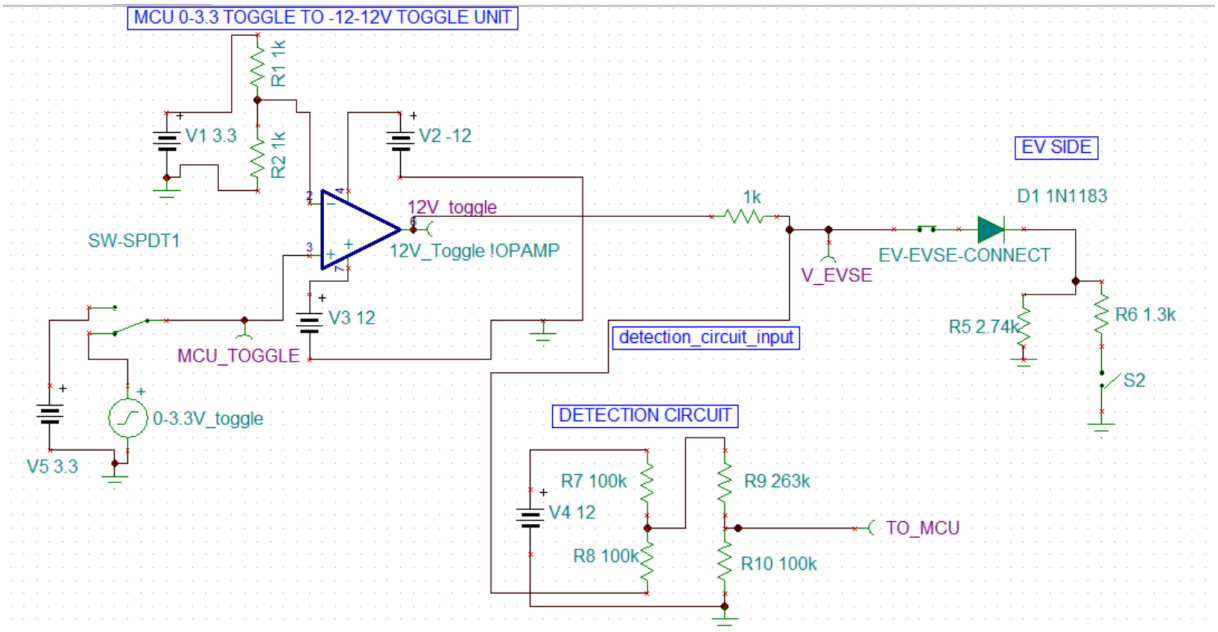
Control Pilot PWM Generation and State Detection

The following circuit has been created for modelling the control pilot PWM generation from MCU 3.3V logic signal and the detection of various charging states.



The EV-EVSE-CONNECT switch is used to model the connection and disconnection of EV via connector effectively.

Now the values of various parameters of circuit and their comparison with corresponding defined standards as per J772 have been given below :

1.Voltage Generation

The defined standard for the pwm voltage generation is as given:

Table 3 - EVSE control pilot circuit parameters (see Figure 1)

Parameter(1)	Symbol	Units	Nominal Value	Max Value	Min Value
Generator					
voltage high, open circuit	Voch	V	12.00	12.60	11.40
voltage low, open circuit	Vocl	V	–12.00	–12.60	–11.40
Frequency	Fo	Hertz	1000	1020	980

The observed values for the implemented circuit are :

1) Voltage Low,open circuit -> -12 Volts
2) Voltage High,open circuit -> 12 Volts
3) Frequency -> 1KHz

2.Control Pilot State Reference Voltages :

Given below are the recommendations for control pilot state voltage reference ranges from mated charge coupler interfaces -

Table 2B - Control pilot state recommended boundary voltage range reference from mated charge coupler interface for the EVSE

State	Min Voltage	Nominal Voltage	Max Voltage
State B1	8.00	9.00	10.00
State B2	8.00	9.00	10.00
State C	5.00	6.00	7.00
State D	2.00	3.00	4.00

In our circuit design , we have been able to model the states A,B1,B2 and C as per the following table :

State Designation	V EVSE (vdc Nominal)(5)	V Vehicle (vdc Nominal)(5)	Description of Vehicle / EVSE State
State A	12.0(1)	0(1)	Vehicle not connected
State B1	9.0(1)	9.0(1)	Vehicle connected / not ready to accept energy EVSE not ready to supply energy,
State B2	9.0(2)(3)	9.0(2)(3)	Vehicle connected / not ready to accept energy EVSE capable to supply energy
State C	6.0(2)	6.0(2)	Vehicle connected / ready to accept energy / indoor charging area ventilation not required EVSE capable to supply energy
State D	3.0(2)	3.0(2)	Vehicle connected / ready to accept energy / indoor charging area ventilation required EVSE capable to supply energy
State E(4)	0	0	EVSE disconnected from vehicle / EVSE disconnected from utility, EVSE loss of utility power or control pilot short to control pilot reference
State F	–12.0(1)(6)	–12.0(1)(6)	Other EVSE problem.

1. Static voltage.

In the circuit , V Vehicle has not been implemented, it can be done by using the same detection circuit on the EV side as shown on the EVSE side in the circuit. Now, we will go over each of the implemented states and how to model them in the circuit :

1) State A : This is modelled by connecting the SW-SPDT1 switch to constant 3.3V to create a static 12V signal on the CP line and by opening the EV-EVSE-CONNECT switch, to reflect a state where EV and EVSE are not connected. The **V EVSE for this state is measured to be 11.99 volts.**

2) State B1 : This state is modelled by closing the EV-EVSE-CONNECT switch and connecting SW–SPDT1 switch to constant 3.3V to create a static 12V signal on the CP line.
   The connected EV then pulls this voltage on the CP line down to **8.92 volts** (S2 is left in an open state) in the circuit, to indicate state B1.
   Which is within the **8V to 10V range** as defined by the J772 standard.

3) State B2 :
   This state is modelled by connecting the SW-SPDT1 switch to the 0-3.3V_toggle source which is used to represent the 0-3.3V signal PWM signal generated by the MCU.Rest of the switch positions remain the same.

   This configuration generates the 12V PWM signal on the CP line, which is pulled down to a **8.92 volt** PWM signal by the R5 load resistance. It indicates that the EVSE is ready for charging but the EV is not

4) State C :
   The EV indicates that it is ready for charging by **closing the switch S2**, which leads to the PWM signal that was being generated in B2 state to be pulled down to a **5.89 Volt PWM signal** due to the change in effective load resistance as R6 is added to the circuit in parallel to R5.
   This value of **5.89 Volts** is within the **5V to 7V** range as defined by the J772 standard.

3.Load Resistance Values :

The J772 standard defined the permissible load resistance value ranges for the charging states:

Table 4 - EV/PHEV control pilot circuit parameters (see Figure 2)

Parameter(1)	Symbol	Units	Nominal value	Max value	Min value
Equivalent load resistance - State B1&B2	R2B	Ω	2740	2822(2)	2658(2)
Equivalent load resistance - State C(3)	R2C	Ω	882	908(2)	856(2)

In the implemented circuit the **observed values** are :

1) Equivalent resistance in State B1 & B2 : 2740 ohms.

2) Equivalent resistance in State C : 882.177 ohms.

These are within the provided range.

Detection Circuit :

A detection circuit has also been implemented using which the PWM voltage signal on the CP line are mapped to a 0-3.3V range allowing for the state measurement by EVSE microcontroller unit

The voltage measured by the MCU and its corresponding meaning with reference to the charging state have been given below :

1) State A : Constant voltage of 2.9 volts.
2) State B1 : Constant voltage of 2.53 volts.
3) State B2 : PWM signal with a voltage high value of 2.53 volts.
4) State C : PWM signal with a voltage high value of 2.17 volts.

For both State B2 and C the voltage low value is 14.4mV.