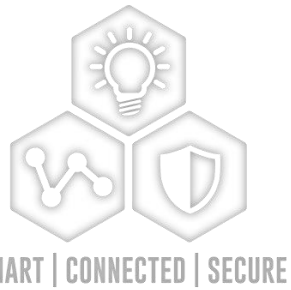
MU導讀 – CAN BUS Basic

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



Luke Lin

2024.04

Agenda

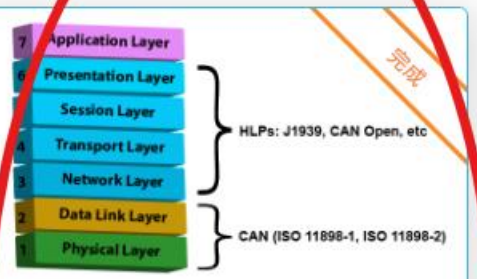
- MU Taiwan 有哪些資源, 怎麼利用
- CAN 基礎知識
- CAN ISO 標準
- CAN 協議基礎
- CAN FD、CAN PN 和 CAN 下一代
- CAN 物理層
- CAN BUS RTC 課程
- MPLabx / Harmony開發操作Demo

Microchip University

- 台灣版Microchip University(MU Taiwan):https://mu.microchip.com/page/tmu

Microchip University (CAN BUS)

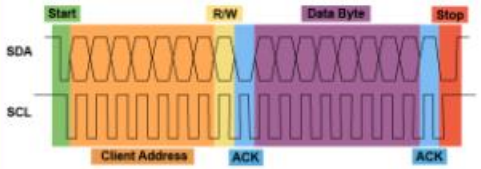
傳輸界面



CAN 和 CAN FD 協議和物理層基礎知識

本課程將教您 CAN 和 CAN FD 協議和物理層基礎知識。

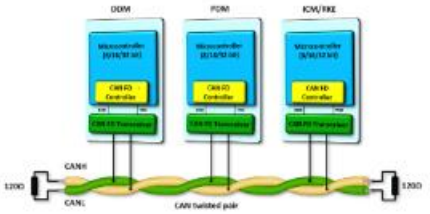
免費 69 分



實用的 I2C 介紹、實現和故障排除

本課程介絕如何使用 MPLAB® X 程式碼配置器（MCC）在 8 位元 PIC 微控制器上實現 I2C 協議。

免費 64 分



設計和實現 CAN FD 網路

本課程將教您CAN FD 協議和實體層。藉著應用實例導引你完成 CAN FD 網路的設計和實現.

免費 157 分

串列通訊 (I2C/SPI/U 錯技巧

我們將探索各種 在不同的情況下 合，以及如何處 未見過的錯誤。

免費

MICROCHIP

Microchip University(MPLabX / Harmony)

軟體框架

MPLAB® Harmony v3基礎

MPLAB® Harmony v3基礎

使用 MPLAB ® Harmony v3 周邊函式庫, 實現簡單的嵌入式應用程式

使用 MPLAB ®Harmony v3 周邊函式庫 建立 32 位元 MCUs/MPUs 的簡單嵌入式應用程式

使用 MPLAB® Harmony v3 軟體框架開發 32 位元微控制器及微處理器的高階嵌入式應用程式

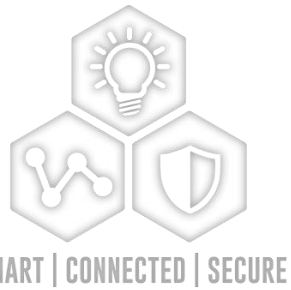
使用 MPLAB® Harmony v3 軟體框架開發 32 位元微控制器及微處理器的高階嵌入式應用程式簡介 本課程展示如何使用

USB裝置應用與 MPLAB® Harmony USB堆疊

利用MPLAB® Harmony USB堆疊開發USB裝置應用

CAN 基礎知識

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



What is CAN?

Asynchronous serial communication protocol

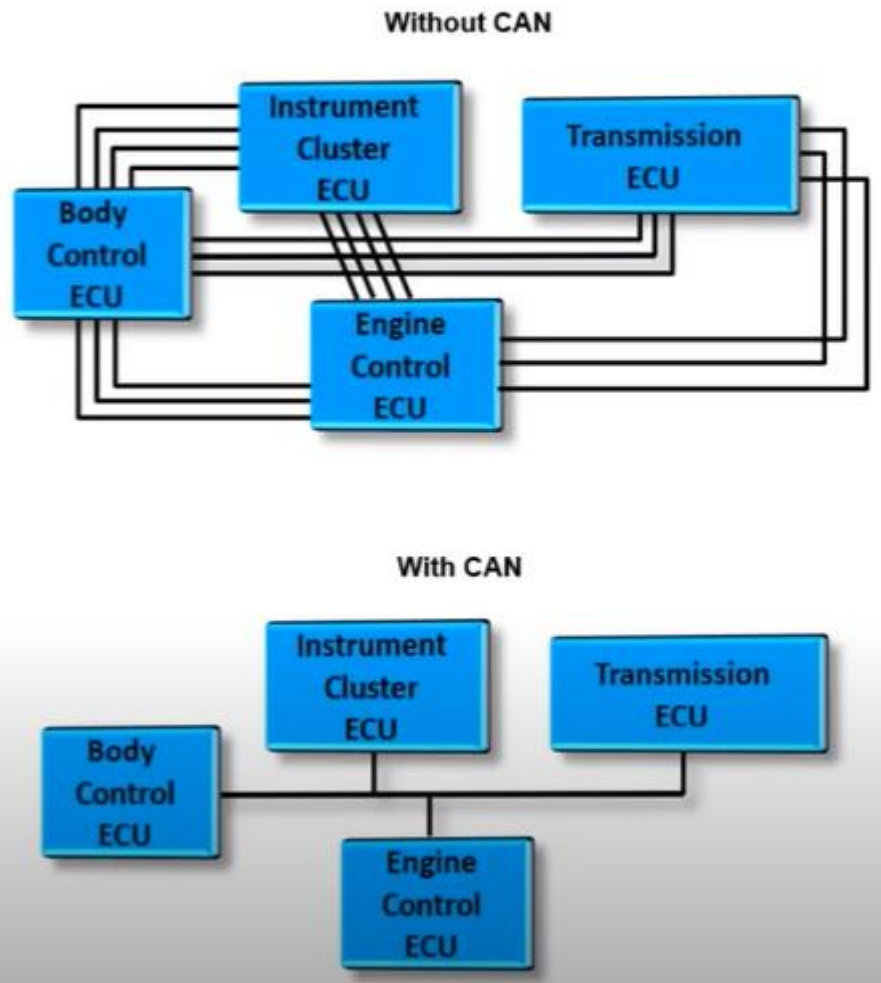
Bus topology

Targeted to Distributed Control Systems

High speed

CAN 2.0: 1 Mbit/s, 8 bytes payload

CAN FD: 2 to 5 Mbit/s, 64 bytes payload



History of CAN

CAN 2.0 (Classical CAN)
Bosch specification
ISO 11898-1
ISO 11898-2

1983-2003

2012-2016

CAN Flexible Data rate (CAN FD)
Bosch specification
ISO 11898-1:2015
ISO 11898-2:2016

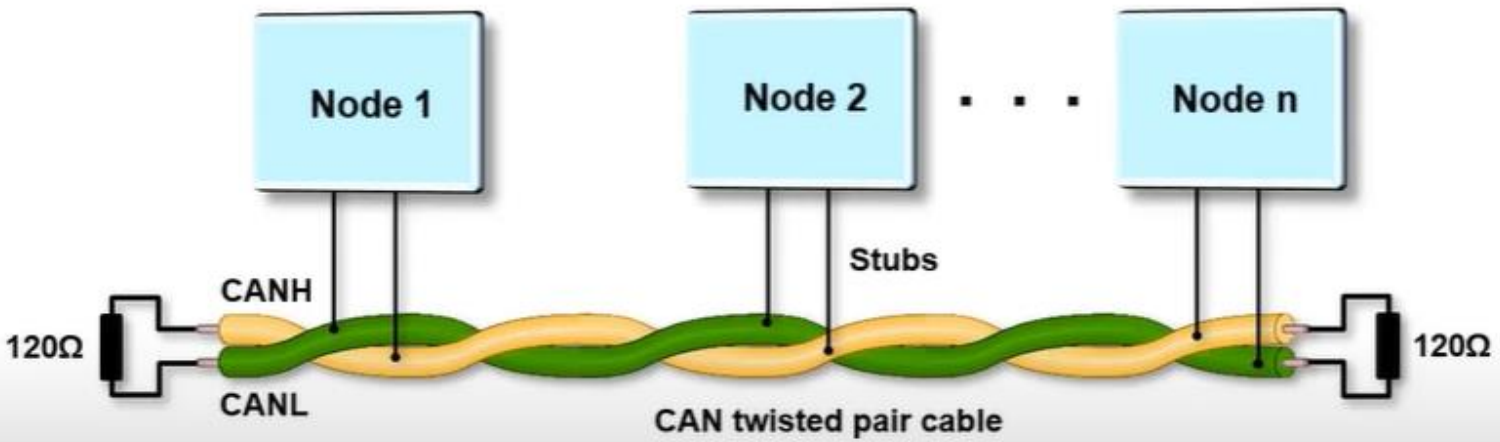
CAN Signal Improvement (CAN SIC)
CiA 601-4

2019

2020

CAN SIC XL
Next generation

CAN Network



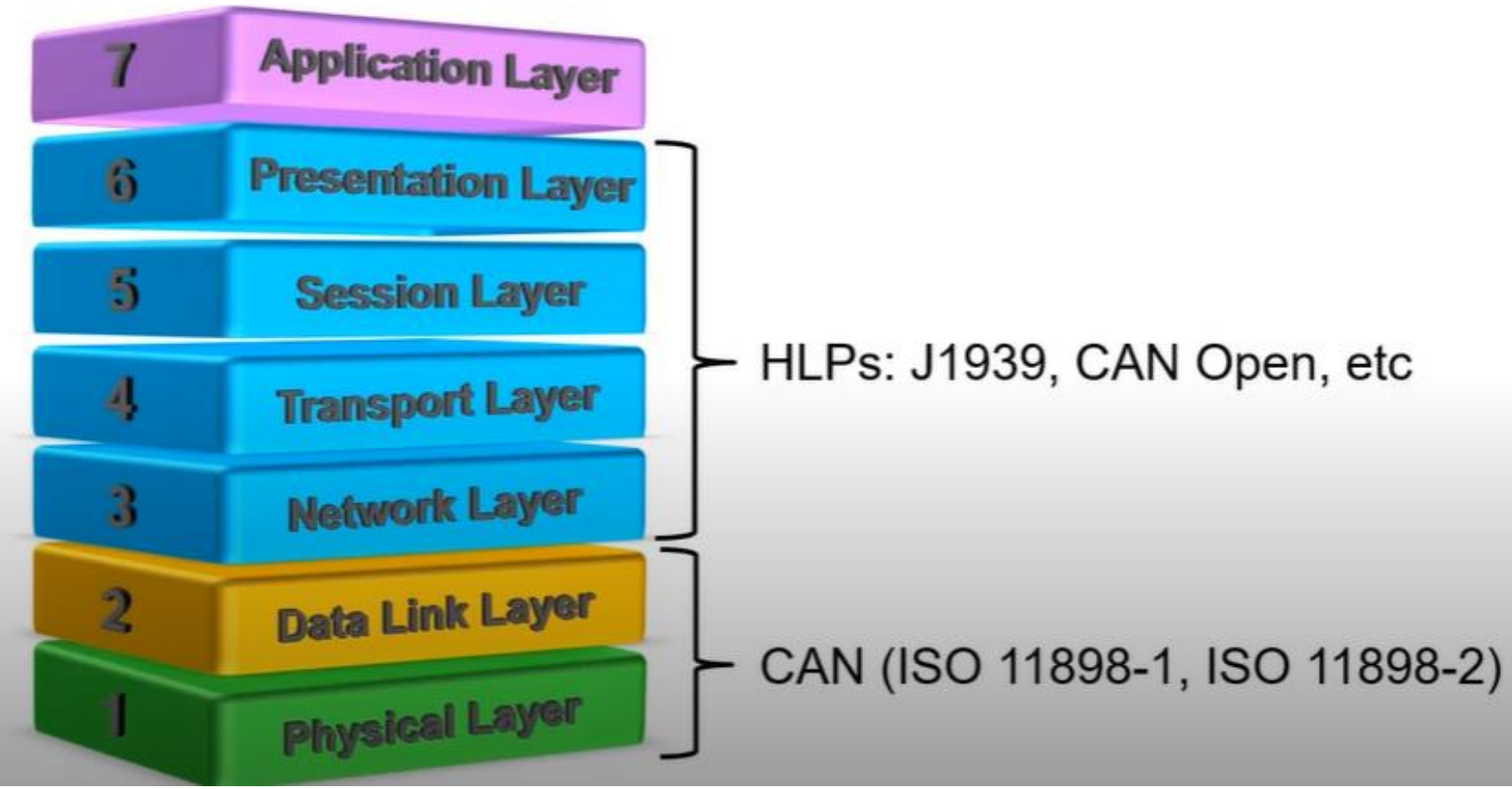
CAN ISO 標準

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

SMART | CONNECTED | SECURE

Network Model

ISO/OSI Seven Layer Network Reference Model



ISO 11898-1: “Data Link Layer & Physical Signaling”

Data Link Layer

Logical Link Control (LLC)

- Acceptance Filtering
- Overload Notification
- Recovery Management

Medium Access Control (MAC)

- Data Encapsulation/De-encapsulation
- Frame Coding (stuffing/destuffing)
- Error Detection/Signaling

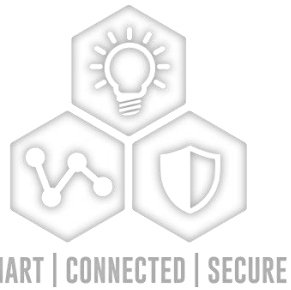
Physical Layer

Physical Signaling (PLS)

- Bit Encoding/Decoding
- Bit Timing/Synchronization

CAN 協議基礎

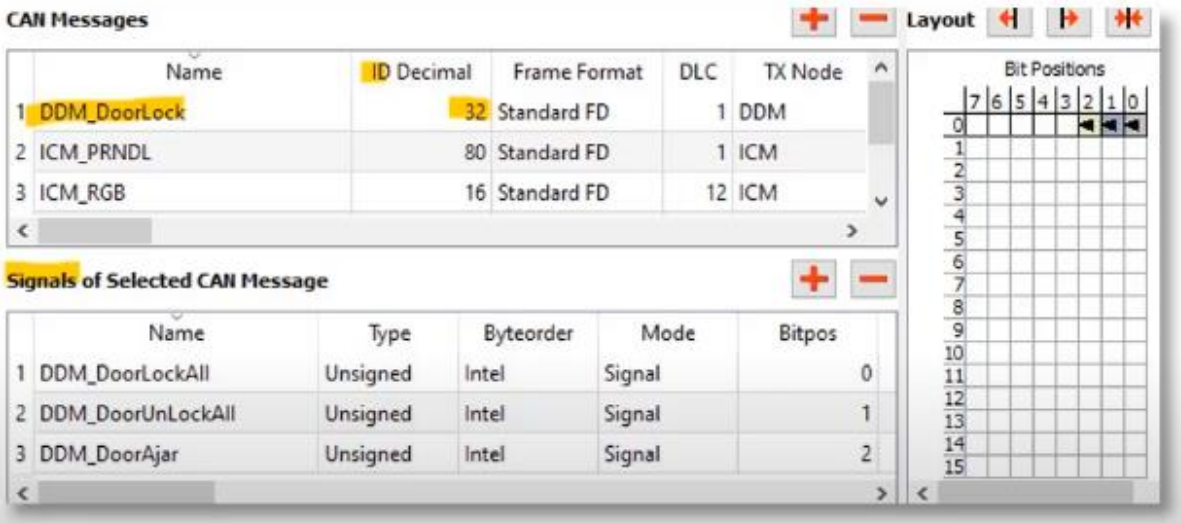
A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



Key Features of CAN

Identifier based,
not address based

- Message includes ID and data
- ID specifies meaning of frame
- ID specifies priority



Bus Access

CSMA/CD-CR

Carrier **S**ense (CS)

Multiple **A**ccess (MA)

Collision **D**etection (CD)

Collision **R**esolution (CR)

Non-destructive

Bitwise

Arbitration

Bus State

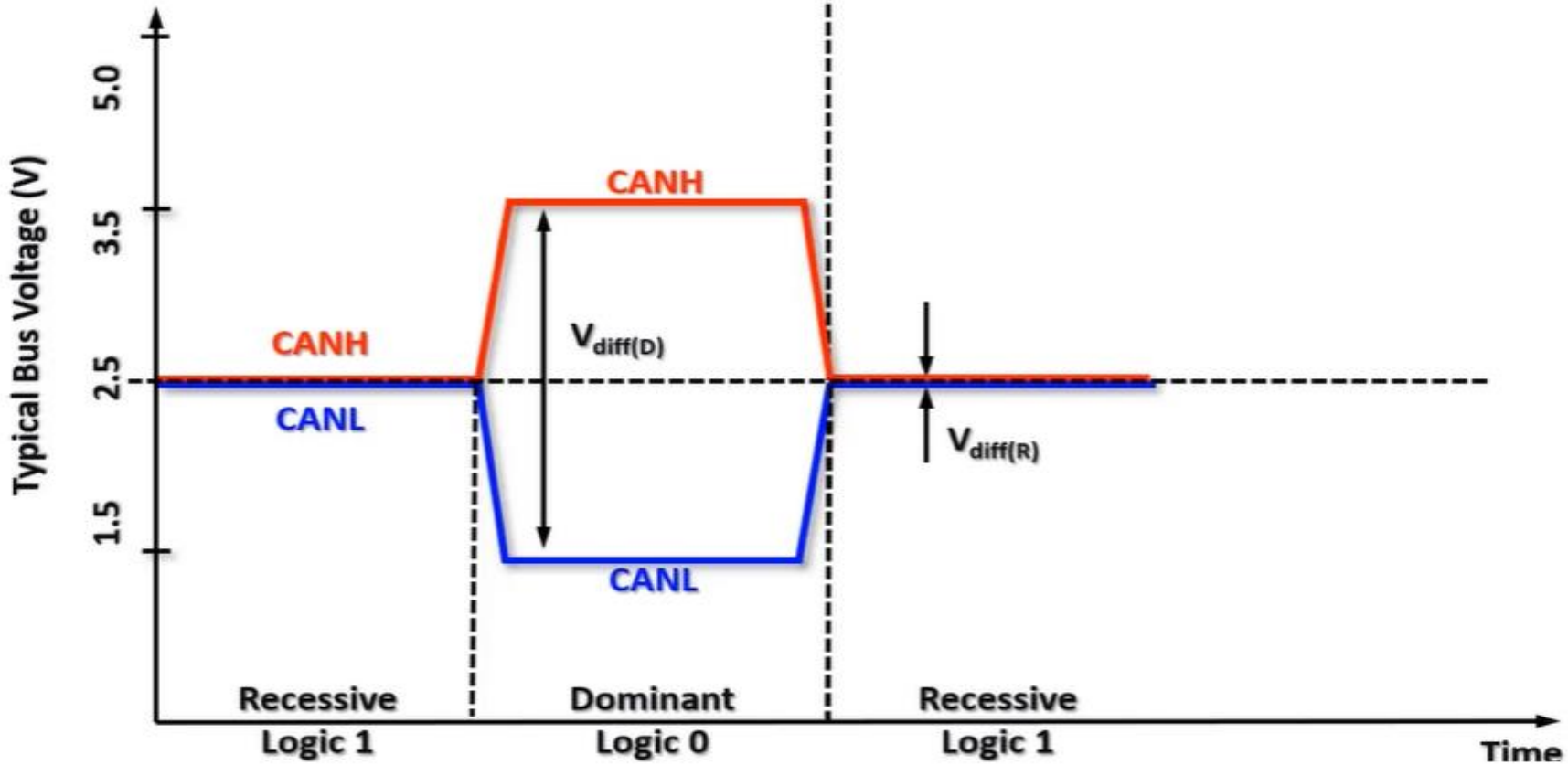
Dominant

Transmission of logical 0

Dominant wins over recessive

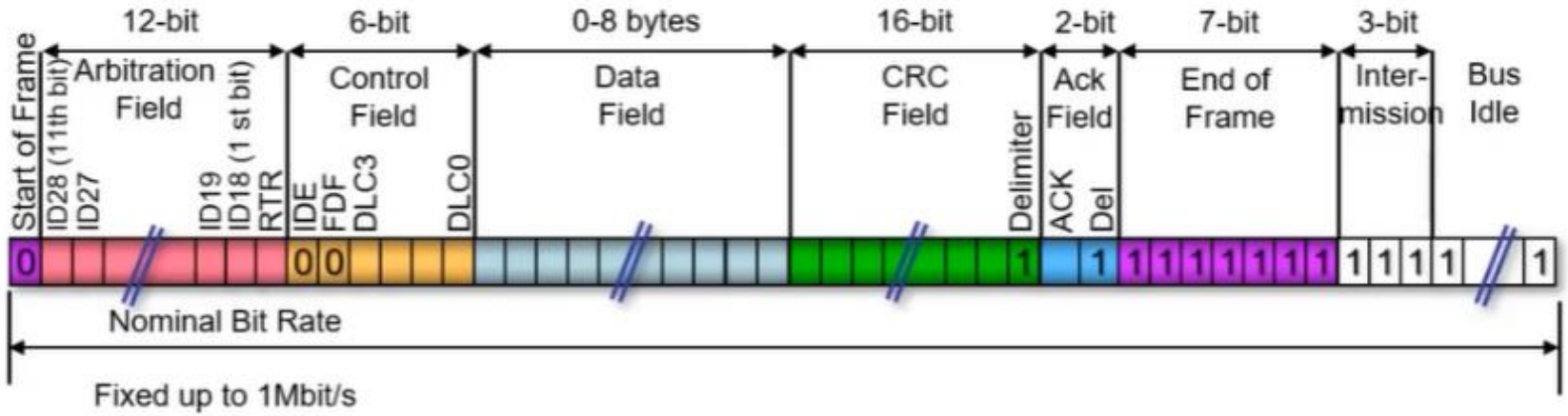
Recessive

Transmission of logical 1

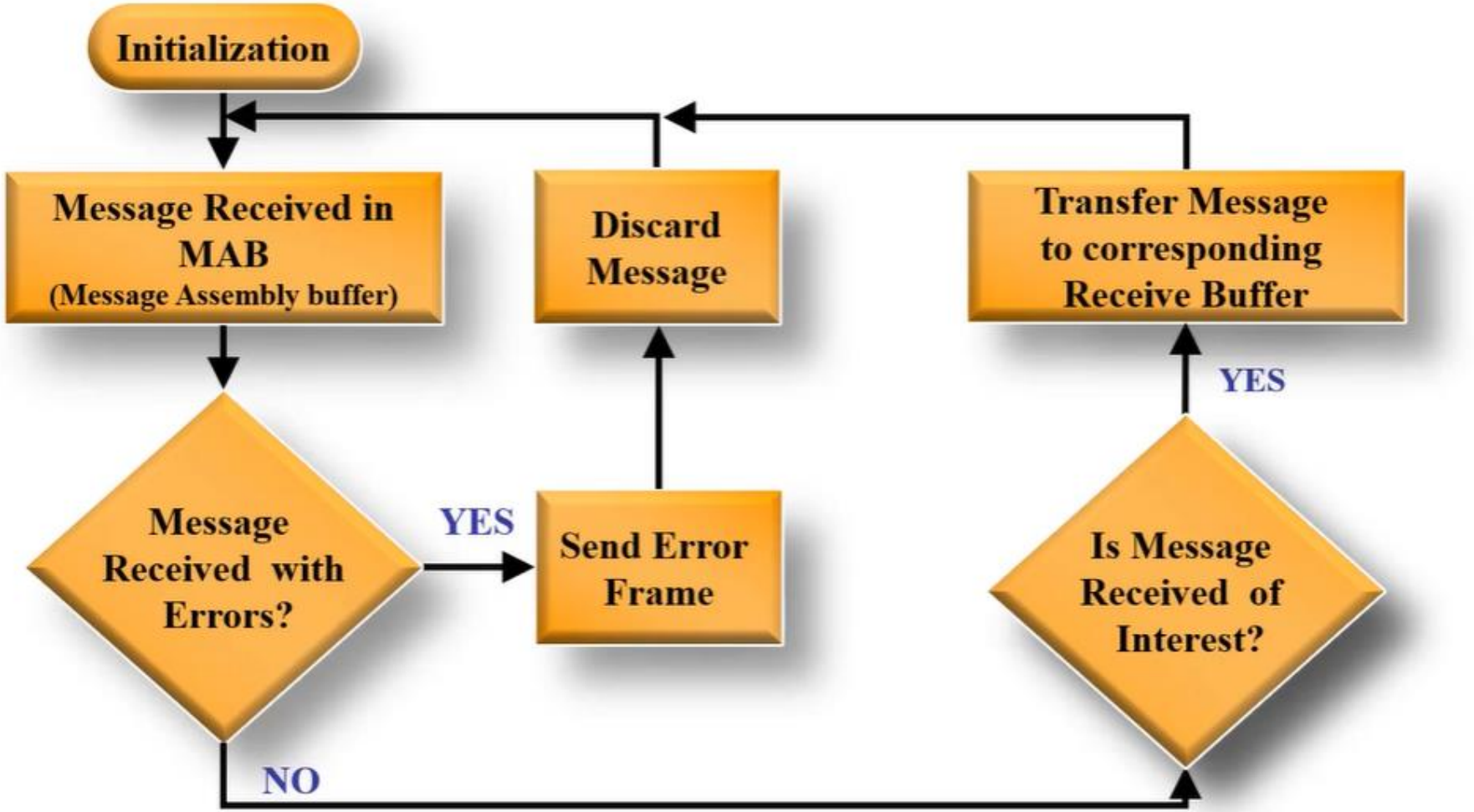


MICROCHIP

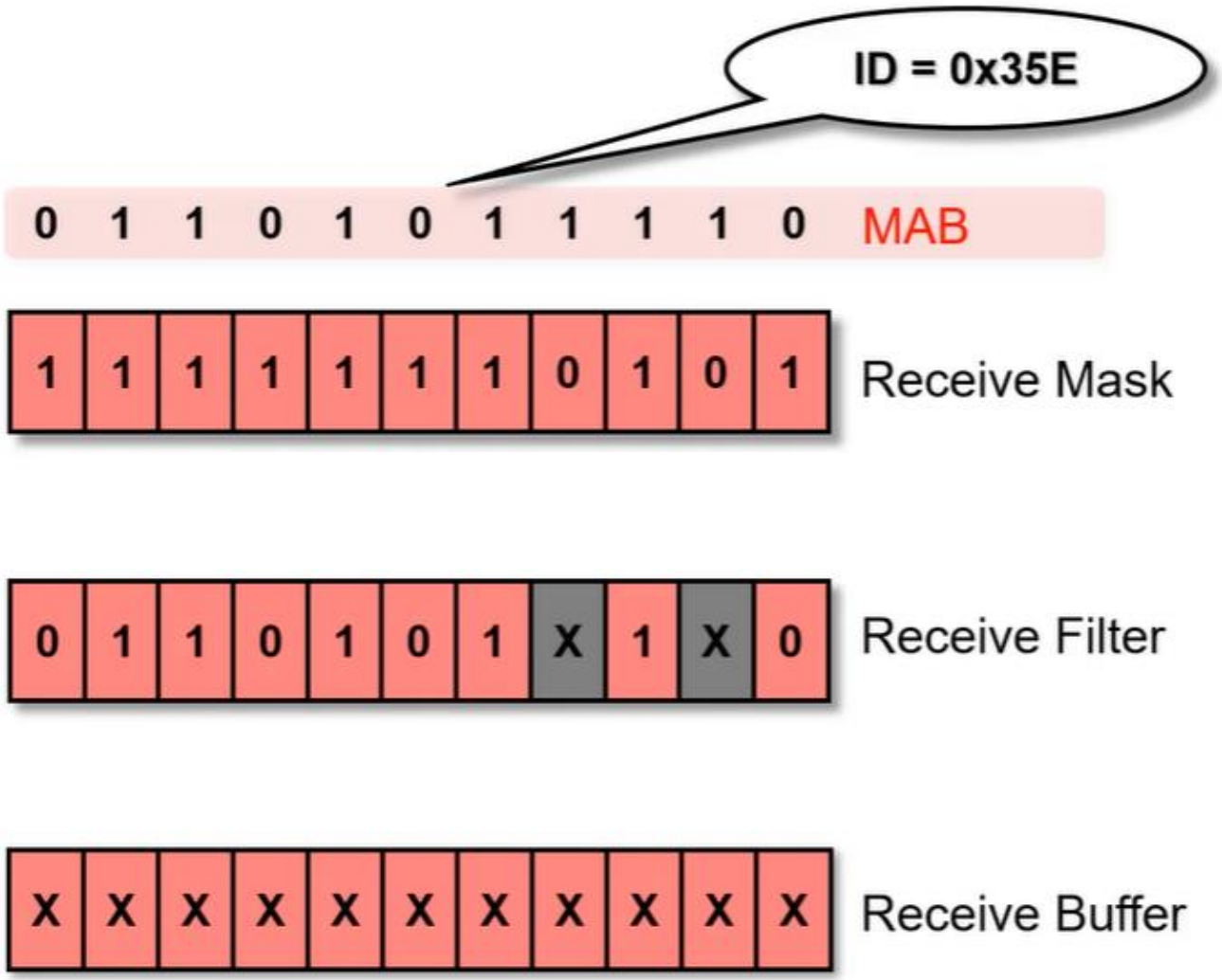
Classical Base Frame



Frame Reception

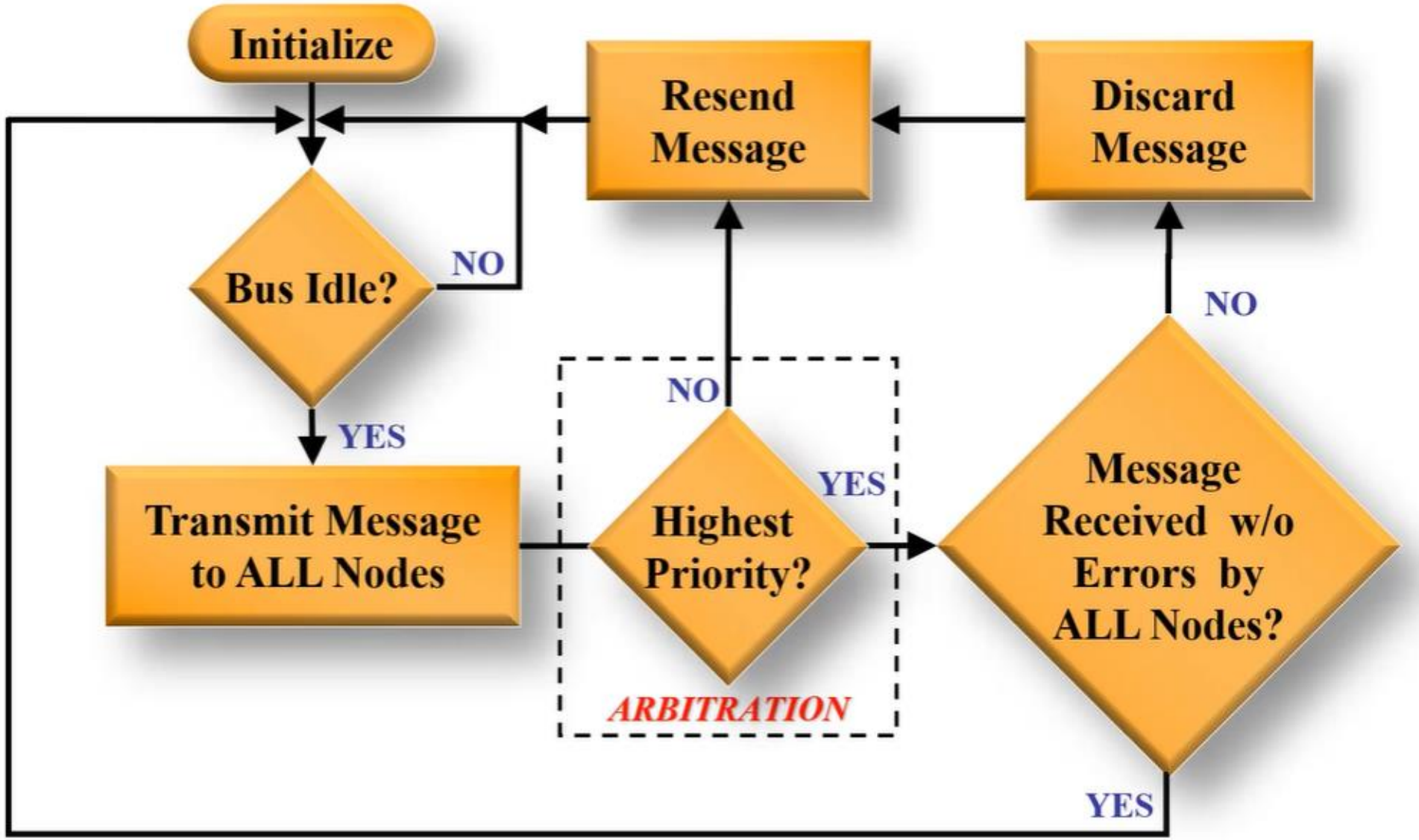


Mask and Filter on ID Bits

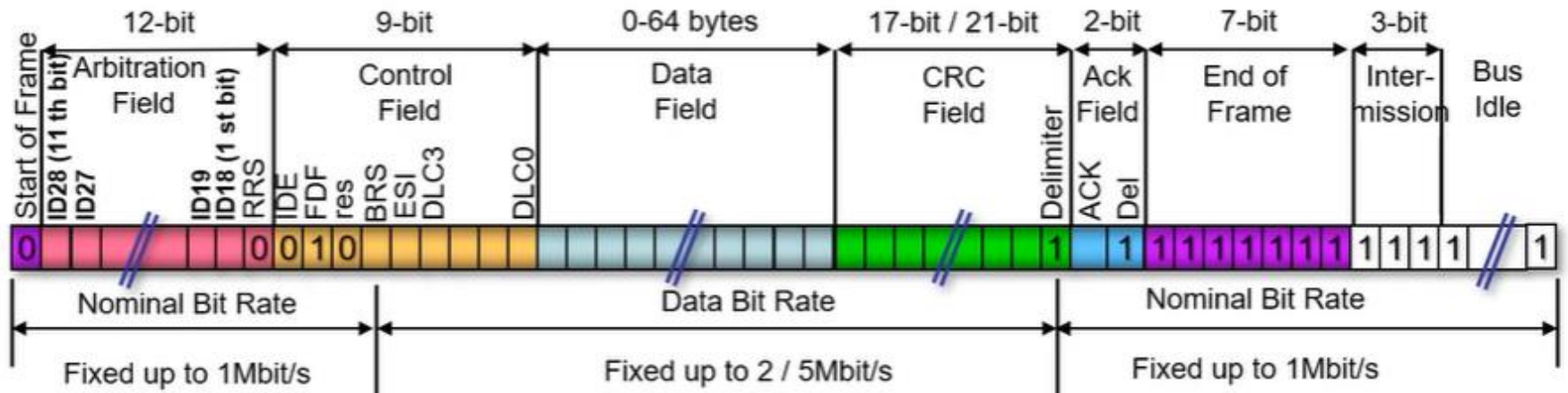


Mask and Filter accept IDs 0x354,0x356,0x35C,0x35E

Frame Transmission



Bit Time vs. Bit Rate



$$NBT = \frac{1}{NBR}$$

$$DBT = \frac{1}{DBR}$$

$$NBT = \frac{1}{NBR}$$

1Mbit/s → 1µs

5Mbit/s → 200ns

1Mbit/s → 1µs

Data Consistency

Valid Frame

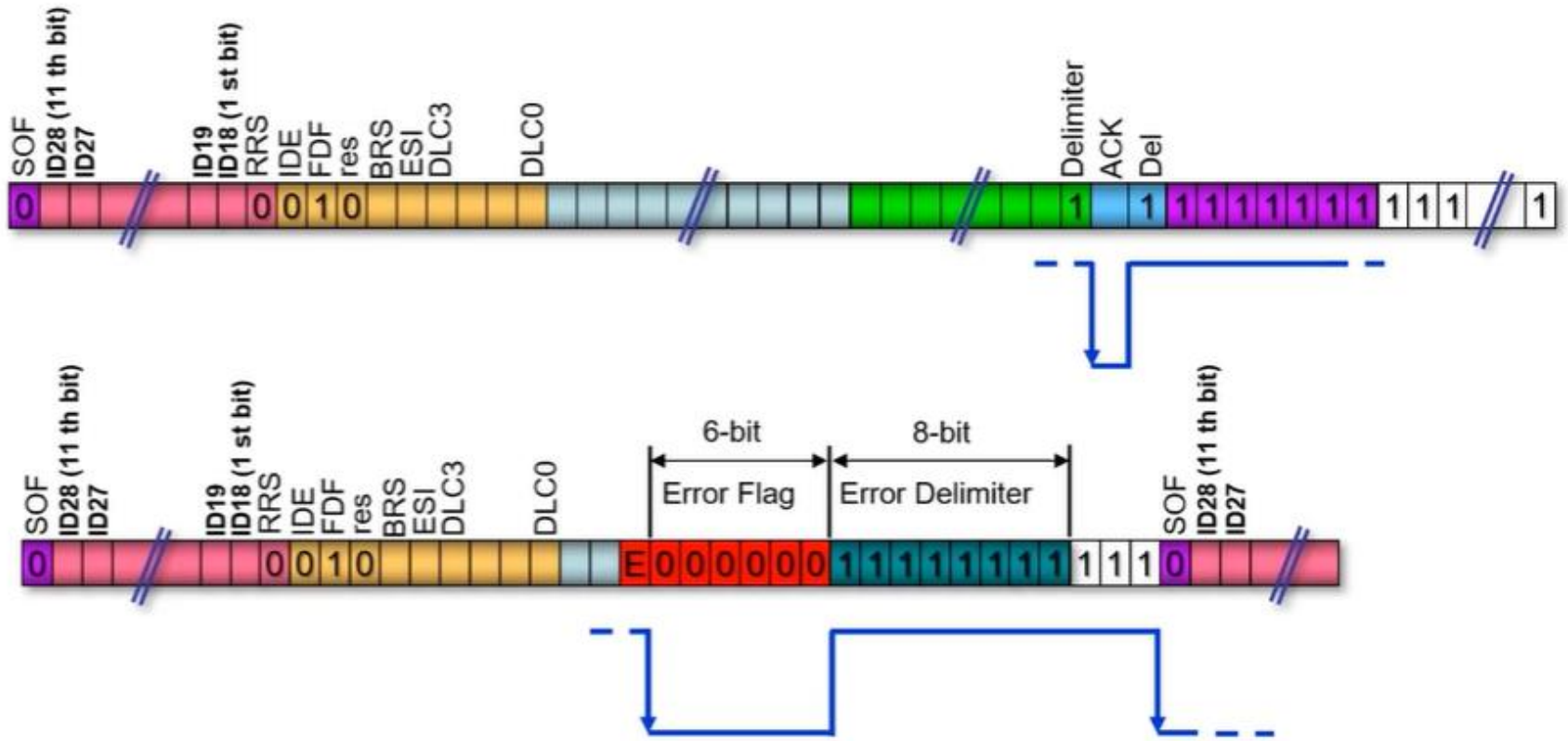
Bit Error

CRC Error

Form Error

Stuff Error

ACK Error

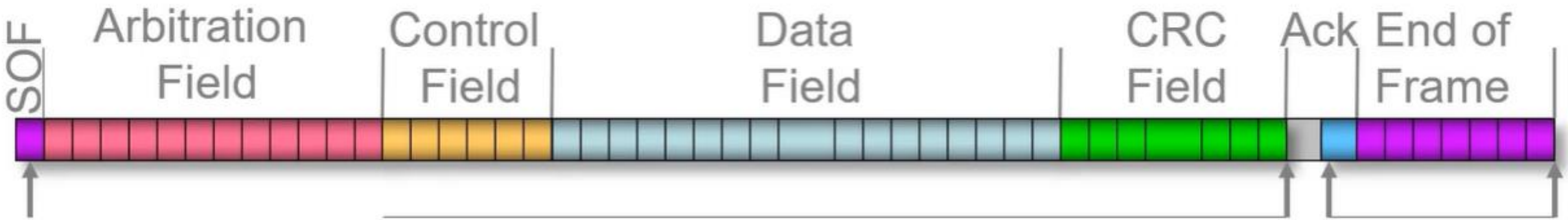


Bit Error

Transmitted bit differs from monitored bit on the bus

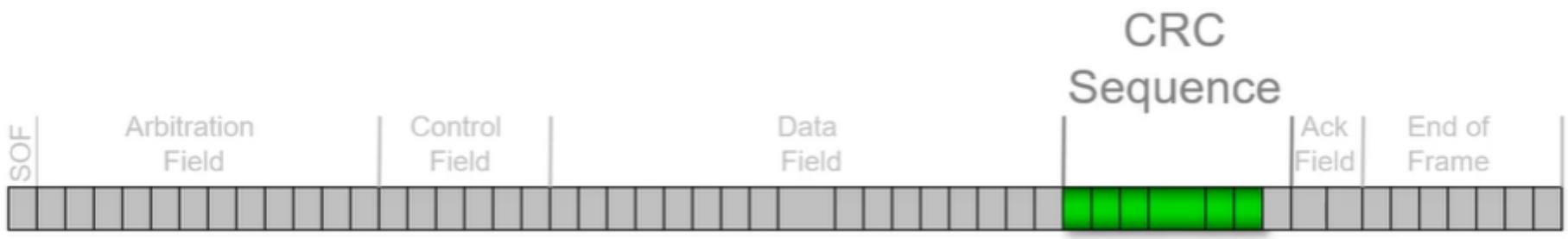
Exceptions

- Dominant bit during arbitration
- Dominant bit in Ack Slot



CRC Error

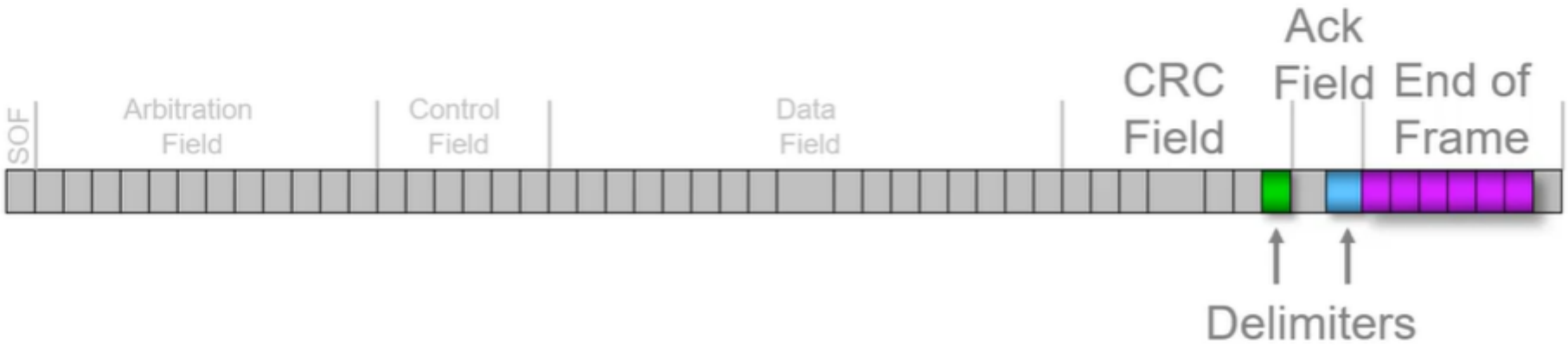
Received CRC sequence doesn’t match



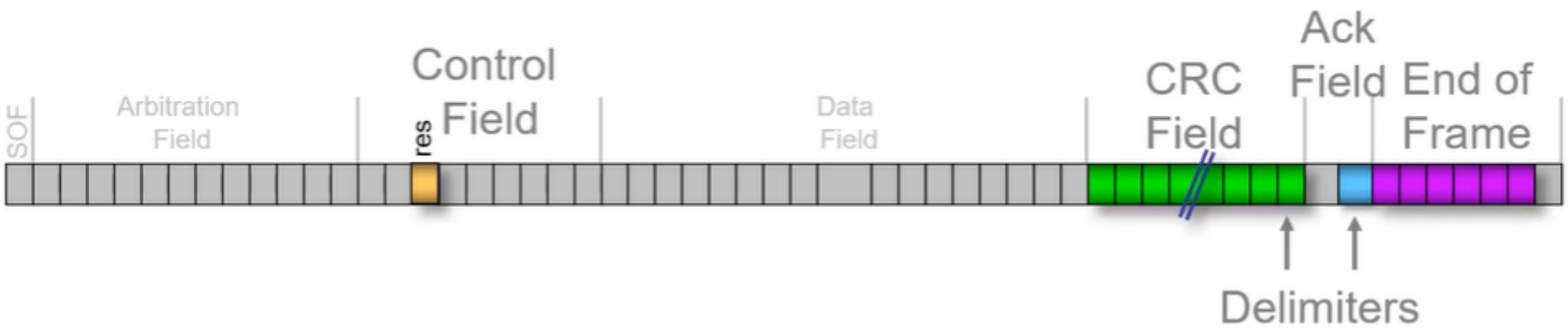
Form Error

Fixed-form bits received incorrectly

Classical CAN Frame

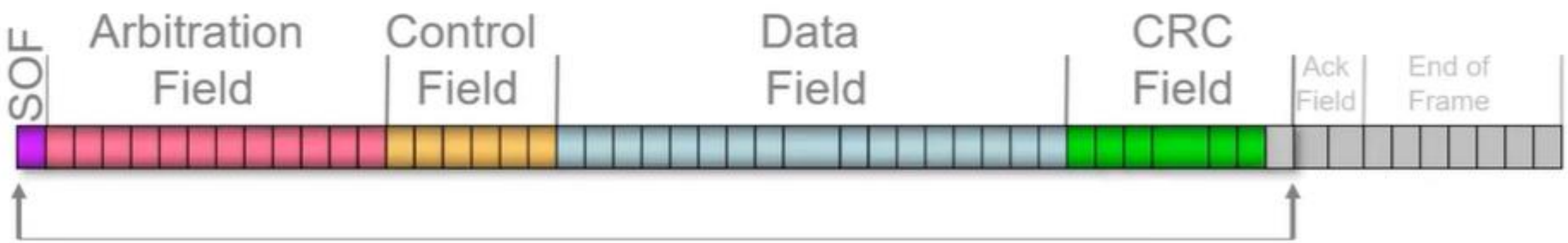


CAN FD Frame



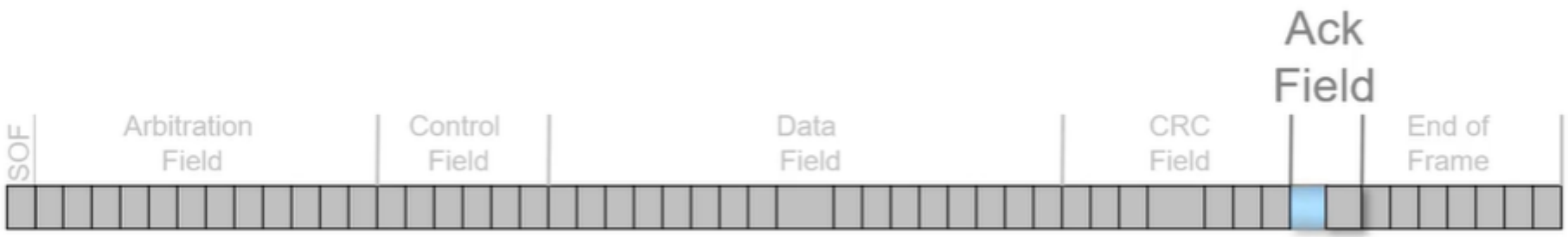
Stuff Error

6 consecutive bits with same value



Acknowledge Error

Transmitting node doesn't receive ACK



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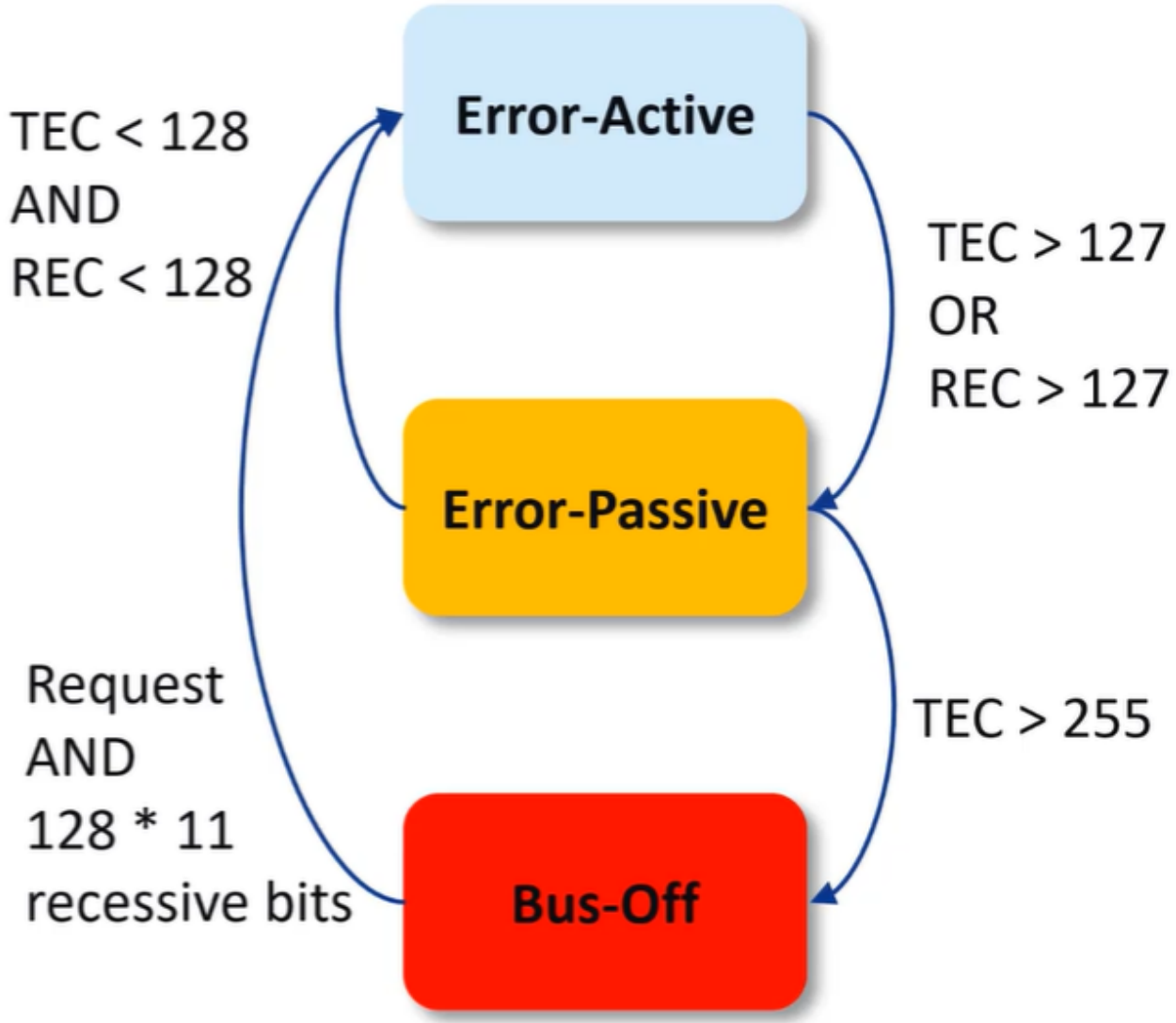
Fault Confinement

Ensures communication despite faulty nodes

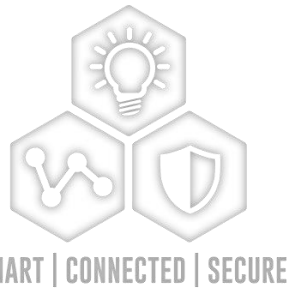
Transmit Error Counter (TEC)

Receive Error Counter (REC)



CAN FD、CAN PN 和 CAN 下一代

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



Classical CAN vs. CAN FD

Increased Bit Rate

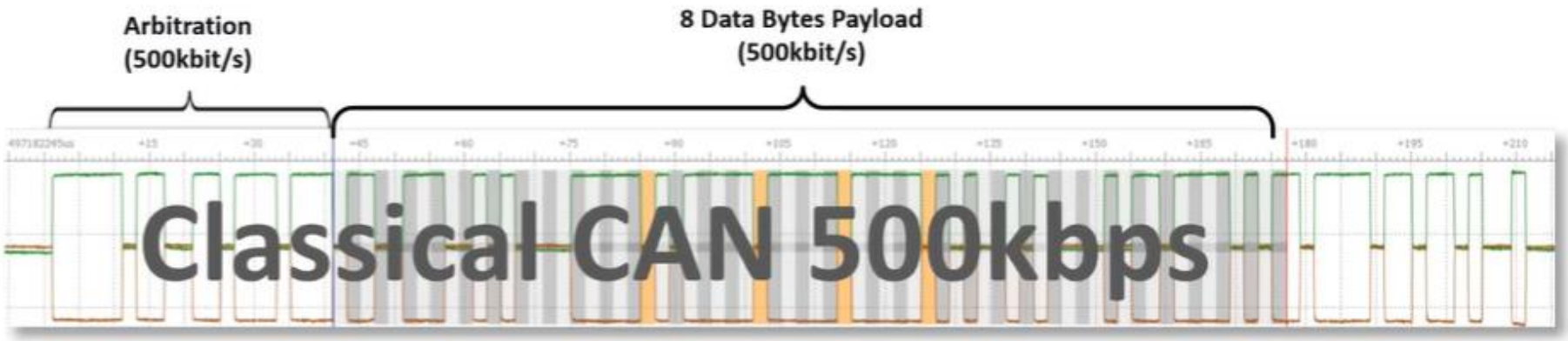
500k -> 2(5)Mbit/s

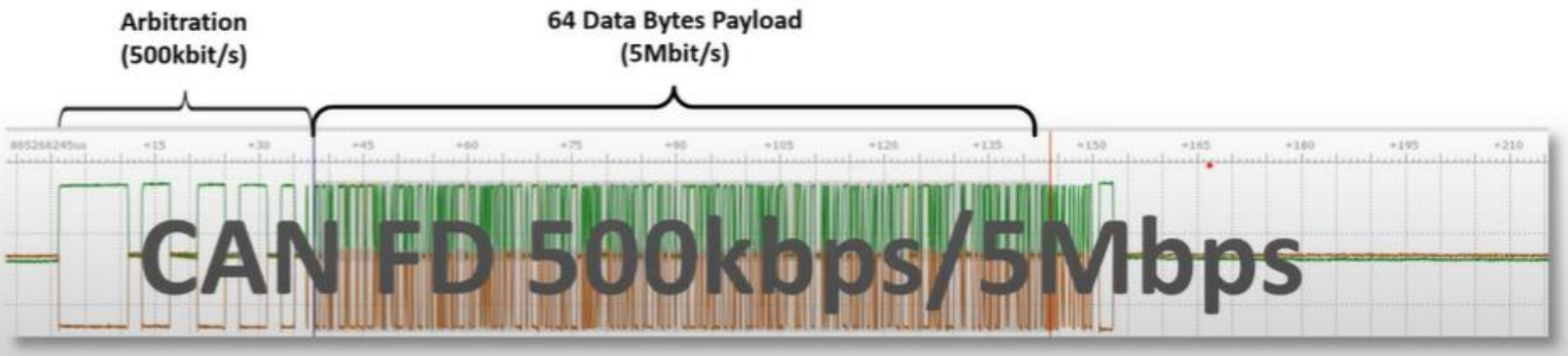
Increased Payload

8 -> 64 data bytes

Benefits

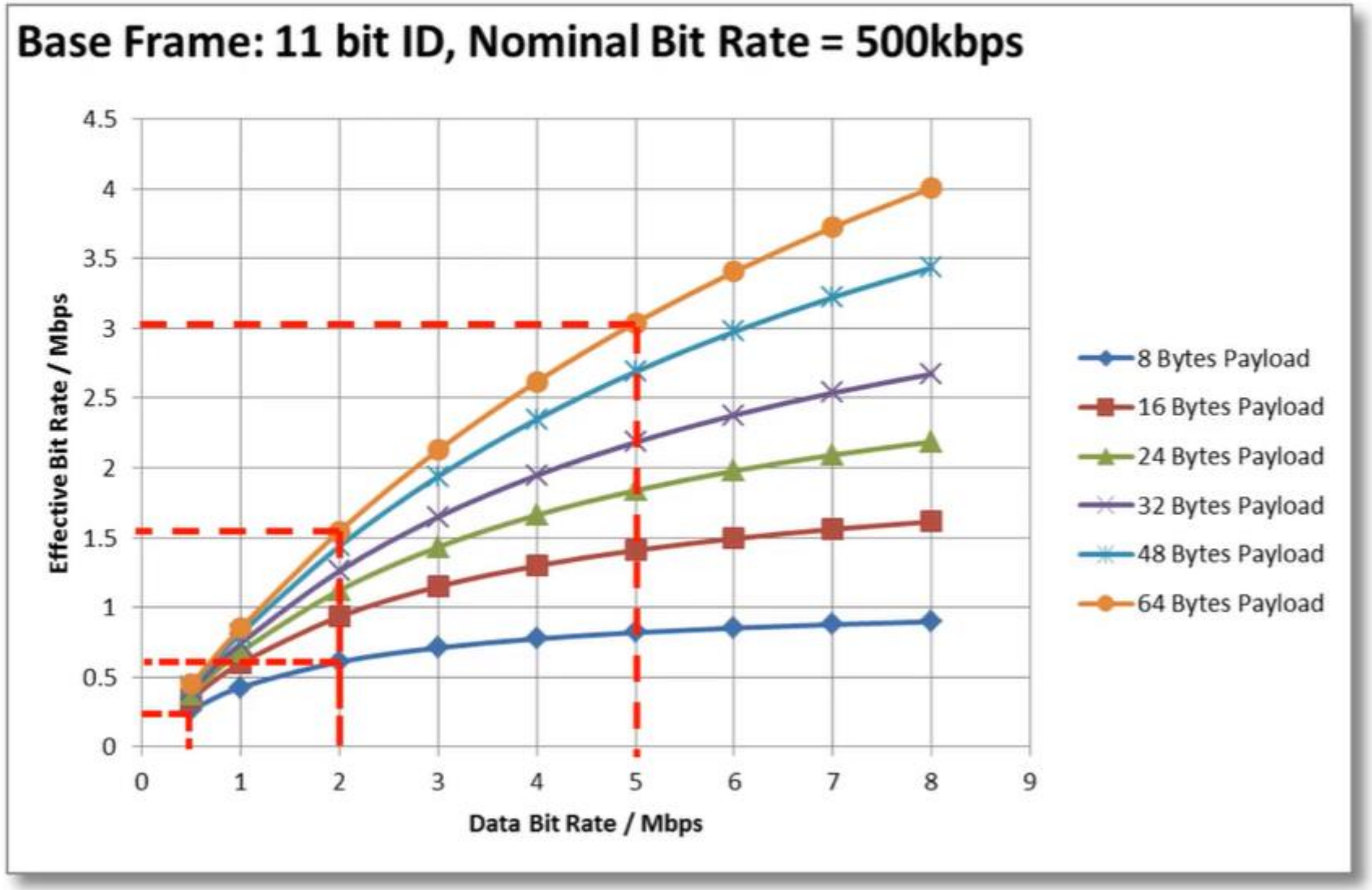
- Faster programming
- More signals/frames
- Less networks
- Less post-processing





MICROCHIP

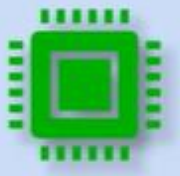
Effective Bit Rate



Mixing Classical CAN and CAN FD

CAN FD is **not** backwards compatible

Classical CAN node detects error!



Solution

Dedicated Classical CAN and CAN FD networks + Gateway

Partial Networking transceivers

CAN Partial Networking

More than 70 ECUs in modern car

ECU in Sleep mode consumes 2 W

Many ECUs inactive 95% of time

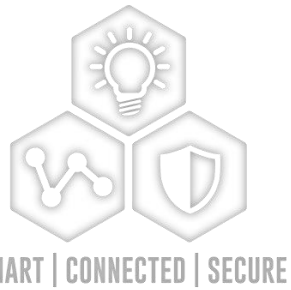
Solution = Partial Networking

Reduces fuel consumption and CO_2 emissions

Selective Wake-Up

CAN 物理層

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



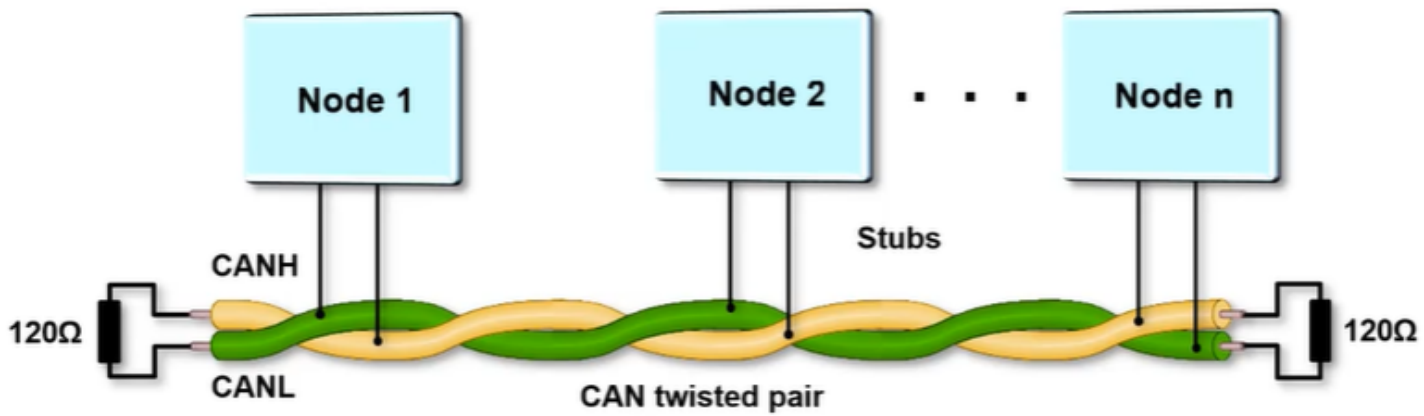
CAN Bus Cabling

Twisted pair Cable with 120Ω impedance

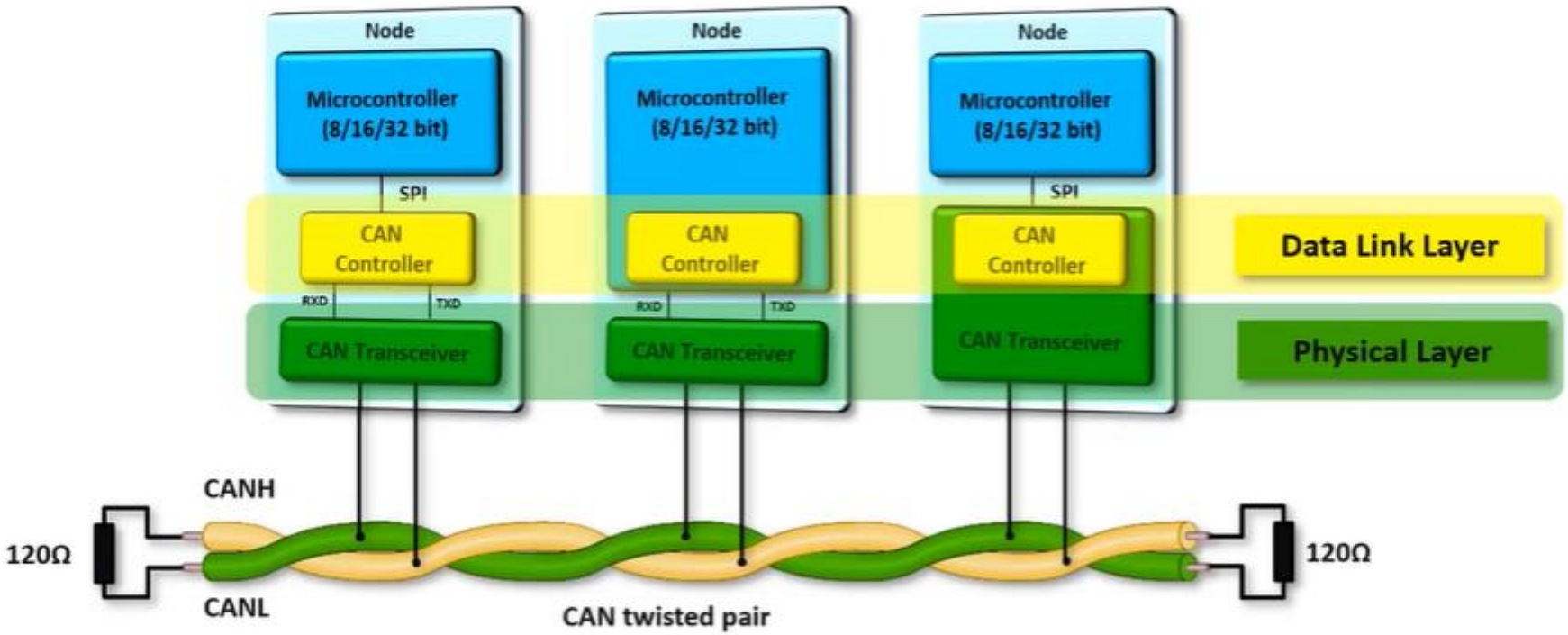
Two 120Ω termination resistors

- Avoids reflections
- Reduces radiated emissions

Optionally use shielded cable for electronically harsh environments



CAN Node Configurations



MICROCHIP

CAN Transceiver

- **CAN Transceiver Modes**
  - Normal Mode – Transmit and Receive
  - Silent Mode – Only Receive, No Transmit
  - Standby Mode – Low Power Mode, No Receive or Transmit

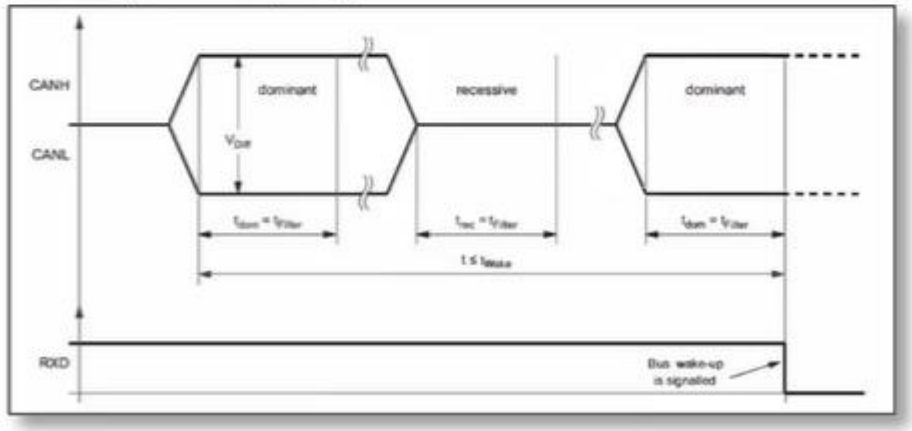
- **Wake-up Scheme**
  - Wake up based on dominant edge
  - Wake Up Pattern (WUP)
  - Wake Up Frame (WUF) – PN (Partial Networking)

- **Speed (Bit Rate)**
  - Classical CAN Transceiver up to 1Mbps
  - CAN FD Transceiver up to 5Mbps
  - CAN SIC XL Transceiver beyond 10Mbps

8 pin Transceivers	
ATA6560	Standby + Silent Mode
ATA6561	Standby Mode, 3.3V- 5V Operation
ATA6562	Standby + Silent Mode , WUP
ATA6563	Standby Mode, 3.3V- 5V Operation, WUP
ATA6564	Silent Mode, + 3.3V- 5V Operation, WUP

14 pin Transceivers	
ATA6565	Dual CAN
ATA6570	Standby + Silent Mode, WUP , Partial Networking capable with SPI interface

Wake Up Pattern (WUP)



MICROCHIP

CAN FD Transceiver

ISO 11898-2: 2016 compliant

Supports up to 5Mbps

VCC: 5V transceiver supply

VIO: 3.3V or 5V I/O supply

CANH and CANL

V_{Diff} > 0.9 V is dominant (0)

V_{Diff} < 0.5V is recessive (1)

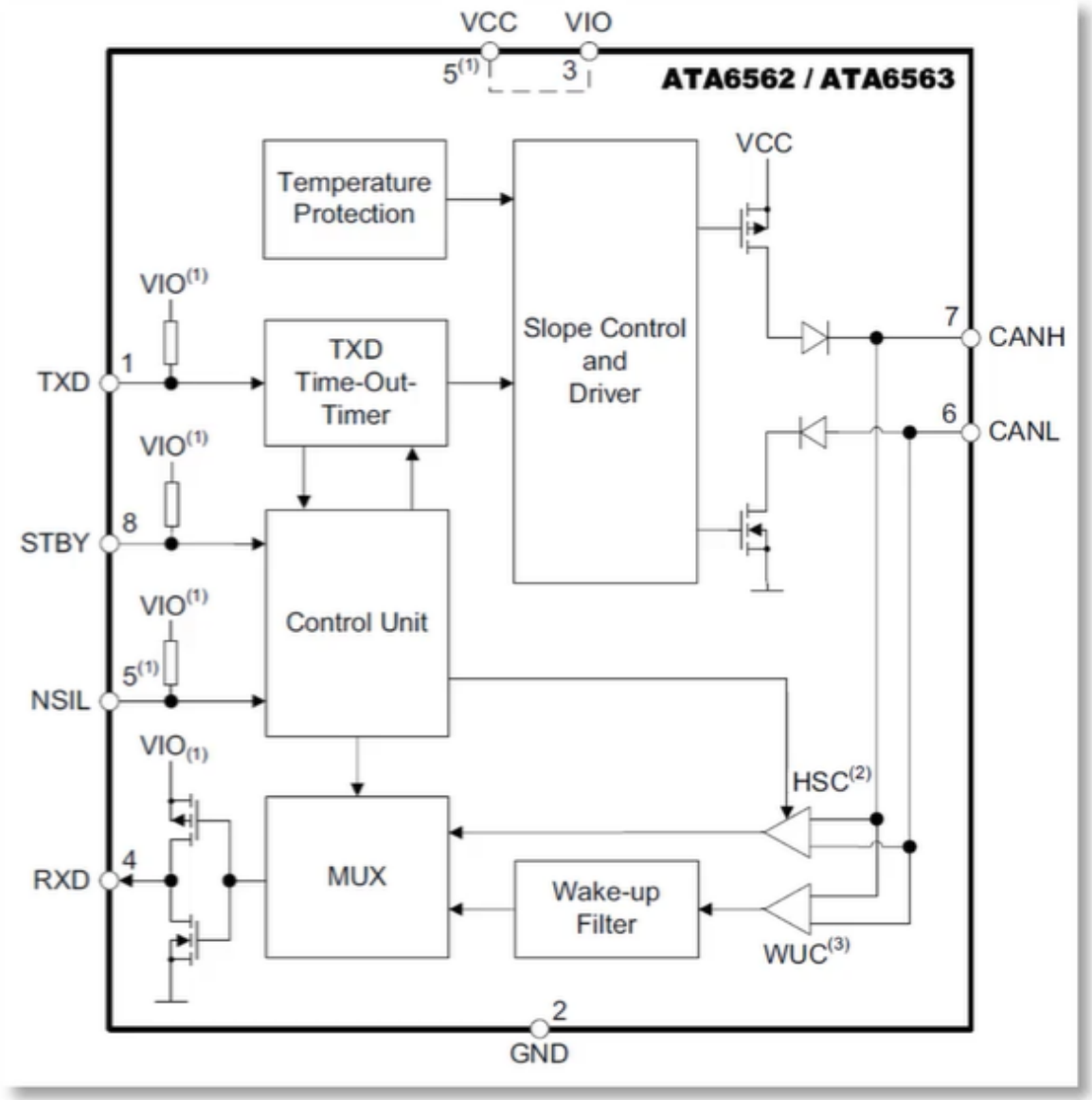
CANH and CANL Maximum Voltage

-27 to 42V DC

-150V to 100V transients

Safety Features

ISO 26262 FuSa Ready



MICROCHIP

ESD and Transient Protection

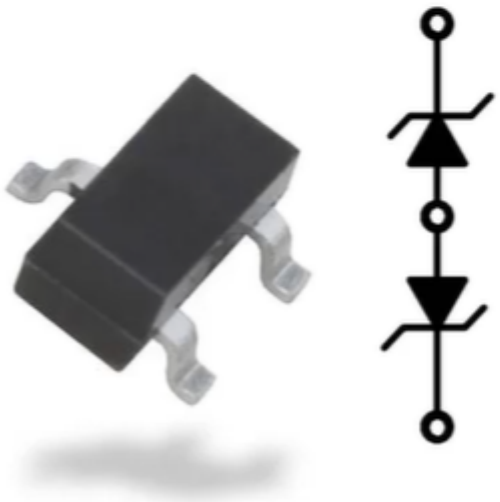
Capacitor

Absorbs voltage transients and keeps out RF energy

Transient Voltage Suppressor (TVS)

Clamps high voltage transients

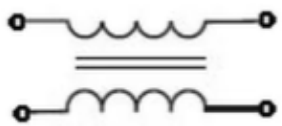
Use dual bidirectional diodes

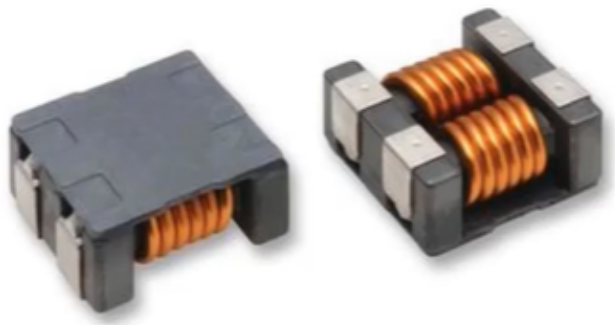


EMI Protection and Reduction of Emissions

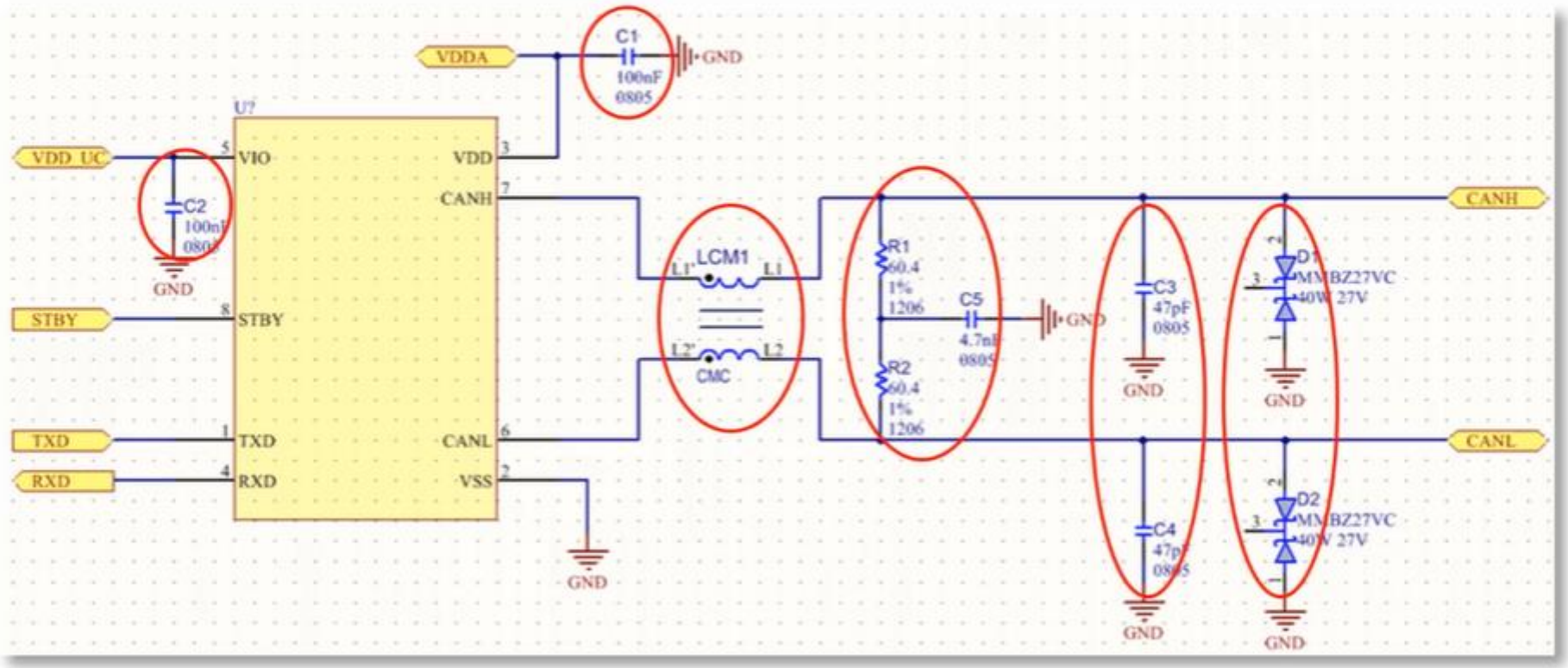
Common Mode Choke (CMC)

- Low impedance for differential CAN signals
- High impedance for common mode signals
- Protects against EMI
- Reduces emissions



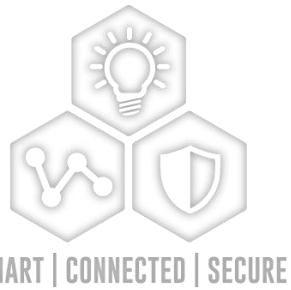


Schematic with Optional Protection

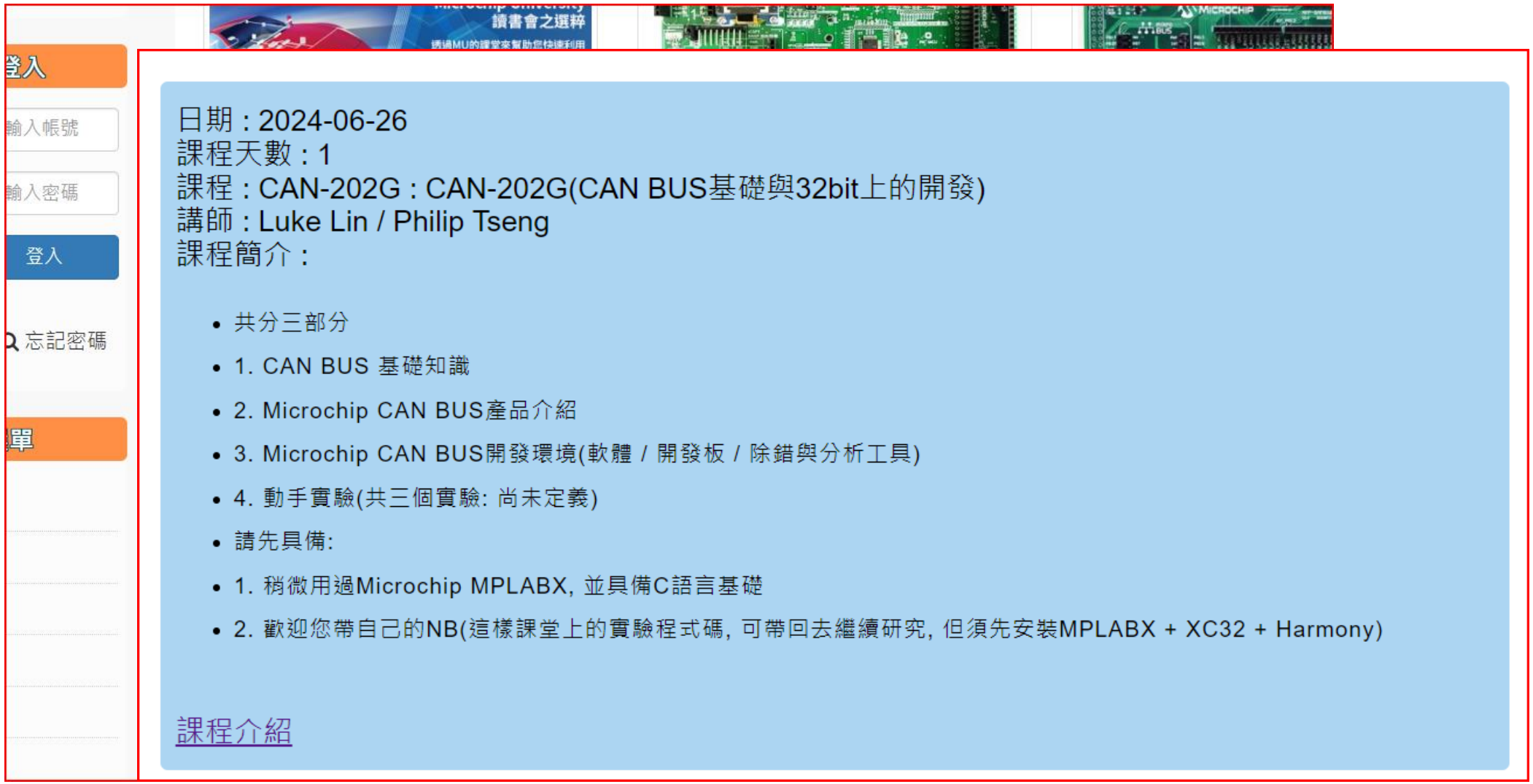


CAN BUS RTC 課程

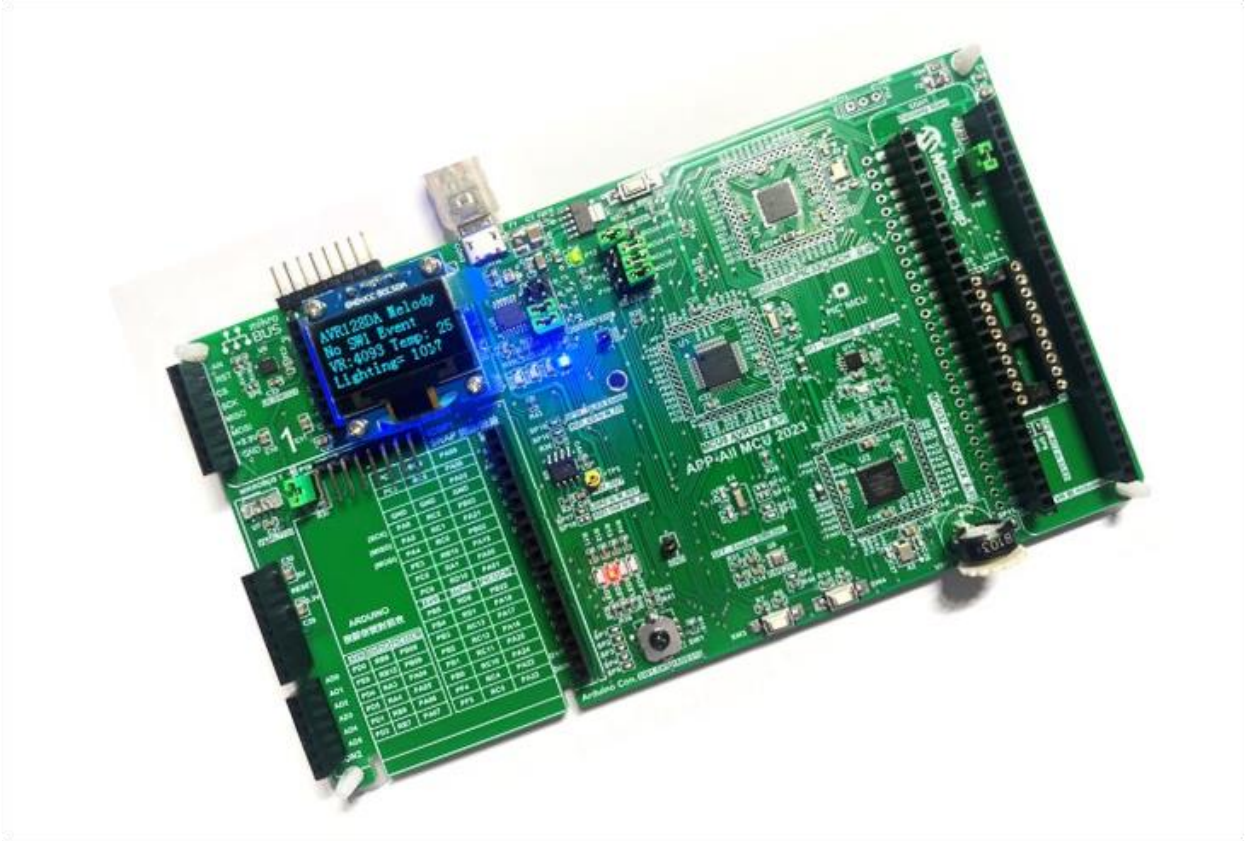
A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

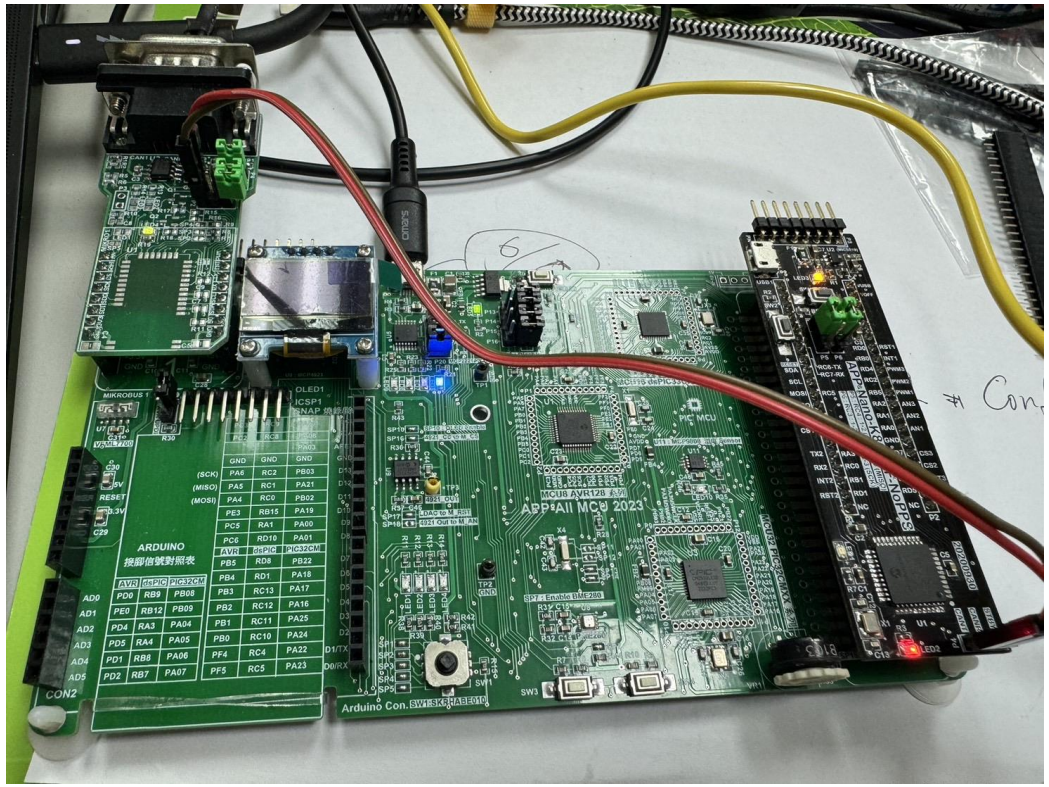


RTC訓練教室(台灣官網: https://www.microchip.com.tw/)



RTC 所使用EVM (APP_All_MCU 2023)





- **EVB資料下載:**
  https://www.microchip.com.tw/uploads/tad_uploader/tmp/288/APP_All_MCU_2023_Dev_Resource.pdf

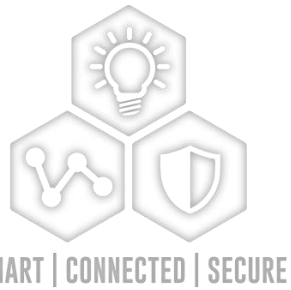
MICROCHIP

MPLabx / Harmony

開發操作Demo

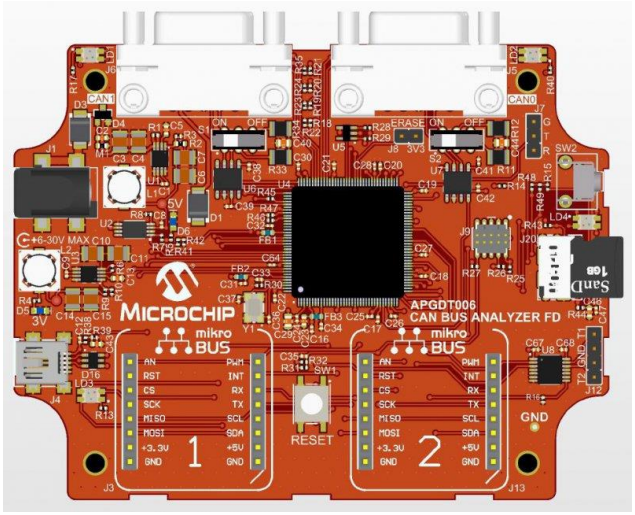
Video Link : https://youtu.be/Hr39KzDhhBI

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

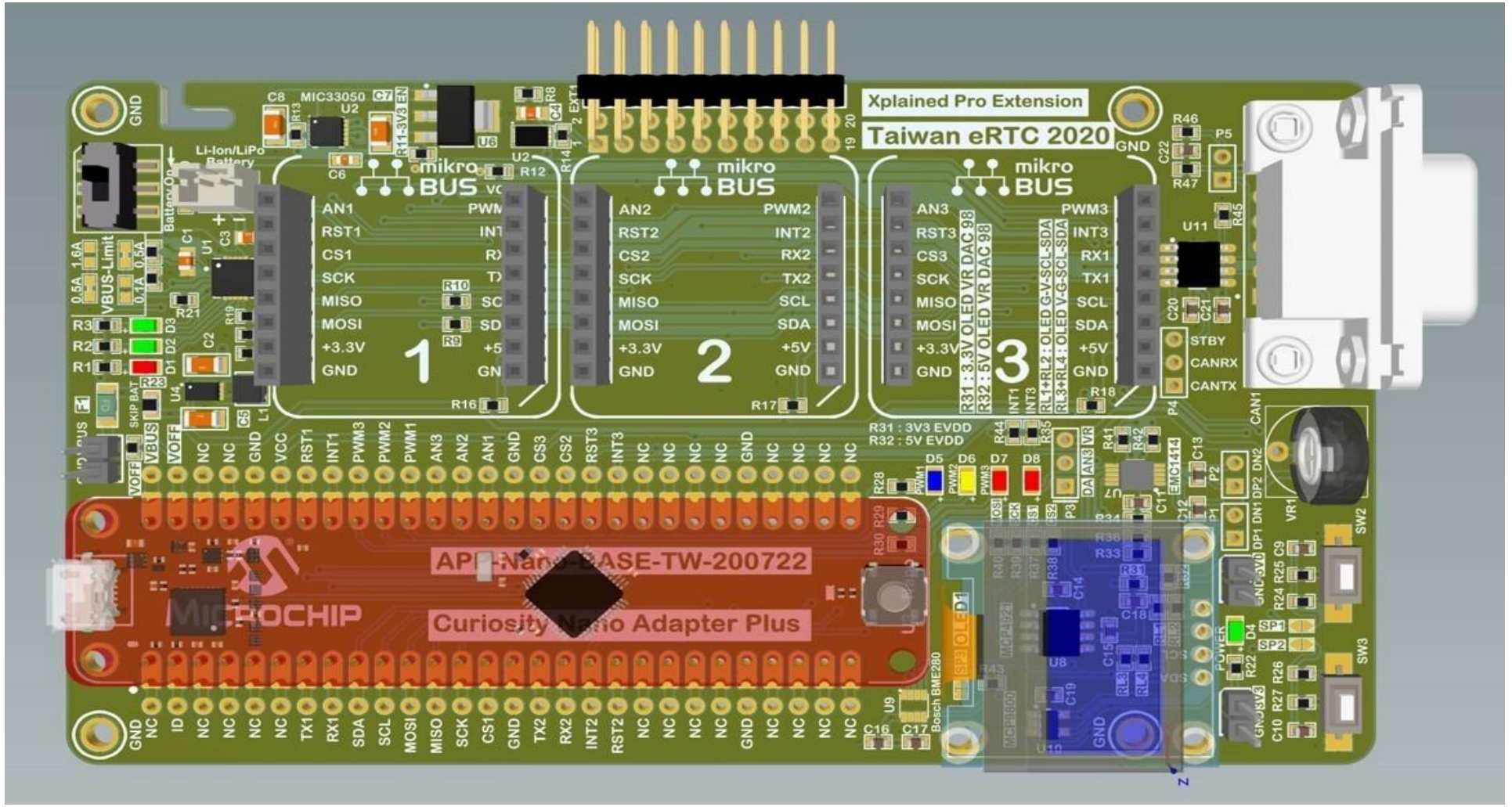


本實驗所使用

- **EVM / Tool / Environment**
  - Tool: MPlabX V6.05以上 / XC32 V4.3以上 / MCC Harmony(線上隨時更新)
  - EVB: Curiosity Nano Base TW + ATSAMC21G Curiosity Nano
  - Programmer Debugger: MPLAB PICkit™ 4/5 or Snap
  - CAN BUS Analyzer: APGDT002 or APGDT006(CAN BUS Analyzer FD)

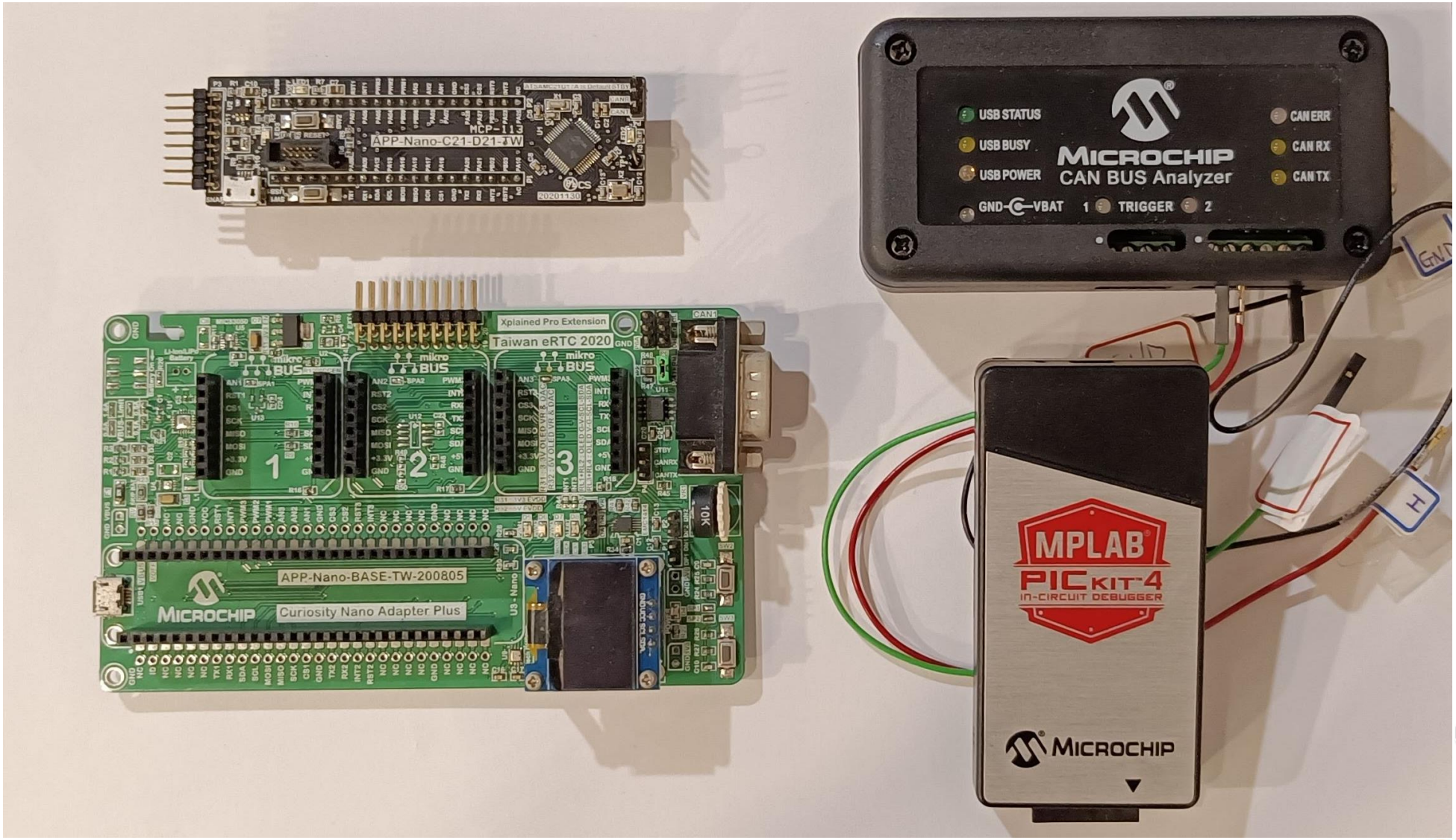


Curiosity Nano Base TW + SAMC21 Nano



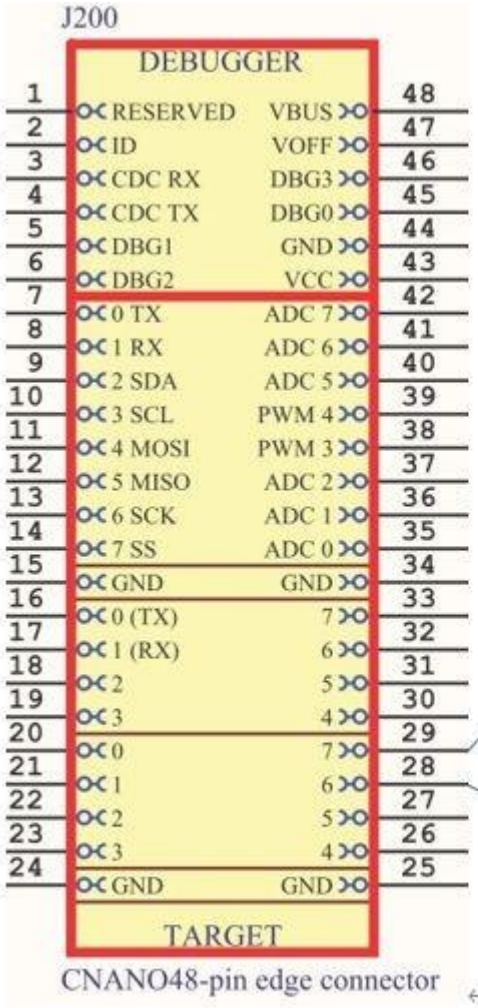
- **EVB資料下載:** https://www.microchip.com.tw/Data_CD/eLearning/

需要這些Kits



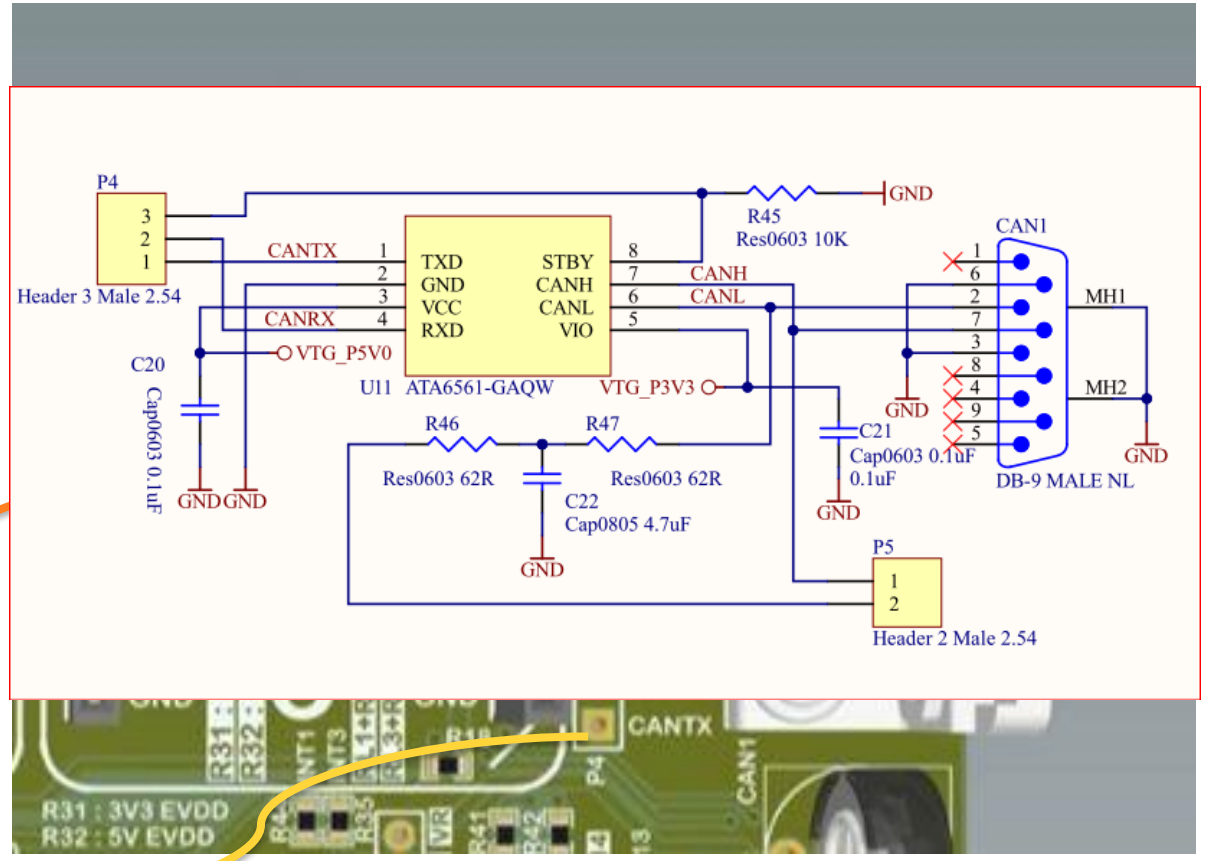
MICROCHIP

SAMC21 Nano connected to Nano Base TW



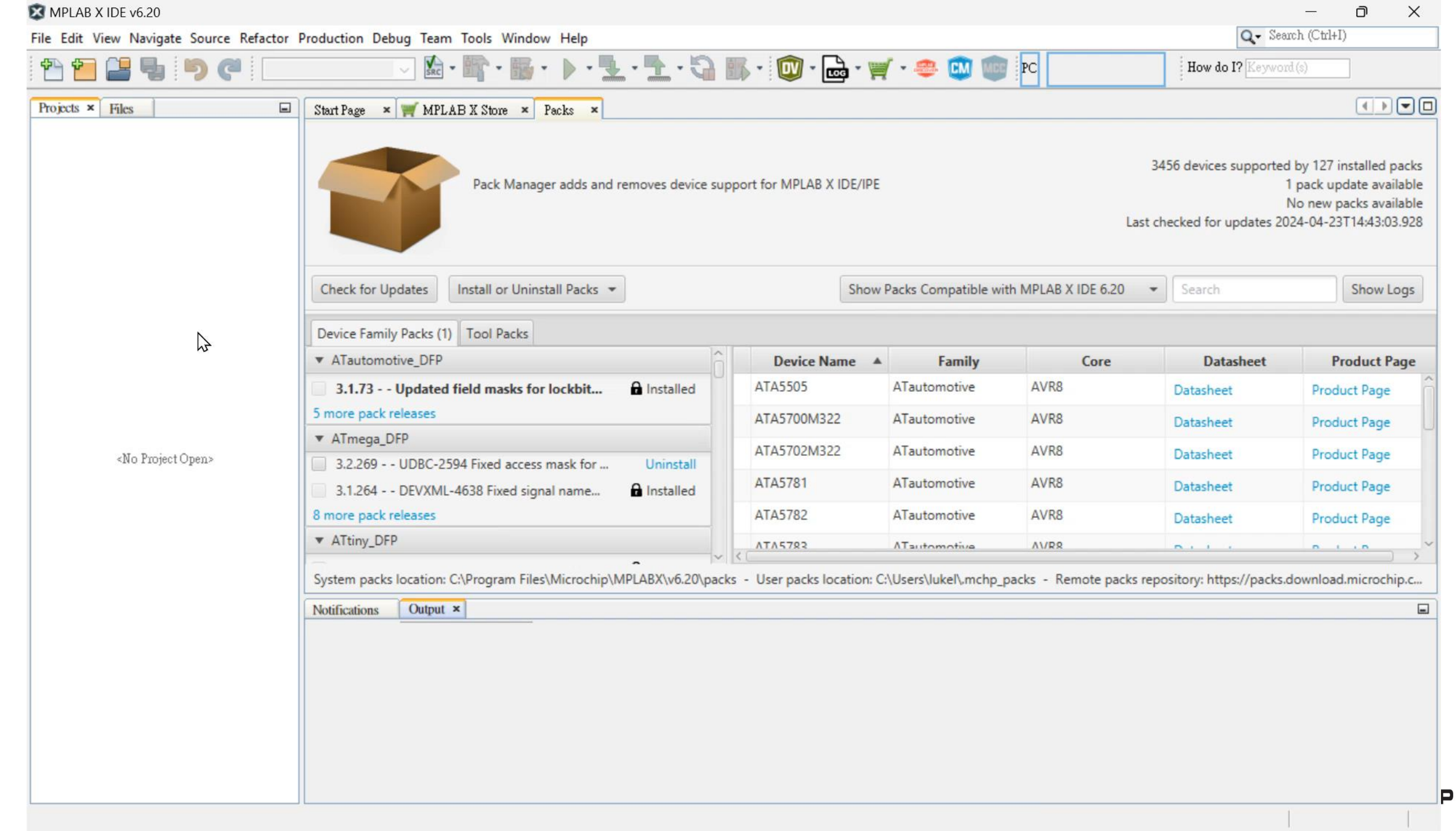
CAN_RX(PA25)

CAN_TX(PA24)



PA15: LED(OUT_LED) ; PA28: INPUT Switch(IN_SW0)

MICROCHIP


MPLAB X IDE v6.20
File Edit View Navigate Source Refactor Production Debug Team Tools Window Help
Search (Ctrl+I)
How do I? Keyword(s)
Projects
Files
<No Project Open>
Start Page
MPLAB X Store
Packs
Pack Manager adds and removes device support for MPLAB X IDE/IPE
3456 devices supported by 127 installed packs
1 pack update available
No new packs available
Last checked for updates 2024-04-23T14:43:03.928
Check for Updates
Install or Uninstall Packs
Show Packs Compatible with MPLAB X IDE 6.20
Search
Show Logs
Device Family Packs (1)
Tool Packs
ATautomotive_DFP
3.1.73 - - Updated field masks for lockbit... Installed
5 more pack releases
ATmega_DFP
3.2.269 - - UDBC-2594 Fixed access mask for ... Uninstall
3.1.264 - - DEVXML-4638 Fixed signal name... Installed
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Device Name
Family
Core
Datasheet
Product Page
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System packs location: C:\Program Files\Microchip\MPLABX\v6.20\packs - User packs location: C:\Users\lukel\.mchp_packs - Remote packs repository: https://packs.download.microchip.c...
Notifications
Output

Thank You!!