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Q.2) i) Describe the key steps involved in ABS algorithm.

Ans :- (1) The desired slip will be a constant value, the relative slip will change with velocity of vehicle.

(2) The desired slip is set as 0.2

(3) Relative slip = $1 - \frac{\text{Vehicle angular velocity}}{\text{Wheel angular velocity}}$

So, to calculate relative slip, we need to calculate vehicle angular velocity & wheel angular velocity. Wheel angular velocity is calculated from tyre torque, while vehicle angular velocity is calculated from braking torque.

(4) Tyre torque = μNR,

where, μ = coefficient of friction between tyre & ground
N = Normal force per wheel
R = Wheel radius.

(5) Coefficient of friction's variation with slip is given by 1D lookuptable.

(6) Normal force per wheel = $N = \frac{mg}{4}$; where m = mass of vehicle.
It is calculated using gain block.

(7) One more gain block is used to give value of R.

(8) One subsystem is created to which inputs are tyre torque & error between slips and output is wheel angular speed. In this subsystem Bang-Bang Controller is used to check error value if it is positive or negative.

(9) Bang-Bang controller outputs 1 if input is greater than 0 and outputs -1 if input is less than 0. It is made by using comparison operators.

(10) Hydraulic lag due to application of brake is taken care by using transfer function. The output of transfer function is integrated over time to compute braking torque

(11) The efficient torque is the difference between tyre torque & braking torque. Dividing this efficient torque by mass moment of inertia of wheel, we get deceleration of vehicle.

(12) By integrating this deceleration with initial velocity as given condition, we will get wheel angular velocity.

(13) To calculate vehicle angular velocity, the tyre torque is divided by $(-1/m)$, where negative sign indicates deceleration. This value is integrated over time to get vehicle velocity.