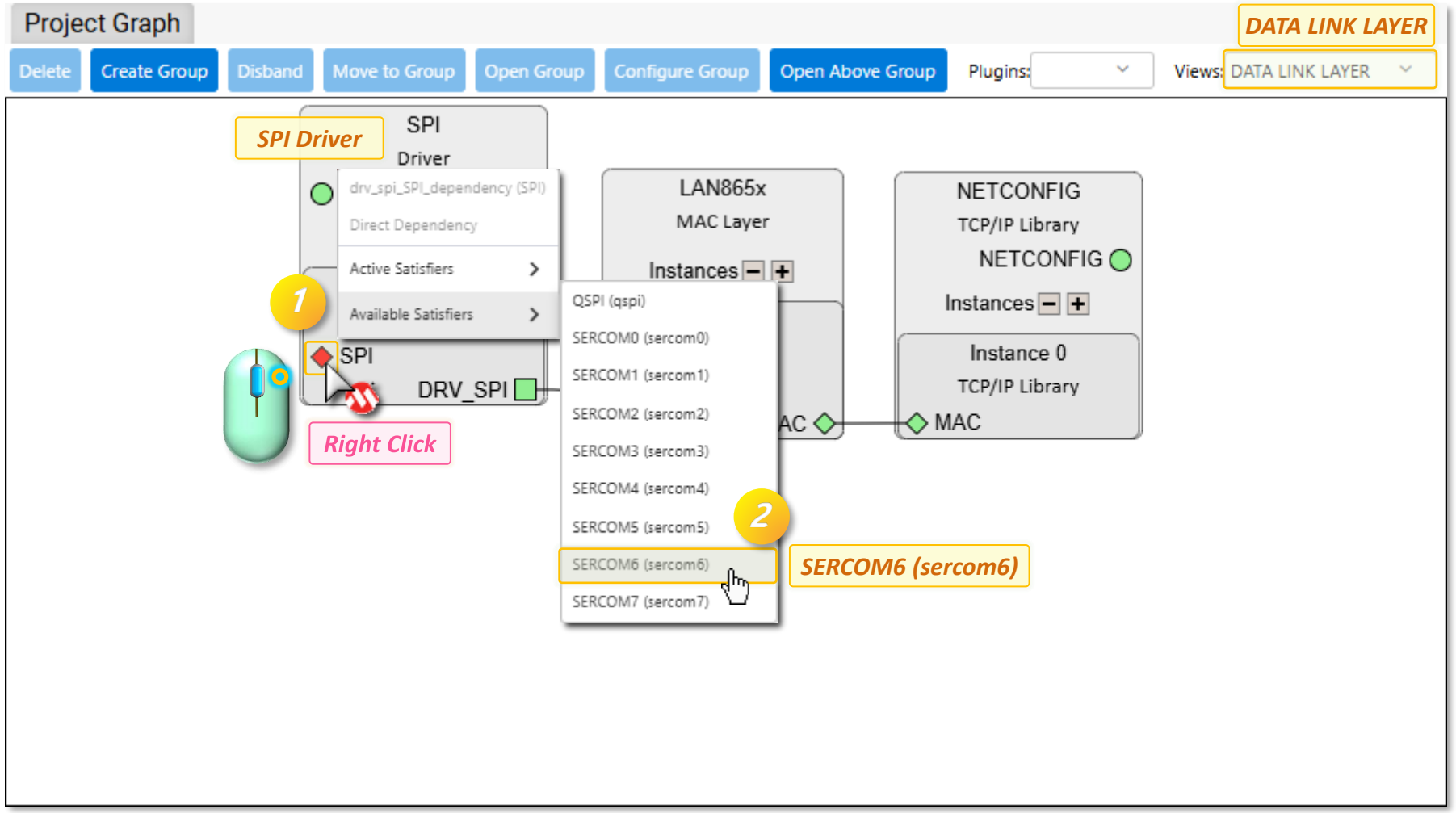
- **Successfully added "SPI Driver" to satisfy the instance 0 of "LAN865x" dependency.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 4

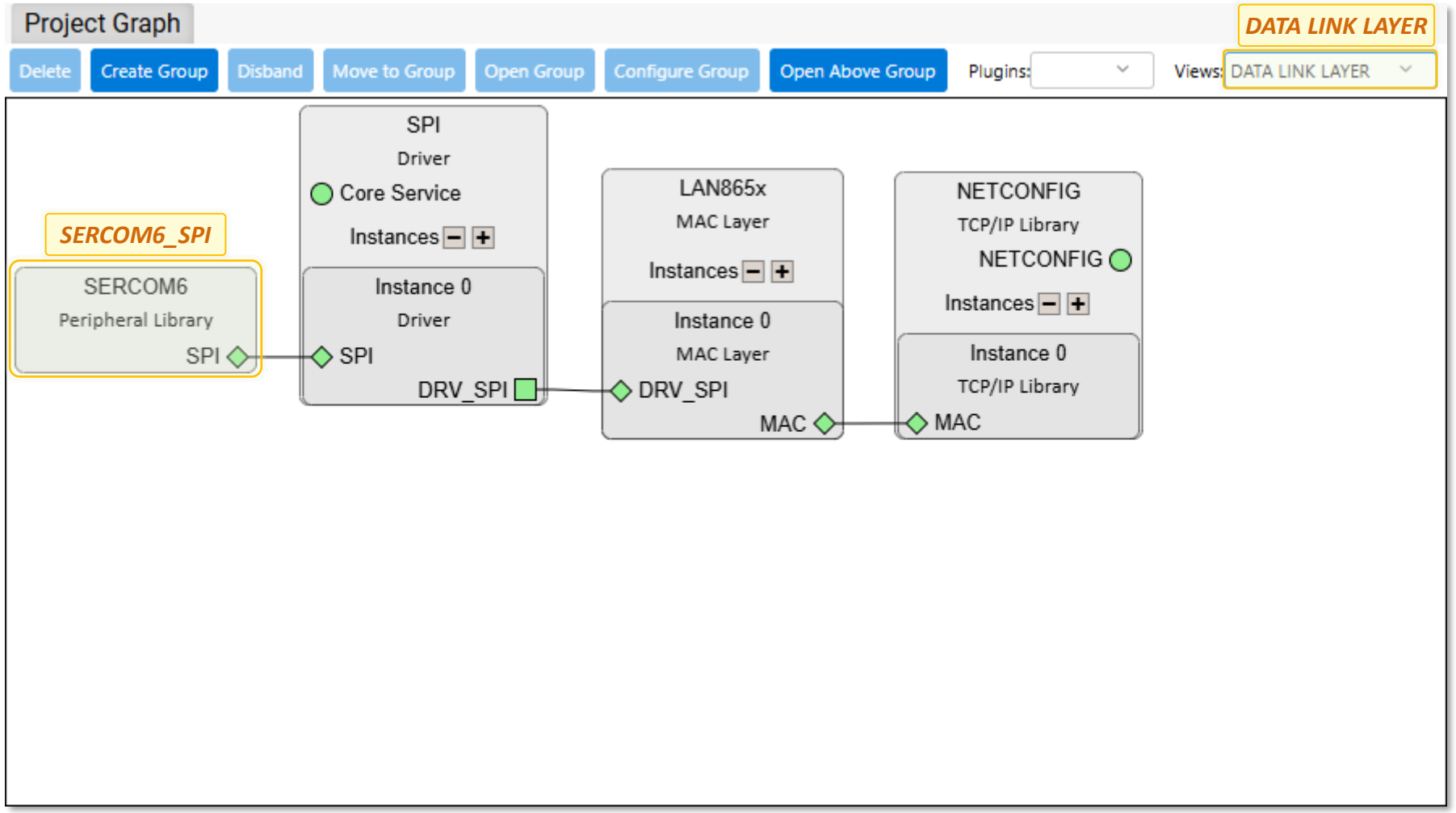
- Right click on "SPI" of SPI Driver, select the "SERCOM6" as Satisfiers of it.



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 5

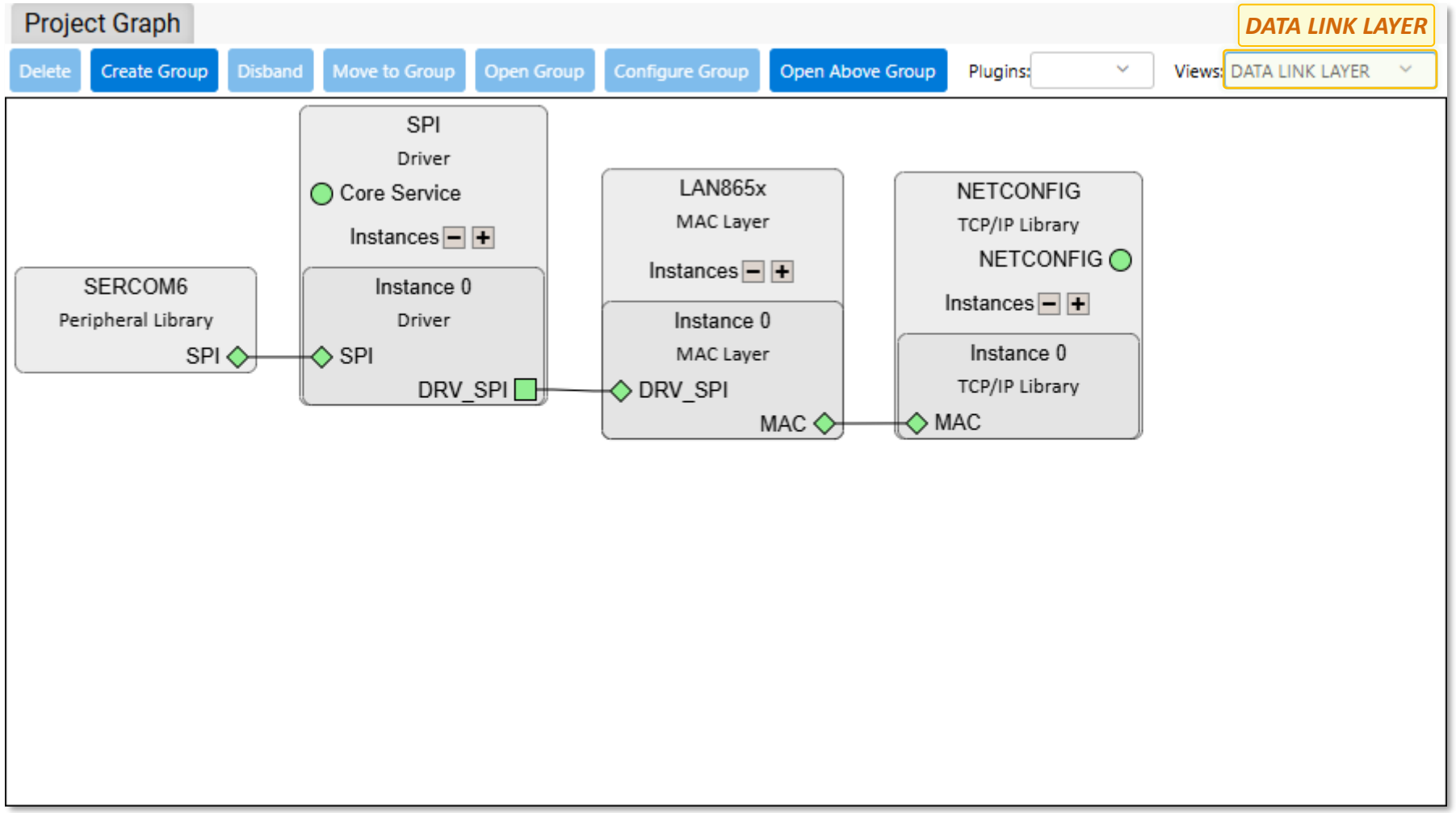
- **Successfully added "SERCOM6_SPI" to satisfy the "SPI Driver" dependency.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 6

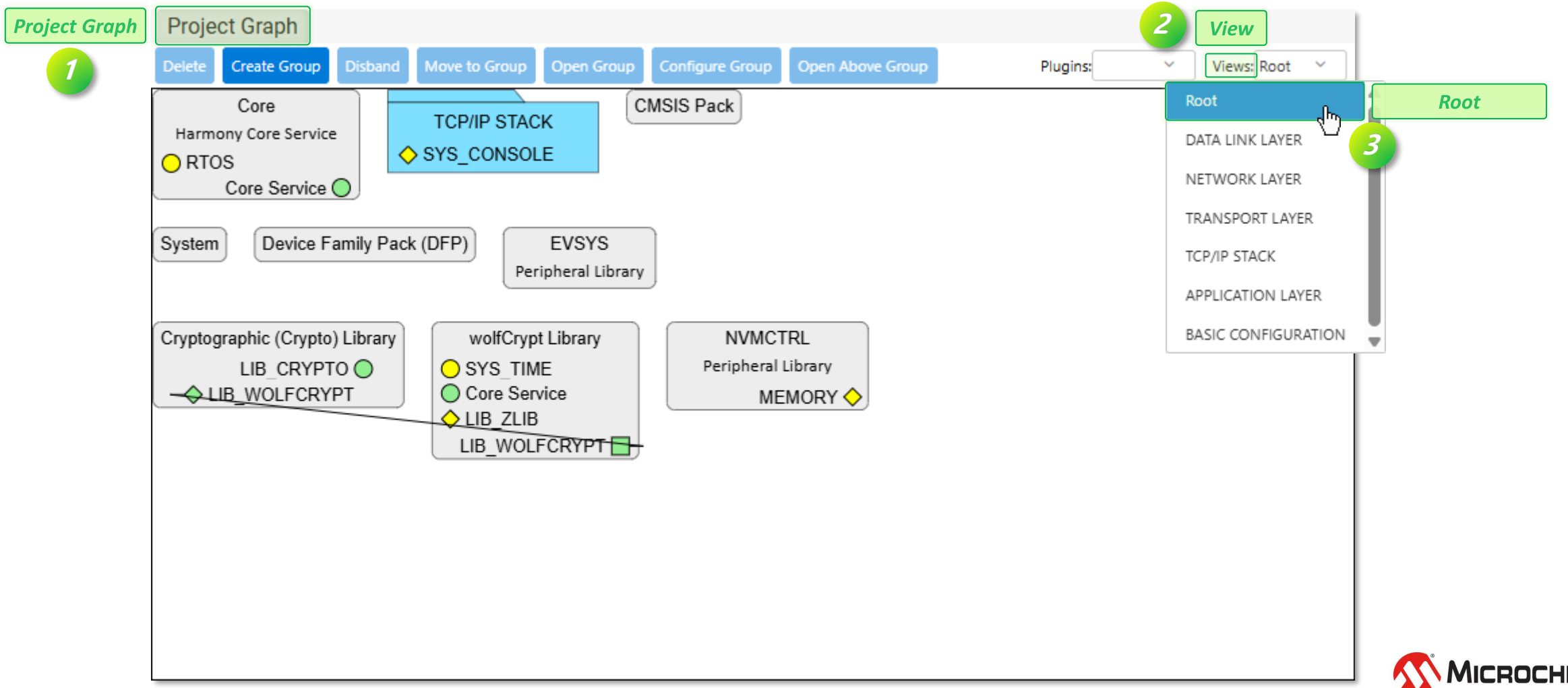
- **Finally, the "DATA LINK LAYER" should look like this.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 7

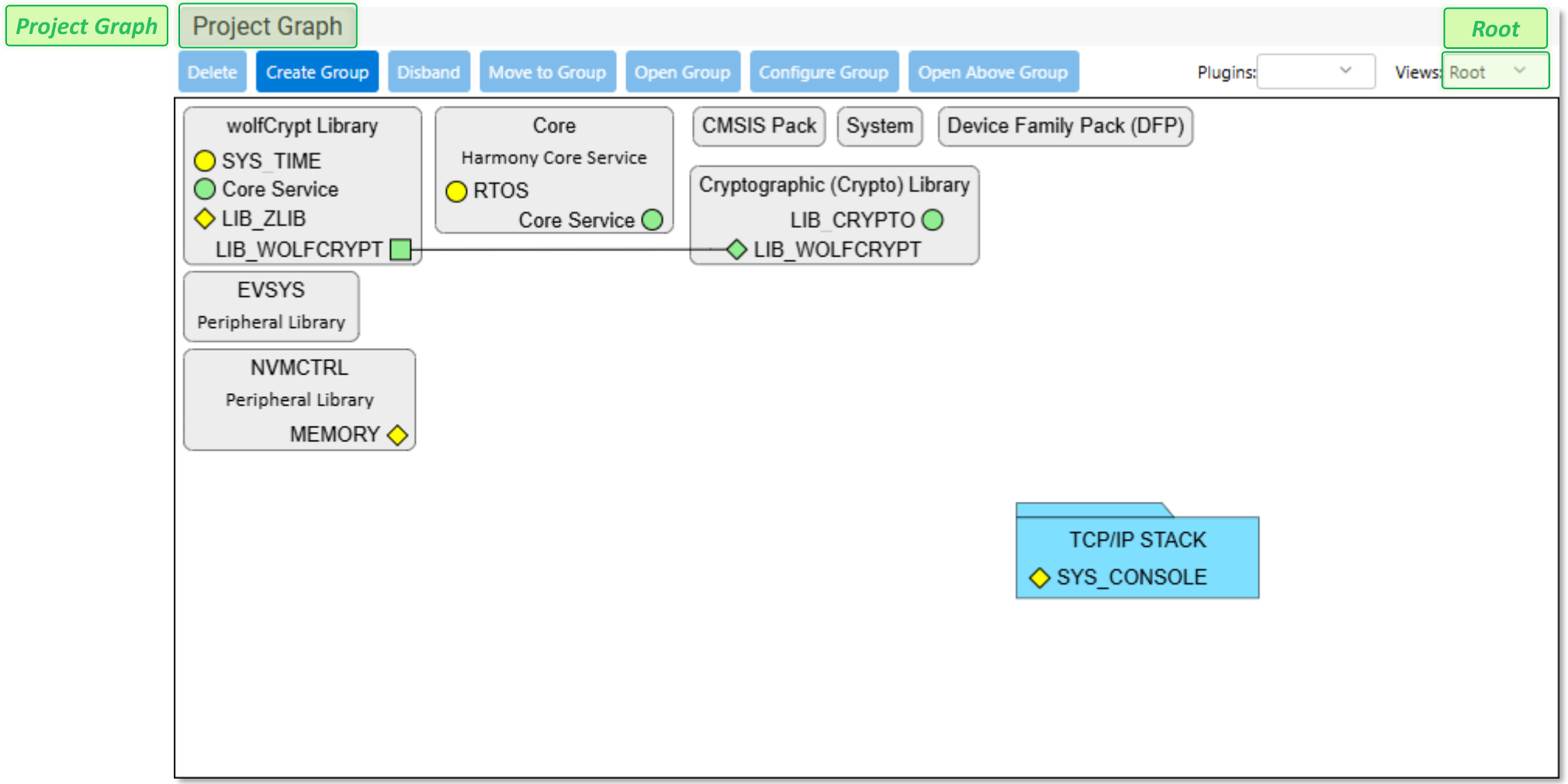
- Select "Root" from the "View".



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 8

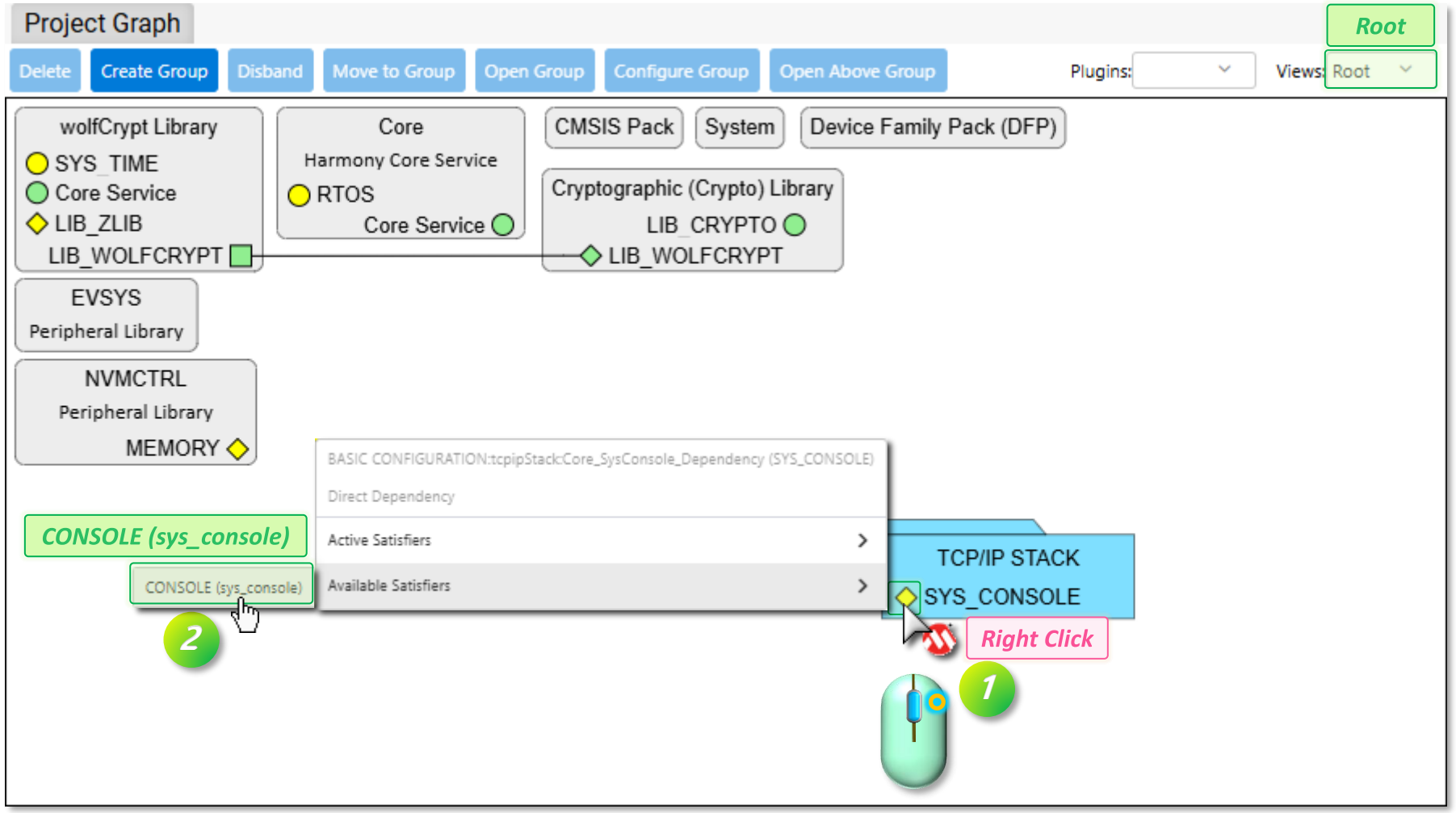
- **Trying to rearrange it a bit so that the hierarchy of modules is easier to understand.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 9

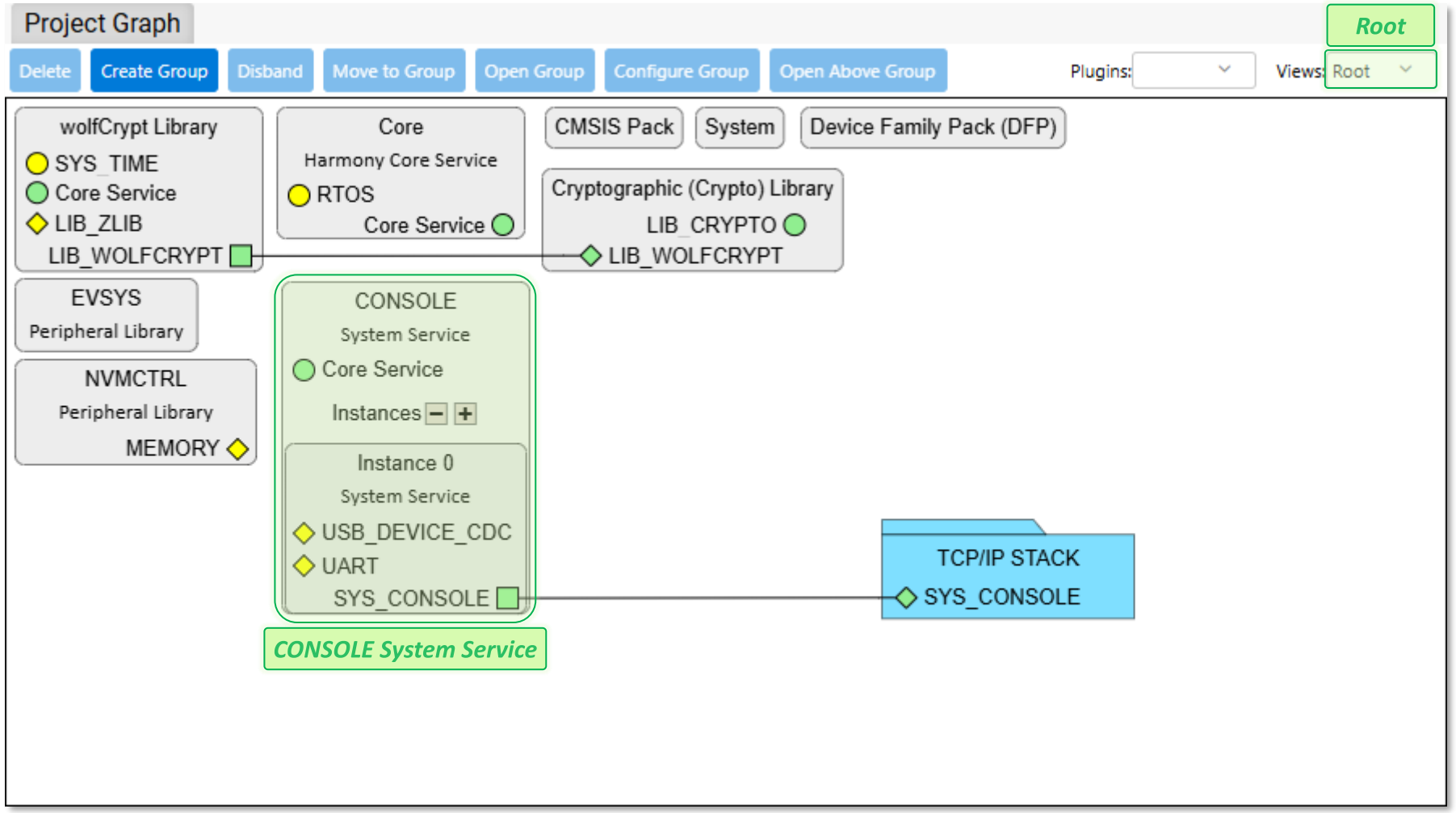
- **Right click on "SYS_CONSOLE" of TCP/IP STACK, select "CONSOLE (sys_console)" as its Satisfiers.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 10

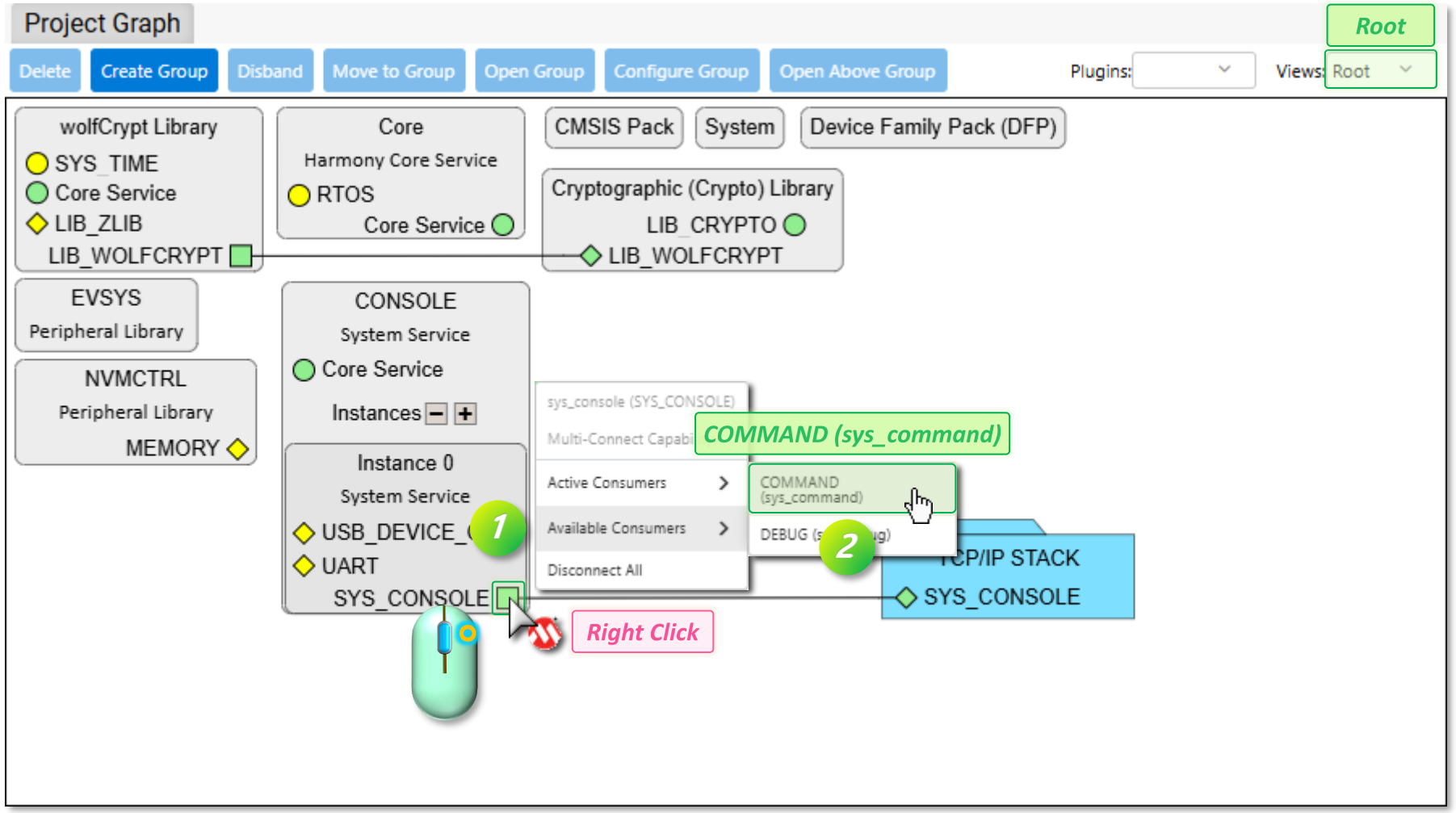
- **Successfully added "CONSOLE System Service" to satisfy the "TCP/IP STACK" console requirement.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 11

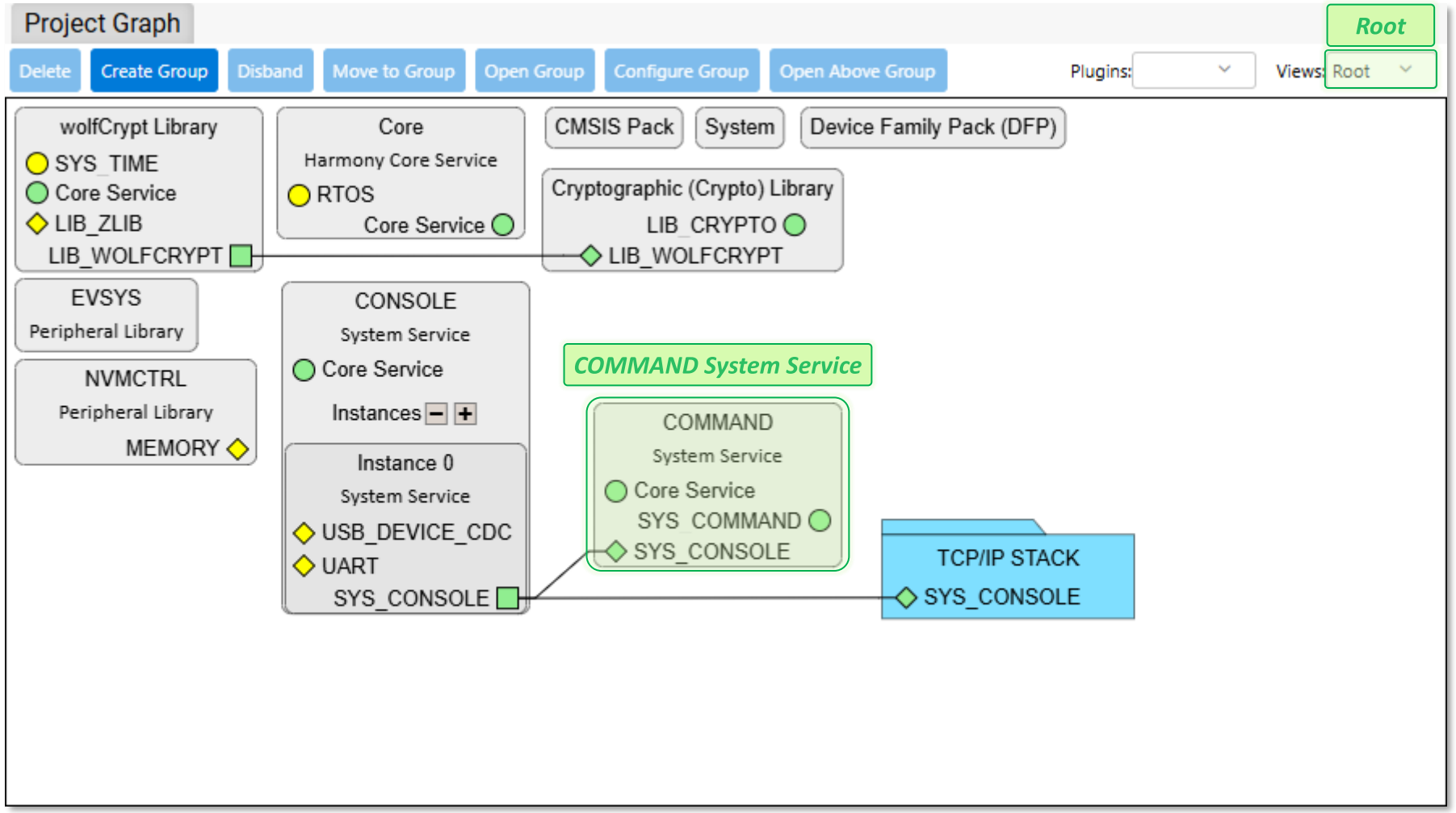
- **Right click on "SYS_CONSOLE" of CONSOLE System Service, let "COMMAND" as its Consumers.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 12

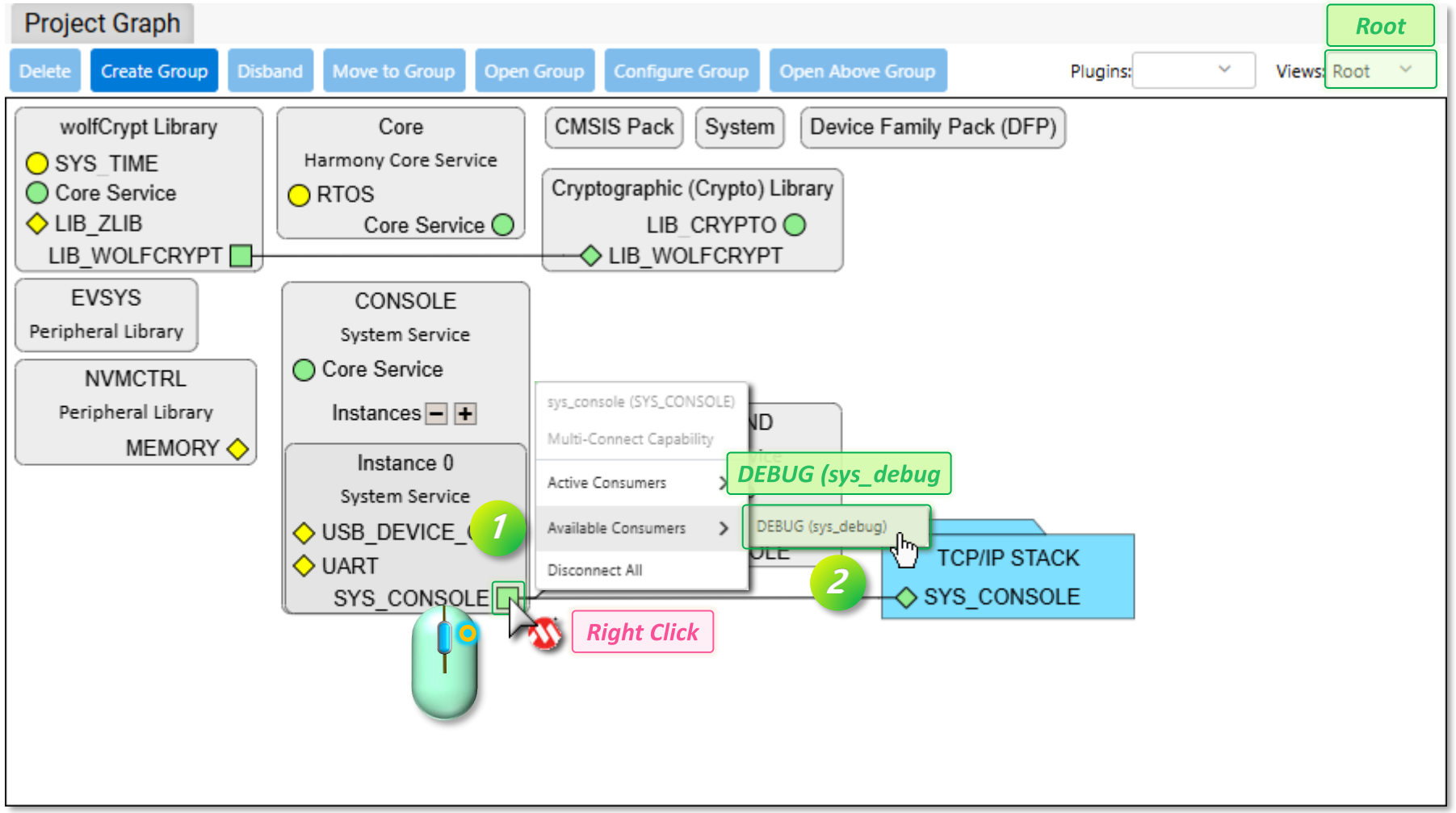
- **Successfully added "COMMAND System Service" as Consumer of "CONSOLE System Service".**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 13

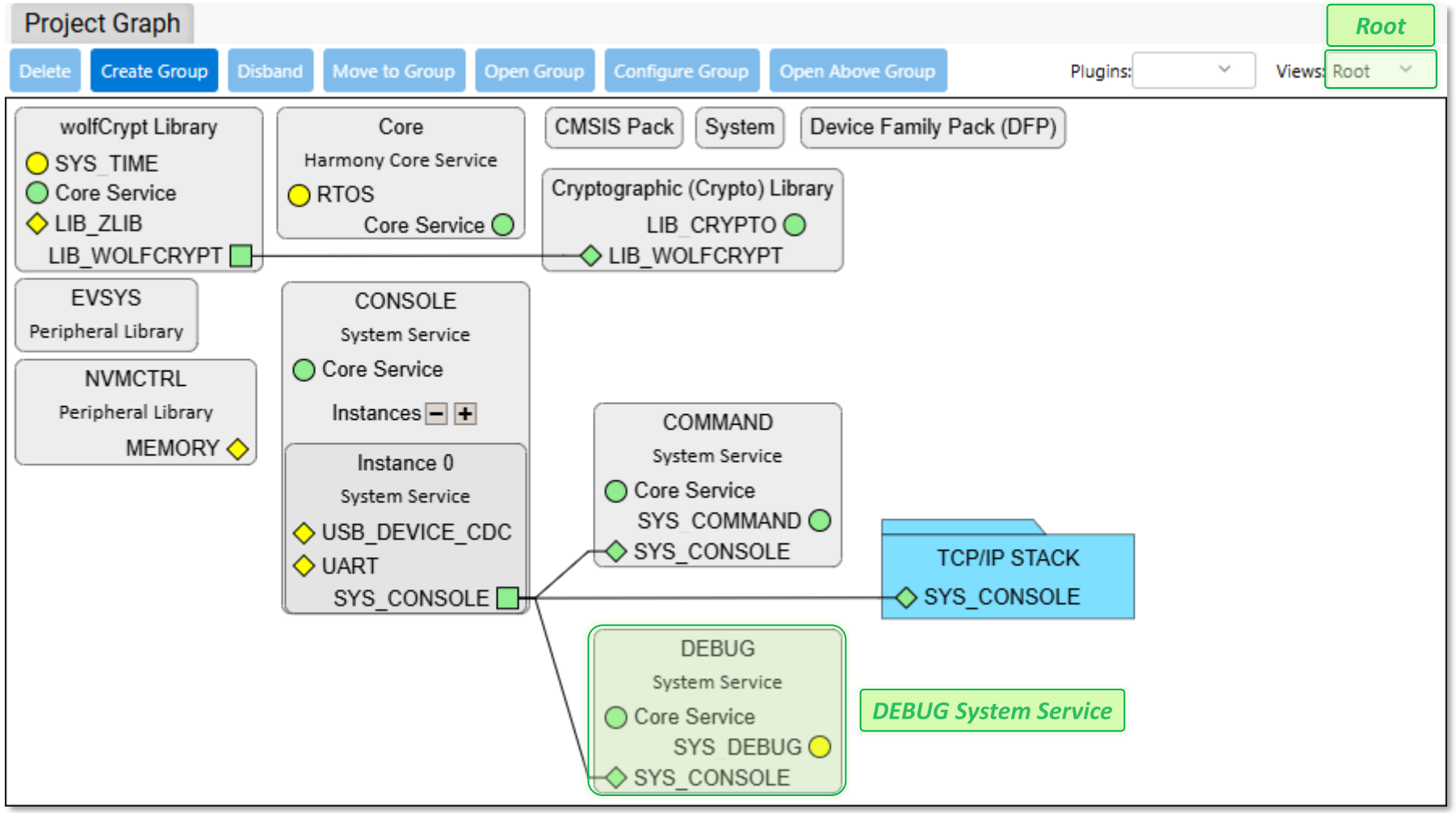
- **Right click on "SYS_CONSOLE" of CONSOLE System Service and add "DEBUG" as Consumers.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 14

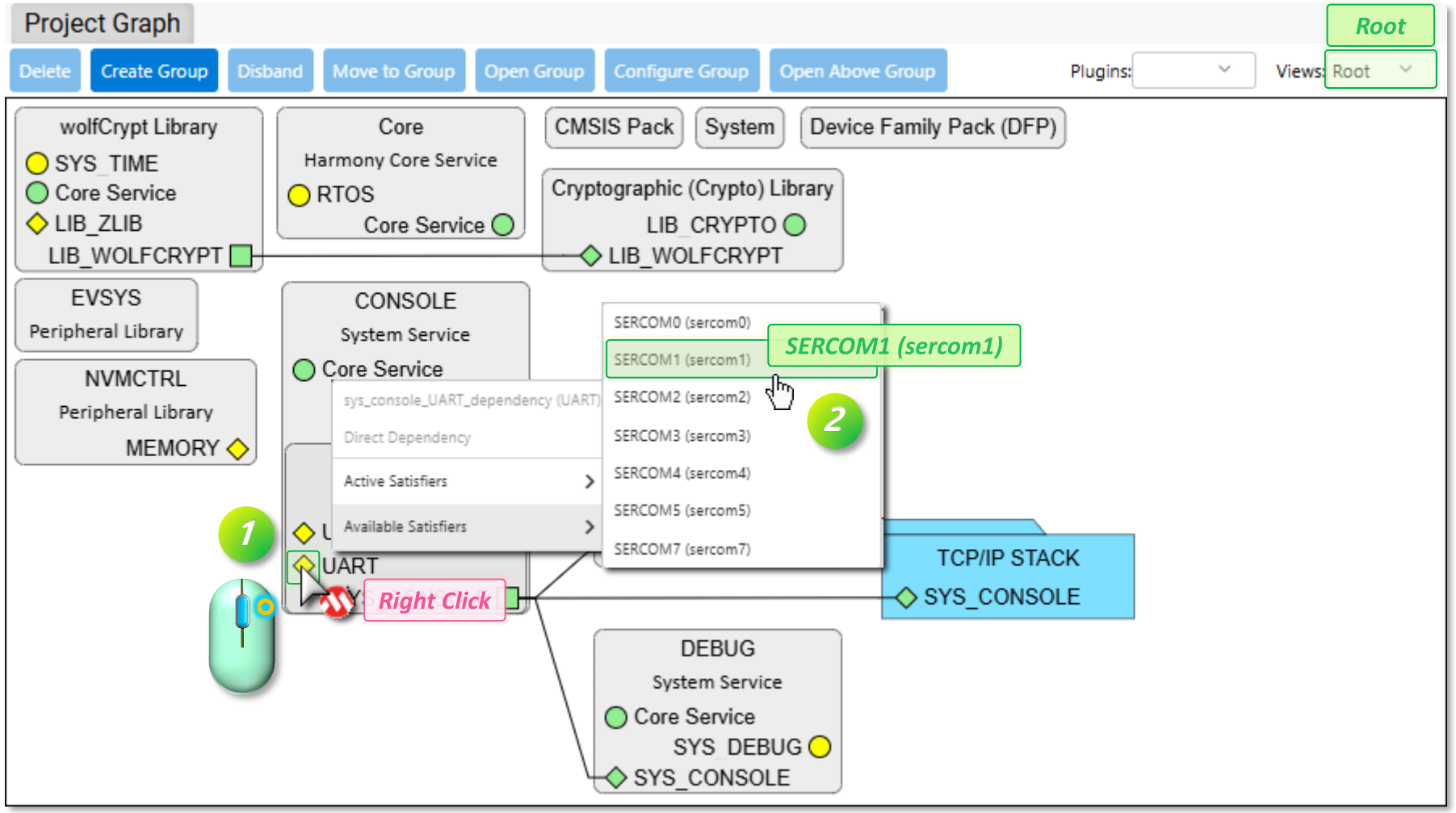
- **Successfully added "DEBUG System Service" as Consumer of "CONSOLE System Service".**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 15

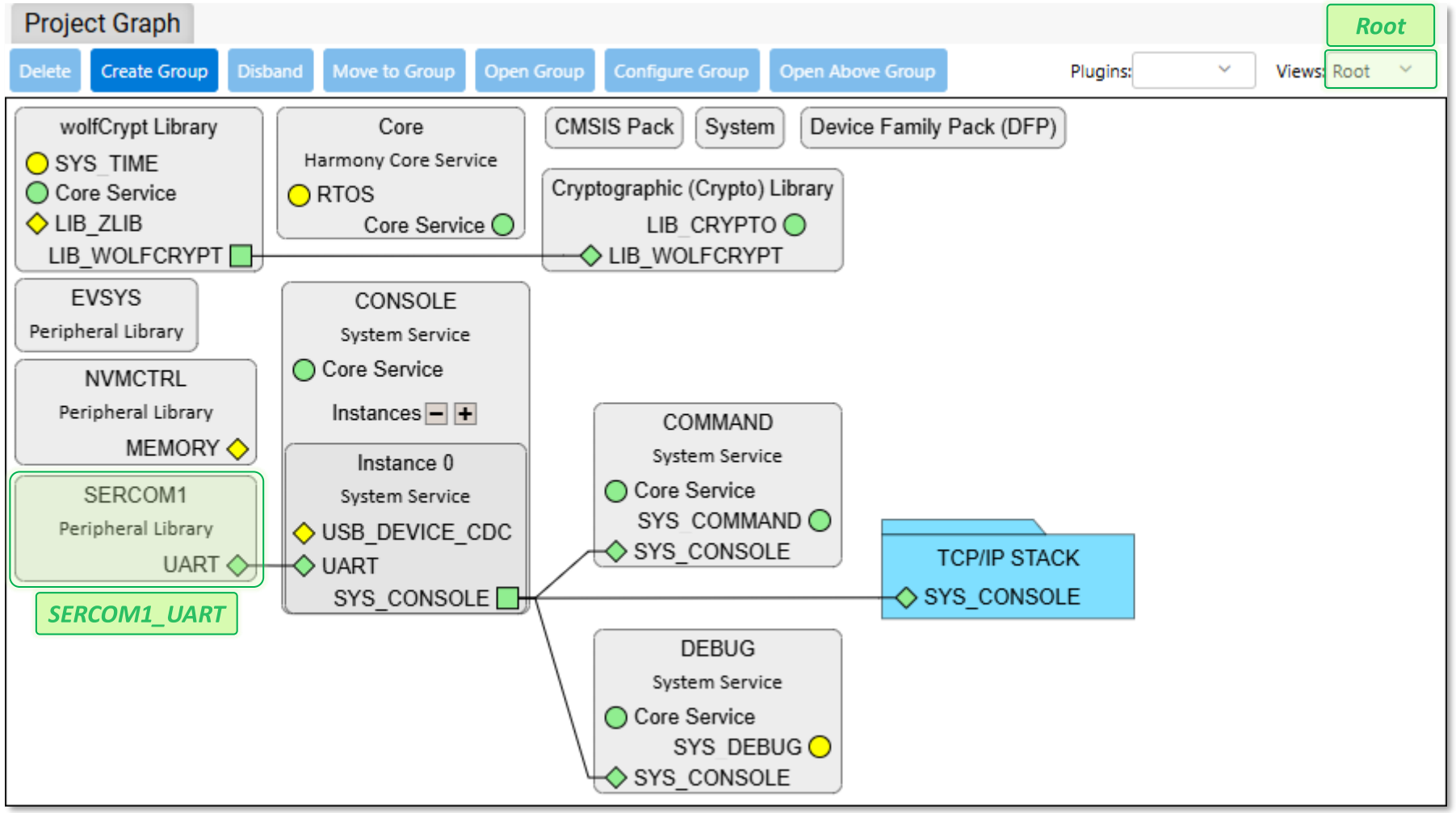
- **Right click on "UART" of CONSOLE System Service , select "SERCOM1" as Satisfiers of it.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 16

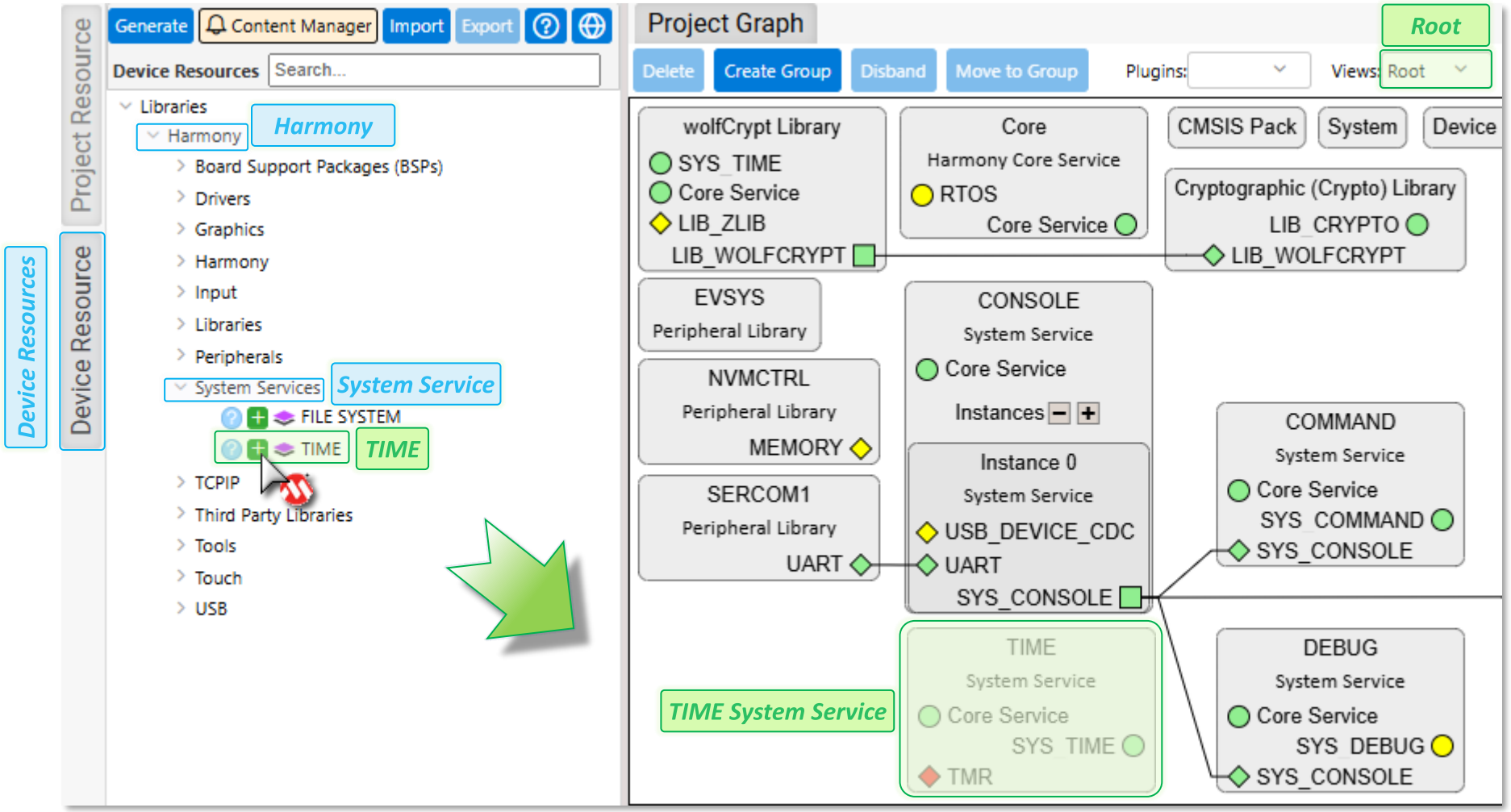
- **Successfully added "SERCOM1_UART" to satisfy "CONSOLE System Service" dependency.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 17

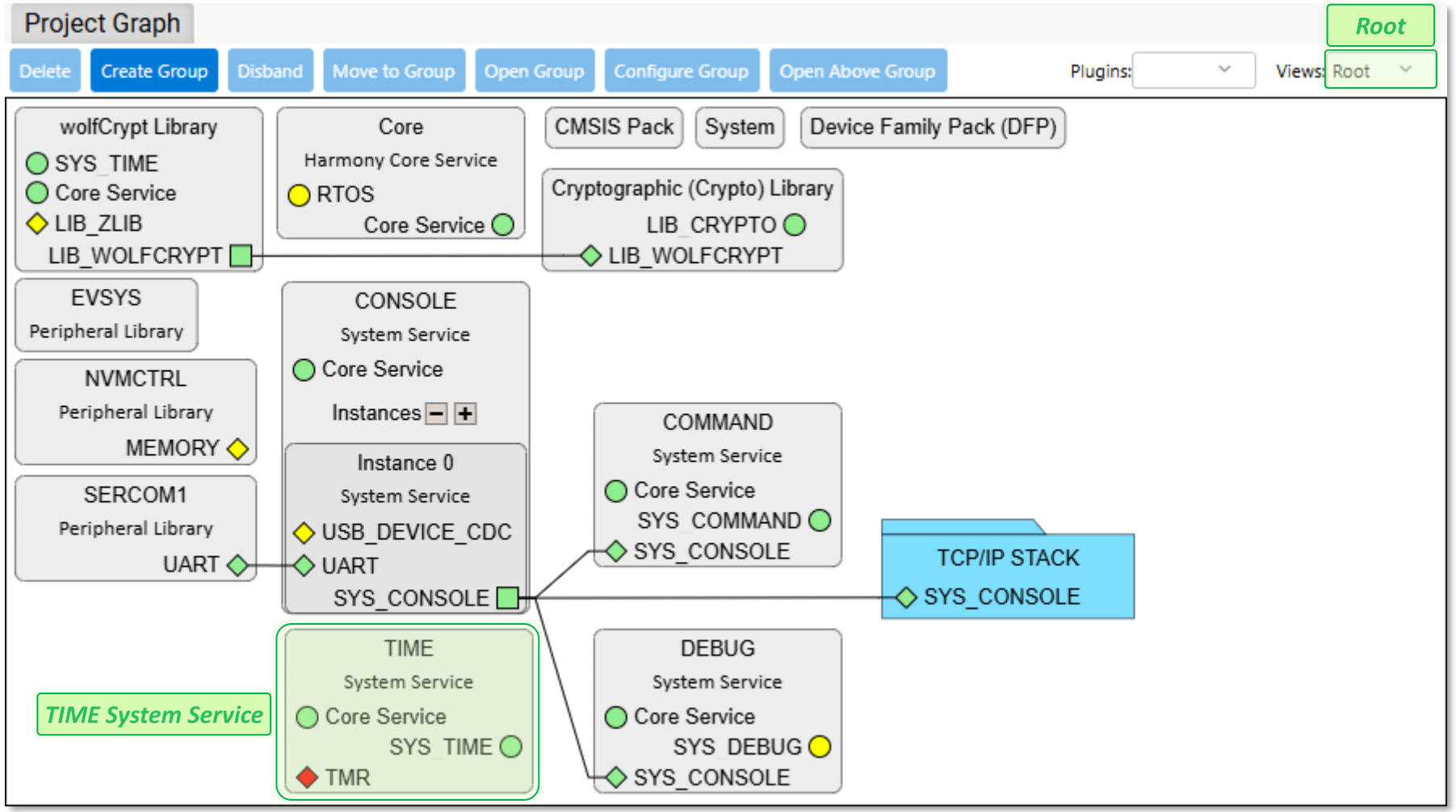
- Add "TIME System Service" from Device Resources of MCC By click TIME.



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 18

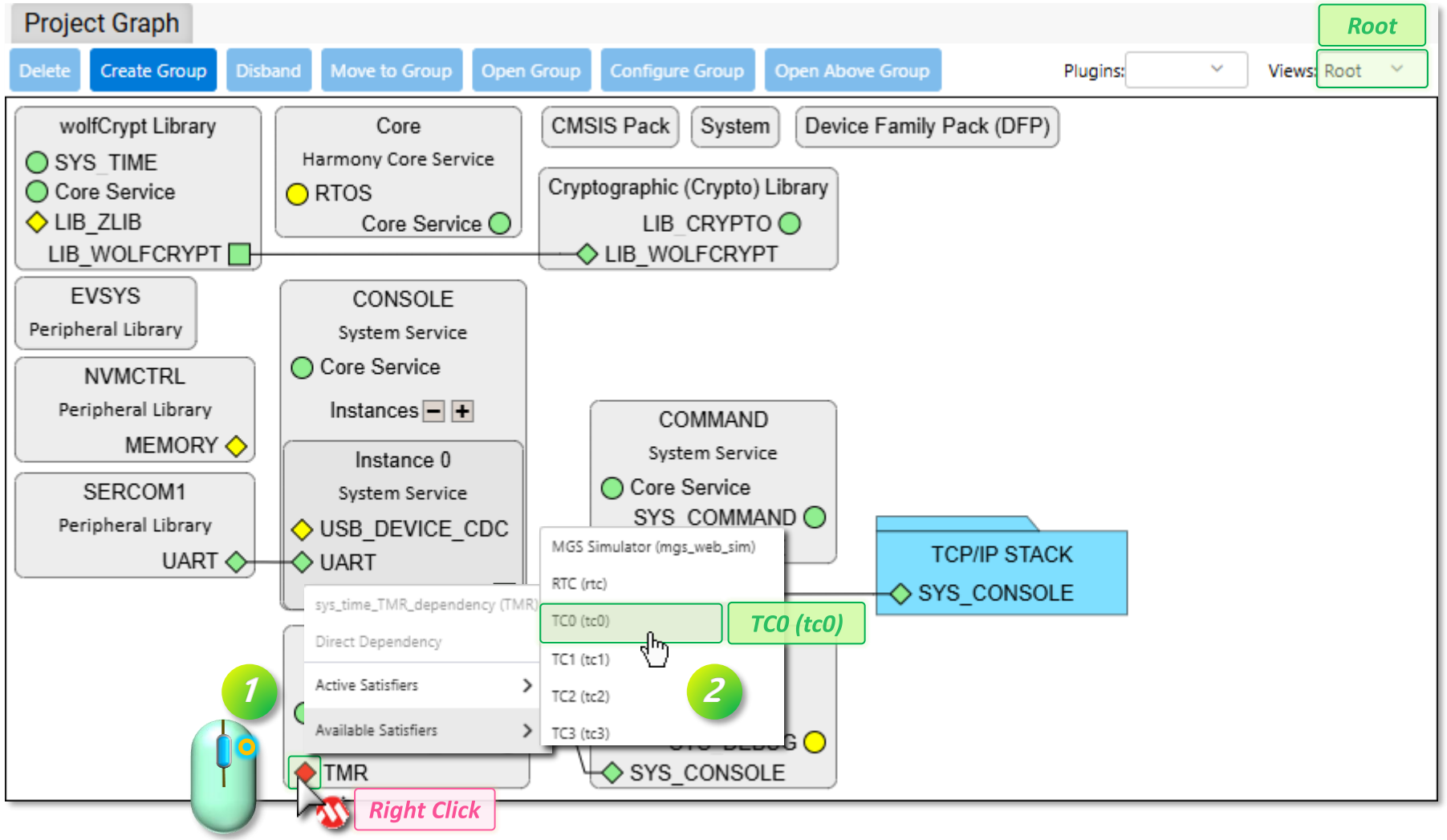
- **Successfully added "TIME System Service" from Device Resources of MCC.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 19

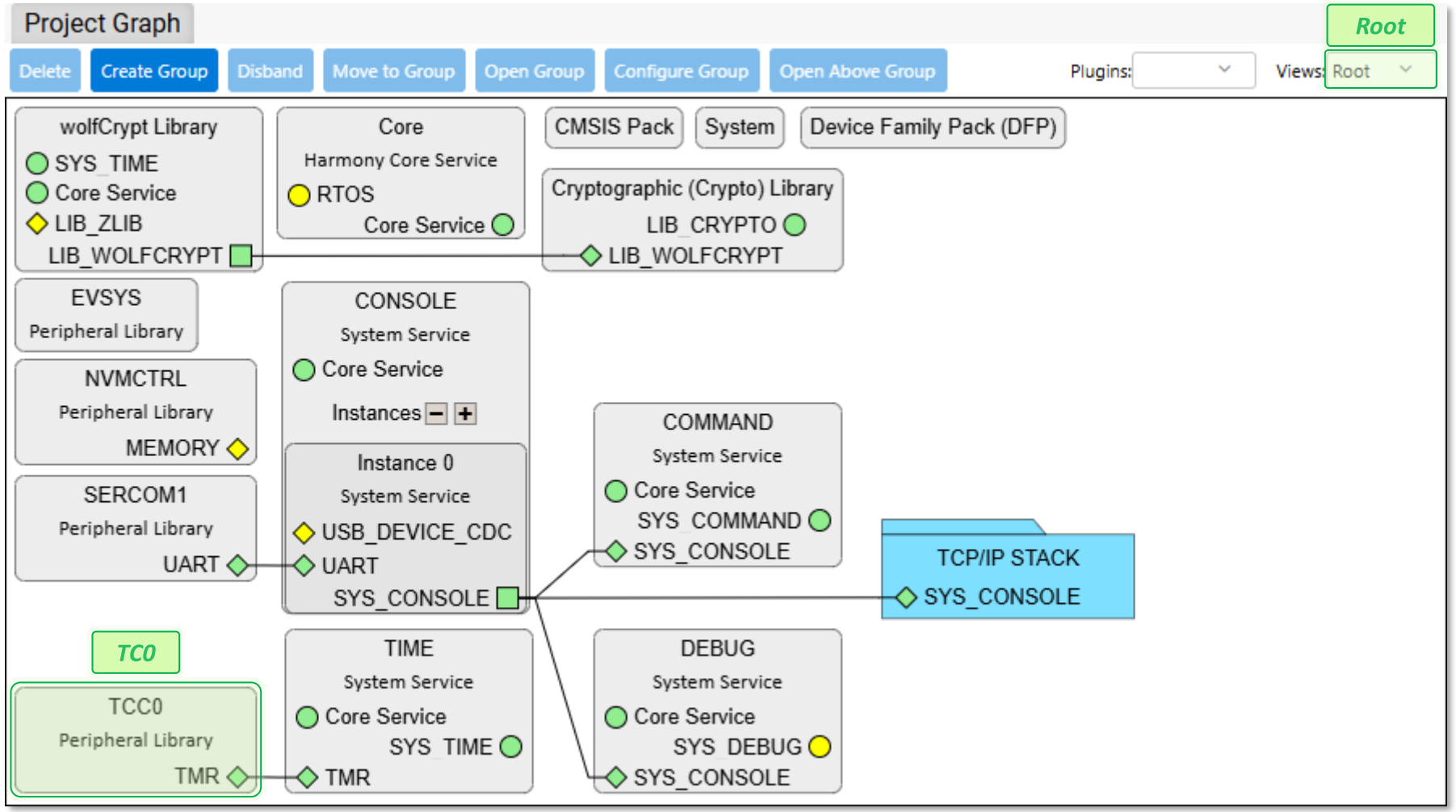
- Right click on "TMR" of TIME System Service , select "TC0" as Satisfiers of it.



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 20

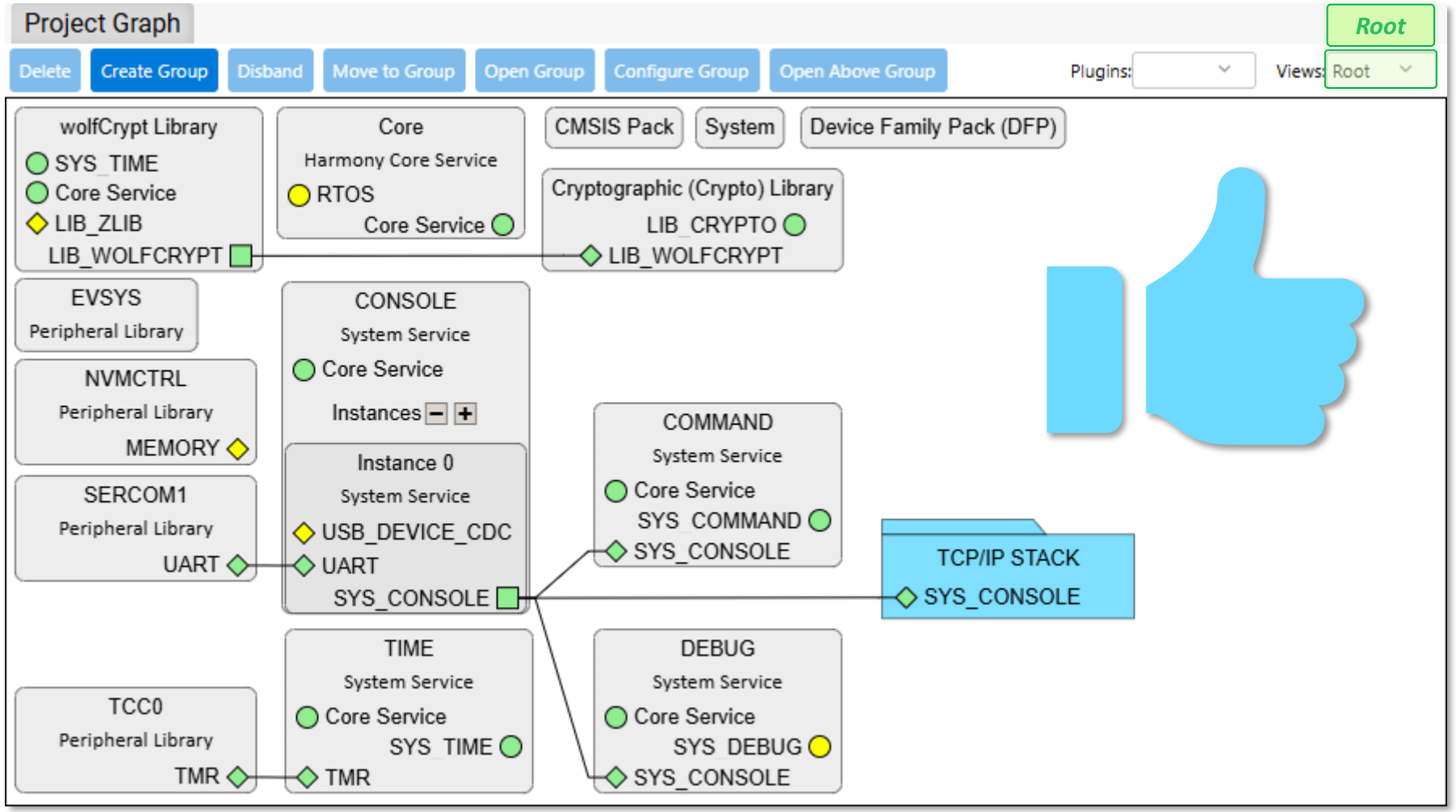
- **Successfully added "TC0" to satisfy "TIME System Service" dependency.**



Added TCP/IP Dependency, System Driver & Peripheral Library

Step 21

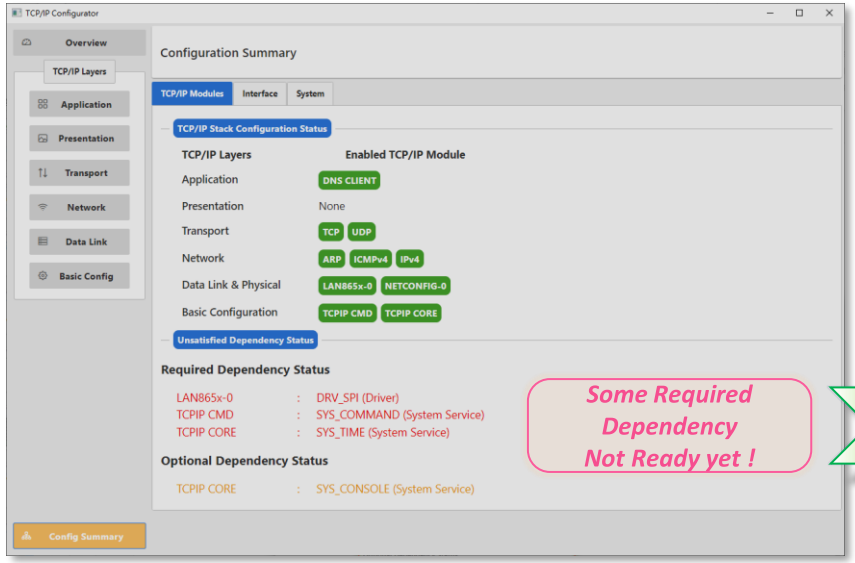
- **Finally, the "Root" layer should look like shown below.**

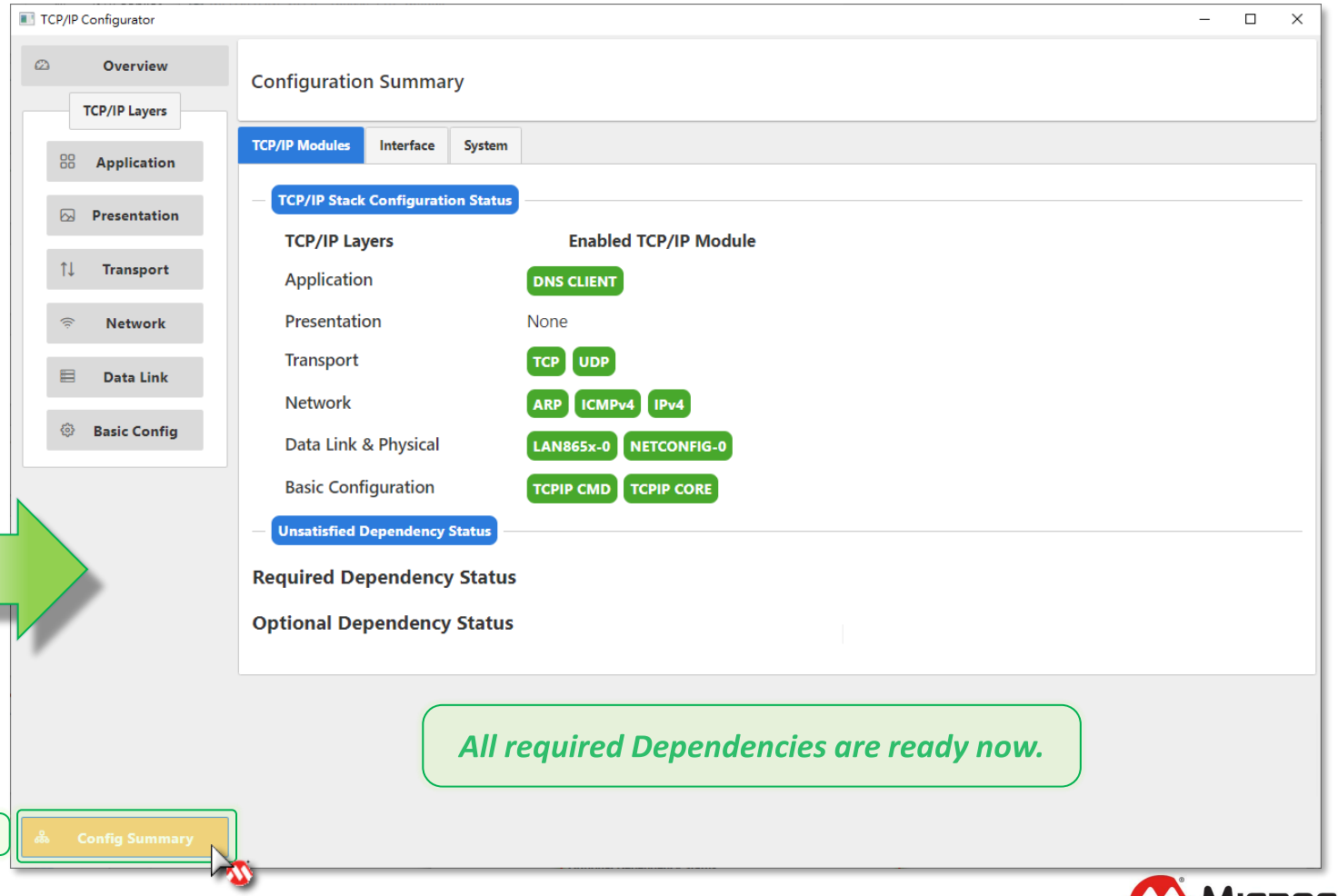


Added TCP/IP Dependency, System Driver & Peripheral Library

Step 22

- **Open the "TCP/IP Configurator" and click the Config Summary to view dependency status.**





MPLAB® Code Configurator (MCC) Configure the Added Modules

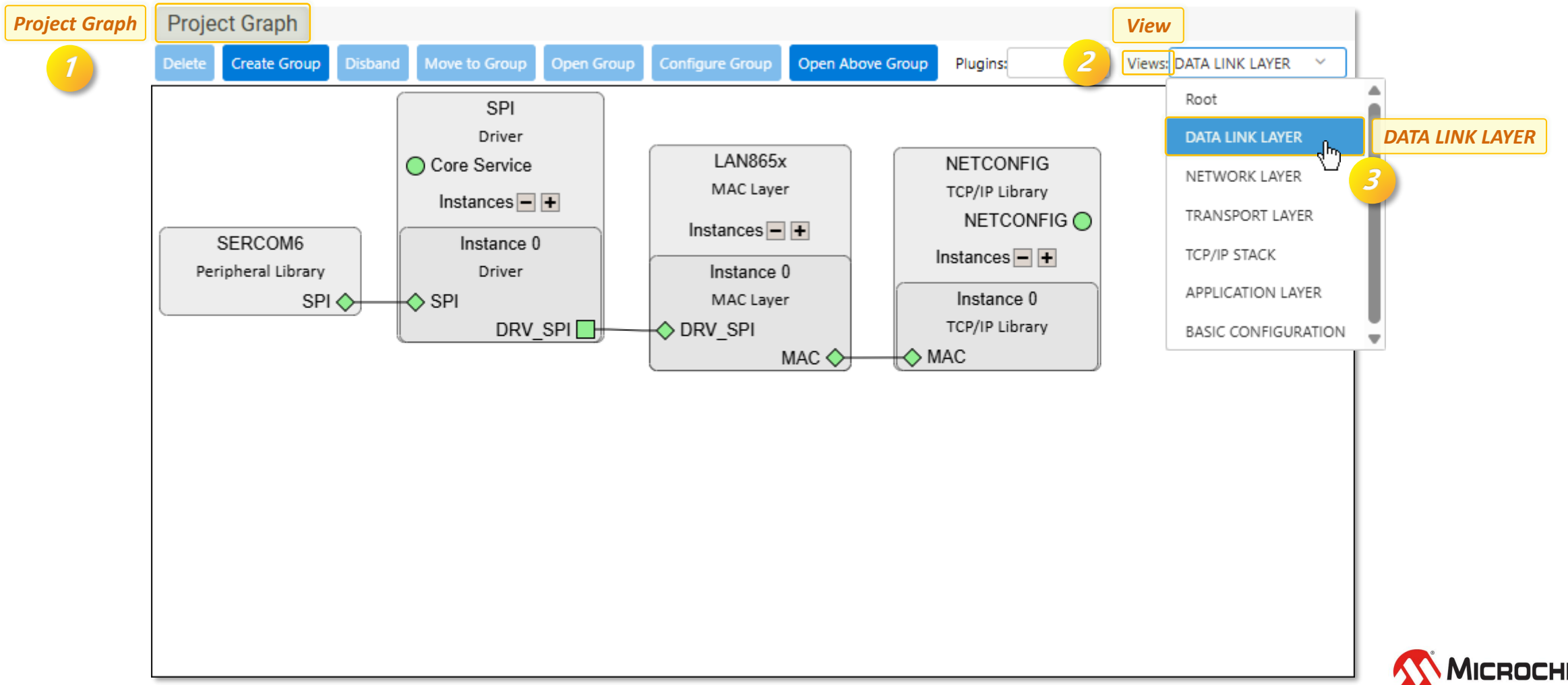
MCC Harmony Configuration

MICROCHIP

Configure the Added Modules

Step 1

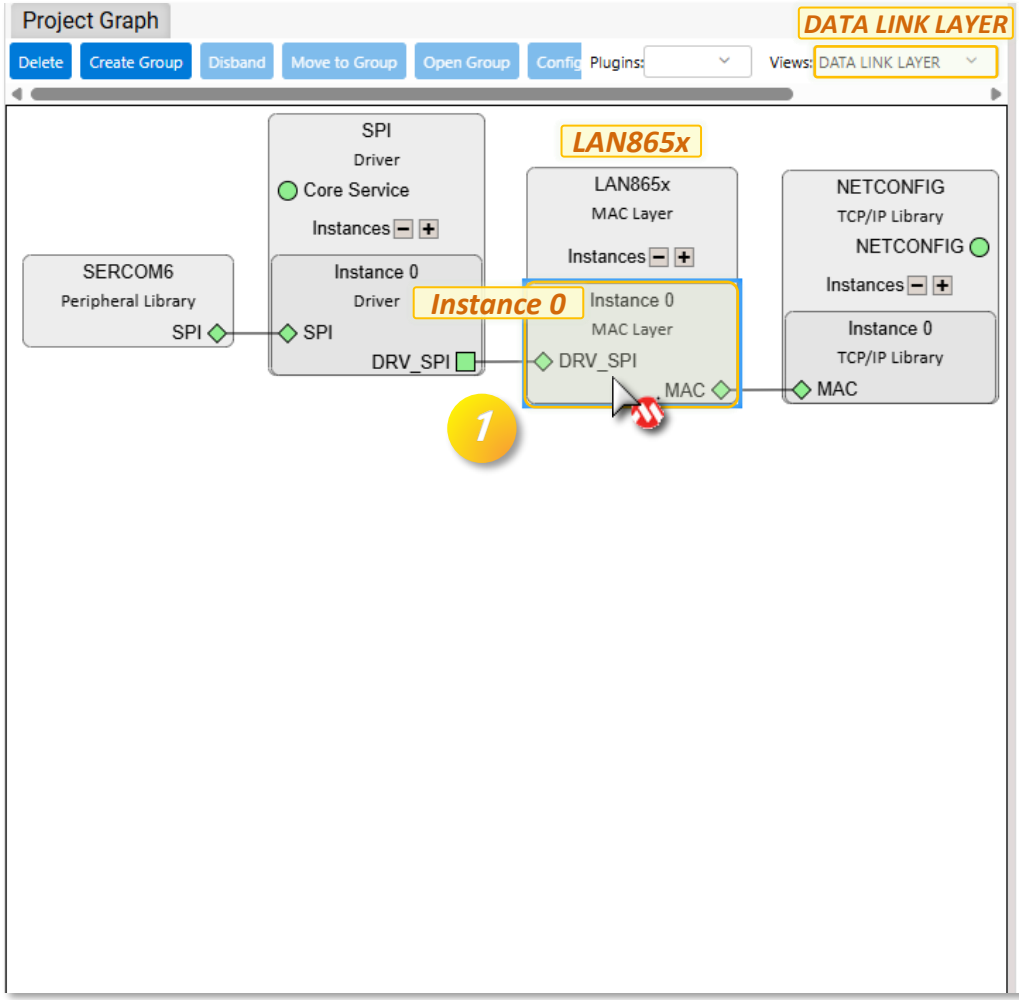
- Return "Project Graph" of MCC Harmony, Select "DATA LINK LAYER" from the "View".

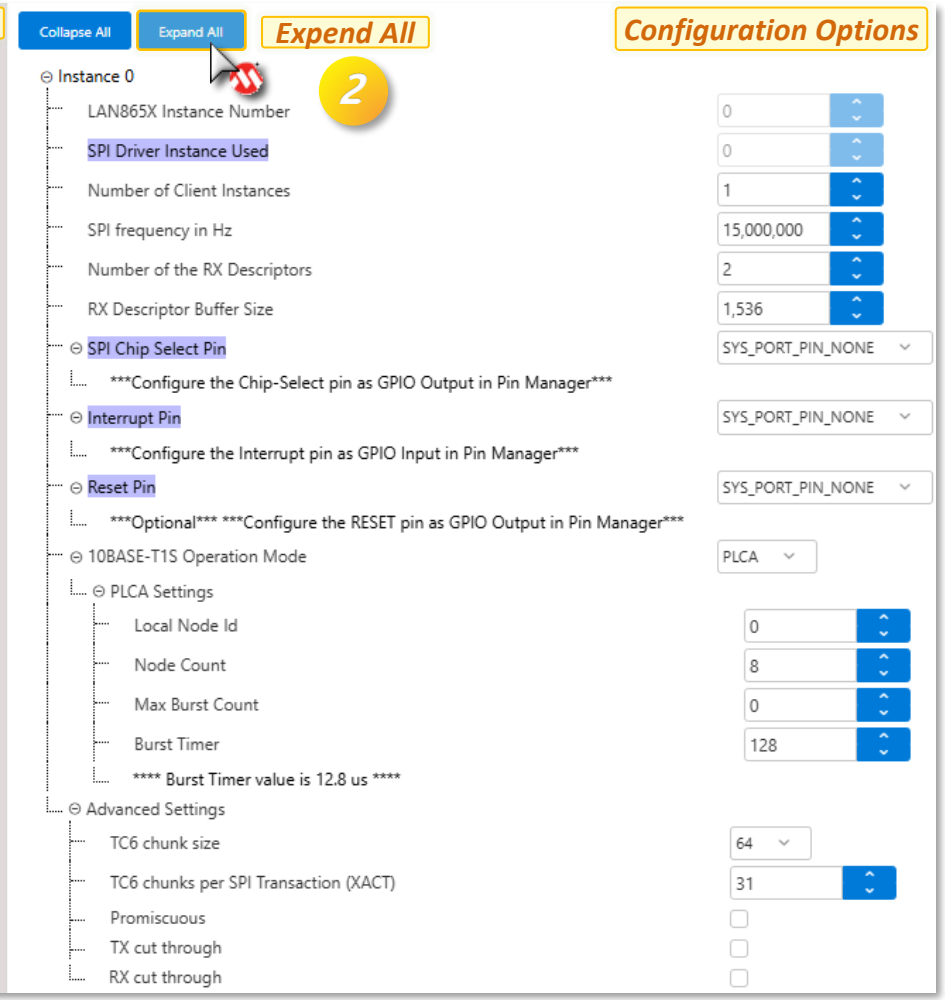


Configure the Added Modules

Step 2

- **Select Instance 0 of LAN865x and Click Expend All to expend options of configuration.**

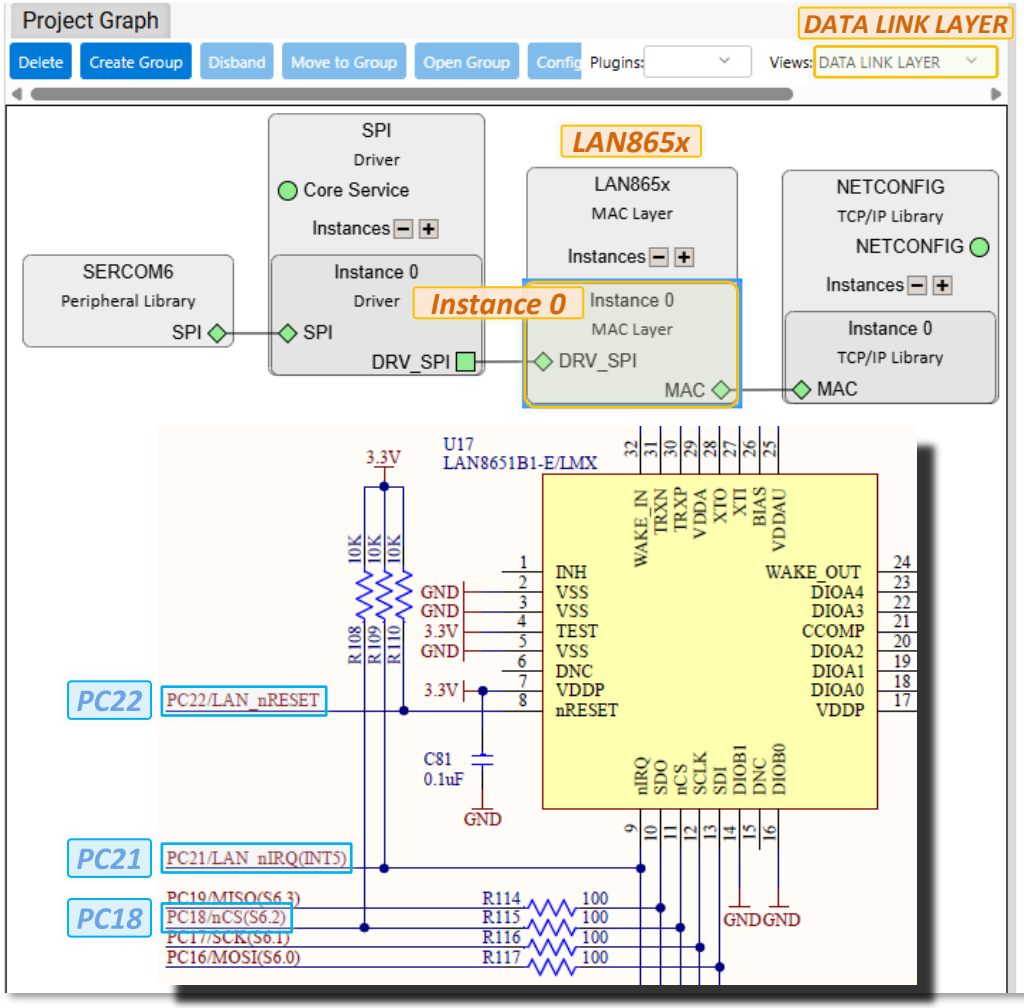


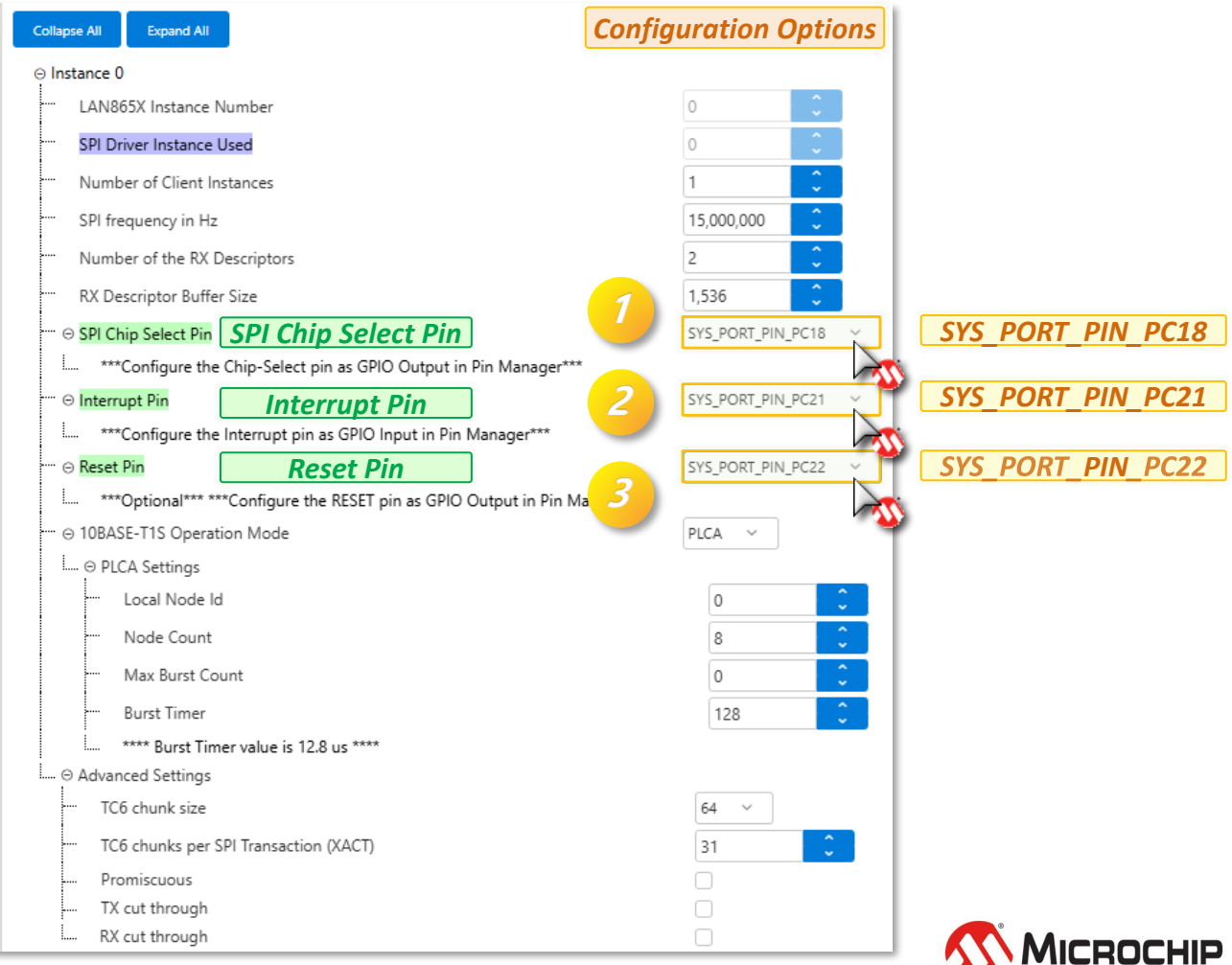


Configure the Added Modules

Step 3

- **Configure GPIO pins (PC18, PC21, PC22) for LAN865x chip (SPI-CS, INT, Reset) as below.**

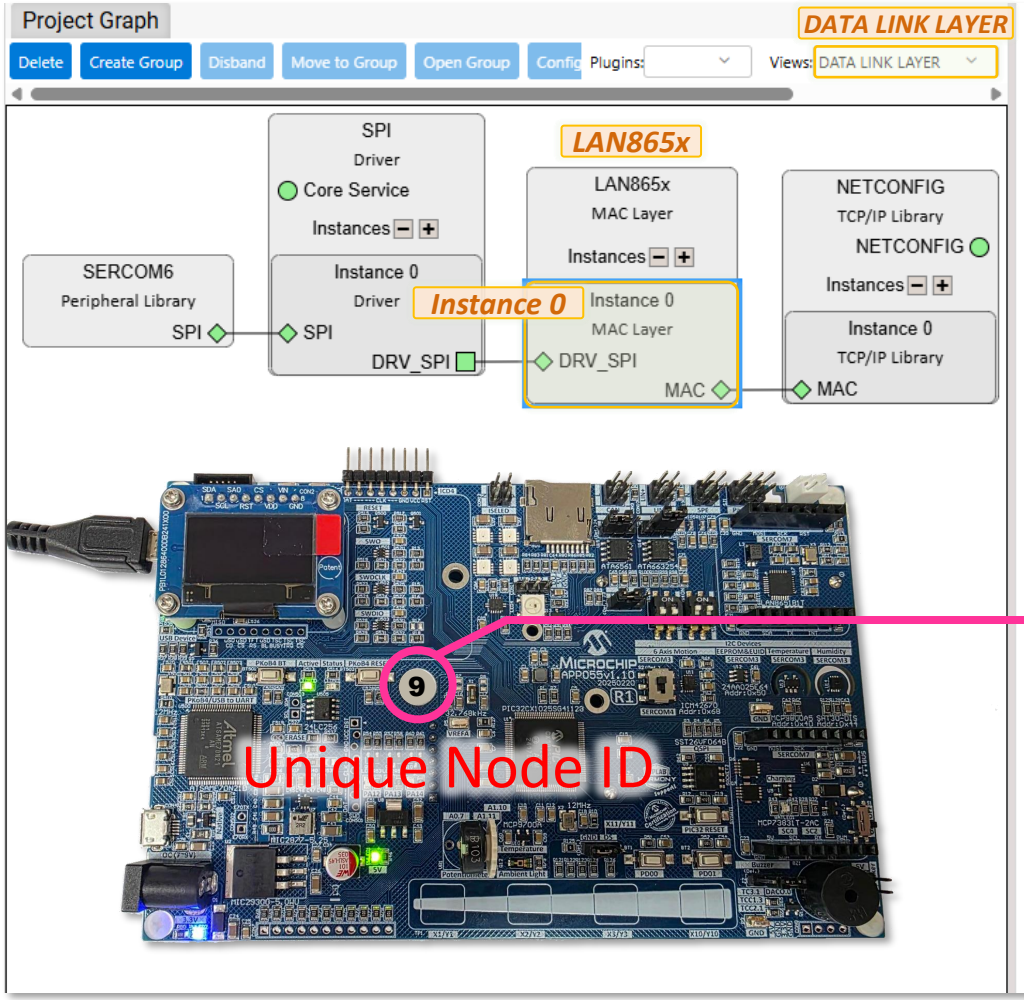




Configure the Added Modules

Step 5

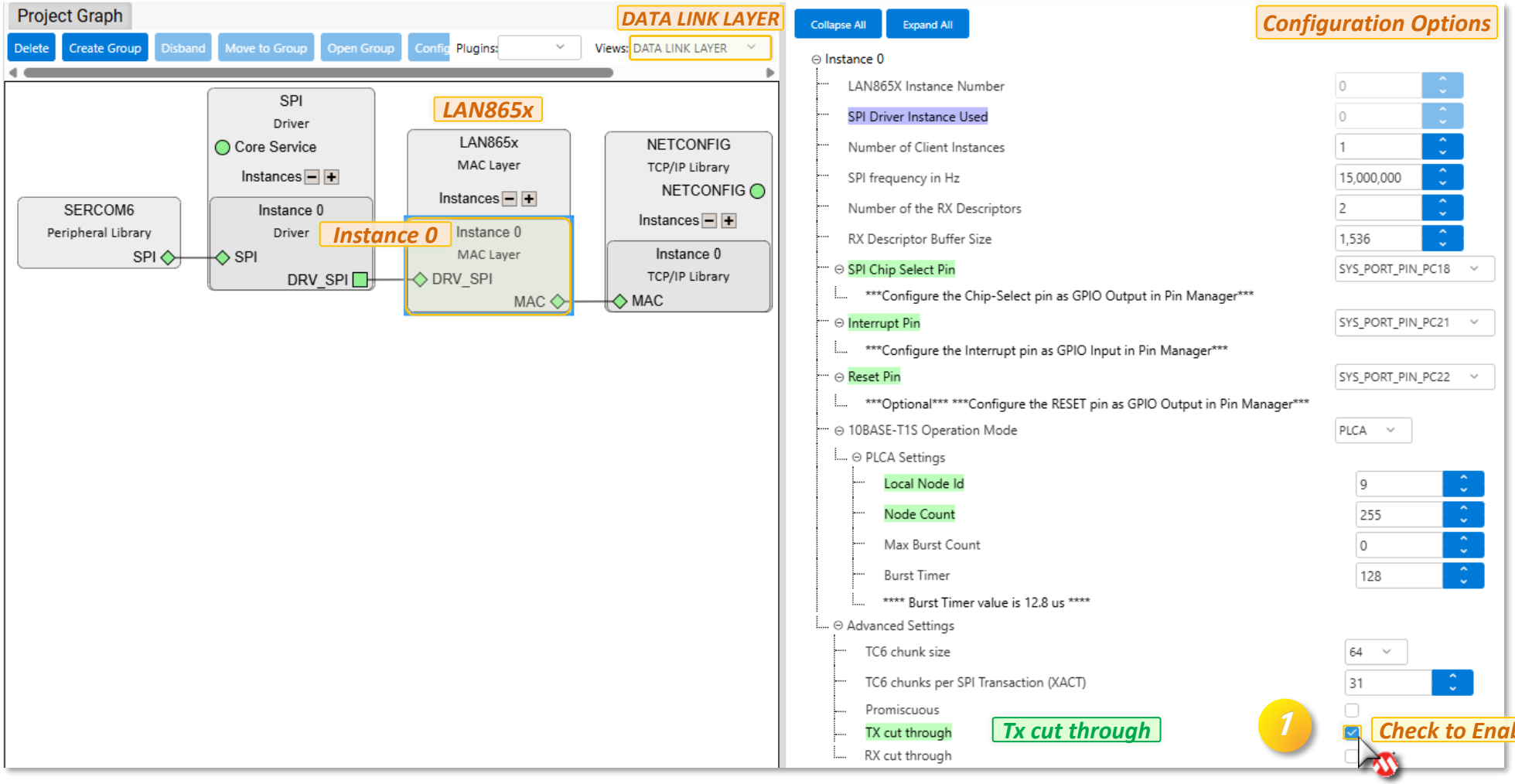
- Configure PLCA Settings, ensure the Local Node Id is unique within T1S network chain.



Configure the Added Modules

Step 6

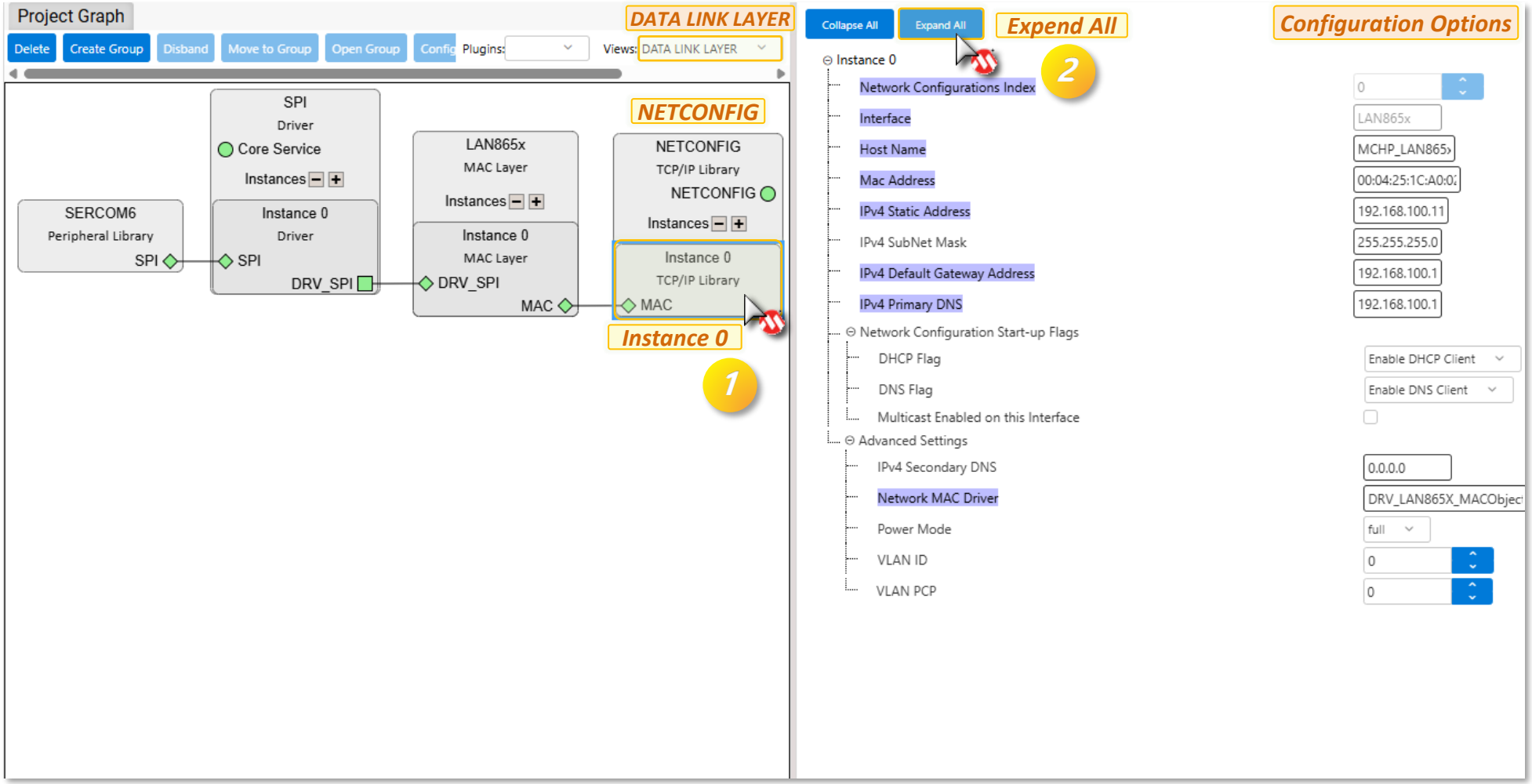
- Configure Advanced Settings, enable the ☑ TX cut through.



Configure the Added Modules

Step 7

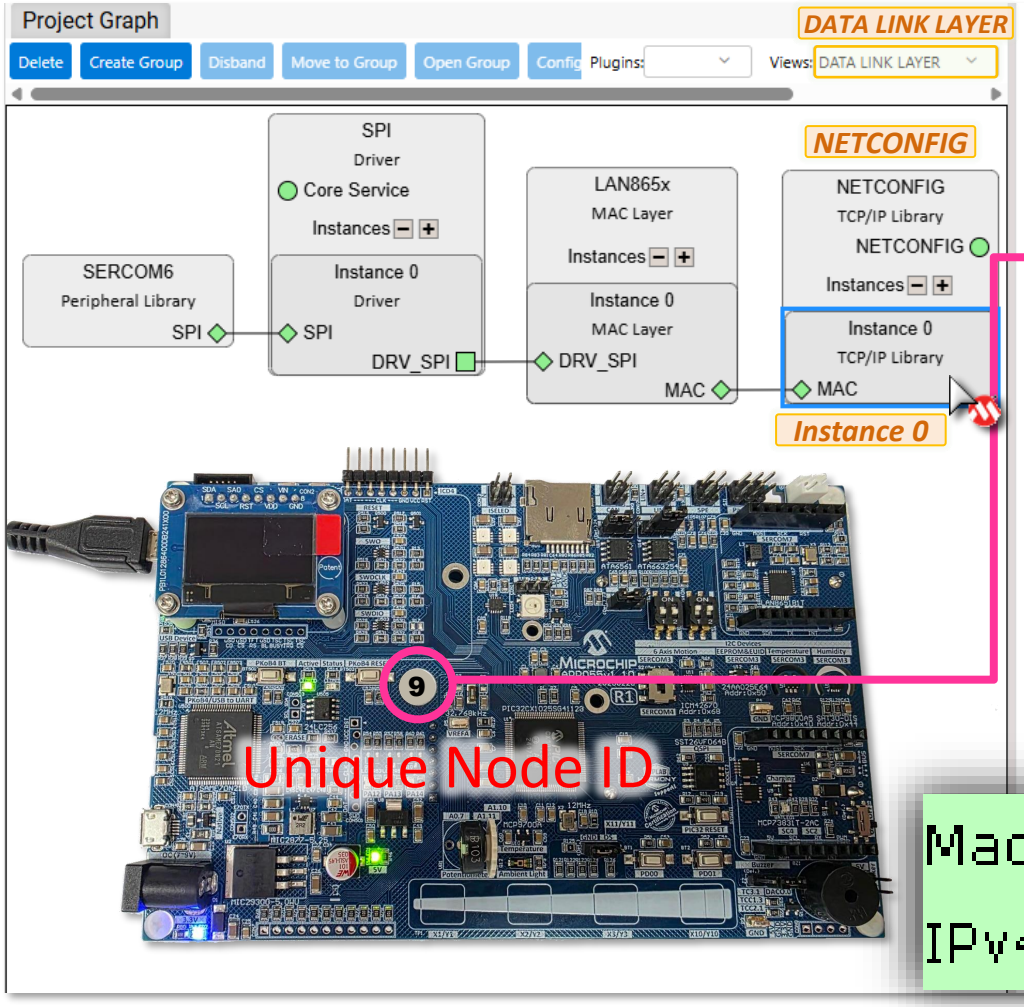
- Select Instance 0 of NETCONFIG and Click Expend All to expend options of configuration.

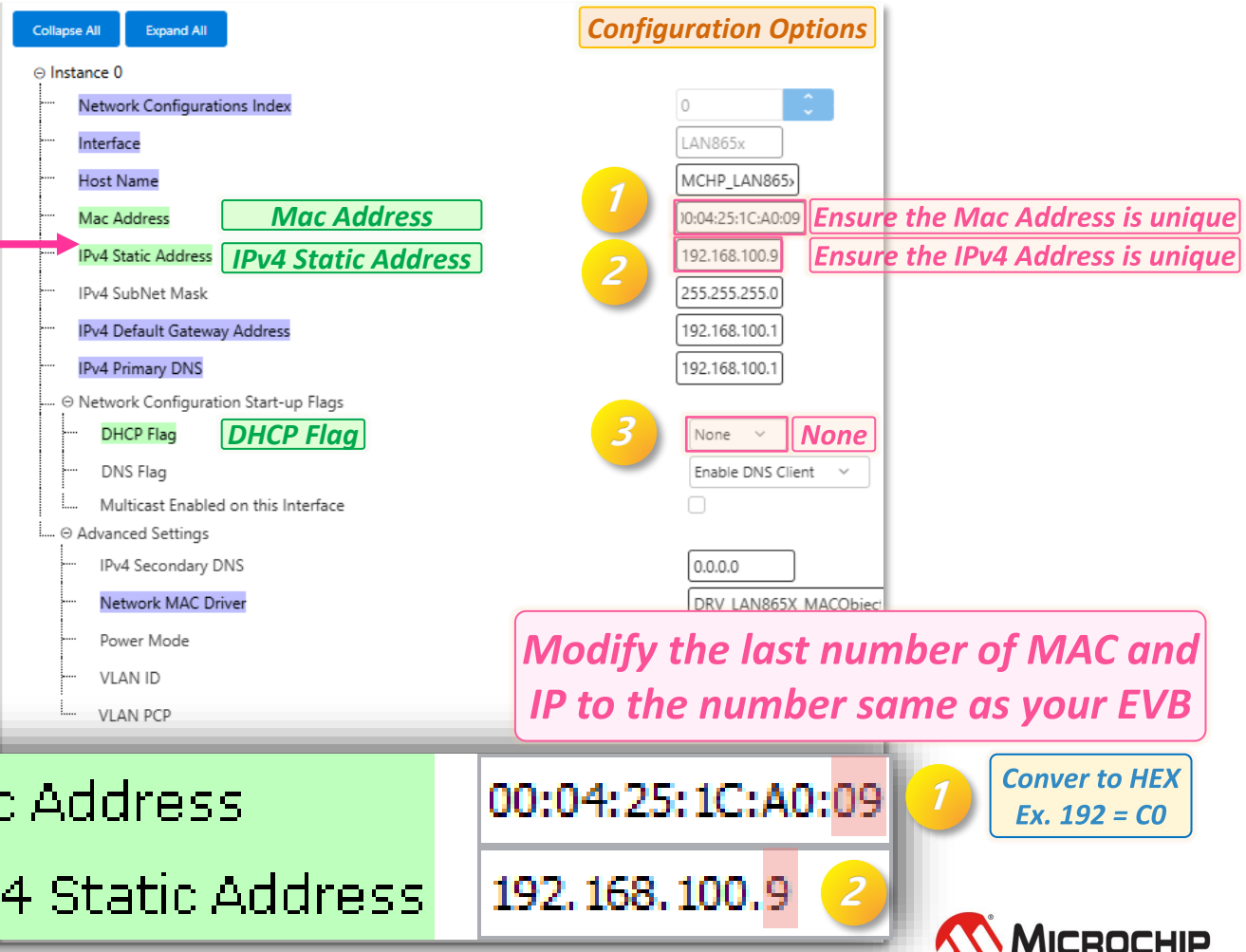


Configure the Added Modules

Step 8

- Ensure IPv4 static and MAC are unique within the T1S network and disable DHCP Flag.

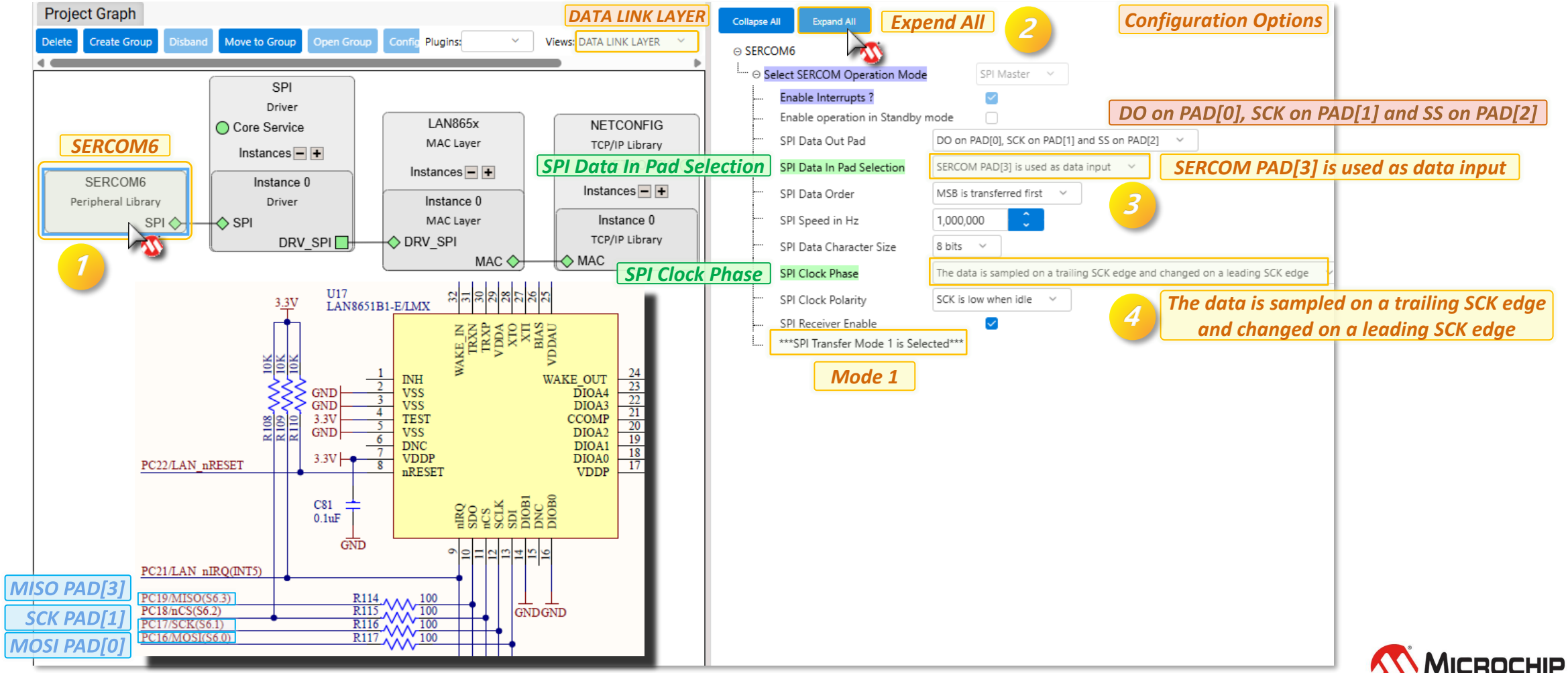




Configure the Added Modules

Step 9

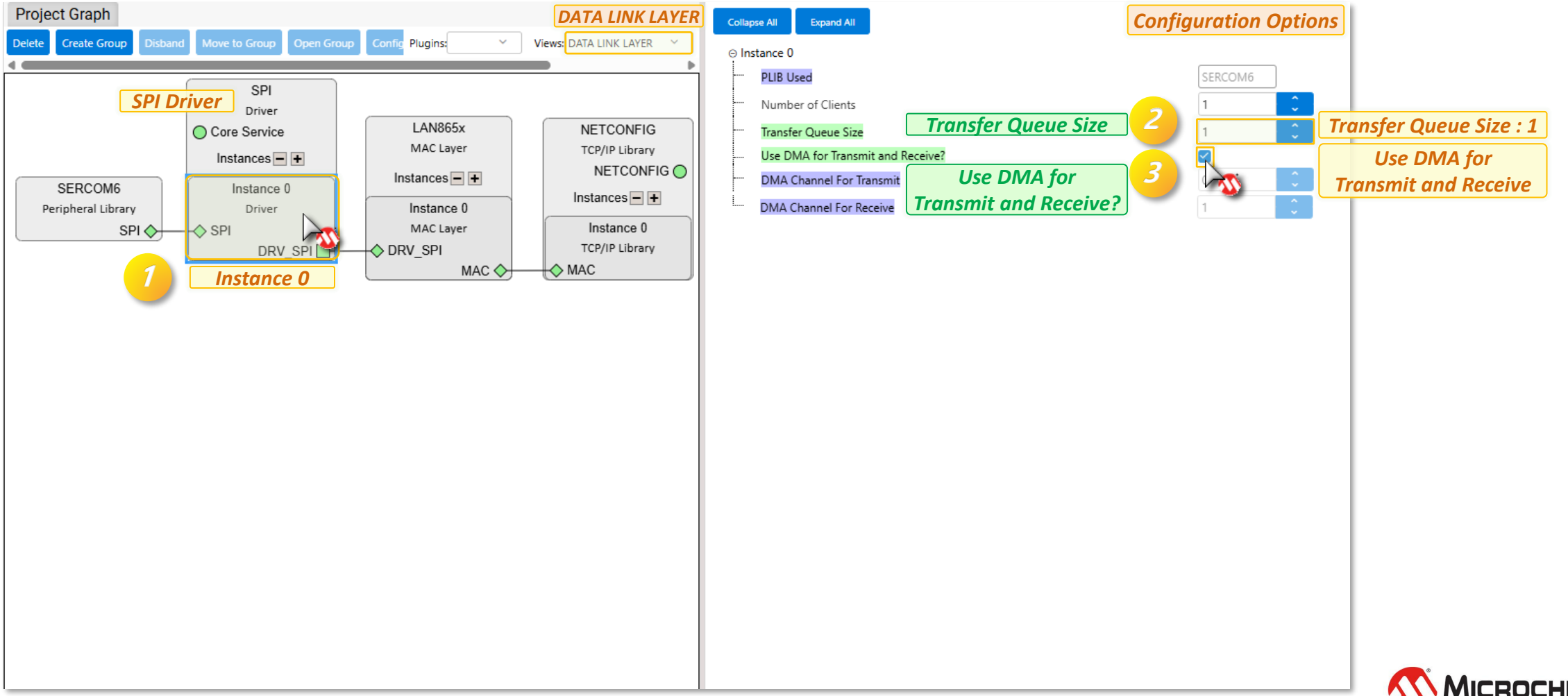
- **Configure the PLIB SERCOM6_SPI for LAN865x chip as below.**



Configure the Added Modules

Step 10

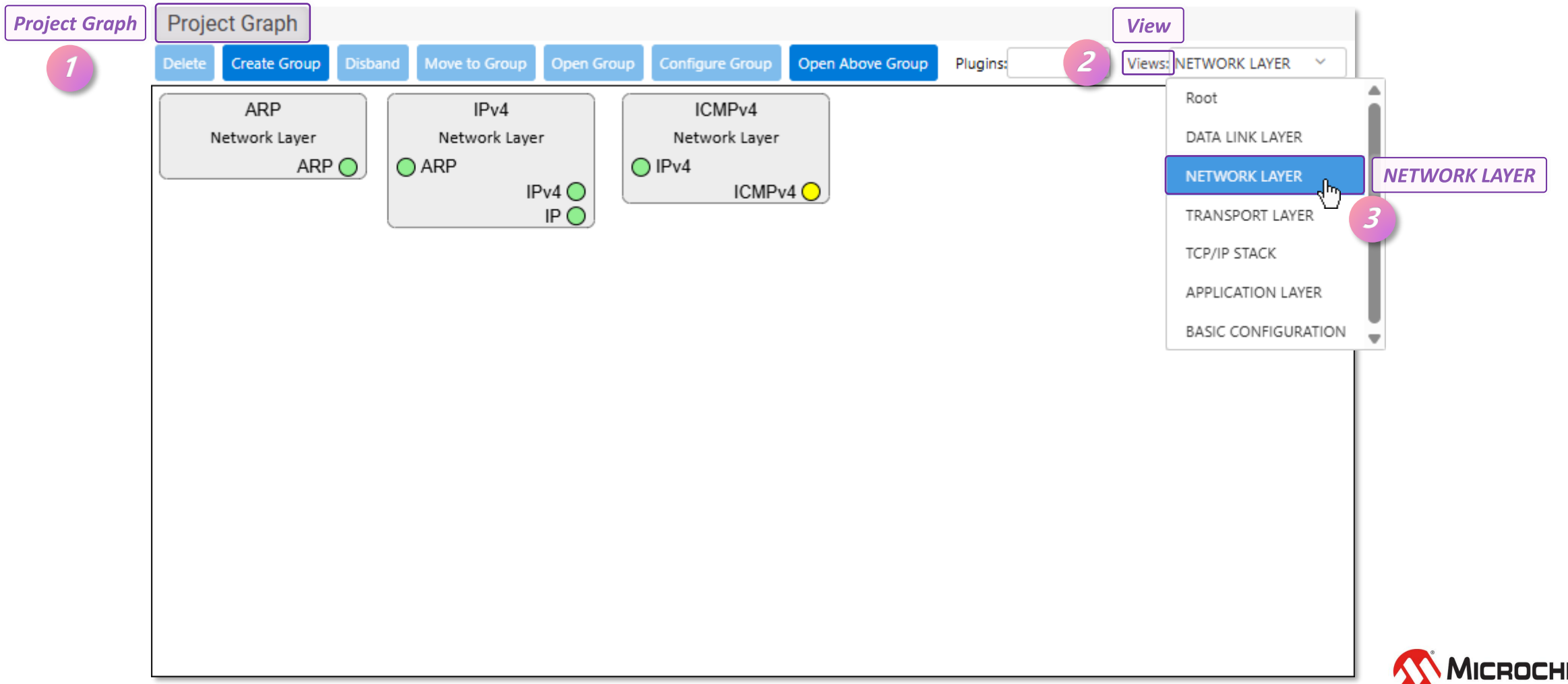
- Configure Instance 0 of SPI Driver, modify Transfer Queue Size to 1 and ☑ Use DMA.



Configure the Added Modules

Step 11

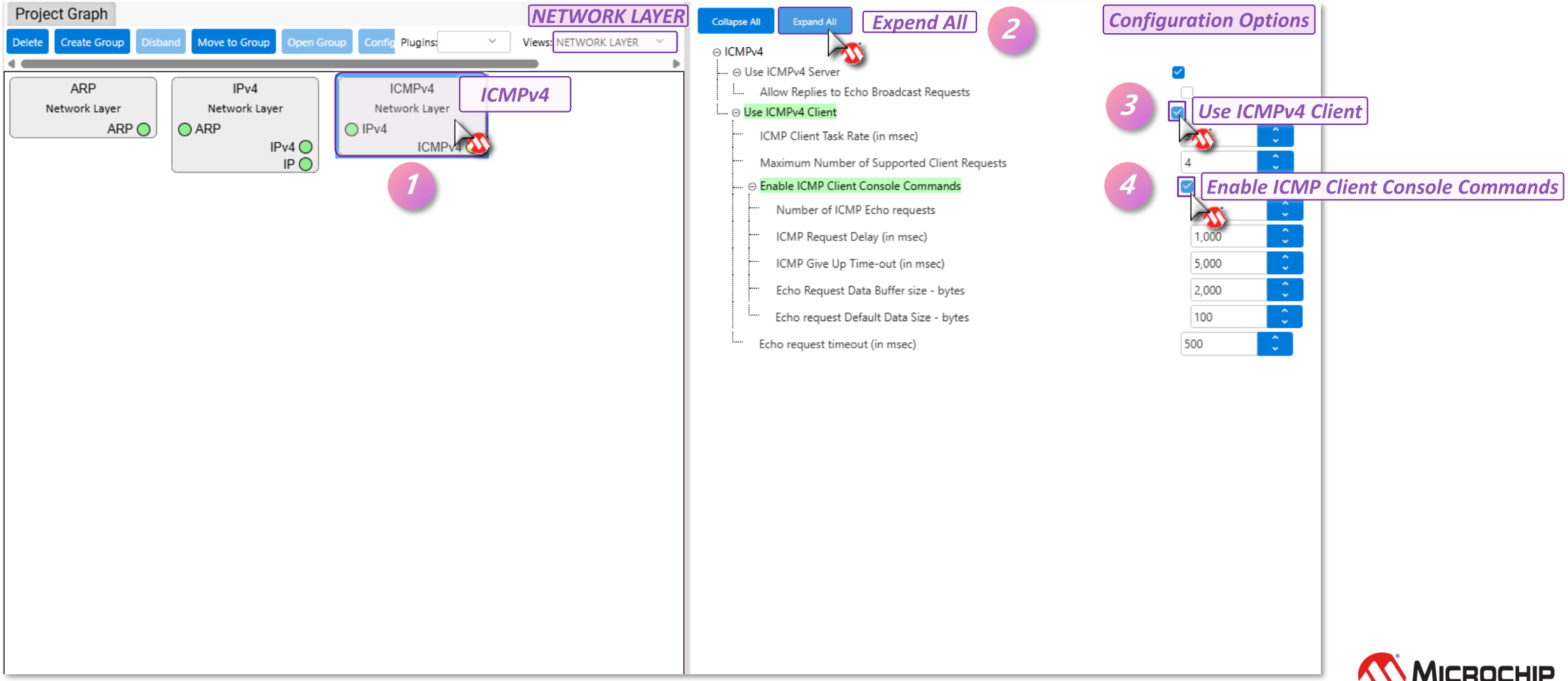
- Return "Project Graph" of MCC Harmony, Select “NETWORK LAYER" from the "View".



Configure the Added Modules

Step 12

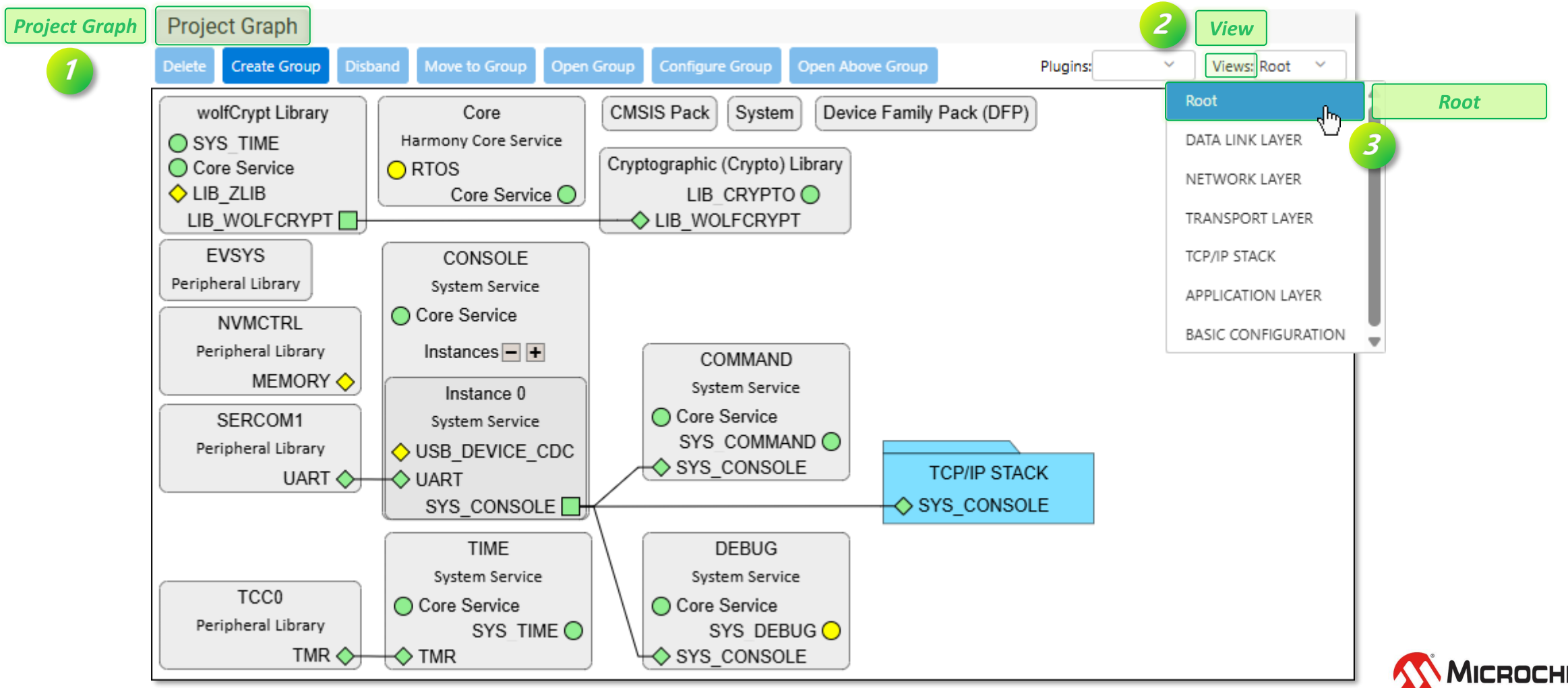
- **Configure ICMPv4, check ☑ Use ICMPv4 Client and ☑ Enable ICMP Client Console Commands.**



Configure the Added Modules

Step 13

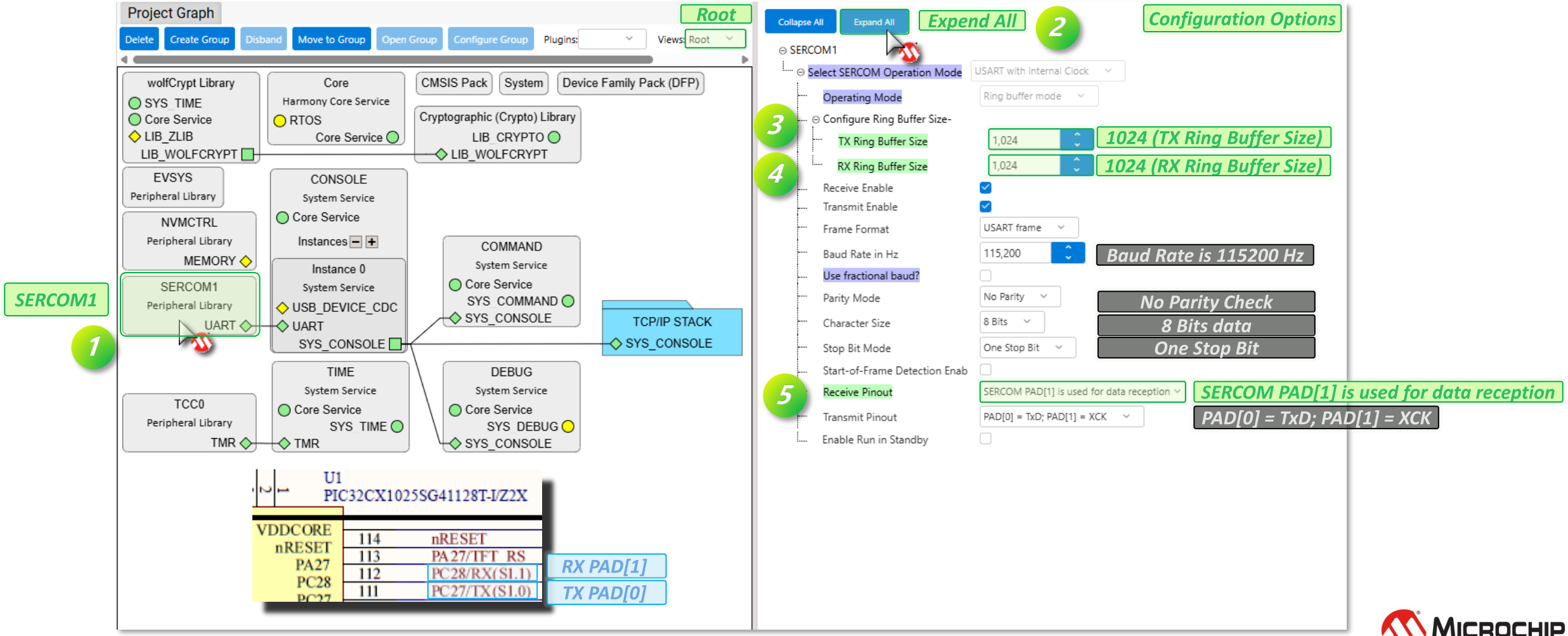
- Select "Root" from the "View".



Configure the Added Modules

Step 14

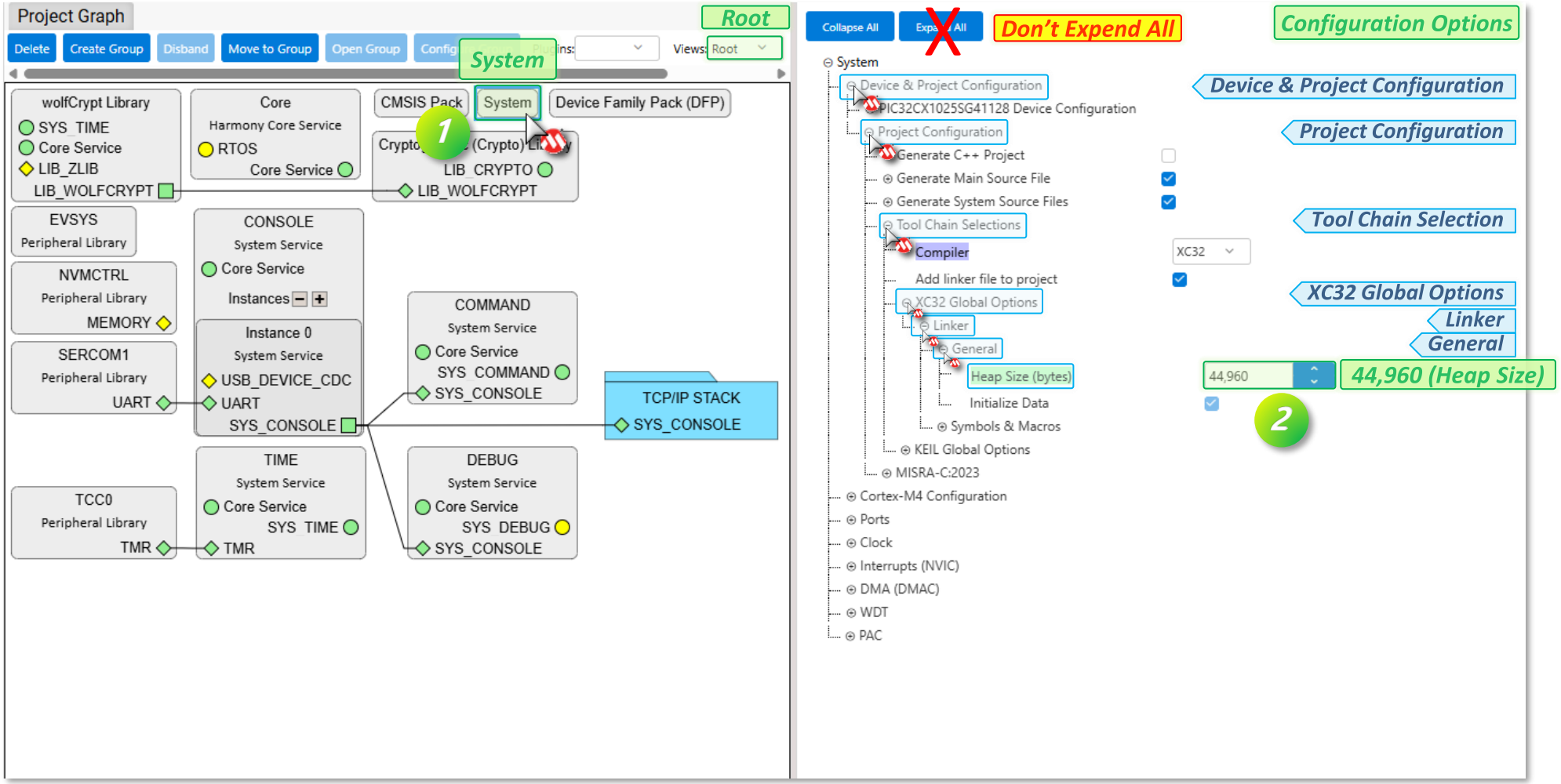
- **Configure the PLIB SERCOM1_UART for USB CDC Debug output as below.**



Configure the Added Modules

Step 15

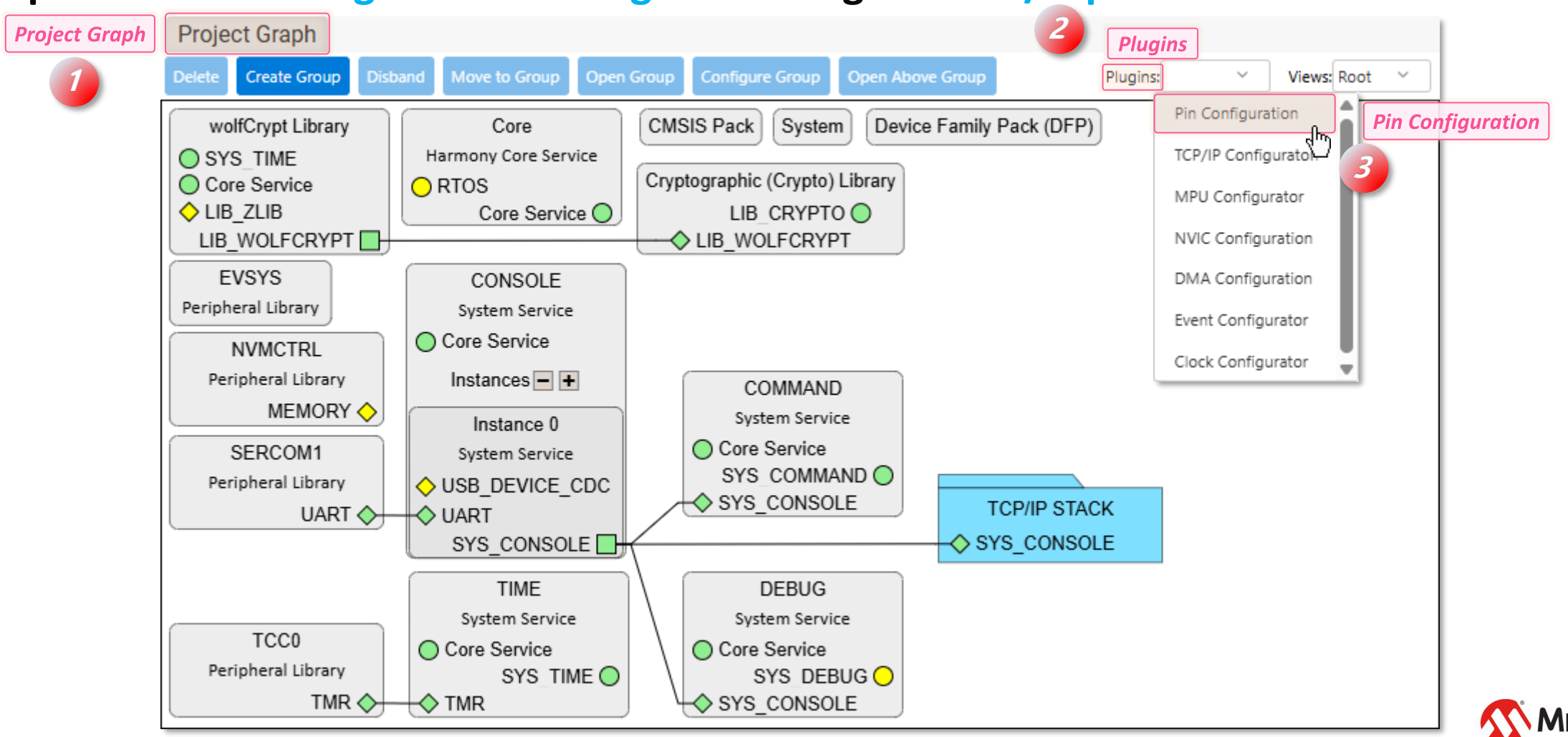
- **Configure the Heap size to 44,960 in System to reserve memory for TCP/IP stack.**



Configure the Added Modules

Step 16

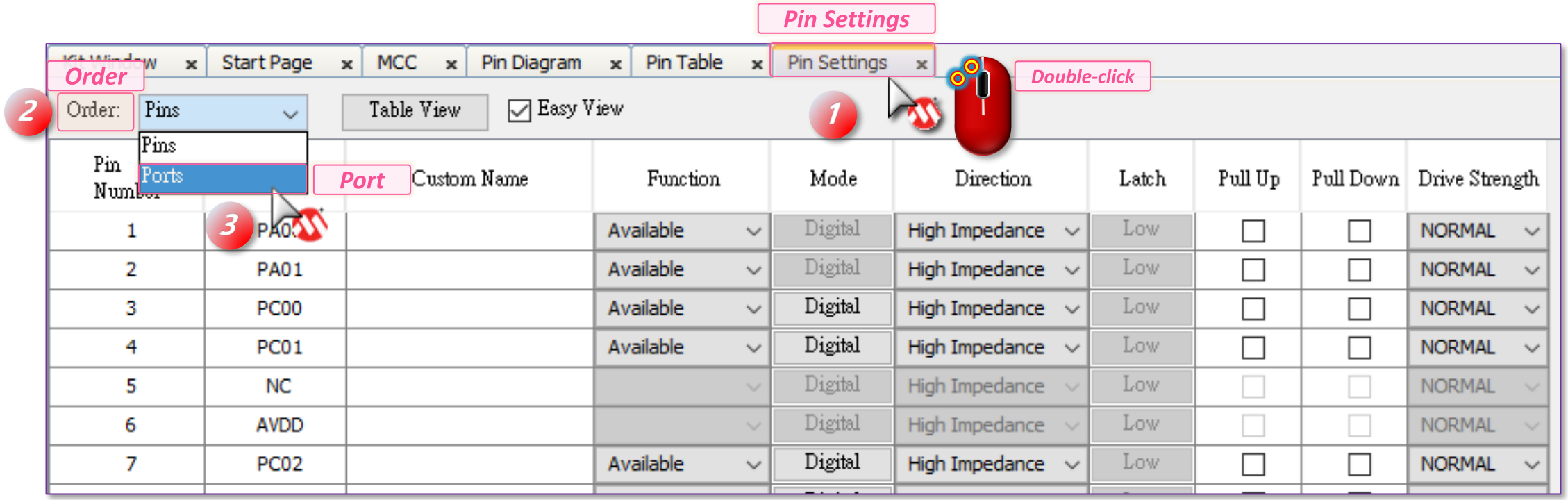
- **Open the Pin Configuration in Plugin to configure the I/O pins.**



Configure the Added Modules

Step 17

- **Double-click the Pin Settings tab to enlarge it and Order the pins by Port.**



Configure the Added Modules

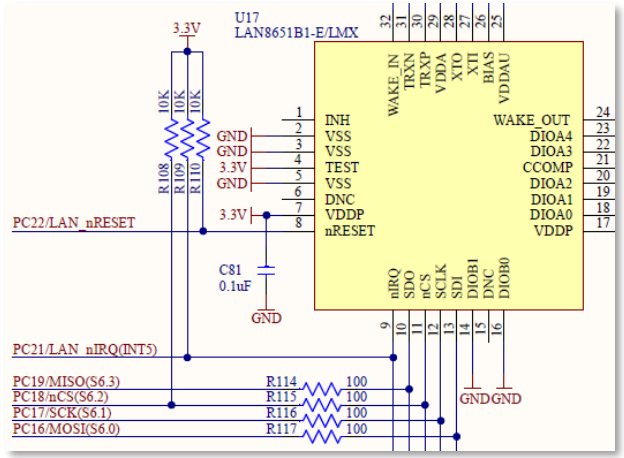
Step 18

- **Configure the SERCOM6_SPI pins as below. (Custom Name of SPI signal is optional)**

Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
70	PC16	PC16	SPI_MOSI	SERCOM6_PAD0	High Impedance	n/a	☐	☐	NORMAL
71	PC17	PC17	SPI_SCK	SERCOM6_PAD1	High Impedance	n/a	☐	☐	NORMAL
72	PC18	PC18	SPI_CS	GPIO	Out	High	☐	☐	NORMAL
73	PC19	PC19	SPI_MISO	SERCOM6_PAD3	High Impedance	n/a	☐	☐	NORMAL

Peripheral	Pin ID	Custom Name	Function	Direction	Latch
SPI (SERCOM6)	PC16		SERCOM6_PAD0		
	PC17		SERCOM6_PAD1		
	PC18	SPI_CS	GPIO	Out	High
	PC19		SERCOM6_PAD3		

Must match the entire word's case without spaces



Configure the Added Modules

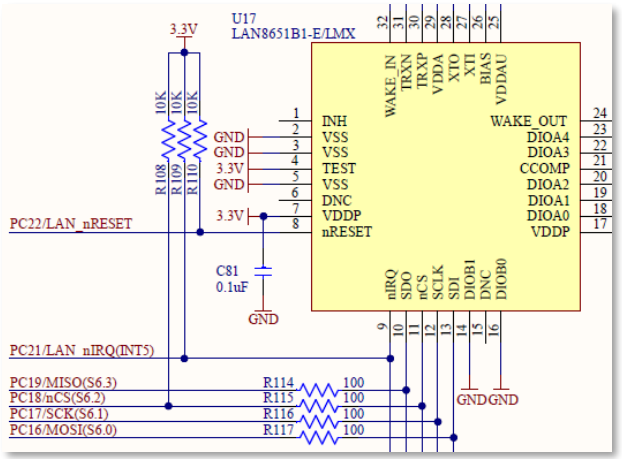
Step 19

- Configure the LAN865x GPIO pins as below. (Custom Name is important)

Pin Number		Pin ID	Custom Name		Function		Mode	Direction		Latch		Pull Up	Pull Down	Drive Strength
75	PC21	PC21	TC6_INT	TC6_INT	GPIO	GPIO	Digital	In	In	Low		☐	☐	NORMAL
76	PC22	PC22	TC6_RESET	TC6_RESET	GPIO	GPIO	Digital	Out	Out	High	High	☐	☐	NORMAL

Peripheral	Pin ID	Custom Name	Function	Direction	Latch
GPIO	PC21	TC6_INT	GPIO	IN	
	PC22	TC6_RESET	GPIO	OUT	High

Must match the entire word's case without spaces



Configure the Added Modules

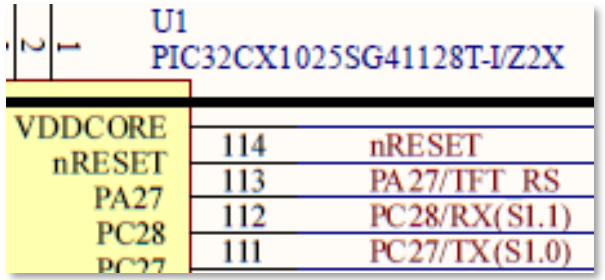
Step 20

- **Configure the SERCOM1_UART pins. (Custom Name of UART signal is optional)**

Custom Name *Function* *Direction* *Latch*

Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
111 *PC27*	PC27	UART_TX	SERCOM1_PAD0 *SERCOM1_PAD0*		High Impedance	n/a	☐	☐	NORMAL
112 *PC28*	PC28	UART_RX	SERCOM1_PAD1 *SERCOM1_PAD1*		High Impedance	n/a	☐	☐	NORMAL

Peripheral	Pin ID	Custom Name	Function	Direction	Latch
UART (SERCOM1)	PC27		SERCOM1_PAD0		
	PC28		SERCOM1_PAD1		



MICROCHIP

Configure the Added Modules

Step 21

- Configure the LED1, LED2 and LED3 on GPIO pin output PA12, PA13 and PA15.
- Configure the user buttons BT1 and BT2 on GPIO pin input PD00 and PD01.

Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
60 PA12	PA12	LED1 LED1	GPIO GPIO	Digital	Out Out	Low Low	☐	☐	NORMAL
61 PA13	PA13	LED2 LED2	GPIO GPIO	Digital	Out Out	Low Low	☐	☐	NORMAL
62	PA14		Available	Digital	High Impedance	Low	☐	☐	NORMAL
63 PA15	PA15	LED3 LED3	GPIO GPIO	Digital	Out Out	Low Low	☐	☐	NORMAL
13 PD00	PD00	BT1 BT1	GPIO GPIO	Digital	In In	Low	☐	☐	NORMAL
16 PD01	PD01	BT2 BT2	GPIO GPIO	Digital	In In	Low	☐	☐	NORMAL

Peripheral	Pin ID	Custom Name	Function	Direction	Latch
LED1	PA12	LED1	GPIO	Out	Low
LED2	PA13	LED2	GPIO	Out	Low
LED3	PA15	LED3	GPIO	Out	Low
BT1	PD00	BT1	GPIO	In	
BT2	PD01	BT2	GPIO	In	

Configure the Added Modules

Step 22

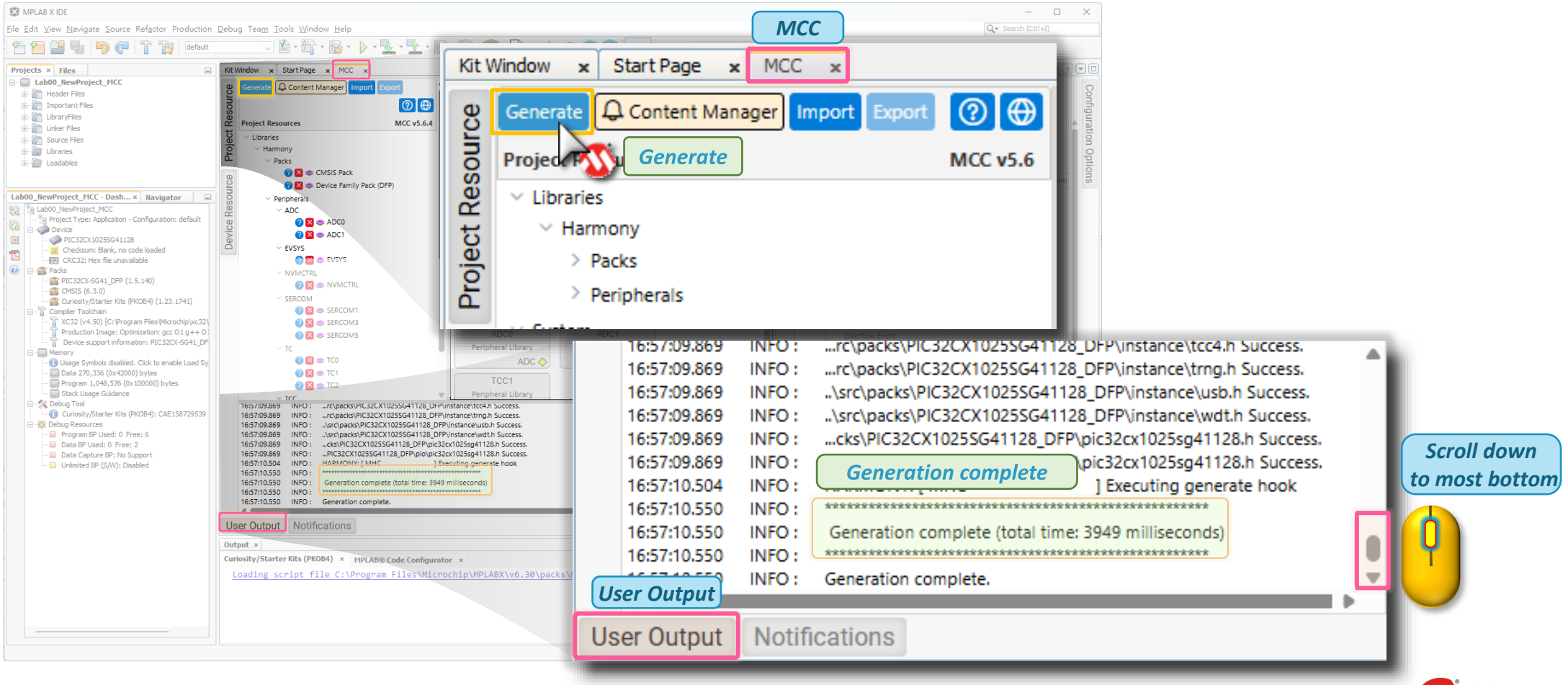
- **Overview of completed Pin Configuration result.**

Pin Number	Pin ID	Custom Name	Function	Mode	Direction	Latch	Pull Up	Pull Down	Drive Strength
60	PA12	LED1	GPIO	Digital	Out	Low	☐	☐	NORMAL
61	PA13	LED2	GPIO	Digital	Out	Low	☐	☐	NORMAL
62	PA14		Available	Digital	High Impedance	Low	☐	☐	NORMAL
63	PA15	LED3	GPIO	Digital	Out	Low	☐	☐	NORMAL
70	PC16	SPI_MOSI	SERCOM6_PAD0	Digital	High Impedance	n/a	☐	☐	NORMAL
71	PC17	SPI_SCK	SERCOM6_PAD1	Digital	High Impedance	n/a	☐	☐	NORMAL
72	PC18	SPI_CS	GPIO	Digital	Out	High	☐	☐	NORMAL
73	PC19	SPI_MISO	SERCOM6_PAD3	Digital	High Impedance	n/a	☐	☐	NORMAL
74	PC20		Available	Digital	High Impedance	Low	☐	☐	NORMAL
75	PC21	TC6_INT	GPIO	Digital	In	Low	☐	☐	NORMAL
76	PC22	TC6_RESET	GPIO	Digital	Out	High	☐	☐	NORMAL
111	PC27	UART_TX	SERCOM1_PAD0	Digital	High Impedance	n/a	☐	☐	NORMAL
112	PC28	UART_RX	SERCOM1_PAD1	Digital	High Impedance	n/a	☐	☐	NORMAL
13	PD00	BT1	GPIO	Digital	In	Low	☐	☐	NORMAL
16	PD01	BT2	GPIO	Digital	In	Low	☐	☐	NORMAL

Code Generation & Application

Step 23

- Click on **Generate** button in top of **MCC** to **generate** your code after configuration.



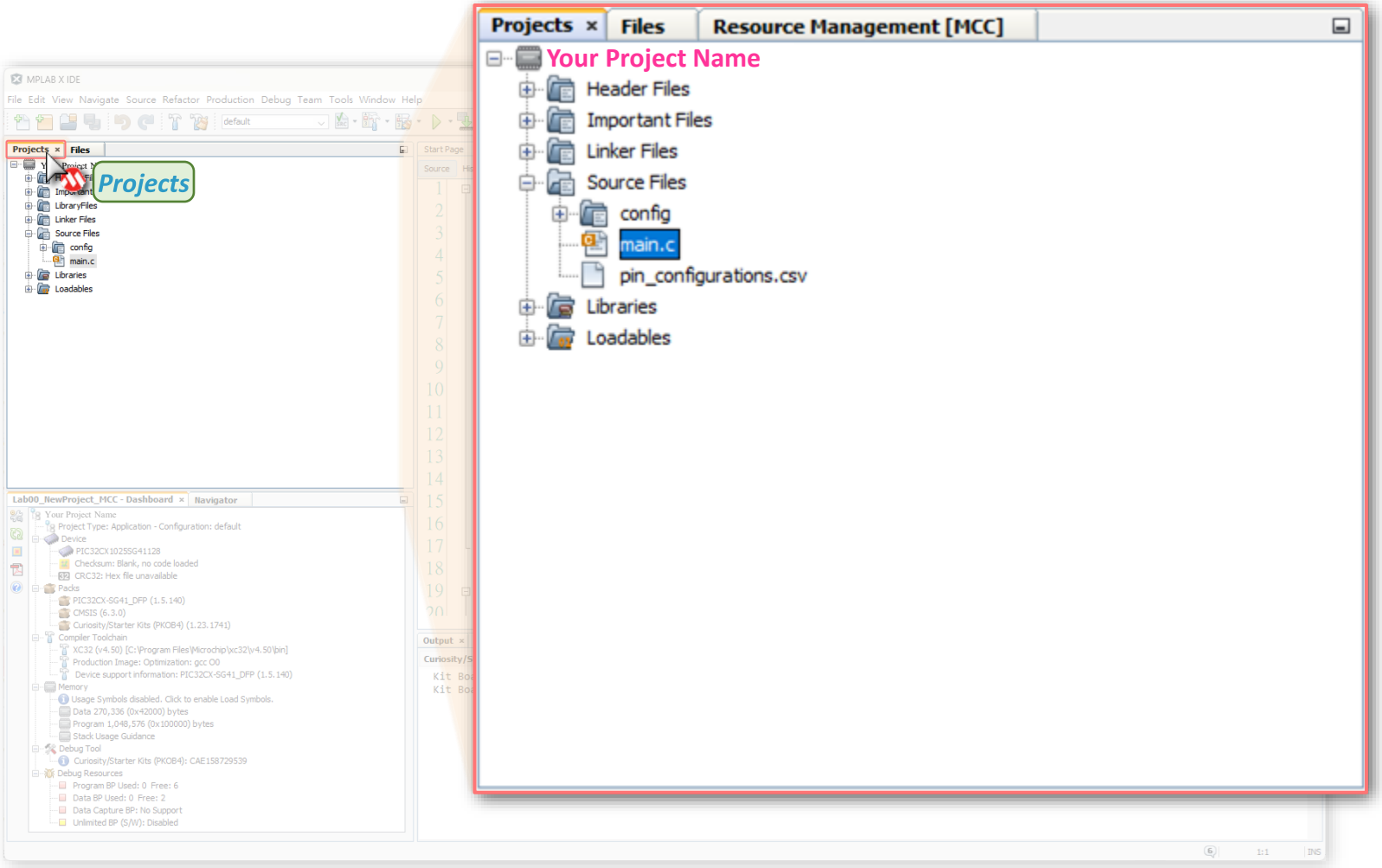
MPLAB® Code Configurator (MCC) Project Properties & Application

MPLAB X IDE Project Manager

MICROCHIP

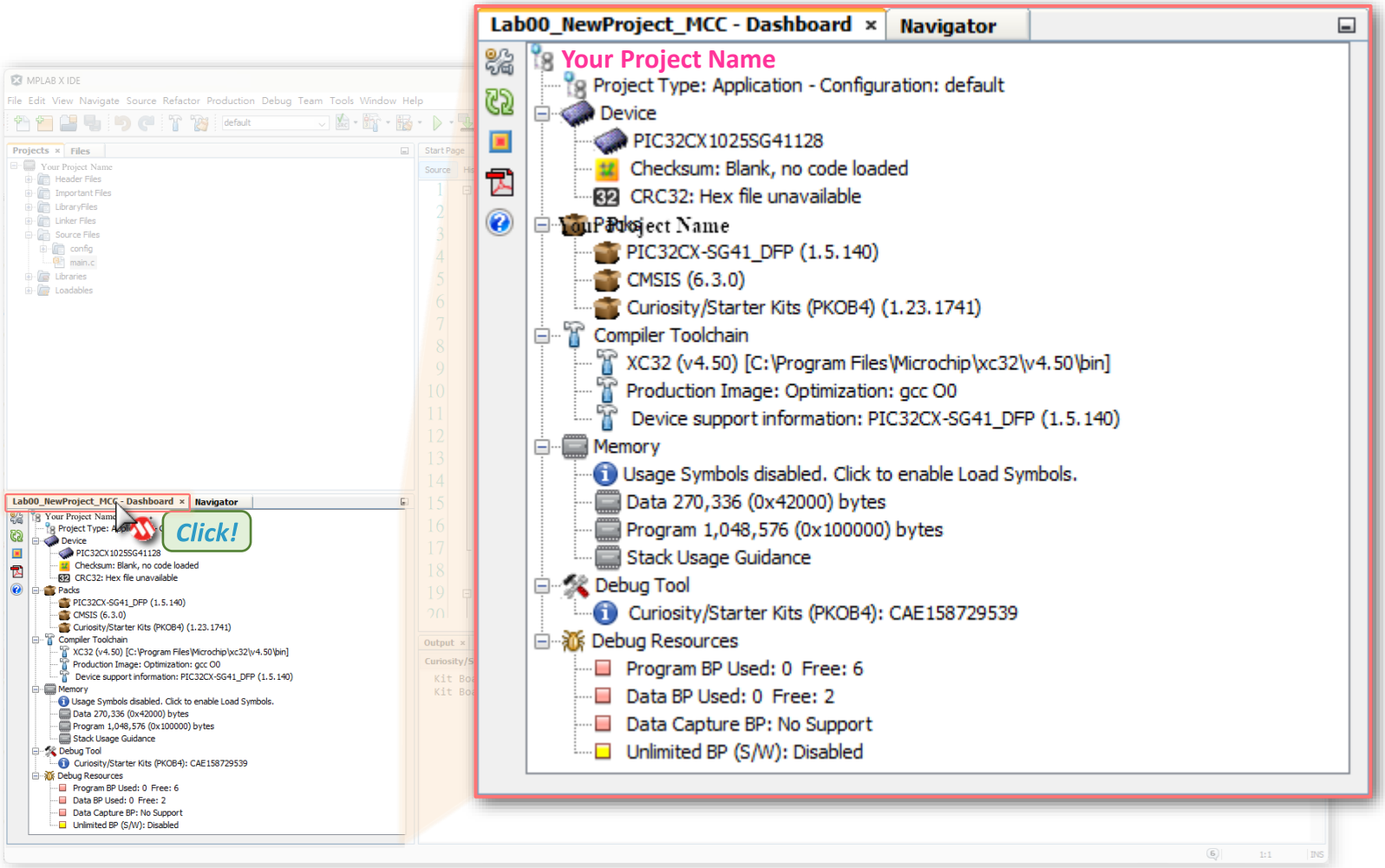
MPLAB X IDE Interface

- **Project window.**



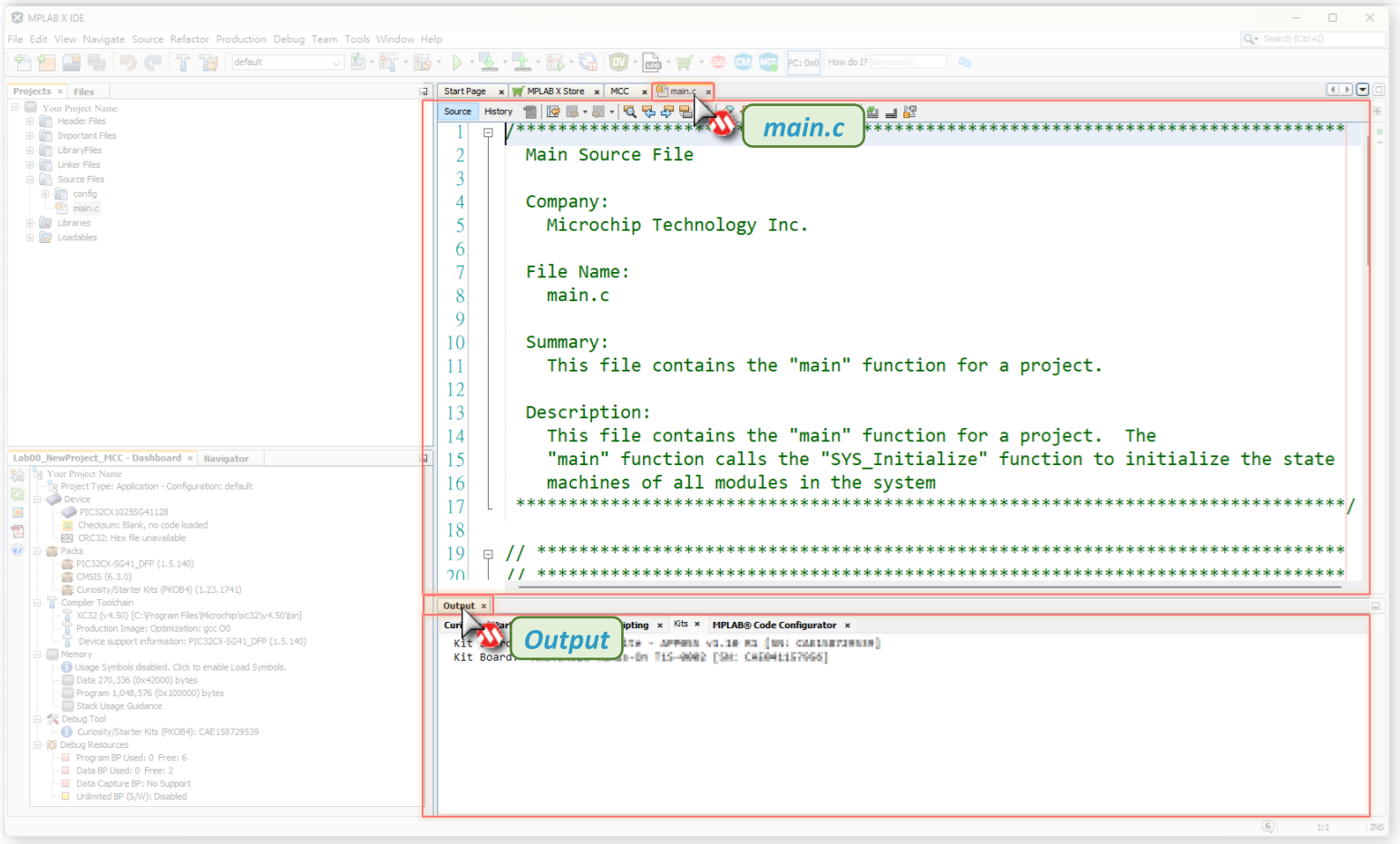
MPLAB X IDE Interface

- **Dashboard window. (The version of modules might be different to yours.)**



MPLAB X IDE Interface

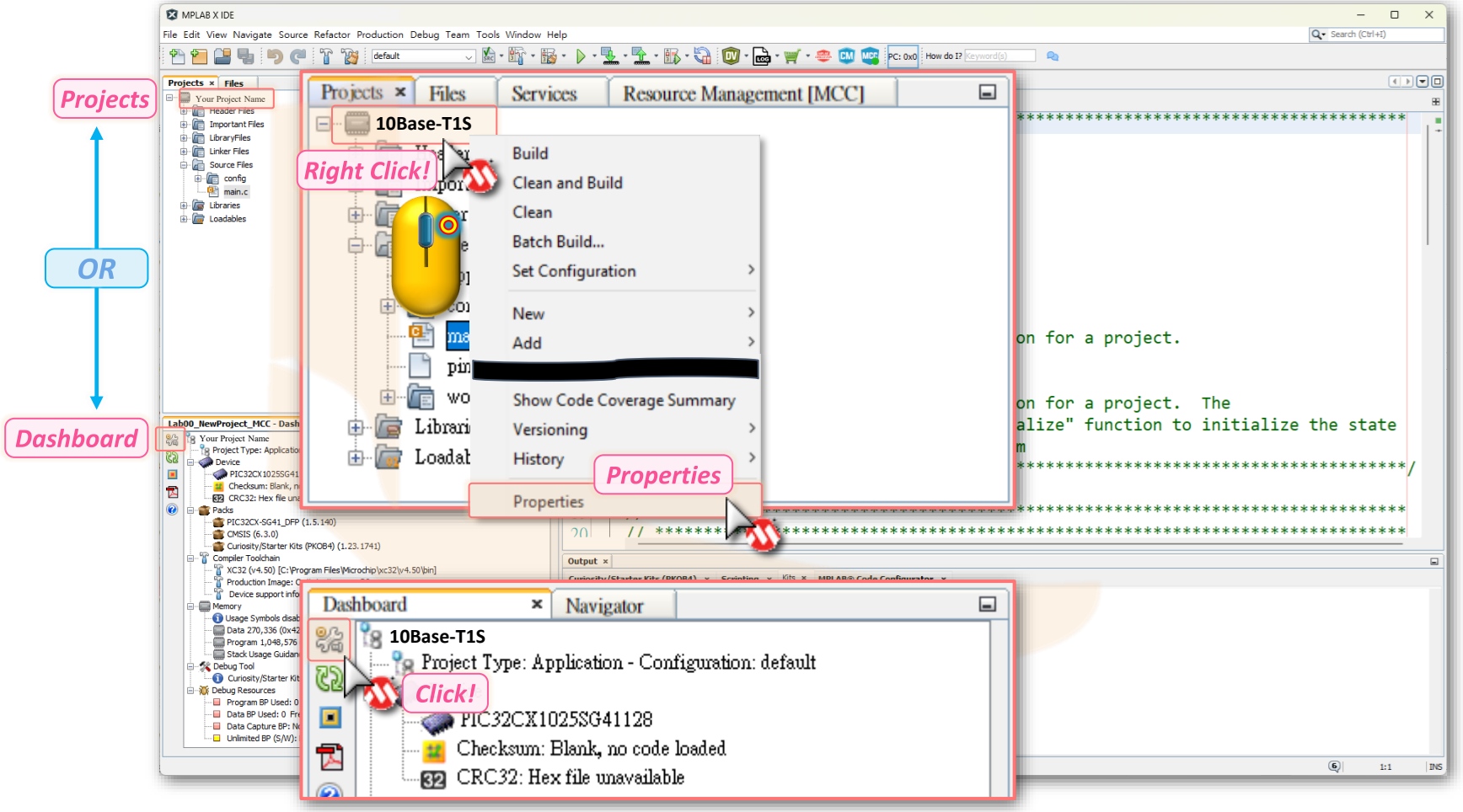
- **Source code and Output window.**



Project Properties & Application

Step 1

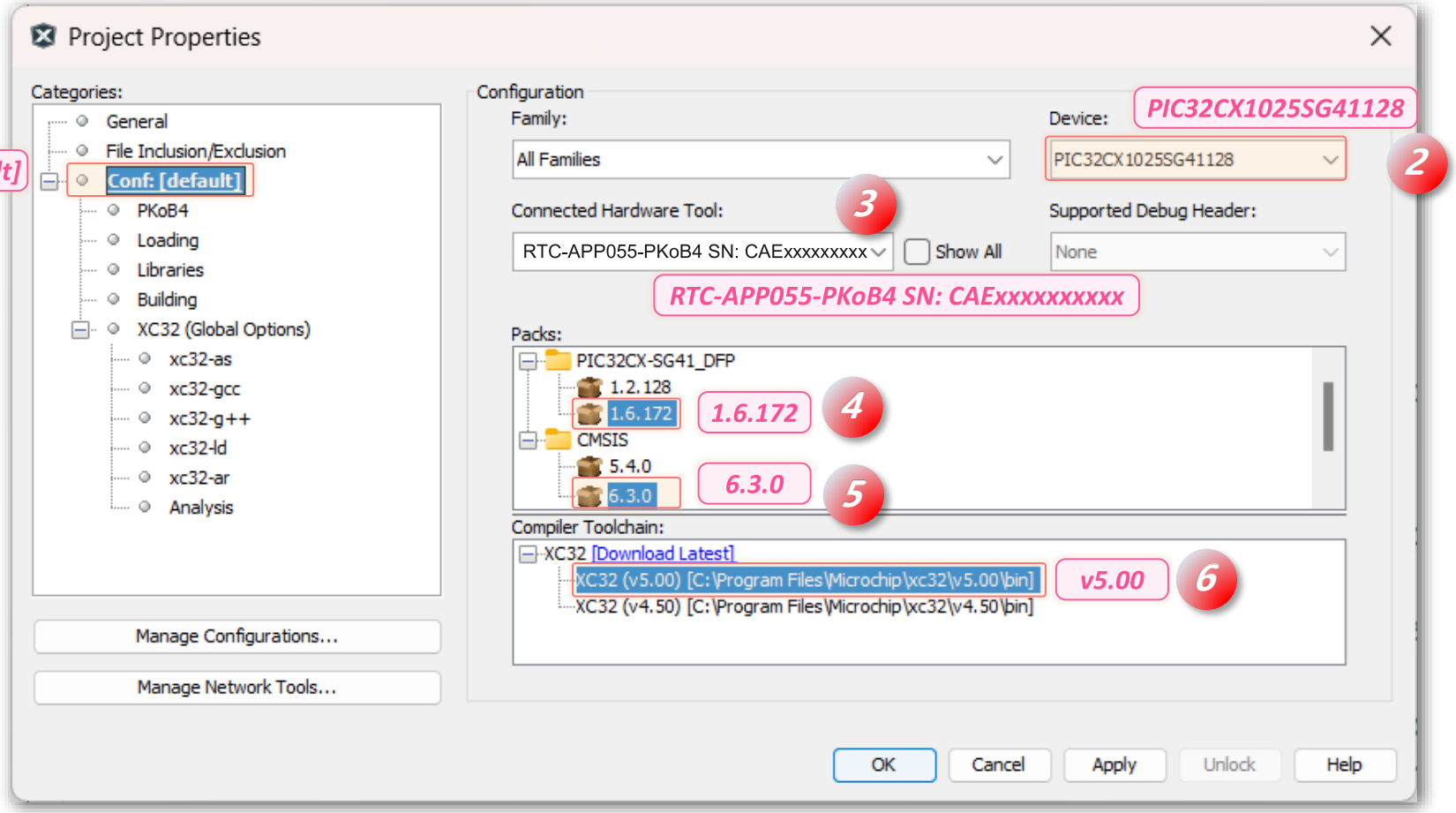
- Click  on Dashboard or Right click on Project Name and select the Properties.



Project Properties & Application

Step 2

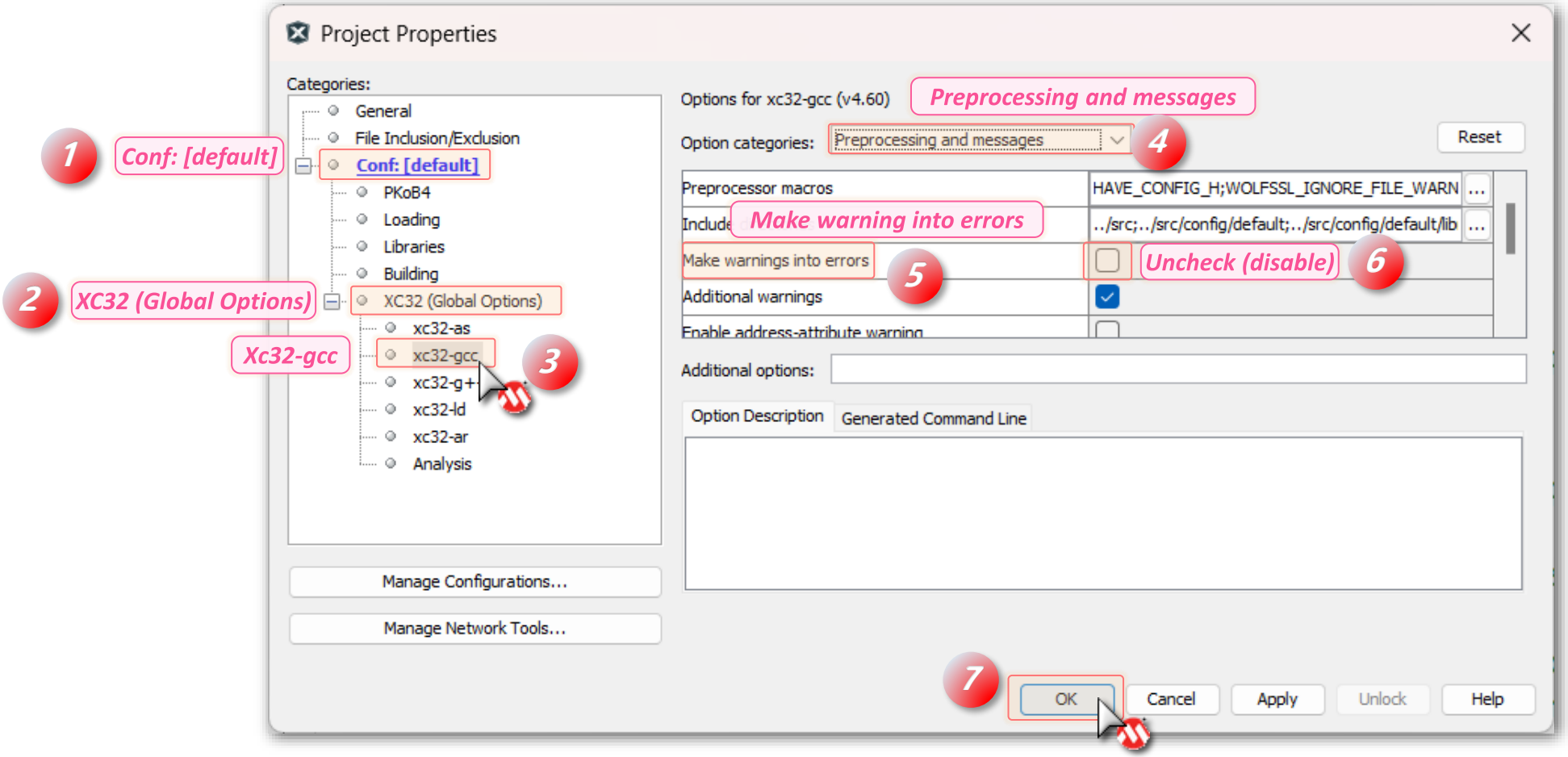
- **Under Conf: [default],**
  Check the Device, Connected Hardware Tool, Packs and Compiler Toolchain versions.



Project Properties & Application

Step 3

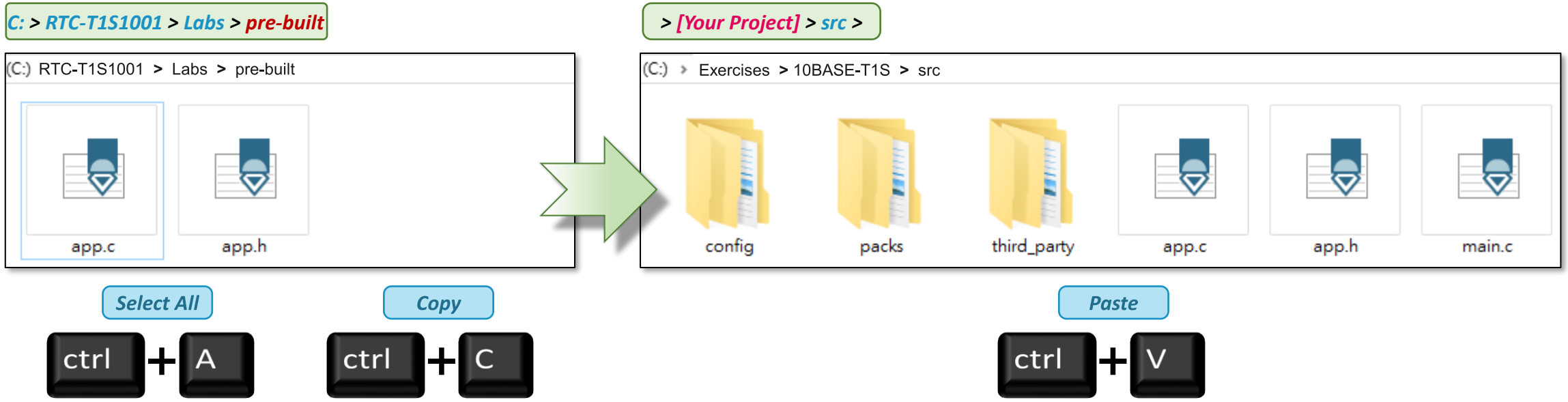
- **Click left configure tree Conf:[default] > XC32 (Global Options) > xc32-gcc and In Preprocessing and messages > uncheck ☐ Make warning into errors to disable it.**



Project Properties & Application

Step 4

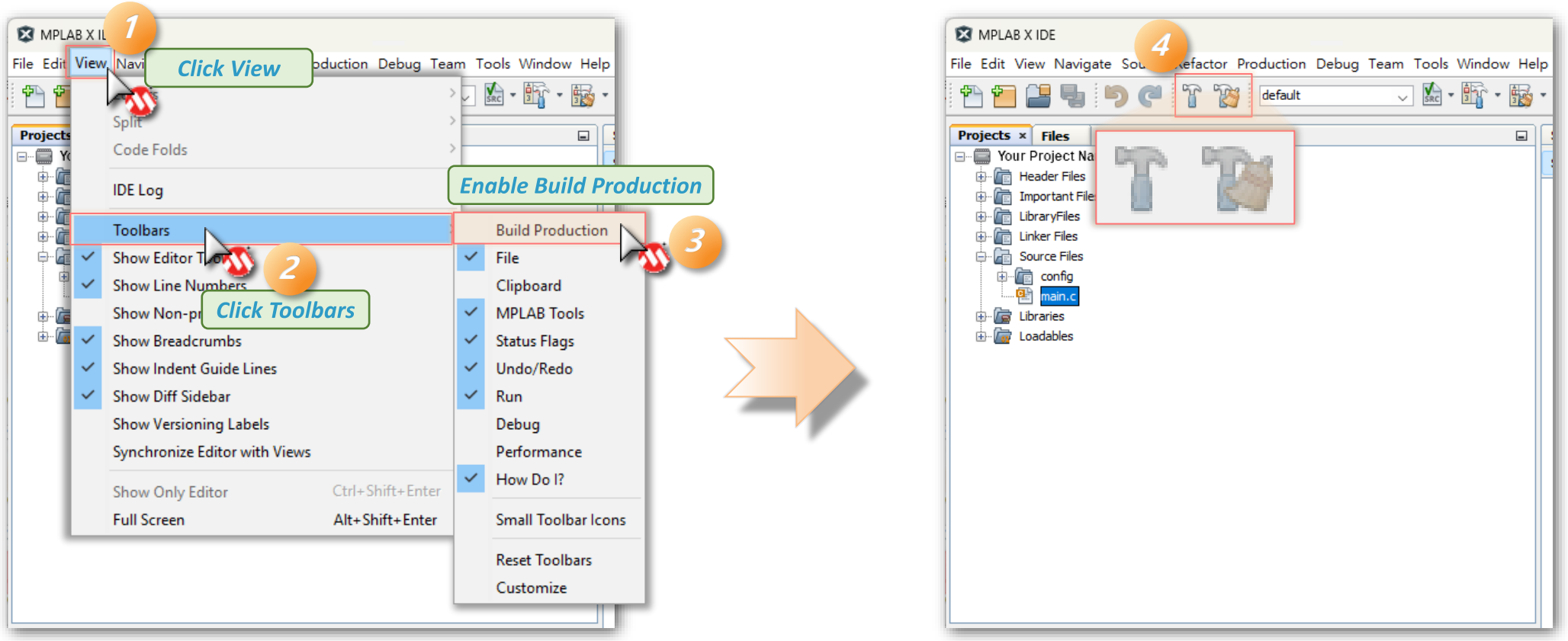
- **Copy the pre-built APP.c and APP.h to overwrite the files in the \src folder.**



Project Properties & Application

Step 5

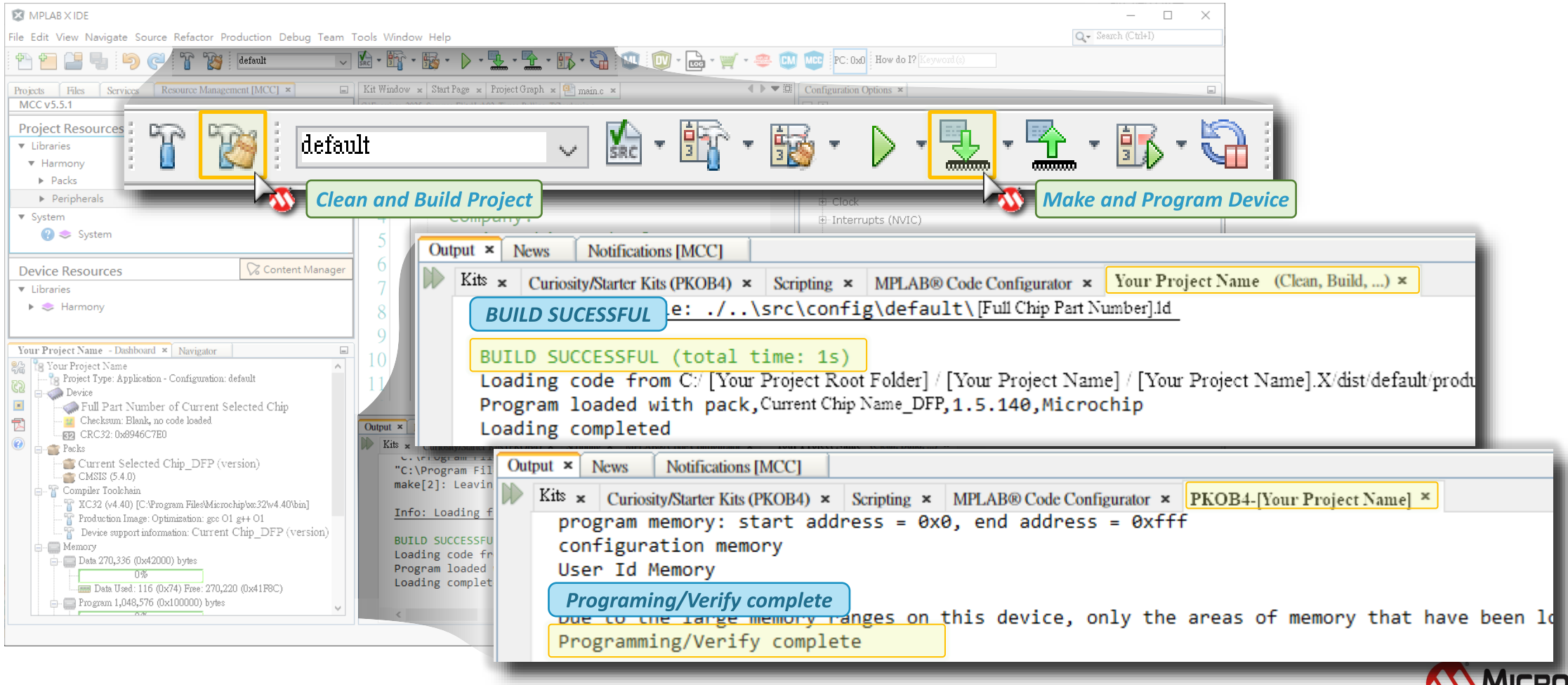
- **Add the Build Production to Toolbars to make it easy to Clear and Build projects.**



Project Properties & Application

Step 6

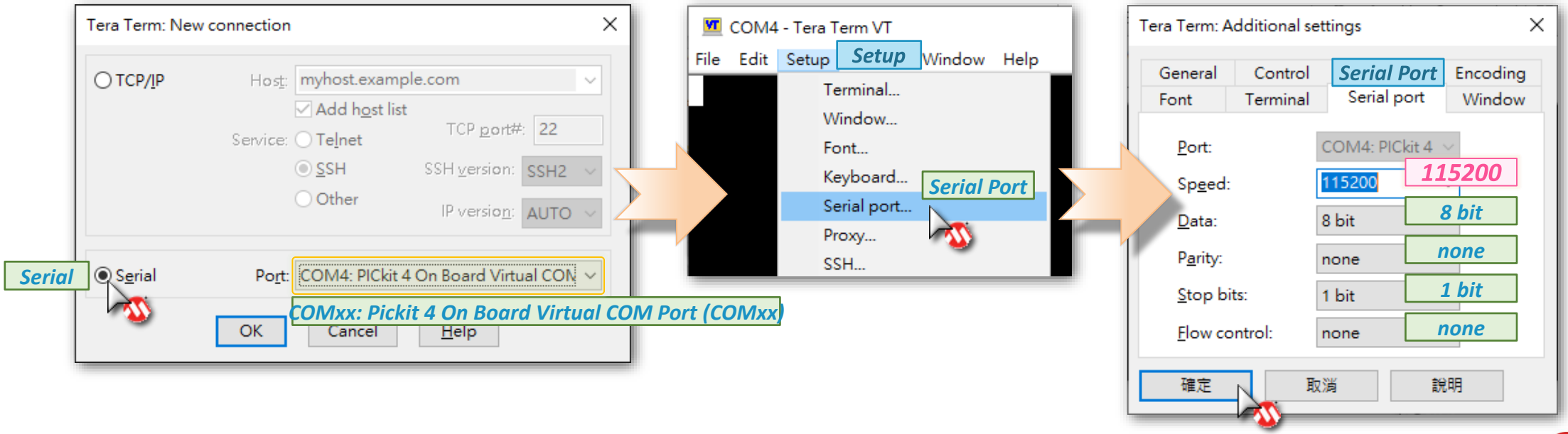
- Click on icon  to Clean and Build Project and then  to Program code to EVB.



Project Properties & Application

Tera Term : The Terminal Console Software

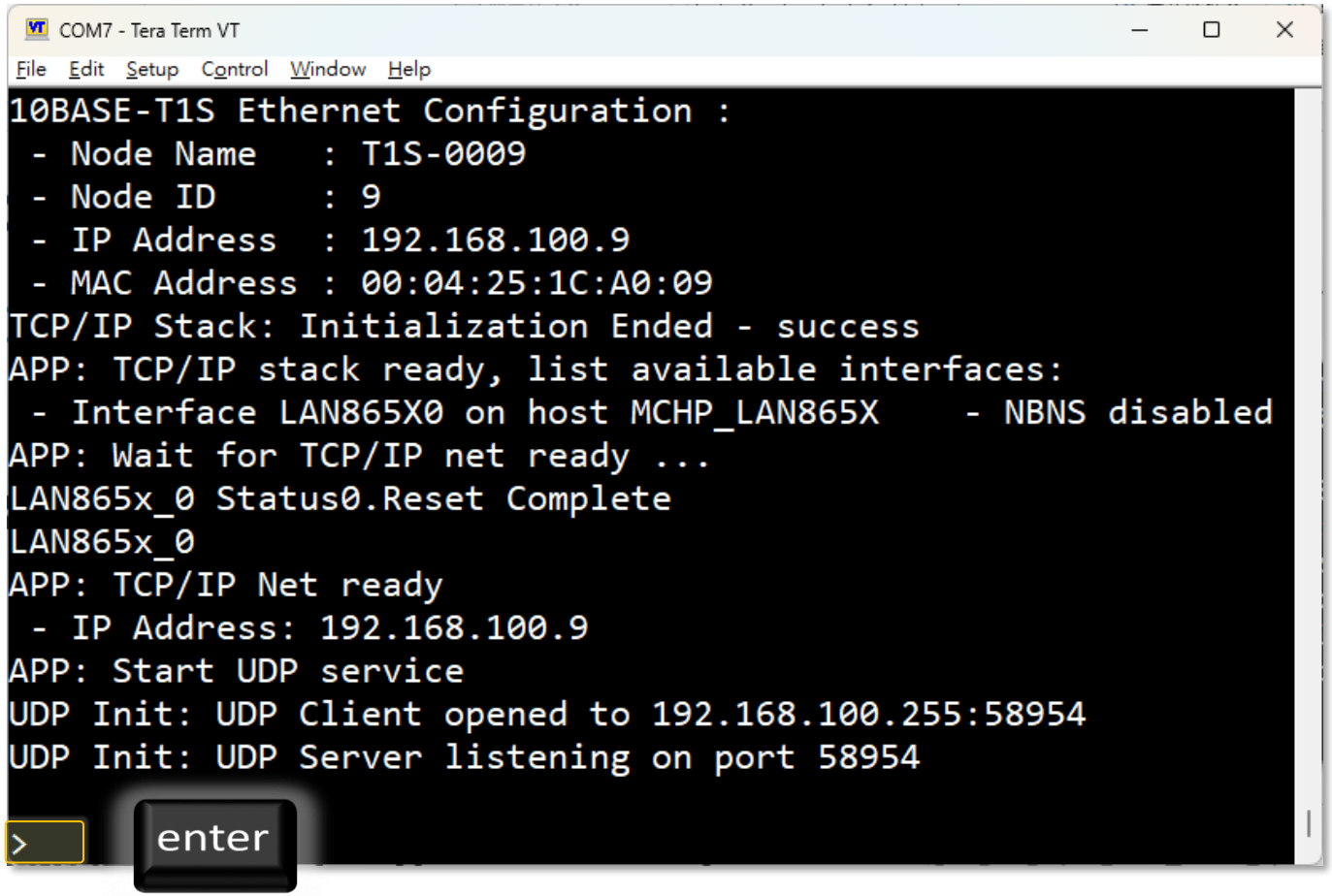
- **Tera Term is a popular and free to use terminal console software, you could download it from https://teratermproject.github.io/index-en.html**
- **Execute the Tera Term by double Click on the Icon**  **on your PC's desktop.**
- **Choice a New Connection "Serial" and select correct COM Port of your EVB,**
  - It might show as **COMxx: Pickit 4 On Board Vritual COM Port (COMxx)**
- **Go to the top menu and enter "Setup" tab and config the "Serial Port" to 115200-n-8-1.**



Project Properties & Application

TCP/IP Command Console

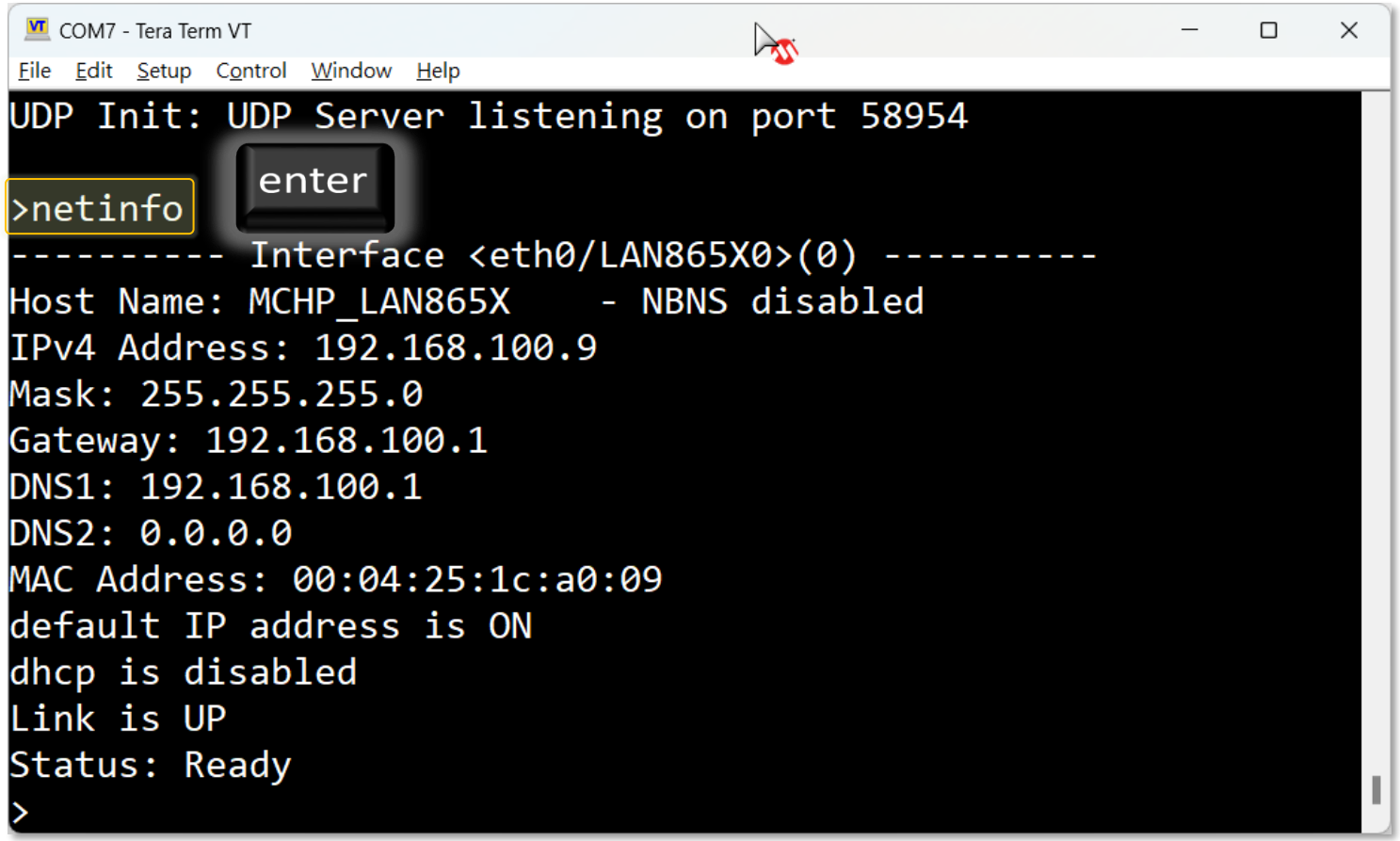
- **Open Tera Term, your will get the UART debug message output as below.**
  Type Enter to display the command prompt character ">" to allow you to type.



Project Properties & Application

TCP/IP Command Console - netinfo

- Typin in : “netinfo” enter will output current network configuration of your EVB.

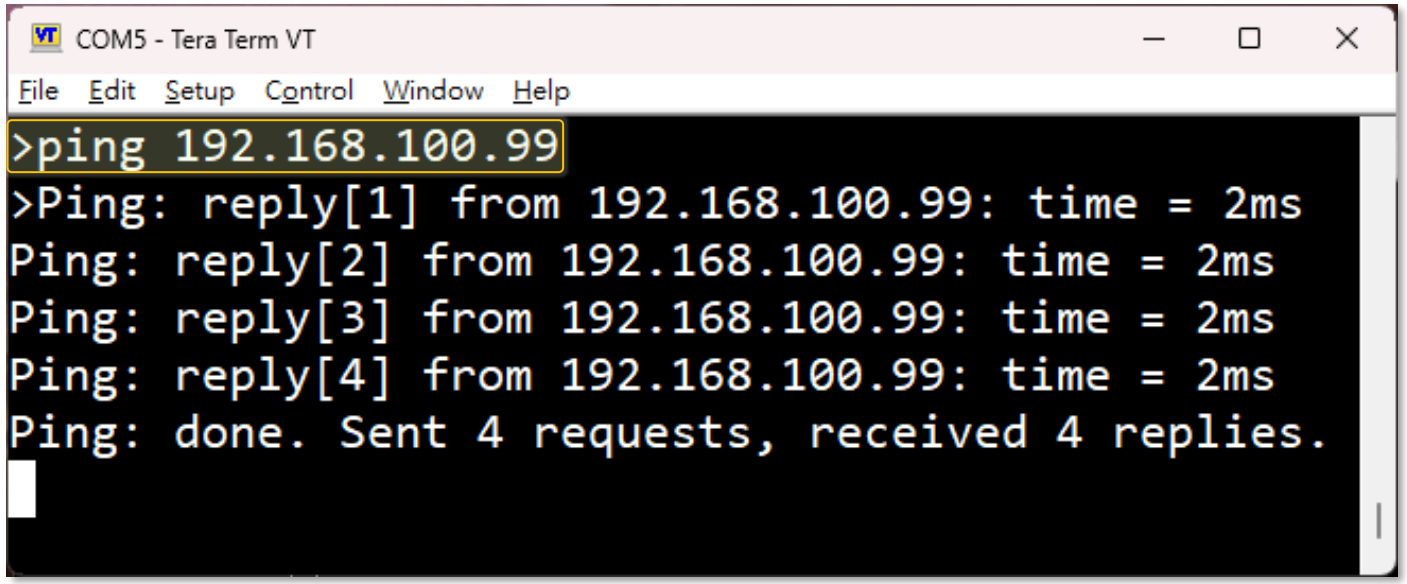


Project Properties & Application

TCP/IP Command Console - ping

- Typing “cls” enter to clean console screen.
- “ping 192.168.100.99” enter will attempt to ping the instructor's host.

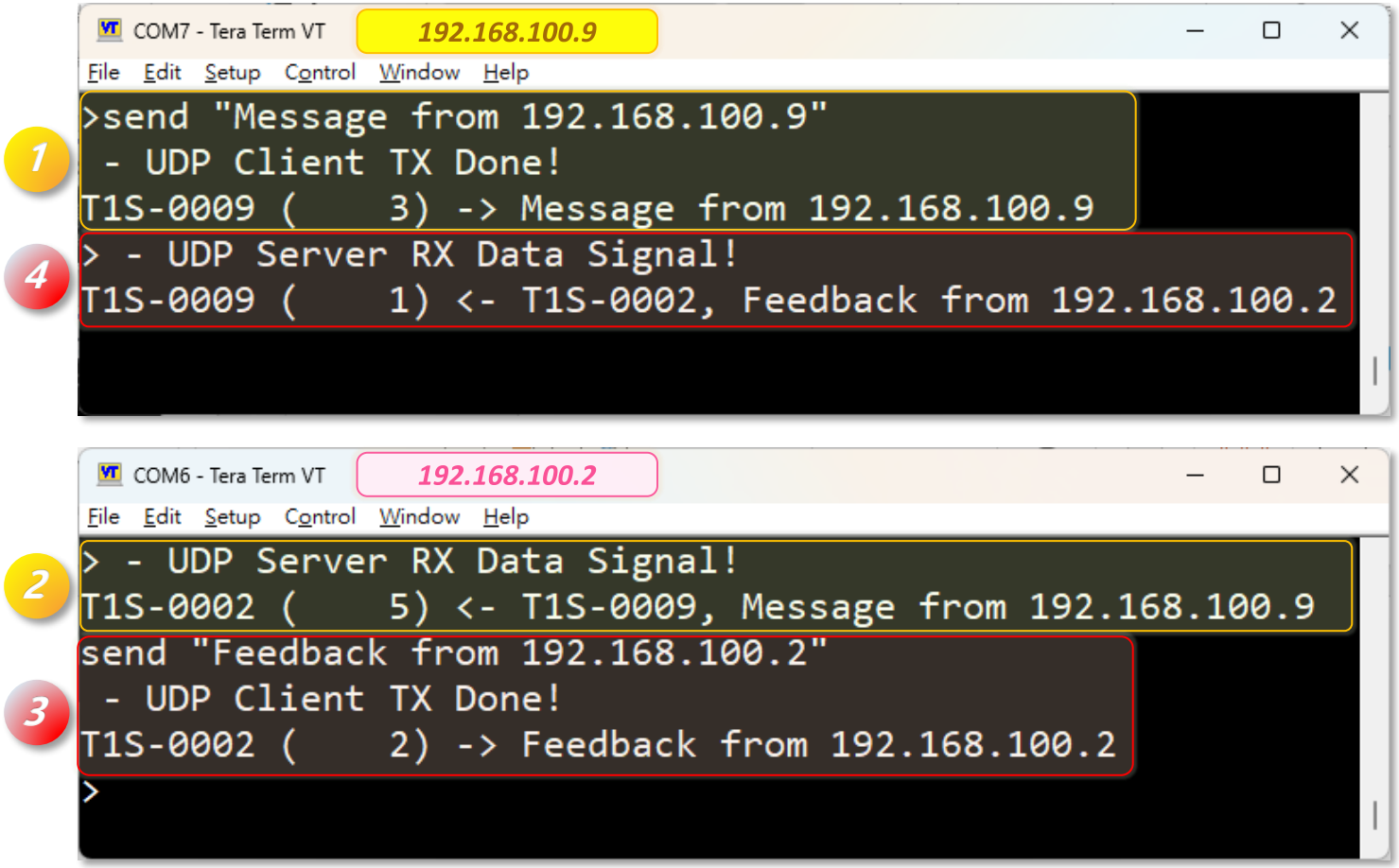
T1S Host IP



Project Properties & Application

TCP/IP Command Console - send

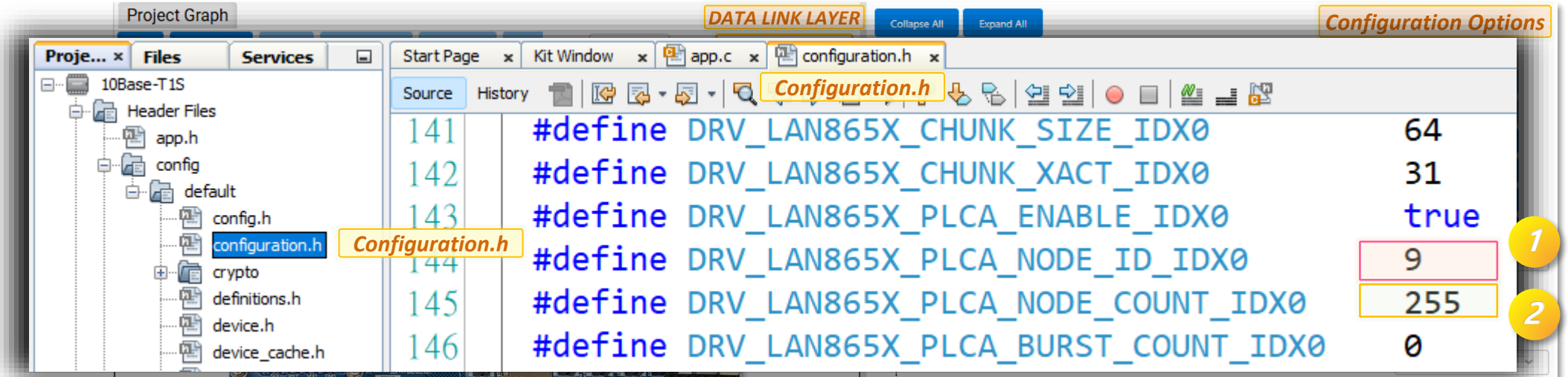
- Typing “send Message” enter to broadcast a message to everyone.
- If your message contains spaces, please use "Message from Microchip".

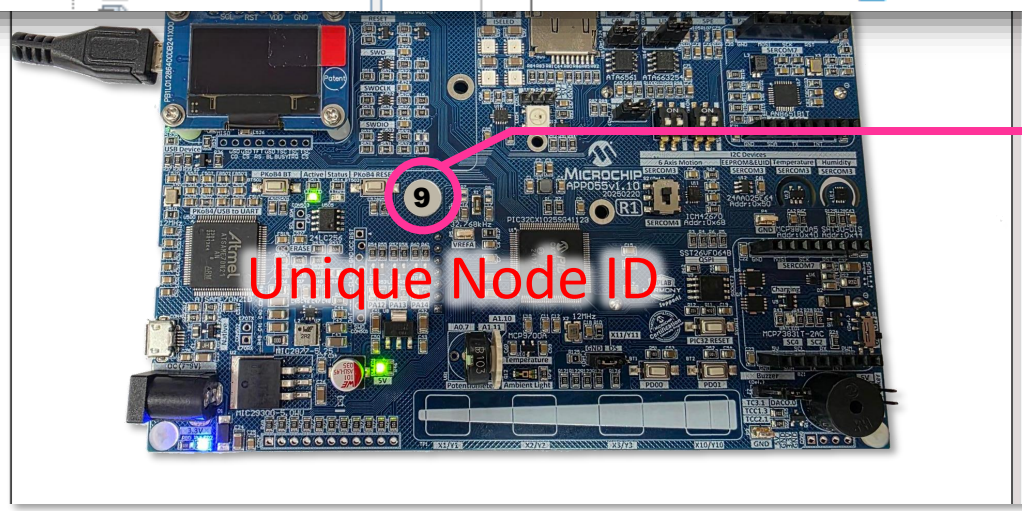


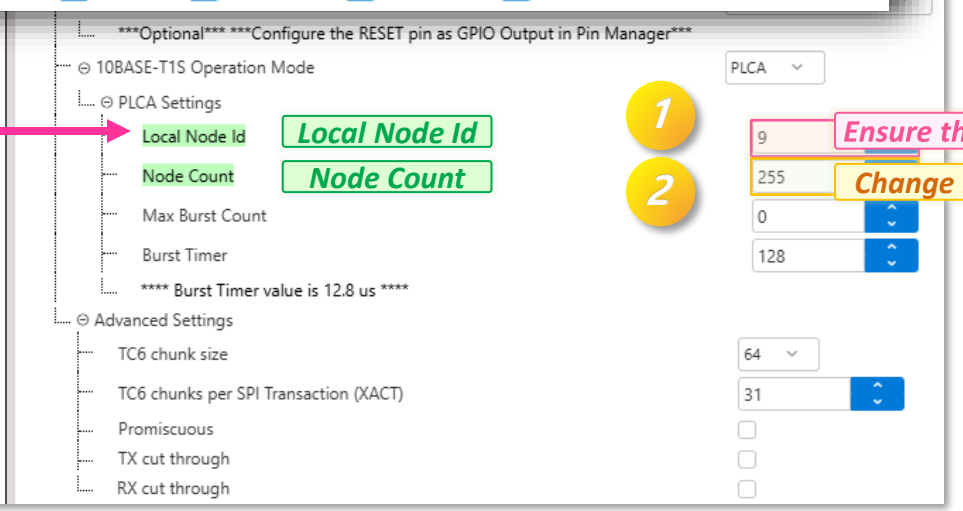
Project Properties & Application

Change the MCC configuration by directly modifying the program code.

- **Modify the Node ID and Node Count in line 144 and 145 of configuration.h**



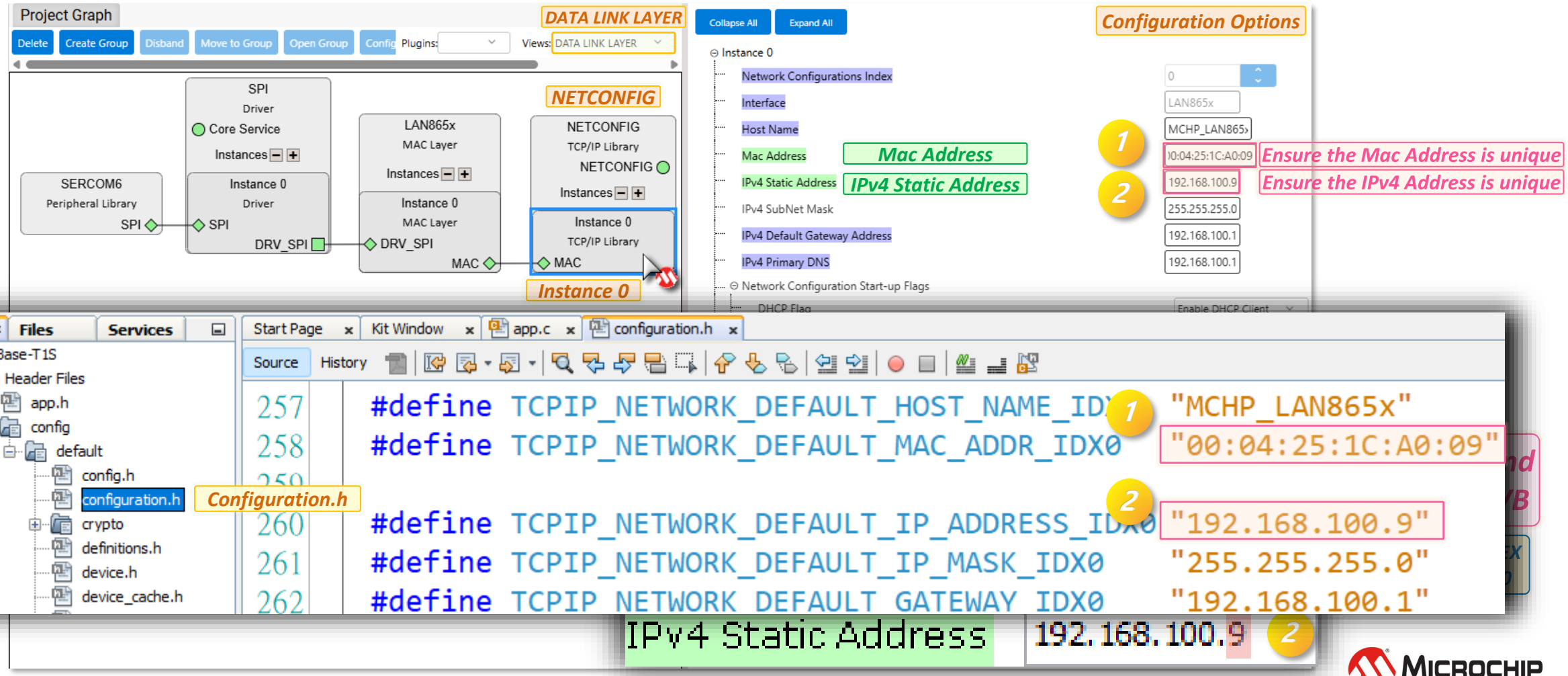




Project Properties & Application

Change the MCC configuration by directly modifying the program code.

- **Modify the MAC Address and IP Address in line 258 and 260 of configuration.h**



EVB-LAN8670-USB Setup

10BASE-T1S Ethernet Host

MICROCHIP

EVB-LAN8670-USB Setup - 10BASE-T1S Ethernet Host

- **The EVB-LAN8670-USB interconnects an USB interface with a 10BASE-T1S Ethernet network interface.**
  The adapter serves as a network card that connects applications via USB 2.0 to the 10BASE-T1S network interface.
  Document and drivers could download from
  https://www.microchip.com/en-us/development-tool/ev08l38a

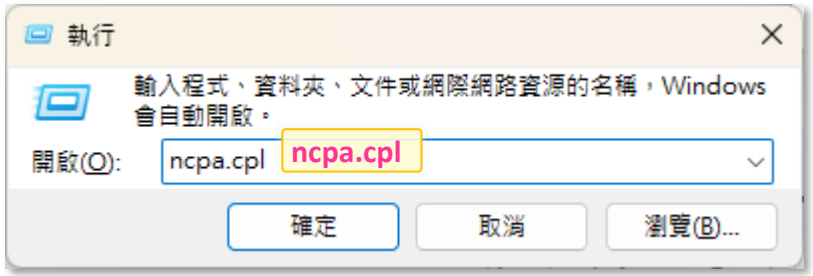
- **Go Control Panel\All Control Panel Items\Network Connections or RUN ncpa.cpl**

Control Panel\All Control Panel Items\Network Connections

Network Card of EVB-LAN8670-USB

or

RUN

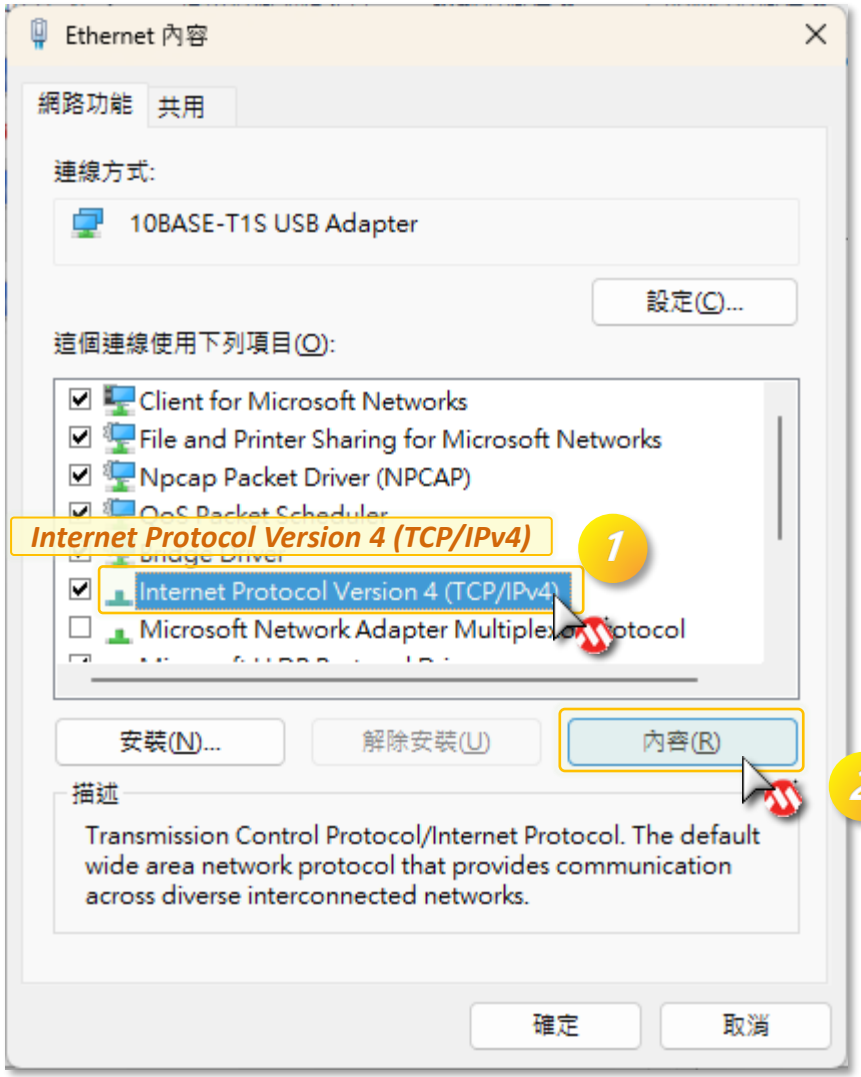


** The Network Card Name could be customized to "10BASE-T1S USB Adapter" to easy find the device*

MICROCHIP

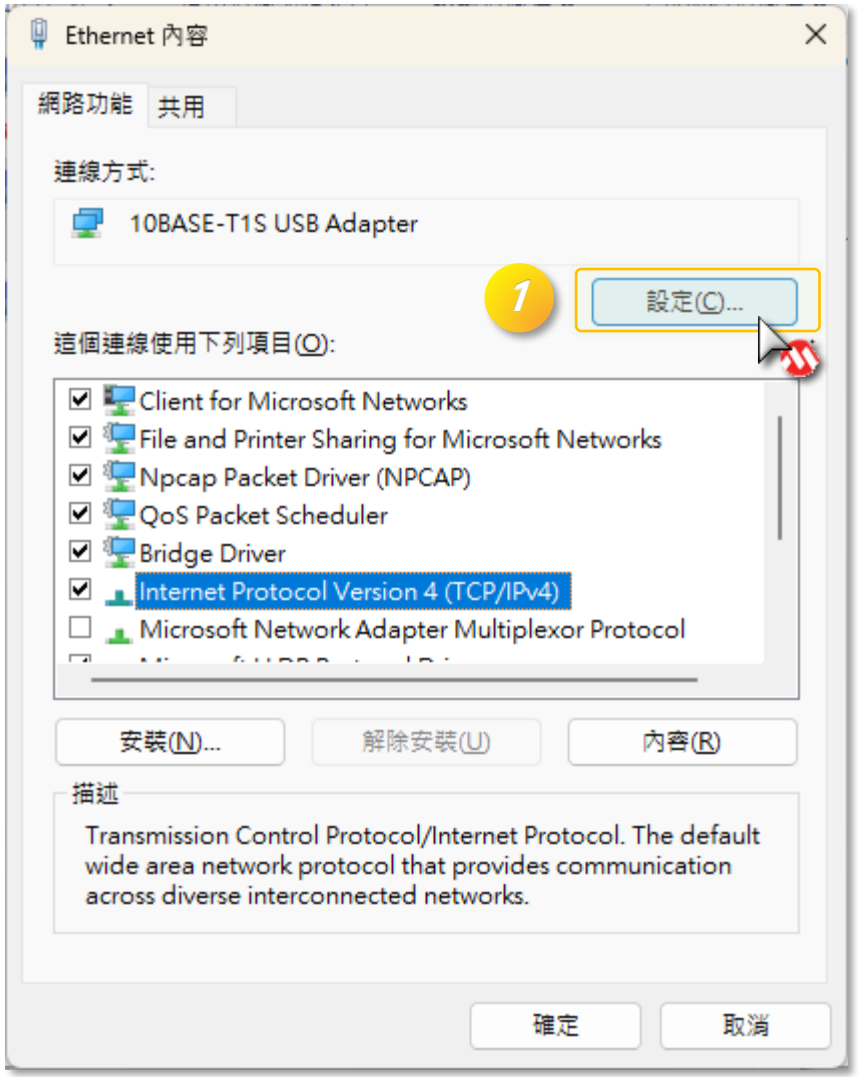
EVB-LAN8670-USB Setup - 10BASE-T1S Ethernet Host

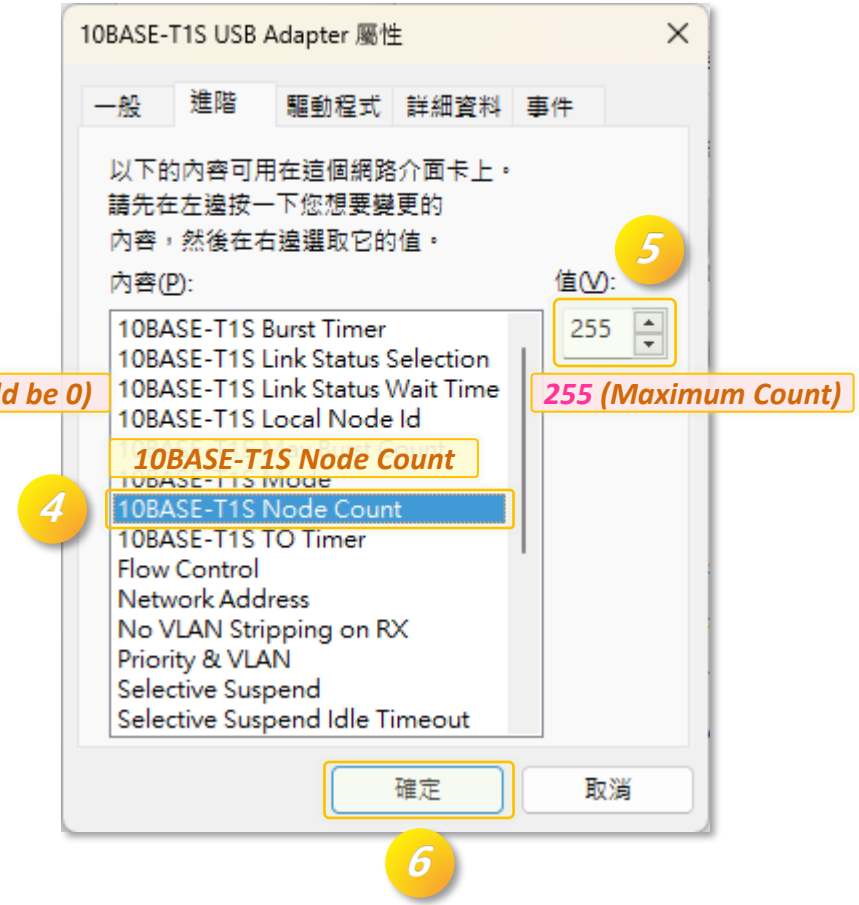
- **Setup Fixed IPv4 address of Network Card of the EVB-LAN8670-USB.**



EVB-LAN8670-USB Setup - 10BASE-T1S Ethernet Host

- **Configure the 10BASE-T1S Node ID (Host should be 0) and maximum Node count 255.**





Microchip Trademarks

https://www.microchip.com/en-us/about/legal-information/microchip-trademarks

Trademark	Description/Appropriate Nouns	Notes
ClockWorks®	configurator, device, family, product, series	US only
CodeGuard™	security	
CryptoAuthentication™	development library, device, family, IC, library	
CryptoAutomotive™	development kit, security IC, technology	
CryptoCompanion™	chip	
CryptoController™	solution, TPM, trusted platform module	
CryptoMemory®	cryptographic security IC, IC	
CryptoRF®	device, transponder	
dsPIC®	DSC, digital signal controller	
dsPIC®	dsPIC® logo	
dsPICDEM™	demonstration board, development board	
dsPICDEM.net™	board	
Dynamic Averaged Matching™ (DAM™)	architecture	
ECAN™	solution, technology	
Espresso T1S™	device	
EtherGREEN™	family, platform, technology	
EtherSynch®	family, platform, technology	US only
EyeOpen™	cable compensation	
Flashtec®	controller, family, product	US only
flexPWR®	technology	
Frequency on Demand®		Registered in other countries (not US)
GestIC®	controller, sensing, technology	
GridTime™	device, GNSS time server, time server	
HELDO®	family, regulator	
Hyper Speed Control®	architecture, family	US only
HyperLight Load®	mode	US only
In-Circuit Serial Programming™ (ICSP™)	programming capability	
IdealBridge™	dual MOSFET-bridge rectifier, rectifier	
IGaT™	board, demonstration board	
IGLOO®	device, family, FPGA, series	
INICnet™	sniffer, technology	

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
MICROCHIP	Microchip name and logo	This is the vertical representation; the horizontal representation is also available.
Microsemi	Microsemi logo	Do not use
Microsemi®		Do not use
Mindi™	analog simulator, analog simulator tool	
MiWi™	application, coordinator, mesh, network, protocol, software, stack, wireless networking protocol	
MOST®	board, cooperation, design, device, evaluation kit, NetServices, network, platform, product, specification, system, technology	
MOST	MOST® logo	
motorBench®	development suite	US only
MPASM™	assembler	
MPE™	device, product	
MPLAB®	**Nouns:** C compiler, compiler, development ecosystem, ICD, ICE, IDE, IPE, in-circuit debugger, in-circuit emulator, integrated development environment, integrated programming environment, library, programmer, server, starter kit, universal device programmer, XC compiler **Tool Names:** AI Edge, Analog Designer, Analysis Tool Suite, Code Configurator, Connect Configurator, Data Visualizer, Discover, Extensions, Harmony, Mindi™, Network Creator, PICkit™, Programmer-to-Go, Programmer-to-Go Mobile App, PTG, SIC Power Simulator, Snap, Xpress	
MPLAB CERTIFIED	MPLAB® Certified logo	
MPLIB™	librarian, object librarian	

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
Ripple Blocker™	attenuator, family of linear regulators, product line, technology	
REAL ICE™	in-circuit emulator	
RTAX™	FPGA	
RTG4™	FPGA	
SAM-BA®	applet, application, host, in-system programmer, ISP, monitor, software	
SAM-ICE™	emulator	
SenGenuity®	product, sensor	
Serial Quad I/O™ (SQI™)	family, Flash device, product	
Silicon Storage Technology®		Japan only
simpleMAP™	protocol	
SimpliPHY™	device, family, product	
SmartBuffer™	device, IC	
SmartFusion®	evaluation kit, FPGA, SoC, System-on-Chip	US only
SmartHLS™	compiler, compiler software, IDE, software	
SMART-I.S.™	technology	
SpyNIC®	device	
SST®	Acronym for Silicon Storage Technology	
SST	SST logo	
STK®	starter kit	
storClad™	encryption technology, technology	
SuperFlash®	device, kit, macro, memory, technology	
SuperSwitcher™	buck regulator, family, regulator	
SuperSwitcher II™	family	
Switchtec™	family, product line, switch, technology	
Symmcom®		China only
Symmetricom®		
SynchroPHY™	device, family, product	
SyncServer®	clock, device, instrument, oscillator, server	

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
	Adaptec "a" logo	Registered in other countries (not US)
Adaptec®	adapter, cable, controller, driver, family, product, series, software, solution	
Adjacent Key Suppression™	technology	
AgileSwitch®	device, digital programmable gate driver, driver, family, gate driver	US only
AKS™	technology	
Analog-for-the-Digital Age™	AIPD family tagline	
Any Capacitor™	stable	
Anyln™	capability, feature, structure	
AnyOut™	capability, feature	
Augmented Switching™	technology	
AVR®	architecture, CPU, device, family, MCU, microcontroller	
AVR	AVR® logo	
AVR Freaks®	forum	
BesTime®	technology	
BitCloud®	SDK, software development kit	
BlueSky®	firewall, subscription service, technology	
BodyCom™	development kit, system, technology	
chipKIT®	I/O shield, board, hardware, network, platform, software	
chipKIT	chipKIT® logo	
Clockstudio™	application, program, software, utility	

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
InitDrive™	driver board, integrated solution, power module	
Intelligent Paralleling™	technology	
IntelliMOS®	family, power stage family	US only
Inter-Chip Connectivity™	technology	
JitterBlocker™	attenuator, family	
JukeBlox®	platform, technology	
jukeblox	JukeBlox® registered word mark with a design	Image is not registered; this is a graphic treatment with the registered word mark
KeeLoq®	protocol, security IC, technology	
Kleer®	technology	
KLEER®	Kleer® registered word mark with a design	Image is not registered; this is a graphic treatment with the word mark
Knob-on-Display™ (KoD™)	device, family, HMI, knob designer, position wizard, solution, technology, touch controller, user interface, widget configurator	
LANCheck®	online design review, online review, review	
Libero®	design file, designer, IDE, SoC design suite, software, tool	US only
LinkMD®	cable diagnostics, diagnostics engine, family, technology	
MarginLink™	signal integrity testing	
maxCrypto™	controller-based encryption, encryption	
maXStylus®	solution	
maXTouch®	family, studio, technology, touchscreen controller	
maxView™	driver, storage manager, tool	
MediaLB®	bus, controller, device	
megaAVR®	device, MCU, microcontroller	
memBrain™	neuromorphic memory product, product, solution, technology	
	Microchip logo	Please do not use this logo; always use the Microchip name and logo.

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
MPLINK™	linker, object linker	
mSiC™	bare die, diode, gate driver, module, MOSFET, product, solution, technology	
mTouch®	development kit, evaluation kit, library, sensing solution, solution, technology	US only
MultiTRAK™	technology	
NetDetach™	technology	
Omniscient Code Generation™ (OCG)	compilation technology	
OptoLyzer®	network analysis tool, studio, tool	
PIC®	assembler, device, MCU, microcontroller	
PIC32	PIC32 logo	
PIC64	PIC64 logo	
PICDEM™	demonstration board	
PICDEM.net™	Internet/Ethernet demonstration board	
PICkit™	debugger, development tool, in-circuit debugger, on-board, programmer, starter kit, tool	
picoPower®	technology	
PICSTART®	development programmer	
PICtail™	board, daughter board	
PolarFire®	device, family, FPGA, kit, SoC, System-on-Chip	
PowerSmart™	designer, development suite, digital control library	
Precision Edge®	family, product family	US only
ProASIC®	architecture, board, family, FPGA, kit	US only
ProASIC Plus®	architecture, device, family, FPGA, switch	US only
Prochip Designer®	software suite	
PureSilicon™	oscillator, technology	
QMatrix™	device, sensor	
QTouch®	board, composer, configurator, device, development platform, library, project builder, sensor, solution, technology, tool	
Quiet-Wire®	enhanced EMI technology, family, technology	

Note: *Always check with the Legal Department for the most current trademarks.

Trademark	Description/Appropriate Nouns	Notes
SyncWorld®	ecosystem program, timing	US only
Tachyon®	controller, family, platform, product, technology	
The Embedded Control Solutions Company®		US only; should be in italics
TimeCesium®	primary frequency reference, product	US only
TimeHub®	platform, system	US only
TimePictra®	platform, software suite, synchronization management system	US only
TimeProvider®	clock, enhanced PRTC, ePRTC, extension, system, grandmaster, kit, module, product, series, server, shelf	US only
TimeSource®	PRC, PRS, primary reference clock, primary reference source, shelf, system	
tinyAVR®	MCU, microcontroller	
Total Endurance™	software model	
TSHARC™	controller, touchscreen controller	
Turing™	hardware security module, programmer	
UNI/O®	bus, communication protocol, firmware, hardware port, memory chip	
USBCheck™	design review	
VariSense™	technology	
VectorBlox™	accelerator, intellectual property, IP, platform, SDK, software development kit, solution, tool, tool chain, tool flow	
Vectron®	oscillators, products	
VelocityDRIVE™	CT, configuration tool, product, solution, software platform, SP	
VeriPHY™	cable diagnostics algorithm, cable diagnostics software suite	
ViewSpan™	technology	
WiperLock™	technology	
XMEGA®	Custom Logic (XCL) device, family, MCU, microcontroller, series	
XpressConnect™	retimer	
ZENA™	analyzer, software, wireless adapter	
ZL®		US only

Note: *Always check with the Legal Department for the most current trademarks.

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