Symmetric versus Asymmetric Sway Control

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This document will explain why electronic asymmetric sway control actually reduces sway with a “minimum number of mathematical equations” and a “minimal amount of physics”. For those whom just want the punch line; asymmetric sway control can provide varying levels of side forces on a trailer where symmetric sway control cannot.

Symmetric sway controllers activate all brakes when a sway event is detected having the same action that occurs when you manually apply trailer brakes by slowing down. The asymmetric sway controller independently applies the left brakes and or right brakes at varying braking levels when a sway event occurs to counteract the side forces.

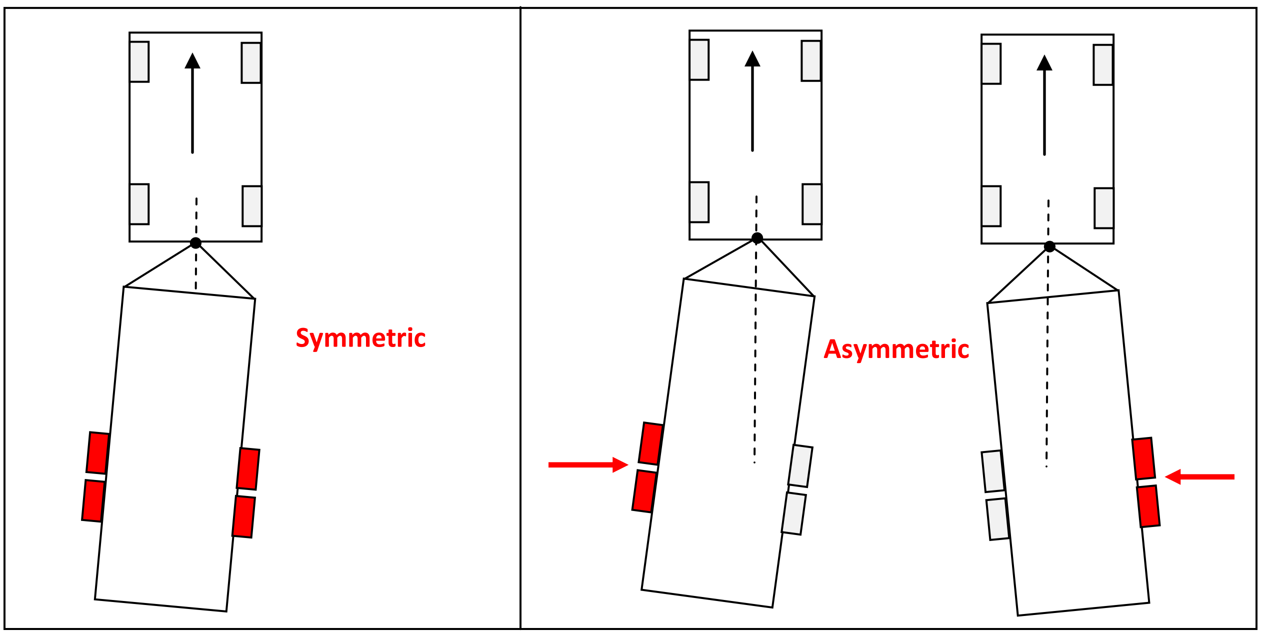

Figure 1: Trailer Braking

To understand the difference in operation of the two systems, one basic law of motion will be described in simple terms. Newton’s First Law of Motion states; “A body in motion will remain in motion unless acted upon by an external force.”

The best example is when you are mormally driving down the road (a body in motion) if you let off the gas your vehicle will continue moving forward (will remain in motion) until you push on the brakes where the brake friction slows the vehicle (unless acted upon by an external force). The trailer remains straight during normal braking because left and right tires are pulling back equally and thus no difference in side forces.

Trailer sway is generally caused by a high wind gust on the side of the trailer or an evasive maneuver avoiding an obstacle in the road. The initial side forces create “momentum” in the trailers side motion where the momentum must be counteracted by a force in the opposite direction to reduce the sway and maintain control of the trailer and tow vehicle. Similar to slowing the tow vehicle during braking, trailer brake friction can be used to slow to the sideways motion to the left and right by providing an opposite force.

How does asymmetric sway control generate side forces to stop sway in the right and left directions?

In Figure 2 assume vehicle is moving straight ahead, no wind and no evasive maneuver, and assume ONLY the right trailer brakes are applied. The slowing/skidding right trailer brake friction will pull back on the tow vehicle and attempt to line up the braking tires with the direction of travel of the tow vehicle, the tow vehicle centerline. The centerline is in line with the trailer pivot point which is the ball hitch. In effect, applying the right brakes and not the left brakes pulls the trailer from right of vehicle centerline to the left. A similar result occurs if you ONLY applied the left brakes where the slowing/skidding left tires will attempt to line up with the centerline of the direction of travel, pulling the left tires from the left of centerline to the right.

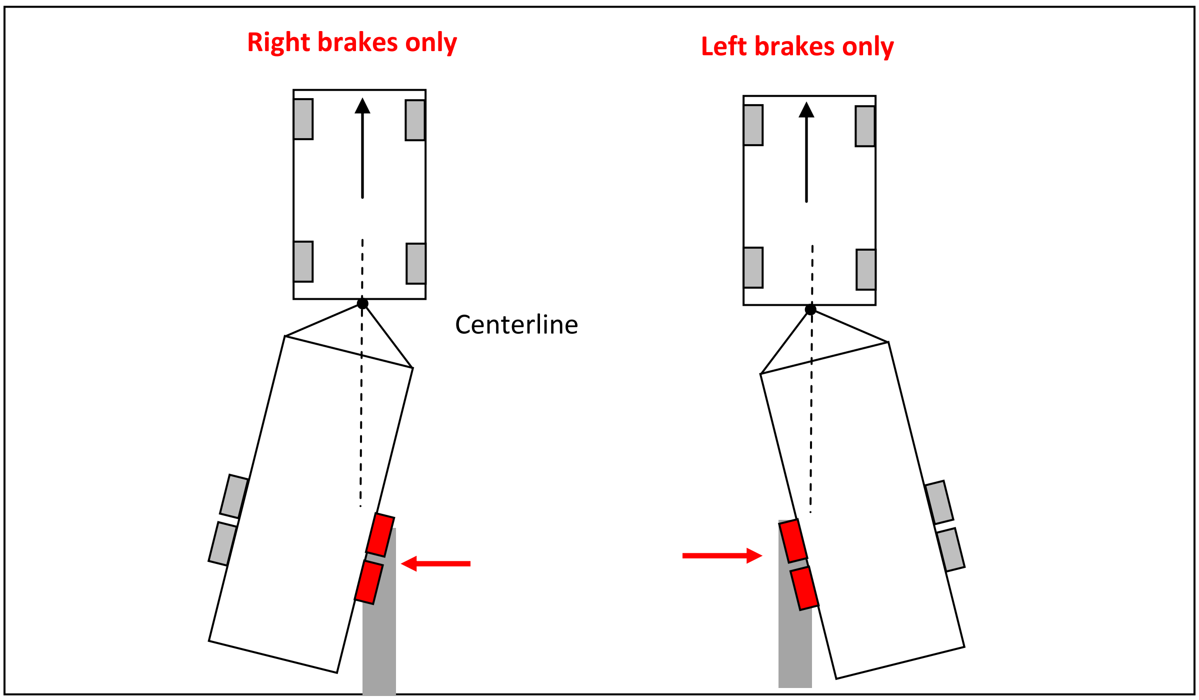

Figure 2: Asymmetric Left/Right Brake force

Asymmetric sway control thus has the ability to independently apply brakes, at varying brake pressures, to either the left brakes or right brakes or both the left and right brakes at the same time. Thus independently applying the left or right brakes will have the affect of applying side forces to the trailer, where the applied brakes will pull towards the vehicle centerline. Obviously, varying the braking levels of left and right brakes does not occur unless a sway event occurs.

So what happens during a wind gust?

When driving down the road and before sway occurs no brakes are applied. Figure 3 indicates a wind gust pushing the trailer to the left, where trailer will begin pivoting around the hitch ball. How quickly the trailer accelerates (changes velocity) to the left is determined by Newton's second law of motion which states; "Force = mass x acceleration."

Stated differently; Acceleration = Force / Mass. Thus for the same velocity wind gust and same size of trailer, a light weight (low mass) trailer will "accelerate" sideways faster than a heavy (large mass) trailer of the same size. Proportional to the velocity of a wind gust the trailer is pushed to the left gaining a momentum (mass x velocity). Thus the greater the mass of the trailer or the greater the angular velocity of the trailer the greater will be the momentum that must be offset to stop the trailer sway.

Without delving into the math, the sideways momentum of the trailer caused by the wind gust must be counteracted with a force in the opposite direction of the sway to reduce the trailer velocity from side to side.

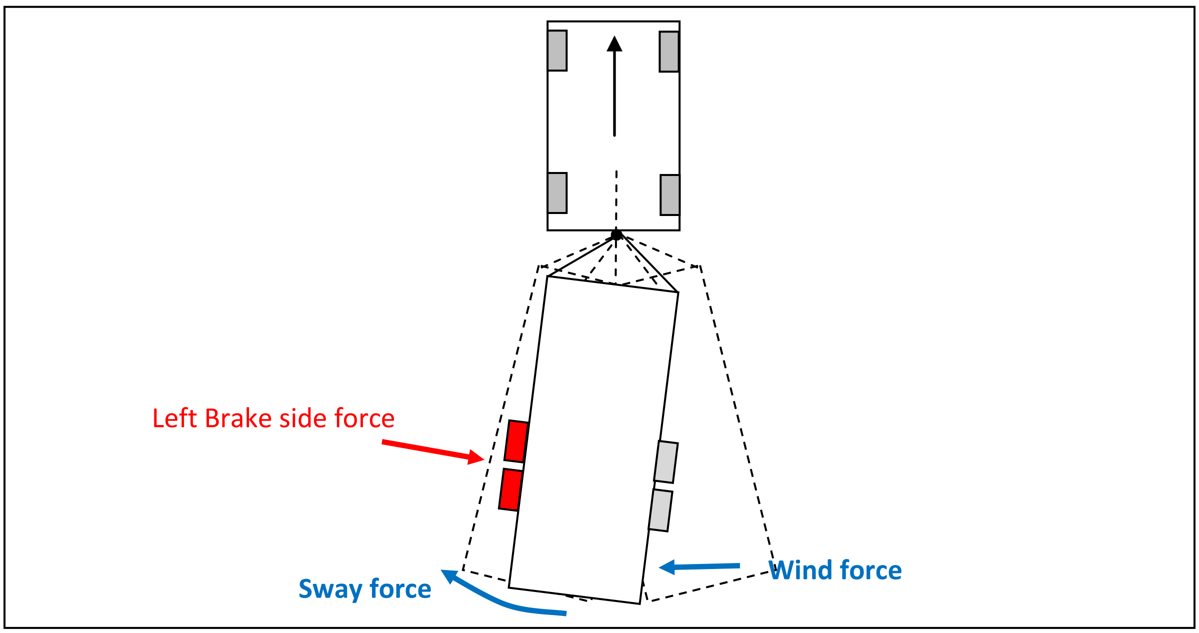

Figure 3: Asymmetric Sway to Left

As the trailer is swaying towards the left, per Figure 3, the application of the left brakes applies a force to the right to offset (cancel out) the energy applied by the wind force by "pulling back" on ONLY the left side to stop/slow the sway velocity to the left. However, if the left brakes remained active for too long of a time, or at too great of a force, while the trailer sways back to the right, excessive application of the left brakes could actually accelerating the trailer in the opposite direction versus just return it to centerline! Thus the left brake pressure, and thus the force applied to pull the trailer back to the right must be sufficient to offset the momentum in the left direction as well as offset the left force still being applied by the wind by "reducing the force to the right" as the trailer returns to the vehicle centerline. Stated differently, the greater the angular velocity of the trailer the greater the brake pressures applied.

In Figure 4 when the trailer transitions from a “left sway direction” by passing the “vehicle centerline” into the “right sway direction” the right brakes are applied at increasing levels to pull the trailer left thus reducing the sway momentum to the right. When sway is at or near the centerline both left and right brakes may be applied.

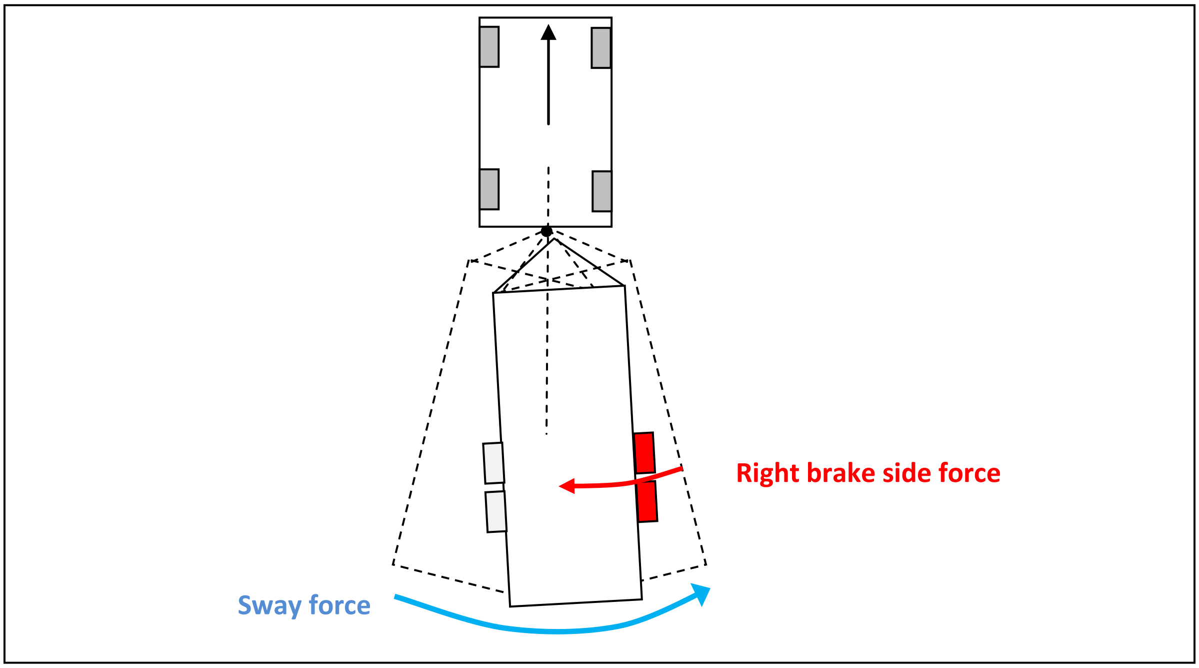

Figure 4: Asymmetric Sway to Right

The level of braking applied to the left brakes and or right brakes is determined by the sway velocity, acceleration and sway angle. In many sway control scenarios the asymmetric sway control will reduce the sway with little to no reduction in the vehicle speed as it applies enough braking to straighten the trailer. Hopefully this short discussion conveys how independent application of left and or right brakes, at varying braking levels (asymmetric brake control) offsets the sway momentum in the left and right directions. When the “sway force plus sway momentum” equals the “left or right braking force” in the opposite direction the sway will stop.

What happens to the tow vehicle during a sway event?

Those whom have experienced a sway event may be familiar with the phrase; “the tail is wagging the dog”. This description previously indicated the hitch ball is the “pivot point” between the trailer and the tow vehicle. During a sway event there exists another pivot point, which is where the length of the trailer is rotating around the trailer axles where the tires are in contact with the road. When connected to a tow vehicle this trailer rotation applies forces to the left and right at the trailer ball hitch, thus pushing the rear of the tow vehicle to the left and or right. A heavy (high mass) tow vehicle moves a little, a light (low mass) tow vehicle can move a lot. With asymmetric sway control, during the brake application scenario (Figure 4), rather than push the rear of the tow vehicle to the left at the hitch ball as the trailer rotates around its pivot point (its tires), the application of the right brakes actually pulls back on the ball hitch attempting to align the trailer’s right tires with the tow vehicle centerline, thus pulling the rear of the tow vehicle to the right, aligning the vehicle and the trailer, reducing the sway angle. The amount of “pull” is dependent upon numerous criteria, including; tow vehicle weight, trailer tire traction, condition of trailer brakes, trailer loading and so forth. An asymmetric sway controller should automatically adjust its braking pressures based upon variations in these criteria. Additionally, if during a sway event the vehicle brakes are applied the sway reduction brake forces are "added to" the brake forces applied by the in vehicle brake controller and thus sway control continues to occur even though the trailer brakes are applied.

Relative to the previously descriptions, the only reason asymmetric sway control is able to apply a force in the left and or the right directions is due to the "difference between the left force and right force" based upon the difference in brake pressures applied to each brake.

So what happens when "symmetric sway control" applies all brakes are during a sway event?

To follow the same thought sequence as the prior discussion, what happens when both sides of trailer brakes are applied at the same time under normal braking scenarios? Assuming all brakes on both sides of the trailer work properly the trailer will pull back. Since they are pulling back equally the trailer will remain in line with the tow vehicle.

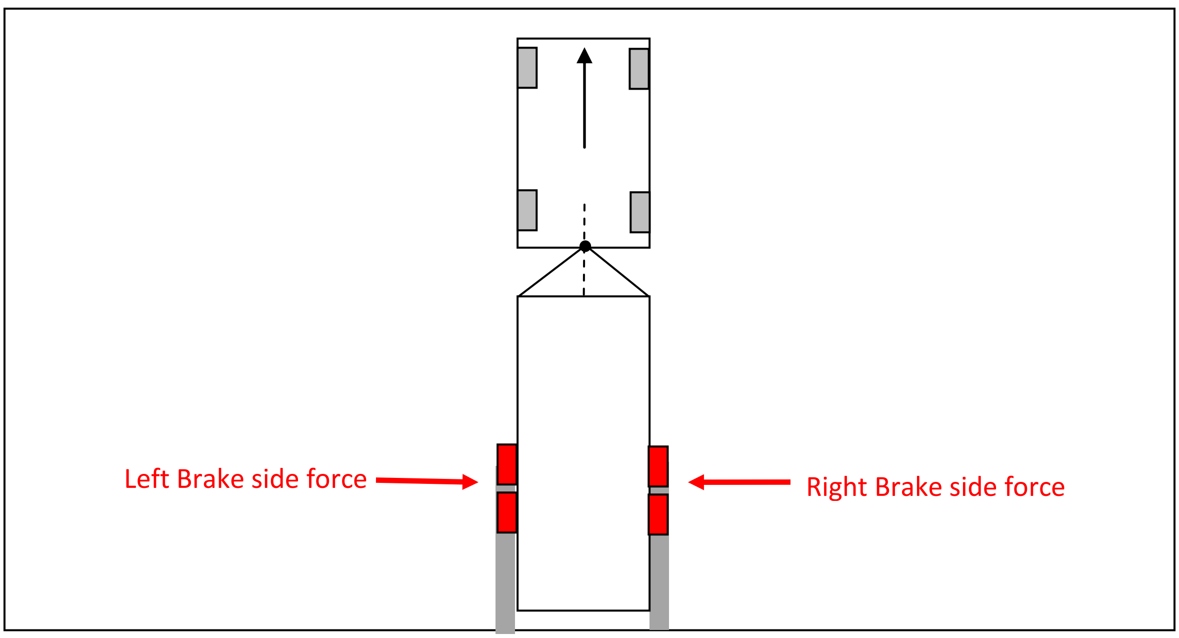

Figure 5: Normal Trailer Braking

So why does the trailer remain in line with the tow vehicle during normal braking?

Per Figure 5, the "left brake side force" will pull the trailer to the right and the "right brake side force" will pull the trailer to the left. If both the left and right side forces are equal, these opposite forces cancel each other out keeping the trailer straight, which is a good thing under normal braking scenarios!

So what does symmetric sway control do during a sway event to offset the sway force and sway momentum to the left sway and right?

Remember; "A body in motion tends to remain in motion unless acted upon by an external force."

Per Figure 5 the application of all the brakes does pull back on the tow vehicle, and if only the trailer brakes are being applied, this will "pull back" on the ball hitch attempting to line up the tow vehicle with the trailer.

However, since both left and right brakes are applied, nothing is offsetting the sway forces and sway momentum applied to the side of the trailer by the wind forces.

Per Figure 6 **since the left brake and right brake side forces offset one another the application of all the brakes does little to offset the side sway forces and momentum.** Application of the brakes does slow the tow vehicle and trailer and thus the decreasing the forward velocity where the reduction in vehicle speed will reduce the sway. This is the same result as manually applying only the trailer brakes. The sole benefit of the symmetric sway controller is that it should react faster than a typical driver to start slowing the vehicle when a sway event occurs, but symmetric sway control does little to nothing to offset the sway velocity and momentum forces applied to the side of the trailer.

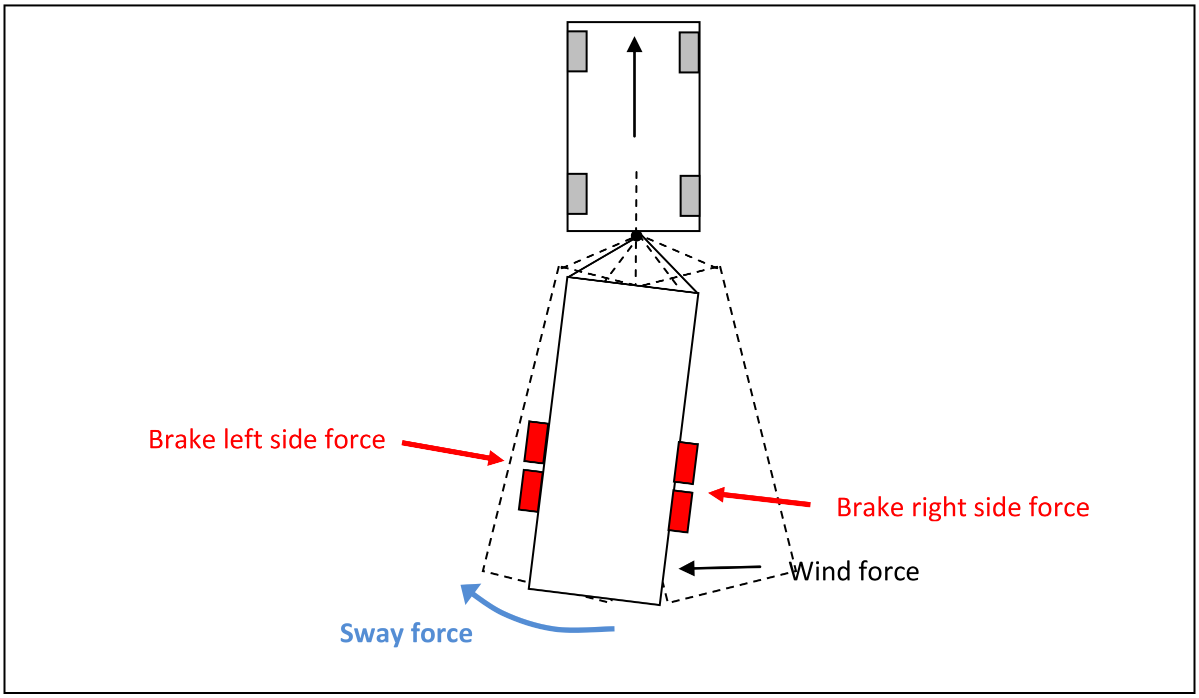

Figure 6: Symmetric Sway Braking

Your tow vehicle maintains vehicle stability by independently controlling each of its four wheels for exactly the same reasons as asymmetric trailer sway control. The complexities of sway events and the various forces involves are significantly more involved than the prior descriptions may indicate, but the description should be sufficient to understand that the ability to apply varying left side forces and right side forces is required to counteract the trailer sway forces. Thus asymmetric sway controllers are the only type of sway controller that actually reduces trailer sway.

The ability of a trailer sway control feature within the tow vehicle separately controls vehicle each brake and reduces the speed of the tow vehicle, attempting to keep the vehicle straight, thus reducing the sway as the tow vehicle does not have independent control of the right and left trailer brakes. If interested in test track testing with all combinations of vehicle sway control and trailer sway control activated see https://www.realtimeobjects.net/video and select the “Electronic Sway Control (Test Track)” button.