[Table 1: Input Signals 2](#_Toc94531627)

[Table 2: Parameters 2](#_Toc94531628)

[Table 3: Output Signals 3](#_Toc94531629)

[Table 4: Constants 3](#_Toc94531630)

[Table 5: Lookup Tables 4](#_Toc94531631)

[Vehicle Fixed Coordinate System [VFC] 5](#_Toc94531632)

[Tire Fixed Coordinate System [TFC] 5](#_Toc94531633)

# Table 1: Input Signals

|  |  |  |  |
| --- | --- | --- | --- |
| Signal Name | Definition | Sign Convention | Unit |
| driver\_input | Proportion of power to use, when the total is 60kW, or -p kW, where p is maximum. This is a single signal that communicates information from pedal box | Positive when +x acceleration is desired [VFC] | none |
| power\_limits\_battery | Maximum and minimum total power that motors can consume, due to battery limits | Positive power will cause vehicle to move forward | W |
| center\_steer\_angle | Angle that the steering column is turned from neutral | Positive angle will yield a right turn [TFC] | rad |
| Vx | Longitudinal cog velocity | Positive when car is moving forward [VFC] | m/s |
| Vy | Lateral cog velocity | Positive when car is moving to the right [VFC] | m/s |
| yaw | Yaw rate of vehicle | Positive when car is making right turn [VFC] | rad/s |
| prev\_torque | Torque requested to motor in previous time step | Positive for +x acceleration  [TFC] | N |
| omega\_w | Tire rotation speed | Positive when car is moving forward [TFC] | rad/s |
| shock\_pot\_disp |  |  | mm |
| Tracking Signal | Previous time step realizes yaw accel | Positive when car is accelerating CW [VFC] | rad/s^2 |
| Control Signal | Previous time step control signal | Positive for CW acceleration [VFC] | rad/s^2 |

# Table 2: Parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter Name | Definition | How To Change | ‘Reasonable’ Range |
| tau | The speed that motor can change torque | Increase for slower torque change | [0.01 1] |
| c\_factor | Contribution that a particular term has to max yaw before loss of control | Increase for larger max yaw | [0.5 1] |
| F | Gain of signal before PI control | Decrease to attenuate | [0 1] |
| P | Proportional gain of PI controller | Increase for larger immediate change | [0 ?] |
| I | Integral gain of PI controller | Increase for large long-term change | [0 ?] |
| Kt | Integral gain of tracking signal to mitigate wind up | Increase for faster integral reset | [0 ?] |
| mu\_factor | , the ratio of the track friction to tire testing consortium friction | Decrease for smaller smaller friction | [0 1] |
| k\_limit | Maximum combined slip allowed | Increase for more slip | [2 5] |

# Table 3: Output Signals

|  |  |  |  |
| --- | --- | --- | --- |
| Signal Name | Definition | Sign Convention | Unit |
| Tx | The torque distribution [fl fr rl rr] | Positive for +x acceleration | N |

# Table 4: Constants

|  |  |  |
| --- | --- | --- |
| Constant Name | Definition | Unit |
| g | Acceleration due to gravity | m/s^2 |
| t | Controller Timing | s |
| r | Radius of tire | m |
| s | Half-track width of the vehicle | m |
| l | Wheelbase | m |
| gr | Gear ratio of each gearbox | none |
| disk\_diameter | Equivalent diameter of the brake disk that the brakeforce acts on | m |
| motor\_limit\_power | Power limits due to motor | W |
| motor\_limit\_torque | Max and min torque that can be requested | N |
| mech\_brake | The value of driver\_input where mechanical braking begins | None |
| RE | Effective rolling radius of tire | m |
| motor\_efficiency | Motor efficiency | none |
| gearbox\_efficiency | Gearbox efficiency | none |
| J\_z | Polar moment of inertia of the vehicle | Kg m^2 |
| K\_u | Understeer gradient of the vehicle | rad/m/s^2 |
| brakeforce\_max | Maximum force that the brakepad can exert on the brake disc | N |
| brakepad\_mu | Coefficient of fraction between brakepad and brakedisc | none |
| tire\_mu | Coefficienct of friction between tire & ground | none |
| min\_speed\_regen | Minimum motor shaft rotation rate for regenerative braking | rad/s |
| m | Mass of the vehicle w/ driver | kg |
| C\_l | Coefficient of lift | none |
| density\_air | Density of air | kg/m^3 |
| surface\_area | Frontal surface area of the vehicle | m^2 |
| k\_front\_lb | Spring rate, front shocks | lb/in |
| k\_rear\_lb | Spring rate, rear shocks | lb/in |
| lb/in2N/mm | pound per in to newton per mm conversion | N in/lb mm |
| b | Damping constant for shocks |  |
| Yf |  | m |
| Shock\_front\_to\_shock\_rear |  | m |
| Xf |  | m |
| Xr |  | m |
| theta\_front | Angle from front shocks to vertical | deg |
| theta\_rear | Angle from rear shocks to vertical | deg |

# Table 5: Lookup Tables

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Input | Location | Model Type |
| kx | FZ | Layer 0 | Analytic |
| mu\_x | FZ | Layer 0 | Analytic |
| mu\_y | FZ | Layer 0 | Analytic |
| C | FZ | Layer 0 | Not Analytic |
| R, R\_max | k, k\_max | Layer 0 | Analytic |
| n, n\_max | k, k\_max | Layer 0 | Analytic |
| rpm\_limit | omega\_m | Layer 2 | Probably Not Analytic |

# Vehicle Fixed Coordinate System [VFC]

Diagram

Description automatically generated

# Tire Fixed Coordinate System [TFC]

Radar chart

Description automatically generated

Radar chart

Description automatically generated

Credit: Mathworks Vehicle Dynamics Block Coordinate Systems