Information sheet
MCR 2-speed soft-shift

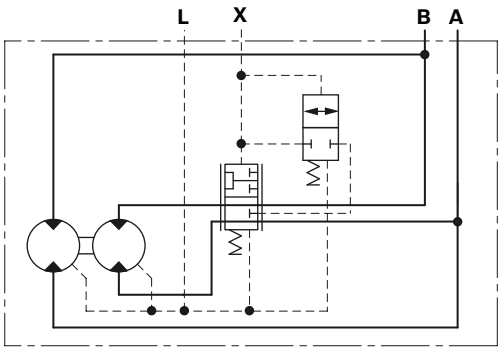
RE 15225-03
Edition: 08.2014

Application and use

Two speed operation

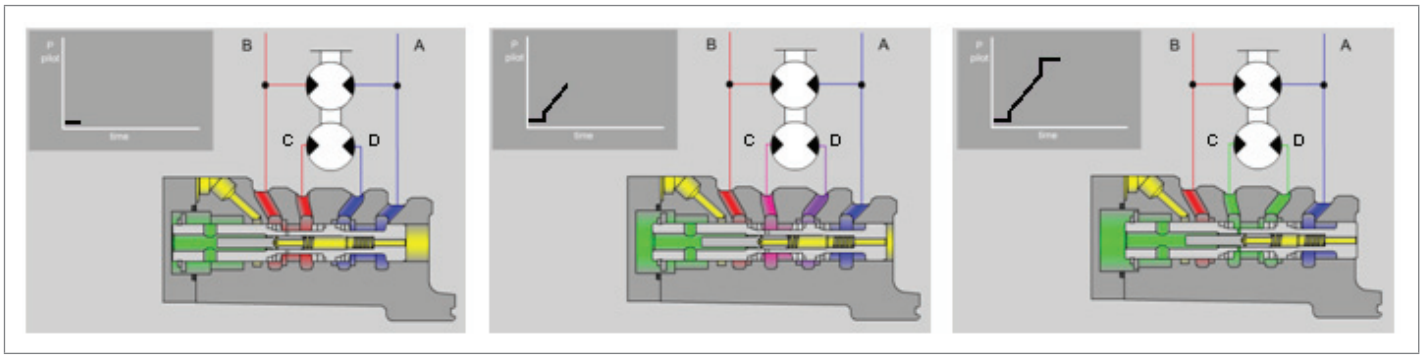
In mobile applications where vehicles are required to operate at high speed, the motor can be switched to a low-torque and high-speed mode. This is achieved by operating an integrated valve which directs hydraulic fluid to only one half of the motor while continuously re-circulating the fluid in the other half. This “reduced displacement” mode reduces the flow required for a given speed and gives the potential for cost and efficiency improvements. The motor maximum speed stated in the relevant data sheet remains unchanged. Rexroth has developed a special spool valve to allow smooth switching from full displacement to reduced displacement mode and back whilst on the move. This is known as “soft-shift” and is a standard feature of 2-speed motors. The spool valve requires either an additional sequence valve or electro-proportional control to operate in “soft-shift” mode.

▼ **MCR motor schematic with 2-speed, soft-shift valve**



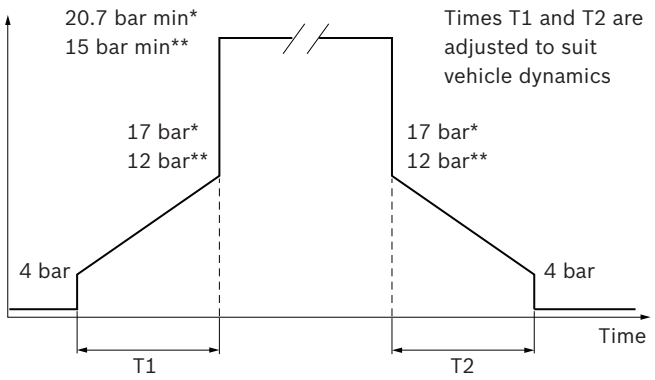
Functional description

MCR 2-speed soft-shift sequence



When a pilot pressure is applied to the **X** port of the motor, the main spool starts to move over its metering notches. During this period, the motor is accelerated until full pump flow passes through the **A-B** half of the motor. The **C-D** half of the motor re-circulates the flow. The inner spool then opens giving a flow path from **X** port to the idling half motor **C-D**. This path maintains the pilot pressure on the idling pistons thus holding them against the cam. In order to ensure the 2-speed shifting sequence, it is required to ramp the pilot pressure as illustrated in the graph below.

▼ **Pilot pressure curve**



* P_{boost} > 20.7 bar
** 15 bar < P_{boost} < 20.7 bar

The ramp times have to be adjusted to suit the vehicle dynamics.

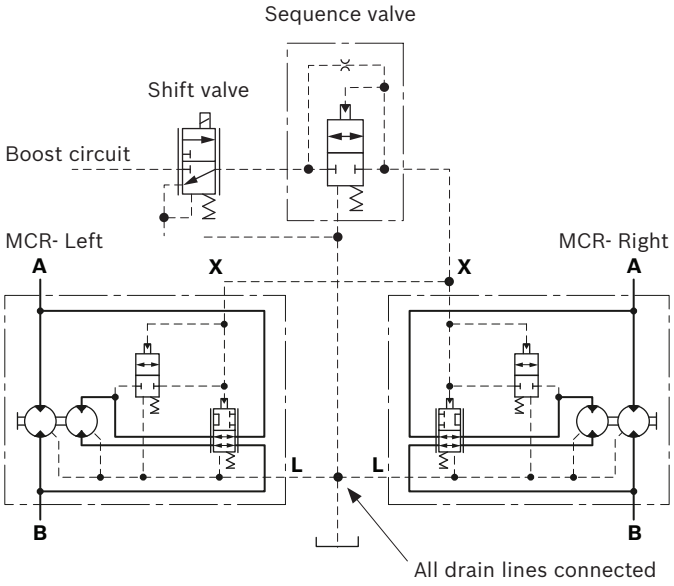
Definition of Solutions

The soft-shift of MCR motor can be realised by selecting a solution as described below that is most suited to the vehicle.

- Hydraulic sequence valve (HCV)
- Electronic sequence valve (ECV)
- Electronic pump control (EPC)

Hydraulic Control Valve (HCV)

▼ **MCR 2-speed shifting using hydraulic pressure sequence valve on a 2-Wheel drive vehicle**



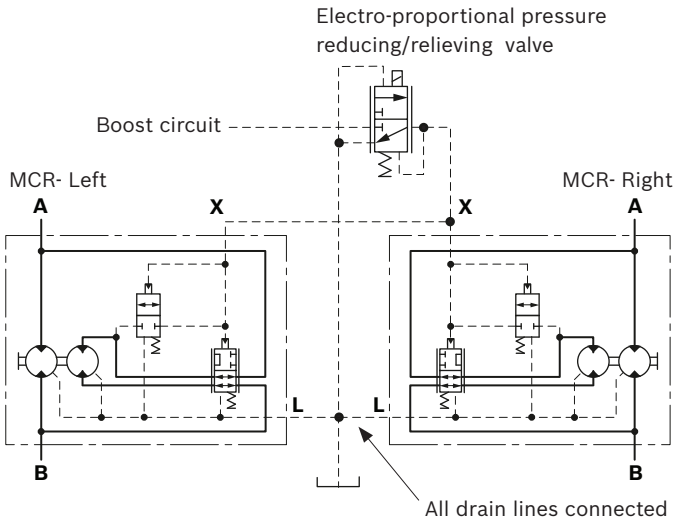
The hydraulic control valve can be used on vehicles that are fitted with a hydraulically controlled pumps.
The hydraulic sequence valve consists of a ramping orifice which restricts flow to the X port of the motors. When the main spool of the 2-speed spool is shifted, the sequence valve which is a directly operated, 2-stage piloted valve is opened so that the orifice is bypassed. The inner spool then opens giving pilot pressure to the idling half of the motor. This provides make-up flow from /to the idling half of the motor. The 2-speed soft-shift behaviour of the machine can be fine tuned by selecting appropriate orifice size for desired ramp time.
The following Rexroth components can be used:

- MCR 2-speed motor
- Hydraulic sequence valve
  - DCOC valve block R934004532: orifice size ø0.4 mm, spring setting 13.5 bar
  - DCOC valve block R934004539: orifice size ø0.5 mm, spring setting 13.5 bar

For any other required combinations please consult Rexroth project engineer for details.

Electronic Control Valve (ECV)

▼ **MCR 2-speed shifting using electronic sequence valve**



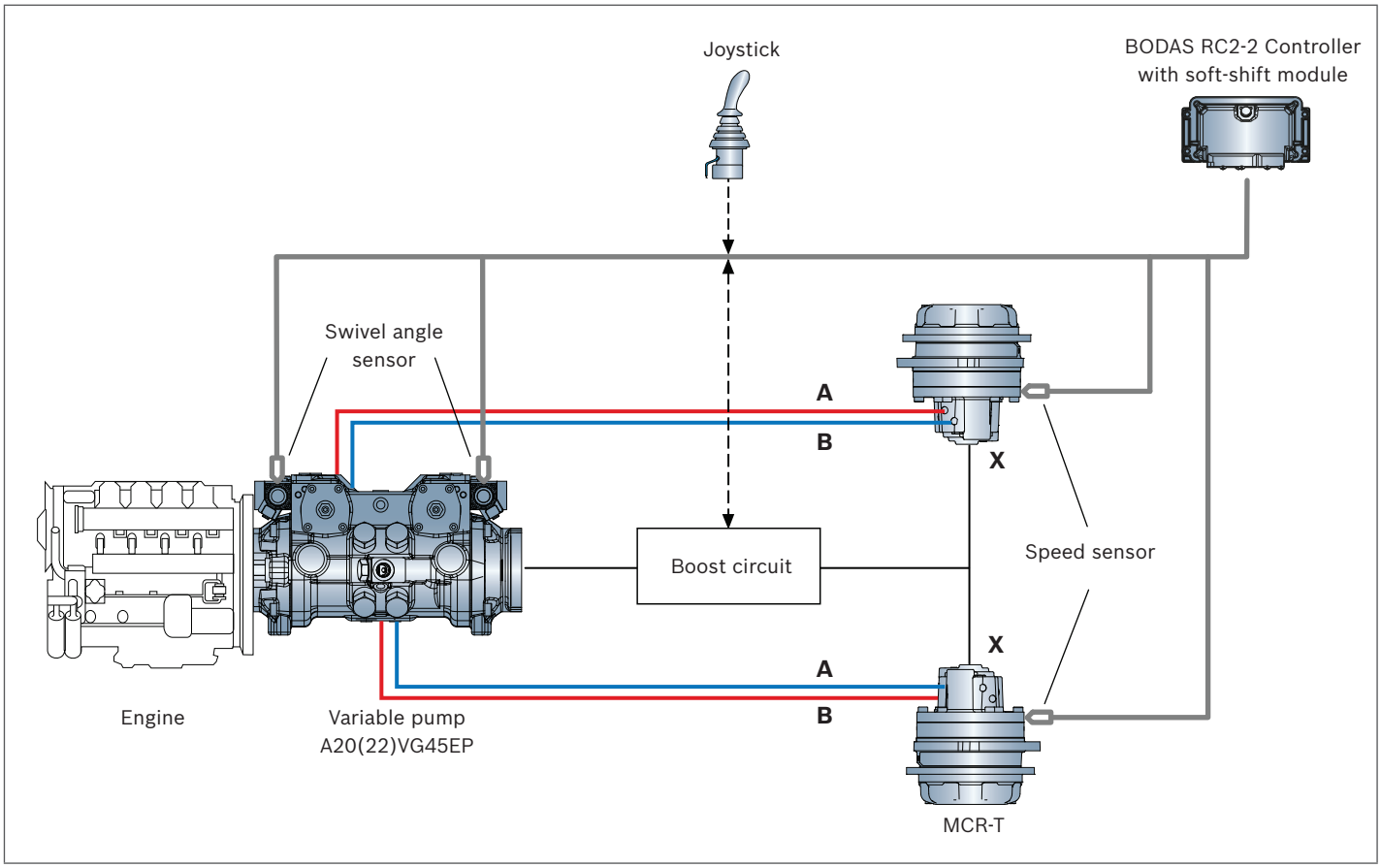
The electronic control valve can be used on vehicles that have electronic control on board. The electro-proportional pressure reducing/ relieving valve can be infinitely adjusted across a prescribed range using a solenoid input. The pressure output is proportional to the DC current input. In this way the ramp time can be proportionally controlled and adapted individually for ramp-up and ramp-down to suit vehicle dynamics as required.
The following Rexroth components can be used:

- MCR 2-speed motor
- Electro-proportional pressure reducing / relieving valve

For any further assistance please consult Rexroth project engineer for details.

Electronic Pump Control (EPC)

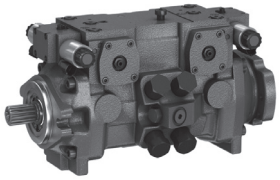
MCR 2-speed shifting using electronic pump controll



Soft-shift using electronic pump control can be used on vehicles that are fitted with a electric proportional control (EP) or electric direct control (ET) pump. The pump swash angle is simultaneously swivelled in/out during MCR 2-speed shifting in order to enhance the MCR 2-speed soft-shift function. When the motor is switched to reduced displacement mode, the RC controller first checks the motor speed and accordingly reduces/increases the pump flow during up shifting/downshifting in order to compensate for the rate of change of pressure during shifting. In this case a shifting valve to supply pilot pressure to the X-port is sufficient. The sequence valve to ramp the pressure is not necessary.

Shifting event

The component level breakdown of phases during soft-shifting of MCR motors from full displacement to reduced displacement modes are explained in the following:

	BODAS 	**MCR Motor** 	**EP Pump** 
Start of shifting motor in full displacement	Motor speed recorded via speed sensor	Pilot pressure applied to 'X' port of the motor	Pump swivel angle = 100%
Time	Reduce swivel angle of pump to reduce displacement and maintain speed	Main spool starts to move over its metering notches	Reduce pump swivel angle by 50% (to be parameterised)
	Increase swivel angle of pump when spool fully shifted	Full pump flow passes through half motor while flow re-circulates in the other half	Maintain pump swivel angle at 50%
End of shifting motor in reduced displacement		Inner spool opens to connect x-port to idling half-motor in order to hold pistons on the cam	Pump swivel angle to match required motor acceleration and speed requirements

Definition of components

- MCR motor with speed sensors
  For technical data see standard DO/100/117
- Bodas RC2-2 Controller or higher
- Software part no: R902187164_XX
- EP/ET pumps with swivel angle sensors

To implement and parameterise the 2-speed soft-shifting of MCR motors consult Rexroth project engineer for details.

References:

MCR motors: Data sheet 15195, 15196, 15197, 15198, 15199, 15200, 15214, 15221 and 15223

Pumps: Data sheet 93220/05.09, 92004-A/12.09, 92003/09.07

Bodas RC2-2: Data sheet 95202/02.12

Speed sensors: DO/100/117

Bosch Rexroth Limited
Viewfield Industrial Estate
Glenrothes, Fife
Scotland, KY6 2RD
UK
Phone +44 15 92 631 777
Telefax +44 15 92 631 936
info.ma@boschrexroth.de
www.boschrexroth.com