Antilock Braking Systems
Buckman Consulting Services, Inc.
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ANTILOCK BRAKING SYSTEMS

ABS CONTROL SYSTEMS

ALGORITHMS HAVE STEADILY EVOLVED SINCE THE 1970'S
- FEATURES AND FUNCTIONS ADDED TO PROVEN PRINCIPLES
- MERITOR WABCO ALGORITHM IS AN EVOLUTION OF AN 1981 PRODUCTION ALGORITHM

REAR WHEELS: GENERALLY INDIVIDUAL WHEEL REGULATION (IR)
- PROVIDES MAXIMUM RETARDATION
- MAINTAINS MAXIMUM STABILITY

FRONT WHEELS: GENERALLY MODIFIED INDIVIDUAL WHEEL REGULATION (MIR)
- REDUCES VEHICLE YAW MOMENT ON SPLIT COEFFICIENT SURFACES
- SIGNIFICANTLY BETTER STOPPING DISTANCES ON SLIT CO SURFACES THAN SELECT LOW SYSTEMS USED IN 1970'S
ANTILOCK BRAKING SYSTEMS

COMPARISON OF CONTROL PHILOSOPHIES

TEST CONDITIONS:
- 16 TON, SHORT WHEELBASE BUS
- 80 KM/HR STOPS ON SPLIT CO SURFACE

MEASUREMENTS:
- STEERING WHEEL ROTATIONAL DEVIATION INDICATES RELATIVE DEGREE OF BRAKE PULL
- UPPER TRACES CHAMBER PRESSURES ON EACH SIDE – INDICATES RELATIVE RETARDATION

RESULTS:
- IR PROVIDES BEST BRAKING HOWEVER WORST BRAKE PULL (APPROX 120 DEGREES)
- SLR PROVIDES LEAST BRAKE PULL HOWEVER LEAST BRAKING
- MODIFIED INDIVIDUAL REGULATION (MIR) PROVIDES BEST COMPROMISE

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MERITOR WABCO CONTROL PHILOSOPHY

POINT 1:

- WHEEL DECELERATION EXCEEDS PHYSICAL LIMIT OF VEH DECELERATION
- REFERENCE SPEED AND WHEEL SPEED DIVERGE
- REFERENCE SPEED BASED ON SPEEDS OF WHEELS OF A DIAGONAL

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32
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MW CONTROL PHILOSOPHY

POINT 2

- WHEEL DECELERATION EXCEEDS $-b$ THRESHOLD

- WHEEL MOVES INTO UNSTABLE REGION OF SLIP CURVE
  - WHEEL HAS REACHED ITS MAX BRAKING FORCE
  - FURTHER INCREASE IN TORQUE DRIVES WHEEL INTO DEEPER SLIP

- SLIP IS CALCULATED FROM ACTUAL WHEEL SPEED AND CORRESPONDING REF SPEED

- ECU SIGNALS MODULATOR TO CLOSE INLET & OPEN OUTLET

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POINT 3:

- DECELERATION SIGNAL CROSSES \(-b\) THRESHOLD

- PRESSURE IS HELD FOR SET TIME (T1)

- NORMALLY WHEEL ACCELERATION WILL EXCEED \(+b\) WITHIN T1

- IF \(+b\) THRESHOLD SIGNAL IS NOT GENERATED IN T1, THEN BRAKE PRESSURE IS FURTHER DECREASED BY SLIP SIGNAL LAMBDA 1. DURING THIS CONTROL PHASE THE HIGHER SLIP THRESHOLD LAMBDA 2 IS NOT REACHED.
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MW CONTROL PHILOSOPHY

**POINT 5:**

- WHEEL DECELERATION FALLS TO +b THRESHOLD
- WHEEL IN STABLE ZONE OF MU-SLIP CURVE
- BRAKE PRESSURE RAPIDLY APPLIED FOR TIME T2 TO OVERCOME BRAKE HYSTERESIS
- T2 IS FIXED FOR FIRST CYCLE - RECALCULATED THEREAFTER

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CONTROL PHILOSOPHY (continued)

POINT 6, 7, 8:

PRESSURE IS INCREASED BY "PULSES" OF ALTERNATING PERIODS OF PRESSURE HOLD AND INCREASE
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CONTROL PHILOSOPHY (continued)

ABS CONTROL LOGIC IS NOT FIXED.
- ADAPTABLE TO DYNAMIC BEHAVIOR OF WHEEL ON DIFFERENT ROAD TO TIRE FRICTION COEFFICIENTS
- NUMBER OF CONTROL CYCLES DEPENDENT UPON MANY FACTORS

CYCLE RATE LIMITED BY WHEEL ROLL-UP AND/OR BRAKE CHAMBER AIR EXHAUST RATE
- TYPICALLY 3-5 CYCLES/SECOND
  Function of How Fast Can You Get Air in, out, & back in Chamber
- SURFACES LIKE WET ICE ARE LESS
ANTILOCK BRAKE SYSTEMS

ALGORITHM IS MORE COMPLICATED THAN BASIC PHILOSOPHY:

- BRAKE CHARACTERISTICS
  - I.E. BRAKE INDUCED VIBRATIONS FROM OVERLY AGGRESSIVE LININGS AND HIGH BRAKE POWER

- RANGE OF BRAKING PRESSURES (LESS THAN 1% OF BRAKE APPLICATIONS ARE FULL PRESSURE)

- IMPACT LOADS, WHEEL LOADING, BRAKE SYSTEM RESPONSE, SUSPENSIONS, VEHICLE CONFIGURATIONS, ETC.
  - I.E. FRONT AXLE MIR AGGRESSIVENESS DETERMINED BY SHORT WHEELBASE VEHICLE RESPONSE

ALGORITHM MUST ACCOMMODATE:

- DIFFERENT SIZE TIRES ON THE VEHICLE'S AXLES
- ENGINE BRAKES OR RETARDERS
- SPECIAL OFF-ROAD OPERATIONAL FACTORS
ANTILOCK BRAKING SYSTEMS

FRONT TO REAR TIRE SIZE ACCOMMODATION

ECU CAN AUTOMATICALLY ACCOMMODATE APPROX +/- 5% (Rolling Radius)

ECU CAN HAVE PARAMETER SETTING TO ACCOMMODATE APPROX +/- 14%

ECU MANUFACTURER CAN ADJUST PARAMETERS TO ACCOMMODATE +/- 20%

AUTOMATIC ADJUSTMENT BY ECU
PARAMETER SETTING BY OEM
PARAMETER SETTING BY Rockwell WABCO

AUTOMATIC ADJUSTMENT BY ECU
BASIC CHECK OF RATIO 12 SECONDS
SAFETY CHECK OF RATIO 16 SECONDS

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