Does a DIY Audio Crossover make sense? How passive filters work! || EB#41

Before looking at the old audio cross over we have to look the audio signal. The signal should get amplified before entering the audio crossover. Oscilloscope shows that the freq of the signal is 20-2k hertz. This frequency band shows why the bookshelf speaker features a big and a small loudspeaker.

Big Loudspeaker : Have more inertia that moves slower but pushes more air. It is suitable for low frequency like 40-2k hertz. If it crosses 2k hertz there will be distortion in sound.

Small Loudspeaker : It is suitable for the frequency bands above 2k hertz.

Audio crossover does the job of separation between the low and high frequency.

Components :

Name	Rating
Resistor	2ohm
Capacitor	10 microfarade
Inductor	150 microhenry

Is it easy to create your own Transformer? Everything you need to know about Transformers! || EB#42

A **transformer** is an electrical device that transfers electrical energy between two or more circuits through **electromagnetic induction**. It is mainly used to increase (**step-up**) or decrease (**step-down**) voltage levels in AC (alternating current) systems.

How a Transformer Works

1. **Primary Coil (Input Winding)**: When an alternating current (AC) flows through the primary coil, it generates a changing magnetic field around it.

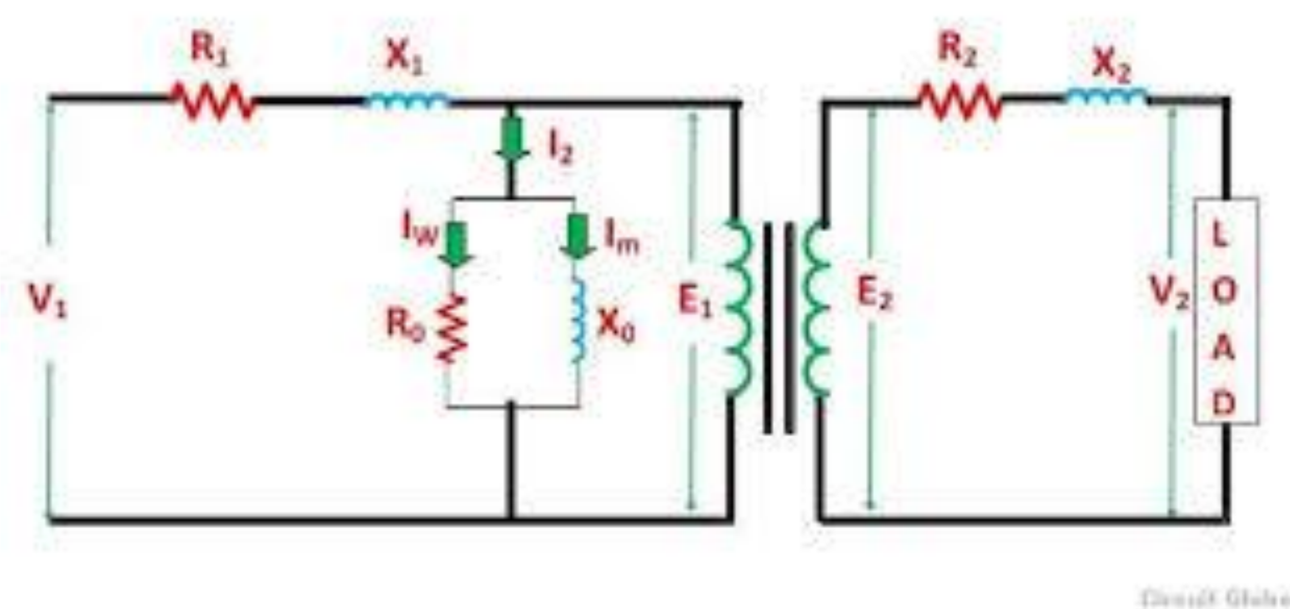
2. **Magnetic Core**: The core (usually made of laminated iron) helps in efficiently transferring the magnetic field from the primary coil to the secondary coil.
3. **Secondary Coil (Output Winding)**: The changing magnetic field induces an alternating voltage in the secondary coil, which results in electrical energy being transferred from the primary coil to the secondary coil.

Transformer Working Principle: Faraday's Law of Electromagnetic Induction

- The voltage induced in the secondary coil depends on the ratio of turns (number of wire loops) in the primary and secondary coils.
- **Formula:**

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

- where:
  - Vs = Secondary voltage
  - Vp = Primary voltage
  - Ns = Number of turns in the secondary coil
  - Np = Number of turns in the primary coil



Controlling Mechanical 7-Segment Displays?! How RS-485 and UART works! || EB#43

In this engaging video, the host introduces mechanical seven-segment displays that operate differently from traditional LED displays. Rather than using LEDs, these displays utilize white plastic segments manipulated by magnets. Each segment contains a magnet that interacts with electromagnets to display numbers. The video explores how these segments are controlled via an ATmega32A microcontroller and explains the asynchronous RS-485 communication protocol used to command the displays. With the assistance of a MAX485 breakout board, the host successfully interfaces an Arduino with the control circuit to create a subscriber counter for their YouTube channel. This innovative project reflects on the practical application of technology while revealing insights into communication protocols and display mechanics.

Highlights

- 📟 Unique Display Technology: Mechanical seven-segment displays use movable plastic segments operated by magnets rather than LEDs.
- 📡 Electromagnetic Control: Displays utilize electromagnets for display control, ensuring segments maintain their position without constant power.
- 🔧 Complex Control Circuit: The display’s control circuit involves an ATmega32A microcontroller and various ICs, showcasing advanced electronics.
- 🔄 Asynchronous Communication: The RS-485 standard facilitates asynchronous serial data transfer, crucial for managing the displays.
- 🔗 Arduino Integration: The host successfully interfaces an Arduino with the control circuit to execute commands via the RS-485 protocol.
- 🎛️ Subscriber Counter Creation: The project culminates in a functional subscriber counter for the host’s YouTube channel using the unique display technology.
- 🔍 Educational Experience: Viewers gain insights into both mechanical displays’ workings and the intricacies of electronic communication protocols.

Key Insights

- ⚙️ **Understanding Mechanisms: The mechanical display's unique operation, with magnets controlling each segment, not only enhances its visual appeal but also reflects a clever use of physics. This mechanism contrasts starkly with more conventional electronic displays, emphasizing alternatives in creative electronics.**
- 📊 **Microcontroller Proficiency: The usage of the ATmega32A microcontroller indicates a high level of sophistication needed for modern display systems. It also illustrates the challenge of hardware design and software coding in managing multiple display units seamlessly.**
- 🔌 **Electromagnetic Efficiency: The ability of the electromagnets to hold their state without continuous current is a significant highlight of the design. This efficiency is crucial for reducing energy consumption and increasing system reliability, especially in battery-powered or remote applications.**
- ⚡ **RS-485 Advantages: The RS-485 protocol offers robust noise immunity and longer cable lengths, making it a favorable choice for industrial and remote applications. Understanding this communication standard is essential for improving connectivity in various electronic projects.**
- 💡 **Connection Protocol Nuances: The distinction between RS-485's electrical specifications and proper communication protocols highlights an area where many DIY enthusiasts may stumble. Familiarity with these distinctions can lead to better designs and more successful implementations.**
- 📈 **Arduino's Versatility: Utilizing Arduino for the control of the display not only simplifies the coding aspect but also opens up endless possibilities for integration with other devices and systems. This flexibility can inspire viewers to explore further applications in IoT or robotics.**
- 🎉 **Innovative Use Case: Transforming the mechanical display into a subscriber counter is a demonstration of creative thinking in electronics. This hands-on project inspires viewers to think of their own unique applications, bridging the gap between theoretical knowledge and practical implementation.**

Overall, the video is a rich source of knowledge for electronics enthusiasts, illustrating the blend of mechanical design, programming, and communication technology in a practical and engaging manner. The project encapsulates a holistic approach to learning through experimentation, providing invaluable insights into both the workings of modern electronic displays and the underlying principles that govern them.

Controlling Electromagnetic Small Mechanical 7-Segment Displays with RS-485 and UART

Mechanical **7-segment displays** (such as **flip-disc, flip-dot, or vane-based displays**) use **electromagnetic coils** to change the position of segments instead of LEDs. These displays are commonly found in **public transport signs, clocks, industrial meters, and vintage scoreboards**.

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1. How Electromagnetic 7-Segment Displays Work

Unlike LED-based displays, these use:

- **Electromagnetic coils**: Each segment has a small coil that, when energized, flips the segment between ON and OFF states.
- **Bistable operation**: The segment remains in its last state without continuous power.
- **Relay or transistor drivers**: Control the high-current requirements of the coils.
- **Microcontroller (MCU) or driver ICs**: Send signals to control which segments flip.

Basic Control System

1. **Microcontroller (MCU) / Embedded System** (e.g., ATmega32A, ESP32, STM32)
2. **RS-485 Transceiver** (Long-distance communication)
3. **Shift Registers / Driver ICs (ULN2003, L293D, or H-Bridge circuits)**
4. **Electromagnetic 7-Segment Display**

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2. Using UART and RS-485 for Control

What is UART (Universal Asynchronous Receiver/Transmitter)?

- A **serial communication protocol** used for sending data between microcontrollers and peripherals.
- Uses **TX (Transmit)** and **RX (Receive)** lines.
- Works for **short-distance** (a few meters).

What is RS-485?

- A **differential signal serial communication protocol** (half-duplex or full-duplex).

- Works for **long-distance** (up to **1200 meters**).
- Supports **multiple devices on a single bus** (multi-drop configuration).
- Uses **two wires (A and B lines)** instead of a single wire like UART.

Why Use RS-485 Instead of UART?

Feature	**UART**	**RS-485**
Distance	Short (<5m)	Long (up to 1200m)
Devices	1-to-1	Multi-drop (up to 32 devices)
Noise Immunity	Low	High (Differential Signaling)
Speed	Up to 1 Mbps	Up to 10 Mbps

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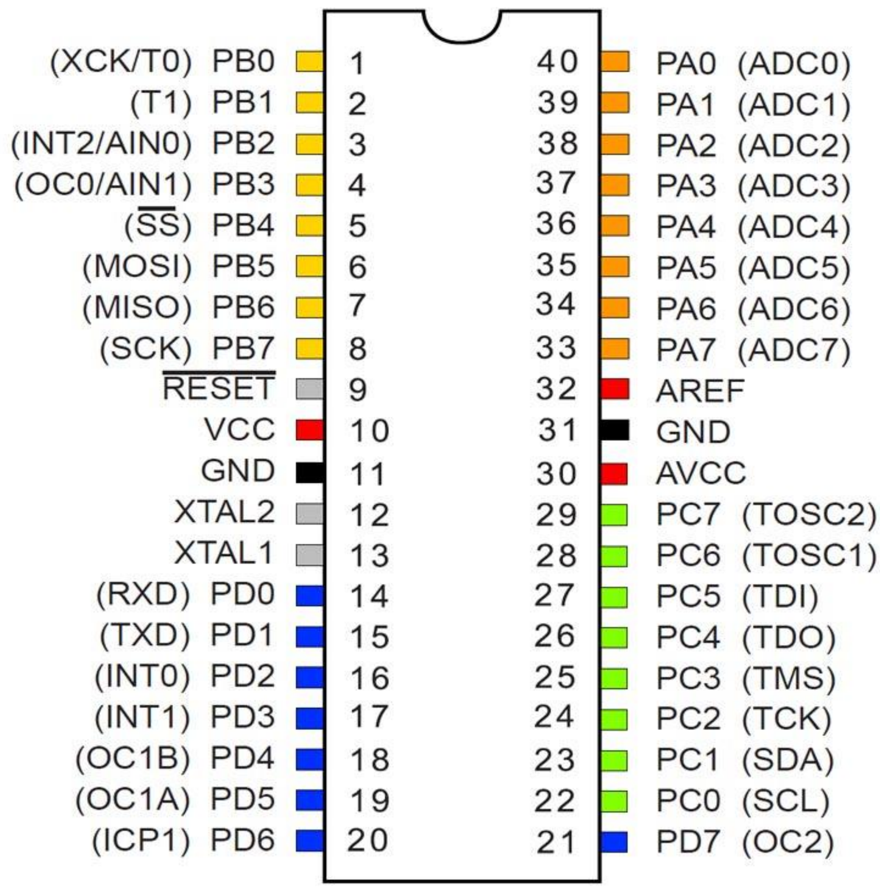
3. How to Interface RS-485 with a Mechanical 7-Segment Display

To control a **mechanical 7-segment display** over **RS-485**, follow this structure:

1. **Microcontroller (ATmega32A, ESP32, STM32, Arduino, etc.)**
   - Sends display data via UART.
2. **RS-485 Transceiver (e.g., MAX485, SN75176)**
   - Converts UART signals to RS-485 differential signals.
3. **RS-485 Bus (A & B Lines)**
   - Transmits data over long distances.
4. **RS-485 Receiver (Another MAX485)**
   - Converts RS-485 back to UART for the display controller.
5. **Display Controller (Shift Registers / ULN2003 / Relay Board)**
   - Drives the electromagnetic coils of the 7-segment display.

ATmega32A microcontroller :

This microcontroller through the help of voltage source driver IC and Darlington transistor array ic controls the electromagnetic coils . One side of the electromagnets are connected to one source while other is connected to Darlington IC array pins. The source serially turns on the display segments and through the IC array we can command to display the numbers.



What is RS485?

RS485 or TIA485 or EIA485 is an asynchronous serial data transfer. Which basically tell the receiver when to read the data. When a RS485 gives the data signal the receiver by recognizing voltage edge and then using its own clock and set baud rate in order to sample the sent data at the correct time .

It is also very important to note that, unlike SPI or I2C, which are proper protocols the RS485 only defines the electrical properties of the communication signals. It is not a protocol, nor does it define connection plug arrangements. That is why when you work with RS485 you have to get the proper communication protocol and hardware pinout from the manufacturer .

It typically uses one twisted pair of wires where one carries the non-inverted data signal and the other carries the inverted data signal. The receiver then creates the original data signal by creating the difference between those two.

USART (Universal Synchronous/Asynchronous Receiver/Transmitter)

USART is a communication protocol used for serial data transmission between devices. It supports both **synchronous** and **asynchronous** communication, making it versatile for different applications.

How USART Works

1. Modes of Operation

✅ **Asynchronous Mode (UART Mode)**

- No clock signal is shared between devices.
- Transmits data using **start & stop bits** to synchronize communication.
- Common in **RS-232** and TTL serial communication.

✅ **Synchronous Mode**

- A **shared clock signal** is used between transmitter and receiver.
- More reliable for high-speed communication.
- Used in **SPI-like applications** where timing is critical.

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2. USART Communication Steps

1. **Start Bit**: Indicates the beginning of data transmission.
2. **Data Bits**: 5 to 9 bits of actual data.
3. **Parity Bit (Optional)**: Used for error checking.
4. **Stop Bit(s)**: 1 or 2 bits indicating the end of data transmission.

In Synchronous Mode:

- The transmitter sends a clock signal along with data.
- The receiver uses the clock to sample the data accurately.

In Asynchronous Mode:

- No clock signal is shared.

- The receiver must know the **baud rate** (bits per second) to decode data properly.

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3. Baud Rate

- The speed of data transmission, measured in **bits per second (bps)**.
- Common baud rates: **9600, 115200, 57600**.

For more info visit : https://www.circuitbasics.com/basics-uart-communication/

RS485 Design guide :
https://www.ti.com/lit/an/slla272d/slla272d.pdf?ts=1741953336306&ref_url=https%253A%252F%252Fwww.youtube.com%252F

Improving my electric longboard with a CAN Bus! What can the CAN Bus do? EB#44

Upgrading your **electric longboard** with a **CAN Bus (Controller Area Network)** can bring **significant improvements** in communication, efficiency, and real-time data management. Here's what CAN Bus can do for your longboard:

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1. Enhanced Communication Between Components

Instead of using separate signal wires for different components (ESC, battery, BMS, motor controllers, etc.), CAN Bus allows **all components to communicate over a single two-wire system**. This reduces **wiring complexity** and improves **system reliability**.

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2. Real-Time Data Exchange & Monitoring

- **ESC to Battery Communication** → Your ESC (Electronic Speed Controller) can request real-time **battery voltage, current, and temperature data** from the BMS.
- **Motor Controller to ESC** → The ESC can receive **precise RPM, torque demand, and motor temperature data**, optimizing performance.

- **Remote Controller Integration** → A CAN-enabled **remote can display battery life, speed, and error warnings** in real time.

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3. Smart Battery Management & Efficiency

- **Accurate Power Management** → The **BMS (Battery Management System)** can dynamically adjust power output based on **real-time load conditions**.
- **Cell Balancing & Protection** → CAN Bus enables **smarter balancing of battery cells** to extend battery life and prevent over-discharge.
- **Regenerative Braking Optimization** → The system can **adjust braking power dynamically**, ensuring safe and efficient energy recovery.

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4. Fault Detection & Safety Improvements

- **Error Logging & Diagnostics** → CAN Bus allows components to **send error messages** (e.g., over-temperature, low voltage, or motor faults) for **troubleshooting & maintenance**.
- **Automatic Safety Shutdowns** → If a critical failure occurs, the **BMS can shut down power to prevent damage** to the system.
- **Predictive Maintenance** → Detects wear on components, allowing **preemptive part replacements** before failure.

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5. Expandability & Future Upgrades

- **GPS & Tracking** → Add a CAN-compatible GPS module for route tracking and ride analytics.
- **Smart App Integration** → Use Bluetooth/WiFi CAN gateways to send real-time ride data to a mobile app.
- **Dual-Motor Coordination** → If you have **dual ESCs**, CAN Bus allows **perfect synchronization** for smoother acceleration and braking.

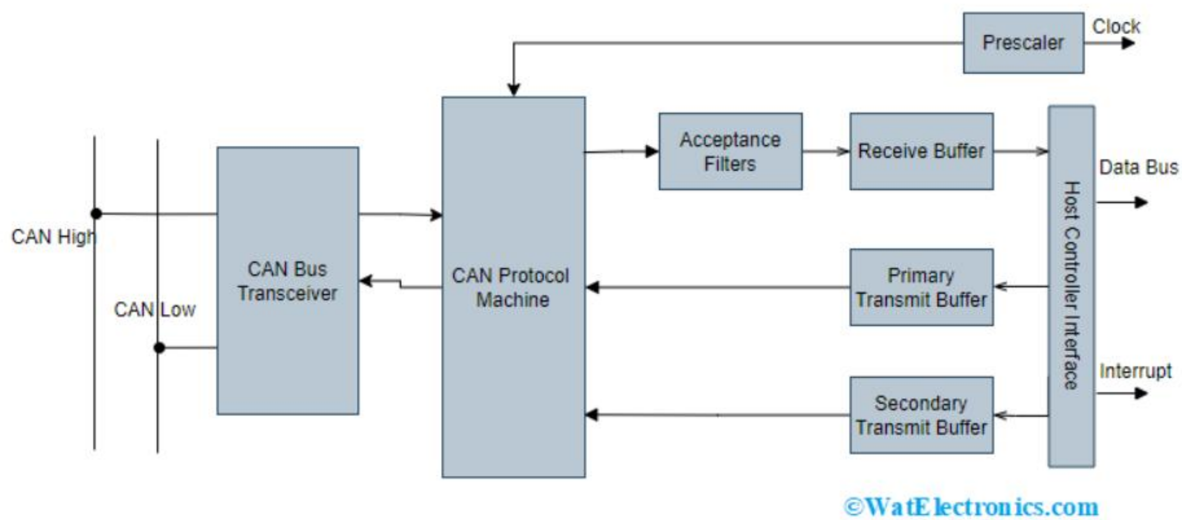
How to Implement CAN Bus on Your Longboard?

- **CAN-Compatible ESCs** → VESC (like VESC 6 or Stormcore) already supports CAN communication.
- **BMS with CAN Support** → Smart BMS units (like DieBieMS or LLT Smart BMS) allow direct communication.
- **Microcontrollers (ESP32, STM32, or Teensy)** → If needed, you can program a **custom CAN node** to collect and process data.

What is CAN Bus?

CAN Bus (Controller Area Network) is a **robust, high-speed communication protocol** that allows multiple electronic components (nodes) to communicate with each other without needing a central controller. It was originally developed for the **automotive industry** but is now widely used in **electric vehicles, industrial automation, robotics, and embedded systems**—including **your electric longboard**.

Introduce the Controller Area Network (CAN) bus



The **CAN** (Controller Area Network) bus is a **serial bus system** that allows multiple **electronic control units** (ECUs) to communicate without a host computer. Each connected device, called a **node**, can send and receive messages over two wires.

Key components include:

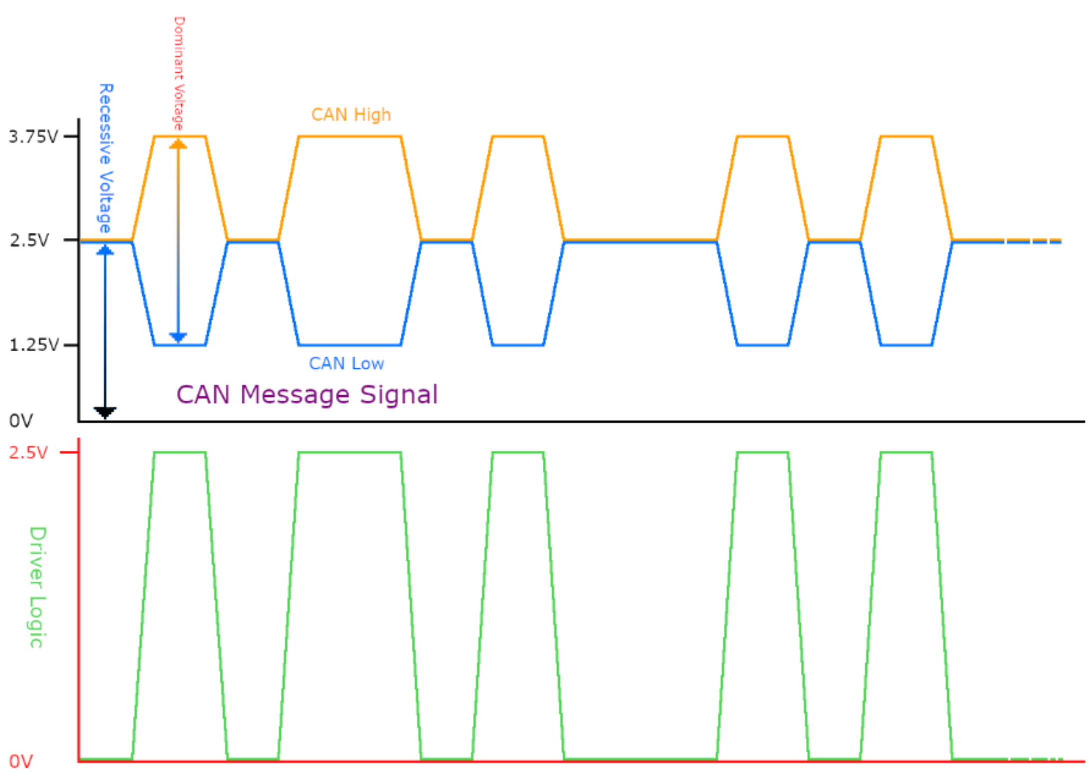
1. CAN Bus Transceiver (connects to physical wires)

2. CAN Protocol Machine (handles communication protocols)
3. Data buffers (for sending and receiving messages)
4. Host Controller Interface (connects to microcontroller)

e.g. In modern cars, CAN connects various systems like ABS, engine control, and infotainment. In longboards, it can synchronize wheel speeds as demonstrated earlier.

The CAN bus communicates through two signal lines: CAN High and CAN Low. The **dominant voltage** state represents logic 0, while the **recessive voltage** state represents logic 1.

State	CAN High	CAN Low
Dominant (0)	~3.75V	~1.25V
Recessive (1)	~2.5V	~2.5V



The **differential voltage** between CAN High and Low should be greater than 2V for reliable communication. This setup helps reduce noise and common-mode interference, as demonstrated in the longboard synchronization where both wheels need consistent signals.

Fore more info : https://www.ti.com/lit/an/sloa101b/sloa101b.pdf

https://www.allaboutcircuits.com/technical-articles/introduction-to-can-controller-area-network/

How Does a CAN Bus Work?

CAN Bus (Controller Area Network) is a **communication protocol** that allows multiple devices (or nodes) to exchange data efficiently **without a central controller**. It is commonly used in **vehicles, industrial automation, robotics, and electric longboards** for real-time data sharing between components like **ESCs, BMS, motor controllers, and dashboards**.

Instead of sending data from **one specific device to another**, CAN Bus **broadcasts messages** to all connected devices on the network. Each device listens to the bus and **decides whether the message is relevant** based on its **message ID**.

How CAN Bus Works – Step by Step

1. **Two-Wire Communication (CAN_H & CAN_L)**
    - CAN Bus uses **two differential signal wires**:
        - **CAN_H (High Line)**
        - **CAN_L (Low Line)**
    - These wires allow **noise-resistant communication** even in electrically noisy environments (like an electric longboard).
2. **Message Broadcasting & Prioritization**
    - Every message has a **unique ID**, which determines its **priority**.
    - Devices listen to all messages and process only the ones relevant to them.
    - If two devices try to send messages at the same time, **the one with the lowest ID (highest priority) is transmitted first** (arbitration process).
3. **Differential Signaling for Noise Immunity**

- Instead of using a **single voltage level**, CAN Bus sends data by **comparing the voltage difference** between CAN_H and CAN_L.
- This makes it highly resistant to electrical interference, crucial in **EVs and longboards**, where motors and power electronics create noise.

How CAN_H and CAN_L Work

State	CAN_H Voltage	CAN_L Voltage	CAN_H - CAN_L Difference	Bus State
Idle (Recessive)	2.5V	2.5V	0V	No Data
Data 1 (Dominant)	3.5V	1.5V	2V	Bit = 0
Data 0 (Recessive)	2.5V	2.5V	0V	Bit = 1

- **Dominant state (Bit = 0)** → CAN_H = 3.5V, CAN_L = 1.5V
- **Recessive state (Bit = 1)** → CAN_H = 2.5V, CAN_L = 2.5V

When a device wants to send a message, it pulls CAN_H up and CAN_L down to create a **2V difference**, representing a **dominant bit (0)**. If no device is sending data, both lines remain at **2.5V (idle state)**.

Why Use CAN_H & CAN_L Instead of a Single Wire?

- **Noise Resistance** → External interference affects both lines equally, so their difference remains **unchanged**.
- **Long-Distance Communication** → CAN Bus works **over several meters** without losing data.
- **Error Detection** → CAN automatically detects faulty messages and resends them.

Example: CAN Bus in an Electric Longboard

1. **ESC sends speed data to the display**
    - ESC broadcasts: *“Motor speed: 25 km/h”*
    - Dashboard receives the message and updates speed on the screen.

2. **BMS sends battery status to ESC**
    - BMS broadcasts: *"Battery at 80%, temperature normal"*
    - ESC adjusts power output based on battery health.
3. **Regenerative Braking Communication**
    - ESC tells BMS: *"Applying regenerative braking, store 3A"*
    - BMS confirms: *"Accepted, charging enabled"*

Since **all components share the same CAN wires**, **less wiring is needed**, and **real-time updates are possible**.