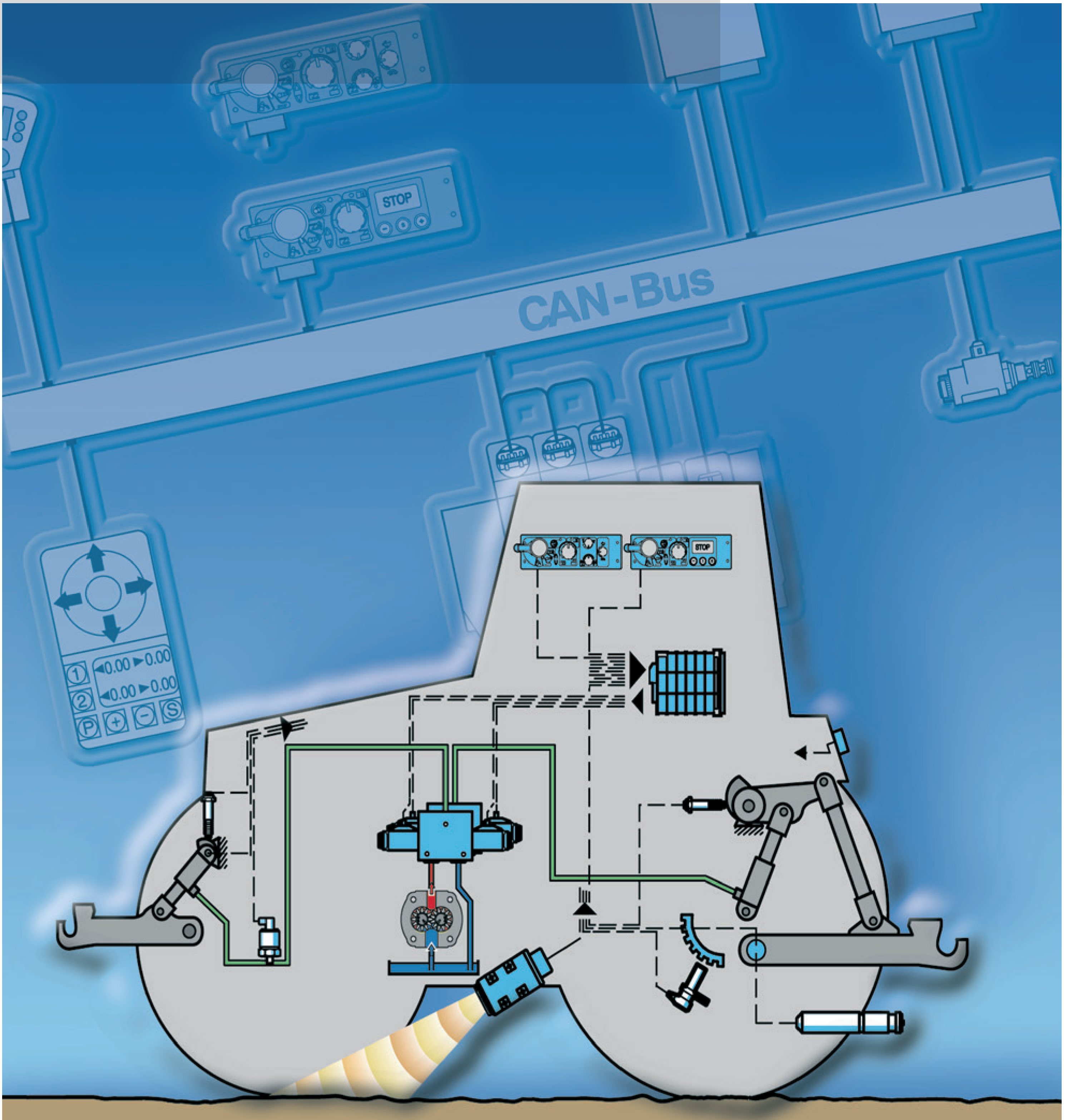
Rexroth
Bosch Group

Hydraulics in Mobile Equipment



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13.3.3 Sensors

13.3.3.1 Draft sensor

The draft sensor takes the form of a bearing pin with which the lower guide rods of the implement are connected to the tractor. It replaces a merely mechanical bolt which would normally be found in this place. Shear stresses occur at the bearing, and these are evaluated as a magneto-elastic effect. This effect occurs in ferromagnetic materials and makes use of the dependence of magnetic permeability on mechanical shear strain.

Operating principle
The magneto-elastic effect is measured by means of primary and secondary coils in a central bore of the sensor. In non-load condition, a symmetrical magnetic field is formed between the poles by means of the primary coil. If tensile or traction forces are introduced, the magnetic properties of the originally isotropic material change. Subsequently, the magnetic field becomes unsymmetrical. Thus, a magnetic potential difference occurs between the secondary poles. This difference causes a magnetic flux through the secondary circuit so that a voltage is induced in the secondary coils. This voltage is proportional to the influencing force.
The electronics are integrated in the sensor.

1 Primary coil
2 Secondary coil
3 Primary pole area
4 Secondary pole area
5 Steel sleeve
a symmetrical magnetic field
b asymmetrical magnetic field

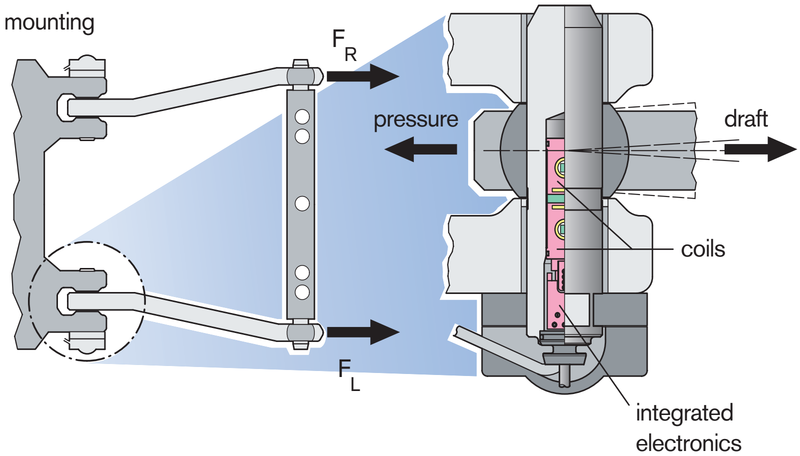


Fig. 13.12 Operating principle of EHR draft measurement of power

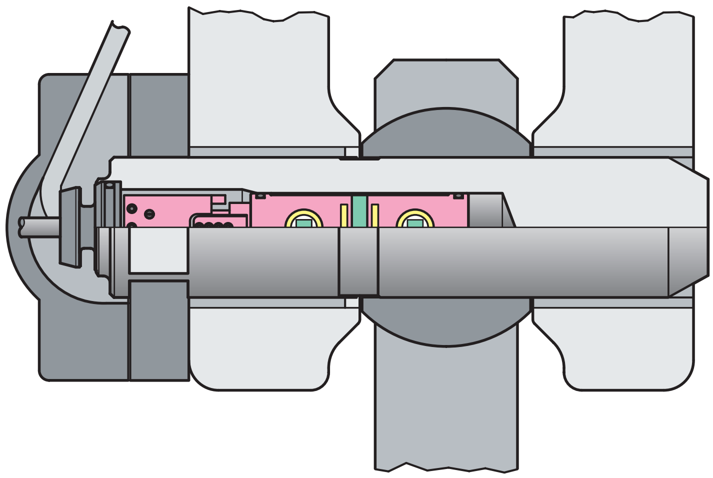


Fig. 13.13 Construction of the draft sensor

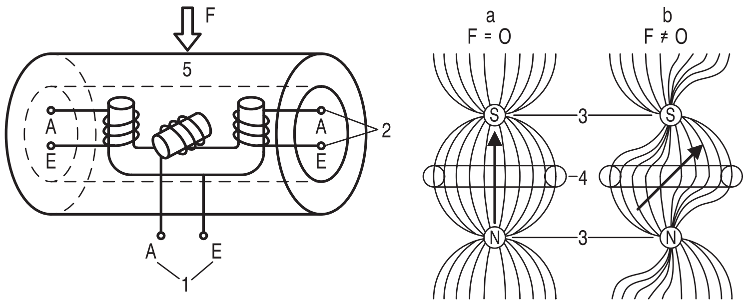
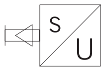
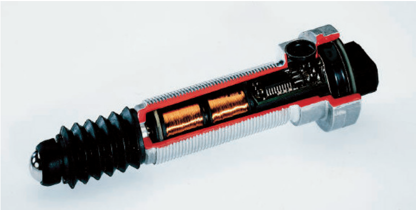


Fig. 13.14 Operating principle of the draft sensor

13.3.3.2 Inductive position sensor





The position of the hitch is sensed via a cam disk by a position sensor whose output is transformed into an electric signal. The position sensor operates according to the principle of the inductive voltage divider and basically consists of a coil with center tapping and a mobile ferrite core which is moved by the cam disk of the hitch. The inductive voltage divider is supplied by alternating current which is generated by means of integrated electronics. The output signal is demodulated (rectified).

Features

- Axially mobile scanner with spring preload
- Inductive position sensor element based on the differential throttle measuring principle
- Integrated electronics with temperature compensation
- Output signal proportional to position
- Precise balance adjustment for zero and sensitivity

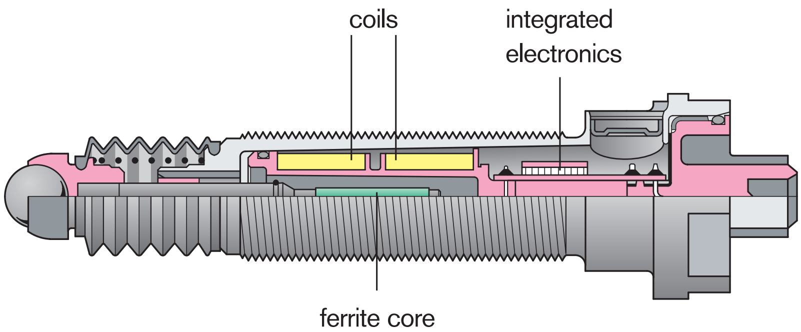


Fig. 13.15 Construction of the inductive position sensor

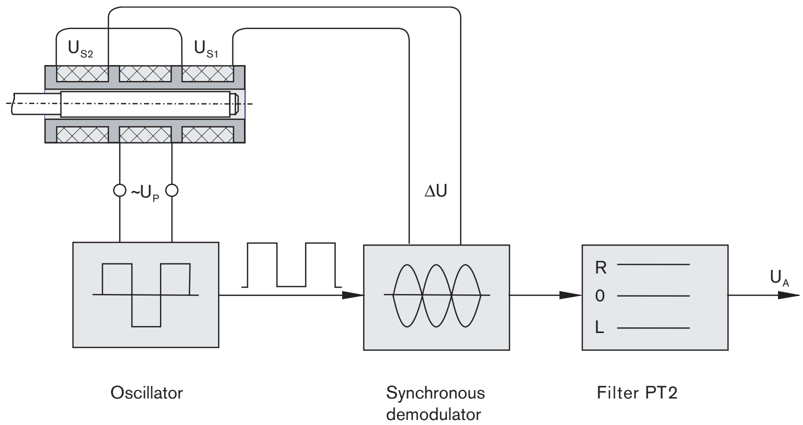


Fig. 13.16 Operating principle of the inductive position sensor

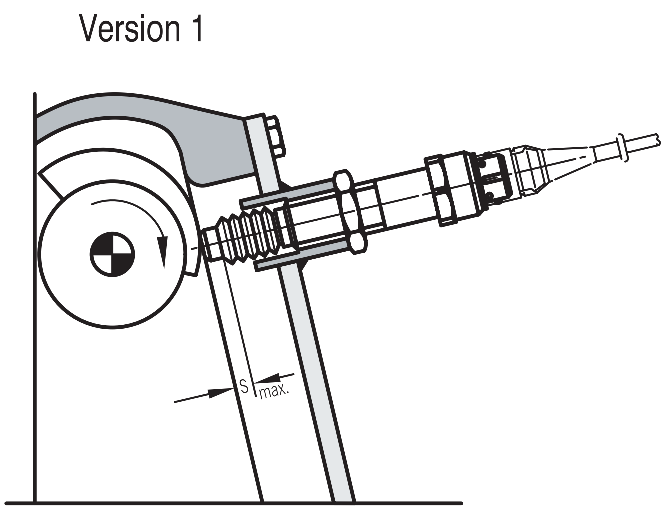
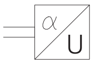
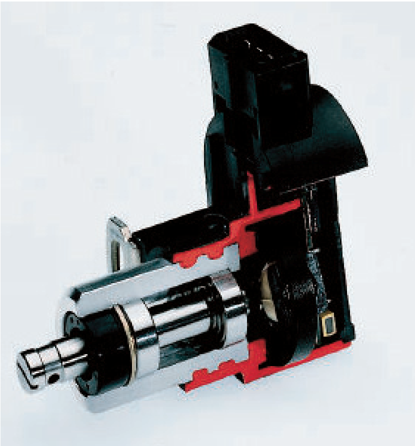


Fig. 13.17 External version of the inductive position sensor

13.3.3.3 Inductive angle sensor





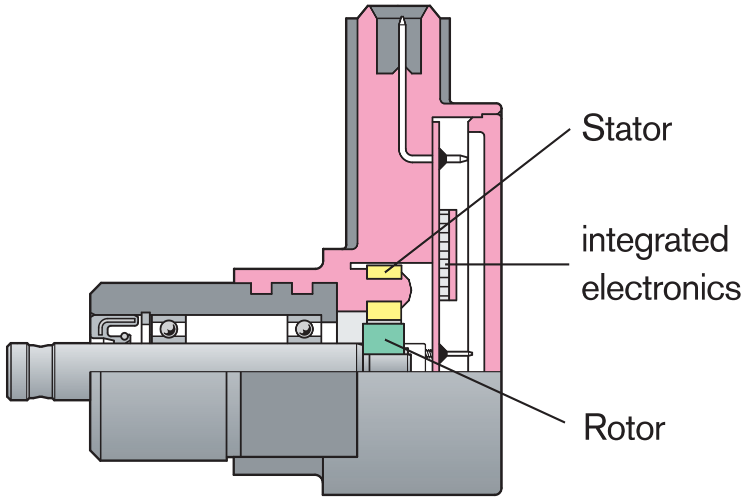


Fig. 13.18 Construction of the inductive angle sensor

The inductive angle sensor serves to register information on angles. It also works according to the principle of the inductive voltage divider. The mechanical information on angles is relayed via the shaft to the rotor made of soft, magnetic material. The eccentricity of the rotor causes the induction in the two coils to change depending on the position of the angle. The output signal is demodulated and is available as a voltage signal for processing.

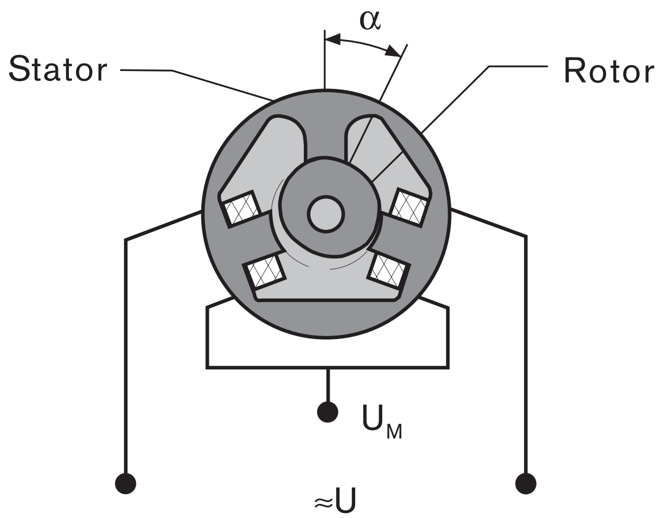
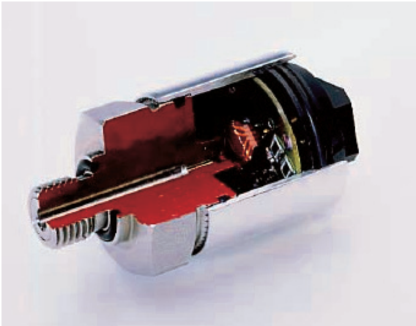


Fig. 13.19 Operating principle of the inductive angle sensor

Features

- Inductive angle sensor element based on the differential throttle principle
- Shaft can be turned mechanically
- Integrated electronics with temperature compensation
- Output signal proportional to angle
- Precise balance adjustment for zero and sensitivity

13.3.3.4 Pressure sensor



The pressure sensor operates according to the thin-layer strain gauge sensor principle. Its measuring element is a stainless-steel membrane on which thin-layer measuring resistors are applied by means of vacuum evaporation.
This is a robust solution which provides high precision, high long-term stability and a low dead volume. The sensor evaluation electronics are integrated.

1 connecting part
2 membrane
3 flexible circuit
4 evaluation circuit
5 connecting plug
6 housing/shell

Features

- Pressure sensor element, consisting of a stainless steel membrane (spring material), with thin-layer strain gauge sensor and full bridge circuitry
- Integrated electronics with temperature compensation
- Output signal proportional to pressure
- Precise balance adjustment for zero and sensitivity
- 3-pin plug connector

Installation instructions

- Position the pressure sensor as close to the consuming device as possible
- Installation position as vertical as possible, plug facing downward, so that the dead volume is bled automatically
- Pressure medium: hydraulic oil
- other fluids and gases on request

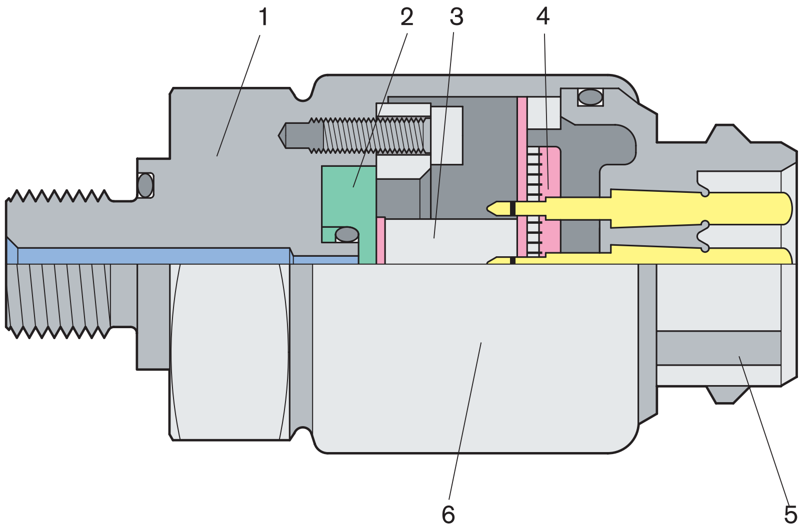


Fig. 13.20 *Construction of the pressure sensor*

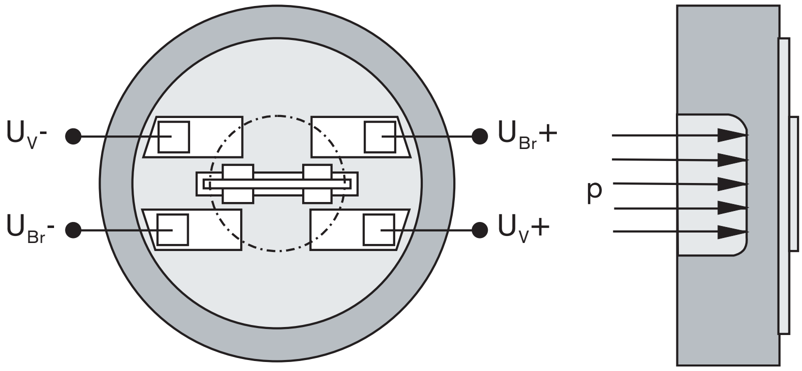


Fig. 13.21 *Operating principle of the pressure sensor*

13.3.3.5 Characteristic curves
Due to the unipolar supply voltage in vehicles, certain specifications must be set for the value range of the test signals of the single sensors. The active signal range is thus set between 2.5 … 7.5 V.
The zero point setting takes place at 2.5 V for position and pressure sensors, whereas the zero point setting for draft sensors occurs at 5 V. Anything below this voltage is considered a draft force, anything above a pressure force.

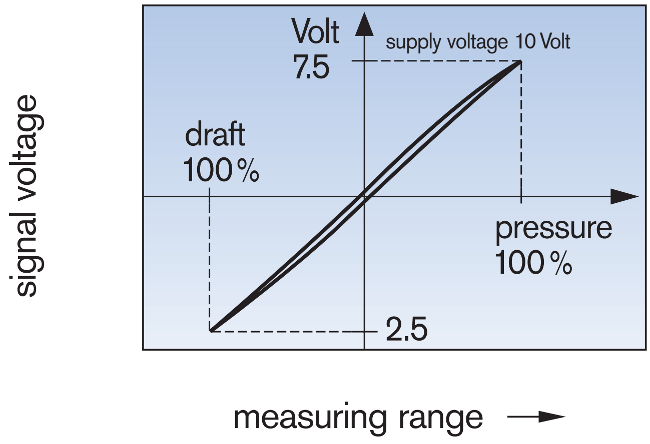


Fig. 13.22 *Characteristic curve for draft sensors*

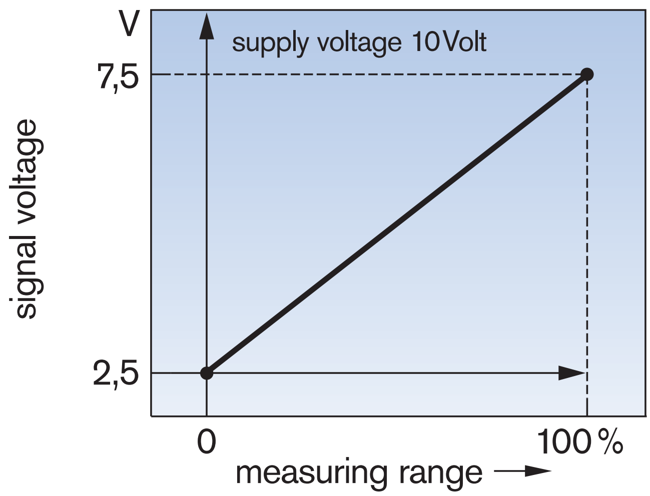


Fig. 13.23 *Characteristic curve for position and pressure sensors*

13.3.3.6 Radar sensor

Two signals are required for slip sensing, one for the actual speed and one for the theoretical speed. A radar sensor which operates according to the Doppler principle is used for measuring the driving speed. It supplies an output signal which is proportional to the actual driving speed; this output signal is standardized to 130 impulses per meter of driven path.
In addition to slip control, the output signal can also be used for display and other control functions.

Specifications

Speed range:	0.4 - 70 km/h
Accuracy:	±1%
Output signal:	36.6 Hz/km/h
	132 pulses/m

Manufacturer: e. g. Dickey-John (F)

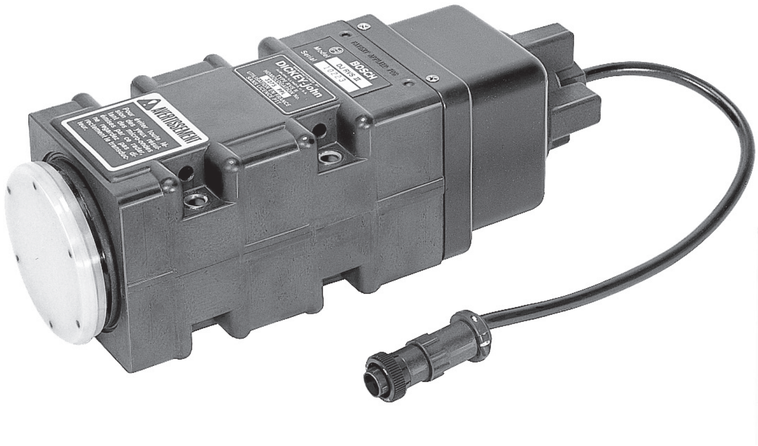


Fig. 13.24 Radar sensor

Fig. 13.25 Inductive speed sensor

13.3.3.7 Inductive speed sensor

Two signals are required for slip sensing, one for the actual and one for the theoretical speed. An inductive speed sensor which is integrated in the gear is used for measuring the theoretical driving speed.

Features
The soft-iron core of the speed sensor, which is encircled by a winding, is located opposite a rotating tooth lock washer. The soft-iron core is connected to a permanent magnet, the magnetic field of which spans the tooth lock washer. On rotation, tooth goes into gash and vice versa. In this way, AC voltage, the frequency of which is suitable for speed determination, is induced in the coil.
Application
This inductive speed sensor is suited to a variety of uses in the recording of speed. It measures engine speed or wheel speed fully contactless and wear-free and converts them to electric signals.

13.3.4 Control panel

Control panels must be adjusted to the cabin design. Therefore they are designed by the tractor manufacturer. Normally, they contain the following functions

- Lift-control lever
- Setpoint potentiometer
- Selection-Draft control
- Operating mode selector
- Lowering velocity
- LED slip display
- LED error diagnosis

Dependent on the number of functions and on customer requirements, further operation and display elements can be provided, e. g. for slip control, pressure control or vibration damping. The Lifting and Lowering functions can not only be controlled on the control panel but also manually, from the rear of the tractor, by means of buttons.

Circuit diagram

[1] Lift-control lever
4 positions:
- a Transport, Lifting
- b Stop
- c Control, Lowering
- d Neutral, Rapid retraction (spring return)

[2] Lock (transport)
[3] Lowering speed setting
[4] Setpoint setting for hitch positions
[5] Limit upper end position
[6] Mixture; infinitely variable setting between draft and position control
[7] Lamp: Diagnosis
[8] Lamp: Lifting
[9] Lamp: Lowering

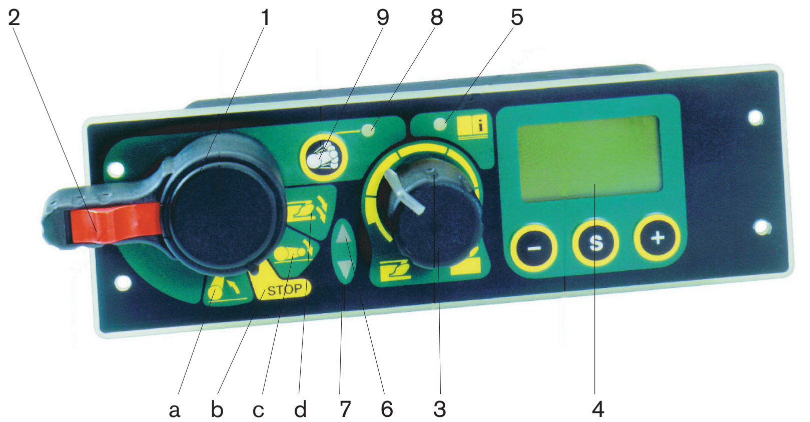


Fig. 13.26 EHR control panel

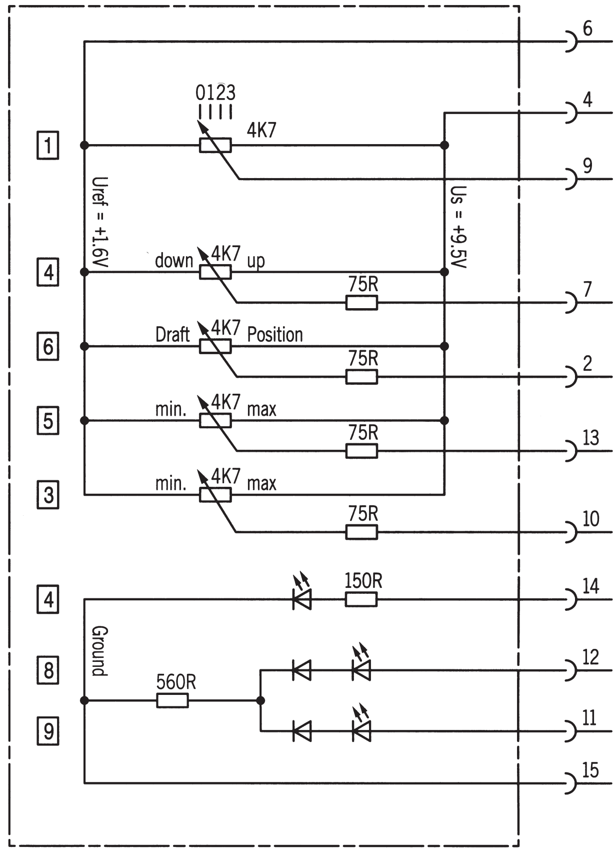


Fig. 13.27 Circuit diagram for a simple EHR control panel

13.4 Operating modes

13.4.1 Position control

Position control is used to transport attached implements to a specified position in relation to the tractor. The distance to the ground is pre-selected by means of the setpoint setting at the control panel (10/11). The position sensor (9), which is operated by a cam disk on the hitch, supplies the actual value as the feedback signal for position control. The electronic control unit (12) processes the setpoint and the actual value to achieve a manipulated variable which is supplied to the servo solenoid valve (2/3). At the start and at the end of operation, the lifting control lever brings the hitch out of the controlled position or into it. The lowering velocity is adjustable.

13.4.2 Draft control

Draft control is used in ploughs or listers. In this case, the controlled variable is the force at the trailing linkage. If it can be kept constant, it means that the tractor power is being used optimally, for instance when ploughing undulating land and inhomogeneous soil.
In the case of draft control, two electronic draft sensors (6/14), which are constructed as bearing pins, sense the occurring draft and pressure forces in the trailing linkages. The draft setpoint which is necessary for achieving the working depth is set at the control panel (10/11). The draft setpoint only becomes effective when draft control is selected, not when position control is selected. The draft is adjusted by varying the working depth of the attached implement (e. g. plough).

13.4.3 Mixed control

In this case, the control deviations of position and draft are mixed in an adjustable ratio at the control panel and then processed as the control variable. Mixed control allows variations in working depth due to fluctuations in soil resistance, which occur with pure draft control, to be reduced.

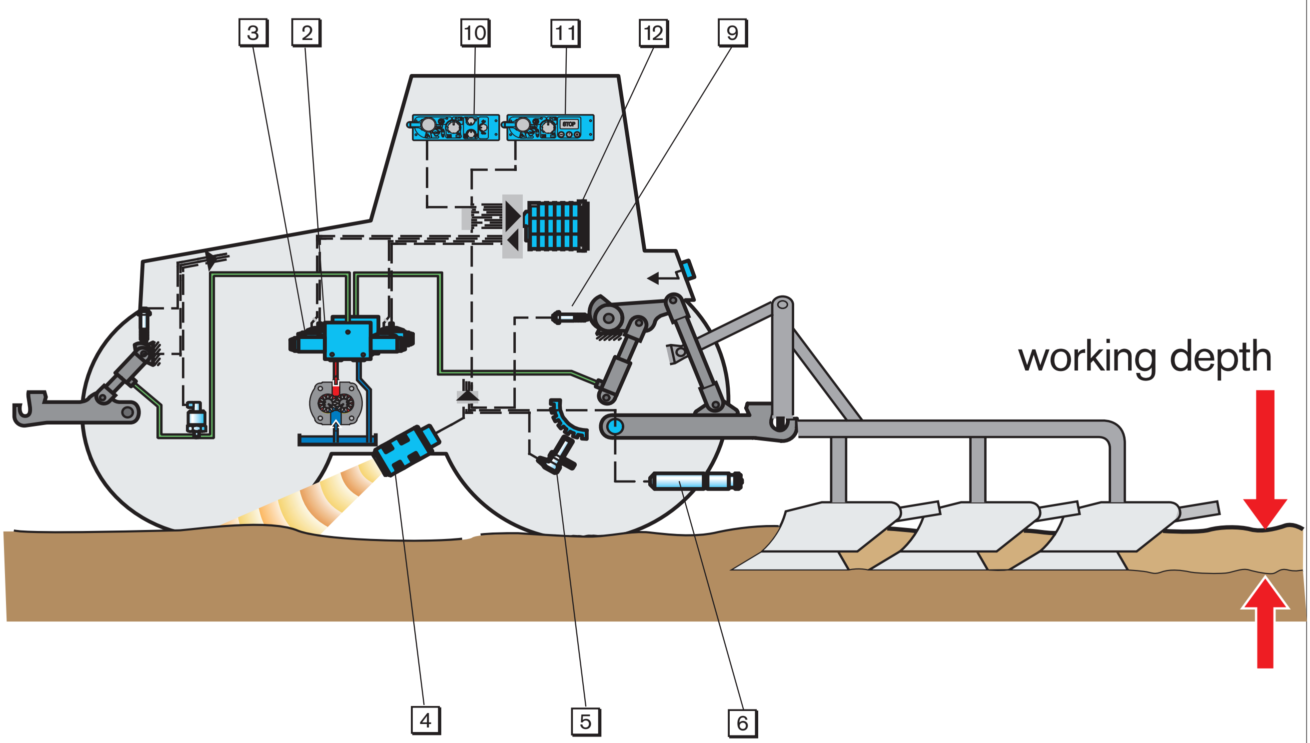


Fig. 13.28 Operating principle of position, draft and slip control

13.4.4 Slip control in draft

With optimum utilization of the draft of a tractor in the field, a relatively large slip of the drive wheels is physically unavoidable. If the slip, however, exceeds values of 25 to 30%, unacceptable disadvantages occur. For a targeted slip control, the actual driving speed is ascertained by means of a radar sensor (4) and compared to the speed sensor. (5). Increasing slip has the same effect on the controller as increasing draft, i. e. the hitch is raised with increasing slip, and thus decreases the draft of the devices by reducing the working depth. The slip control is actuated by the operating mode switch at the control panel (10/11).

Slip control offers the following advantages:
- savings in both time and fuel,
- reduced tire wear,
- the soil is treated with greater care,
- the driver is under less strain,
- the vehicle does not get stuck.

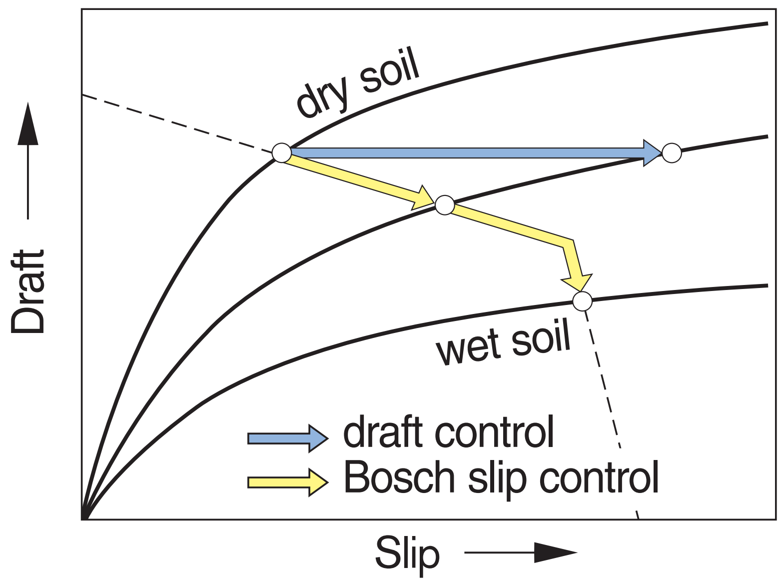


Fig. 13.29 The effect of slip control

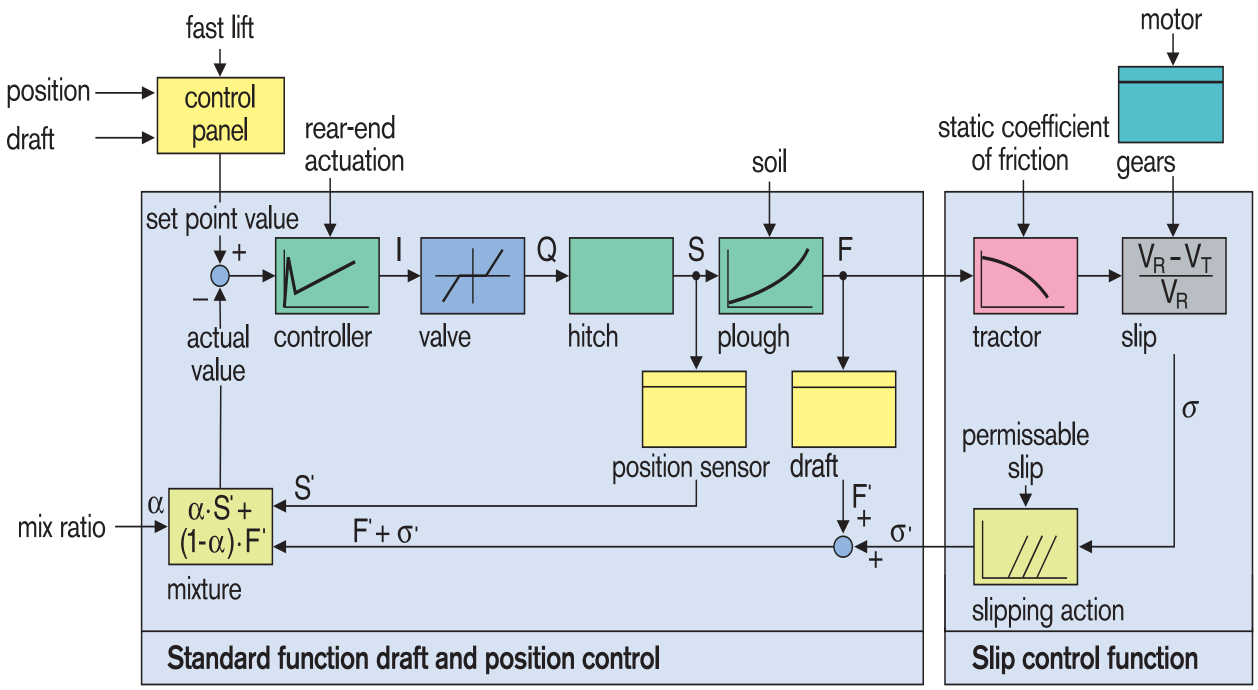


Fig. 13.30 Block diagram of the position, draft and slip control

13.4.5 Pressure control

Pressure control enables optimum packing of the soil by means of pakking rollers. To control the pressure force of working devices, it is sensed by a pressure sensor (1) and fed to the control electronics as the actual value. In the arrangement shown, the load pressure (2) is varied by the weight (3) which can be hydraulically adjusted. The control is maintained very precisely in dynamic movements as well, e. g. in the pitching of the tractor.

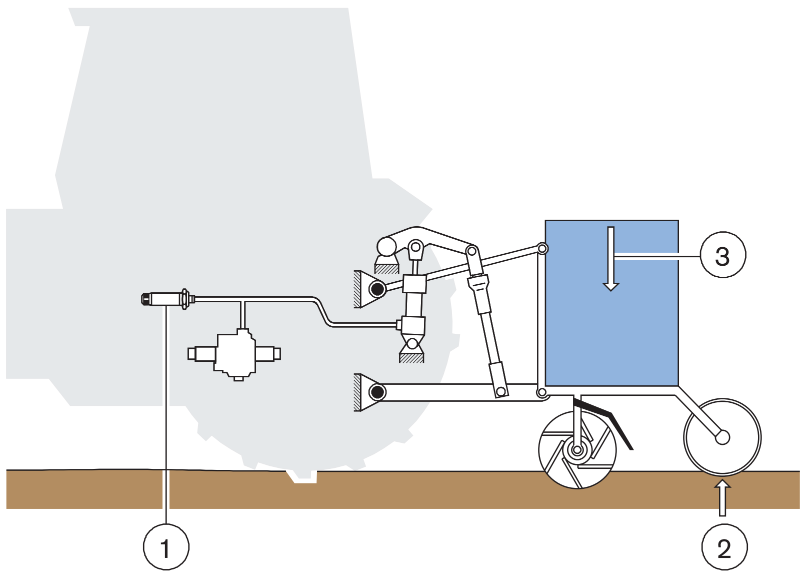


Fig. 13.31 Pressure control

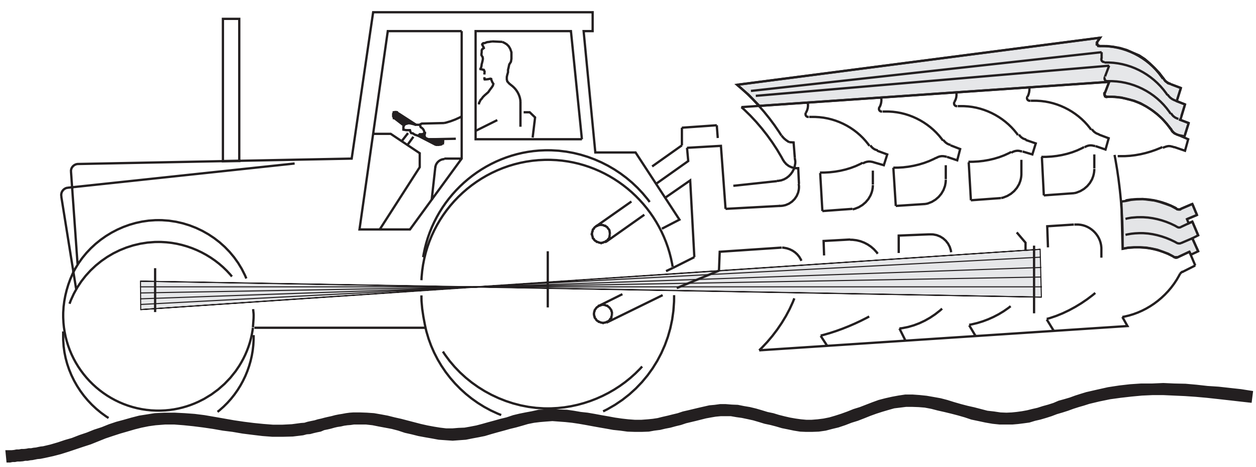


Fig. 13.32 Active vibration damping

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R961000791
ISBN 978-3-9816398-0-3
9 783981 639803