Air drag: Fd

eq. 1

Rolling drag: Fr

The force F2 that is needed to move car

eq. 2

Eq. that sums up all forces that interact on the car

eq. 3

We combine eq. 1 and eq. 2 into eq. 3. We estimate that the rolling resistance to be negligible, hence we get eq. 4.

eq. 4

The vehicle engine transmits the power to the wheels from this equation

eq. 5

We insert eq. 5 into eq. 4

eq. 6



Figure

Now let have a look at the vehicle electric motor. The torque is a linear proportional to the current and is motor torque constant.

eq. 7

We can derive eq. 6

eq. 8

The angular velocity is defined as a linear voltage difference, proportional to the angular velocity of the armature shaft and

eq. 9

By using Kirchoff’s laws in figure 1, the following equation can be derived

eq. 10

From eq. 10 the torque of the electric engine have been found and can be inserted into eq. 6

eq. 11

Before eq. 11 is Laplace transformed all the constants will be substitute

And we have:

eq. 12

Laplace transformed eq. 12 and we have:

Parameter definition

mass of the vehicle

wheel inertia

radius of the wheel

electrical resistance in the motor

angular velocity constant

torque constant

( 0   - (-P\*1/s     \*  0,06068/(s+1,1)) \*     1/s      \*        1

(-150s -28,5)/s => -150s/s + -28,5/s => -150 + (-28,5)\*s => -150 + (-28,5) \* 1/s => -150 \* (1 + 0,19 \* 1/s) => -150 \* (1 + 1/5,26316 \* 1/s), i.e. Kp = -150 and Ti = 5,263