

LIPPERT ANTI-LOCK BRAKING SYSTEM

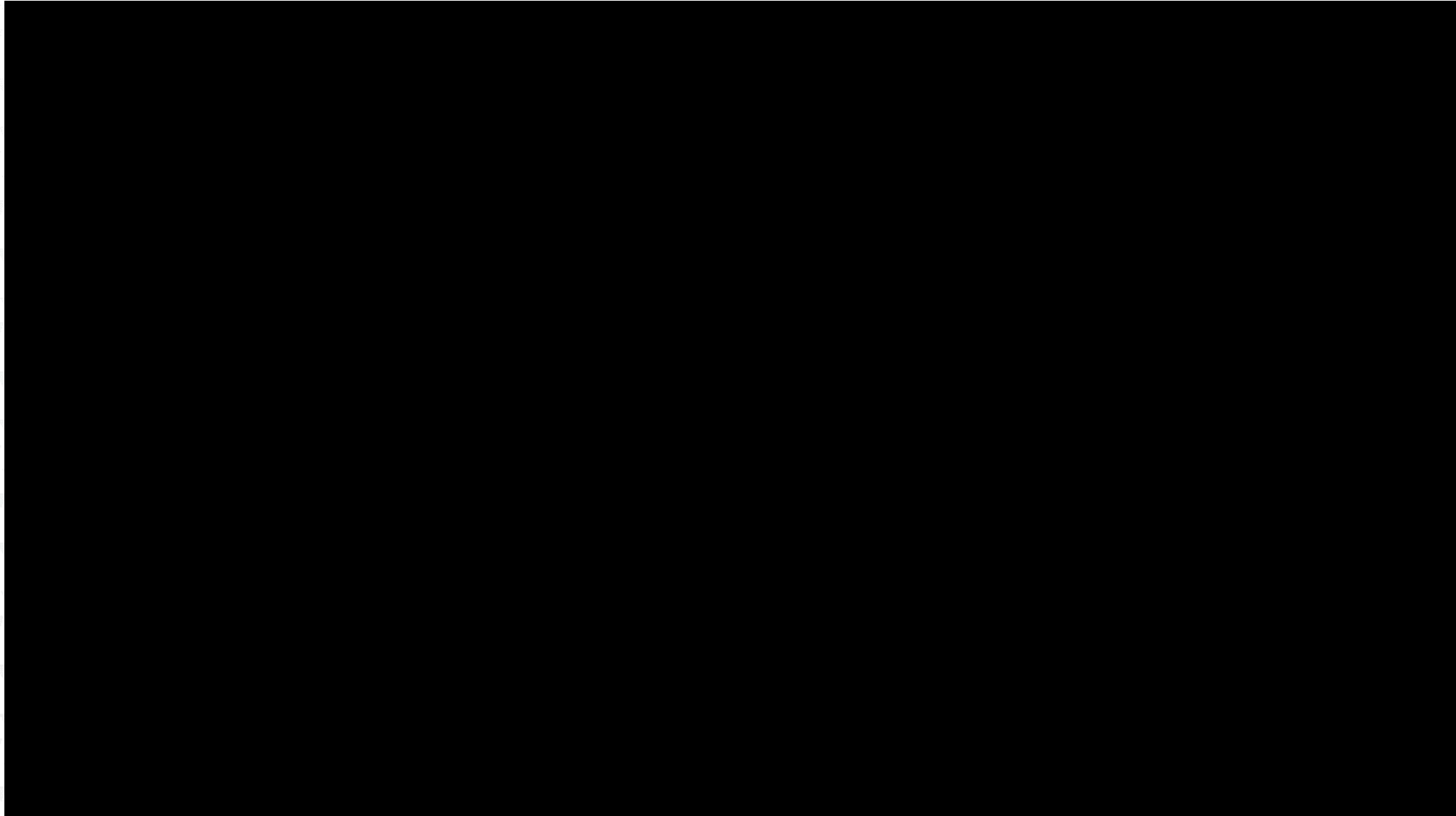
ENHANCING TOWING CONTROL AND TRAILER SAFETY

Adam Buchanan
Chief Engineer
Anti-Lock Braking Systems



*Whenever, wherever,
we make your experience better.*

LIPPERT ABS IN ACTION



LIPPERT ABS PORTFOLIO



- Within the Lippert ABS product line, we offer 3 variants of ABS with increasing feature content

ABS



Stability during braking

ABS + Sway



Trailer sway mitigation

ABS + Sway + DBB

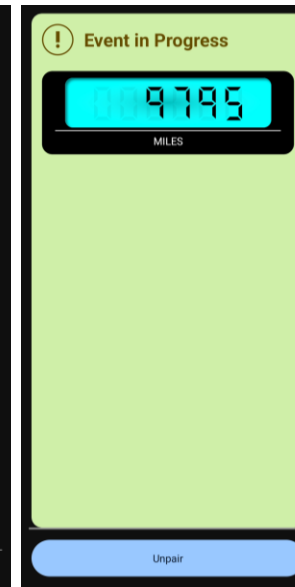
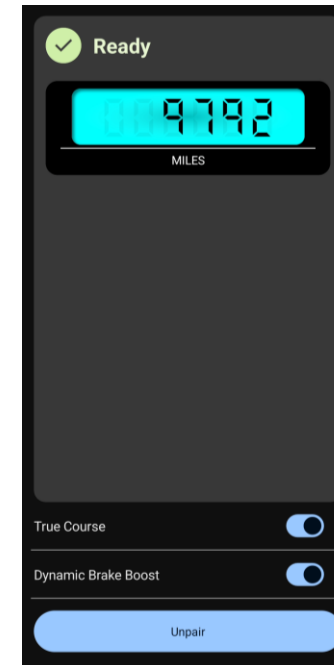


Decreases stopping distance during emergency situations

LIPPERT ABS FEATURES



- System activates when trailer brakes lock is pending, reducing brake torque, improving trailer stability and vehicle control in emergency and low traction situations.
 - During typical driving, the brakes are controlled by the tow vehicle trailer brake controller.
 - ABS module passes through the brake signal, unmodified, until ABS needs to activate
- Integrated brake load eliminates the concern for tow vehicle and integrated brake controller compatibility.
- Capable of monitoring up to six (6) wheel ends.
 - One module for single, tandem, and triple axle configurations
- Digital odometry broadcast over Bluetooth to the OneControl mobile app.
- System diagnostics (DTCs) and self-checks reported through mobile app.
 - If any failure is detected, the ABS system reverts to pass-thru braking, and ABS is deactivated on the axle which has an active fault
 - Axles which do not have an active fault will have active ABS control
 - Lippert Diagnostic App is available to get specific fault history information from the module.



ANTI-LOCK BRAKING SYSTEMS



- Anti-Lock Braking Systems (ABS) are designed to prevent wheel lock and enhance control of the vehicle in emergency situations, such as:
 - Harsh braking
 - Loss of traction
 - Evasive maneuvers



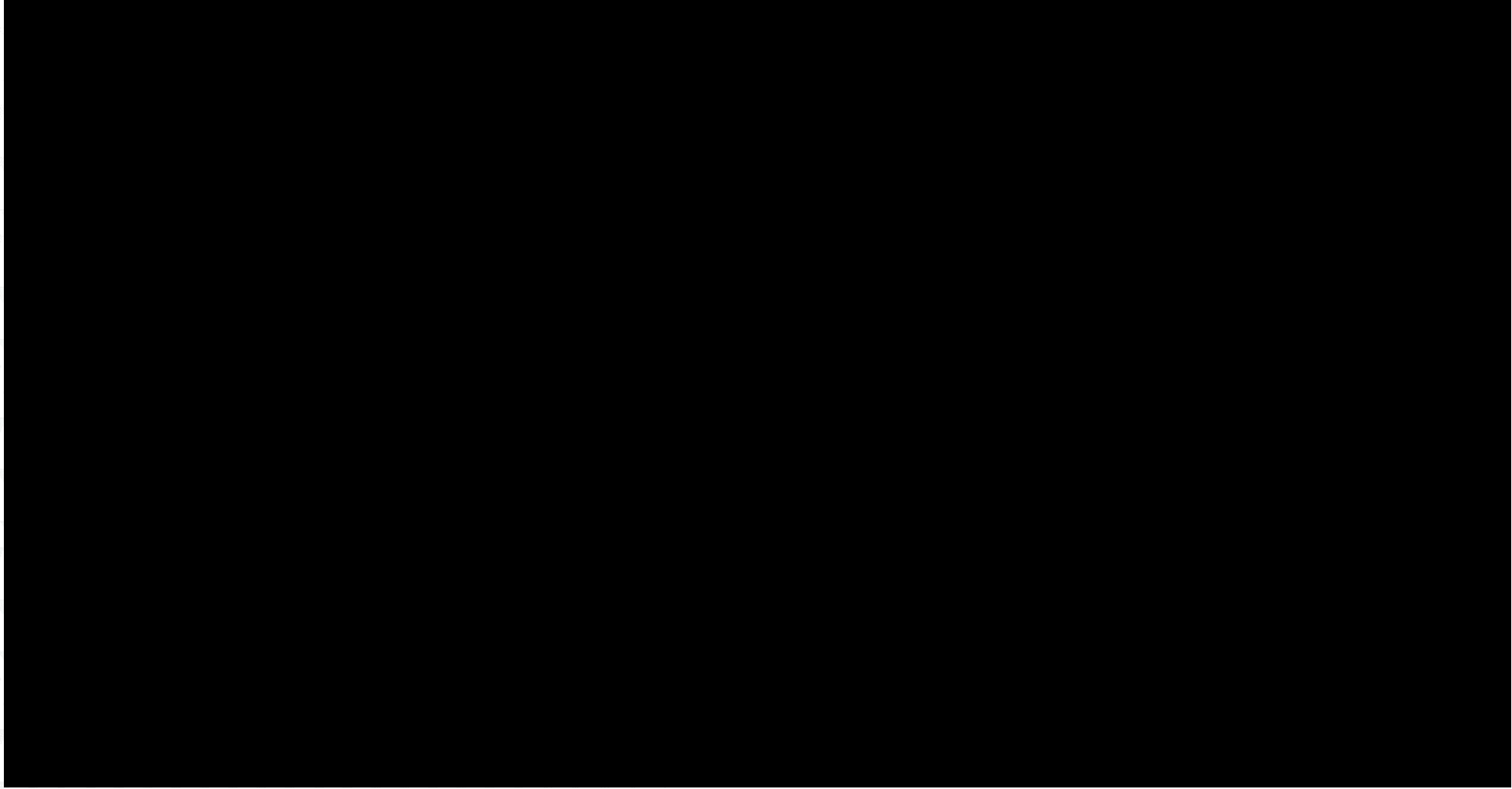
TRUECOURSE SWAY MITIGATION



- Trailer sway can occur in different ways
 - Cross wind
 - Passing semis
 - Poor road conditions
 - Evasive steering maneuvers
 - Improper trailer load distribution
- TrueCourse monitors the lateral motion of the trailer to detect sway
- Once sway is detected and confirmed, the ABS module applies the precise amount of brake torque needed to eliminate the sway, keeping the trailer and tow vehicle under control
- If the driver applies the brake while TrueCourse is active, the TrueCourse brake command is added to the driver's brake command, allowing for a seamless user experience
- TrueCourse works in conjunction with weight distribution hitches, and mechanical sway control devices, or as a standalone sway mitigation system for fifth wheel, gooseneck, pintle or ball-mount hitching applications.



TRUECOURSE SWAY MITIGATION



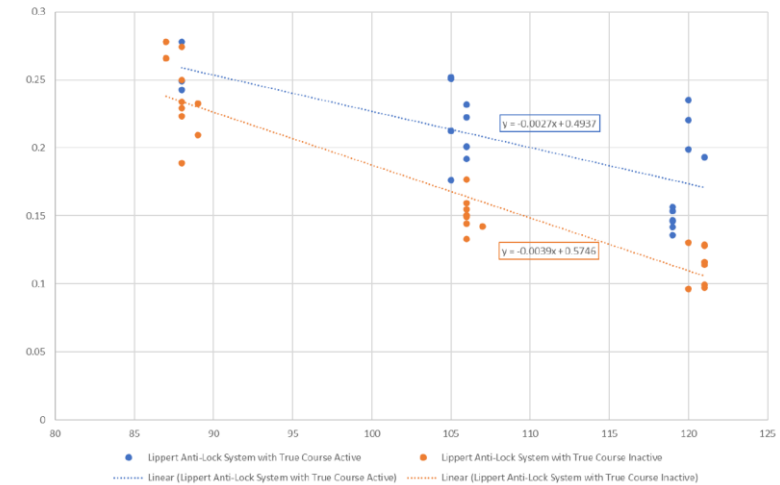
TRUECOURSE SAE J2664 TEST RESULTS



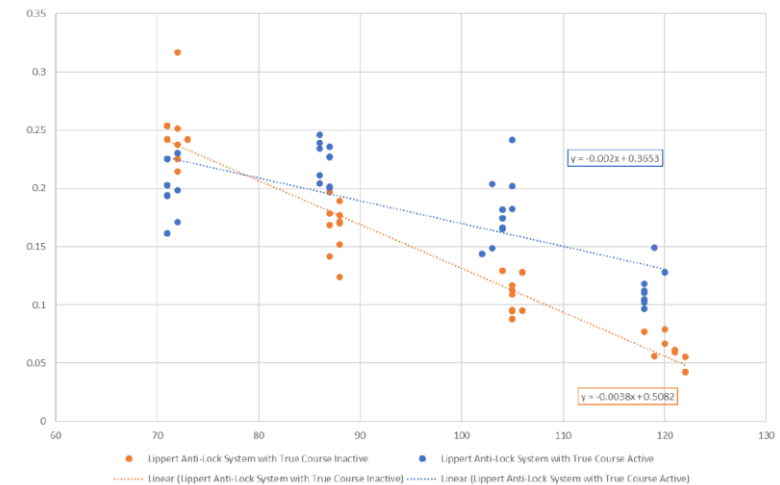
- Testing independently performed by TRC
- Tow Vehicle
 - 2023 Ram 3500 SRW
 - 8510lb Test Weight
- Trailer
 - 2011 Prime Time Tracer 3140BHD
 - 7570lb Curb Weight, 770lb Tongue Weight @10% TW
 - 8080lb Test Weight, 570lb Tongue Weight @7% TW



Configuration – 1: 10% Tongue Weight
(\$7.5 Average Peak-to-Peak Method)



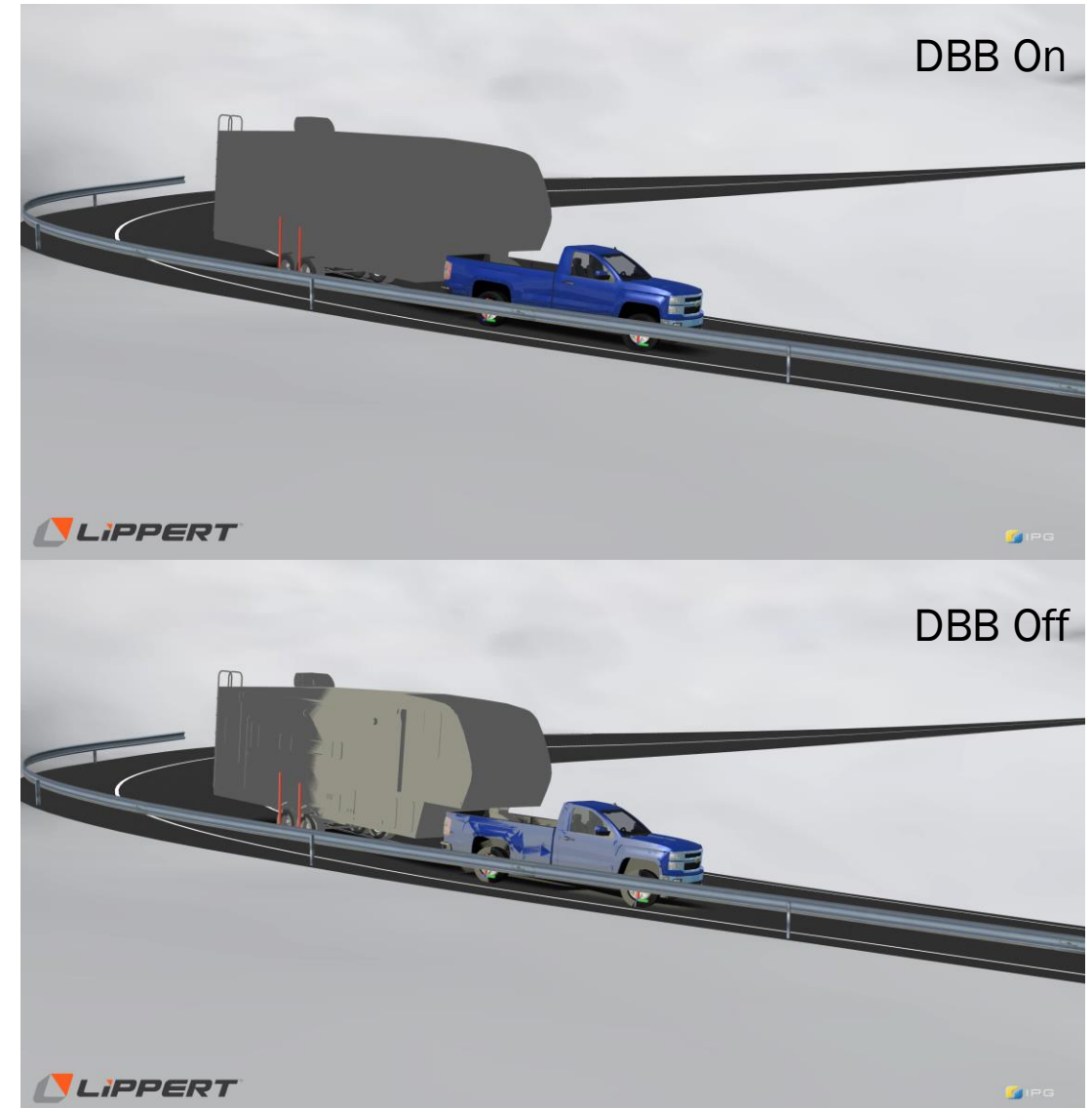
Configuration – 2: 7% Tongue Weight
(\$7.5 Average Peak-to-Peak Method)



DYNAMIC BRAKE BOOST



- Trailer brake controllers (TBC) typically reach the maximum output between 0.2-0.3g of deceleration
 - TBC's are designed with the assumption the trailer is not equipped with ABS
 - Limiting output in the 0.2-0.3g range helps ensure trailer stability during harsh stopping events
- Dynamic Brake Boost (DBB) is an advanced braking feature enabled by Lippert's Anti-lock Brake technology
- DBB increases the trailer braking output when emergency braking is detected
- Over-boosting of trailer brakes during emergency braking conditions increases the brake output from the trailer, resulting in shorter stopping distances
- Increase in brake output is proportional to the driver's brake command to the tow vehicle braking system, resulting in a smooth and seamless experience



DYNAMIC BRAKE BOOST PERFORMANCE



2021 Chevrolet 3500 w/ 2011 Prime Time Tracer 3150BHD

Speed (kph)	System Status	Stopping Distance (m)	% Reduction	Distance Reduction (m)
50	DBB Off	19.2475	9.8%	1.88
	DBB On	17.3675		
75	DBB Off	34.5	7.3%	2.5175
	DBB On	31.9825		
100	DBB Off	70.2575	10.2%	7.2
	DBB On	63.0575		

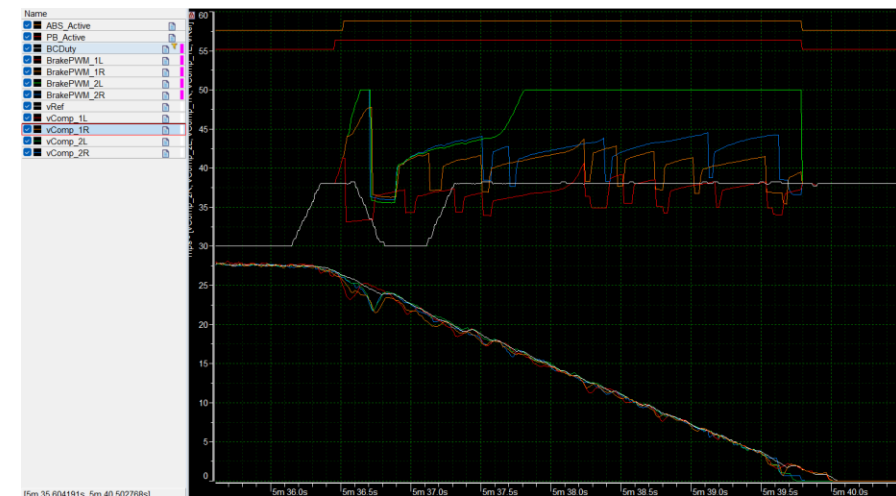
2021 Chevrolet 3500 w/ Diamond C Fmax 216 Unloaded

Speed (kph)	System Status	Stopping Distance (m)	% Reduction	Distance Reduction (m)
50	DBB Off	16.9725	16.2%	2.7525
	DBB On	14.22		
75	DBB Off	38.49	15.3%	5.9025
	DBB On	32.5875		
100	DBB Off	68.215	16.9%	11.5
	DBB On	56.715		

2021 Chevrolet 3500 w/ Diamond C Fmax 216 w/ 8k Load

Speed (kph)	System Status	Stopping Distance (m)	% Reduction	Distance Reduction (m)
50	DBB Off	19.58	19.7%	3.8625
	DBB On	15.7175		
75	DBB Off	41.0325	12.5%	5.145
	DBB On	35.8875		
100	DBB Off	77.7875	14.0%	10.865
	DBB On	66.9225		

- Each speed and configuration ran 4 times to establish the average for a defined speed and system status
- Utilized Racelogic VBoxII to capture corrected stopping distance
 - Equipment is accurate to 0.1m
- Baseline brake gain used in DBB off stops was a brake gain where minimal ABS activity occurs on the front axle during panic stops
 - The same brake gain was used for DBB on stops, demonstrating the improved braking performance achieved by using DBB technology

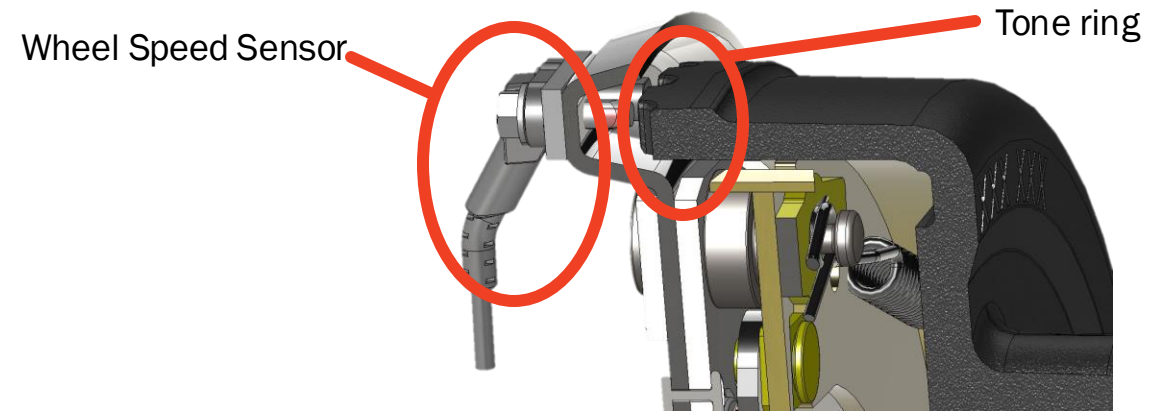


AXLES AND BRAKES

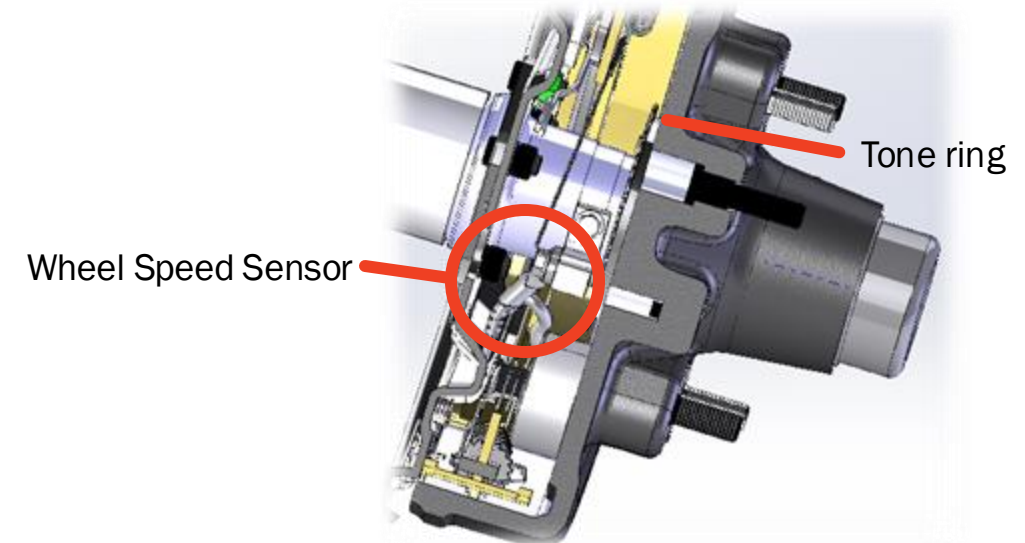


- 10" and 12" drum brake have been designed for Anti-Lock Brake applications.
- 3.5K, 4.4K, 5.2K, 6K, 7K, 8K, 10K, 12K, 16K
- All forward self-adjusting brakes
- Gen 1 changes to standard axles include:
 - 48-tooth tone ring located on the brake hub
 - Sensor installed on brake backing plate
- 12" Brake Gen 2 changes to standard axle include:
 - 48-tooth tone ring press fit on OD of hub inner bearing race
 - Sensor mounted directly on spindle, inside the wheel end
 - 4.4k, 5.2k, 6k, 7k
- 8K, 10K, 12K, and 16K brakes have ABS sensor and tone ring mounted internally
 - 48-tooth tone ring press fit on OD of hub inner bearing race on 8K and 10K
 - 48-tooth tone ring mounted between hub face and brake drum on 12K and 16K
 - Wheel speed sensor mounted to the spindle on all HD axles

Gen 1 ABS Brake Packaging, 10" and 12" <7K



Gen 2 ABS Brake Packaging, 12" Only and > 8K



SYSTEM ROBUSTNESS



- Annual Winter and Summer Road testing
- 150,000+ miles accumulated on public road and private test facilities
- Third-party Lab Testing
 - IP / Water Ingress
 - HALT
 - EMC, electrical durability
- Functionally and compatibility tested on 28+ vehicles with integrated brake controllers, 30+ aftermarket brake controllers
 - 60,000+ modules currently in the field with 0 compatibility issues reported
- Tested and compatible with equalized leaf spring, slipper spring, slipper roller, independent, torsion, and touring coil suspension systems



WHY CHOOSE A TRAILER WITH LIPPERT ABS



- Digital odometer can be leveraged to push maintenance reminders to the owner
- Provides the safest towing experience on the road today
- System works seamlessly in the background, allowing the owner to focus on the road ahead, and leave their worries behind
- System costs less than replacing a set of flat spotted tires



CUSTOMER TESTIMONIAL



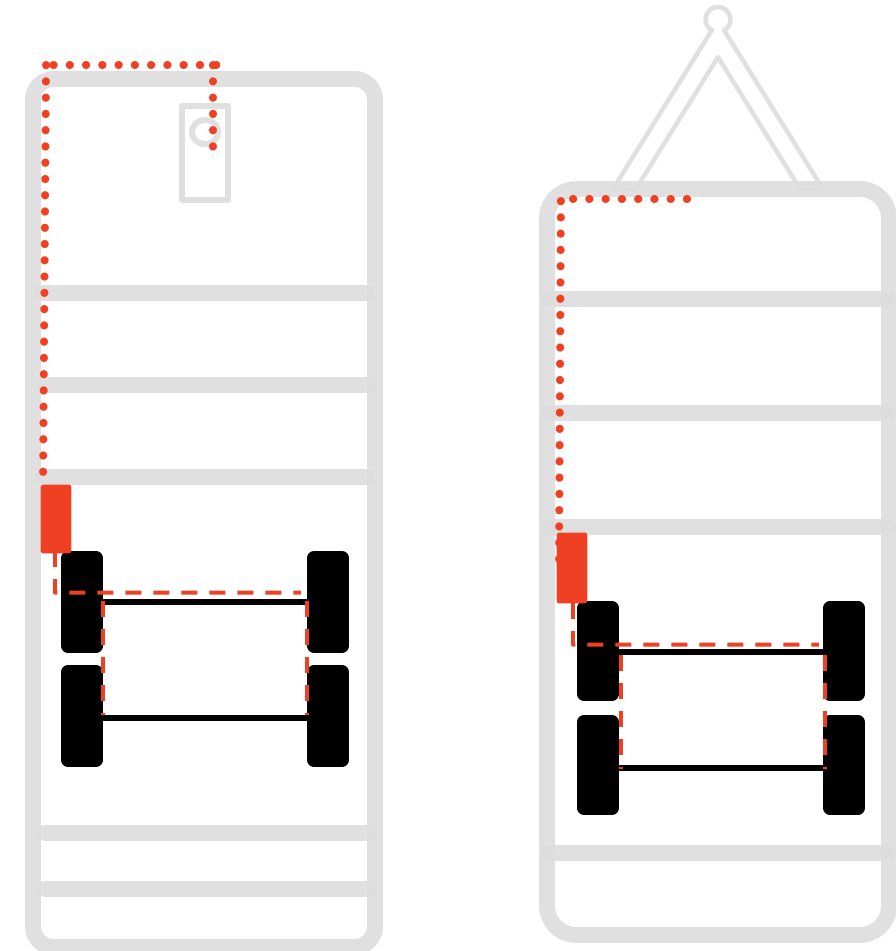
- No matter how much experience you have towing, or how defensively you drive, accidents can happen to anyone at anytime.
- Having ABS on your trailer could be the difference between a close call, or the end of a life.
- This is truly a life saving technology.

QUESTIONS OR COMMENTS

LIPPERT ABS INSTALLATION



- In addition to the ECU, we have 2 harnesses which complete the system
 - Default ABS module installation position is near the front axle, on the driver side, inside the chassis main I-beam
 - In some cases, the ABS module may be installed behind the rear axle, or on the camp side of the trailer
- Power Harness
 - Runs from the module to the barge ment junction box at the front of the unit
 - Power connection made at a 30amp mini breaker, before the battery disconnect
 - 25ft length for most travel trailers and fifth wheels
 - 50ft power harness for large fifth wheels and toy haulers
- Axle Harness
 - Single Axle
 - Tandem Axle
 - Triple Axle
- For diagnostics, axle 1 is the most forward or rearward axle, installed closest to the ABS module



- Power Harness
- - - - Axle Harness
- ABS Module

LIPPERT ABS SYSTEM COMPONENTS



- ABS ECU
- Main Power Harness
 - Terminates at the trailer junction box
 - Connects to the ABS ECU
- Axle Harness
 - Connects each wheel end to the ABS module
 - Metripack 150 2 pin connector for the wheel speed sensor
 - Weatherpack 150 2 pin connector for the brake
 - For the axle harness, Axle 3 pins are plugged on single and tandem axle harnesses. Axle 2 pins are plugged on single axle harnesses

Main Harness Pinout		
Pin	Function	Color/Stripe
1	Battery +	Black
2	Battery +	Black
3	Right turn and stop light In	Brown
4	Right turn and stop light out	Brown/White
5	Left turn and stop light In	Red
6	Battery +	Black
7		Plug
8	Backup light	Yellow
9	Left turn and stop light out	Red/White
10	(Tow) Brake	Blue
11	(Tow) Brake	Blue
12	(Tow) Brake	Blue
13		Plug
14	Battery -	White



Triple Axle Harness Pinout		
Pin	Function	Color/Stripe
GND WIRE	Ground	White (Spliced)
1		Plug
2		Plug
3	Axle 1 far side brake	Blue/Green
4	Axle 1 module side brake	Blue/Orange
5	Axle 2 far side brake	Blue/Violet
6	Axle 2 module side brake	Blue/Yellow
7	Axle 3 far side brake	Blue/White
8	Axle 3 module side brake	Blue/Black
9		Plug
10	Axle 1 far side WSS return	Red/Green
11	Axle 1 module side WSS return	Red/Orange
12	Axle 2 far side WSS return	Red/Violet
13	Axle 2 module side WSS return	Red/Yellow
14	Axle 3 far side WSS return	Red/White
15	Axle 3 module side WSS return	Red/Black
16	CAN low	Pink
17	CAN high	Brown
18	Axle 1 left speed sensor	Green
19	Axle 1 right speed sensor	Orange
20	Axle 2 left speed sensor	Violet
21	Axle 2 right speed sensor	Yellow
22	Axle 3 left speed sensor	White
23	Axle 3 right speed sensor	Black

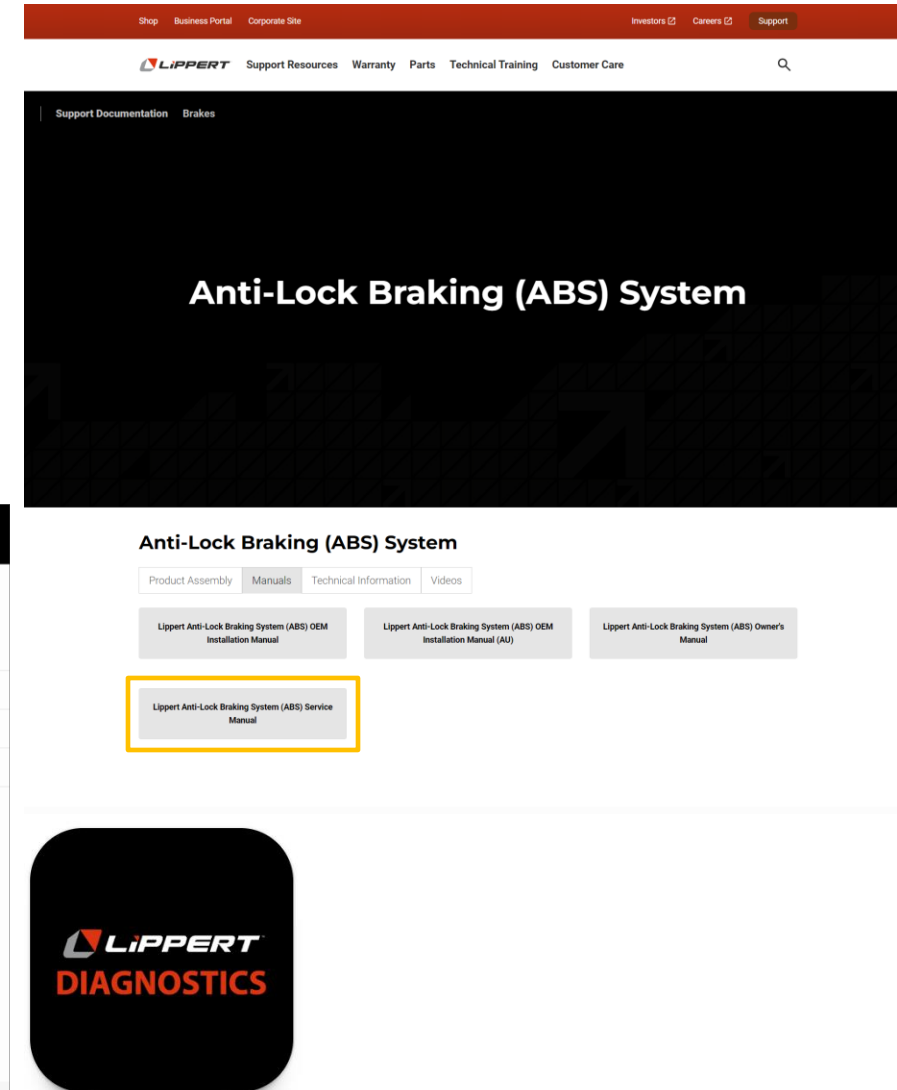
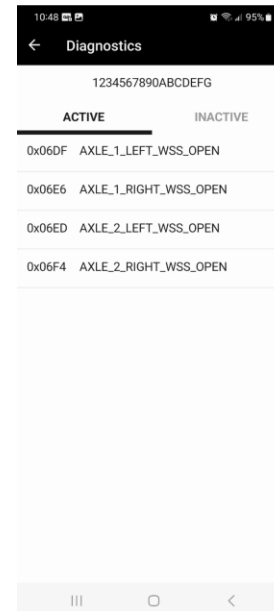


View Looking Into Harness Connector

LIPPERT ABS SERVICE MANUAL



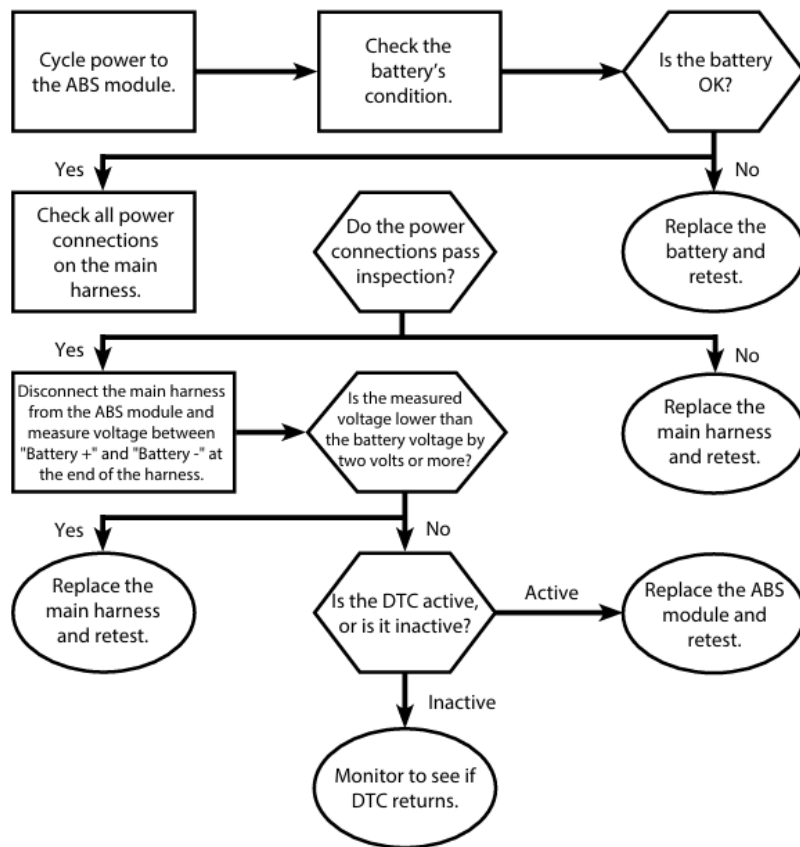
- The latest ABS Diagnostic and Service manual can be found on the LCI support website.
 - <https://support.lci1.com/anti-lock-braking-abs-system>
- All diagnostic faults are the same, regardless of system type
 - ABS
 - ABS + TrueCourse
 - ABS + TrueCourse + Dynamic Brake Boost
- Faults fall into 4 categories
 - Voltage induced faults
 - Module level faults
 - Brake Actuator level faults
 - Wheel Speed Sensor faults
- To pull DTC's, download the Lippert Diagnostics app from the Google Play Store or the Apple App Store



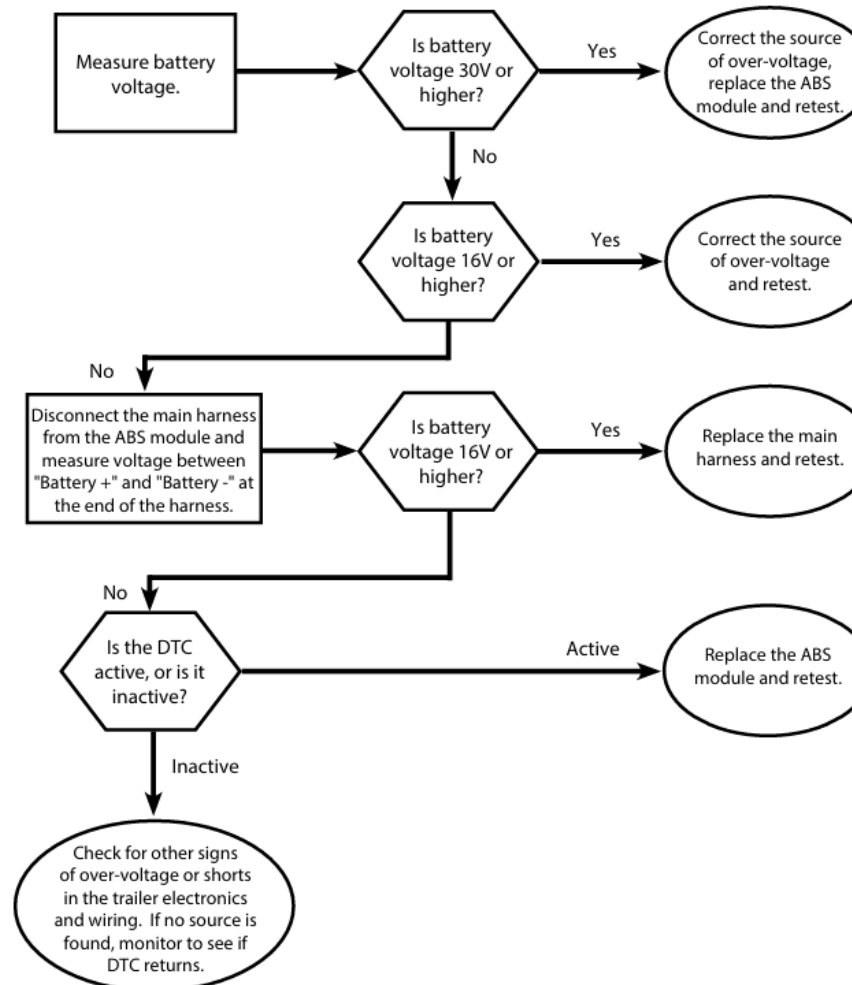
VOLTAGE INDUCED DTC'S



DTC #	DTC Name	Description
068Ah	BATTERY_TOO_LOW_TO_OPERATE	Input battery voltage to the module is too low for proper operation.



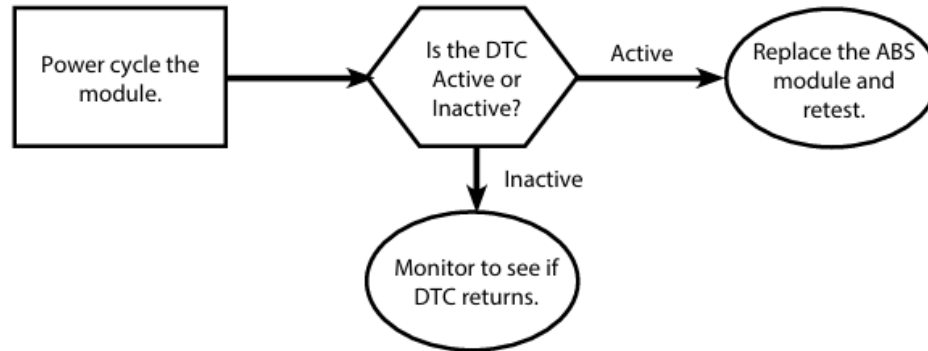
DTC #	DTC Name	Description
0006h	BATTERY_VOLTAGE_HIGH	Input battery voltage to the module is too high for proper operation.



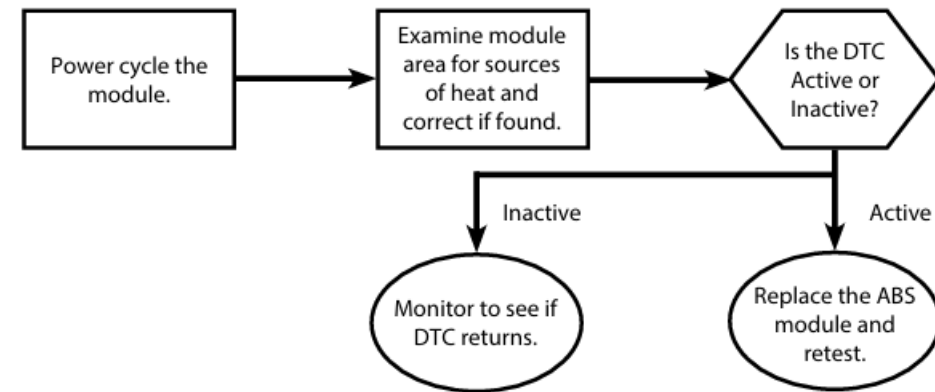
MODULE LEVEL FAULTS



DTC #	DTC Name	Description
071Fh	BRAKE_CONTROLLER_MODULE_FAILURE	Module has had an internal component failure.



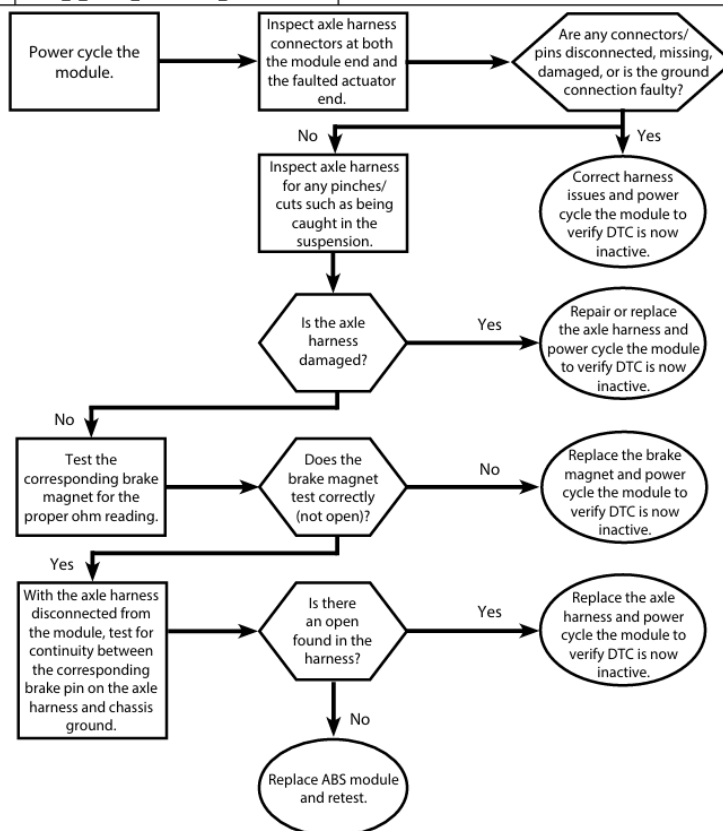
DTC #	DTC Name	Description
0726h	BRAKE_CONTROLLER_MODULE_OVER_TEMPERATURE	Module temperature is too high for proper operation.



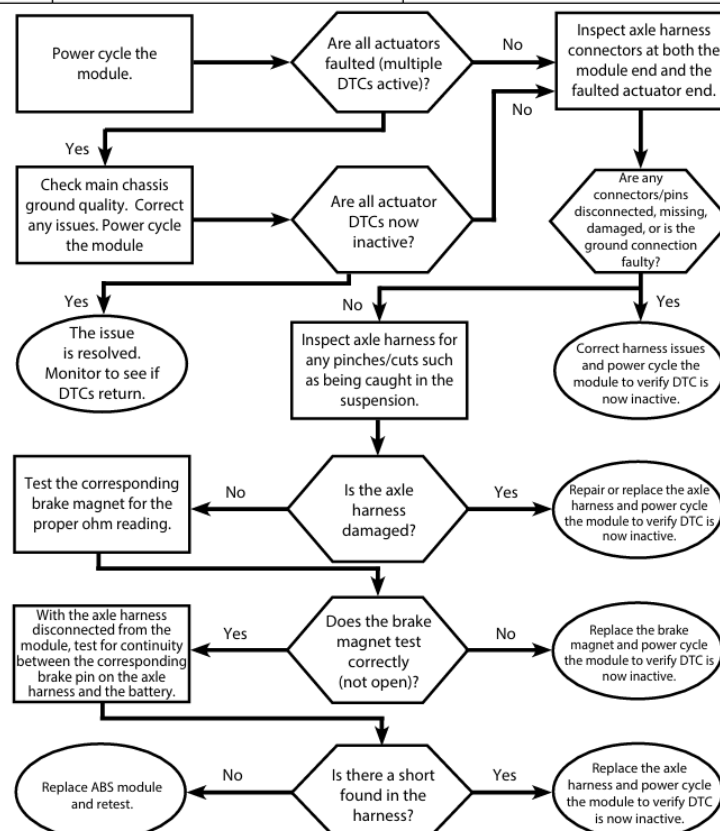
BRAKE ACTUATOR FAULTS



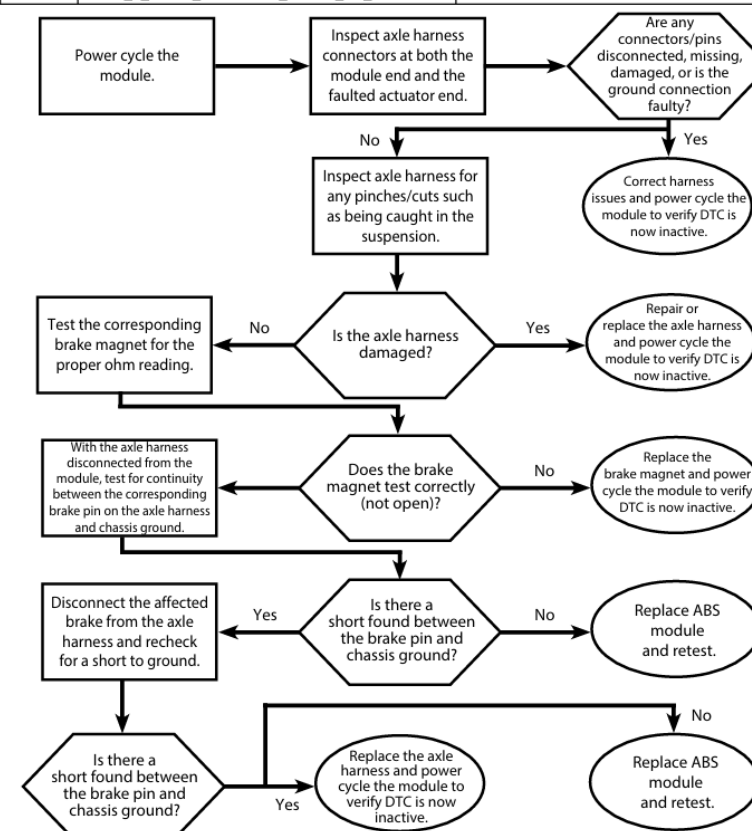
DTC #	DTC Name	Description
06DBh	AXLE_1_LEFT_ACTUATOR_OPEN	The corresponding brake magnet actuator circuit is open.
06E2h	AXLE_1_RIGHT_ACTUATOR_OPEN	
06E9h	AXLE_2_LEFT_ACTUATOR_OPEN	
06F0h	AXLE_2_RIGHT_ACTUATOR_OPEN	
06F7h	AXLE_3_LEFT_ACTUATOR_OPEN	
06FEh	AXLE_3_RIGHT_ACTUATOR_OPEN	



DTC #	DTC Name	Description
06DCh	AXLE_1_LEFT_ACTUATOR_SHORT_TO_BATT	The corresponding brake magnet actuator circuit is shorted to the battery.
06E3h	AXLE_1_RIGHT_ACTUATOR_SHORT_TO_BATT	
06EAh	AXLE_2_LEFT_ACTUATOR_SHORT_TO_BATT	
06F1h	AXLE_2_RIGHT_ACTUATOR_SHORT_TO_BATT	
06F8h	AXLE_3_LEFT_ACTUATOR_SHORT_TO_BATT	
06FFh	AXLE_3_RIGHT_ACTUATOR_SHORT_TO_BATT	



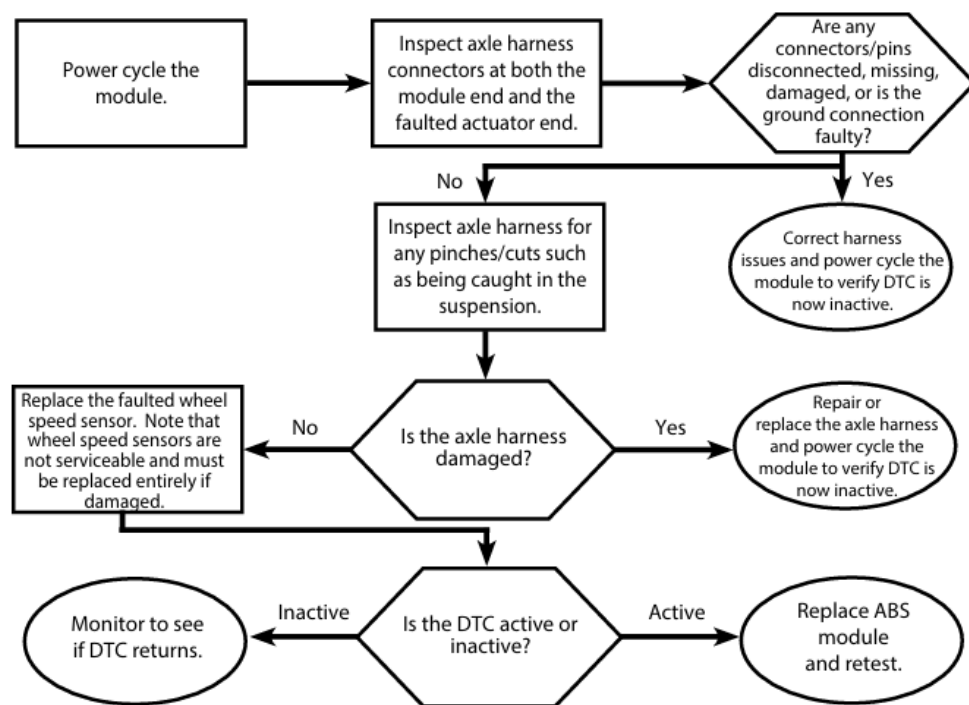
DTC #	DTC Name	Description
06DDh	AXLE_1_LEFT_ACTUATOR_SHORT_TO_GROUND	The corresponding brake magnet actuator circuit is shorted to ground.
06E4h	AXLE_1_RIGHT_ACTUATOR_SHORT_TO_GROUND	
06EBh	AXLE_2_LEFT_ACTUATOR_SHORT_TO_GROUND	
06F2h	AXLE_2_RIGHT_ACTUATOR_SHORT_TO_GROUND	
06F9h	AXLE_3_LEFT_ACTUATOR_SHORT_TO_GROUND	
0700h	AXLE_3_RIGHT_ACTUATOR_SHORT_TO_GROUND	



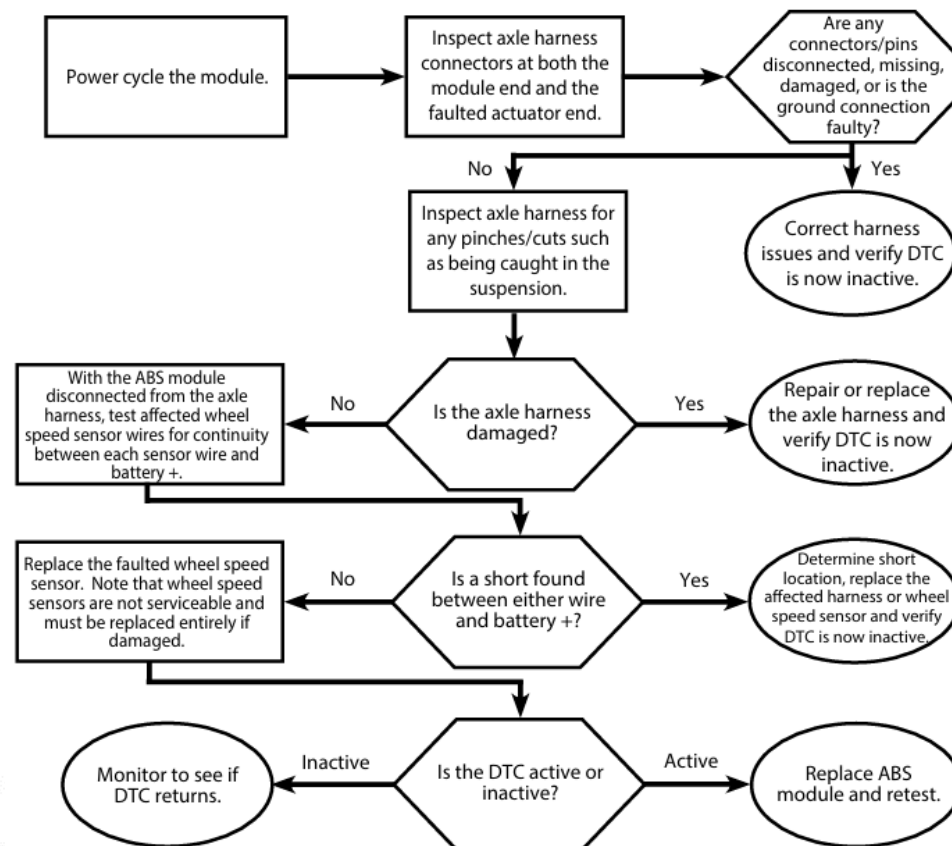
WHEEL SPEED SENSOR FAULTS PAGE 1



DTC #	DTC Name	Description
06DFh	AXLE_1_LEFT_WSS_OPEN	The corresponding wheel speed sensor circuit is open.
06E6h	AXLE_1_RIGHT_WSS_OPEN	
06EDh	AXLE_2_LEFT_WSS_OPEN	
06F4h	AXLE_2_RIGHT_WSS_OPEN	
06Fbh	AXLE_3_LEFT_WSS_OPEN	
0702h	AXLE_3_RIGHT_WSS_OPEN	



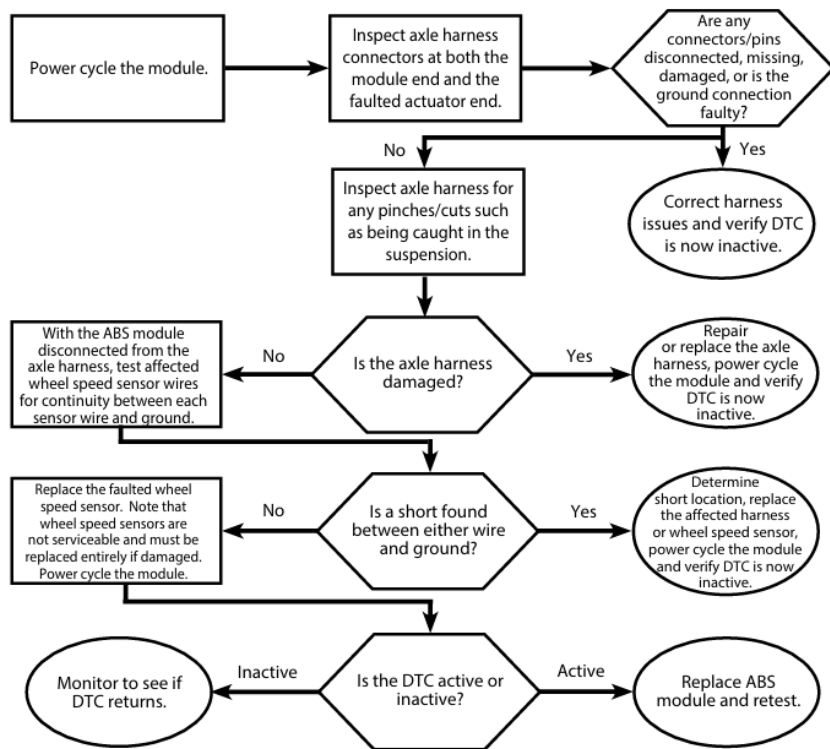
DTC #	DTC Name	Description
06E0h	AXLE_1_LEFT_WSS_SHORT_TO_BATT	The corresponding wheel speed sensor circuit is shorted to battery.
06E7h	AXLE_1_RIGHT_WSS_SHORT_TO_BATT	
06EEh	AXLE_2_LEFT_WSS_SHORT_TO_BATT	
06F5h	AXLE_2_RIGHT_WSS_SHORT_TO_BATT	
06FCh	AXLE_3_LEFT_WSS_SHORT_TO_BATT	
0703h	AXLE_3_RIGHT_WSS_SHORT_TO_BATT	



WHEEL SPEED SENSOR FAULTS PAGE 2



DTC #	DTC Name	Description
06E1h	AXLE_1_LEFT_WSS_SHORT_TO_GROUND	The corresponding wheel speed sensor circuit is shorted to ground.
06E8h	AXLE_1_RIGHT_WSS_SHORT_TO_GROUND	
06Efh	AXLE_2_LEFT_WSS_SHORT_TO_GROUND	
06F6h	AXLE_2_RIGHT_WSS_SHORT_TO_GROUND	
06Fd	AXLE_3_LEFT_WSS_SHORT_TO_GROUND	
0704h	AXLE_3_RIGHT_WSS_SHORT_TO_GROUND	



DTC #	DTC Name	Description
0720h	WSS_A1L_MECHANICAL_FAILURE	The corresponding wheel speed sensor circuit has experienced a mechanical failure.
0721h	WSS_A1R_MECHANICAL_FAILURE	
0722h	WSS_A2L_MECHANICAL_FAILURE	
0723h	WSS_A2R_MECHANICAL_FAILURE	
0724h	WSS_A3L_MECHANICAL_FAILURE	
0725h	WSS_A3R_MECHANICAL_FAILURE	

