Split Pump Intelligent Flow Control Architecture: Application on a Wheel Loader

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Typical Wheel Loader Architecture

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Typical North American and European wheel loaders utilize system concepts based on load-sensing technology. The main functions are implement control and steering. Some systems use a single pump for both functions, while others use two pumps.

The implement control valve can be either flow sharing or arranged with built-in priorities between boom and bucket and auxiliary. These architectures achieve a reasonable performance and energy balance, but there is room for consistent improvement.

Open-Center Intelligent Flow Control (IFC)

- Simplification: No compensators and shuttle networks.
- Reliability: Less complexity means more dependability.
- Energy Savings: Controlling flow through pump displacement reduces pressure losses. One pump per function optimizes energy balance.

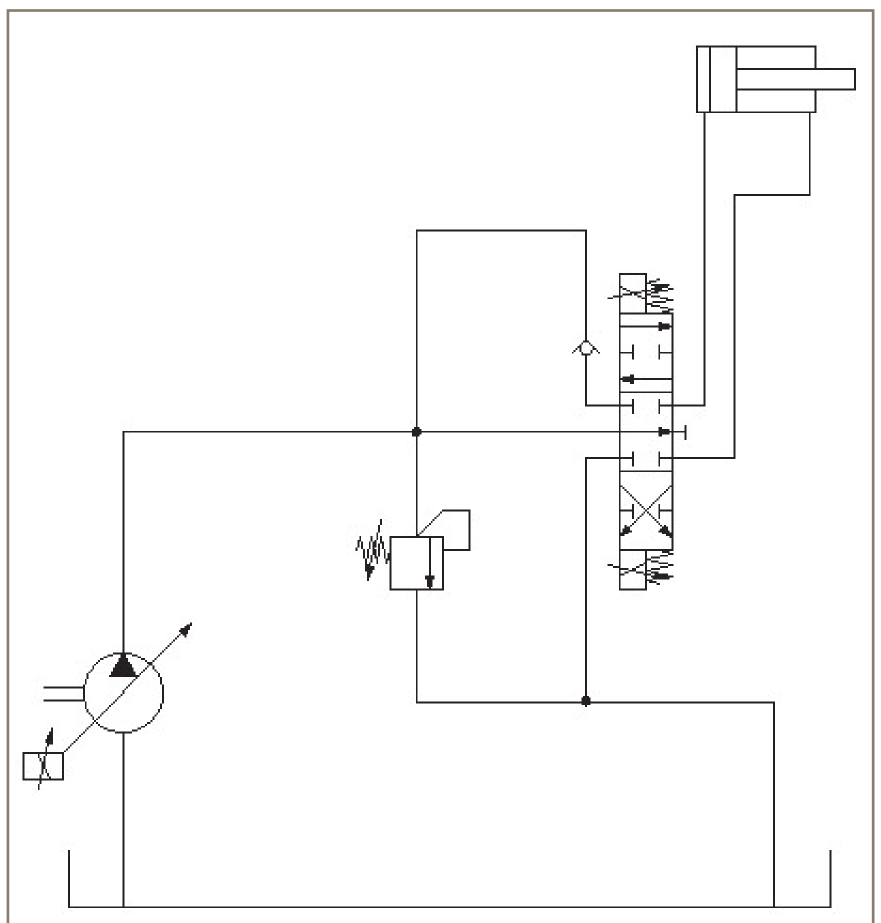

Figure 1: IFC Concept

The Parker Global Mobile Systems team has developed an innovative concept for a wheel loader that takes performance and efficiency to a new level while also reducing system complexity. This concept uses two electric displacement controlled pumps and an electric controlled open center valve with three sections. The bucket is controlled by the middle section, while the first and last sections supply the boom cylinders, as shown in Figure 2. With this type of architecture, each function can utilize full flow from both pumps during single function operation. For multifunctioning, each function is controlled by a dedicated pump for optimized energy balance.

How It Works:

When high flow is required to raise the loader arms, the first and third spool sections shift to full stroke; the pumps then provide the necessary flow, up to the total combined flow available from both pumps. The flows from ports 1A and 3A are combined, allowing the full flow from both pumps to be used to extend the lift cylinders.

Similarly, if the bucket requires full flow from both pumps, the second spool can be shifted to full stroke; the pumps then provide the necessary flow up to the total combined flow available from both pumps. The flow from the first pump passes through the open center of the first valve section to the second section.

When multifunctioning is required, the flow from Pump 1 is used for lift and the flow from Pump 2 is used for the bucket.

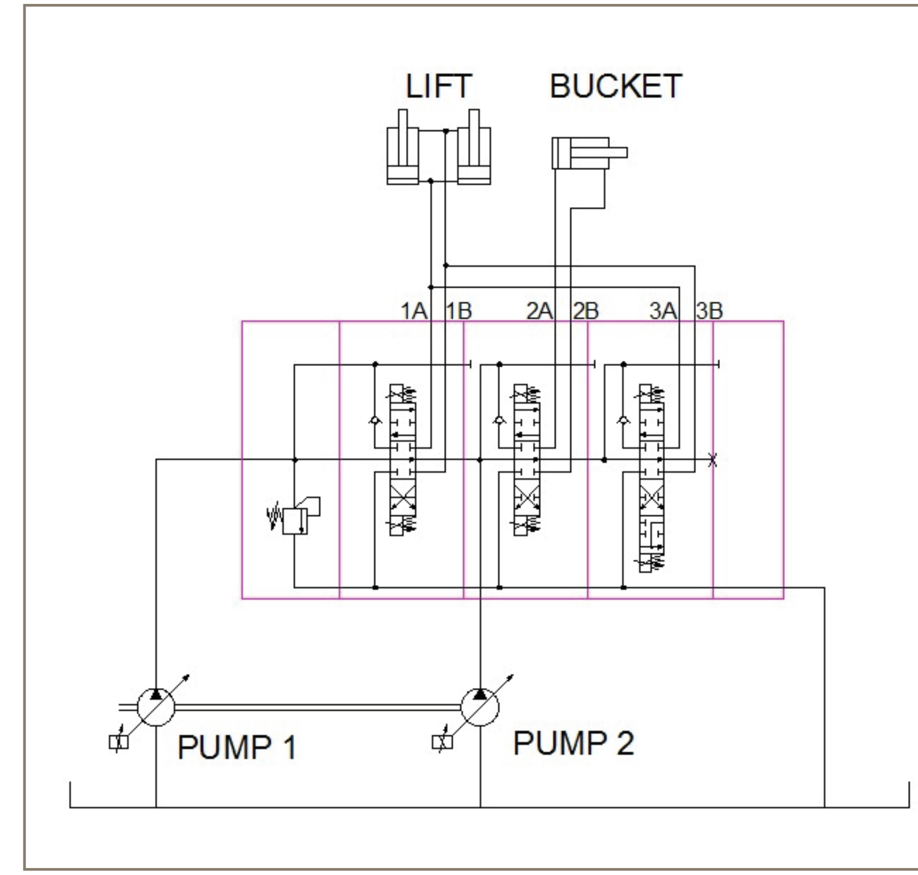

Figure 2: Hydraulic Architecture

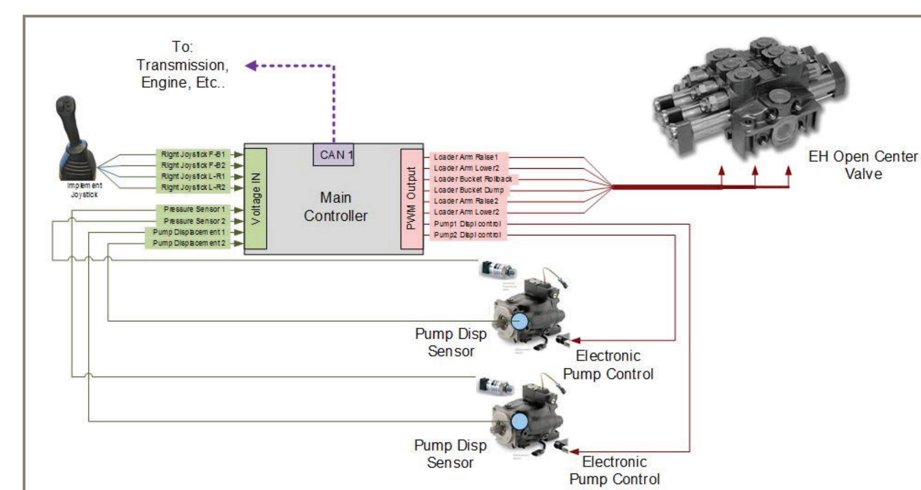

Figure 3: Electronic Architecture

How It Performs:

The Parker Global Mobile Systems team tested the hydraulic power consumption of the IFC split pump system versus a common wheel loader architecture based on a load-sensing valve and a priority flow control. Figures 4 and 5 show the layouts of the systems compared.

The performance of the two vehicles was compared on the traditional "Y" duty cycle as shown in Figure 6. This type of duty cycle is common in wheel loader applications. The measurement of the power consumption was divided in six different steps within the cycle. The results showed favorable overall results throughout the cycle as shown in Figure 7; in particular, the power consumption is significantly reduced during the breakout and reversing phase.

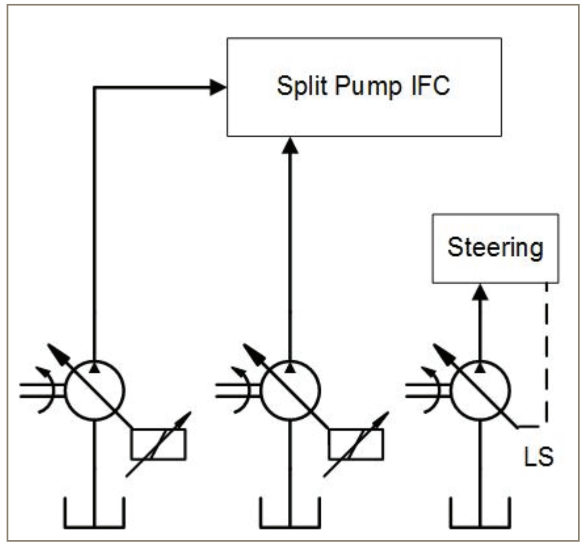

Figure 4: Split Pump IFC Architecture

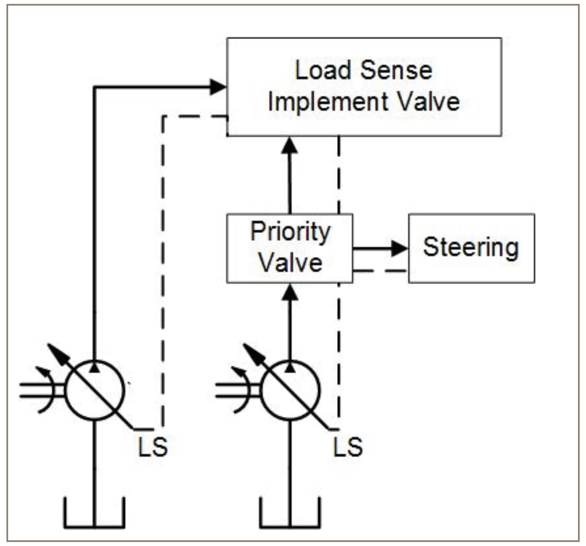

Figure 5: Baseline Load Sense Architecture

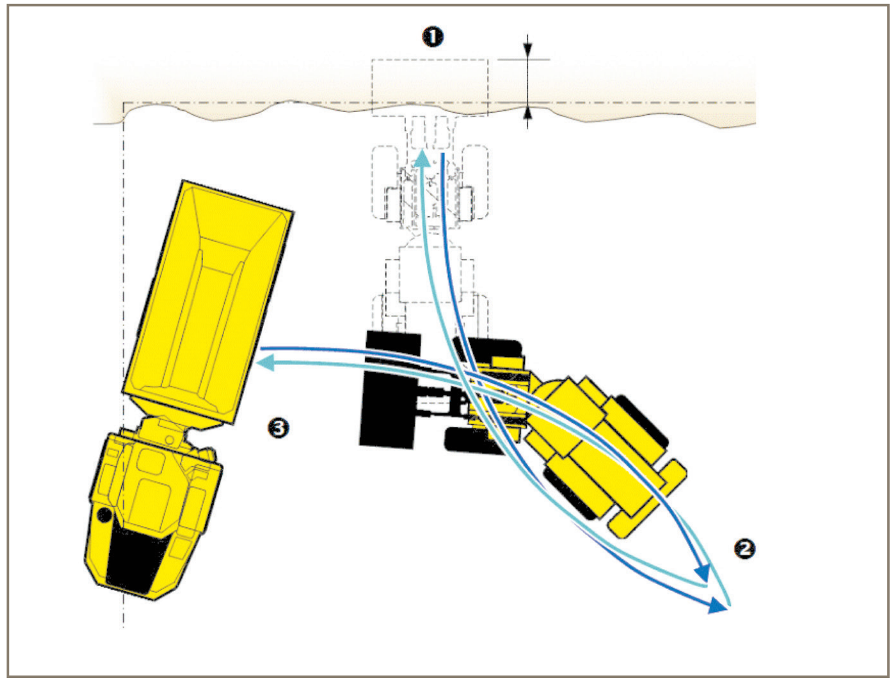

Figure 6: Wheel Loader Y Cycle

Value Analysis

The hydraulic energy consumed by the split pump IFC system resulted 24% less than the baseline load-sensing system. This translates into an overall performance improvement of the machine of 8%, assuming a 33% to 66% power split ratio between implements and transmissions.

In terms of fuel consumption improvement, the split pump IFC system allows fuel savings of up to 7 liters/day, which corresponds to a potential yearly saving of $900 in the US and €1600 in EU.

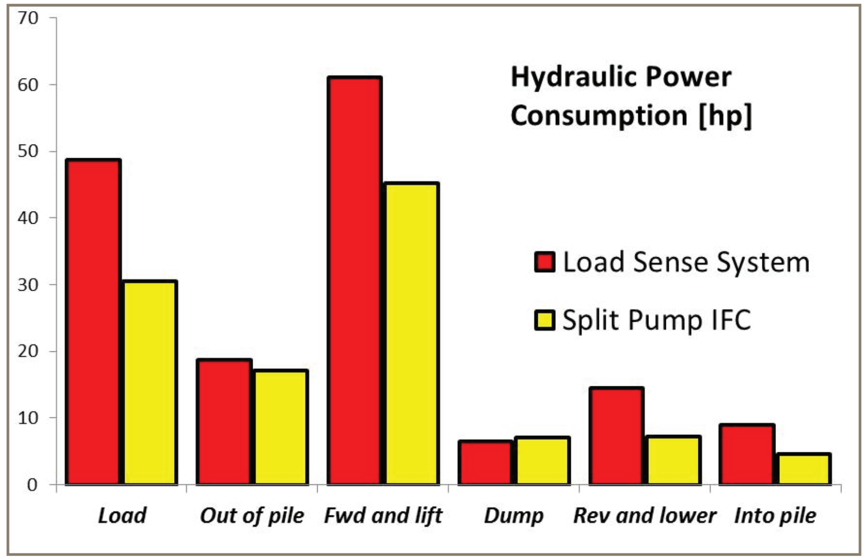

Figure 7: Hydraulic Power Consumption

Advantages over a Traditional Load-Sensing System:

Simplified architecture

- Using open-center valves in combination with electronic displacement control pump removes the complexity of compensators as well as the load-sensing signal network from the valve, reducing failure points, leak paths and cost.

Reduced energy losses

- With flow control to specific functions controlled with the pump, the losses through the valve are minimized as the valve can be shifted to full open during single function operation.
- Two pumps allow for simultaneous operation of two-function operation without pressure compensation.
- Removal of load-sensing signal line and bleed provides some energy savings.

Improved response time

- Traditional load-sense systems react to load by signaling the pump to come on stroke. By using an electric control pump, the time from operator input to pump stroking up to a desired displacement is reduced. The valve and pump can be commanded simultaneously, improving the system response.

Control Flexibility

- By offering proportional control of both valve and pump flow, valve spools depending on the desired behavior, valve spool or pump displacement can be controlled to provide the exact amount of flow required.

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