Traction Control Using HTD Hydraulic Torque Divider

Overview

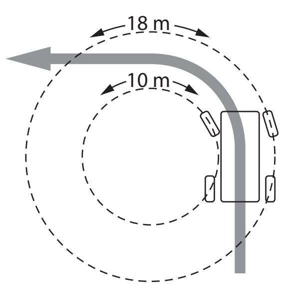
Controlling traction in propel applications can be a slippery problem. Parallel circuits can send all your flow to a spinning wheel. Series circuits can lead to wheel scuffing or damaging cavitation.

Traditional solutions to this problem fall into two categories: inefficient and expensive.

The inefficient solutions use an orificed leak path between the wheel motors to allow the outside motors additional flow when cornering. This solution can allow unwanted slippage when traveling on slick terrain.

The expensive solutions involve sensors to determine when the flow needs of each wheel are different, valving to regulate the flow, and controllers to process the information. Not all applications can afford the added cost.

Applications such as turf care machines are particularly sensitive to wheel scuffing. Ice surfacing machines are highly susceptible to slippage. And there are non-propel applications where torque must be evenly distributed between motors in series.



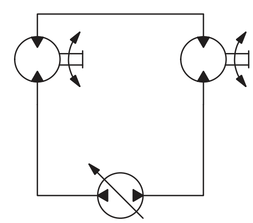
Basic steering geometry: cornering vehicles must spin outside wheels faster.

This 4-way 2-position valve halves the inlet pressure to balance torque between series motors in a drive circuit.

Traditional Solutions

Series Circuits

We all know that oil in a hydraulic circuit follows the path of least resistance. In terms of traction control, this presents the need to equalize flow to multiple motors. Placing them in series is the easiest way to ensure they all receive the same flow.



Flow in series circuit is equal, pressure is additive

Series circuits have some limitations, however: the first being that pressure is additive in a series circuit. The pressure available to the system must be shared by all motors in series. Motors in a series circuit must also be able to accommodate back pressure.

For detailed information and specifications, visit www.hydraforce.com or contact your local HydraForce representative at www.hydraforce.com/distribs/world.htm

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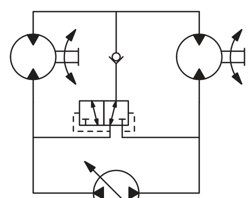
The second limitation of series motor circuits is that flow through all motors is equal. Cornering vehicles need to spin the outside wheels faster than the inside ones. Failing to accommodate this fact leads to outside wheels scuffing the surface or worse, cavitating your motors.

Make-up Checks

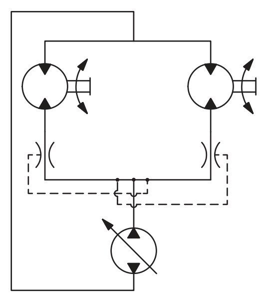
Make-up checks can alleviate cavitation, but all the pressure is dropped by the first motor. The downstream wheel provides no tractive effort: it's just along for the ride.



Makeup check allows extra flow (at charge pressure) to the second motor

Parallel Circuits

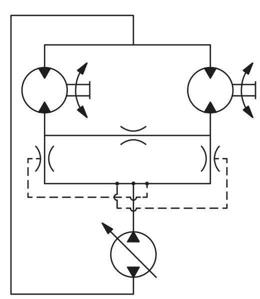
Parallel circuits require flow divider(s) to ensure all wheels spin, not just the one with no traction. This configuration has the same limitation: the outside motors require more flow when the vehicle turns. Flow dividers can be a strain on the system (pressure drop) in low speed conditions: a big disadvantage for machines with a creep mode.



Flow divider/combiner equalizes flow to both motors

Slip and Slop

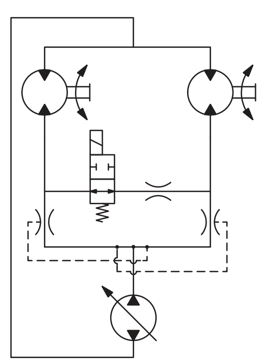
A slip orifice allowing limited bypass from left to right solves the problem, but inefficiently. It can lead to unwanted wheel slip if one wheel loses traction: a problem made worse at very low speeds.



Slip orifice allows limited bypass

Bypass Valve/Differential Lock

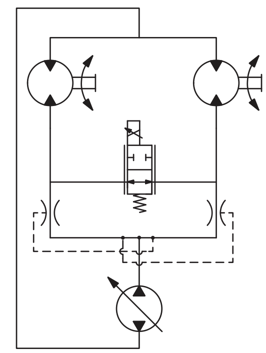
A bypass valve or differential lock allows flow to bypass when cornering, but closes when driving straight. This requires some switching to close and open the valve at the appropriate time.



Diff-lock blocks flow through slip orifice when activated

Steering Angle Feedback

The ideal system bypasses flow as needed while maintaining pressure. A system with a steering angle sensor and a proportional flow control can achieve this with the penalty of cost and complexity.



Steering angle bypass allows flow proportional to steering angle. Supporting sensors and electronics are required.

The Worst of Both Worlds

Cost-sensitive applications typically favor the sloppy solution. For some vehicles, operating in low-traction environments such as driving on ice, a little slip becomes a big problem.

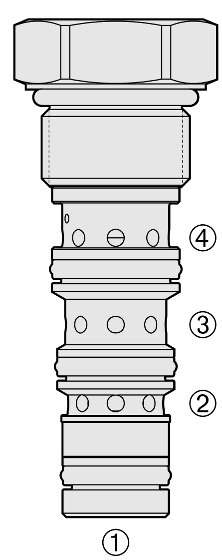
The Torque Divider

HydraForce has a better option: the HTD Hydraulic Torque Divider. This unique valve lets you size your traction control system for performance in the curves and down the straightaways; without adding oversized components and complex electronics.

It's a Pressure Control

Looking at traction control as a pressure control problem instead of a flow control problem led our application engineers to the solution. What is needed is a solution that allows necessary bypass without unwanted pressure drop.

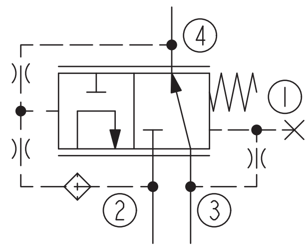
The HTD does just that. It can bypass flow around either of two series motors without shunting. The internal pressure divider directs the balancing act. Flow through the valve is only the differential flow the cornering vehicle requires.



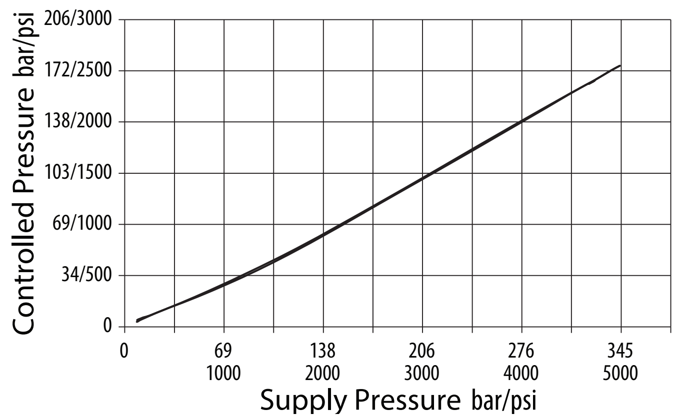
Operation

The HTD is a pressure reducing/relieving valve that adjusts its setting to half the pressure across 2 and 4. It allows flow from 3 to 4 or 2 to 3 as needed to balance the spool. The spool is balanced when pressure at 3 is half the pressure across 2 and 4.

Symbol HTD10-40



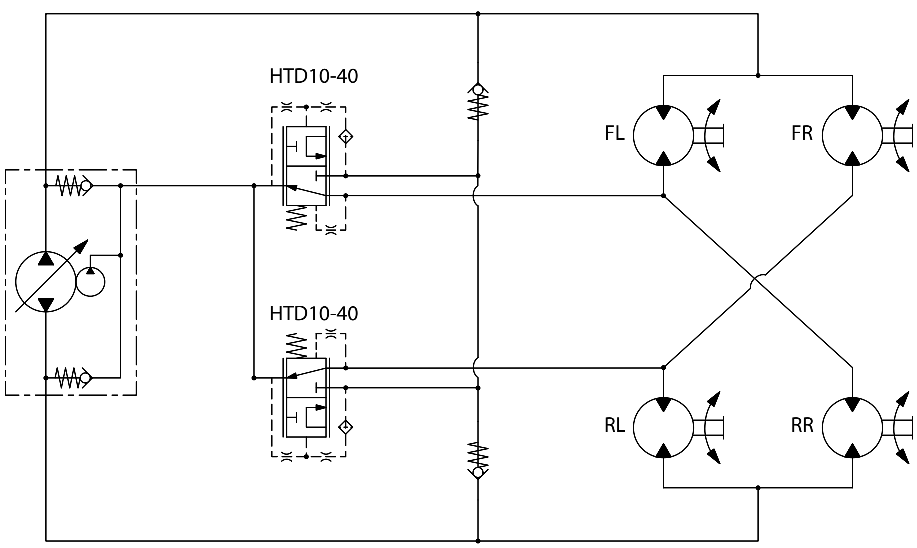
Performance HTD10-40



Application

Applied between two series motors, the valve balances the pressure drop across each motor. This achieves efficient torque division regardless of differing motor speeds. The valve is sized to accommodate the flow difference between the two motors.

Four Wheel Series-Parallel Drive Circuit with HTD10-40 Torque Dividers



The series-parallel circuit is common in four-wheel drive applications: dividing the circuit into two parallel paths with series flow to opposite wheels. The two HTD10-40 torque dividers either divert or supply flow to the center point between the series motors while balancing the pressure to both. They are sized to accommodate the flow difference only. This approach requires no large flow dividers with associated pressure drop/heat buildup. Some extreme low-traction applications benefit from small flow regulators inline with the torque dividers.

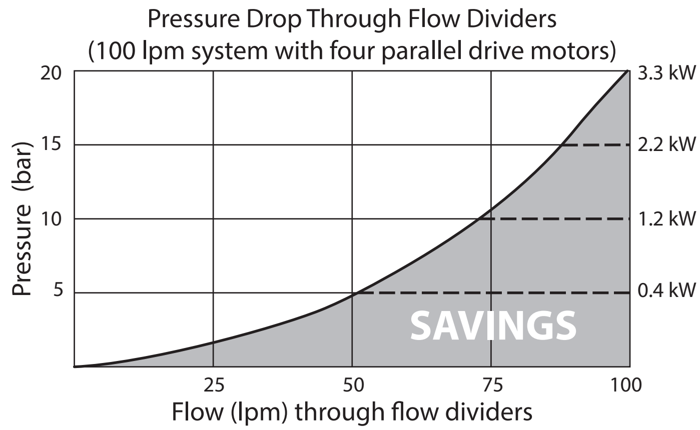
The HTD is useful in any application where series motors require some limited variation in speed such as auger and conveyor/spinner, sweepers/brooms, drill motors in series, etc. New applications are popping up all the time.

Power Savings

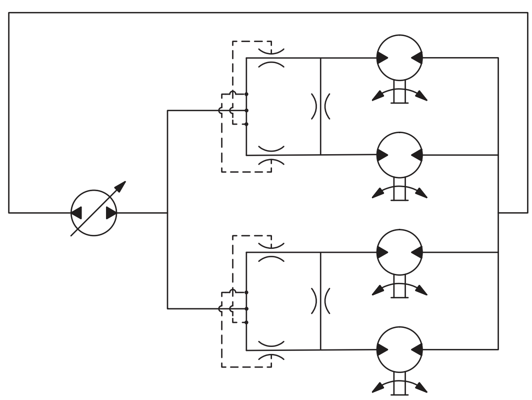
Comparing two systems: one with traditional flow dividers, one using HydraForce HTD10-40 torque dividers, we can show a power savings of 3.3 kW at full system flow (100 lpm).

The traditional system achieves traction control by dividing the *flow* equally among all motors. Fluid passing through a flow divider exhibits a pressure drop that is converted to heat in the system. This pressure drop increases with flow.

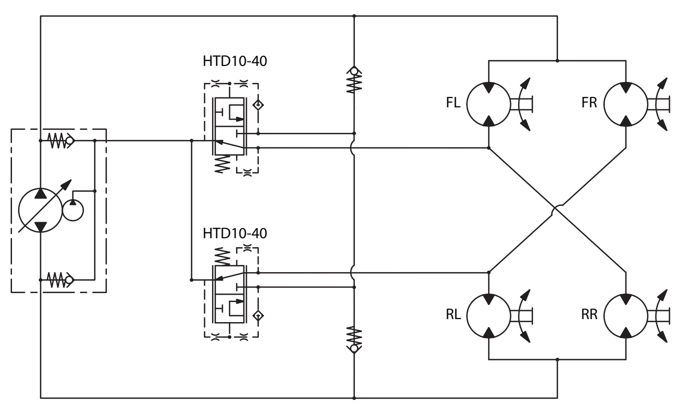
The system using torque dividers achieves traction control by dividing the *pressure* equally to all motors. Fluid only passes through the torque dividers when the wheels must turn at different speeds during cornering. Keeping all wheels at equal pressure ensures balanced torque without the losses and heat generation that flow controls exhibit.



Flow Divider Circuit



Torque Divider Circuit



Traction Performance

Both systems solve the primary traction control problem: flow favoring the wheel with the lowest traction. In the flow divider system, flow is equalized to all motors, but pressure (torque) can vary from wheel to wheel. The torque divider system outperforms the flow dividers because pressure is controlled, ensuring all wheels share the load (torque) of moving the vehicle forward.

Benefits

This is a new solution to an old problem. The benefits that make HTD10-40 the right choice for most applications are these:

- All hydraulic solution—no sensors or controllers
- No electronic development or fine-tuning
- Simplified circuit—easy service and troubleshooting
- Optimized flow rating—sized for the differiential only
- Good in low-traction applications
- Great for cost-sensitive applications—low valve count

Contact your HydraForce application engineer or technical service representative for information or application assistance with the HTD10-40 torque divider.

Product Variations

Alternative Ratios

The HTD is internally piloted through two orifices in a series configuration that form a pressure divider network. Remembering that all pressure drops in a series circuit are additive, and the total pressure across the network is equal to the total system pressure, we can vary the orifice sizes to derive alternative ratios. Two equal orifices divide pilot pressure in half. A 75/25 ratio is available as a standard product, but any ratio is possible.

Possible applications of alternative ratios include motors of different sizes or different loading characteristics.

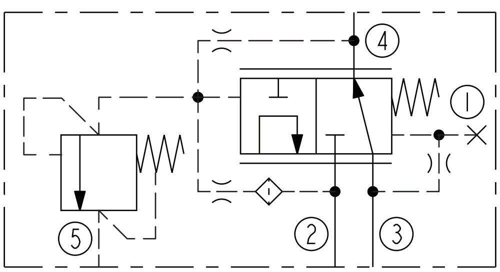
Variable (Two-stage) Torque Divider

HTD10-E50 (patent pending)

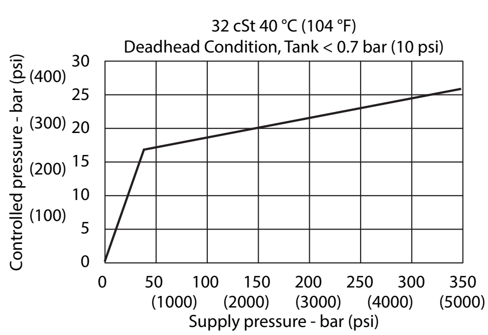
A five-ported valve (HTD10-E50) is available with an internal pilot-stage relief. This valve allows the dividing ratio to change based on the total circuit pressure. As the pressure in the circuit increases, the pilot relief opens, changing the dividing ratio. This achieves a two-stage response curve as shown in the performance chart.

Applications for this valve include vehicles or systems with variable load dynamics. One example is a rear-engine vehicle that may lose tractive effort in the front axle as the load shifts while driving uphill. The change in grade drives up the circuit pressure up just as the load shifts off of the front axle.

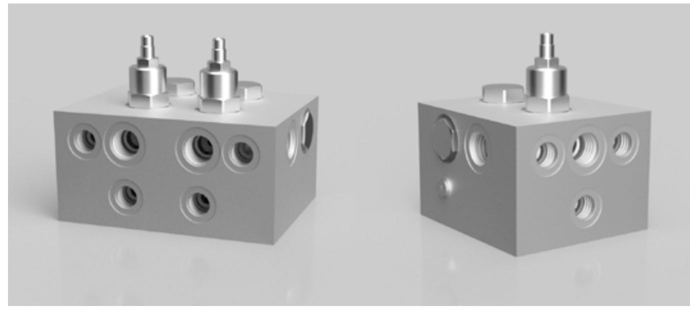
Symbol HTD10-E50



Performance HTD10-E50

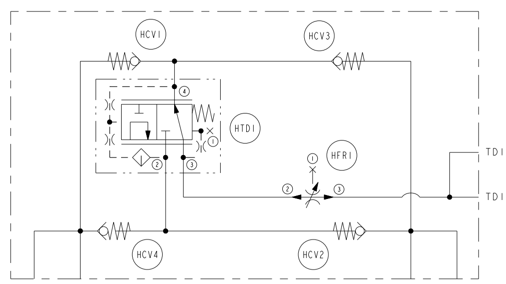


Testing Manifolds

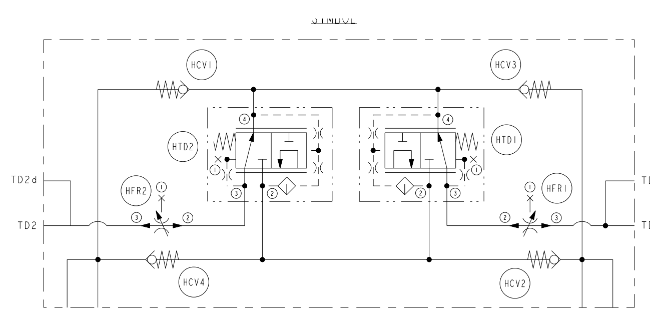


For testing HTD in an existing drive circuit, or for prototyping a new system, two pre-designed testing manifolds are available. You can easily add them to your test vehicle with a few simple plumbing connections. One or two HTD10-40 valves provide torque control, an adjustable HFR10-32A limits slip in extreme low-traction conditions, while four check valves allow bi-directional operation.

Two-wheel Drive



Four-wheel Drive



Port TD1/2 connects between the series motors. Ports A and B connect to the A and B ports of the hydrostatic pump. For bi-directional operation, check valves HCV2 and HCV4 resolve high loop pressure to port 2 of the HTD. Check valves HCV1 and HCV3 resolve low loop pressure to port 4 of the HTD. HFR1/2 can be adjusted to limit the maximum differential flow. HTD1/2 internally pilots to maintain port TD1/2 at half the pressure between ports A and B.