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Report for ABS

→ ABS are meant to control the wheel slip in order to maintain the friction coefficient close to the optimal value.

→ wheel slip :- Relative motion between a wheel and the surface of the road, during vehicle movement.

Consider vehicle moving in a straight direction under braking conditions.

so for horizontal direction

$$F_f = F_i \quad \text{--- (1)}$$

F_f → frictional force

F_i → Inertial force

$$F_f = \mu \cdot m_v \cdot g \quad \text{--- (2)}$$

m_v - total vehicle mass

g - gravitational acceleration

$F_i = m_v \cdot a_v$ (a_v - vehicle acceleration)

where $a_v = \frac{dV_v}{dt}$

∴ vehicle acceleration (from (1), (2), (3))

$$\frac{dV_v}{dt} = \frac{1}{m_v}(\mu \cdot m_v \cdot g)$$

ABS system has to control the wheel slip around an optimal target.

for slip,

$$s = 1 - \frac{\omega_w}{\omega_v}$$

ω_v → equivalent angular speed of the vehicle.

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$$\omega_v = \frac{V_v}{r_w}$$

V_v (m/s) → Vehicle speed

→ friction coefficient depends on several factors like - wheel slip, vehicle speed, the type at road surface.
For our purpose we are going to take into account only the variation on wheel slip.

friction Coefficient

Stability zone.
· friction coeff increases with the wheel slip increases

Unstable zone
· friction coeff decreases with the wheel slip increase

Friction coeff. can be expressed as empirical function, where slip is functional argument.

$$\mu(S) = A \cdot \left(B \cdot \left(1 - e^{-C \cdot S}\right) - D \cdot S\right)$$

S [-] - wheel slip.
A, B, C, D [-] - empirical coefficients

Depending upon the value at coeff A, B, C, D empirical formula can be used to represent the friction coefficient for diff road types.

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	Type			
	dry	wet	snow	Ice
A	0.9	0.7	0.3	0.1
B	1.07	1.07	1.07	1.07
C	0.2773	0.5	0.1773	0.38
D	0.0026	0.003	0.006	0.007

→ wheel model:-
Wheel speed W_w integrator is initialised. The linear wheel speed V_w is obtained by multiplying the angular speed with wheel radius. distance covered obtained by integrating linear speed.

i/p :- braking force F_b
friction force F_f

o/p :- angular wheel speed W_w
linear wheel speed V_w
wheel distance d_w.

→ Controller
bang-bang type controller reacting on wheel slip feedback. max value at friction coeff. is obtained around slip at 20% (0.2) thus target is 0.2. slip error is the diff. between actual slip & target slip.
Hydraulic system modeled as first order transfer function amplification factor K. time const is T. o/p is braking ~~forkward~~.
T_b accumulated over time by integrator
i/p → wheel slip S[-]
o/p → vehicle speed V_v [m/s].

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→ Simulation:-

- Simulation run for 20 sec and results are stored in data inspector.
- When ABS disabled braking ~~force~~ ramps up to maximum value & causes slip. with ABS braking torque modulated to maintain optimal slip ratio
- When ABS deactivated wheel slip climbs to 1 as torque increases. When ABS is activated slip is controlled by controlling braking force. When ABS is deactivated wheel locks before coming to complete halt with ABS active wheel is prevented from locking thus reducing slip.