

CASE STUDY

BACKGROUND

The customer operates a mobile vehicle-loading machine that relies on two hydraulic cylinders extending approximately 10 feet to raise and lower a ramp. For safe operation, the ramp must remain square and level, so the safety ratchet teeth engage on the same tooth on both sides of the machine.

Even minor misalignment causes the ratchet teeth to land unevenly, which can:

- Twist the structure
- Accelerate bearing and upright wear
- Lead to premature mechanical failure
- Create unsafe loading conditions for automobiles

A traditional hydraulic solution using a flow divider circuit was not sufficient. While flow dividers are typically accurate to 95–98%, that level of precision is unacceptable over a 10-foot stroke. At 95% accuracy, the resulting mismatch exceeds the 1.5-inch allowable ratchet tooth spacing, creating a significant safety and reliability issue.

ENGINEERING CONSTRAINTS

Several real-world operating challenges had to be addressed:

- The machine is frequently driven and parked on uneven terrain
- Auto-leveling could not activate while the ramp was static
- The solution needed to be backward compatible with the existing fleet
- The system needed to handle unbalanced vehicle loads on the ramp
- Fault conditions had to be detected and safely managed without worsening the problem

SOLUTION

Instead of relying on hydraulic flow balancing alone, the engineering team implemented a closed-loop electro-hydraulic control strategy using:

- A Danfoss controller
- Two inclinometers
- Two proportional valves
- Updated wiring harnesses
- Minimal hydraulic modifications



...SOLUTION

The control system continuously compares the relative angle between the ramp and the base, rather than referencing gravity alone. This means the ramp stays square to the base regardless of whether the machine is parked on level ground or an embankment.

If one cylinder begins to move faster than the other during extension or retraction, the system automatically bleeds the higher cylinder through proportional valves, keeping both sides synchronized.

BACKWARD COMPATIBILITY

A major advantage of this design is that it required no complete hydraulic redesign.

The solution:

- Reused the existing manifold
- Required only minor valve changes
- Involved hose rerouting rather than replacement
- Can be deployed across the entire installed fleet

This significantly reduced implementation cost and downtime for the customer.

INTERFACE & ADJUSTABILITY

An intuitive user interface was developed to give operators and technicians control without complexity. **Adjustable parameters include:**

- How far out of level the ramp can be before correction begins
- The ability to disable auto-leveling if abnormal conditions are detected
- Protection thresholds that prevent valve actuation during fault states

This design balances automation with operator awareness and safety.

AUTO-LEVELING LOGIC

To prevent unintended behavior, several safety and logic layers were built into the system:

- **Motion-Based Activation:** Auto-leveling only occurs while the ramp is actively extending or retracting. If the ramp is static, the system will not open valves.
- **Relative Angle Control:** The system maintains the ramp angle relative to the base, not gravity.
- **Extreme Angle Protection:**
 - If the system detects:
 - Excessive tilt between cylinders
 - A ramp angle near end-of-travel
 - Or an abnormal fault condition

RESULTS

The final system delivers performance far beyond what traditional hydraulic flow dividers can achieve:

- Ramp level maintained within $\pm 0.25^\circ$
- Accurate synchronization over the full 10-foot stroke
- Reliable operation with unbalanced vehicle loads
- Reduced structural stress, bearing wear, and long-term maintenance costs
- Improved safety and consistency during vehicle loading

By combining electronic sensing, proportional hydraulic control, and intelligent logic, the engineering team delivered a precise, reliable, and fleet-wide solution to a problem that could not be solved hydraulically alone.

The result is a safer machine, longer component life, and a modernized control system - without requiring customers to replace or redesign their existing equipment.

