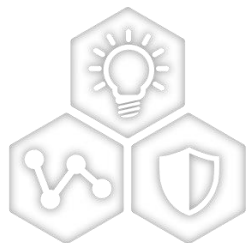


# MU導讀 – CAN BUS Basic



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SMART | CONNECTED | SECURE

**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>



The image shows a screenshot of the Microchip University website. At the top left is the Microchip University logo. At the top right is a search bar with the Chinese characters '搜尋' and a magnifying glass icon, and a user profile icon. The main heading reads '歡迎來到Microchip University!'. Below it is a paragraph of text in Chinese. At the bottom, there are five navigation buttons: 'English Catalog', '中文目录', '中文目錄', '한국어 카탈로그', and '日本語コース'. A blue speech bubble with the text '1. Login' points to the user profile icon. Another blue speech bubble with the text '2. 繁體中文' points to the '中文目錄' button. On the right side, there is an illustration of a person sitting at a desk with a computer monitor, surrounded by various technology-related icons like a clock, gears, a microchip, a rocket, a cloud, and a car.

MICROCHIP UNIVERSITY

搜尋

## 歡迎來到Microchip University!

Microchip技術精英年會以往為我們的客戶提供了寶貴的學習經驗。今年，所有的課程均免費在線提供！而我們嶄新的在線Microchip University計劃的目標是為您提供當使用Microchip解決方案來設計強大的嵌入式控制系統時所需的所有資訊。目前所有 Microchip University 的課程是免費提供的。

新的課程一直在增加中 - 請經常回來看看那些新的課程。

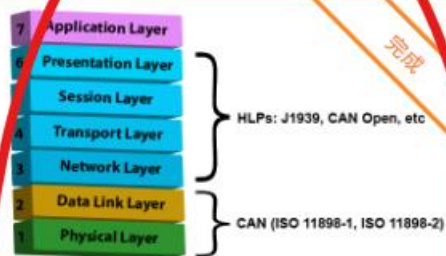
1. Login

2. 繁體中文

English Catalog 中文目录 中文目錄 한국어 카탈로그 日本語コース

# Microchip University (CAN BUS)

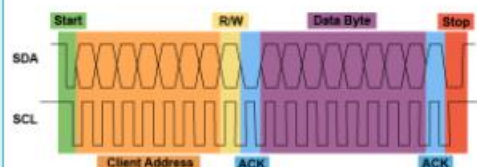
## 傳輸界面



### 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。

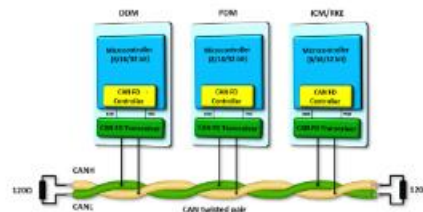
免費 69 分



### 實用的 I2C 介紹、實 現和故障排除

本課程介紹如何使用 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如何處理錯誤，以及如何處理未見過的錯誤。

免費

# Microchip University(MPLabX / Harmony)

## 軟體框架

開發  
這組  
IDE自  
式打  
譯器



### 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

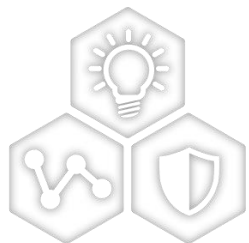
利用MPLAB® Harmony USB堆疊開發USB裝置應用

# CAN 基礎知識



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# What is CAN?

Asynchronous serial communication protocol

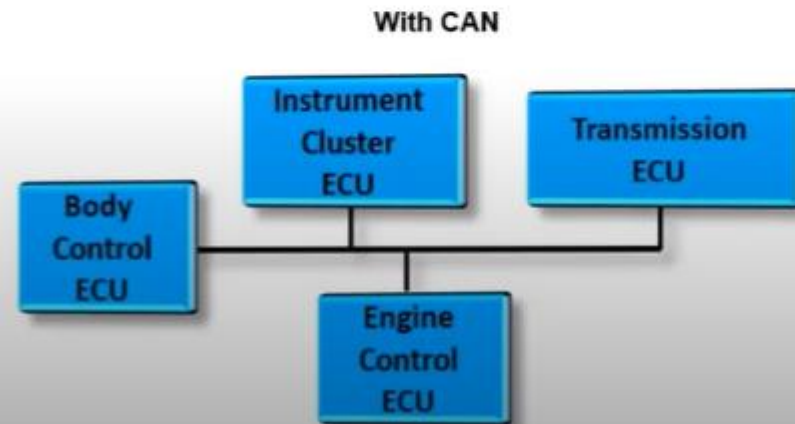
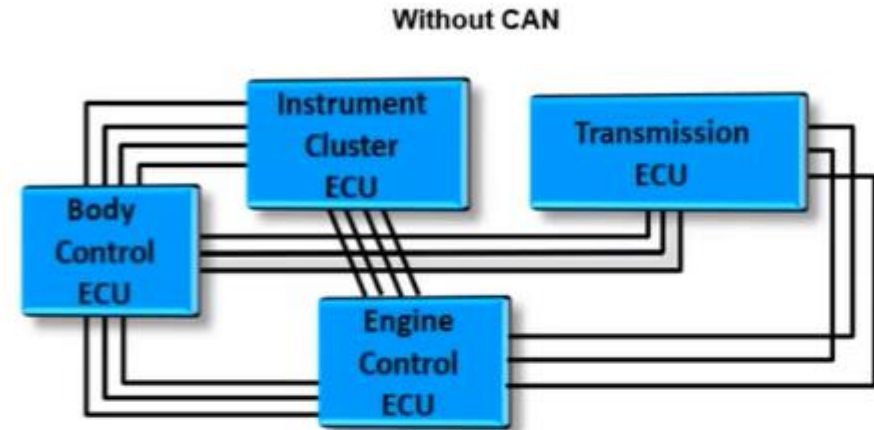
Bus topology

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

## CAN Signal Improvement (CAN SIC)

CiA 601-4

2019

## CAN Flexible Data rate (CAN FD)

Bosch specification

ISO 11898-1:2015

ISO 11898-2:2016

2012-2016

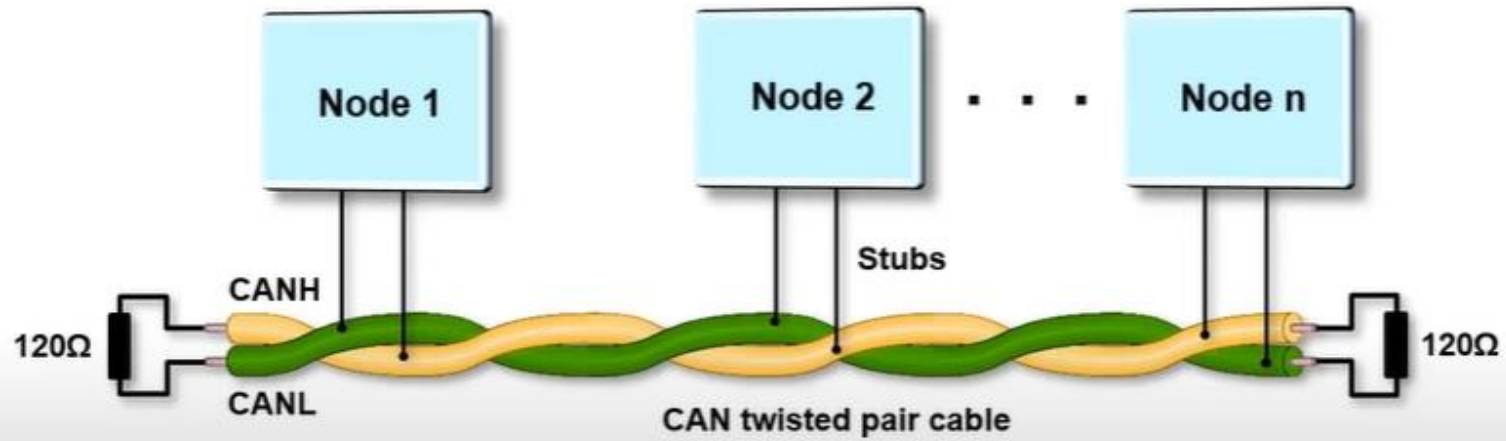
## CAN SIC XL

Next generation

2020



# CAN Network

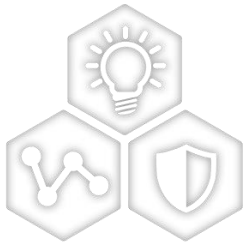


**CAN ISO 標準**



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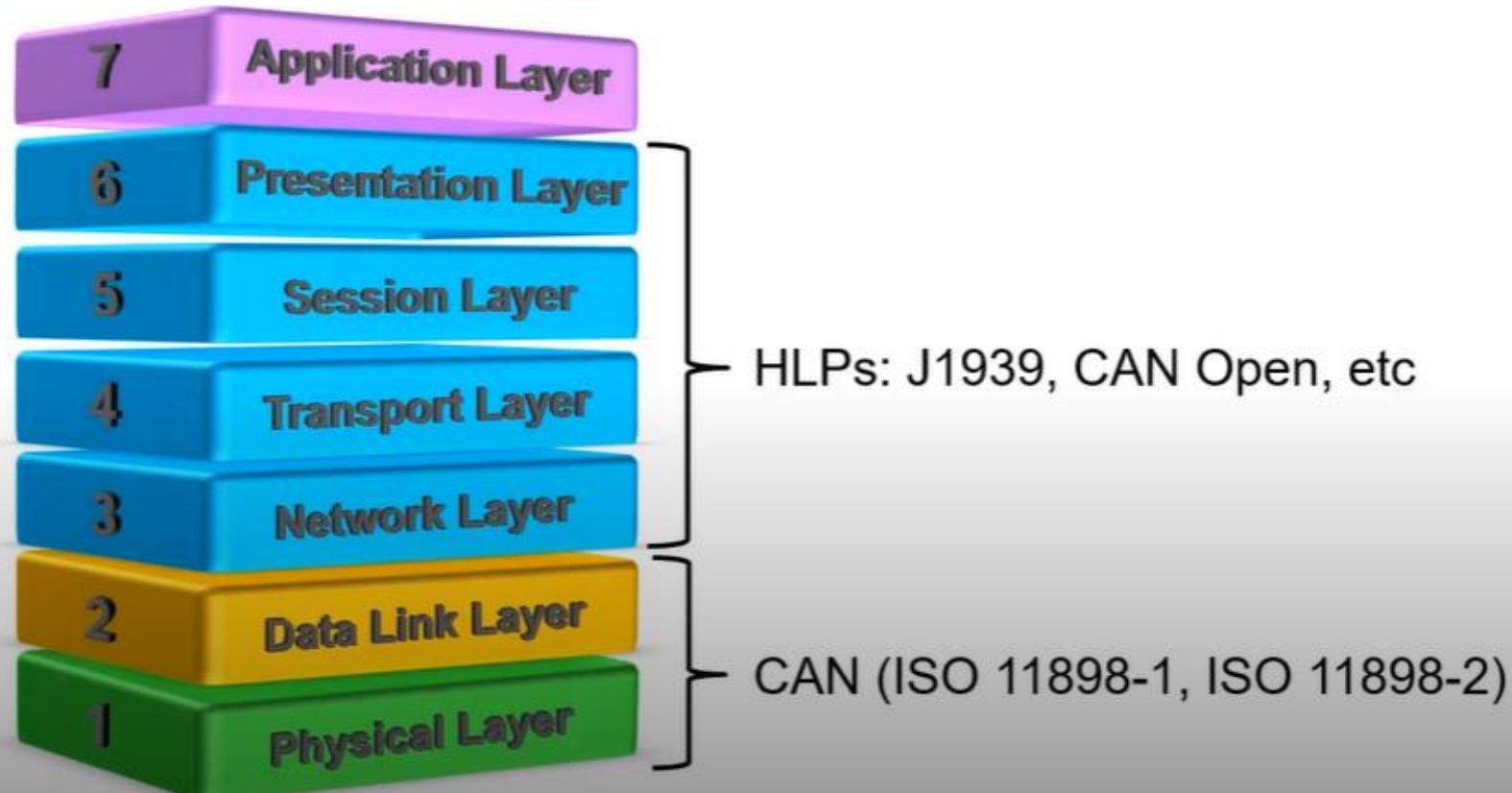
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# Network Model

## 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)

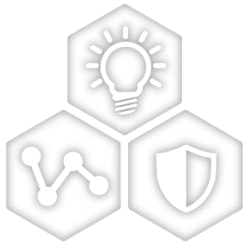
- Bit Encoding/Decoding
- Bit Timing/Synchronization

# CAN 協議基礎



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# Key Features of CAN

Identifier based,  
not address based

Message includes ID and data

ID specifies meaning of frame

ID specifies priority

The screenshot displays a software interface for CAN bus analysis. It features two main tables and a bit position diagram.

**CAN Messages Table:**

	Name	ID Decimal	Frame Format	DLC	TX Node
1	DDM_DoorLock	32	Standard FD	1	DDM
2	ICM_PRNDL	80	Standard FD	1	ICM
3	ICM_RGB	16	Standard FD	12	ICM

**Signals of Selected CAN Message Table:**

	Name	Type	Byteorder	Mode	Bitpos
1	DDM_DoorLockAll	Unsigned	Intel	Signal	0
2	DDM_DoorUnLockAll	Unsigned	Intel	Signal	1
3	DDM_DoorAjar	Unsigned	Intel	Signal	2

**Bit Positions Diagram:**

The diagram shows a grid for bit positions 0 through 15. The top row is labeled 'Bit Positions' and has columns for bits 7, 6, 5, 4, 3, 2, 1, and 0. The grid shows bit positions 0 through 15, with bit 0 having a value of 1 and bit 1 having a value of 0. The rest of the bits are empty.



# Bus Access

## CSMA/CD-CR

Carrier **S**ense (CS)

**M**ultiple **A**ccess (MA)

Collision **D**etection (CD)

Collision **R**esolution (CR)

**Non-destructive**

**Bitwise**

**Arbitration**

# Bus State

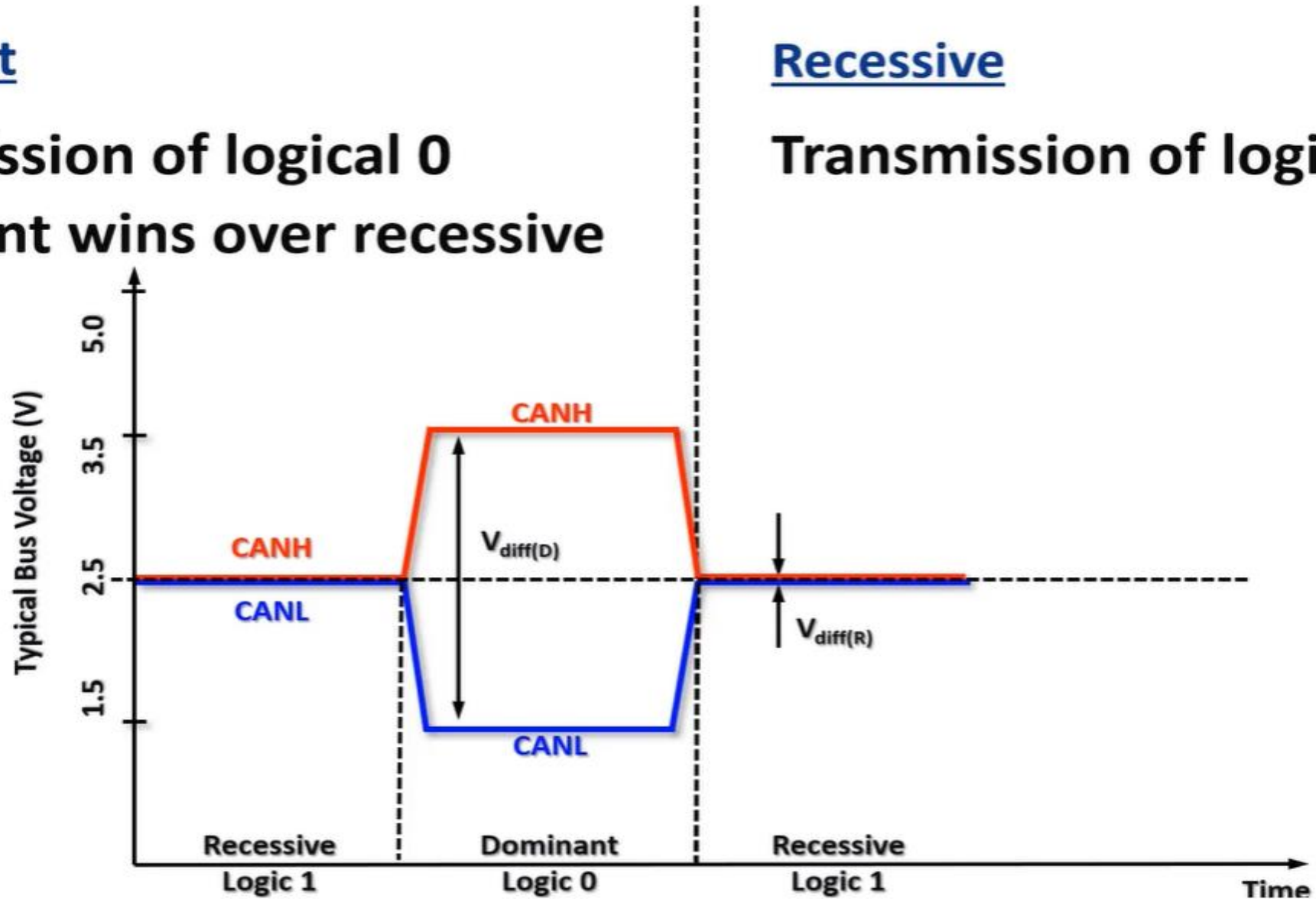
## Dominant

Transmission of logical 0

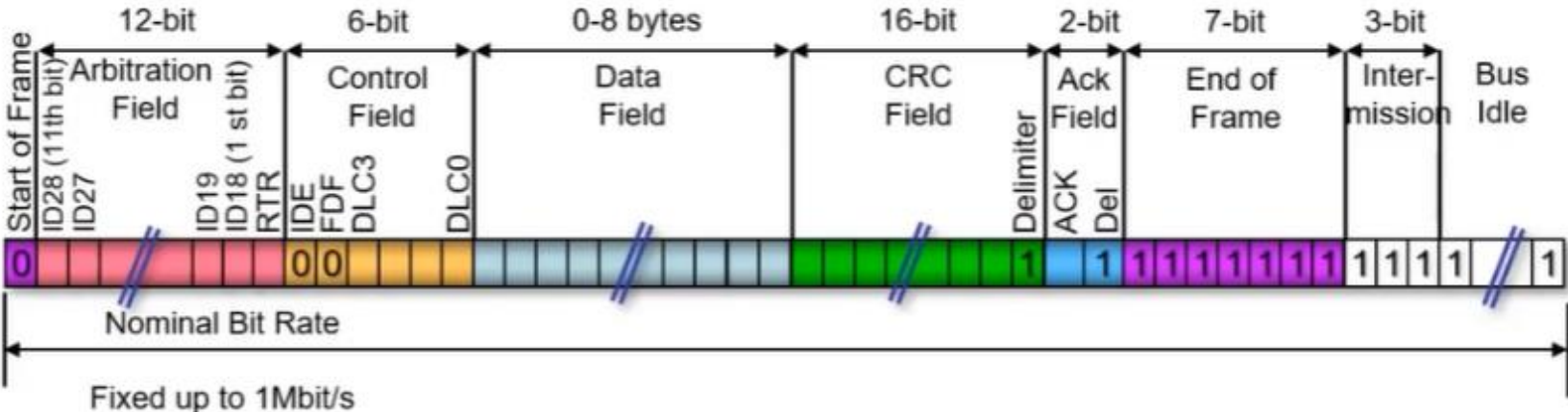
Dominant wins over recessive

## Recessive

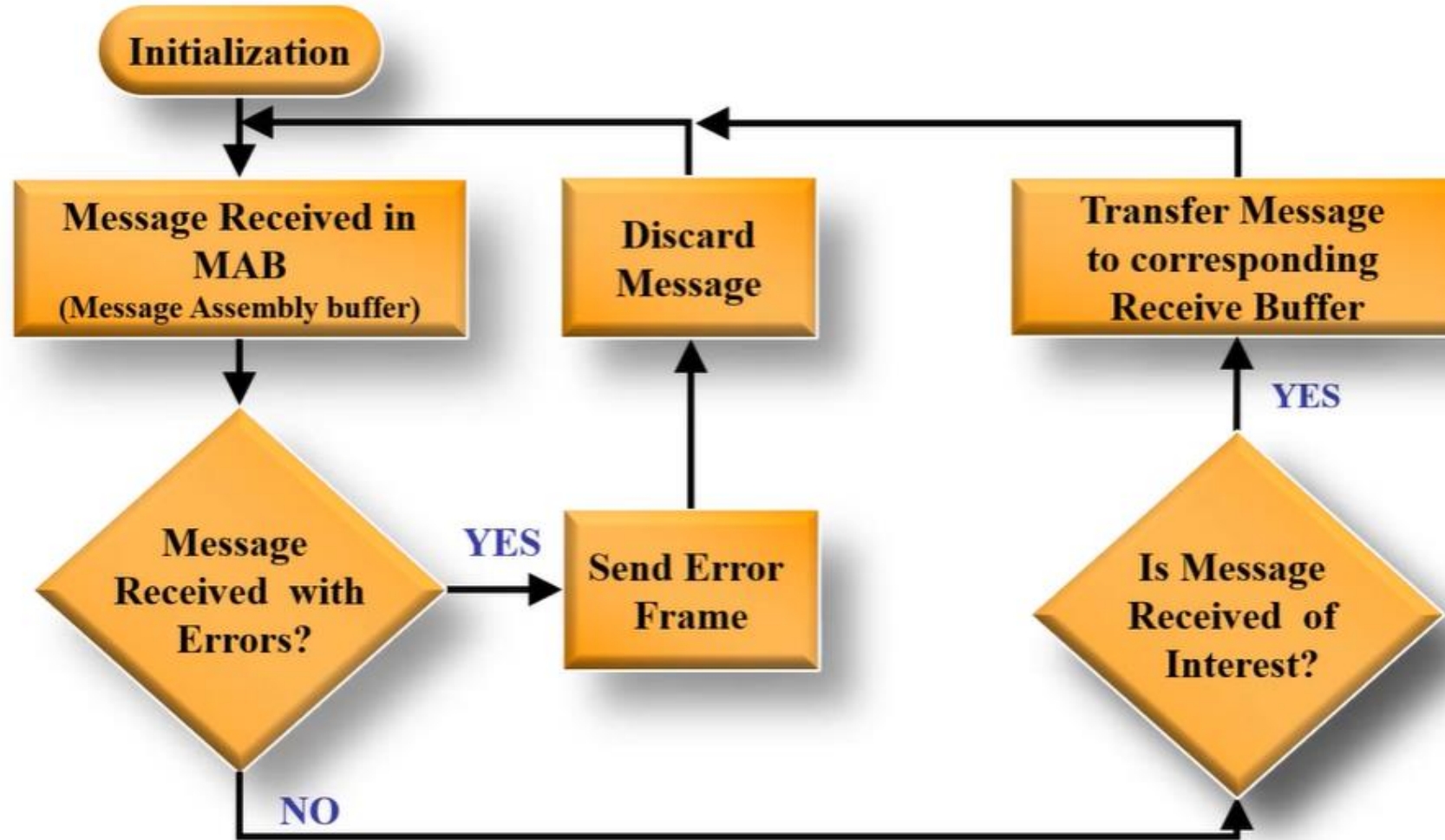
Transmission of logical 1



# Classical Base Frame



# Frame Reception



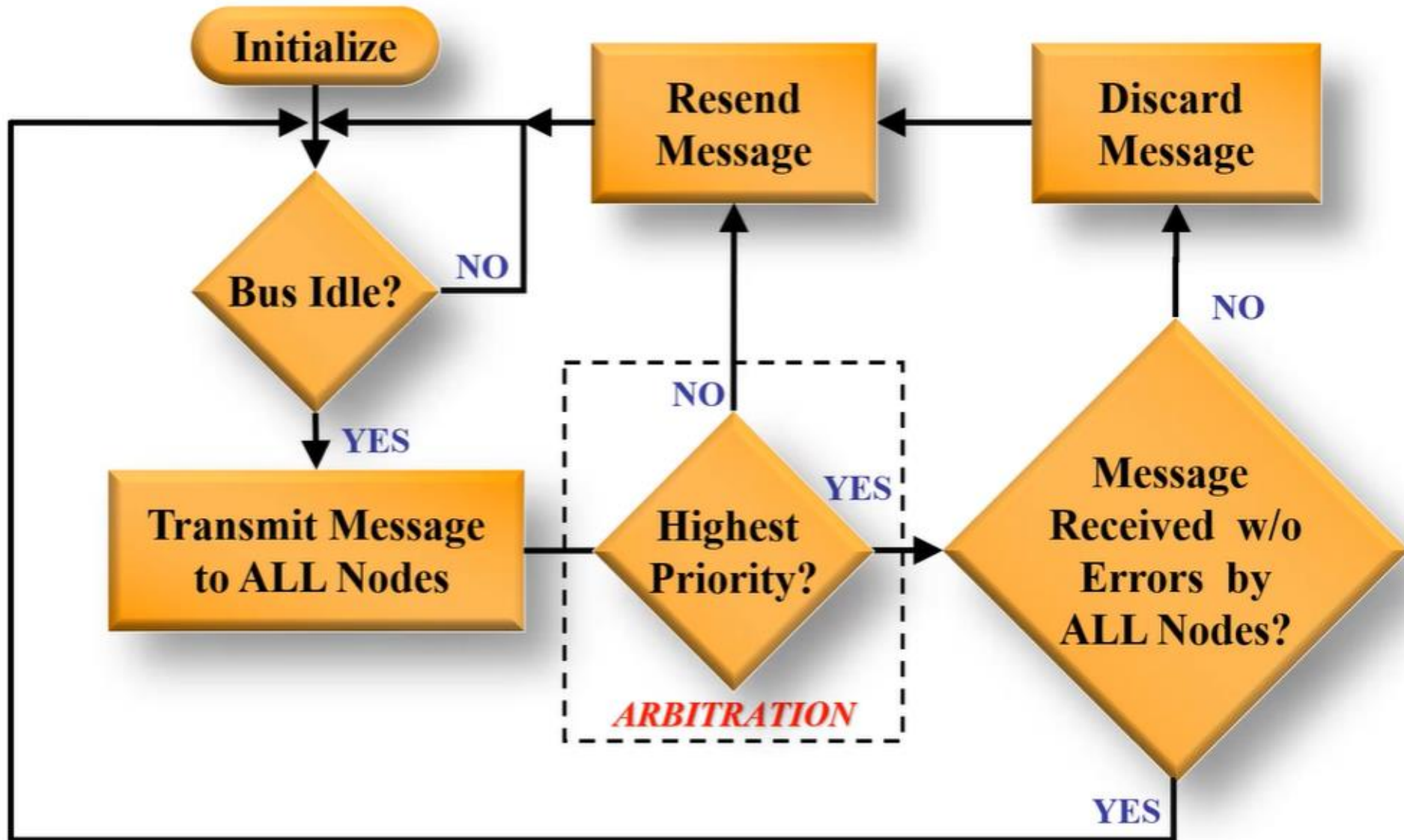
# Mask and Filter on ID Bits



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

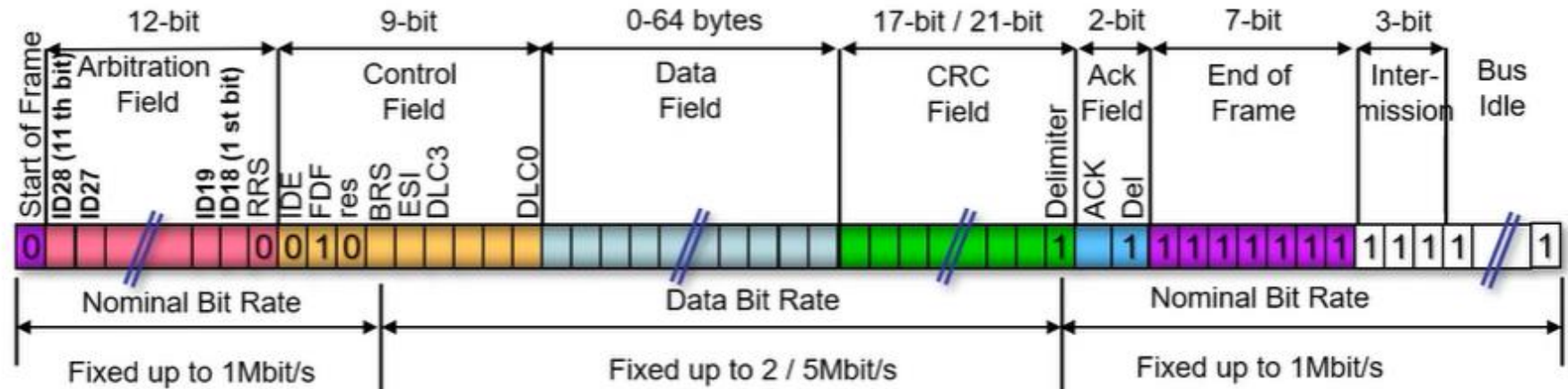


# Frame Transmission





# Bit Time vs. Bit Rate



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

1Mbit/s → 1μs

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

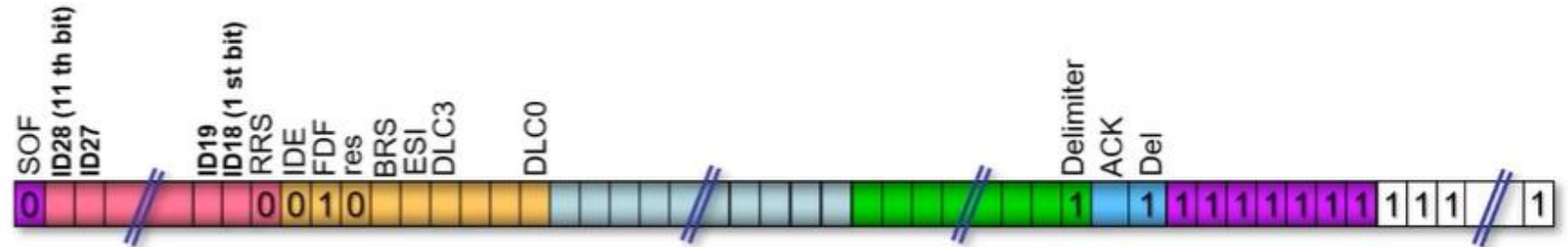
5Mbit/s → 200ns

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

1Mbit/s → 1μs

# Data Consistency

Valid Frame



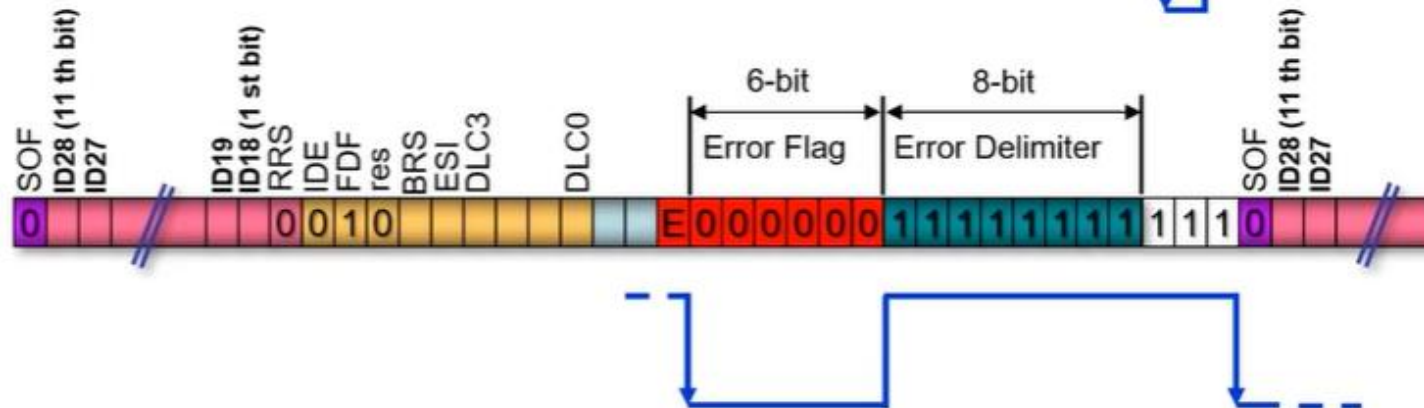
Bit Error

CRC Error

Form Error

Stuff Error

ACK Error



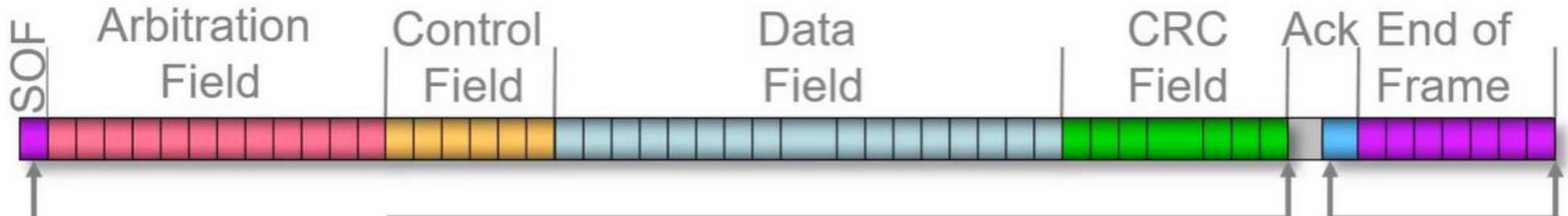
# Bit Error

Transmitted bit differs from monitored bit on the bus

## Exceptions

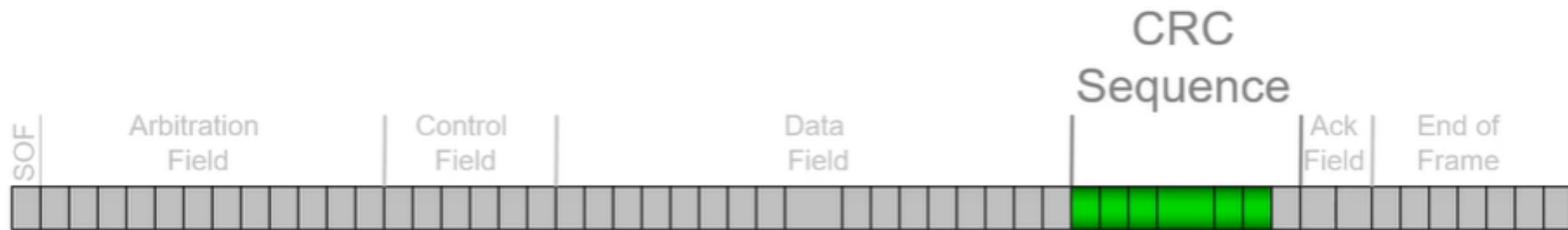
Dominant bit during arbitration

Dominant bit in Ack Slot



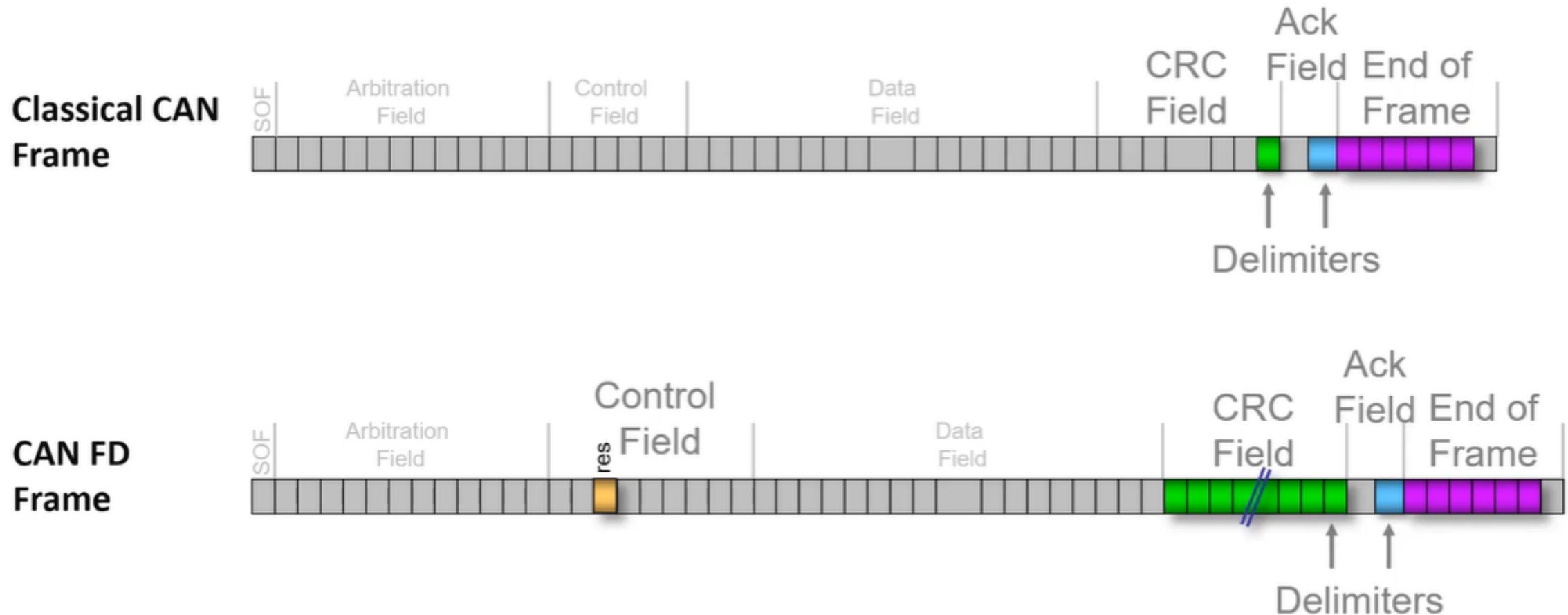
# CRC Error

Received CRC sequence doesn't match



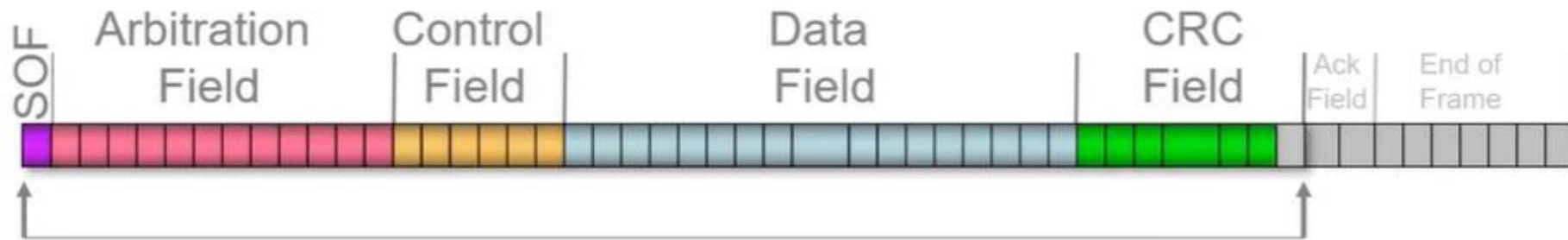
# Form Error

## Fixed-form bits received incorrectly



# Stuff Error

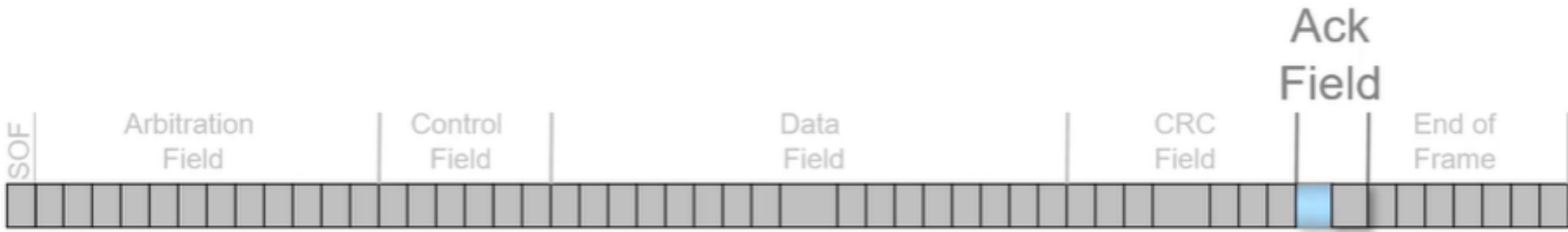
6 consecutive bits with same value





# Acknowledge Error

Transmitting node doesn't receive ACK

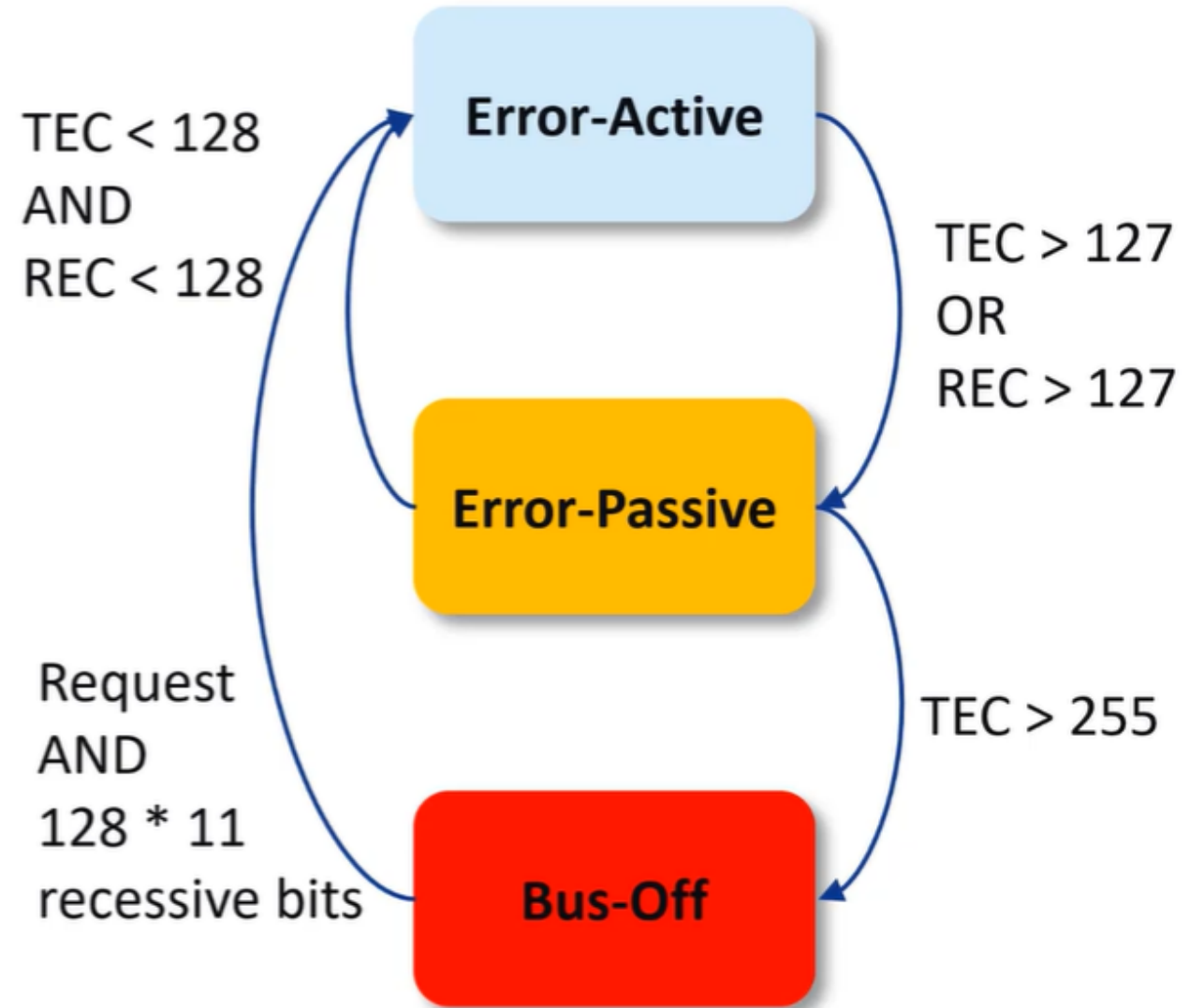


# Fault Confinement

Ensures communication  
despite faulty nodes

Transmit Error Counter (TEC)

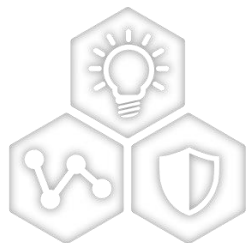
Receive Error Counter (REC)



# CAN FD、CAN PN 和 CAN 下一代



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# Classical CAN vs. CAN FD

## Increased Bit Rate

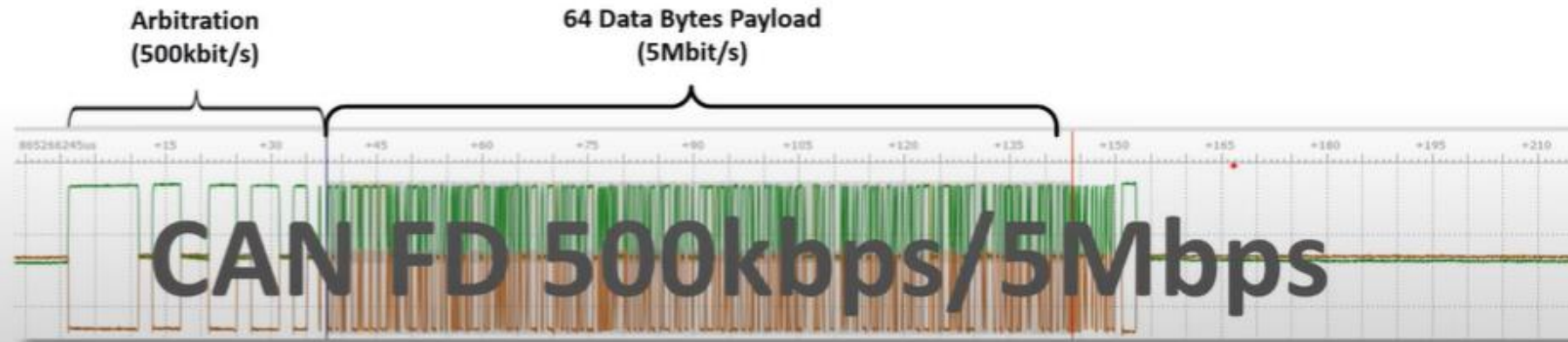
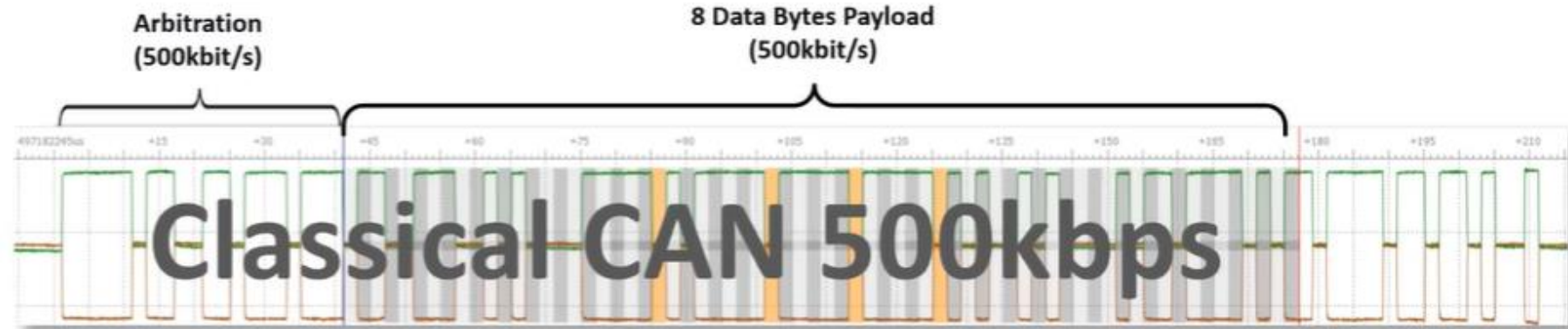
500k -> 2(5)Mbit/s

## Increased Payload

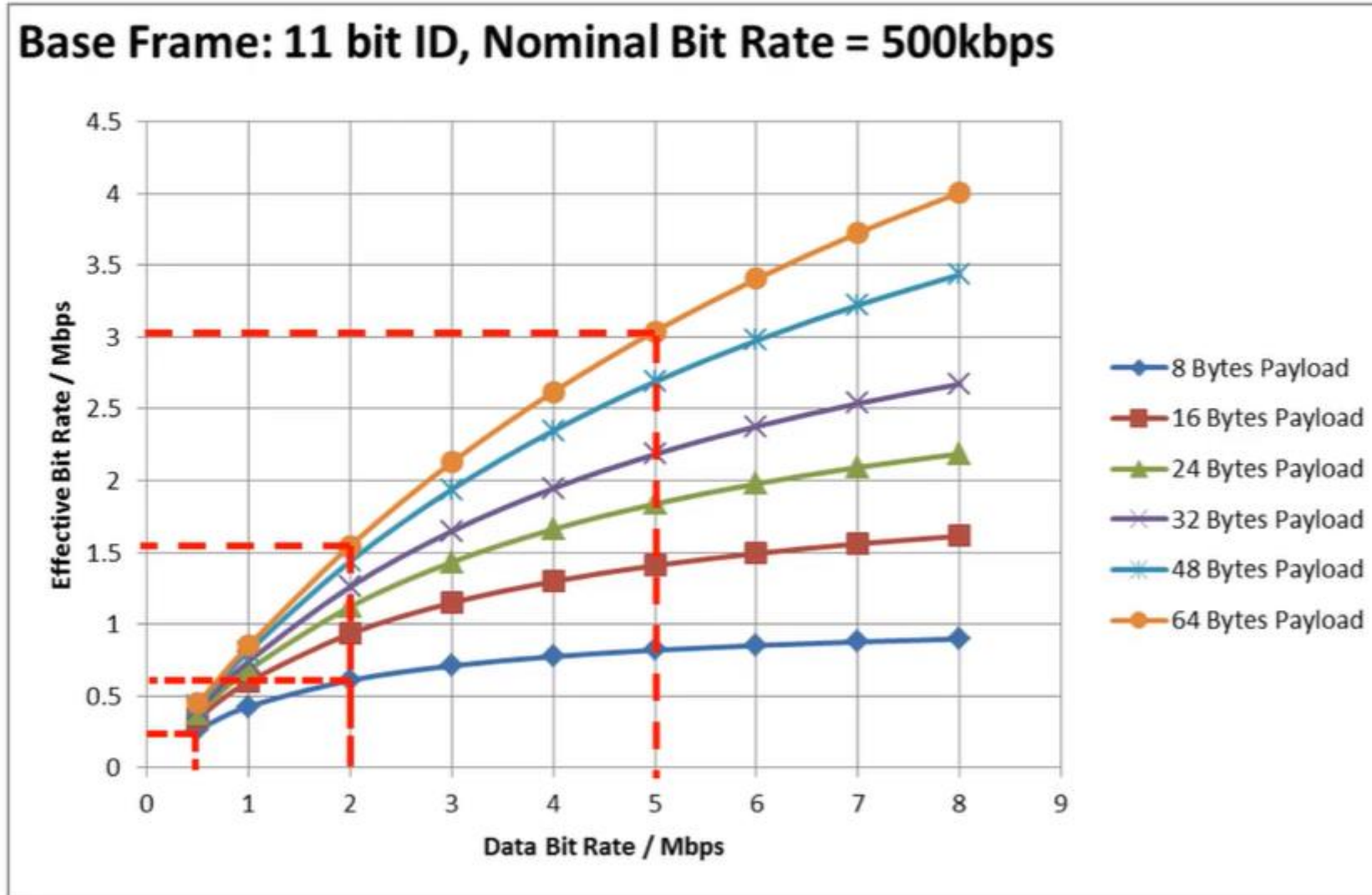
8 -> 64 data bytes

## Benefits

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



# 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<sub>2</sub> emissions  
Selective Wake-Up

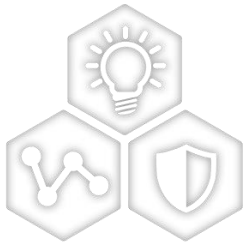


CAN 物理層



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# CAN Bus Cabling

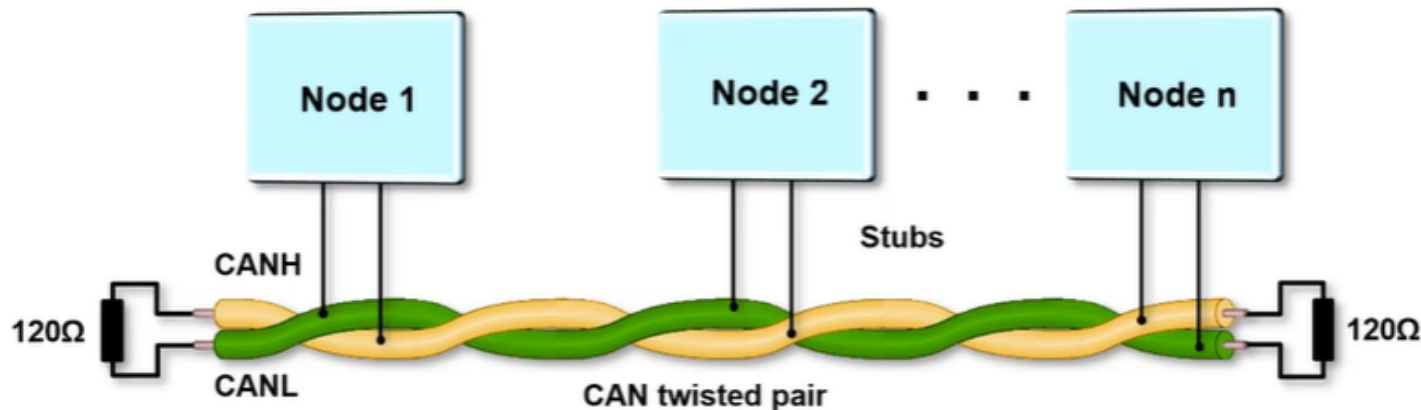
**Twisted pair Cable with 120Ω impedance**

**Two 120Ω termination resistors**

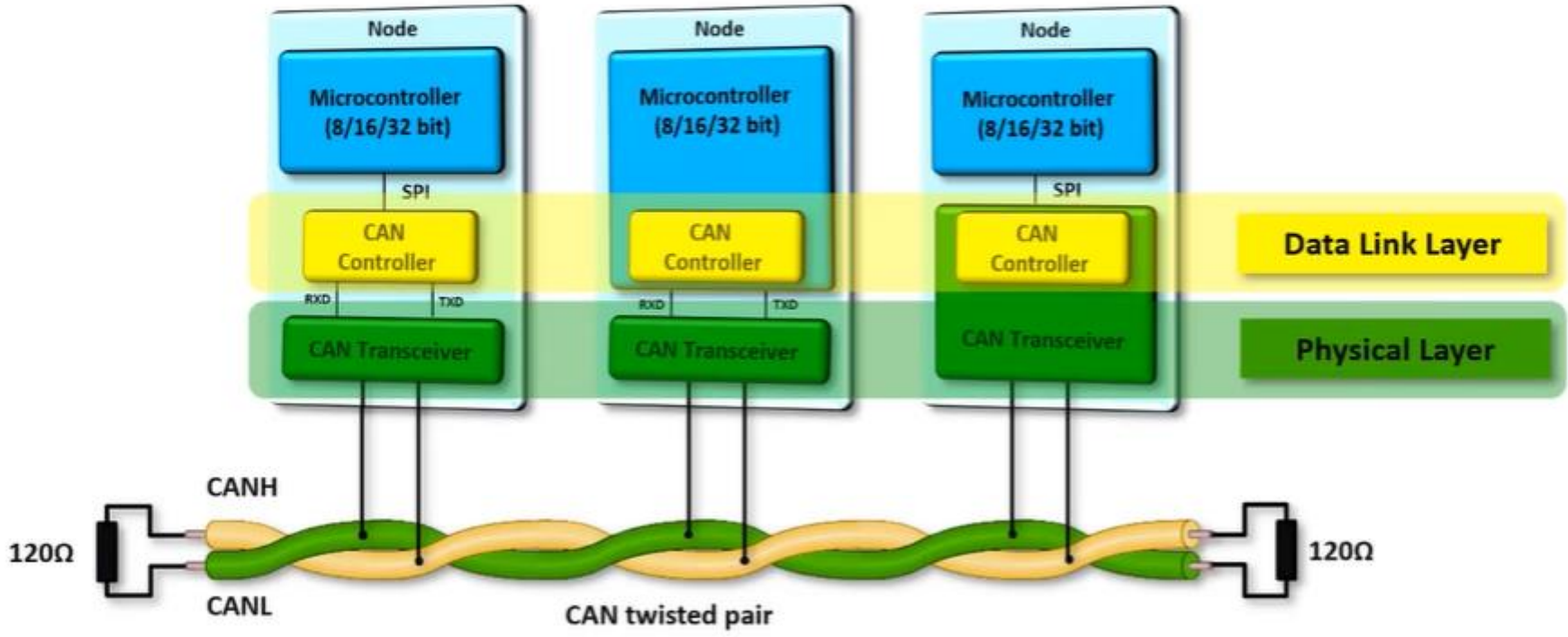
Avoids reflections

Reduces radiated emissions

**Optionally use shielded cable for electronically harsh environments**



# CAN Node Configurations



# 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

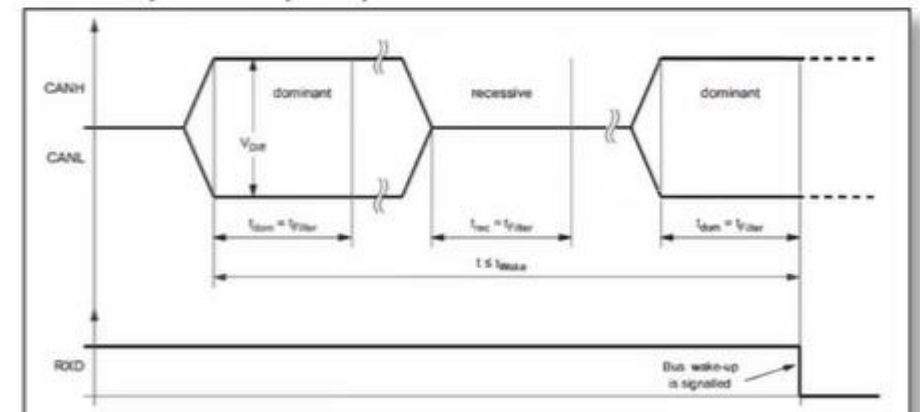
CAN FD Transceiver up to 5Mbps

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)





# 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

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

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

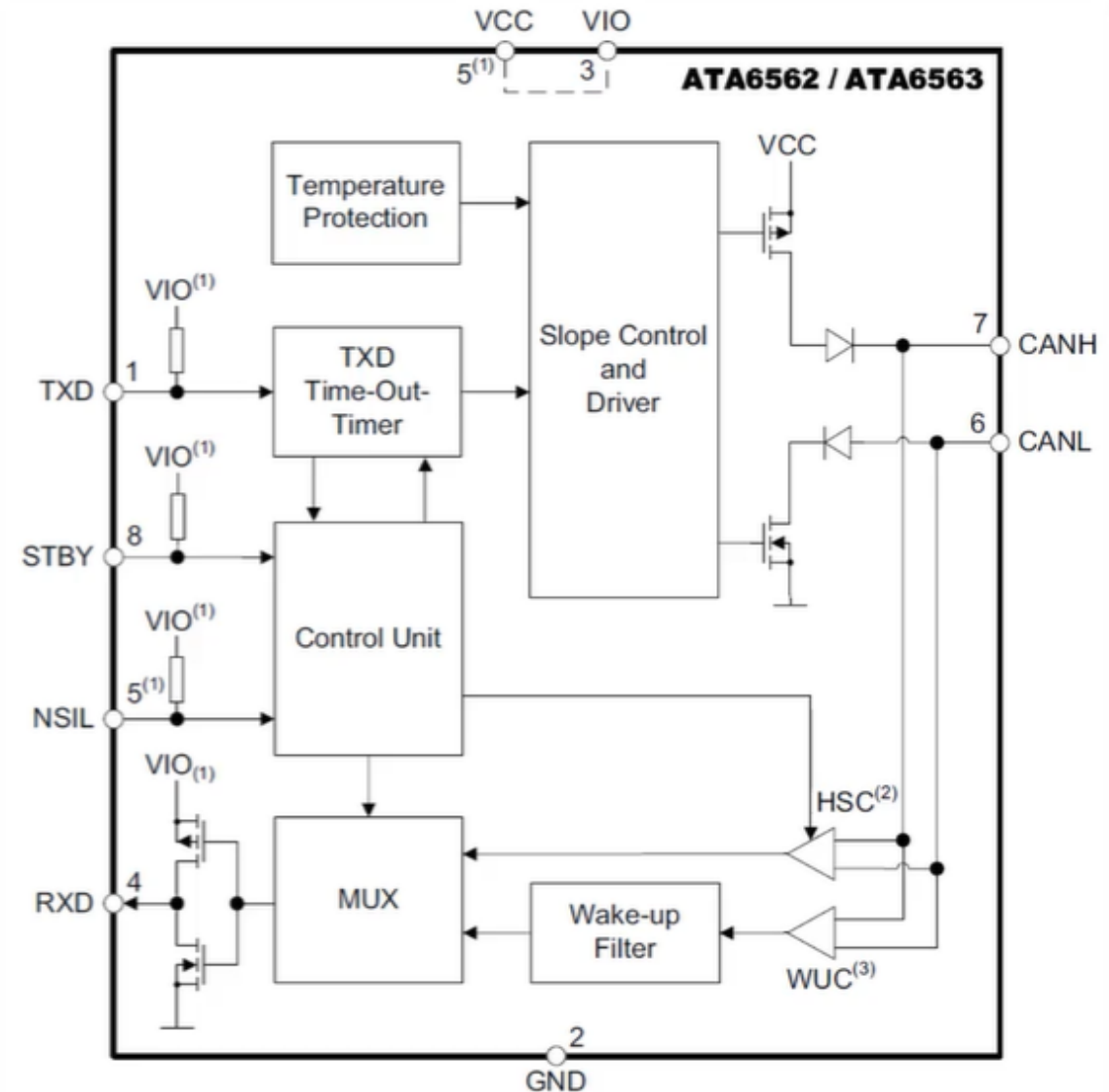
CANH and CANL Maximum Voltage

-27 to 42V DC

-150V to 100V transients

Safety Features

ISO 26262 FuSa Ready





# 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

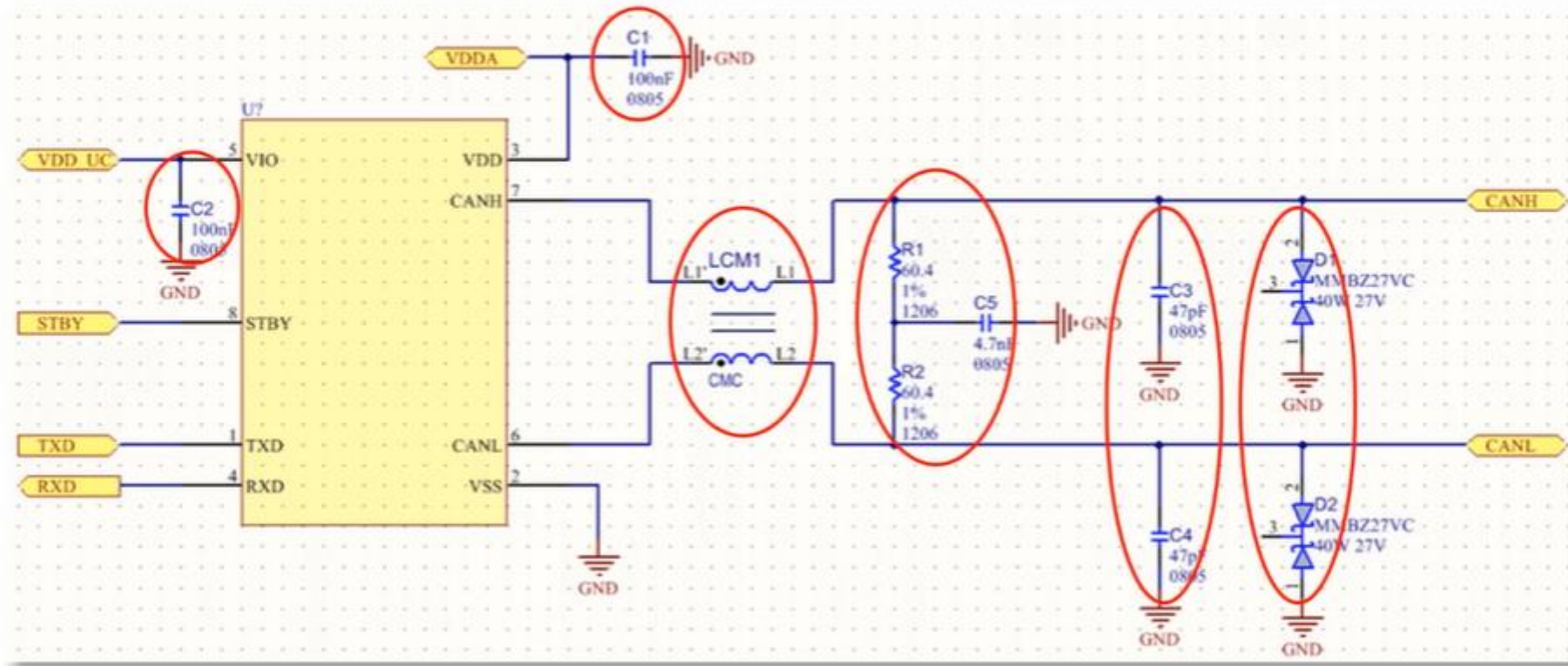
High impedance for common mode signals

Protects against EMI

Reduces emissions



# Schematic with Optional Protection

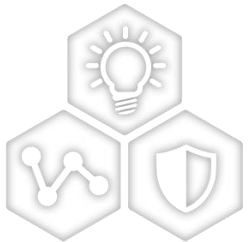


# CAN BUS RTC 課程



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

登入

輸入帳號

輸入密碼

登入

忘記密碼

單

日期 : 2024-06-26  
課程天數 : 1  
課程 : CAN-202G : CAN-202G(CAN BUS基礎與32bit上的開發)  
講師 : Luke Lin / Philip Tseng  
課程簡介 :

- 共分三部分
- 1. CAN BUS 基礎知識
- 2. Microchip CAN BUS產品介紹
- 3. Microchip CAN BUS開發環境(軟體 / 開發板 / 除錯與分析工具)
- 4. 動手實驗(共三個實驗: 尚未定義)

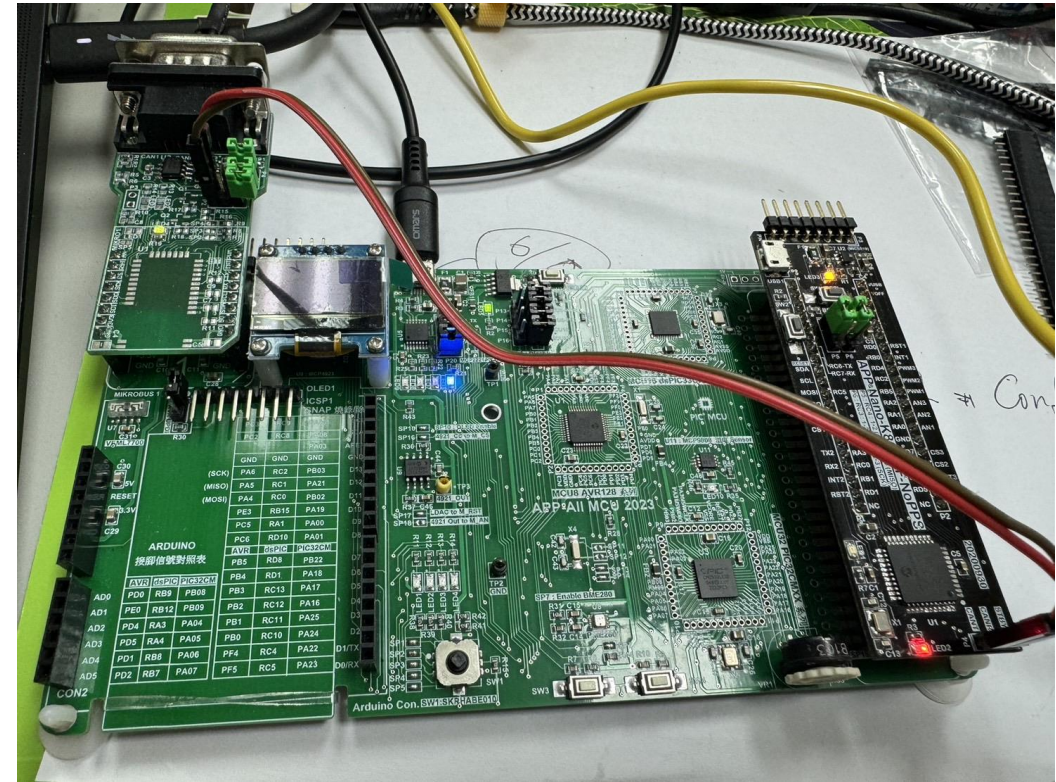
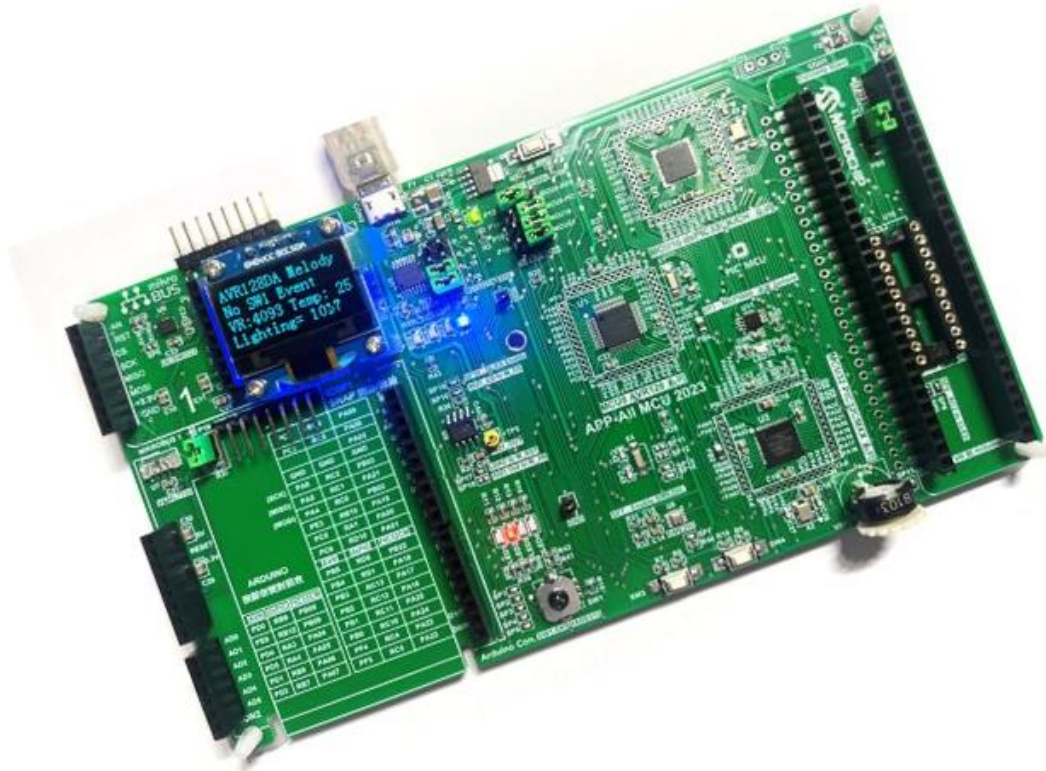
請先具備:

- 1. 稍微用過Microchip MPLABX, 並具備C語言基礎
- 2. 歡迎您帶自己的NB(這樣課堂上的實驗程式碼, 可帶回去繼續研究, 但須先安裝MPLABX + XC32 + Harmony)

[課程介紹](#)



# 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](https://www.microchip.com.tw/uploads/tad_uploader/tmp/288/APP_All_MCU_2023_Dev_Resource.pdf)



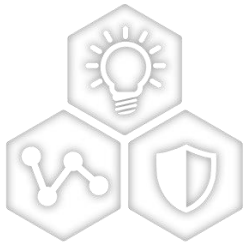
# MPLabx / Harmony 開發操作Demo

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



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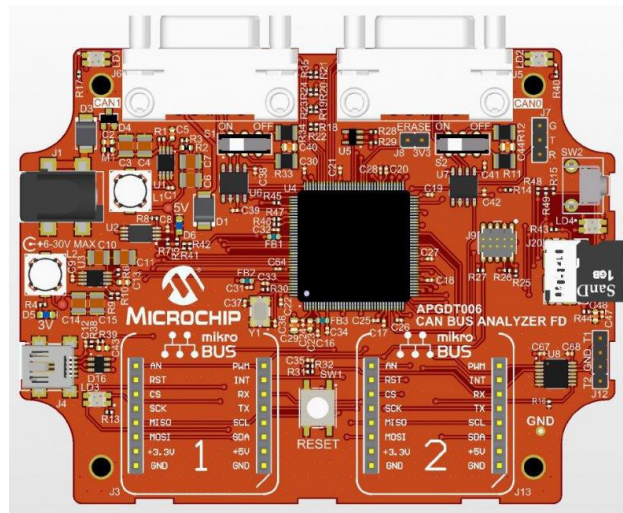


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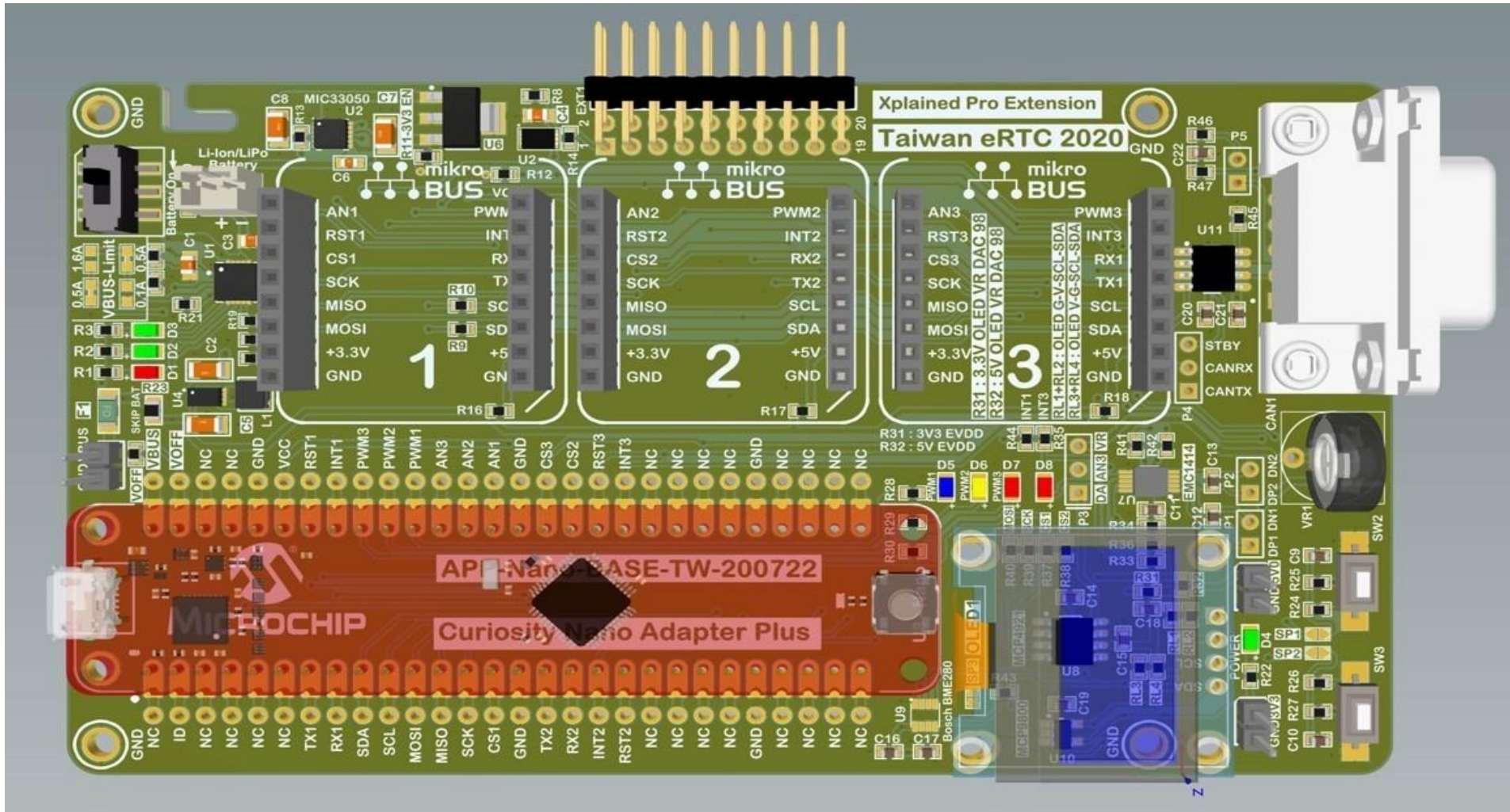
# 本實驗所使用

## ● 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)



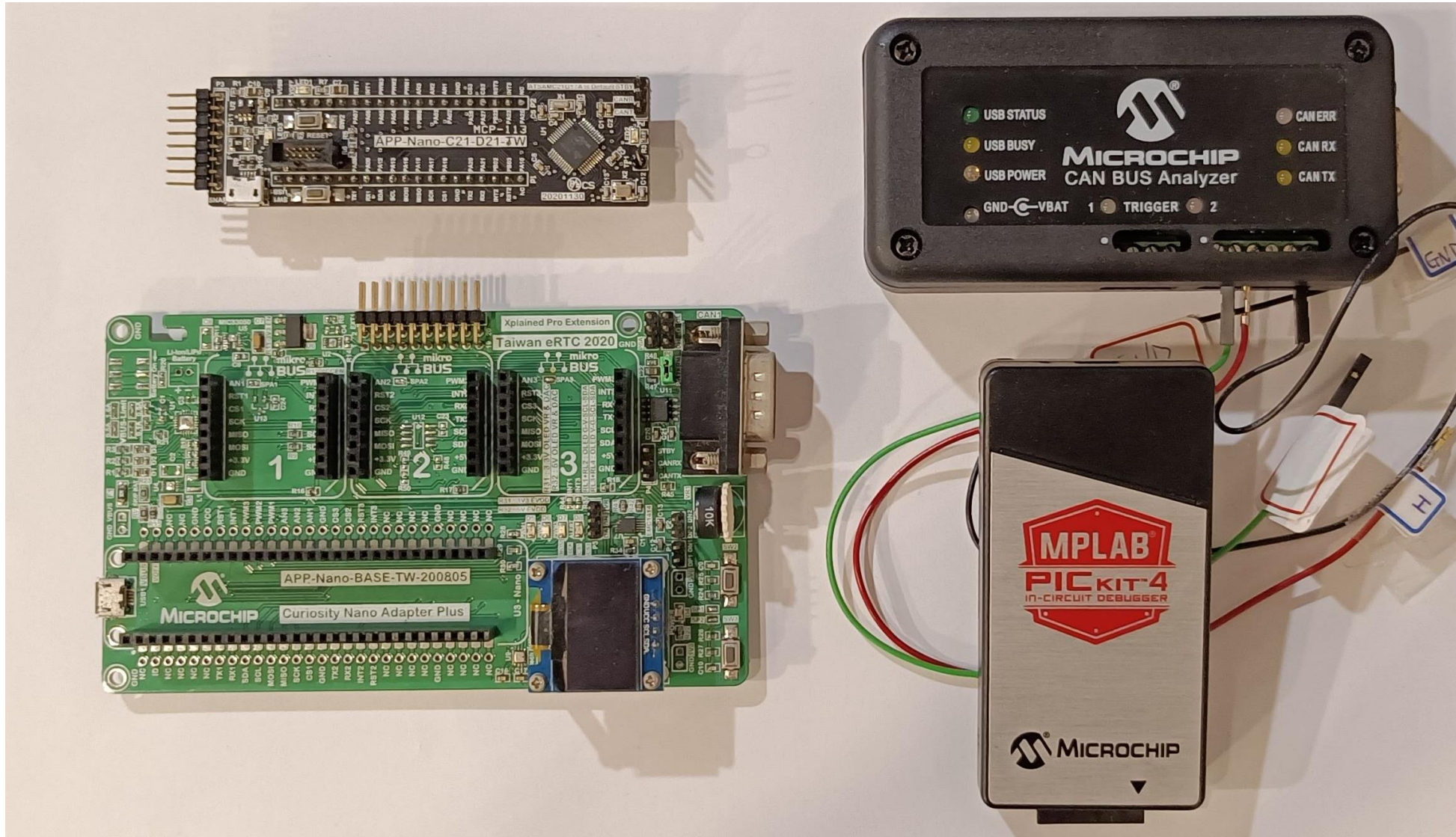
# Curiosity Nano Base TW + SAMC21 Nano



- EVB資料下載: [https://www.microchip.com.tw/Data\\_CD/eLearning/](https://www.microchip.com.tw/Data_CD/eLearning/)



# 需要這些Kits



# SAMC21 Nano connected to Nano Base TW

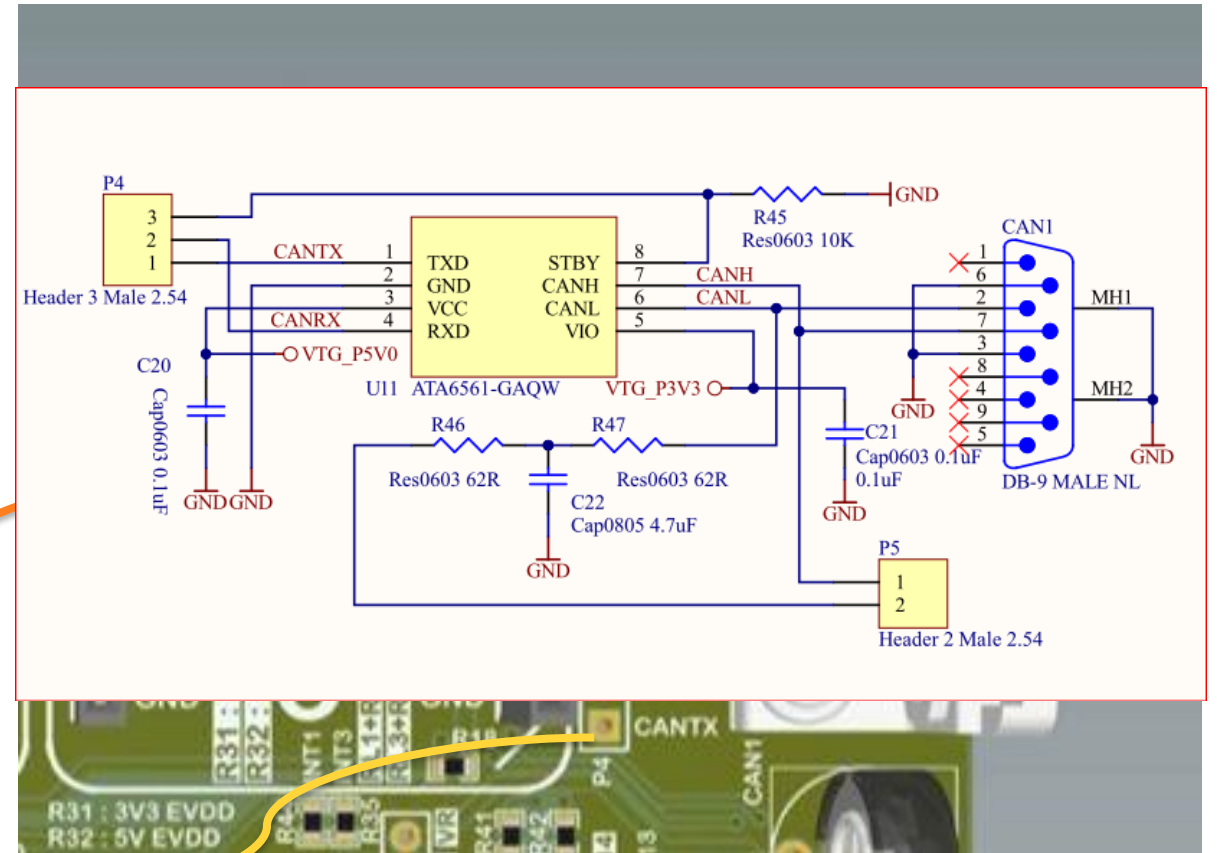
J200

DEBUGGER			
1	RESERVED	VBUS	48
2	ID	VOFF	47
3	CDC RX	DBG3	46
4	CDC TX	DBG0	45
5	DBG1	GND	44
6	DBG2	VCC	43
7	0 TX	ADC 7	42
8	1 RX	ADC 6	41
9	2 SDA	ADC 5	40
10	3 SCL	PWM 4	39
11	4 MOSI	PWM 3	38
12	5 MISO	ADC 2	37
13	6 SCK	ADC 1	36
14	7 SS	ADC 0	35
15	GND	GND	34
16	0 (TX)	7	32
17	1 (RX)	6	31
18	2	5	30
19	3	4	29
20	0	7	28
21	1	6	27
22	2	5	26
23	3	4	25
24	GND	GND	

CNANO48-pin edge connector

CAN\_RX(PA25)

CAN\_TX(PA24)



PA15: LED(OUT\_LED) ; PA28: INPUT Switch(IN\_SW0)





Projects x Files

Start Page x MPLAB X Store x Packs x



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  
[8 more pack releases](#)
  - ▼ ATtiny\_DFP

Device Name	Family	Core	Datasheet	Product Page
ATA5505	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>
ATA5700M322	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>
ATA5702M322	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>
ATA5781	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>
ATA5782	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>
ATA5783	ATautomotive	AVR8	<a href="#">Datasheet</a>	<a href="#">Product Page</a>

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 x

<No Project Open>







**MICROCHIP**

**Thank You!!**

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