Effects of Tyre Dynamics on Slip Control

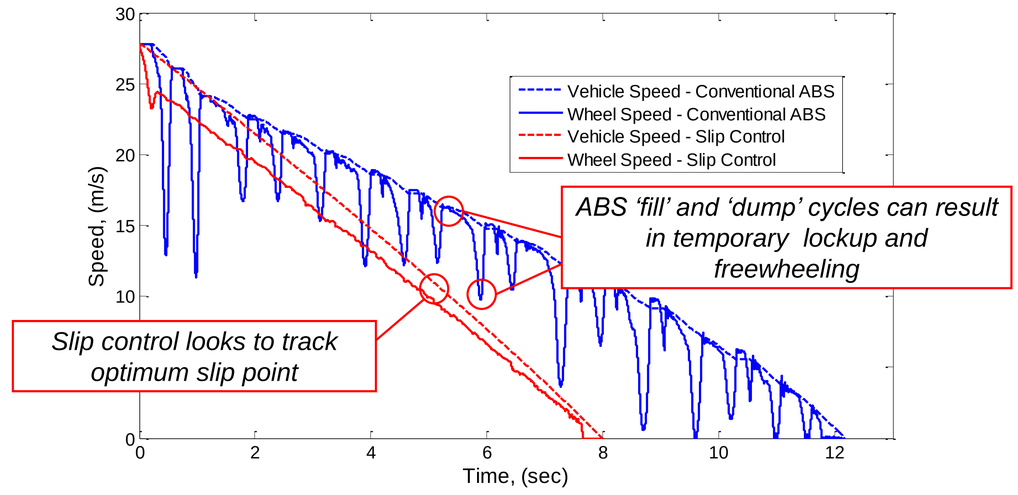
Leon Henderson and Professor David Cebon

Project Overview

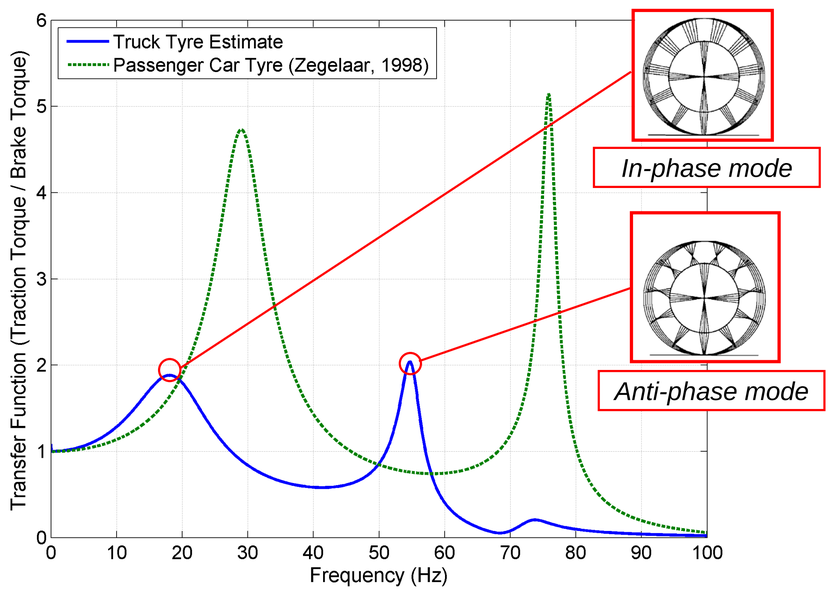
- Heavy Vehicles currently require up to 40% more distance to stop than passenger cars
- Slip Control is an alternative braking strategy to conventional ABS, requiring faster brake actuators

Questions:

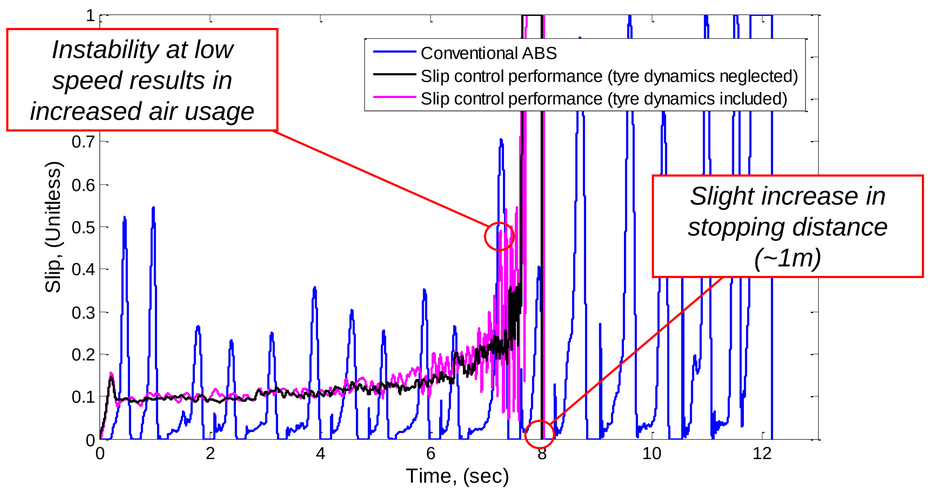
- How is slip control performance affected by tyre vibration?
- What benefits can be achieved by using a Smart Tyre signal?



Emergency Stop Performance – Conventional ABS vs Slip Control with Fast Actuators



Predicted Transfer Function Between Changes in Brake Torque and Tractive Tyre Force

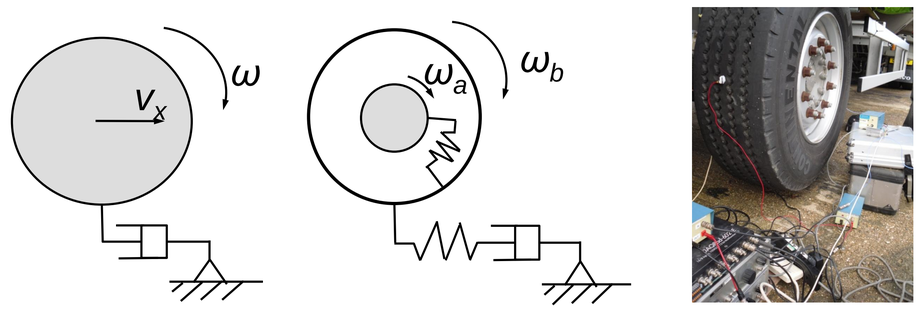


Slip Controller Performance With and Without Tyre Dynamics in Plant Model

Effects of Tyre Vibration

Modelling a Truck Tyre

- ABS simulations typically neglect tyre dynamics
- Fast actuators may induce vibration modes not predicted by lumped models



Lumped Tyre Model (left), Rigid Ring Tyre Model with Relaxation Length (centre), Experimental Setup Used to Estimate Torsional Stiffness (right)

Effects of Tyre Dynamics on Slip Control

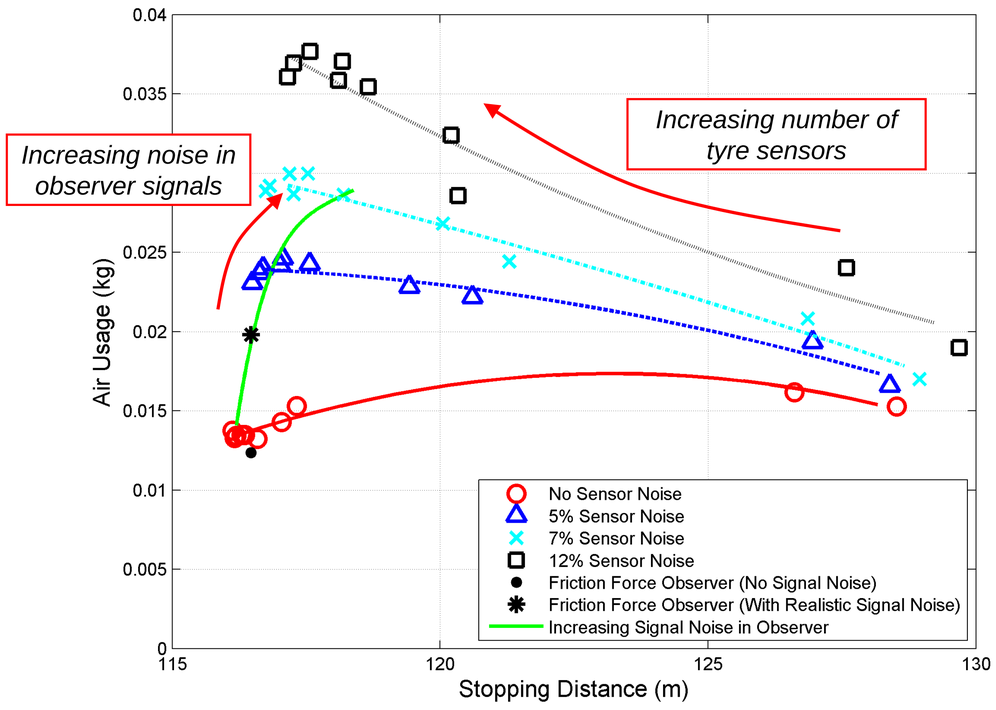
- Stopping distance is increased only slightly (<1%) when tyre dynamics are included in plant model
- Instability at low speeds results in increased air usage (13%)
- Instability can be reduced by retuning controller using more advanced vehicle model

Benefits of Smart Tyres

Smart Tyre Model

- Strain gauges imbedded in the tyre provide an alternative to observing friction force indirectly
- Each strain gauge measures the friction force directly as it passes through the contact patch
- Using multiple strain gauges in each tyre allows faster sampling rate to be achieved

Block Diagram Showing Smart Tyre Signal (red dashed) and Friction Force Observer Signal (blue dashed)



Smart Tyre Straight-Line Braking Performance on Smooth, Wet Road

Predicted Smart Tyre Benefits

- Five sensors, with less than 5% sensor noise, are required to provide similar performance to friction force observer

Braking Control

CVDC

ArvinMeritor
Camcon
Denby Transport
Firestone
Fluid Power Design
FM Engineering
Goodyear
Haldex
Intec Dynamics
Mektronika Systems
MIRA
QinetiQ
Shell UK
Tinsley Bridge
Volvo Trucks