A Simple Load Sense System

Shown in the illustration above is a load sense system with a simple, inexpensive gear pump and unique HydraForce components, such as the SPxx-47x electro-proportional control valve.

Initially, when a load sense system is activated and the operator has *not* selected a function, all flow from the pump is diverted to tank through the EPFR bypass compensator.

This is advantageous from an efficiency standpoint, because the energy consumed is only that related to the flow from the pump and the bias spring value of the EPFR flow regulator.
Load-Sense System Basics

For example, as current is applied to one of the coils of SP1, oil flows through EC1, SP1 and finally out through the work ports of either A1 or B1. As the actuator at A1 moves it imposes a load on the hydraulic system. This load pressure is transmitted through the load sense port of SP1 and further passed on to the function compensator. Ultimately, the load pressure is conveyed across the load sense network across the load sense check valves (CV1 through CV3) to the main load sense line.

Selecting Multiple Functions
When multiple functions are operated simultaneously, only the highest load sense signal is allowed to pass to the main line through one of these check valves. As the operator demands a greater speed from the actuators (pressure doesn't necessarily increase as function flow increases) and/or if the load pressure increases because of resistance, the load sense pressure increases. The EPFR1 opens or closes in response to a change in the load pressure.

This changes the restriction in the pump to tank passage so that less or more flow is available in the hydraulic control circuit. Finally, the maximum pressure which the system can develop is regulated by the setting of the relief valve, RV1.

Three Functions in Operation
One typical operating scenario could be that all three functions are running simultaneously. Assume that the resistance from the load between A2 and B2 is the greatest. The load pressure is transmitted through CV2. This pressure acts on EPFR1 and it closes in response to this pressure. The system pressure increases by the pressure required to move the load at port A2 or B2 plus the spring value of EPFR1. As the load pressure requirement increases eventually EPFR1 will close completely and all flow will be available to move the actuators up until the point that the pressure equals that of the setting of RV1. Then flow will begin to exhaust across RV1. This system pressure is applied at the inlet of all three work functions. The individual function compensator valves (EC1, EC2 and EC3) will limit this pressure to each function to ensure consistent differential pressure across each SP valve. Thus, the speed at each actuator is controlled based on the opening of the orifice of the spool at the given work function and is not a function of the inlet pressure.

Cartridge Valves Are The Building Blocks
Apart from the clear efficiency advantages of a properly designed load sense system, a HydraForce circuit will take full advantage of customizing for each individual application. Cartridge valves, which are the building blocks of the hydraulic world, can be arranged and installed into a custom manifold, eliminating the necessity to connect individual valves externally. Further, the correct size cartridge relative to the flow demand can be selected for each actuator. Therefore, the cost and size of the valve assembly is decreased while improving performance.
Theory of Operation - Direct-Acting Directional Control

Shown below is a schematic of a typical directional control circuit, consisting of an SPxx-47C with an ECxx-32 and HLSxx-30 in combination to form the basis of a closed center, internally compensated load sensing directional control valve rated between 3 to 6 gpm (11 to 22 lpm) and 3500 psi (250 bar).

"A typical directional control circuit featuring the SPxx-4x cartridge valve that provides a pressure-compensated, load-sensing directional control valve."

The HCV06-20 completes the circuit when it is in use with multiple parallel functions. The directional valve has two solenoids, S1 and S2. When the S1 coil is energized, flow is allowed to Work Port B. When S2 is energized, flow is allowed to Work Port A.

Note that unlike the schematic shown in the “Load Sense Basics” section, no load-holding valves are shown. These could be counterbalance valves or pilot operated check valves depending on the type of function being controlled as well as the neutral position of the directional control spool. Also, the relief valve and anti-cavitation protection check valves have been omitted. Only the essential valves of the circuit are identified.

In Figure A, the pump is off and no pressure is fed to the directional control.

CARTRIDGE VALVE and PORTING KEY

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<tbody>
<tr>
<td>1</td>
<td>SPxx-47C</td>
<td>A</td>
<td>Work Port A</td>
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<tr>
<td>2</td>
<td>ECxx-32</td>
<td>B</td>
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<tr>
<td>3</td>
<td>HCV06-20</td>
<td>LS</td>
<td>Load Sense Port</td>
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<tr>
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<td>HLS06-30</td>
<td>P</td>
<td>Inlet Port</td>
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<td>Tank</td>
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<tr>
<td>S2</td>
<td>Solenoid 2</td>
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Schematic showing directional control for double-acting actuator control

Pressure Limiting Circuit

FIGURE A - Direct-acting, spool-type pressure-compensated directional control
In Figure B, the pump is on and system pressure is fed to the inlet of the directional control compensator. Since no current is applied to S1 and S2, the compensator closes and blocks the flow of oil to the SPxx-47C.

Figure C depicts what occurs when the S1 coil is energized and the pump is on. The main spool of the directional control opens to allow oil to flow to Work Port B. At the same time oil is fed to the load sense network. The oil pushes the ball of the HLS06-30 load sense shuttle into a secondary position.

The oil also biases the compensator into an open position. The pressure demand at the load plus the spring force acting on the compensator spool balances the inlet pressure. The compensator moves in response to a change in load or system pressure, thereby regulating the pressure drop across the main directional spool.

As long as the hydraulic cylinder or motor demands flow, the compensator is in equilibrium. However, when the load or inlet pressure suddenly changes, the compensator responds accordingly. In other words, flow through the directional control is determined by the difference between load pressure induced at the actuator in the system and the main system pressure in combination with the restriction of the directional control valve (SPxx-47C working with the ECxx-32).

As long as the actuator at Port A and B is moving (flow is required) the compensator will remain in an open equilibrium position. Oil also flows out of the load sense check valve that feeds the main load sense element. This main load sense element may be a valve that is external to the pump or it may be internal to the pump.