Electronic Controls for Proportional Valves

Wilbert Schenkel

1 Definitions and Explanations

In this chapter, the most important components of control electronics for proportional valves are explained together with terms, functions and block diagrams. This is intended as an aid for those who previously have had little or nothing to do with this subject.

1.1 Ramp Generator

The ramp generator *(Fig. 99)* produces from a stepped command signal as the input signal a slowly raising or falling output signal. The temporal change of the output signal can be varied by means of a potentiometer which can be fitted on the frontplate of the amplifier.

The operating principle of the ramp generator is based on the concept that the capacitor C is charged with a delay so that the output voltage constantly changes slowly with respect to a stepped input signal.

The increase in the output voltage can be influenced via the variable resistor *R*, thereby determining the charge rate of the capacitor *(Fig. 100)*. The set ramp time is always referred to 100 % comand signal (stepped input signal).

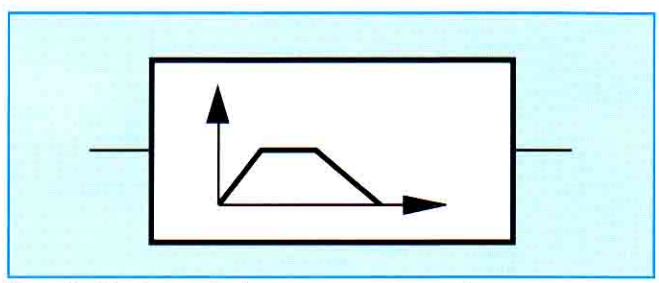


Fig. 99: *Block circuit diagram: ramp generator*

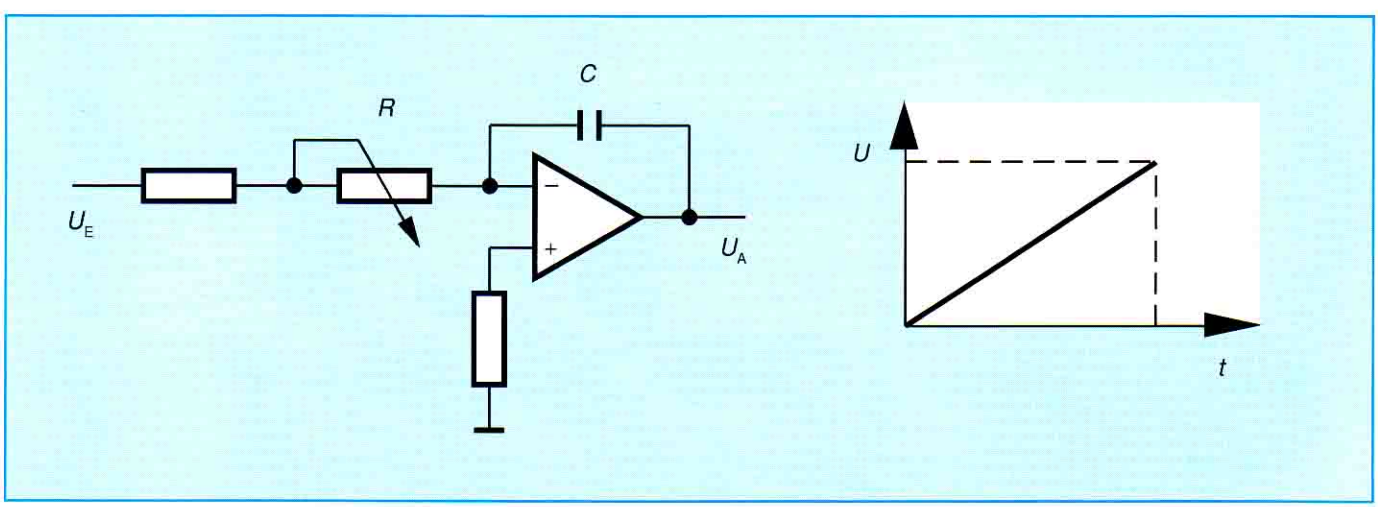
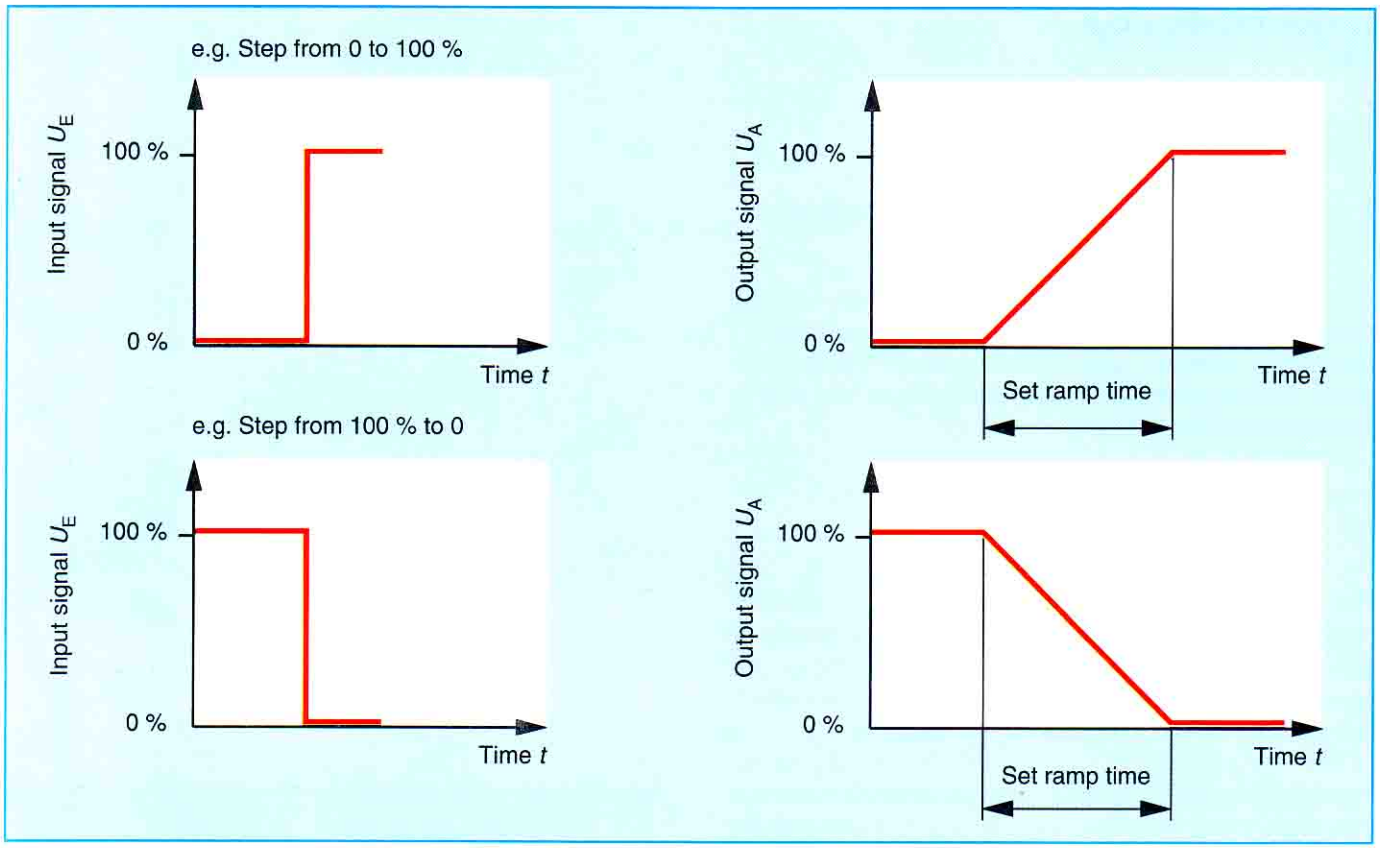


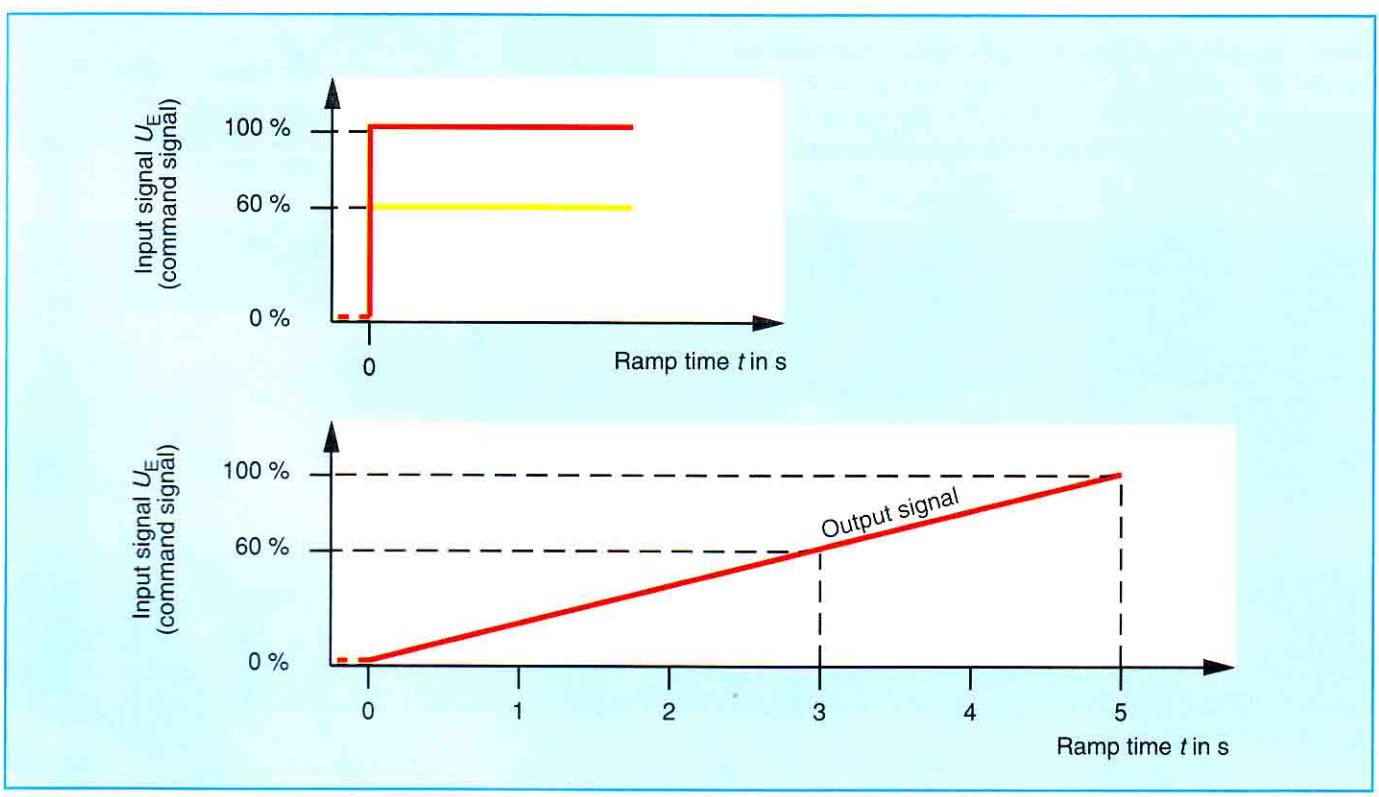
Fig. 100: *Ramp generator*

1.1.1 Example

A ramp time of max. 5 s may be set at 100 % command signal : If, for example a command signal of 60 % is set then the command signal is reached after approx. 3 s.



Diag. 24: *Stepped signal, ramp time*



Diag.25: *Ramp time as function of input signal*

1.2 Pulsed Output Stage

The command voltage is converted into a solenoid current in the output stage. The solenoid current is pulsed in order to maintain as low as possible the power loss of the output stage and therefore the theoretical load of the pc board.

The pulse frequency is determined by the pulse generator dependent on the type of valve.

The power supply to the solenoid is varied corresponding to the duty cycle of the terminal power transistor.

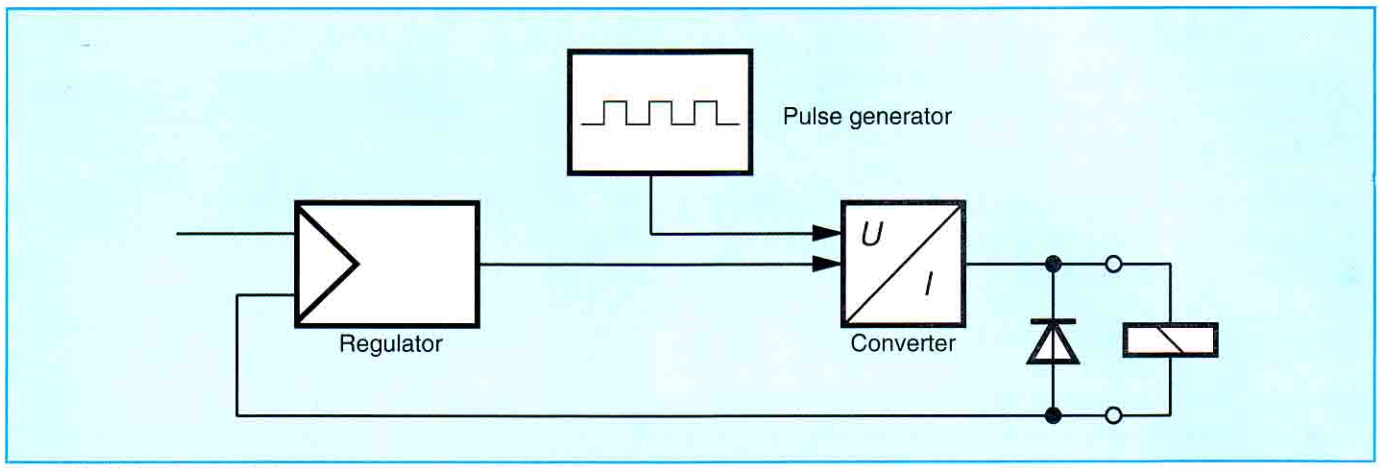


Fig. 101: *Pulsed output stage*

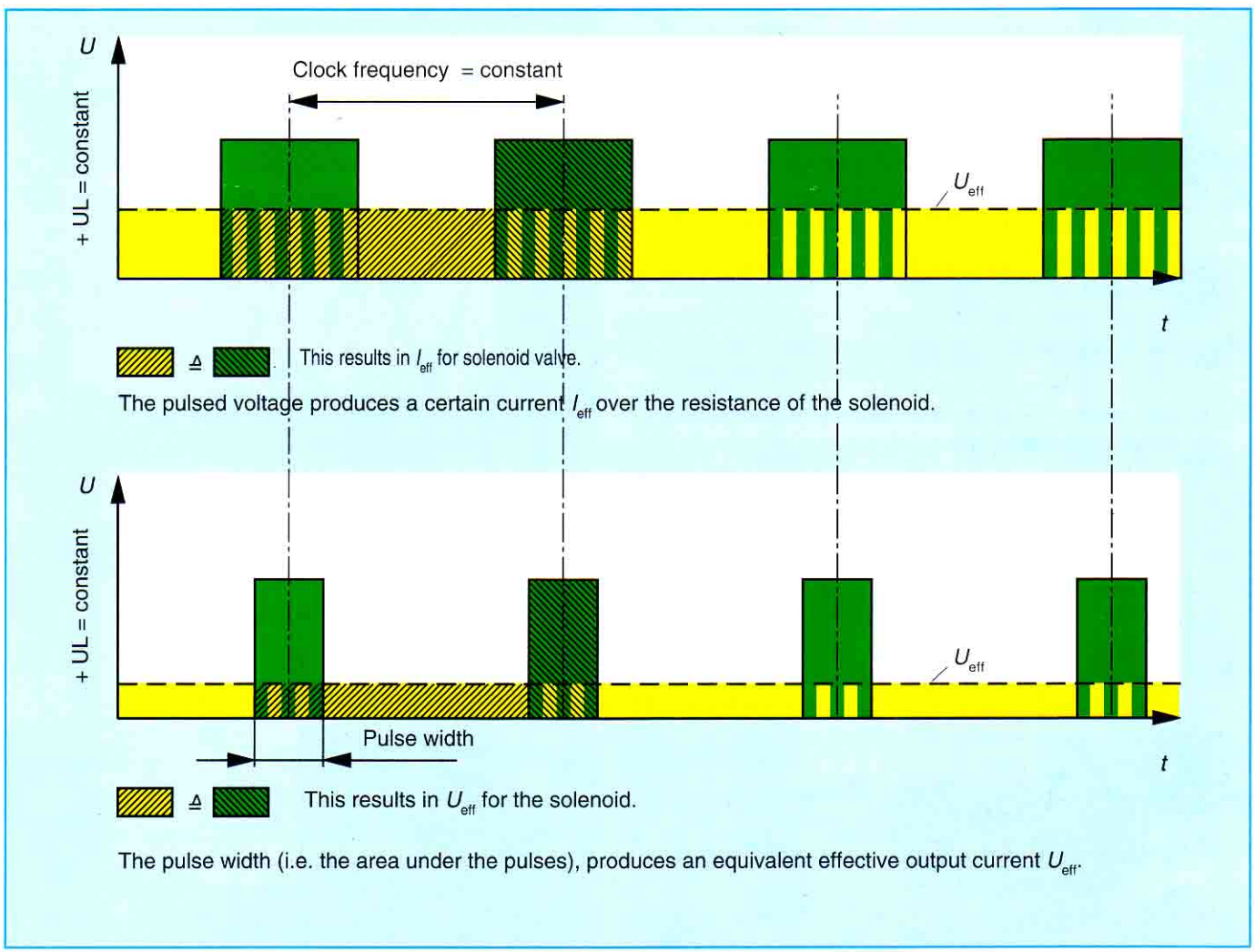


Fig. 102: *Pulsed output stage fully "on" (upper diagram) and partly "on" (lower diagram)*

1.3 Power Supply

The power supply for all proportional amplifier cards can be formed as shown in *Diag. 26.*

To increase contact reliability, 2 terminals are used for the power supply *(Fig. 103).*

1.3.1 Example

Configuration of the voltage supply stages on the amplifier cards based on the example of the single-phase full-wave rectifier stage *(Diag. 27).*

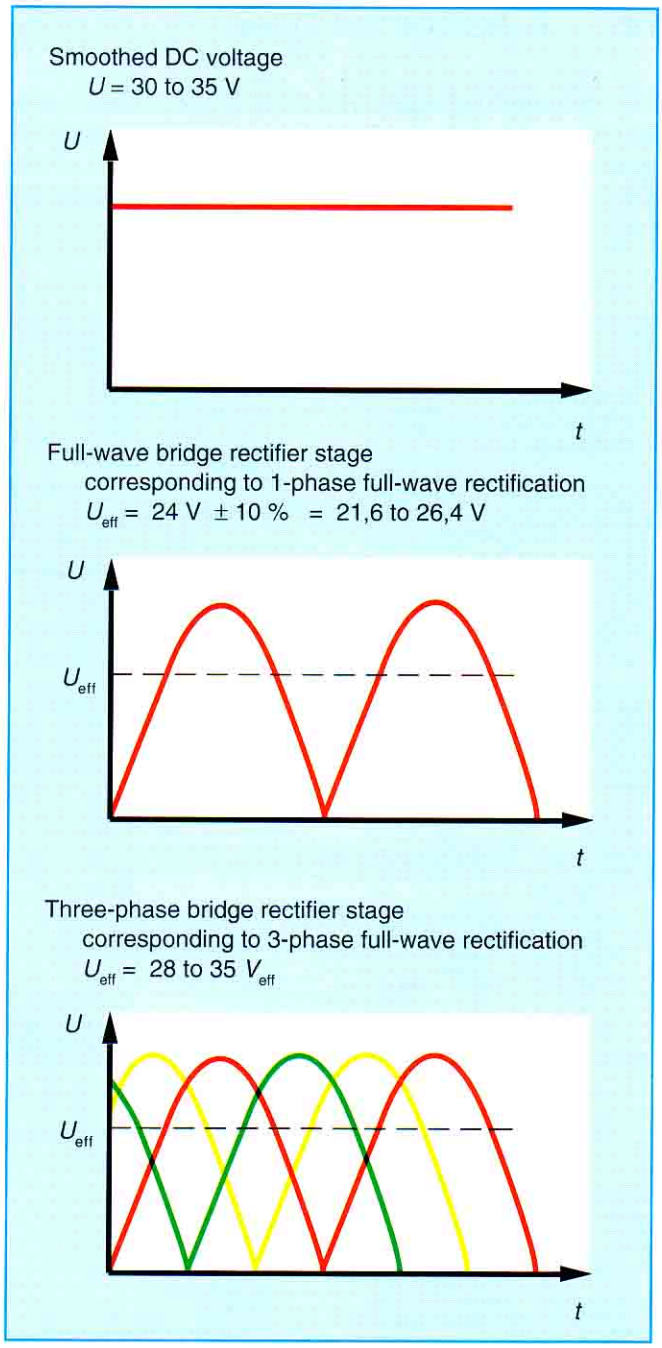
Conversion of the voltage available from the actuator network takes place in the first section from 220 V to 24 V. It is then fed to the amplifier card.

The input voltage is smoothed in the 2nd section.

Conversion of the smoothed voltage into a stabilized voltage of 18 V takes place in the 3rd section. By selecting a new reference point M0, the stabilized voltage of ±9 V is obtained referred to this point M0.

1.3.2 The following points must be observed for all amplifier cards:

- The power supply must be disconnected before unplugging the amplifier card.
- Measurements in DC voltage position.
- Measured (control) zero (M0) is raised by + 9 V with respect to 0 V supply voltage.
- Do not connect M0 to 0 V supply voltage.
- Do not connect the ground symbol on the inductive positional transducer to the 0 V supply voltage.
- A minimum distance of 1 m must be maintained from radio equipment.
- Signals must be switched only by means of contacts, suitable for currents < 1 mA.
- Signal lines and lines of the inductive positional transducer must be screened. Leave screen open on one side: connect card side to 0 V supply voltage.
- Do not lay solenoid lines in the vicinity of power lines.
- When using the internal relay the 24V relay contact voltage must be used



Diag. 26: *Power supply*

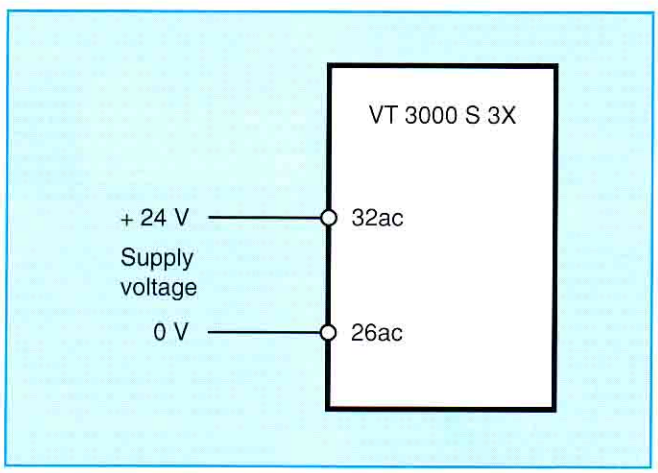
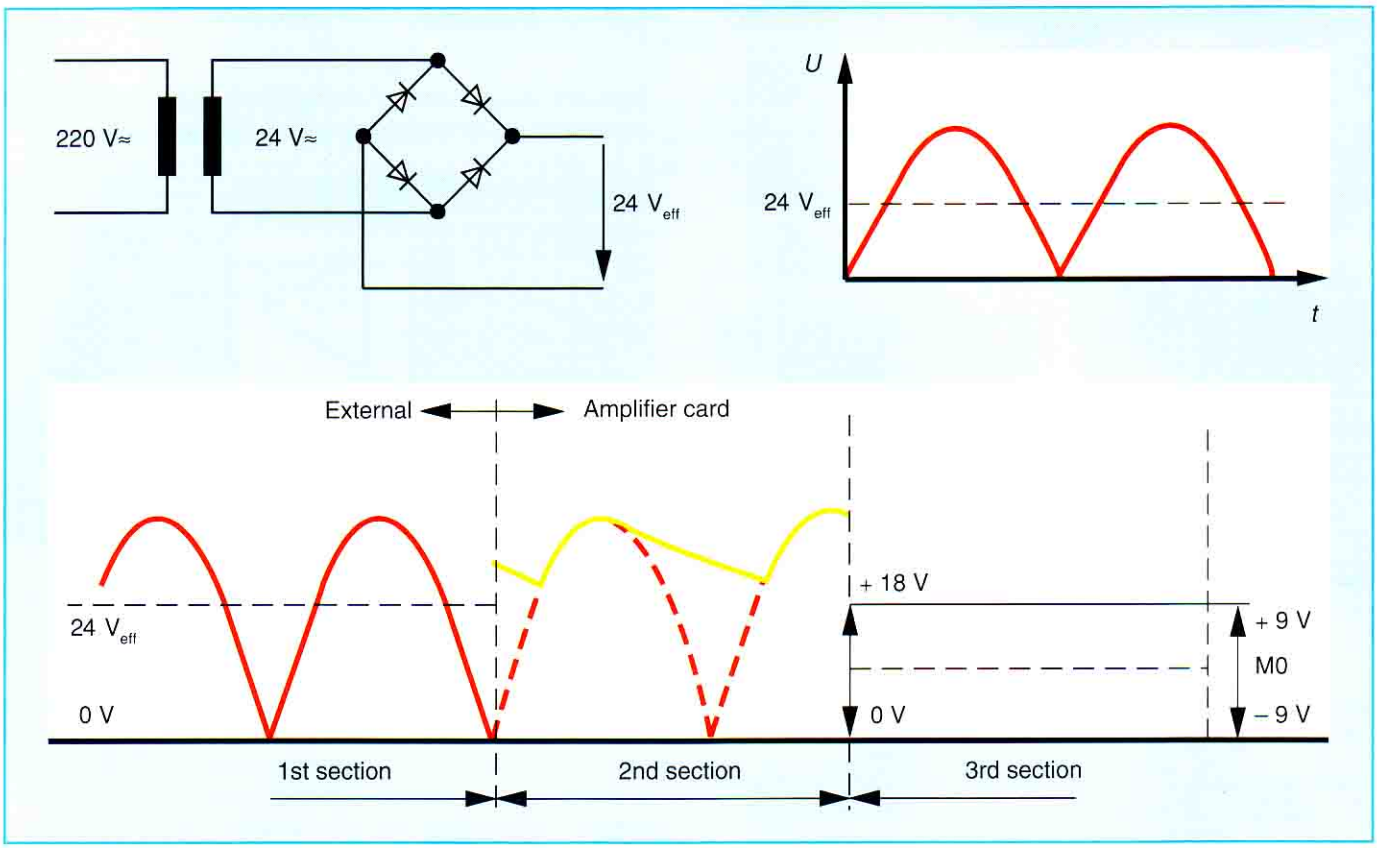


Fig. 103



Diag. 27 : *1-phase full-wave rectifier stage*

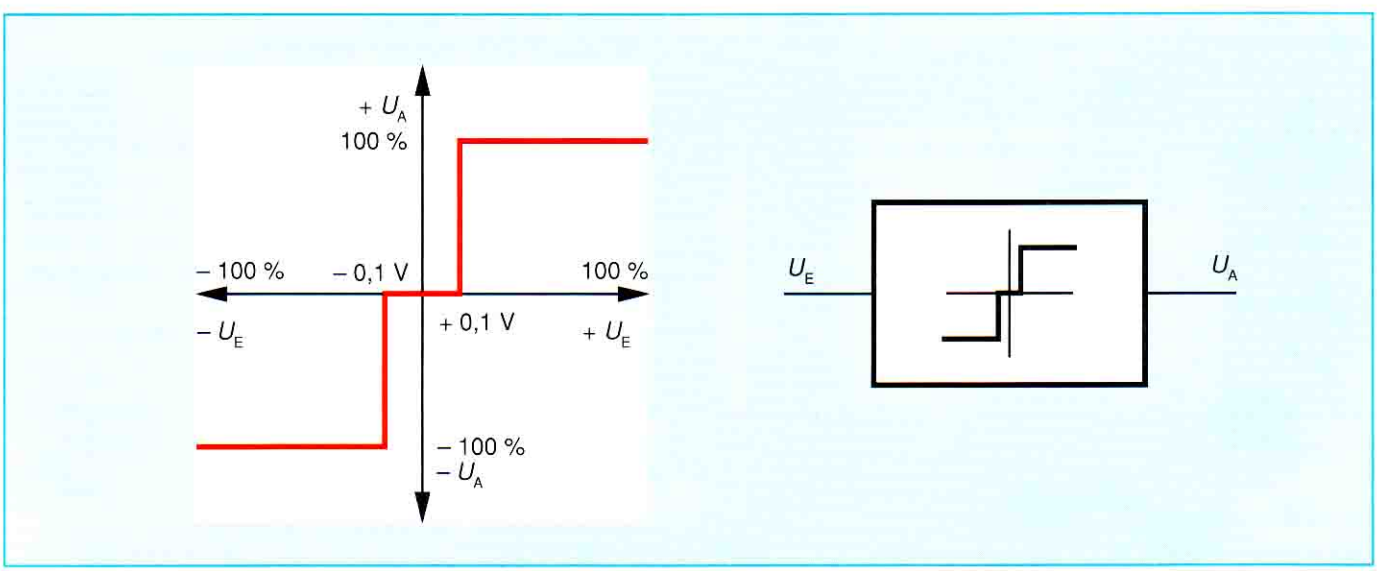
1.4 Cable Break Detection

The cable break detection facility monitors the supply line to the transducer. In the case of fault, i.e. one of the three cores of the connecting cable for the positional transducer is broken, the power to both solenoids A and B is cut and the valve assumes its mid-position.

1.5 Step Generator

The step generator produces a constant output signal at command voltages greater than 100 mV. The output signal is 0 V at command voltages less than 100 mV.

The output signal of this function generator causes a current step at the solenoid. This current step serves the purpose of quickly overcoming the positive overlap of the proportional valves.



Diag. 28: *Step function generator*

1.6 Regulator on Proportional Amplifier Cards

The regulators of the proportional amplifier cards are specially adapted to the various types of valve. Corresponding to the difference between actual and feedback signals, the regulator produces an output signal which controls the pulsed output stage.

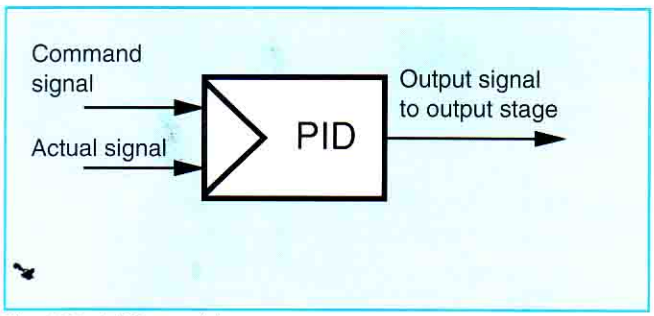


Fig. 104: *PID regulator*

1.7 Summator

The summators on the proportional amplifier cards add two voltages, whereby the output signal is inverted.

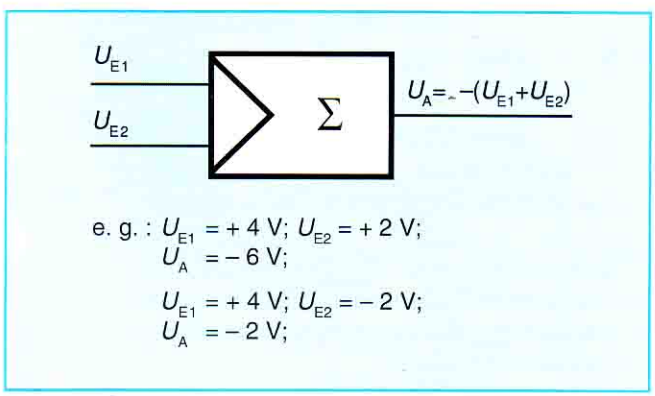


Fig. 105: *Summator*

1.8 Inverter

The purpose of the inverters on the proportional amplifier cards is to reverse the polarity of the input voltage.

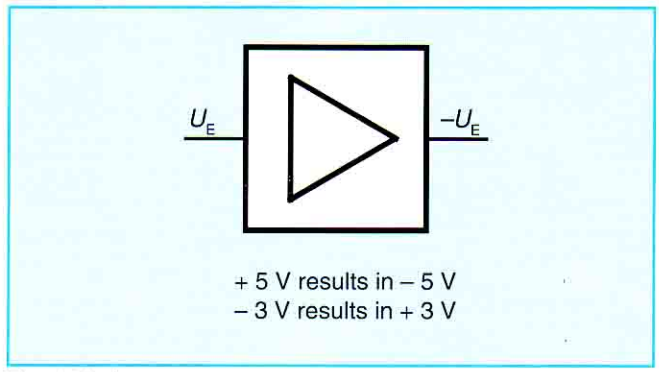


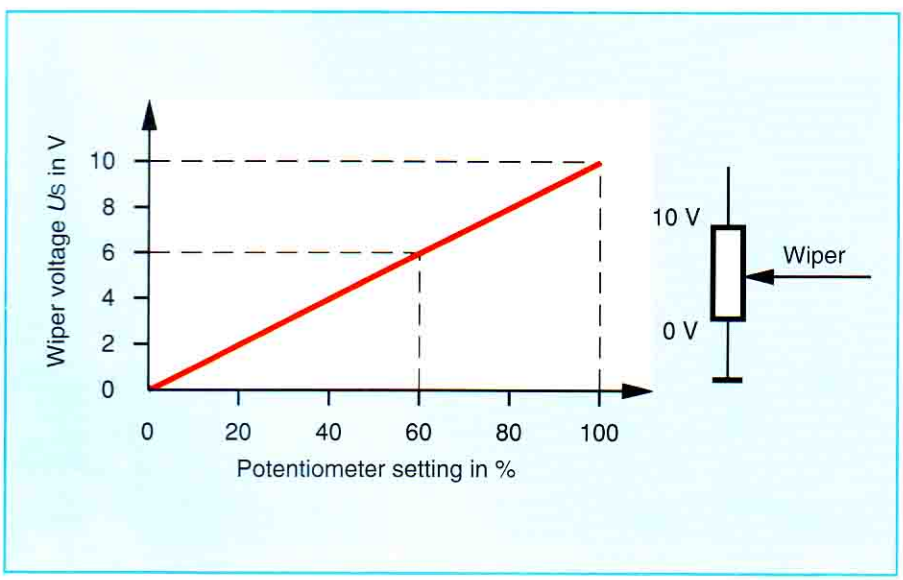
Fig. 106: *Inverter*

1.9 Potentiometer

If the ends of the potentiometer are connected to 0 V and 10 V, any voltage between 0 and 10 V can be obtained at the wiper.

1.9.1 Example

At a setting of 60 %, a voltage of 6 V is available at the wiper.



Diag. 29: *Potentiometer*

1.10 Pilot Current

The pilot current is a solenoid current. The pilot current of the solenoid is applied as soon as the amplifier card is connected to the supply voltage and the valve on the amplifier is also connected. It is used for maintaining the pulse frequency, for pre-magnetization of the solenoid and ensures the solenoid of the valve starts quickly from its initial position when a signal is given.

1.11 Inductive Positional Transducer on the Valves

The inductive positional transducer is used to measure the spool stroke.

The inductive positional transducer consists of a cylindrical body, within which a measuring armature with a ferro-magnetic core is installed.

The sensor consists of two coils which are connected such as to form an inductive centre tapped coil. The inductive positional transducer is fed with a carrier frequency of 2.5 kHz. The amplitude of this carrier frequency varies at the output depending on the position of the measuring armature. The inductance of the coils varies as the measuring armature is shifted.

The output amplitude amounts to U_S when the measuring armature is in the centre position. If the measuring armature is deflected, the output amplitude *(Diag. 30)* shifts in direction U_{S1} or U_{S2}, according to the solenoid being used.

The demodulator converts the output amplitude into a corresponding DC signal.

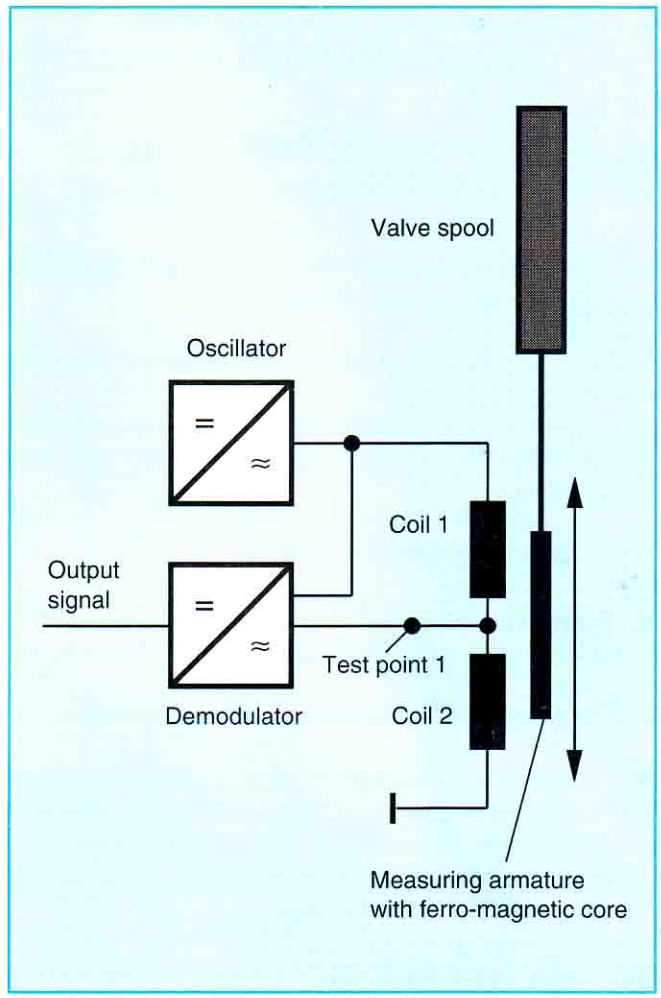
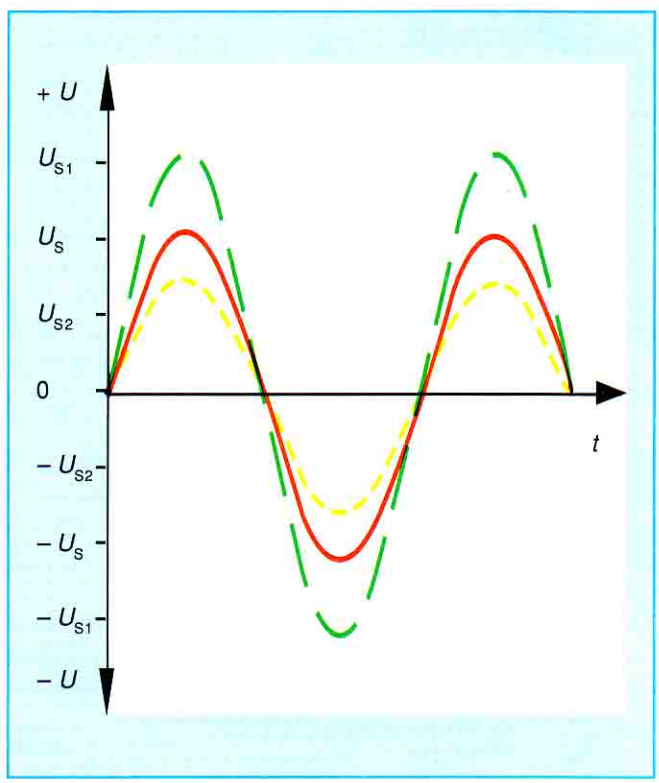


Fig. 107: *Schematic diagram of inductive positional transducer*



Diag. 30: *Output amplitude measured at test point 1 corresponding to Fig. 107*

2 Proportional Amplifiers for Proportional Valves

100x160 mm Euro-cards have been developed and standardized for the various proportional valves. A certain amplifier card is assigned to a certain type of proportional device in order to achieve optimum adaptation and therefore optimum results.

The proportional amplifiers are divided into two categories:

- Proportional amplifiers without electrical feedback (for force-controlled proportional solenoids)
- Proportional amplifiers with electrical feedback of the proportional valve spool (for stroke-controlled proportional solenoids).

3 Proportional Amplifiers without Electrical Feedback

3.1 Proportional Amplifier VT 2000 for Proportional Pressure Control Valves

The function of the proportional amplifier is described based on the given block diagram.

The supply voltage is applied to the terminals 24 ac (+) and 18 ac (0 V).
This supply voltage is smoothed on the amplifier card (1) and a stabilized voltage of ±9 V is derived from this smoothed voltage (5).

The stabilized voltage of ±9 V is used for:

a) The supply of external or internal potentiometers. The voltage + 9 V is tapped off at 10 ac and –9 V at 16 ac.

b) The supply of the internal operational amplifiers.

The control of the amplifier VT 2000 is achieved through the command signal input 12ac. The input voltage is measured with reference to the potential measured (control) zero (M0). The maximum signal voltage is +9V - referred to M0 (terminal 10ac).

The command signal can either be taken directly from the +9V measured voltage of the power supply (5) or via an external potentiometer.

If the command signal is taken directly from the measured voltage the command voltage can be varied using the potentiometer R2 and, thereby altering the solenoid current. When using an external potentiometer, R2 acts only as a limiter.

The input to the VT2000 can also be entered via the differential amplifier input (7) (terminal 28c and 30ac). Here terminal 28c must have a potential of 0 to +10V referred to 30ac. When using the differential amplifier input , care must be taken that both signal carrying lines are switched on and off simultaneously.

The ramp generator (1) generates from a stepped signal a slowly rising or falling output signal. The gradient of the output signal i.e. the change with time, can be set via potentiometers R3 (for up ramp) and R4 (for down ramp).

The specified ramp time of max. 5 s can only be reached over the entire voltage range of 9 V. If the full 9V signal range is not utilised at the ramp generator, the maximum ramp time will be correspondingly shorter.

The output signal of the ramp generator (1) will be added to the value of the R1 potentiometer in the current regulator. Through modulation with the oscillator signal (4) a pulse width signal results, which activates the output stage power transistor. In the solenoid the pulse width modulated current acts as a constant current with superimposed dither signal.

The output signal of the current regulator (2) is fed to the output stage.

The output stage (3) actuates the proportional solenoid at 800 mA max. The current flowing through the proportional solenoid can be measured at the test point X2, the output of the ramp generator can be measured at the test point X1 (mV = mA).

3.1.1 Test Points on Proportional Amplifier

1) Measure the supply voltage of + 24 V at the terminal 24 ac with respect to 18 ac.

2) Measure the stabilized voltage ±9 V
+9 V at 10 ac with respect to 14 ac
–9 V at 16 ac with respect to 14 ac

3) Measure the command voltage of 0 to +6 V at the test point X1

4) Measure the solenoid current of 0 to 800 mA at the point X2 (mA = mV)

3.1.2 External Control

- Remote control via potentiometer with interlock release via relay
- Remote control via differential input
- Switch off external ramp up and down

Fig. 108: *Proportional amplifier Type VT 2000 S 4X*

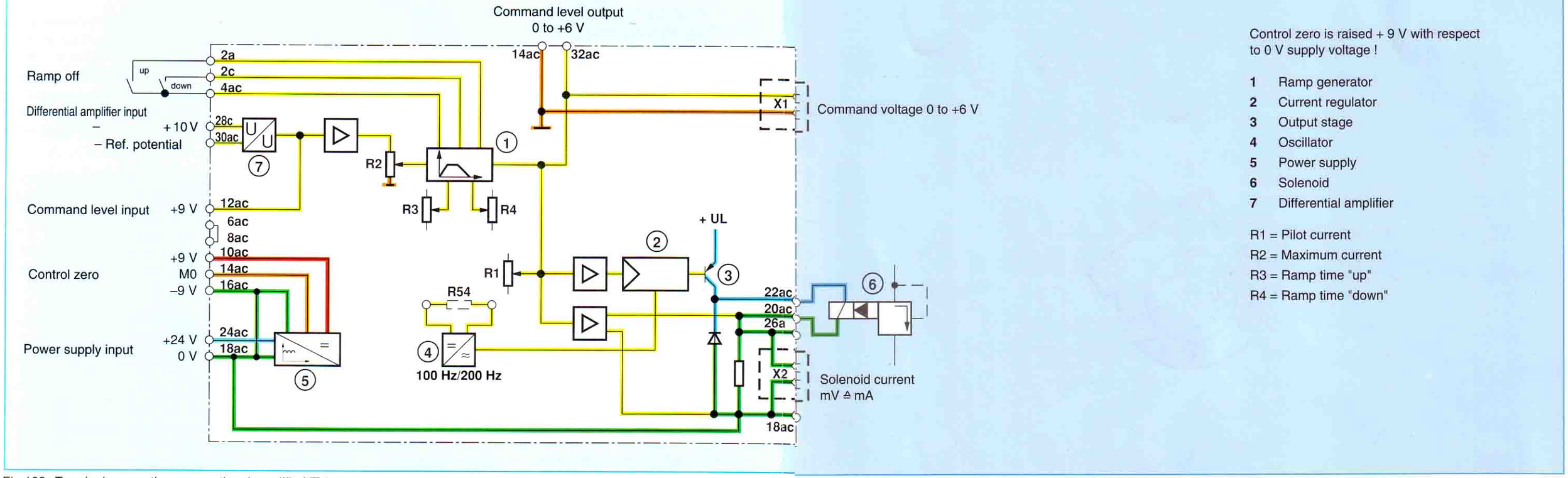


Fig.109: *Terminal connections proportional amplifierVT 2000*

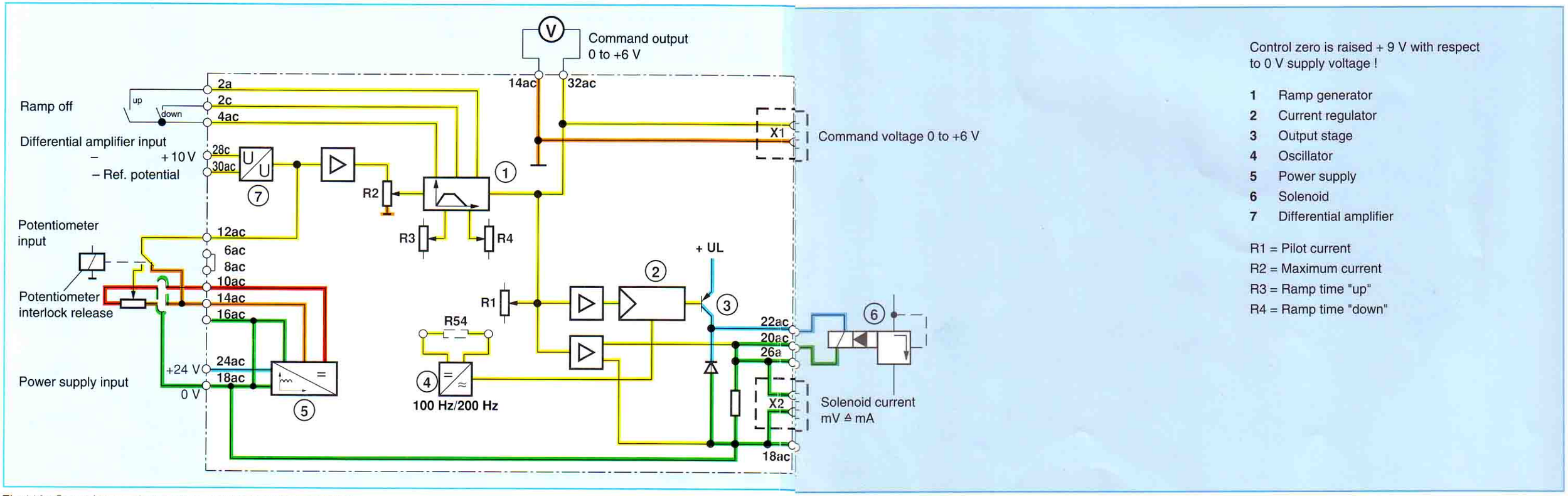


Fig.110: *Control example with proportional amplifier VT 2000*

3.2 Proportional Amplifier VT 3000 for Pilot Operated Proportional Directional Valve without Positional Control

With reference to the block diagram shown, the function of the proportional amplifier will be described.

The proportional amplifier is supplied with voltage via terminals 32ac (+) and 26ac (-). This voltage supply is smoothed on the amplifier card and a stabilised voltage of ±9 V is then produced.

The stabilised voltage supply of ±9 V is required for

a) supply of external or internal potentiometers

b) supply of internal operational amplifiers

Amplifier VT 3000 has four command signal inputs with respect to potential M0 and a differential amplifier input (terminals 16a and 16c).

In order to set a command voltage, the four terminals 12a, 8a, 10a and 10c must be connected to the stabilised voltage +9 V (terminal 20c) or -9 V (terminal 26ac).

These four command signal inputs may be either connected directly to ±9 V measurement voltage from the power supply (7) or to an external command signal potentiometer.

If the four command signal inputs are connected directly to ±9 V measurement voltage, then four different command signals may be set on potentiometers R1 to R4.

If external command signal potentiometers are used, the internal postentiometers R1 and R4 are used as limiters.

The command signals are released via relay contacts K1 to K4.

If the command signal voltage is supplied by external rather than internal means, the differential amplifier input must be used. If the differential amplifier input is used, care must be taken, when connecting or disconnecting the command voltage, that both signal lines are connected or disconnected simultaneously.

The ramp generator (1) generates a slowly rising output signal from a step input signal. The ramp time (gradient) of the output signal may be set via potentiometer R8. The given ramp time of up to 1 or 5 s may only be attained over the whole voltage range (of 0 V up to ±6 V, measured at command signal test points.

A command voltage of ±9 V at the input produces a voltage of ±6 V at the command signal test points. If a command voltage of less than ±9 V is fed to the input of the ramp generator (1), the maximum ramp time is reduced.

The output signal from the ramp generator (1) is fed to the summator (3) and step generator (2). The step generator (2) produces a step function at its output, which is added to the output signal from the ramp generator (1) in the summator. The step function is required for quicker traverse of the positive overlap in proportional directional valves.

This step is only effective for command voltages of more than 100 mV. If the command voltage increases to a higher value, the step generator (2) produces a constant signal.

The output signal from the summator (3) is fed to both output stages comprising current regulator (4), pulse generator (5) and power amplifier (6). If a positive command voltage is fed to the amplifier the output stage for solenoid B is controlled, whereas if a negative commans voltage is fed to the amplifier the ouput stage for solenoid A is controlled.

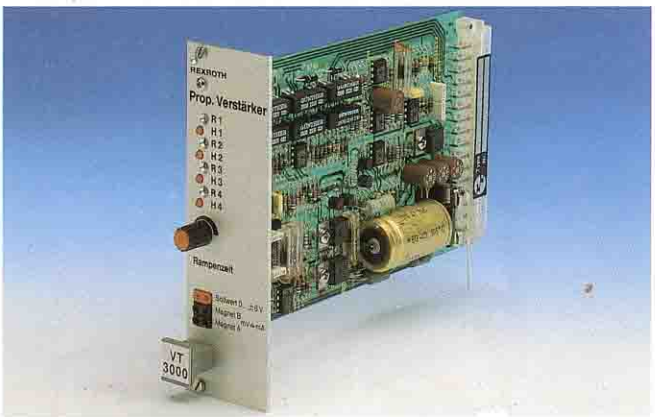


Fig. 111: *Proportional amplifier, type VT 3000 S 3X*

Additional information:

a) Differential amplifier input of 0 to ±10 V
This input is required when a high resistance separation is required between amplifier card and external control electronics.

b) The relay K6 may be used forto create an oscillation. The voltage is switched from -9 V to +9 V via the relay contact K6.
If output 2a is connected to one of the command signal inputs, the polarity of the signal may be changed via release of the relevant relay and relay K6 (contact 4c).

c) If relay K5 is released the ramp generator is bridged, i.e. it does not function. Hence the smallest ramp time of approx. 50 ms becomes effective.

d) The relay release voltage must be fed from 28c via potential free contacts to the relay inputs 8c, 4a, 6a and 6c.

3.2.1 Test Points on Proportional Amplifier:

1) Measure the supply voltage of +24 V at terminals 32ac referred to 26ac

2) Measure the stabilized voltage ±9 V :
+ 9 V at 20c with respect to 20a
– 9 V at 26ac with respect to 20a

3) Measure the relay release voltage at 28c with respect to 26ac

4) Measure the signal voltage of 0 to ± 6 V at test point BU1:
0 to + 6 V for solenoid A
0 to – 6 V for solenoid B

5) Measure the solenoid currents of 20 to 800 mA at the test point BU3 (solenoid A) and at BU2 (solenoid B)

The voltage drop is measured over a resistance of 1 Ohm, i.e. mV ≙mA.

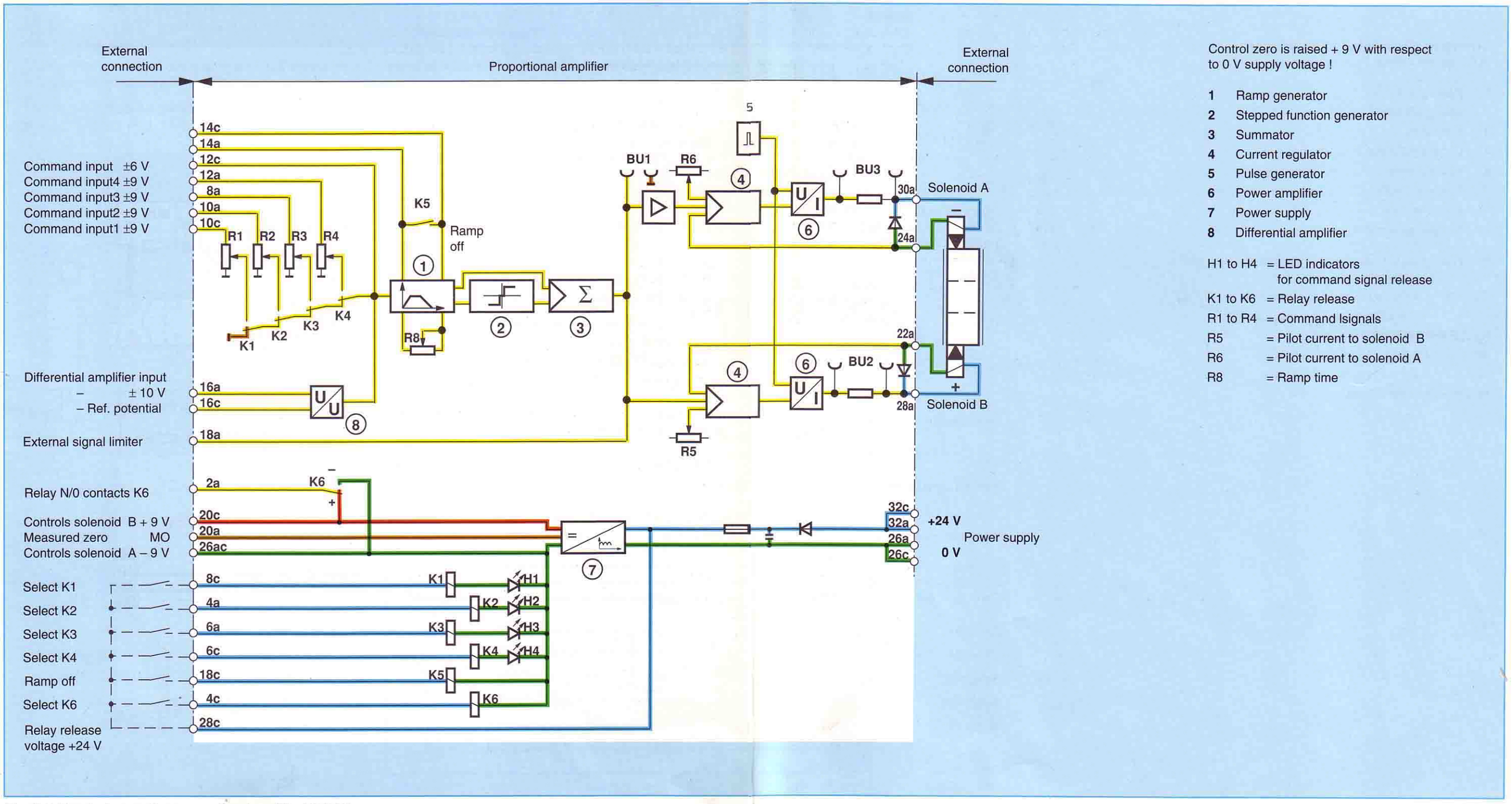


Fig. 112: *Terminal connections proportional amplifier VT 3000*

To complete the shown proportional amplifier VT 3000, proportional amplifier VT 3006 exists with 5 adjustable ramp times *(Fig. 113)*

The only difference in this amplifier is an additional card, which enables each command signal release to be given its individual adjustable ramp time.

Command signal release R1 is paired with ramp time t_1 (adjustable at R11).

Command signal release R2 is paired with ramp time t_2 (adjustable at R12).
Command signal release R3 is paired with ramp time t_3 (adjustable at R13).
Command signal release R4 is paired with ramp time t_4 (adjustable at R14).

If no command signal is connected, the last command signal selected is reduced to zero via the fifth ramp time t_5 (adjustable at R10).

Control zero (M0) is raised + 9 V with respect to 0 V supply voltage !

1 Ramp generator
2 Step generator
3 Summator
4 Current regulator
5 Pulse generator
6 Power amplifier
7 Power supply
8 Differential amplifier

H1 to H4 = LED indicators for command release
K1 to K6 = Relay release
= Additional card
R1 to R4 = Command signals
R5 = Pilot current to solenoid B
R6 = Pilot current to solenoid A
R10 to R14 = Ramp time

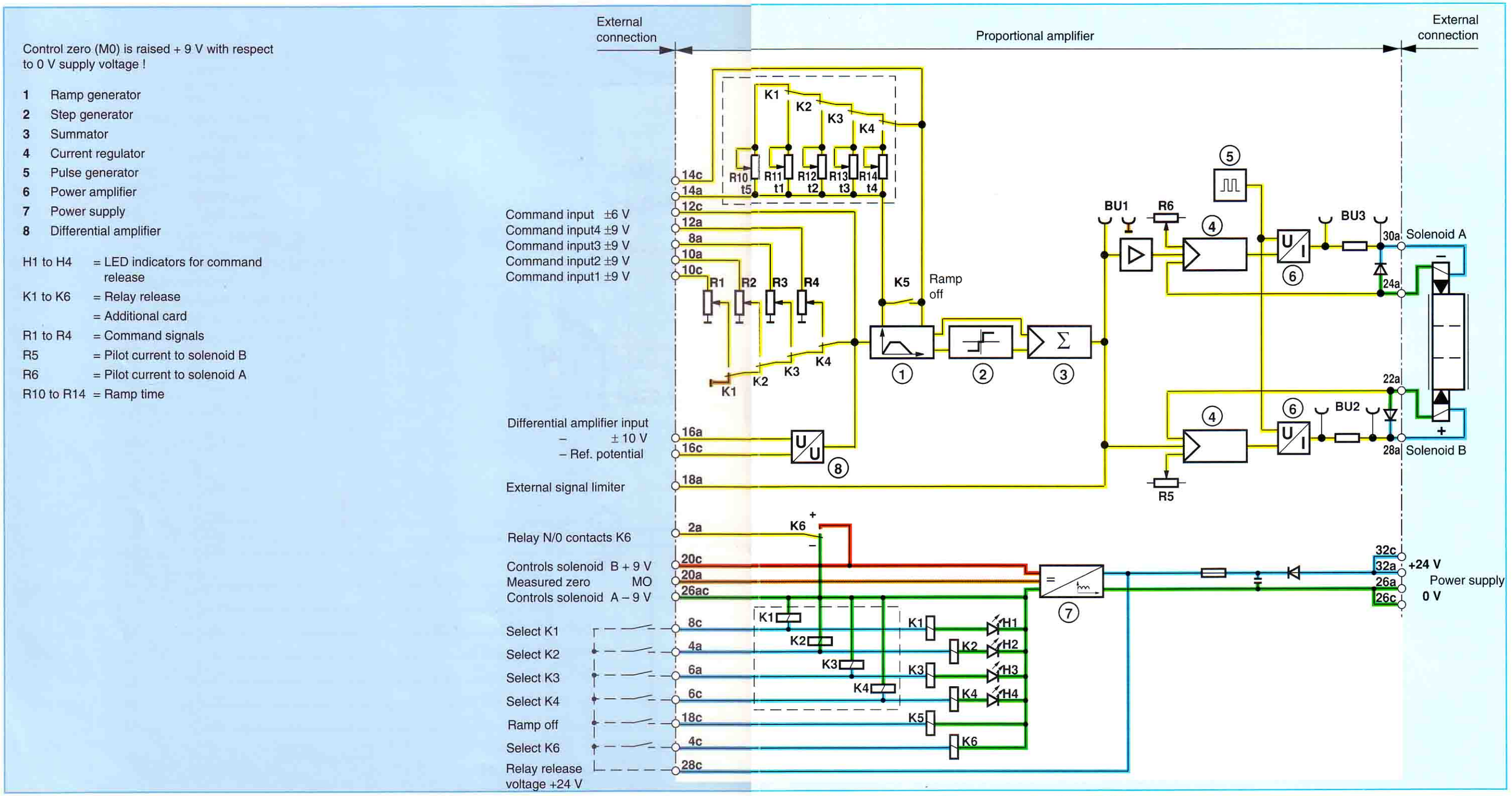


Fig. 113: *Terminal connections proportional amplifier VT 3006*

3.2.2 Control examples

The following connections are the same for any amplifier control:

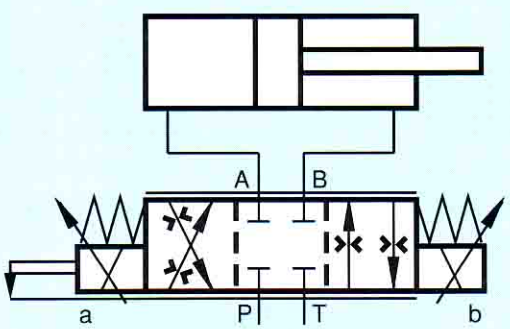
- Solenoid A is connected to 24a and 30a, solenoid B is connected to 28a and 22a
- Supply volage of +24 V is connected to 32ac and 0 V to 26ac

Operation

1 How can a cylinder (or hydraulic motor) with the help of a proportional directional valve and proportional amplifier be made to accelerate or decelerate smoothly and slowly and stop at a particular position?

Movements should proceed as shown in the speed-time diagram *(Diag. 31)*.

The amplifier must be connected as shown in the connection diagram *(Fig. 114)*.



Description of circuit

The N/O contact (1) releases the start command for the cylinder to extend. Relays K1 and K2 close . In a series circuit K2 has a higher priority than K1 and hence only the comand signal from R2 via K2 is effective.

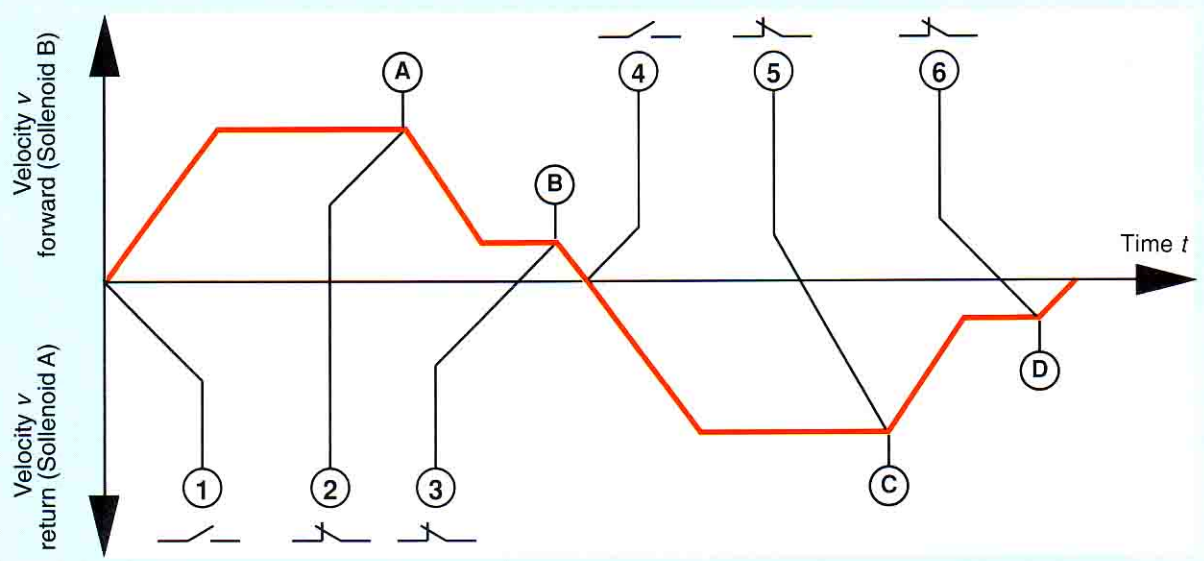
Correspondingly, the ramp time set at R8 is used to accelerate the cylinder until the set velocity at R2 has been reached.

Once the limit switch (A) has been reached, the N/C contact (2) disconnects the supply to K2 and the signal at the relay is removed. Hence R1 becomes active (K1 remains connected) and the cylinder starts to decelerate to the creep speed. Limit switch (B) then also enables the signal at relay K1 to be removed and the cylinder then decelerates to a stationary position.

N/O contact (4) releases the start command for the cylinder to return, whereby the velocity is set at R3 and the creep speed is set at R4. Relays K3 and K4 close. Once limit switch (C) has been reached, the N/C contact (5) disconnects the supply to K4 and the signal at the relay is removed. Hence R3 becomes active (K3 remains connected) and the cylinder starts to decelerate to the creep speed. Limit switch (D) then also enables the signal at relay K3 to be removed and the cylinder then decelerates to a stationary position.

The diagram shows that all acceleration and deceleration processes are identical and hence the ramp times with respect to the command signals are also always identical.

A change in ramp time may be introduced via potentiometer R8.



Diag. 31: *Velocity-time diagram*

Control zero (M0) is raised + 9 V with respect to 0 V supply voltage !

1 Ramp generator
2 Step generator
3 Summator
4 Current regulator
5 Pulse generator
6 Power amplifier
7 Power supply
8 Differential amplifier

H1 to H4 = LED indicators for command signal release
K1 to K6 = Relay release
R1 to R4 = Command signals
R5 = Pilot current to solenoid B
R6 = Pilot current to solenoid A
R8 = Ramp time

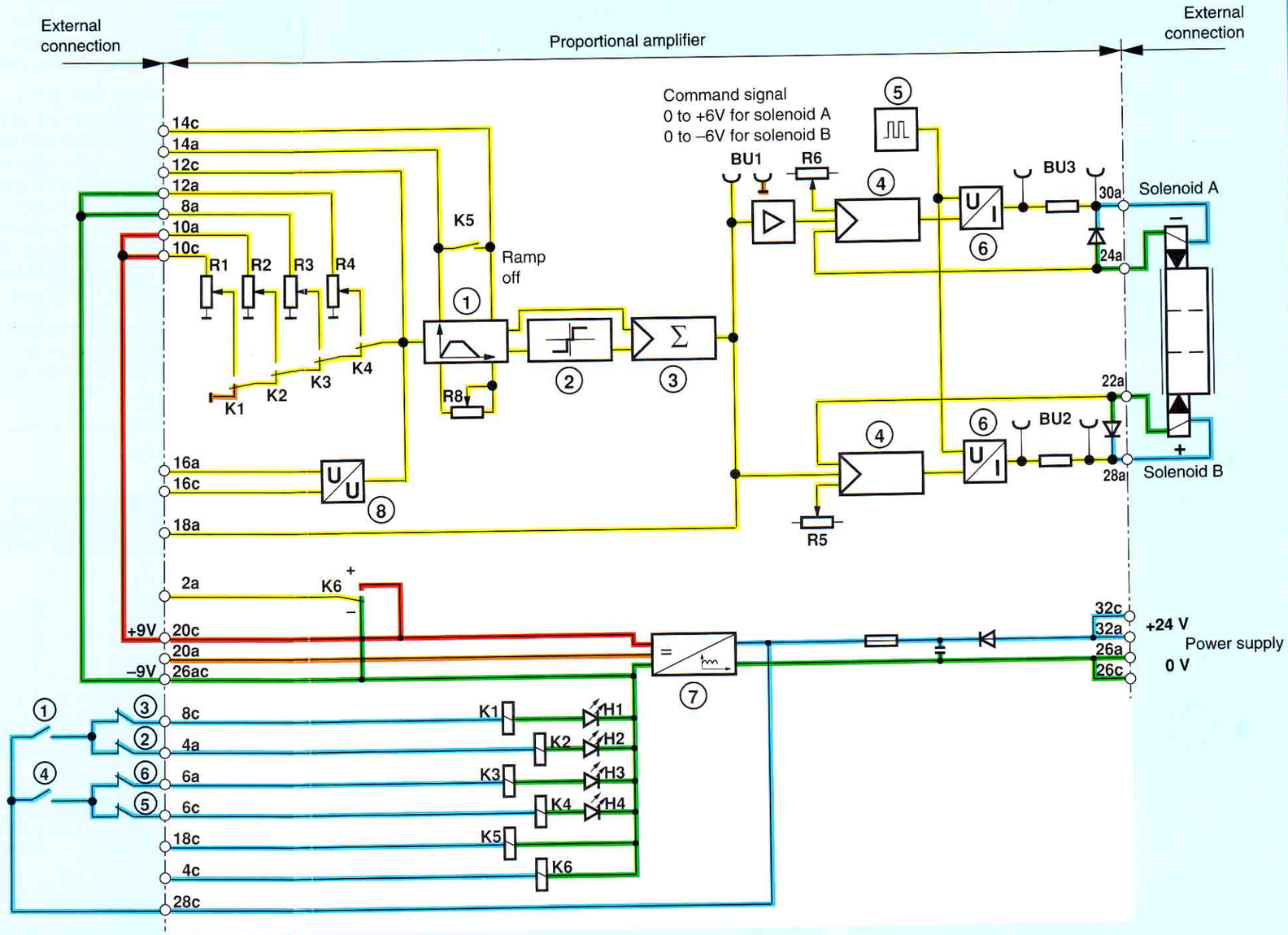
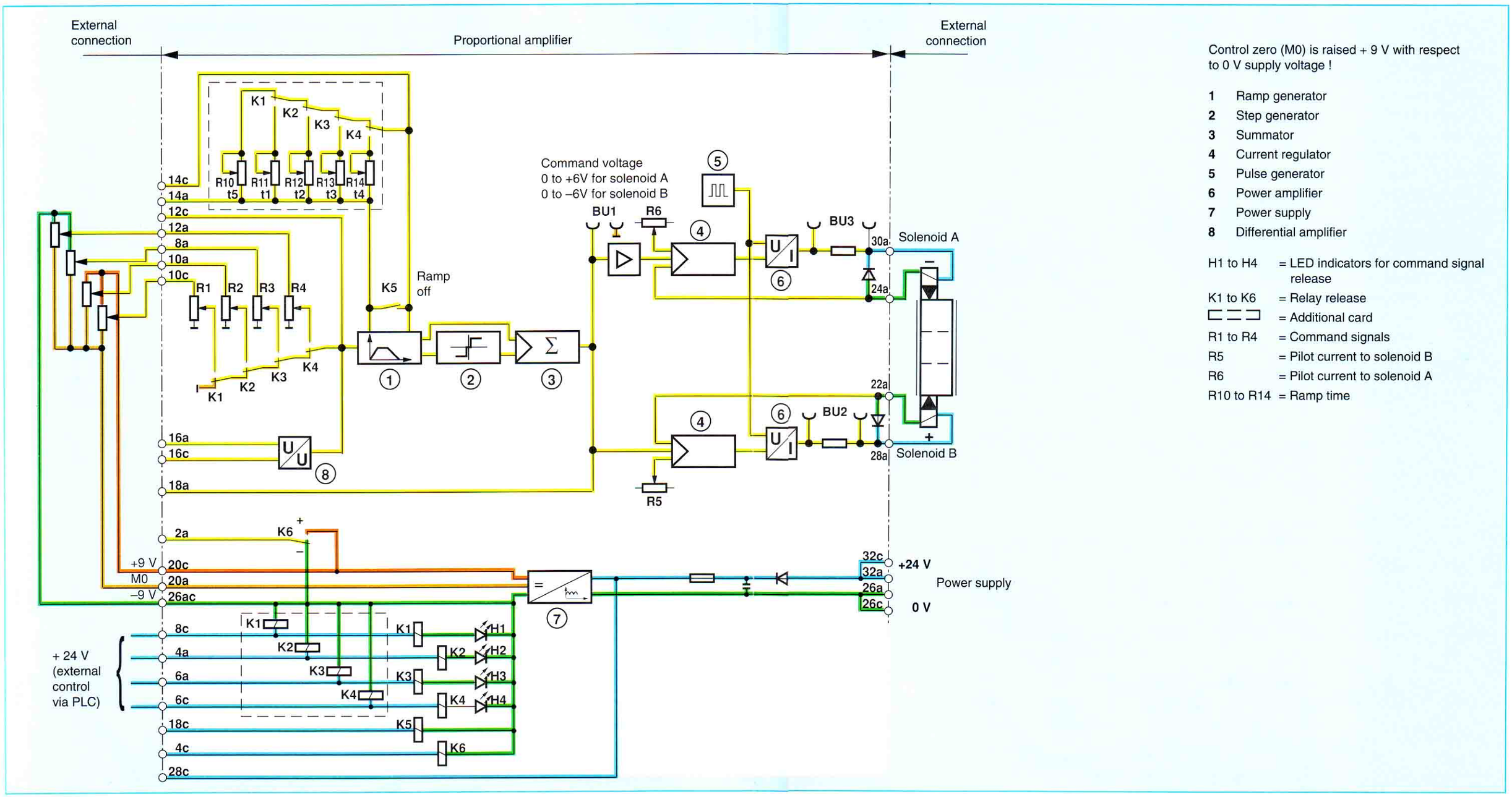


Fig. 114: *Connection diagram for proportional amplifier VT 3000*

2) Terminal connections as in 1), but:

– command signals are set via external potentiometers (Warning: R1 to R4 must be set to max.!)

– Command signals are released externally via PLC



Control zero (M0) is raised + 9 V with respect to 0 V supply voltage !

1 Ramp generator
2 Step generator
3 Summator
4 Current regulator
5 Pulse generator
6 Power amplifier
7 Power supply
8 Differential amplifier

H1 to H4 = LED indicators for command signal release
K1 to K6 = Relay release
⊏ = = ⊐ = Additional card
R1 to R4 = Command signals
R5 = Pilot current to solenoid B
R6 = Pilot current to solenoid A
R10 to R14 = Ramp time

Fig. 115: *Control diagram for proportional amplifier VT 3006*

3) Terminal connections as in 1), but:

– command signals are set via an external potentiometer, which can alternately control both solenoids A and B (Warning: R4 must be set to max.!)

Control zero (M0) is raised + 9 V with respect to 0 V supply voltage !

1 Ramp generator
2 Step generator
3 Summator
4 Current regulator
5 Pulse generator
6 Power amplifier
7 Power supply
8 Differential amplifier

H1 to H4 = LED indicators for command signal release
K1 to K6 = Relay release
R1 to R4 = Commandsignals
R5 = Pilot current to solenoid B
R6 = Pilot current to solenoid A
R8 = Ramp time

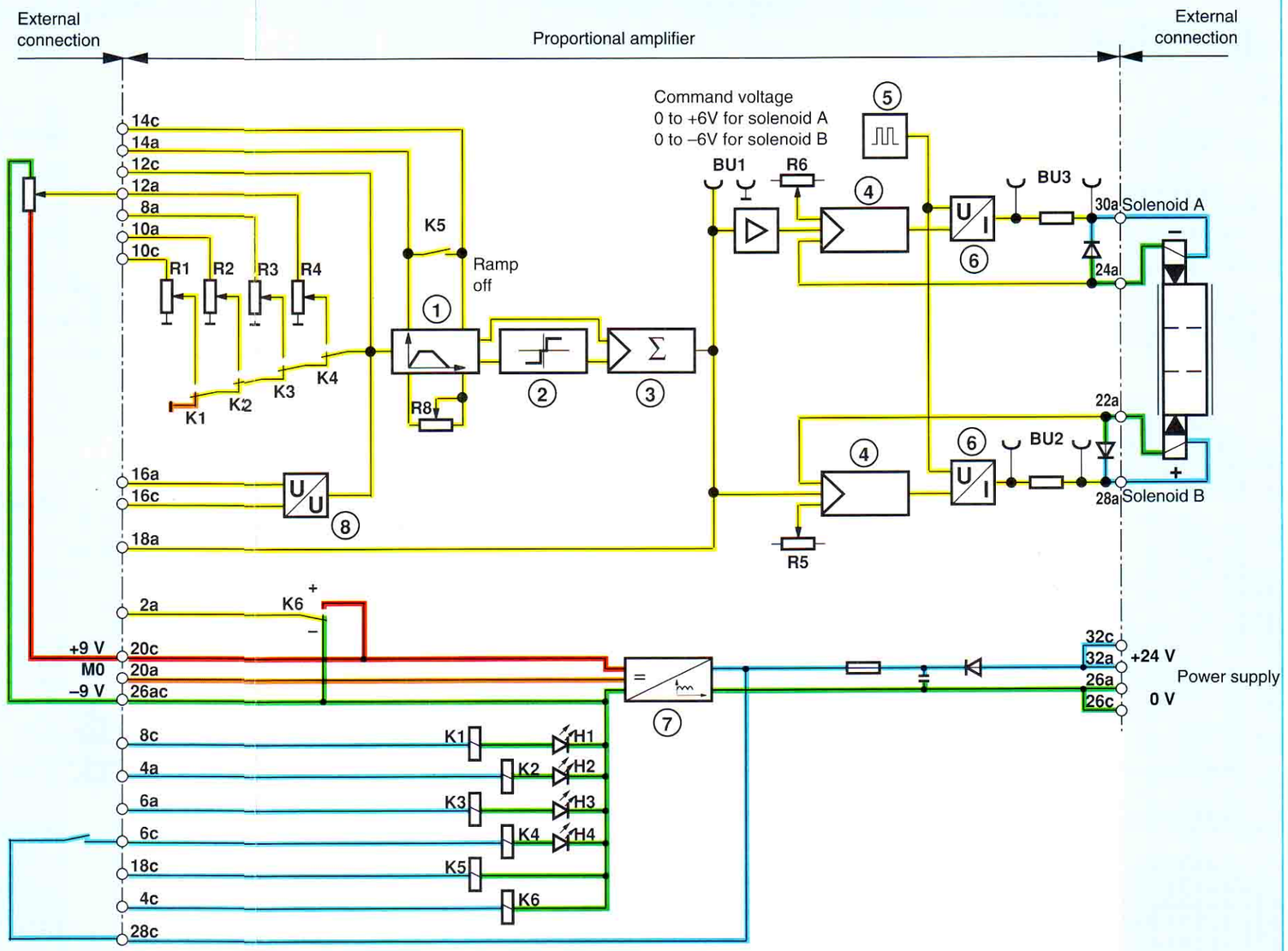


Fig. 116: *Connection diagram for proportional amplifier VT 3006*

4 Proportional Amplifiers with Closed Loop Positional Control

4.1 Proportional Amplifier VT 5005 for Pilot Operated Proportional Directional Valves with Closed Loop Positional Control

The function of the proportional amplifier is described based on the given block diagram.

The proportional amplifier receives its voltage supply via the terminals 22 ac (+) and 28 ac (0 V). The supply voltage is smoothed on the amplifier card (7) while at the same time being used to form a stabilized voltage of ±9 V.

The stabilized voltage ±9 V is used

a) for supplying the external potentiometers or the internal potentiometers.

b) for supplying the internal operational amplifiers.

Amplifier card VT 5005 has four command inputs referred to potential M0 and a differential amplifier input (terminals 6c and 6a).

In order to set a command voltage, the 4 terminals 20c, 20a, 14a and 14c must be connected to the stabilized voltage of + 9 V (terminal 26a) or - 9 V (terminal 24a).

The 4 command inputs can be taken either directly from the ±9V measured voltage of the power supply (9) or via an external command signal potentiometer.

If the 4 command signals are connected directly to the ±9V measured voltage, 4 different command signal can be set on the potentiometers R1 to R4.

When using an external command signal potentiometer the internal potentiometers R1 to R4 act as a limiter.

The command voltages are released via the relays K1 to K4.

When the command voltage is taken from a separate unit the differential amplifier input should be used. Care must be taken that both signal lines are switched on or off simultaneously.

The ramp generator (1) generates from a step input signal a slowly rising output signal. The ramp time (gradient) of the output signal can be varied with the potentiometer R5. The specified maximum ramp time (1 or 5 s) can only be reached over the entire voltage range from 0 V to ±6 V, measured at the command signal test points.

The command voltage ±9 V at the input results in a voltage of ±6 V at the command signal test points. The maximum ramp time is shortened if a command signal less than ±9 V is switched to the input of the ramp generator (1).

The output signal of the ramp generator (1) is fed to the summator (3) and the step generator (2). The step generator (2) generates at its output a step function which is added in the summator (3) to the output signal of the ramp generator (1). The step function is requiredfor traverse of the positive overlap of the proportional directional valve to occur quickly.

This step is only effective with command voltages greater than 100 mV. The step generator (2) generates a constant signal if the command voltage increases to a higher value.

The output signal of the summator acts as the command signal for the PID regulator (4).

The oscillator (6) converts the DC voltage into an AC voltage. This signal activates the inductive positional transducer (11).

The inductive positional transducer (11) varies the AC output voltage according to the position of the valve spool. This AC voltage signal is fed back from the demodulator (7) as a DC voltage signal.

The matching amplifier (8) amplifies the DC voltage up to a maximum voltage of ±6V (max. spool stroke). This output signal becomes the actual signal fed to the PID regulator (4).

The PID regulator (4) is specially adapted to the valve 4 WRE 6/... . Depending on the difference between the actual signal and command signal it transmits a signal which controls the self-modulating output stage (5).

Solenoid A is activated by a positive command voltage from the amplifier, and solenoid B by a negative command voltage.

The feed line to the inductive positional transducer (11) is monitored by a cable break detection system (10), which shuts off the current in both solenoids if a fault occurs. At the same time an LED display (13) on the front plate of the amplifier indicates “cable break”.

4.1.1 Additional Information

a) Differential amplifier input from 0 to ±10 V

This input is required in order to achieve high impedance solation between the valve amplifier card and an external electronic control system.

b) The relay K6 can be used for oscillatory movement.

The voltage is switched from - 9 V to + 9 V via the relay contact K6.

When the output 30a is connected with one of the command inputs, the direction can be changed by selecting the corresponding relay and the relay K6 (contact 18c).

c) The ramp generator is bypassed, i.e. ineffective, by releasing relay K5. As a result, the minimum ramp time of approx. 50 ms is effective.

d) Relay contact voltage must be taken from 24c and fed via potential-free contacts onto the relay inputs (12c, 12a, 16a, and 16c).

4.1.2 Test Points on Proportional Amplifier:

1) Measure the supply voltage of + 24 V at the terminals 22ac referred to 28ac.

2) Measure the stabilized voltage ±9 V
+ 9 V at 26a with respect to 26c
- 9 V at 24a with respect to 26c

3) Measure the relay selection voltage (smoothed supply voltage) at 24c with respect to 28ac

4) Measure the command voltage of 0 to ±6V at the test socket BU2

5) Measure the actual voltage of 0 to ±6 V at the test socket BU1

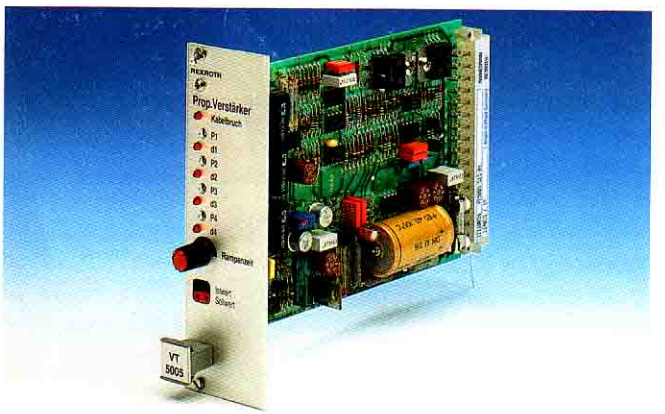
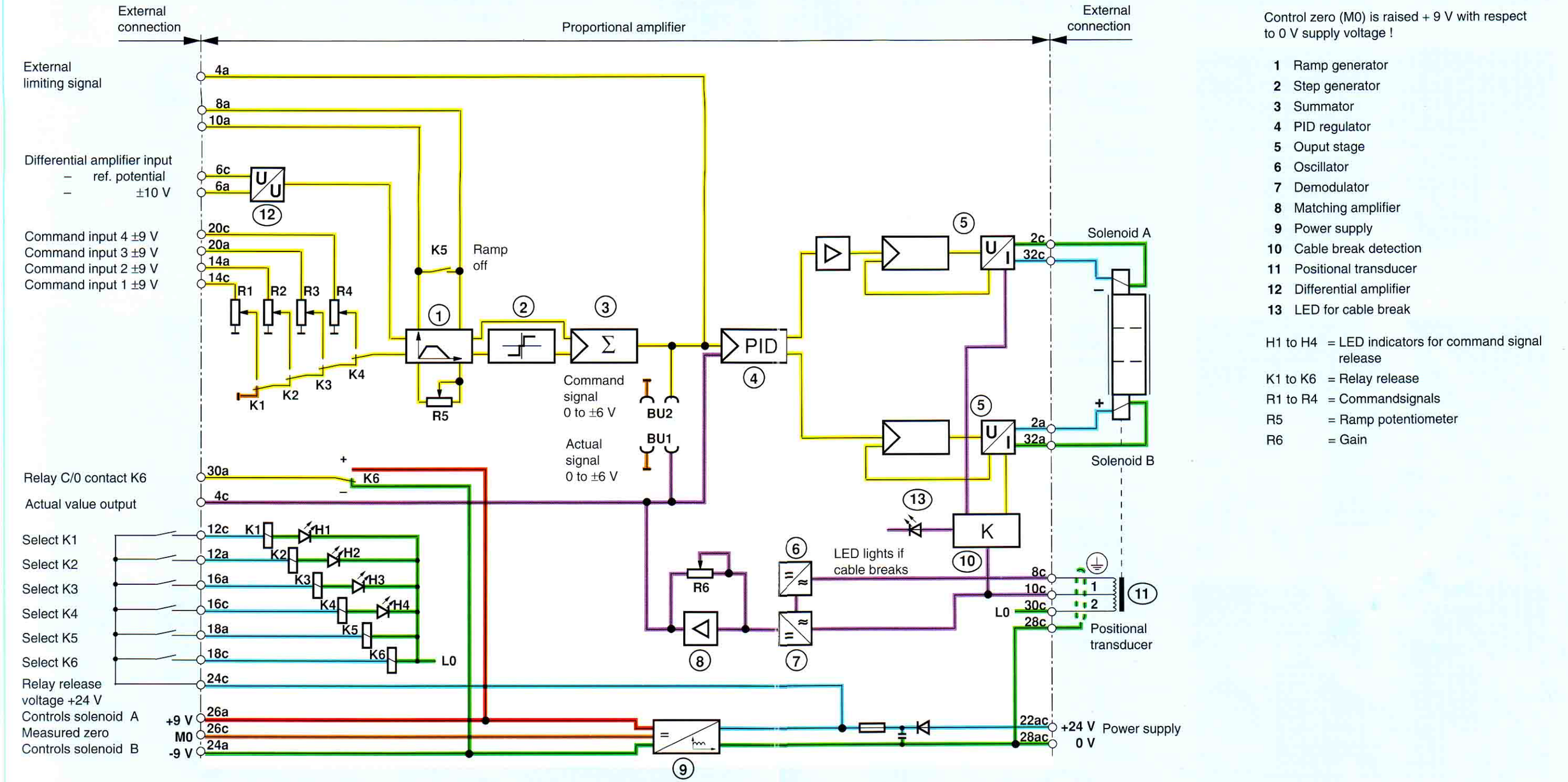


Fig. 117: *Proportional amplifier VT 5005S1X*



Control zero (M0) is raised + 9 V with respect to 0 V supply voltage !

1 Ramp generator
2 Step generator
3 Summator
4 PID regulator
5 Ouput stage
6 Oscillator
7 Demodulator
8 Matching amplifier
9 Power supply
10 Cable break detection
11 Positional transducer
12 Differential amplifier
13 LED for cable break

H1 to H4 = LED indicators for command signal release
K1 to K6 = Relay release
R1 to R4 = Commandsignals
R5 = Ramp potentiometer
R6 = Gain

Fig. 118: *Terminal connections for proportional amplifier VT 5005*

5 The Module System

5.1 Differences in using 19" plug-in cards

The module system differs from conventional electronics in the following ways:

- through SMD technology (surface mounted devices) it is possible to reduce electronics in size, i.e. compact and space-saving mounting can be achieved *(Fig. 119)*.
- the module body consists of a plastic housing in which the electronics are contained *(Fig. 120)*.
- the electrical connection for the operating voltage is the same for all modules so that mistakes in fitting are avoided *(Fig. 121)*.
- the module sockets are clipped onto the mounting rails similar to those used for relay switches and relays *(Fig. 122)*.

The amplifier module can control proportional and servo valves with or without feedback. Control is achieved by a ±10V differential amplifier input which serves as high impedance device, thus decoupling internal electronics from harmful external effects.

As in the case of amplifier cards, the module system groups valves and amplifiers together to achieve optimum settings and, consequently, optimum results.

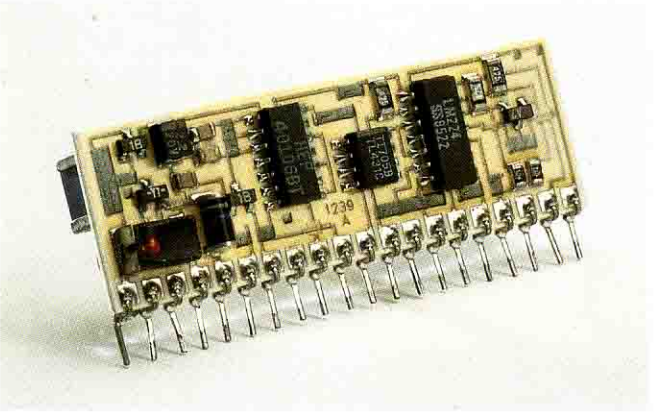


Fig. 119: *Hybrid*

Fig. 120: *Amplifier module, inner view*

Fig. 121: *Amplifier module, front plate*

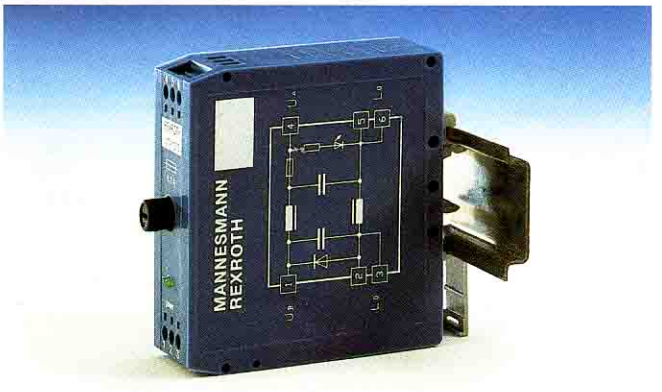


Fig. 122: *Mounting rail with amplifier module*

5.2 Module System Components

- amplifier module *(Fig. 123)*
- power supply module *(Fig. 124)*
- capacitor module *(Fig. 125)*
- relay module *(Fig. 126)*

Fig. 123: *Amplifier module*

The power supply module *(Fig.124)* generates 2 stabilised voltages of ±15V and provides the voltage supply for external use.

Fig. 124: *Power supply module*

The capacitor module *(Fig. 125)* provides the smoothing of the operating voltage for the various amplifier modules.

Fig.125: *Capacitor module*

The relay module *(Fig. 126)* permits various devices to be switched on and off, e.g. electronic amplifiers (N.B. care should be taken where devices have a large capacitance), solenoids and resistive loads.

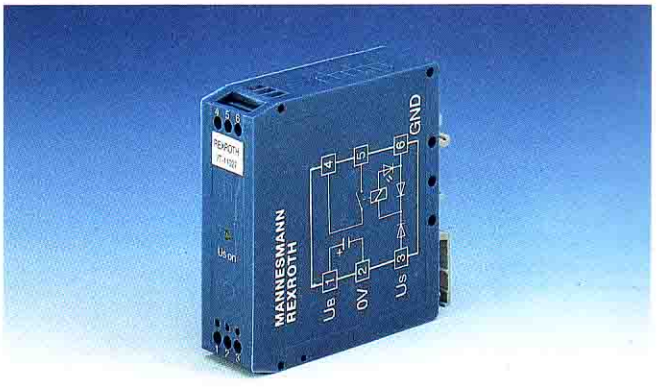


Fig. 126: *Relay module*

5.3 Amplifier Module VT 11029 for Pilot Operated Proportional Pressure Relief Valves without Closed Loop Positional Control

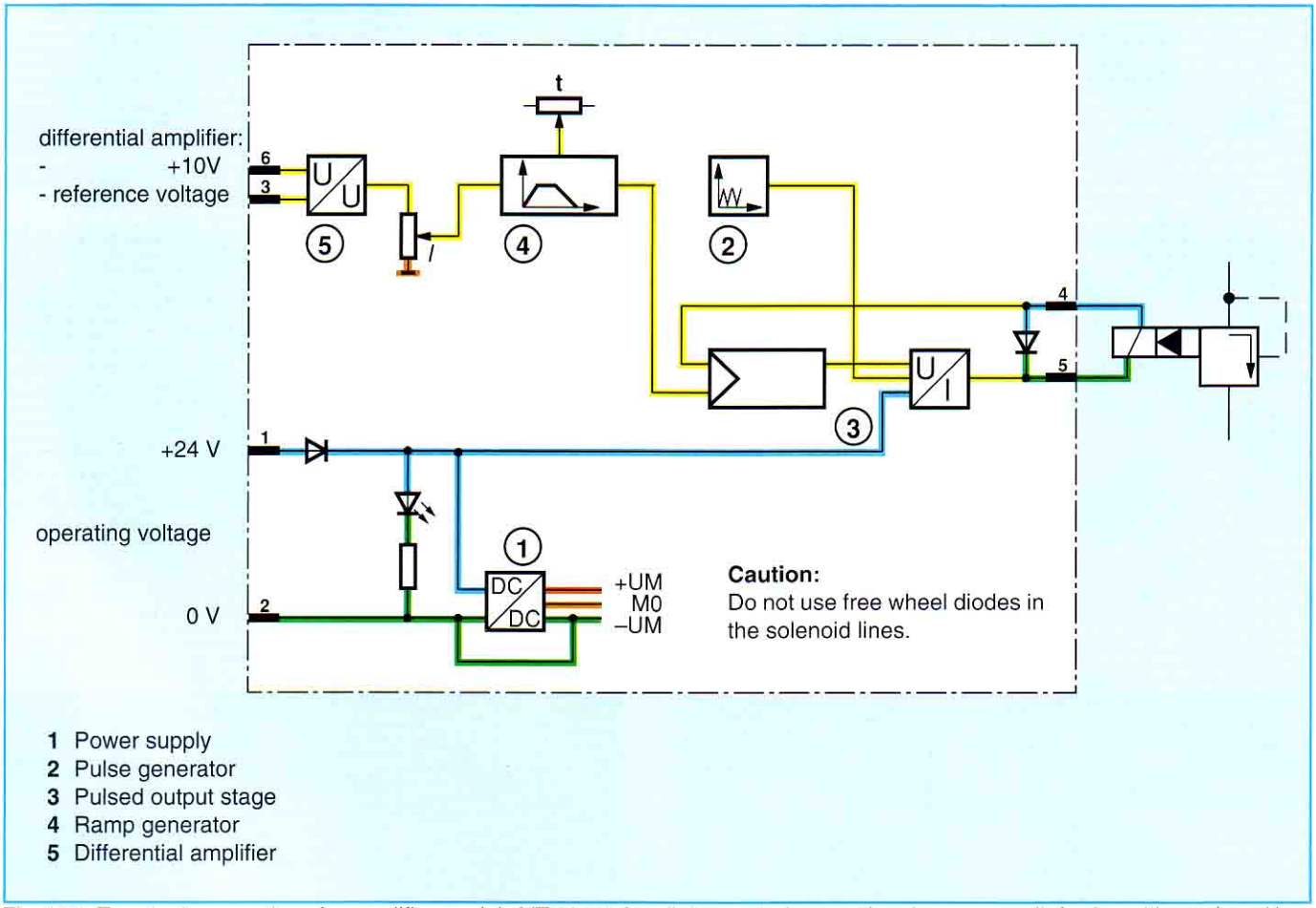
The function of the amplifier module is described based on the given block diagram.

The amplifier module provides the control for the proportional solenoids. The operating voltage is connected to the terminals (1) (+24V) and (2) (0V). Please note that each module must be equipped with an external smoothing capacitor of 2200 µF. The solenoids are connected to terminals (4) and (5). The command input operates via the differential amplifier input (terminals (3) and (6)). The command input is loaded via terminals (3) and (6), where terminal (3) is the reference signal and the command voltage at (6) must be positive with respect to terminal (3). The reference voltage level may lie between 0V and +10V with reference to terminal (2).

The ramp time t and the gradient of the control curve I (=maximum output current) can be set externally via potentiometers.

The ramp time, i.e. the acceleration and deceleration of the opening and closing of the valve can be varied with the potentiometer t from approx. 50 ms to approx. 5s.

The potentiometer I can raise and lower the gradient, i. e. the maximum level of the control curve. The adjustment range lies between 100 mA and 800 mA.



1 Power supply
2 Pulse generator
3 Pulsed output stage
4 Ramp generator
5 Differential amplifier

Fig. 127: *Terminal connections for amplifier module VT 11029 for pilot operated proportional pressure relief valve without closed loop positional control.*

5.4 Amplifier Module VT 11013 for Pilot Operated Proportional Directional Valves without Closed Loop Positional Control

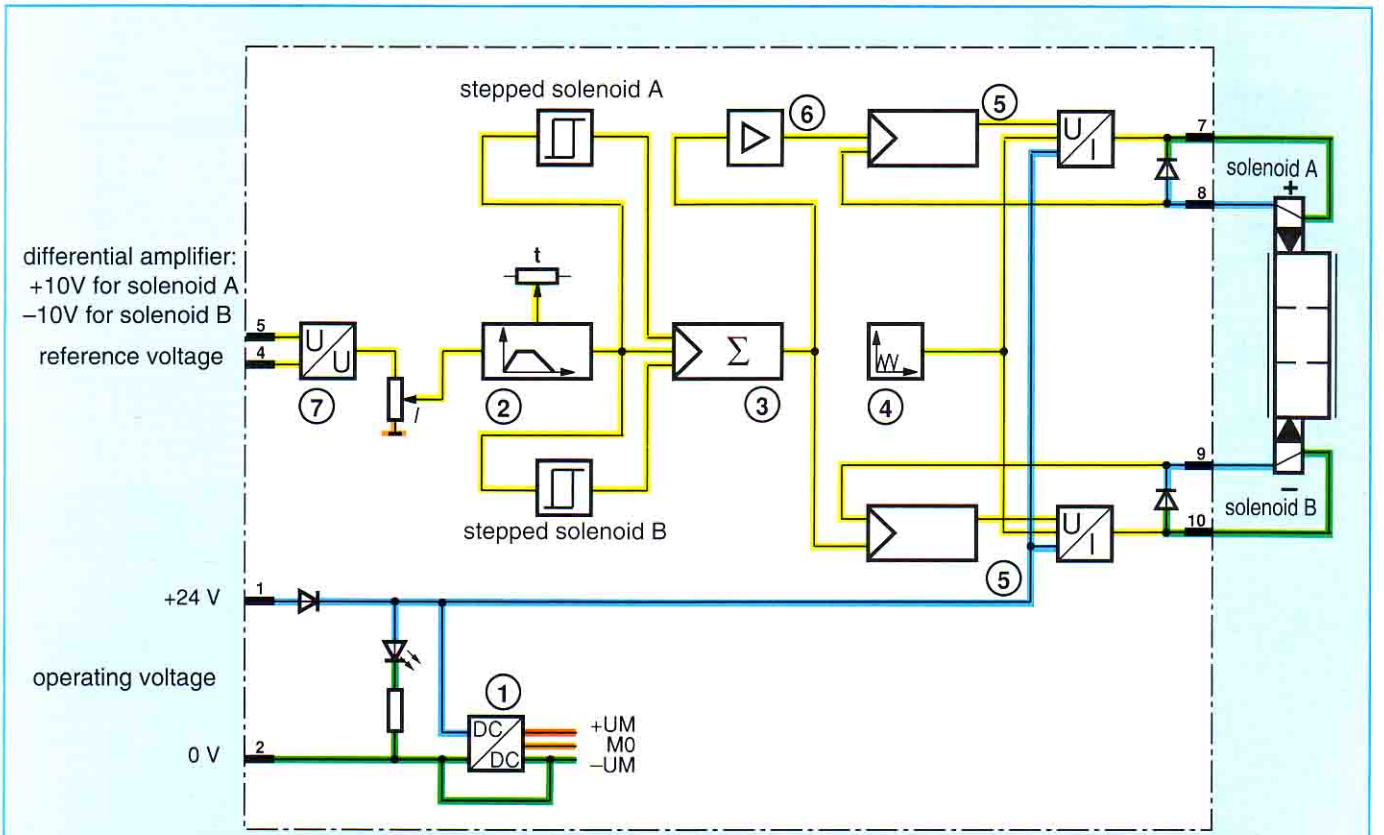
The function of the amplifier module is described based on the given block diagram.

The amplifier module provides the control for two proportional solenoids. The operational voltage is generated at the terminals (1) (+24V) and (2) (0V). Please note that each module must be equipped with an external smoothing capacitor of 2200 µF. Solenoid A is connected to terminals (7) and (8) and solenoid B to terminals (9) and (10). The command input operates via the differential amplifier input (terminals (4) and (6)). The command input is loaded via terminals (3) and (5). Terminal (5) is set either positive or negative (up to 10V) with respect to terminal (4) according to the movement and direction required. A negative signal controls solenoid B, and a positive signal solenoid A. Terminal (4) is the reference voltage.

The ramp time t and the gradient of the control curve I (= maximum output current) can be set externally via potentiometers.

The ramp time, i.e. the acceleration and deceleration of the opening and closing of the valve can be varied with the potentiometer t from approx. 50 ms to approx. 5 s.

The potentiometer I can raise and lower the gradient, i. e. the maximum level of the control curve. The adjustment range lies between 100 mA and 800 mA. The given voltage on the control curve is only effective if the command voltage is greater than 0.1V.



1 Power supply
2 Ramp generator
3 Summator
4 Pulse generator
5 Pulsed output stage
6 Inverter
7 Differential amplifier

Fig. 128: *Terminal connections for amplifier module VT 11013 for pilot operated proportional directional valve without closed loop positional control.*

5.5 Amplifier module VT 11 023 for pilot operated proportional directional valves with closed loop positional control

With respect to the block diagram shown, the operation of the amplifier module will be described.

The amplifier module is used to control two proportional solenoids and a positional transducer. The operating voltage is connected to terminals (1) (+24 V) and (2) (0 V). Care must be taken that each module must be fitted with an external smoothing capacitor of 2200 µF. Solenoid B is connected to terminals (7) and (8), and solenoid A is connected to terminals (9) and (10). Command signals are supplied via the differential amplifier input (terminals (4) and (5)). Depending on the movement or direction of rotation a positive or negative 10 V voltage is connected to terminal (5). A negative signal controls solenoid A and a positive signal controls solenoid B. The reference potential is connected to terminal (4).

The regulator and output stage may be disconnected via terminal (3).

The positional amplifier connection is via terminals (6), (11) and (12).

The ramp time P1 and the command signal P2 may be set via external potentiometers.

The ramp time, i.e. the acceleration and deceleration time for the opening and closing of the valve may be adjusted from approx. 50 ms to approx. 5 s via potentiometer P1.

The adjustment range of the command signal potentiometer P2 lies between about 20 and 100 %. The step generator is only active for command voltages greater than 0.1 V

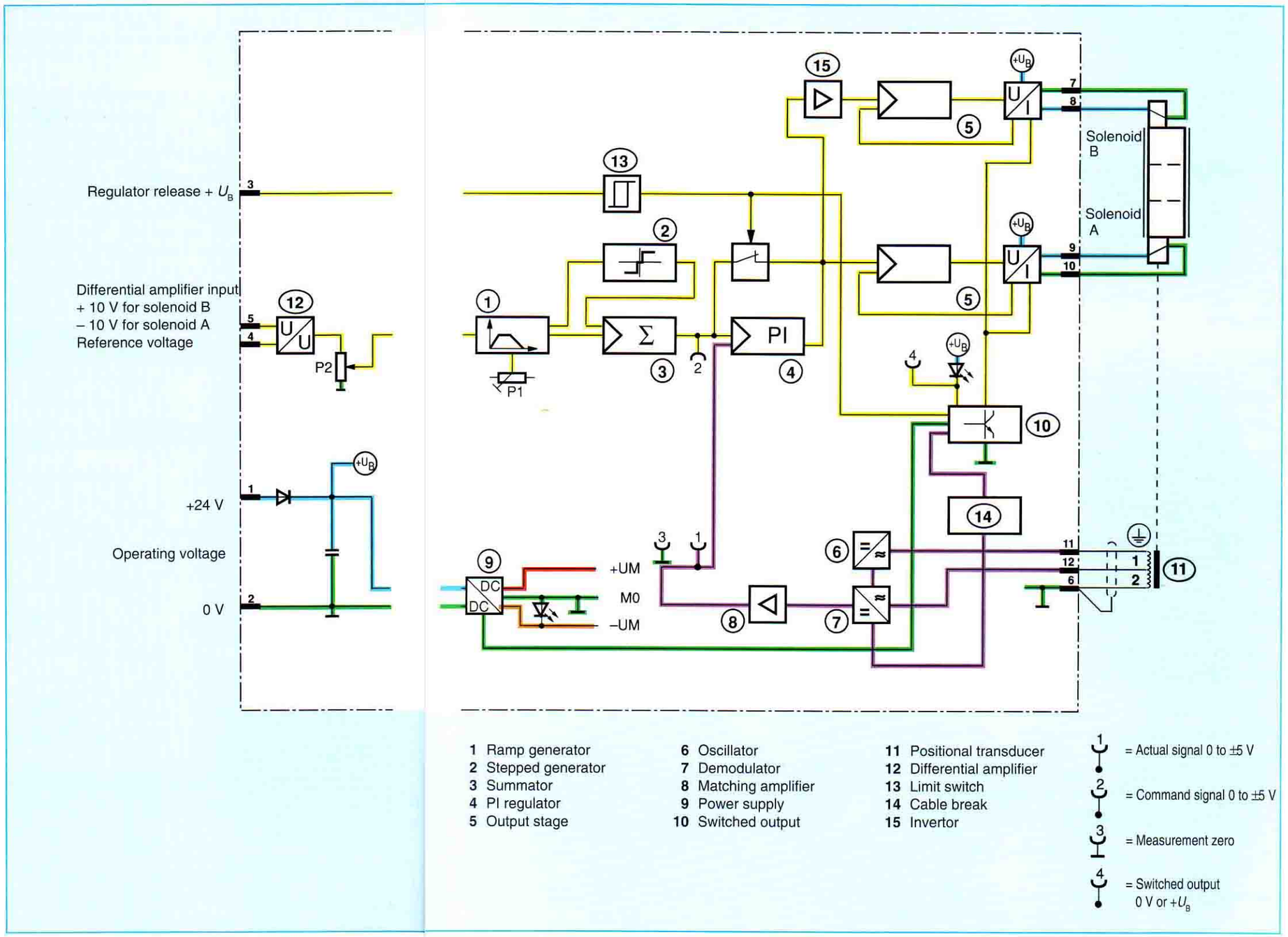


Fig.129: *Terminal connections for proportional amplifier VT 11023 for proportional directional valves with closed loop positional control*