HyTech Racing Charging Circuits Training

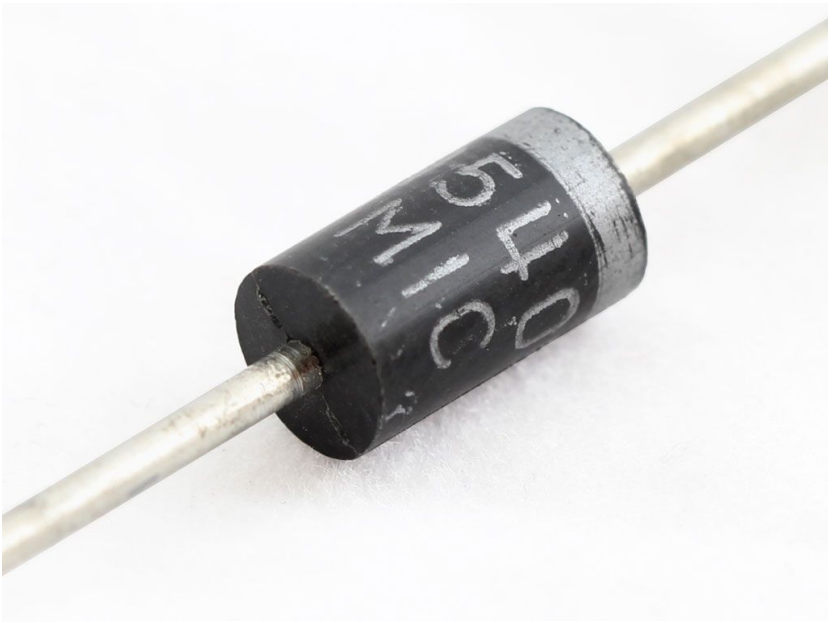
2019-2020

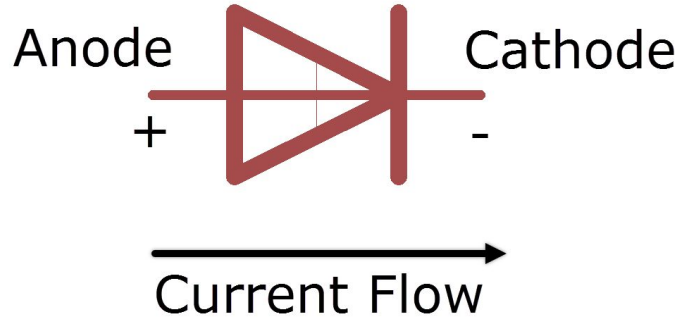
Dues

- If you would like to officially join HyTech Racing, you can pay dues using **Venmo**, **PayPal**, **Square**, or **Cash**.
  - Venmo: **@hytechracing**
  - PayPal: **gthytech@gmail.com**
  - Square: **https://squareup.com/store/hytech-racing**
  - Cash: **See an Officer**
- Paying dues gets you access to our Slack, Trello, Github, and Google Drive.
- Deadline is 9/15.

Diodes

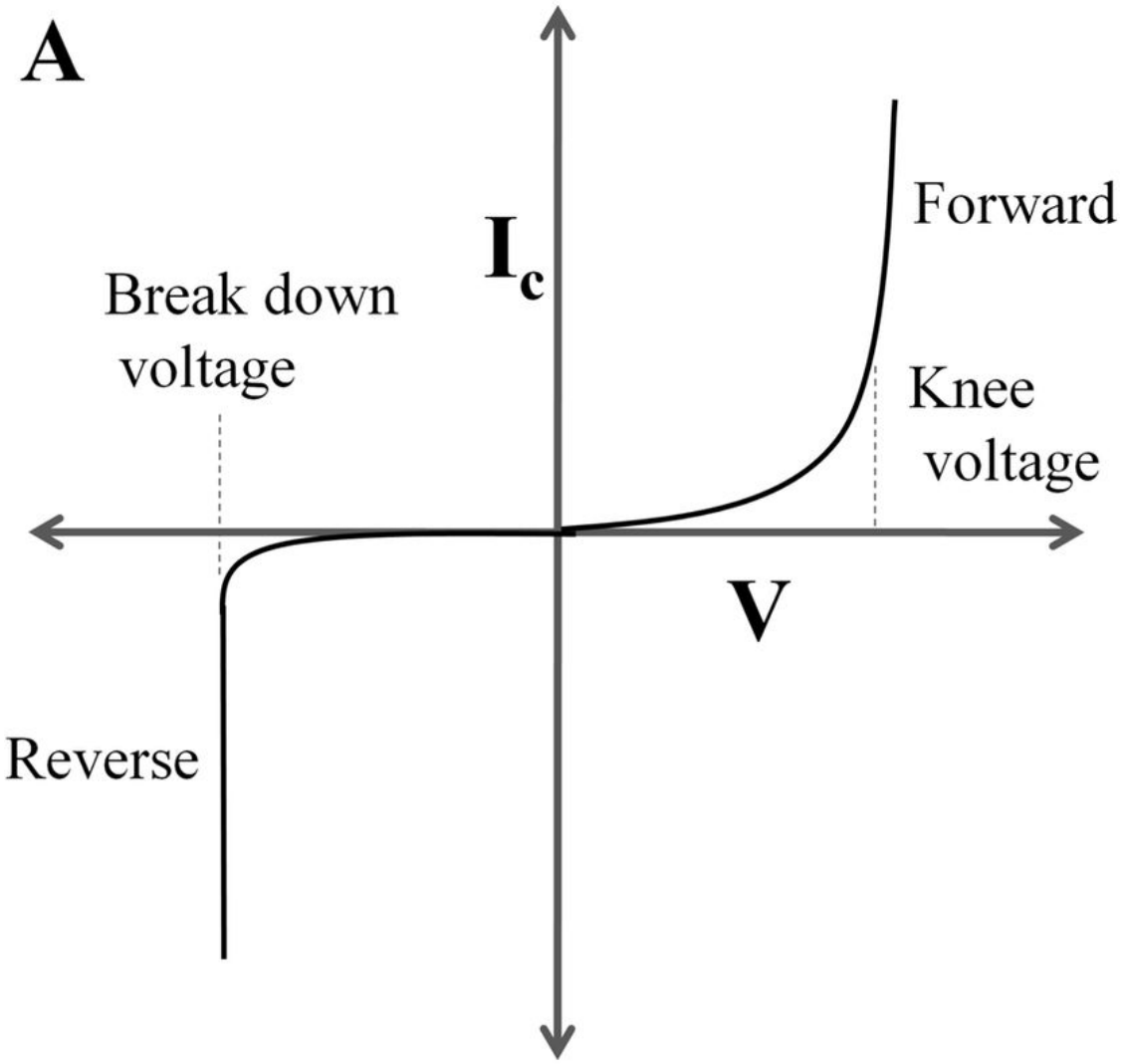
- A **diode** is a two-terminal device that conducts current primarily in **one direction**:
  - It has a very **low resistance** in one direction after a certain voltage.
  - It has a very **high resistance** in another direction.
- There are several different kinds of common diodes:
  - **LEDs** emit light.
  - **PN Junction diodes** are the main diodes HyTech uses.





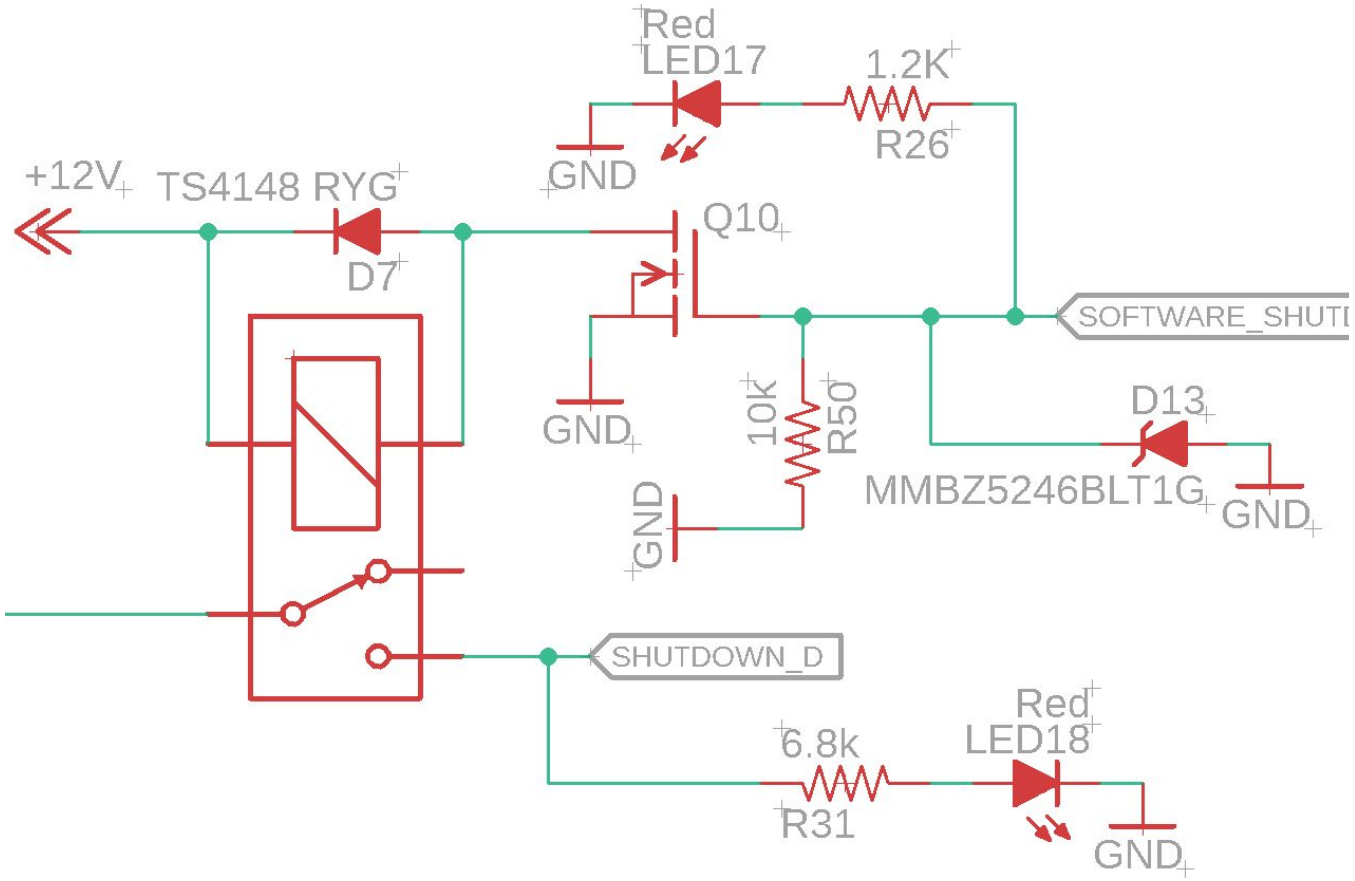
Diode Characteristics

- Diodes have a **bias** or direction.
- Diodes have a **knee voltage**.
  - Before its knee voltage, the diode has a very high resistance.
  - After the knee voltage, the diode has a very low resistance.
- Diodes have a **breakdown voltage** or **reverse bias voltage**.
  - This is the maximum voltage that can be applied in reverse.
  - Beyond this point usually causes **damage** to the diode.



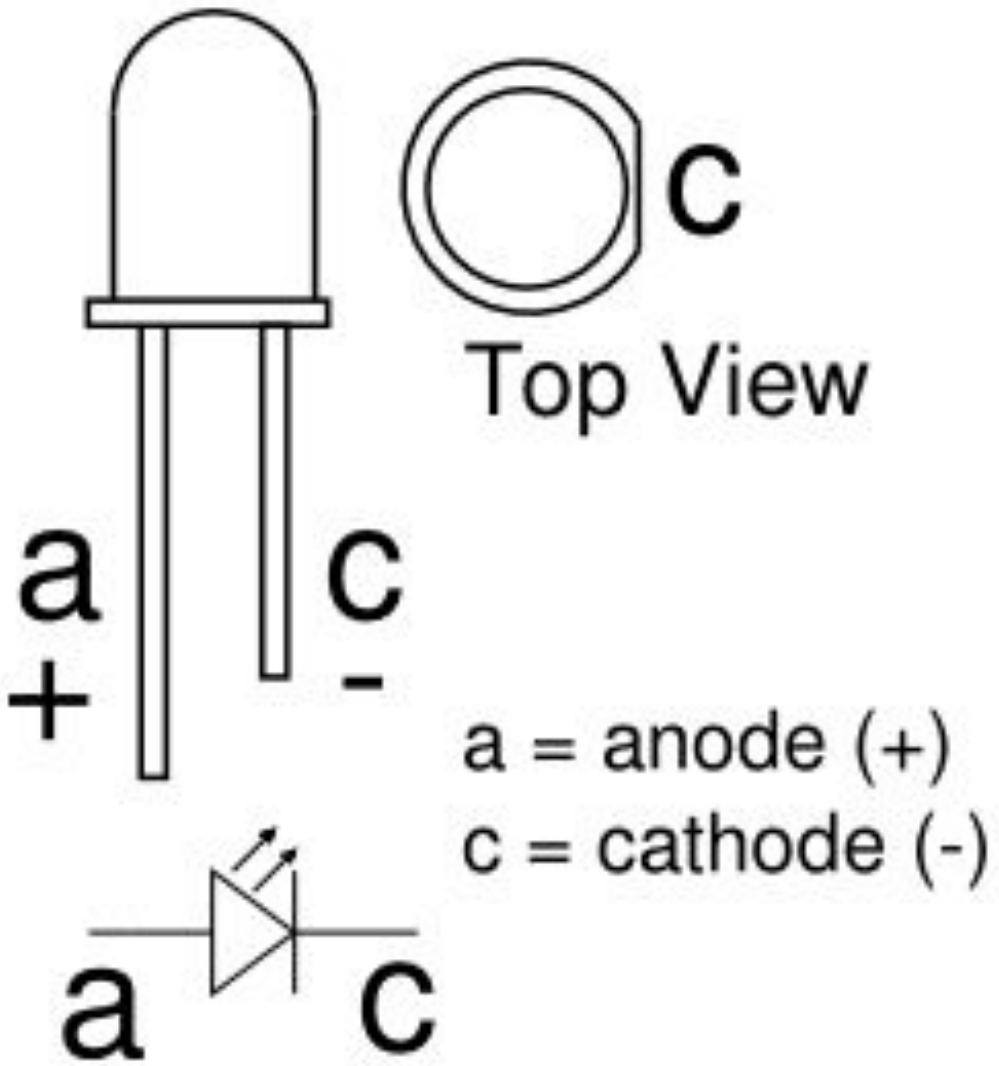
Diode Applications

- A **flyback diode** (**D7** in the schematic) is a PN Junction diode used to eliminate voltage spikes.
  - The reason for those spikes is complicated, but is due to the change in state of the big square relay.
- LEDs (**LED17** and **LED18** in the schematic) are used as status indications.
  - These are especially useful in debugging.



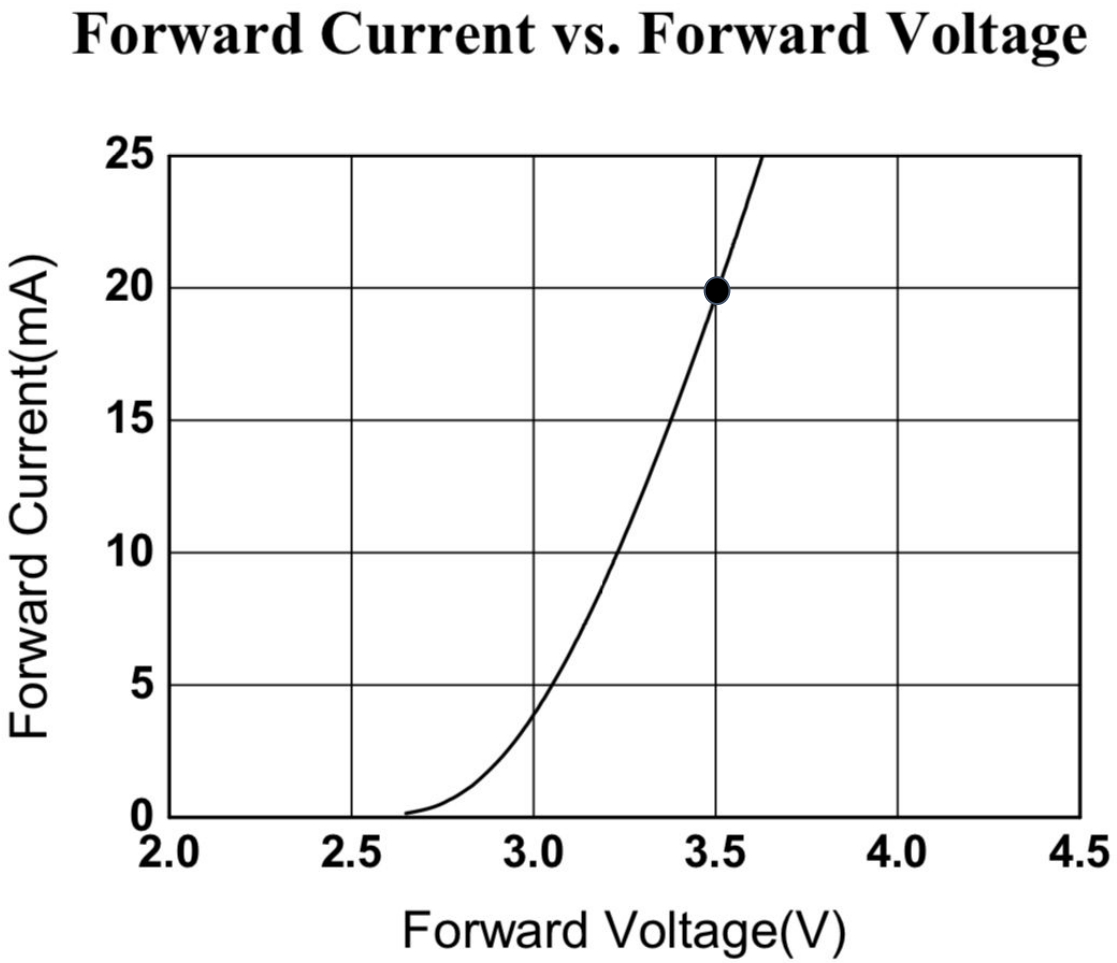
Light Emitting Diodes (LEDs)

- A **LED** is a two-terminal **diode** that **emits light** when current passes through it.
- It acts like a normal diode otherwise.
- It is important, however, to maintain a constant current for a steady brightness.
  - That value is usually listed in a datasheet.
  - Every color of LEDs have a different relationship between voltage and resistor.



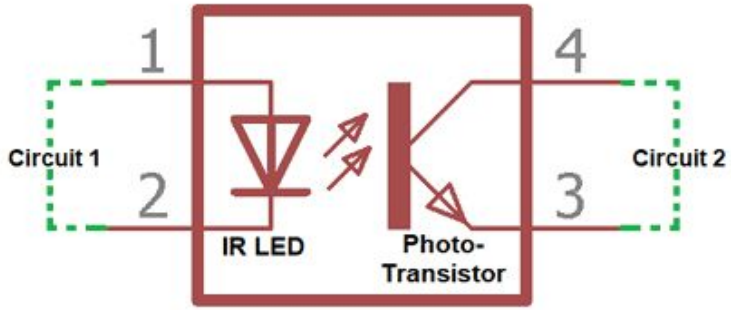
LED Applications

- The goal is to send a **constant current** to the LED.
- That means, if we have a known input voltage into the circuit, we need to figure out what resistor we need in series with the LED.
- It requires use of a **Current vs. Voltage Curves** like the one the right.
- If there is a 5V input, and 20mA needs to go through the LED:
  - We need to have 3.5V through the LED and 1.5V through the resistor (5V - 3.5V = 1.5V) and now apply Ohm's Law.
  - It should be a 75Ω resistor from 1.5V / 20mA = 75Ω.

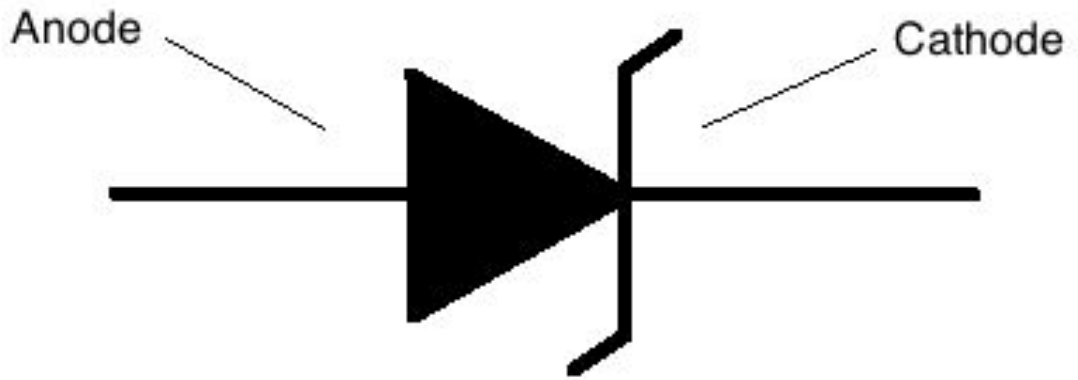


Specialized Diodes

- **Optocouplers** are a special integrated circuit that uses LEDs to **switch other components on and off**.
- **Zener diodes** are used to suppress voltage spikes and to **regulate voltage**.
  - **Transient Voltage Suppression (TVS) diodes** are made up of multiple zener diodes and provide specialized **bi-directional voltage spike suppression**.

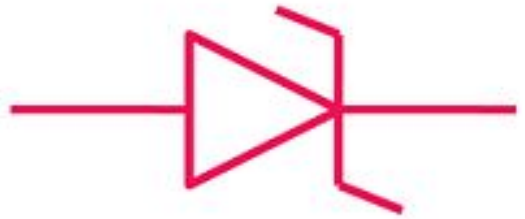


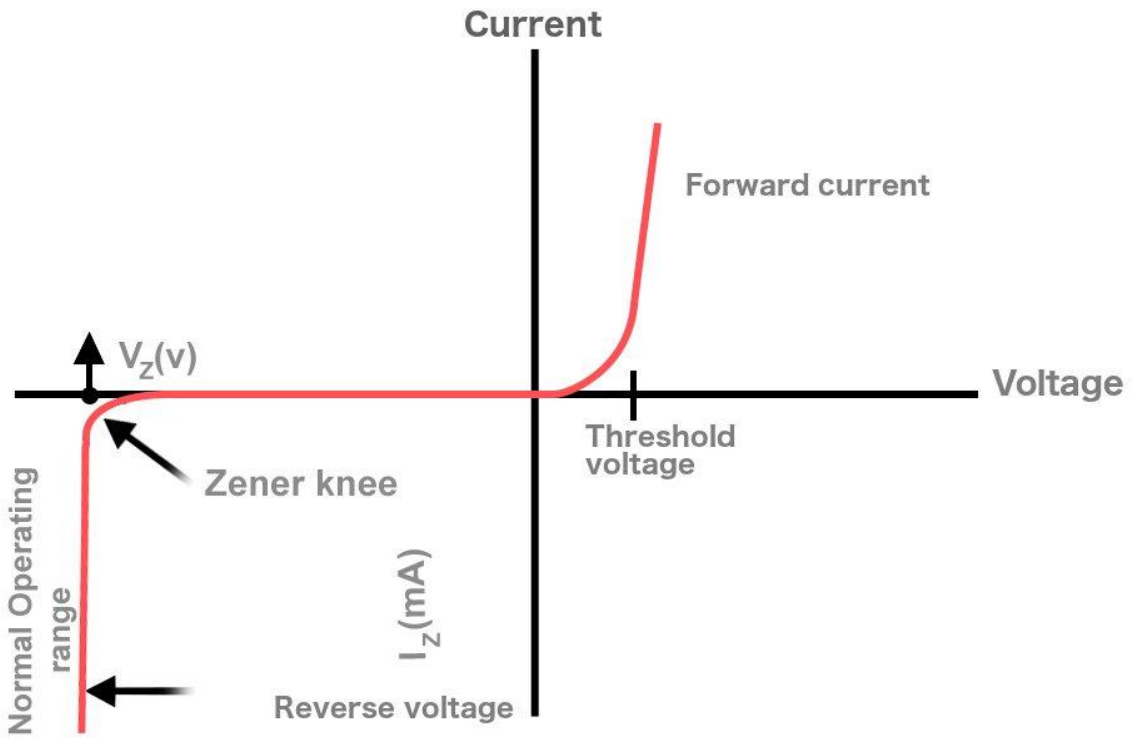
Opto-coupler



Zener Diode

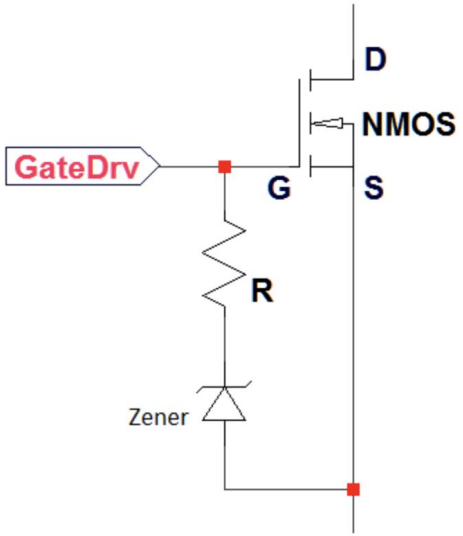
- Zener diodes have **two knee voltages**.
- Between the two, and for positive voltages above the knees, zeners act like **normal diodes**.
- At the zener diode's **reverse voltage** however, it begins to conduct again.
  - It **does not breakdown** like normal diodes do.
- This allows us to **clamp** or **suppress** voltages above this point.
  - This means we lock the range of voltages we can have to eliminate sudden spikes in voltages or **transient voltages** which could destroy components in our circuit

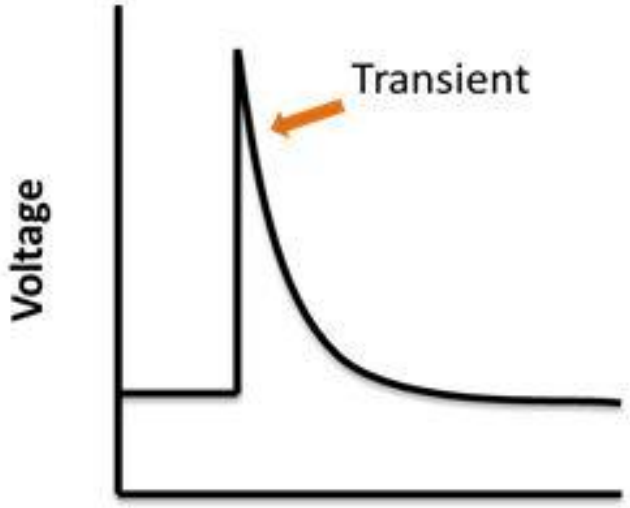


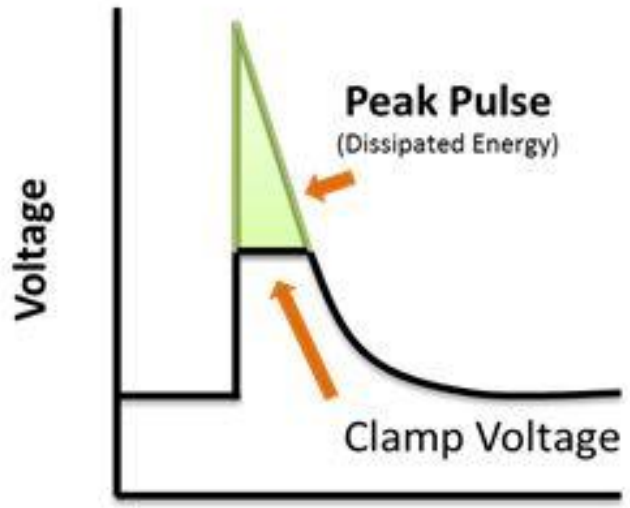


Voltage Suppression

- We already discussed MOSFETs as a type of transistor.
  - The pin that turns them on or off is called the **gate**.
  - That pin is very **vulnerable to damage** from transient voltages.
- Placing a zener diode between the **gate** and **ground** limits these spikes to the zener's reverse voltage, protecting the mosfet

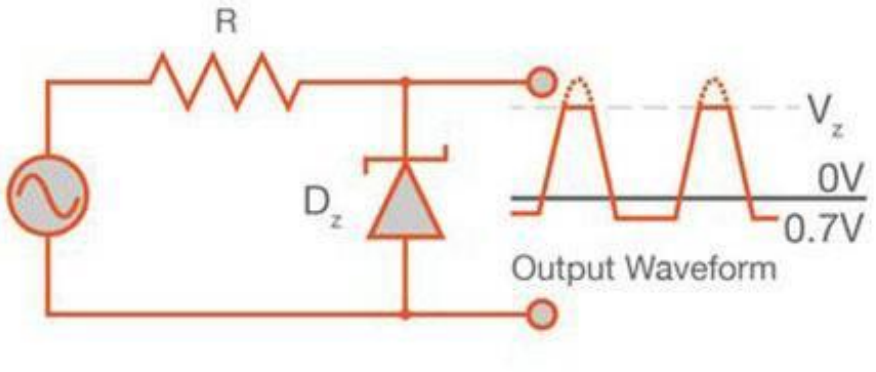




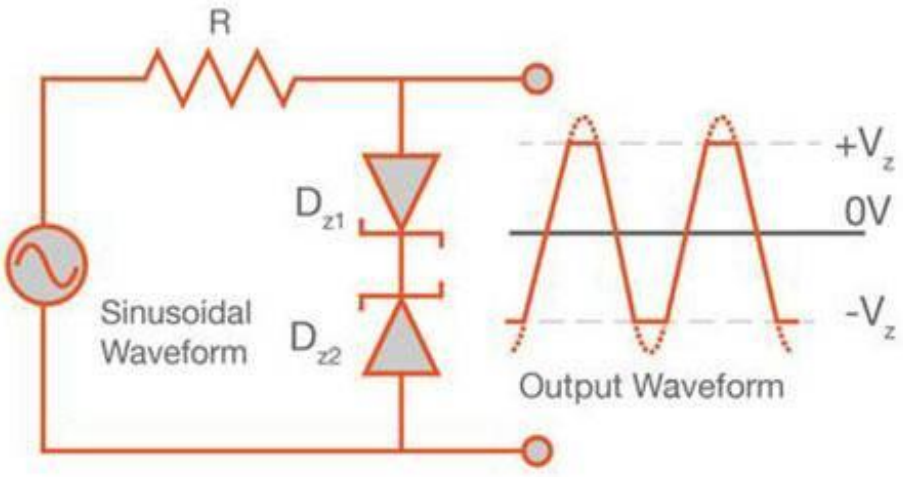


TVS Diode

- A TVS diode is made up of **two zener diodes in opposition**.
  - A single zeners conduct when its voltage is outside of the range of its bias voltages (commonly **-15V** and **0.7V**).
  - Combining two zeners lets you set a positive and lower bound (**-15V** to **15V**).
- A TVS diode thus **limits the potential difference** between two points in the circuit.
  - This property makes them useful for protecting **differential signals**.



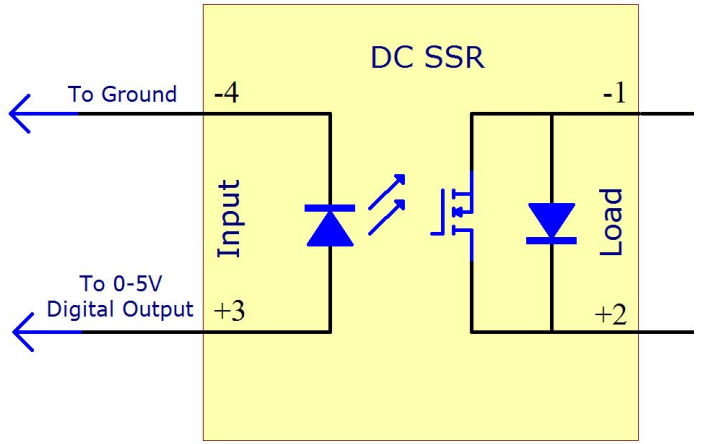
Single Zener Diode Clipping

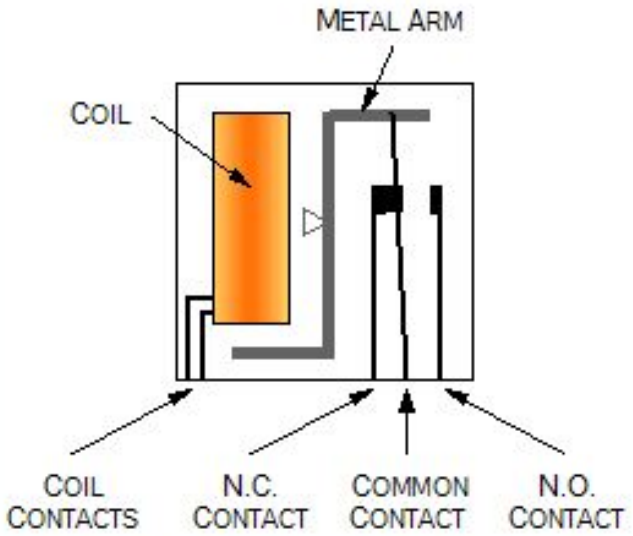


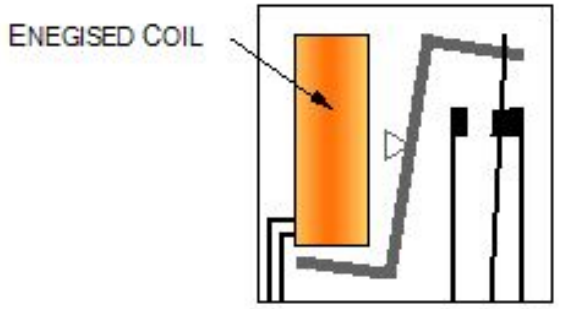
Double Zener Diode Clipping

Relays

- A **relay** is device used to switch another part of a circuit on or off while remaining **isolated**.
- Similar to diodes, there are several types:
  - **Mechanical relays** use a **magnetic coil** to physically switch a contact and are used in our shutdown circuit.
  - **Solid state relays** are another name for a **optocoupler**, using a LED to switch states.
- For each type, there are two versions:
  - **Normally open**
  - **Normally closed**

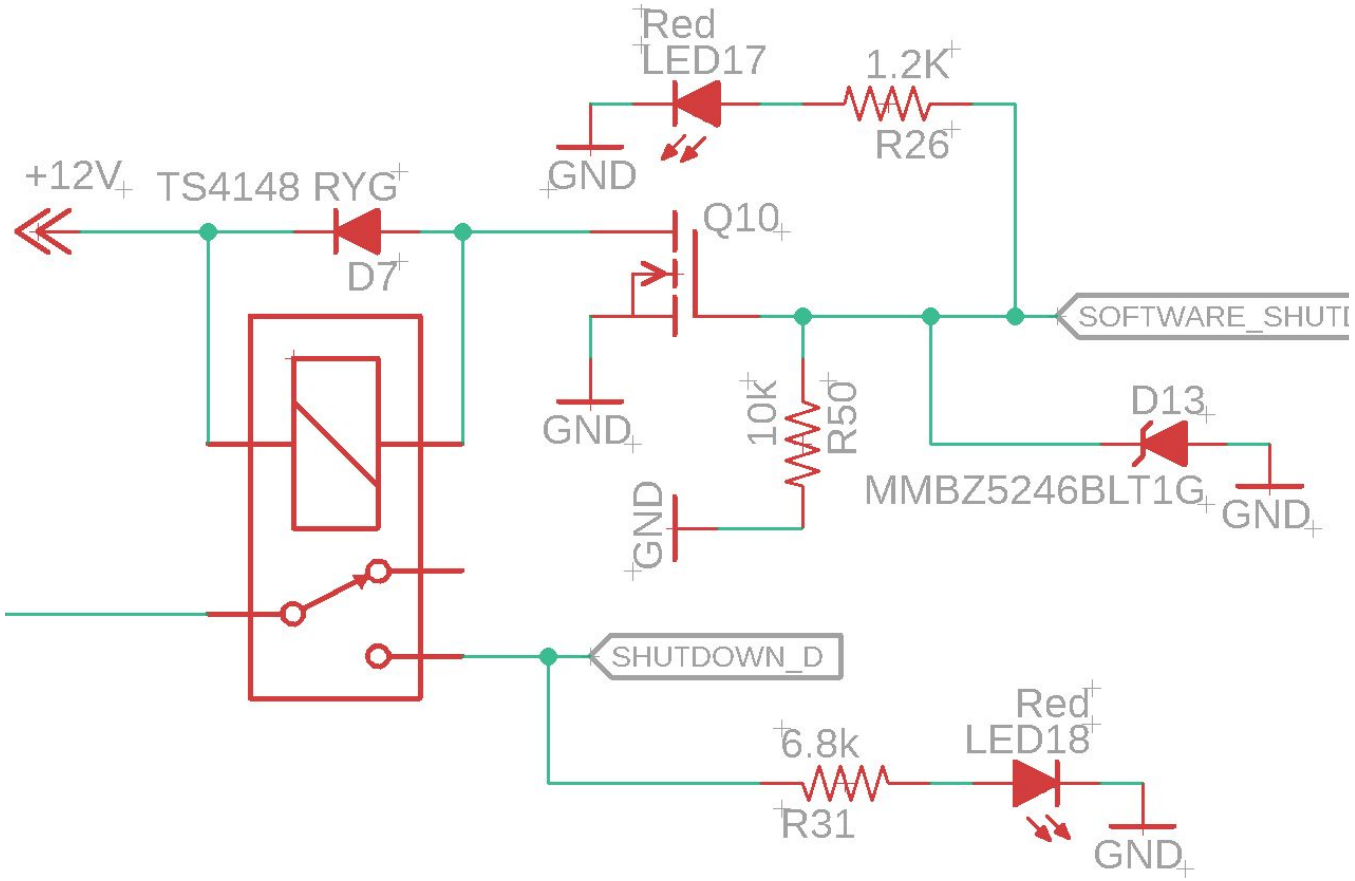






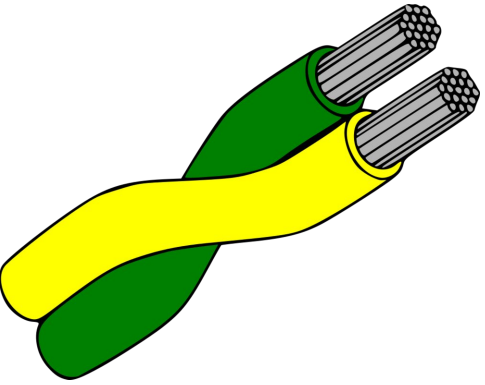
Relay Applications

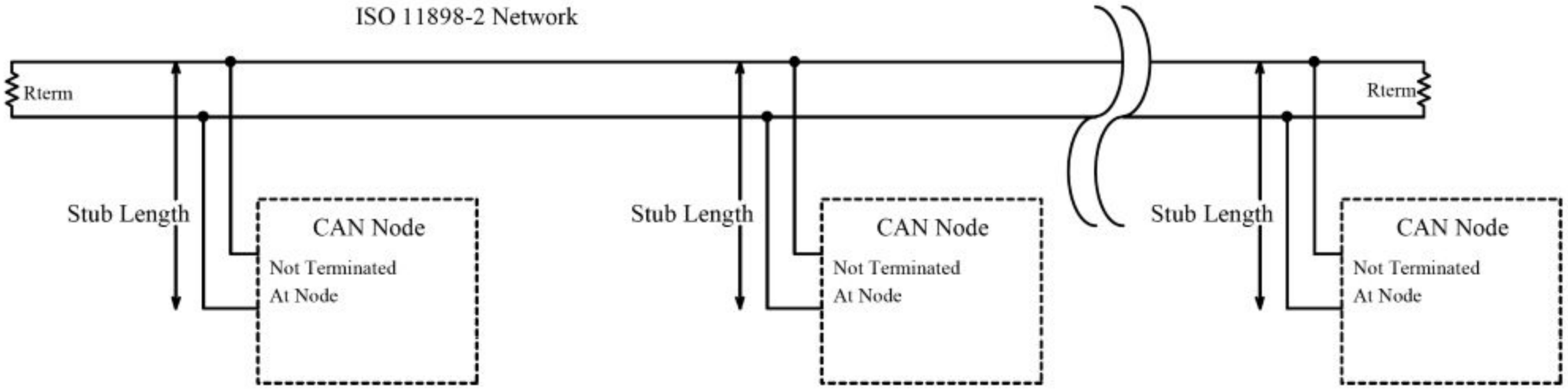
- A **relay** (**TS4148 RYG** in the schematic) here is used for the shutdown circuit.
  - The line through it is labelled Shutdown_D
  - This is a normally open mechanical relay, so power through the coil **closes** the circuit, **enabling** the tractive system.
- There is a catch, mechanical relays are an **inductive** load.
  - That means they work best with a **constant current**.
  - Changing their state produces a **voltage spike** that can be up to **60V**, well more than the **5V** the rest of the circuit expects.



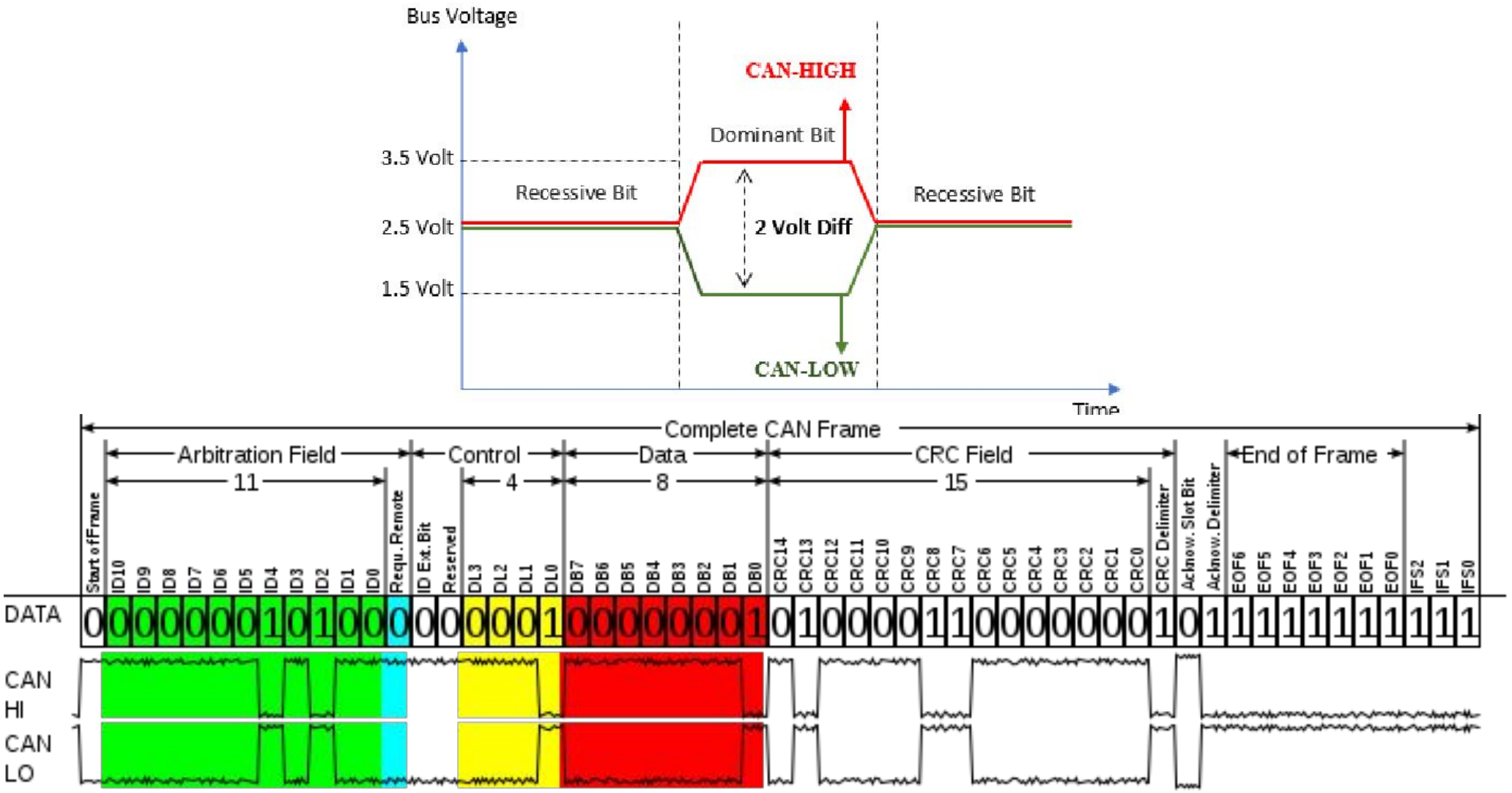
Control Area Network (CAN) Bus

- The **Controller Area Network Bus** is the primary way devices in our car **communicate**.
  - It's an industry standard practice for automobiles.
- It uses **differential signaling** with **twisted pair wiring**, with one line being **CAN High (Yellow)** and **CAN Low (Green)**.
- It also has concepts of **nodes** and **data frames**.
- We use a **bus** topology.



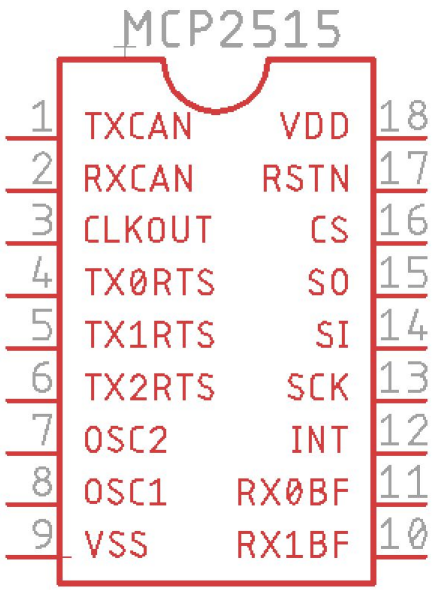


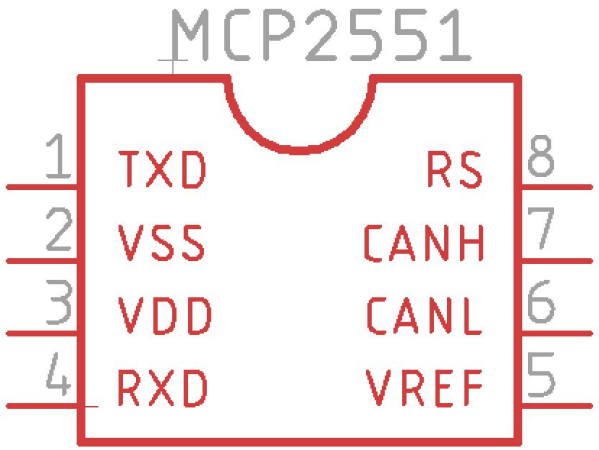
CAN Bus Signaling



CAN Hardware

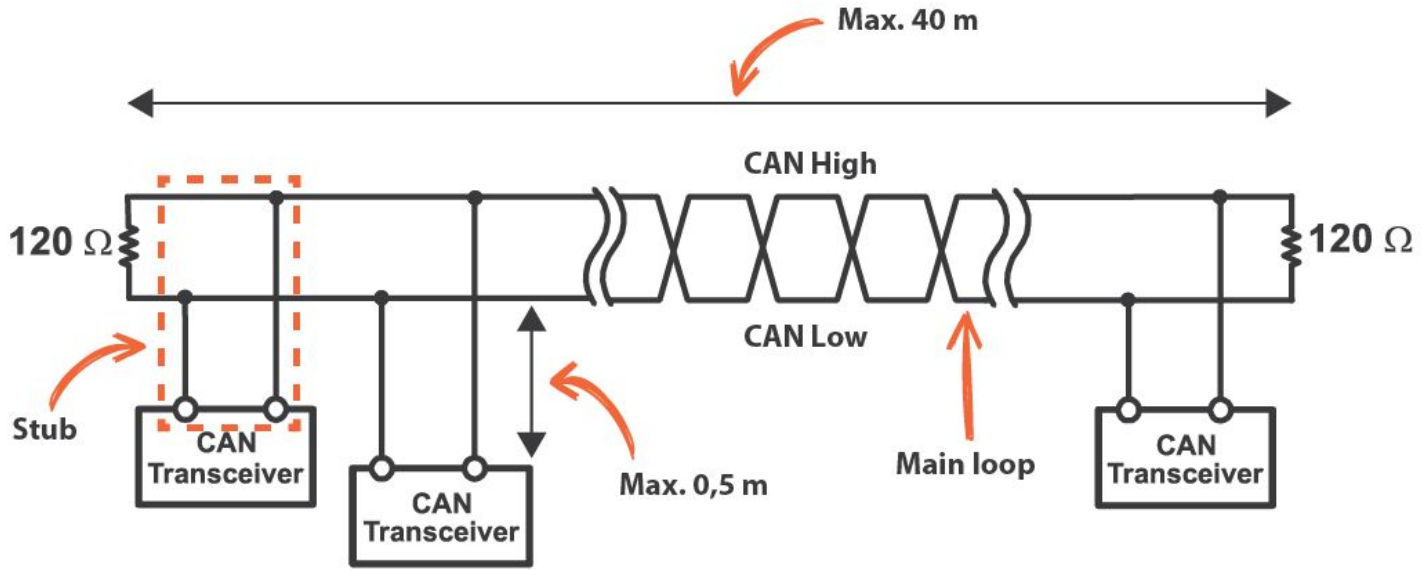
- The hardware for CAN is made up of a **controller** and a **transceiver**:
  - The transceiver converts **controller output** into **physical output** on the CAN lines and converts **physical input** to **controller input**.
  - The controller **packages the data** from the **microcontroller** to send to the transceiver and **packages transceiver data** to send to the **microcontroller**.
- We use the **MCP2551 Transceiver** and **MCP2515 Controller**.

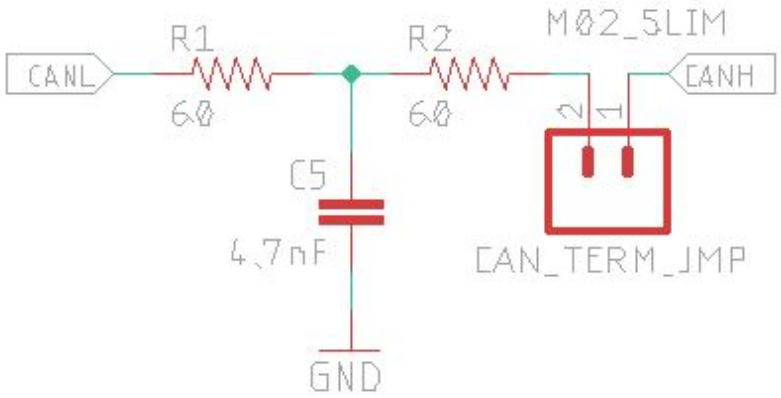


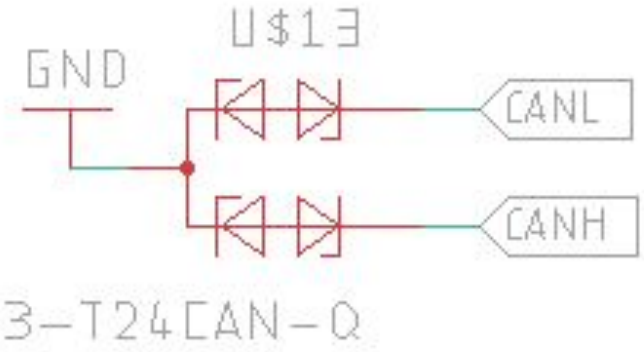


CAN Noise Reduction

- CAN requires **120 ohm termination resistors**
  - These resistors are necessary per specification to reduce **ringing**.
- We use **split termination** which uses a capacitor to further reduce noise between the signal lines.
- We use a pair of **TVS diodes** to protect the CAN lines from extreme voltages spikes.







Training Schedule

Date	Time	Location	Theme
Sunday 9/15	4:00pm - 6:00pm	SCC (Shop) AP Classroom	Safety