In order to tune the PID controller parameters manually, first all the parameters are chosen as zero, and the code is run. It can be seen that the car diverges from the lane after just a few seconds. In the next step, a proportional controller is designed by choosing the value 0.1 for the Kp and keeping Ki and Kd as 0. The result show that the car precedes for a while, but it goes off the bridge later. By increasing the proportional gain, steering behavior improves but oscillations start to appear and amplify as time passes until the car goes out of lane. The reason is that the control signal is only proportional to the error value, and once the car diverges and error is large, a relatively large control signal is applied to the vehicle which causes it to diverge to the other side, and so on.

To reduce the oscillations, the derivative gain Kd is increased. This term reduces the distance between the current error and the previous error signals. As a result, the output turns out smoother.

For a more smooth performance and smaller error, the integral gain is used. This gain minimizes the sum of errors; therefore it can decrease the small error between target and actual signals. In other words, the integral gain removes the steady state error. In cases where the error is relatively large, the integral term in the error increases accordingly and may lead to overshoot. The Ki gain must be chosen small so the total error value is not saturated.

Overall, a tradeoff exists between Kp and Kd values, so they are chosen in a way that steering behavior is acceptable and the oscillations are reduced. By starting from 0.1 for both gains, the final values can be Kp = 0.3 and Kd = 20. Then, a much smaller value for Ki is chosen to reduce the steady state error which is Ki = 0.0005.