

WEST

Application Note: AN-109

PAM-198-P

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Electronics*

1 Application Area

The PAM-198-P power amplifier is used to control valves with spool position control. In order to adapt this device to a specific valve series, some settings are required. A good result can only be achieved if these are carried out systematically and in the correct order.

Subsequent changes to parameters of a previous step are not recommended.

These instructions are to be understood as a supplement to the product documentation. There you will find a detailed description of all setting options and further information such as technical data and connection diagrams.

In these instructions, only the most important parameters are mentioned which should definitely be set for a good function. The module also has additional options, such as free linearization of the characteristic curve.

2 Wiring and Electrical Interfaces

Please refer to the AN-105-EN, which can be found under

<https://www.w-e-st.de/service/pdf-downloads/>

3 Variants of valves and control systems

The PAM-198-P is basically suitable for the following constellations:

- Directly controlled directional control valves with two solenoids
- Directly controlled directional control valves with one solenoid
- Pilot operated directional valves with barometric adjustment, i.e. pressure valves are used to position the main stage spool against return springs
- Pilot operated directional control valves with main spool actuation in the manner of a follower piston

A common feature of these cases is that the process is self-regulating, i.e. there is a clear, albeit not necessarily linear and precise, relationship between solenoid actuation and spool position. Such valves are referred to below as "Type I".

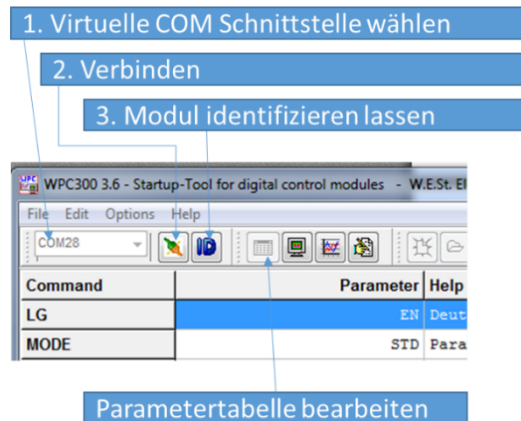
In contrast, there are unbalanced controlled systems that exhibit an integrating behavior. With constant control (not equal to zero), the controlled variable changes more and more. An example of this is the positioning of a main stage using a directional control valve for pilot control. These valves are hereinafter referred to as "Type II".

In general, electrical feedback of the slide travel is necessary for full use of the possibilities. However, the device can also be operated as a pure power amplifier (CTRLMODE OL). In the case of type II valves, this is necessary during the settings, but later in regular operation a purely controlled actuation cannot result in any meaningful behavior with these valves.

4 Connect to the WPC

If the module has a power supply, the connection to the WPC can be established.

1. Select the virtual COM interface (if necessary, check in the device manager whether the latency of the COM interface is set to 1 or 2 ms).
2. Connect (only the COM port is opened, no communication takes place yet)
3. Identify (the parameter table is read in)



Caution: If no connection can be established, then an incorrect COM interface has usually been selected, or the USB/COM driver has not been installed. Unplug the module and plug it in again. Observe on your PC whether the driver is installed or which COM port was added.

5 Step 1: Pre-parameterization

Initially, settings based on the basic system properties and data sheet values are made here. The hydraulics should be switched off first so that you can safely make any adjustments. Please also note that the device can already become active now if the external signals specify the corresponding. It is therefore advisable not to set the external "ENABLE" signal for the time being or to disconnect the wire at terminal 15 for the time being.

The following parameters must now be set:

Command	Parameter	Description	Group
LG	DE EN	Choose your preferred display language	-
CTRLMODE	OL CL	For the next steps it is necessary to first switch to "OL" = controlled mode.	SYSTEM
SENS	ON OFF AUTO	Decide how the device should behave in the event of an error.	SYSTEM
AIN:W	a/b/c/x	Adjustment of the setpoint input	IO_CONF
SIGNAL:U	1S+ 1S- 2S+ 2S-	Is it a valve with one or two magnets? The polarity is initially assumed to be "+".	IO_CONF
CURRENT	500... 2600	Enter the nominal current of the valves here. If this is below 500 mA, you can use the parameters VA:MAX:A/B to further reduce the activation.	PAM
DFREQ DAMPL PWM	60... 400 0... 3000 61... 2604	Use the data sheet information for the valve. ¹	PAM
C:FF	0... 20000	First set the value "10000" = 100%. The final setting follows in step 3.	CTRL

End of step controls (optional):

Check in the monitor window of the WPC whether the target value WA is transmitted correctly.

Activate the RC mode in the WPC and check whether the activation of the magnets works. To do this, tick the "ENABLE" checkbox. The READY LED should light up. If this is not the case, an error is displayed above the red LEDs, which must first be rectified.

By clicking in the WA field (number turns red) you can now specify the setpoint using the slider between -10000 (= -100%) and 10000 (= 100%).

Since the module works in the "OL" mode, i.e. purely controlled, this value is output almost unchanged as the manipulated variable "U".

So it is now possible to control both magnets with your rated current. This applies to 2-solenoid valves. If you have parameterized a 1-solenoid valve, you can adjust its control in the range 0 - 100% by moving WA between -10000 (= -100%) and 10000 (= 100%).

¹ There are two basic principles:

1. The magnet is operated with the highest possible PWM frequency in the kHz range and an additional dither signal. This is the predominant variant in industrial hydraulics.
2. In the mobile sector, valves are mainly used that are controlled with a low PWM frequency. In this case no DITHER signal is used. It is not necessary to use the exact PWM frequency, so the input for our devices is made step by step by selecting from a table. The next level should be chosen.

Attention: The information in the data sheet on this topic is often incomplete or misleading, as the terminology is often confused. If there is only one frequency specification, the PWM setting is usually meant. When the DITHER signal is meant, there is usually an indication of frequency and amplitude. If there are no instructions, starting with the factory settings is recommended.

Process Parameter

---	---	---	---
WA	WA	100,00	%
Eingangssignal			
IA	IA	1876,00	mA
Magnetstrom			
IB	IB	10,00	mA
Magnetstrom			
U	U	100,00	%
Stellsignal			
---	---	---	---
---	---	---	---
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Remote Control / Status Info

Enable Remote Control

Analogue Inputs

WA

10000

-10000 10000

Digital Inputs / Outputs

ENABLE

Status Info

- READY
- EEPROM
- SYS_ERROR
- INPUT PIN 9
- INPUT PIN 14
- SOLENOID A
- SOLENOID B

6 Step 2: Scaling the displacement sensor

The slider travel is usually recorded using an LVDT displacement encoder. Since the device is not able to process the raw signal from such a sensor, external evaluation electronics are required. This can also be integrated directly into the sensor. The sensor's output signal is proportional to the slide travel. It is often possible to calibrate the zero point and gain on the sensor or its evaluation electronics. The fundamental decision must be made as to where an individual adjustment should be made. If an entire series of valves is to be operated with a single parameter set, it makes sense to make an adjustment on the position transducer. In the case of individual applications, this can also be done using the AIN:X command. Both procedures are described here.

a.) Adjustment on the displacement transducer

It is determined which output signal range is used and where the zero point of the signal should be (corresponding to the neutral position of the slider).

Based on these specifications, the module is prepared accordingly using the AIN:X command. This is described in detail in Chapter 5.3.1 of the device documentation.

Example: The sensor is to be adjusted in such a way that it delivers 4 V in the center position, 1 V at full deflection to "B" and 7 V at full deflection to "A": C (offset) = 4000, B (divider) = 300 (3V for 100%), A remains 1000.

In order to be able to set the zero point and the gain on the sensor, the valve must be controlled and the signal that has been read in must be displayed. To do this, use the RC mode as described in the previous chapter. The actual position of the spool is indicated by the process variable "X". With correct scaling, the following picture should result:

2 solenoid valves	WA = U = 0 -> X = 0 (only Type I) WA = U = 100% -> X = 100% WA = U = -100% -> X = -100%
1 solenoid valve	WA = U = 100% -> X = 100% WA = U = -100% -> X = -100%

With single-solenoid valves, the zero point cannot be found using the electrical signals alone, since the spool is not centered. One possibility is to use the oil flow to find the hydraulic zero point.

Zero point for valves of type II (controlled system without compensation):

If the valve has a spring centering, the zero point can be set in a completely depressurized state. Otherwise the position control must first be provisionally adjusted (see step 4), then you can search for the hydraulic zero point with the oil flow.

To set the signal, an adjustment is made on the displacement transducer.

It should be noted that signals greater than 100% and less than -100% are cut off, i.e. it is better to set it to +/- 99%, since at 100% you cannot be sure whether the signal has been limited.

If the system behaves exactly the opposite way (-100% X at U = 100%), you can either swap the valve connection lines or set the U parameter to negative polarity (1S- or 2S-).

b) Adjustment using the scaling function AIN:X

Procedure similar to that described in the product documentation: Standardeinstellung 1000 / 1000 / 0 / V bzw. 1000 / 1000 / 0 / C wählen (Strombereich 0-20 mA)

- o Take the displayed value X at the zero point (in %) * 100 and enter it under C (e.g. 1000 / 1000 / 5120 / V)
- o Control with +100% (see above), note the value
- o Control with -100% (see above), note the value
- o Take the larger value * 10 and enter it under B (e.g. measured is -26.8% and 25.1% -> B is set to 268)
- o Check whether about -100 ... 0 ... 100% is reached.

With regard to polarity, the statement under a) applies.

Zero point for valves of type II (controlled system without compensation):

If the valve has spring centering, the zero point signal can be used in a completely depressurized state. Otherwise, the mean value of the signals in the two end positions should be used first. After setting the controller, you can then search for the hydraulic zero point and correct it if necessary.

7 Step 3: Set minimum control or offset and precontrol

In order to compensate for the dead zone caused by the spring preload for 2-solenoid valves, it is necessary to specify a minimum actuation. The value is set separately for both directions and is easy to determine:

Use the RC mode as above, slowly increase the control with the slider for WA and observe the actual value X. The point from which the display for X begins to rise noticeably with a further increase in WA is sought. Write down the control signal U at this point. The same can be repeated for the other direction towards negative values for WA and X. The value for U found there is also noted. Then the two parameters VA:MIN:A and VA:MIN:B must be set in the "IO_CONF" group: direction A for the positive, B for the negative signal direction. Enter the amounts of the minimum activations (*100, since the entry is made in 0.01%).

It is possible to round off the value generously, but do not enter values that are too large, otherwise the control in the area around the zero point will not work.

In the case of single-solenoid valves, an adjustment of the OFFSET is necessary at this point, i.e. the control that brings the slide into the neutral position. For this purpose, WA must be set to "0" in RC mode, ENABLE is still necessary.

Now set the VA:OFFSET parameter in the "IO_CONF" group so that the slider position "X" reaches the zero point as well as possible.

Pilot control (Type I):

This parameter is very important. The better the pre-control is set, the less the controller has to "work".

Select at least the two process variables X and C (= controller output) in the monitor.

Using the RC mode, slowly move the slider to both end positions via the setpoint WA.

Record the values of C at which full deflection of the slider is achieved in both directions.

You can also take the hysteresis into account here, i.e. also record the values when the signal is lowered, at which the reverse movement begins. An average value of the magnitudes of the signals "C" determined in this way must be entered in the C:FF parameter in the CTRL group (take x 100 again).

Type II valves:

You proceed in a similar way when setting the minimum control, but the integrating behavior of the controlled system must be taken into account. As soon as the slide of the main stage reaches one of the two end positions, first move it back into the working area. A certain drift will be noticeable even with vanishing control. We are looking for the points from which there is a significant increase in speed. If you are controlling a type II single-solenoid valve, try setting the OFFSET parameter to a state of minimum drift. To do this, set the C:FF parameter to "0" and move the slider only by changing this parameter.

Even with 2-solenoid valves of type II, after setting the minimum control, C:FF must be set to "0", because pilot control has no meaning here in normal operation.

8 Step 4: Optimize the position controller

Now it's time to exit the controlled mode and activate the controller. To do this, set the CTRLMODE parameter in the "SYSTEM" group to CL.

Attention: If the controller is activated and incorrectly set, the control can become unstable, which leads to strong vibrations. If anything like this occurs, remove the "ENABLE" signal and reduce the controller gain before trying again.

A number of additional parameters are now displayed in the CTRL group, which must be set in the correct order.

First set C:I_LIM to "0" so that the integral part of the controller is suppressed.

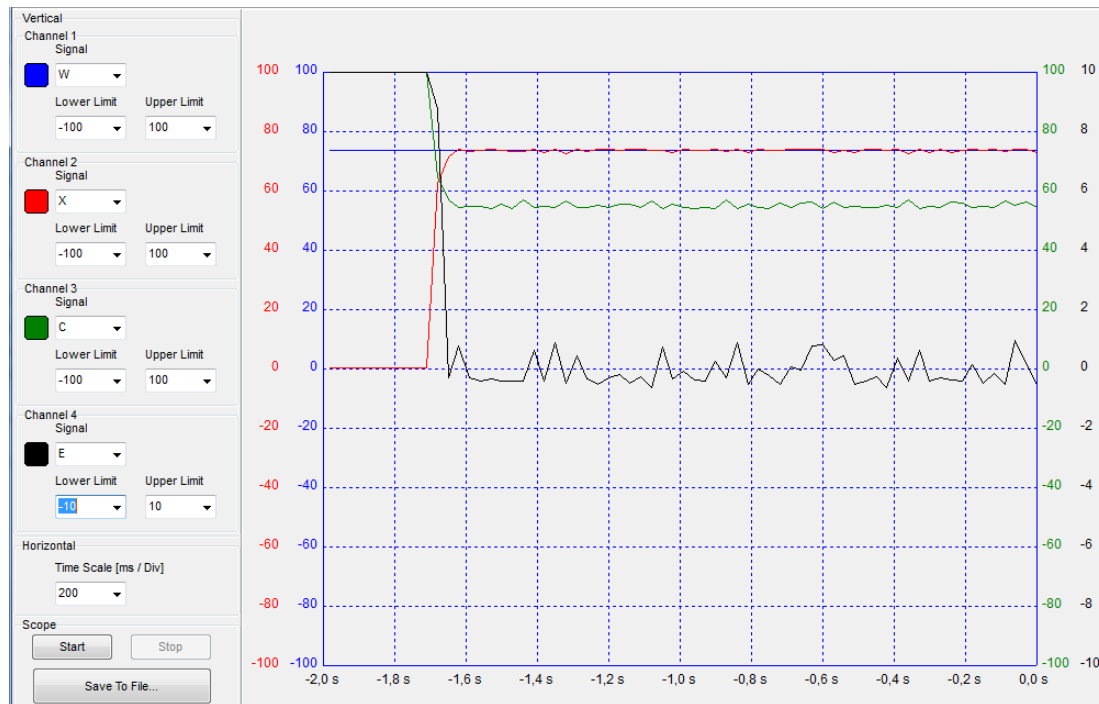
The oscilloscope view in the WPC is useful for assessing transient response.

The signals of interest are: X (spool position), W (set point), C (controller output), E (control error)

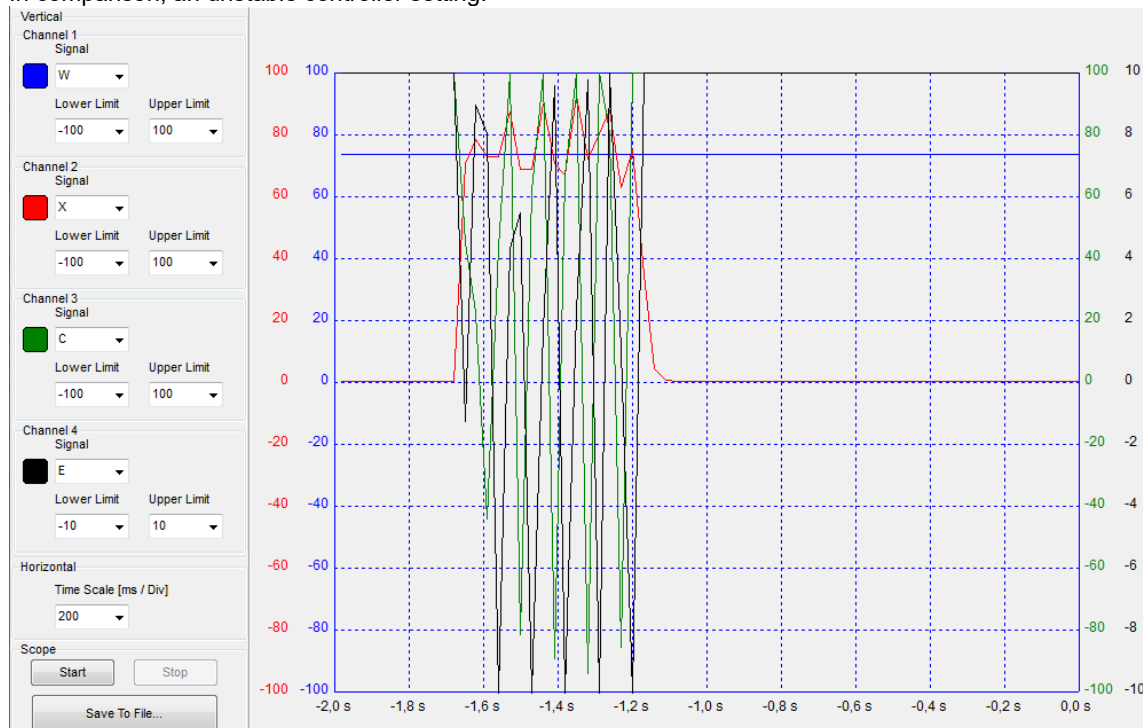
In order to be able to observe the settling, it is necessary to have the oscilloscope window active during a signal change. If you are using WPC < Version 4.0, this is only possible with an external signal specification for W and ENABLE. In order to implement setpoint jumps with a steep rise, the ramp times in the "ADAPT" group should first be reduced to the minimum value of "1" (parameters RA:1 ... RA:4).

Setpoint jumps are caused by rapid changes in the analog setpoint signal or by switching on the ENABLE.

The following illustration shows good transient behavior:



In comparison, an unstable controller setting:



The easiest way to adjust the proportional gain is to gradually increase C:P until instability is encountered. The value of C:P is then divided again by 2-4 to get a definitely stable but high value.

If possible, a test with oil flow should also be carried out at this point, since the behavior can change due to the flow forces and their dynamic components.

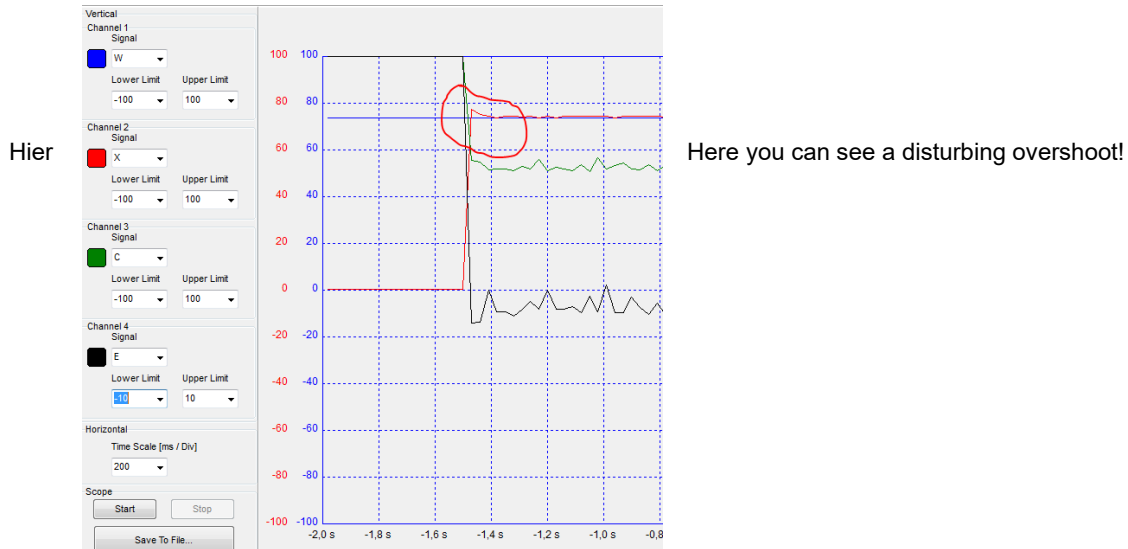
Type I:

After setting the proportional gain, the integral component can be activated. First parameterize a long reset time, i.e. a weak I component: set C:I to 5000, for example.

The first thing to do now is to find the lowest possible limit using C:I_LIM, which is sufficient to correct remaining control deviations, regardless of the operating situation.

So first increase C:I_LIM e.g. to 2000 (= 20%) and carry out tests with different controls with and without oil flow. Observe whether the control deviation "E" only fluctuates around the zero line after steady-state operation has been reached. If this is not the case in some points, but C is not yet 100% or -100%, increase C:I_LIM.

Next, the reset time C:I must be set to an optimum value. Optimal means: As small as possible, but without a tendency to oscillate and with little overshoot. Another disruptive effect when reset times are too short can be that due to the quick response but asymmetrical signal limitation, a permanent control deviation occurs again.



Type II:

In most cases, the integral component can remain deactivated since the controlled system already has an integrating behavior. If you still find that the control deviation is too high without an integrator, you can set it in a similar way to that described above. However, a much lower value must be set for C:I_LIM (typically a maximum of 5%).

The most important control parameters have now been set. Depending on the application, the following can still be useful:

- Activate D-part (this sometimes allows a higher P gain), but is often problematic
- Adapt the dead zone for the integrator (C:I_DEACT) if the slider fluctuates cyclically through the I component in stationary operation (occurrence of so-called limit cycles).
- Set the activation threshold for the integrator if overshooting when the setpoint changes cannot be eliminated by a sensible increase in C:I. (does not apply to Type II, leave C:I_ACT at "0" there).

9 Step 5: Adjust setpoint pre-processing

Now that the slide position control is working optimally, the next steps serve to adapt it to the application.

In step 3, the portion of the dead zone that results from the spring preload has already been compensated. Now the remainder can be compensated, which results from the overlapping of the control edges on the slide.

To do this, determine the values of the input signal WA in both directions required to start flow through the valve.

Enter the amounts of these values in the "ADAPT" group in the MIN:A / MIN:B parameters (as usual * 100).

If you still want to limit the maximum flow or want to achieve symmetrical speeds of the drive in both directions, you can use the parameters MAX:A / MAX:B for this.

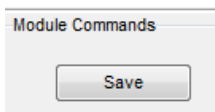
Depending on the application, it makes sense and is necessary to limit the speed of the adjustment:

If the valve is to serve as an actuator in a higher-level control circuit, a limitation is usually not desirable. Leave the parameters RA:1 ... RA:4 at the value "1" = minimum setting, as selected in the last step.

When specifying the setpoint manually, the values from the factory setting (100 ms) are good starting values, but they can be further increased depending on the application. For the exact function of the 4-quadrant ramp, read the corresponding chapter in the product documentation.

10 Step 6: Completion of the work

When all settings are complete, save the settings in the non-volatile memory of the module using the SAVE command:



In addition, we recommend backing up the parameters in a file:



You can use this to save the settings independently of the module and, if necessary, transfer them to other devices.

11 Further information and support

As mentioned at the beginning, all functions are described in detail in the technical product documentation for your device. If you encounter problems or require additional functions, please read this document first.

If further help is required, you can reach us at technics@w-e-st.de or the given telephone number.

Please describe the exact facts in an understandable way and attach:

- Set parameters as *.wpc file
- Screenshots of the WPC monitor window and, if applicable, the oscilloscope view

Another very effective way of support is remote access to your computer using the TeamViewer program.

12 Imprint

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Datum: 18.07.2023

For more detailed information and safety instructions, please refer to the general product documentation.