

Advancements in Lift Truck Steering

Is variable rate steering the next big thing?

Lift trucks picking up loads in material yards often move around at high speeds, then decelerate to make a low-speed turns to pick up or drop off a load.

By Kevin Thayer

Lift trucks were once steered with mechanical linkages powered entirely by operator muscle, but Lynn Charlson changed that when he invented a hydraulic torque generator that provided a hydraulic boost to the mechanical linkage. Charlson's torque generator was originally developed for agricultural tractors but soon found its way into lift trucks.

The company he founded, Char-Lynn, continued to develop the technology, and the torque generator evolved into a fully fluid linked system, known as hydrostatic power steering. Today, hydrostatic power steering is a global standard in off-road equipment. Now part of Eaton, Char-Lynn's systems still provide hydraulic steering boost and manual backup steering capability in case of engine failure.

Hydrostatic steering uses a rotary valve and a gerotor. In powered operation, it works similarly to a directional valve, except the gerotor meters a precise amount of flow for each revolution the steering wheel is turned. In manual mode, the gerotor becomes a hand pump, building pressure with the operator's muscle alone.

It wasn't long before the construction industry discovered this solution for steering heavy vehicles. However, construction had an additional requirement because its vehicles often spend part of the time moving slowly on a jobsite and the rest of the time driving much faster on a road or across large jobsites.

In that environment, it isn't just the amount of energy required to steer the vehicle that creates operator fatigue; it's also the number of steering wheel turns needed to complete each maneuver. If the steering system is set up to provide quick turns at low speed, say two to three turns lock-to-lock, the response will be too quick for road use.

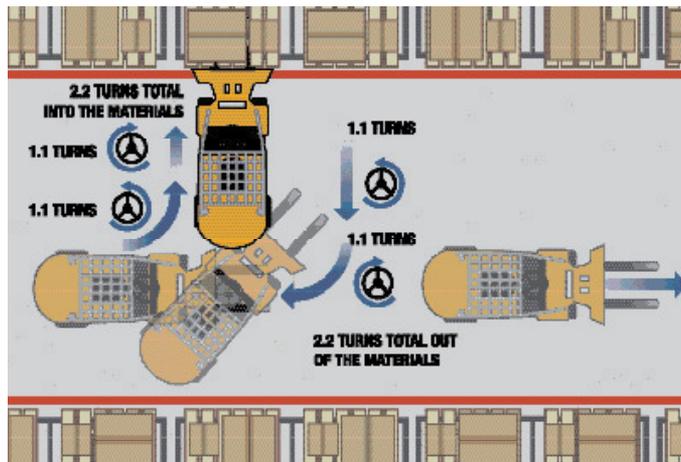
Conversely, if the system is setup to require more turns lock-to-lock for on-road steerability, the operator will be turning the wheel more than necessary during slow speed maneuvers where a two- or three-turn lock-to-lock ratio is much more efficient.

Eaton developed a solution based on the speed at which the vehicle's operator turns the steering wheel. When a vehicle is moving slowly, operators tend to rotate the wheel faster. At higher speeds, the opposite tends to be true.

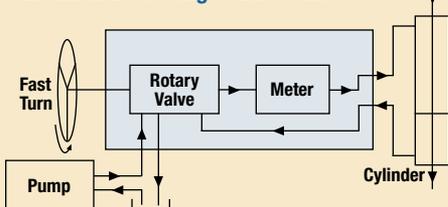
Steering wheel turning speeds in the 80- to 100-rpm range are common at low speed, while 2 to

10 rpm is common for road travel in the same vehicle. By adjusting the steering ratio based on the rate at which the wheel is being turned, the Char-Lynn steering system gives operators the best of both worlds.

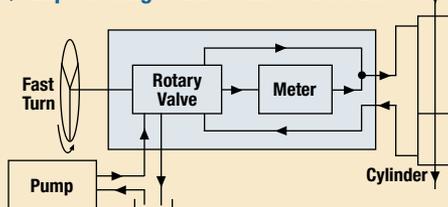
In the slow vehicle travel speed/fast steering wheel turning condition, the system boosts steering gain to reduce the number of turns, lock-to-lock. In the high vehicle travel speed/slow steering wheel turning condition, the gain is not boosted, thereby maintaining fine metering control.



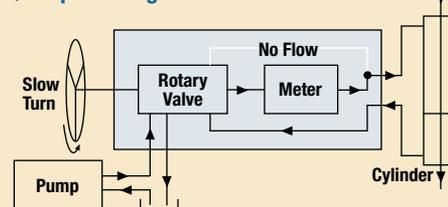
Conventional Steering Control Unit



Q-Amp Steering Control Unit – Fast Turn



Q-Amp Steering Control Unit – Slow Turn



Eaton calls this system “Q-Amp” because it uses the steering wheel turn rate to amplify the flow (“Q”) within the system. Today, Q-Amp steering is standard on many off-road and construction vehicles.

What goes around comes around

Forklifts used in work areas like material yards often move around at high speeds, then decelerate to make a low-speed, right-angle turn to pick up or drop off a load. They will turn back into the material area or aisle, making another low-speed, right-angle turn and proceed at high speed to the destination.

This sequence of maneuvers is similar to those performed by off-road and construction vehicles. The only difference is the absolute speed involved. The question is whether or not the solution developed for construction and off-road vehicles, Q-Amp steering, would benefit a lift truck.

Today, most lift trucks use a fixed steering ratio that takes four to five turns lock-to-lock. This provides the fine metering required for a narrow, short wheelbase vehicle with rear-wheel steering when it’s moving at high speed. It also means the operator will need two or three complete rotations of the wheel to make a low-speed, right-angle turn that could be done with a much quicker steering ratio, resulting in reduced operator motion.

A Q-Amp-equipped lift truck can perform the basic set of maneuvers in a typical duty cycle with only 4.4 total turns of the steering wheel, whereas a fixed-ratio system requires 8.8 turns to perform the same maneuver. Multiply that motion savings by hundreds of repetitions per day, and the result is a significant reduction in operator fatigue and an increase in productivity.

Off-the-shelf solution

The technology behind Q-Amp steering is used on thousands of off-road and construction vehicles around the world. It is available as an option on Eaton’s Series 5 and XCEL45 steering control units, which are suited to most lift truck applications.

A Q-Amp system’s additional flow path to the steering cylinder is controlled by a rotary valve. As the steering wheel is turned faster, the valve opens proportionally so extra flow helps move the steering cylinder faster. The effect changes the apparent steering ratio in direct relation to changes in the steering wheel’s speed of rotation.

Unlike the two-speed systems now widely in use, the change in steering ratio in a Q-Amp-equipped lift truck is smooth and seamless. There are no steps, no buttons to push, or switches to engage. Operation is completely automatic and transparent to the operator.

When the steering wheel is turned quickly, the vehicle responds quickly. When it’s turned slowly, the vehicle responds slowly, thereby maintaining fine metering at higher speeds. If the engine dies, the Q-Amp system still has a gerotor that can provide manual steering control.

The only system requirement other than the Q-Amp steering unit is load sensing, which is typically achieved with a priority valve. This approach is common on many internal combustion lift trucks in North America and Europe. Given the wide variation in vehicle dynamics, however, Q-Amp-type variable ratio steering is most economically applied as an OEM option rather than an aftermarket add-on.

What started out as a power-assisted steering system for ag tractors and lift trucks morphed into a variable-ratio steering solution for off-road and construction vehicles. It has now come full circle as a productivity enhancer for lift trucks. ☐

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