

S700

Application note

"Servo pump"

Version 12/2016
Translation of the original language

Versions published to date:

Version	Comments
09/2015	First english version
12/2016	ASCII commands removed, reference to Online Help added

Subject to technical modifications that improve the devices.
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1 General

In the firmware version 5.82, the functionality of the S700 has been expanded to include the module "servo pump".

1.1 Functional description

Together with the servo pump functionality, an S700 servo amplifier can be used to power a hydraulic cylinder. The entire system usually consists of a servo amplifier, a motor with position feedback unit, and a hydraulic cylinder with pressure feedback unit.

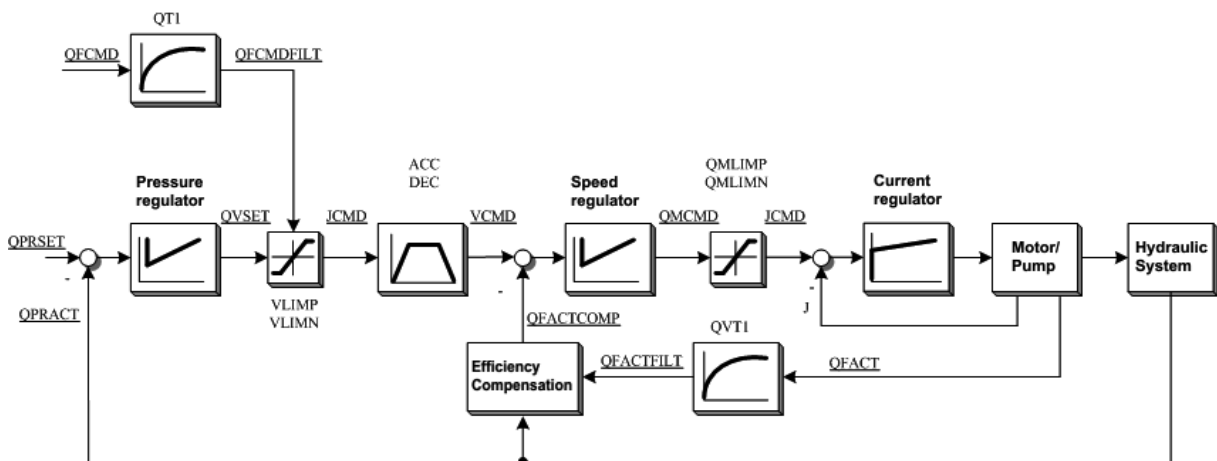
The cascaded pressure/volume regulation in S700 ensures compliance with a specified cylinder pressure or flow profile.

1.2 Activation

The servo pump function is activated by ticking the "Activate servo pump function" checkbox in the "Servo pump" section of the S700 operator program. Alternatively, the ASCII command "QENA 1" may be used.

Once the drive is in the "Digital speed" operating mode (OPMODE 0), the servo pump module is integrated into the real-time regulation. In all other operating modes or when the blocked servo pump function is activated ("QENA 0"), the standard amplifier functionality is active.

The general structure of the cascaded pressure/volume flow regulator can be seen in the following diagram:



2 Starting up the servo pump

2.1 First step (digital setpoint specification)

The following information applies under the assumption that the motor has already been started up and that the motor can be moved in operating mode "Digital speed" (see S700 Instructions Manual).

1. Connection of the pressure sensor (+/- 10V) to setpoint input 1 on the amplifier, connector X3B pins 9 and 10.

Definition of a table for pressure-sensor calibration PTAB.
In the simplest case, a linear 200 bar pressure sensor can be defined using the commands below.

```
PTAB 1 -10000 -200000  
PTAB 2 10000 200000
```

2. Setting the PID controller parameters for the pressure and volume flow regulator.

3. Definition of the displacement (QFACTOR) in cm³ per motor revolution

4. Setting the regulator operating mode "Digital speed" (OPMODE 0).

5. Activating the pump function (QENA 1).

6. Specification of a constant pressure setpoint (QPRSET command in bar)

7. Specification of a constant volume flow in liters/minute (QFCMD)

2.2 Analog setpoint specification

The pressure and/or volume-flow setpoints can be specified via the analog interface SW2 (+/- 10V, connections 11 and 12 of terminal X3B).

The following parameterizations are required for this:

To specify a pressure setpoint via SW2

QCNFG Bit 4 = 0

QCNFG Bit 5 = 0

QCNFG Bit 6 = 0

QCNFG Bit 7 = 1

QPRMAX – pressure setpoint in bar which corresponds to an input voltage of 10V.

To specify a volume-flow setpoint via SW2

QCNFG Bit 4 = 1

QCNFG Bit 5 = 1

QCNFG Bit 6 = 1

QCNFG Bit 7 = 0

QFMAX – volume-flow setpoint in l/min which corresponds to an input voltage of 10V.

Switching the setpoint specification between pressure and volume flow via digital input 1

QCNFG Bit 4 = 1

QCNFG Bit 5 = 0

QCNFG Bit 6 = 0

QCNFG Bit 7 = 0

QPRMAX – pressure setpoint in bar which corresponds to an input voltage of 10V.

QFMAX – volume-flow setpoint in l/min which corresponds to an input voltage of 10V.

The "High" state at digital input 1 activates pressure setpoint specification; volume-flow specification is activated by the "Low" state.

When the POSIO option card is connected, both analog channels are configured with the volume/pressure setpoint specification:

Analog-IN 3 (terminal 21/22) – volume setpoint specification 10V = QFMAX

Analog-IN 4 (terminal 24/25) – pressure setpoint specification 10V = QPRMAX

In this case, the SW2 interface does not have any function.

2.3 Setpoint specification via a profile order

A profile order can be defined on the "Motion tasks" menu page. The order consists of a target pressure setpoint, a target volume setpoint, a setpoint build-up time, and a setpoint release time. A follow-up order and a delay time can also be defined.

Profile order 0 can also be defined using the following ASCII commands:

- O_P** – target pressure setpoint in mBar
- O_V** – target volume-flow setpoint in ml/min
- O_C** – profile control value

- Bit 3 = 1 follow-up profile available, follow-up profile number in O_FN
- Bit 4 = 1 flying changeover to the follow-up profile
- Bit 7 = 1 follow-up profile after delay O_FT
- Bit 19 = 1 profile order for the servo pump (execution in OPMODE=0)
- Bit 19 = 0 positioning motion service (execution in OPMODE>=4)
- Bit 20 = 1 pressure profile generator, volume flow adopted on start-up
- Bit 20 = 0 volume-flow generator, pressure setpoint adopted on start-up

- O_ACC** – pressure/volume-flow build-up time in msec
- O_DEC** – pressure/volume-flow release time in msec
- O_FN** – number of a follow-up profile
- O_FT** – delay time in msec
- O_TAB** – number of an acceleration profile table.

- 0 – linear profile (trapezoid).
- 1 – sinus² – profile
- 2 – jerk-limited profile

The "OCOPY 0 nr" command copies the temporary profile order 0 to the number 0.

Example:

The following 3 profiles 111,112,113 are continuously called up one after the other (100 msec delay between profiles).

```
ORDER 111 50000 20 524440 200 200 0 0 112 100
ORDER 112 30000 10 524440 200 200 0 0 113 100
ORDER 113 40000 15 524440 200 200 0 0 111 100
```

An active profile can be canceled using the STOP command.

The START/STOP functions for the digital inputs can also be used to activate/cancel profiles (INxMODE=16,17,23,29).

2.4 Speed-dependent switching of the regulator parameters

The parameter setting of the pressure regulator (PID1) can be switched depending on the speed. There are 5 parameter sets that can be defined on the "ServoPump/PID" menu page. Each parameter set also has a speed value. The regulator settings apply as soon as the current speed has exceeded the threshold value. They also remain valid if there is no parameter set with a lower switching threshold. If only one parameter set is defined, it will apply for all speed ranges.

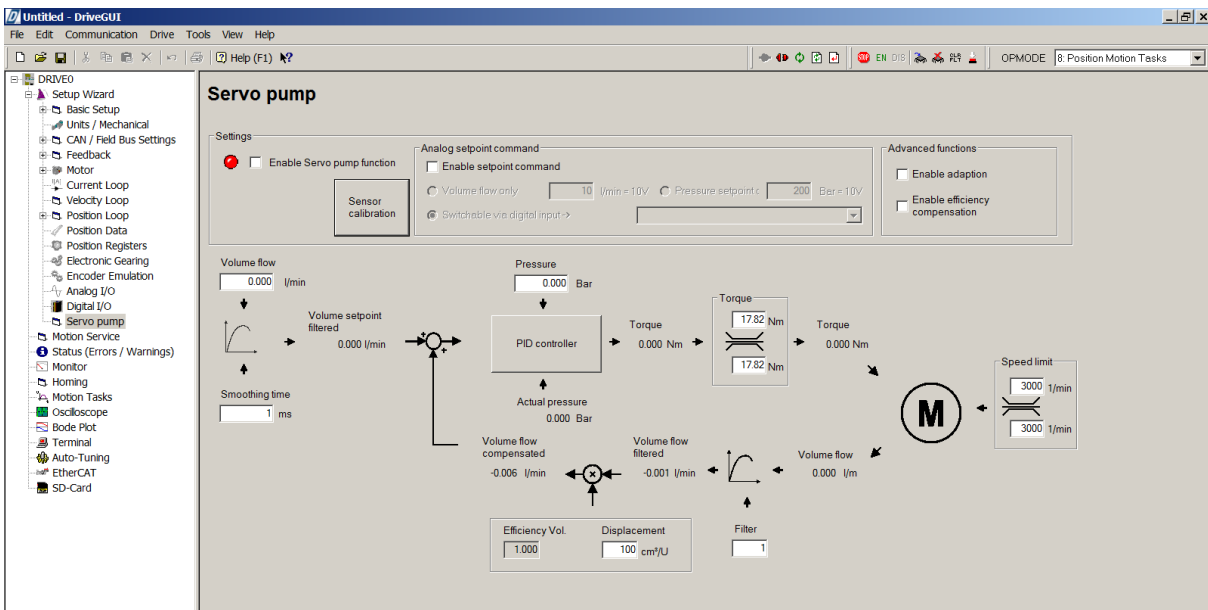
The parameters for the volume-flow regulator (PID2) cannot be switched. The settings apply for all speed ranges.

2.5 Creating a table for the efficiency compensation

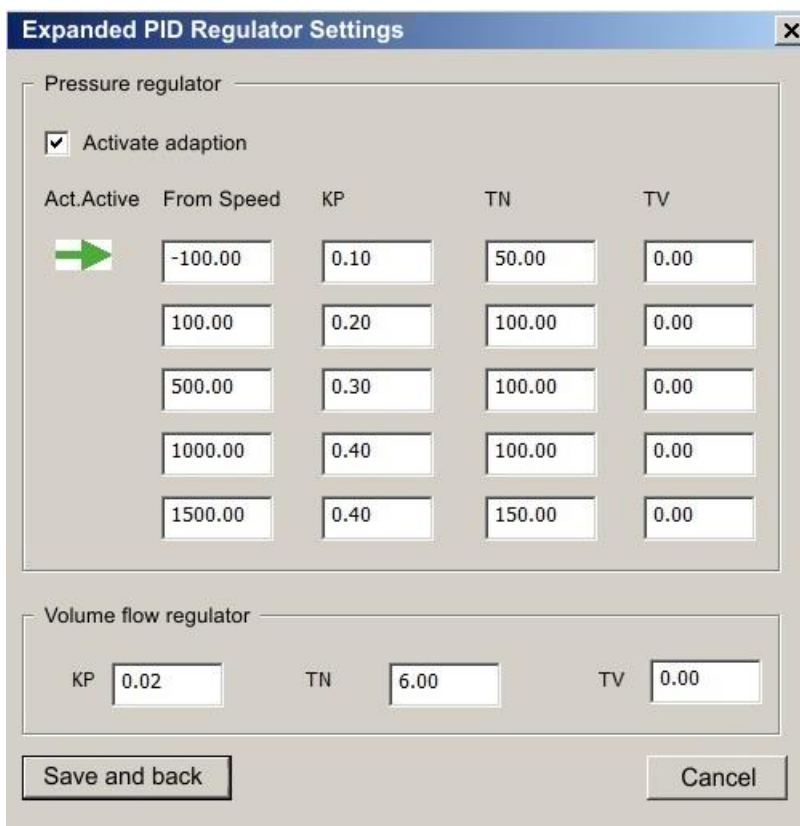
The efficiency of the set pump being used can be defined based on the current speed and the actual pressure value. The efficiency is defined in the form of a text table that will need to be created using an external editor. The table contains whole-number values that are interpreted as multipliers with 3 decimal places (1000 corresponds to a factor of 1.000). The factor has an impact on the valuation of the current volume flow: With values > 1000, the volume flow increases. With values < 1000, it decreases.

3 DriveGUI – menu pages

3.1 Main page - servo pump



3.2 Regulator parameters (adaption)



3.4 Profile parameters

Motion Task Parameters

Number: 160

Trajectory / Profile: acc. (sine ²)

Table / Acc. No.: 0

Target volume: 12000 ml/s

Acceleration: 300 ms->v_max

Deceleration: 3000 ms->v_max

Motion Type: Vol Profile

Target Position / Distance / Target pressure: 10000 mbar

Units: Incr.

Next Motion Task: Next Motion Task

Next Number: 152

Motion blending: a, b, c

Start Condition: [Dropdown]

Start by I/O Edge: [Dropdown]

Delay Time: 100 ms

Buttons: Clear Motion Task, OK, Cancel, Apply, Help

3.5 Scope recording for a volume profile

Untitled - DriveGUI

File Edit Communication Drive Tools View Help

OPMODE: 0: Digital Velocity

Time: 0.399 0.799 1.198 1.598

Channels: Trigger Recording / Scope Files Motion Service Tuning Settings

Resolution: normal

Time/Div: 200 ms

Channel 1: Press_Cmd Auto-scale

Channel 2: Flow_Cmd Auto-scale

Channel 3: MOVEP_NR Auto-scale

Channel 4: off Auto-scale

Ready S706 (DRIVE0) @ COM1 (38,4 kBaud)

4 Servo pump: Implementation information

There is a separate input screen for the "Parameter adaption" function.

The "Q setpoint" and "P setpoint" fields are used as target/actual fields. When inputting values, the corresponding setpoint is set. Otherwise, the current setpoint is shown. Setpoints can only be specified manually if there is no active setpoint specification via the fieldbus (or via SW2 (analog)).

4.1 Allocation of parameter/actual field to ASCII command

1. Q setpoint unfiltered QFCMD (float) : ACTUAL/TARGET
2. Q setpoint filtered QFCMDFILT (float) : ACTUAL
3. Smoothing time setpoint QT1 (float) : TARGET
4. Smoothing time actual value QVT1 (float) : TARGET
5. Q actual value QFACT (float) : ACTUAL (before filter)
6. Q actual value QFACTFILT (float) : ACTUAL (after filter)
7. Q actual value QFACTCOMP (float) : ACTUAL (after efficiency compensation)
8. Current efficiency compensation QFCFACT : ACTUAL
9. P setpoint QPRSET (float) : ACTUAL/TARGET
10. P actual value QPRACT (float) : ACTUAL
11. QENA activation = 0/1 : TARGET
12. Displacement volume QFACTOR (float) : TARGET
13. Current torque QMACT [in Nm] : ACTUAL
14. Current torque setpoint QMCMD before limitation: ACTUAL
15. Current torque setpoint QMCMDLIM behind the limitation : ACTUAL
16. Positive torque limit QMLIMP : TARGET
17. Negative torque limit QMLIMN : TARGET

Configuration variable QCNFG (32 Bits) : TARGET

QCNFG Bit 0 – pump direction 0=right, 1=left

QCNFG Bit 1 – adaption active

QCNFG Bit 2 – efficiency compensation active

QCNFG Bit 4 - configuration of SW2

QCNFG Bit 5 - configuration of SW2

QCNFG Bit 6 - configuration of SW2

QCNFG Bit 7 - configuration of SW2

SW2 configuration bits

Bit 4,5,6,7 = 0 SW2 deactivated

Bit 4,5,6,7 = 1 SW2 switchable via input 1

Bit 4,5,6,7 = 2 SW2 switchable via input 2

Bit 4,5,6,7 = 3 SW2 switchable via input 3

Bit 4,5,6,7 = 4 SW2 switchable via input 4

Bit 4,5,6,7 = 5 SW2 switchable via input 5

Bit 4,5,6,7 = 6 SW2 switchable via input 6

Bit 4,5,6,7 = 7 SW2 always volume setpoint 10V = QFMAX

Bit 4,5,6,7 = 8 SW2 always pressure setpoint 10V = QPRMAX

4.2 Allocation of regulator parameters to ASCII command

Pressure regulator

Up to speed	KP	Tn	TV
QTAB1V	QTAB1KP	QTAB1TN	QTAB1TV
QTAB2V	QTAB2KP	QTAB2TN	QTAB2TV
QTAB3V	QTAB3KP	QTAB3TN	QTAB3TV
QTAB4V	QTAB4KP	QTAB4TN	QTAB4TV
QTAB5V	QTAB5KP	QTAB5TN	QTAB5TV

Current values

QPE	QKPEFF	QTNEFF	QTVEFF
-----	--------	--------	--------

QTABID – current index 1...5

Volume-flow regulator

KP	Tn	TV
GV	GVTN	GVTV

4.3 Creating a table for the efficiency compensation

The efficiency compensation table contains speed factors (1000 = 1.0) that are used as multipliers for the actual-speed calculation, dependent upon the current speed and the current pressure value. The table is designed as follows:

- Table ID TABID
- Number of speed entries VCNT
- Increment of speed entries VSTEP (in RPM)
- Number of pressure entries PCNT
- Increment of pressure entries PSTEP (in mBar)
- (PCNT*VCNT) Factors as 3-digit fixed point numbers
Factor = 1000 corresponds to a value of 1.000

This structure can be defined as follows:

```
{
WORD TABID=5;
LONG VCNT;
LONG VSTEP
LONG PCNT;
LONG PSTEP;
LONG Factor[VCNT][PCNT];
}
```

The max. number of table entries (PCNT*VCNT) is 16320.

A table with 136 x 120 values can therefore be created (table[136][120]).

The VCNT*PCNT values are arranged as follows:

```
Factor_v1_p1,Factor_v1_p2,Factor_v1_p3...Factor_v1_pPCNT,
Factor_v2_p1,Factor_v2_p2,Factor_v2_p3...Factor_v2_pPCNT
```

...

```
Factor_vVCNT_p1,Factor_vVCNT_p2,Factor_vVCNT_p3...Factor_vVCNT_pPCNT
```

The speed/pressure differences are always the same and match the VSTEP and PSTEP values.

The table is defined by the user as a pure text file. The Windows program CalcLookUp5.exe is then used to turn this file into an S-record file, which can then be imported into the S700 amplifier using the Download tool. The values from the table are viewed internally as support points. Regardless of the number of defined support points, a 128 x 128 matrix is constructed internally in the S700 by means of linear interpolation, and is then used for volume efficiency compensation.

The ASCII command QFCFACT gives the current value of the compensation factor.

Example of a table with 5 x 4 elements

Speed/pressure	0 bar	50 bar	100 bar	150 bar
0 RPM	1,000	1010	1020	1030
500 RPM	1100	1110	1120	1130
1000 RPM	1200	1210	1220	1230
1500 RPM	1300	1310	1320	1330
2000 RPM	1400	1410	1420	1430

5, /* table ID for the efficiency compensation (5) */

5.500, /* 5 speed rows, 500 RPM apart*/

4.50000, /* 4 pressure columns, 50000 mBar apart */

10,11,12,13, /* factor values for 0 RPM */

20,21,22,23, /* factor values for 500 RPM */

30,31,32,33,34, /* factor values for 1000 RPM */

40,41,42,43,44, /* factor values for 1500 RPM */

50,51,52,53,54 /* factor values for 2000 RPM */

By entering the text PUMPTAB as a trigger variable and the pressure value as a trigger threshold, the speed/factor curve for the pressure value can be shown on the Scope page. The X axis shows the speed in 1000 RPM, while the Y axis shows the efficiency factor.

If a pressure value <0 is entered, then 4 channels are recorded with the pressure values $P=0$, $P=P_{max}/3$, $P=P_{max}*2/3$, and $P=P_{max}$.

4.4 Creating a table for the pressure sensor calibration

The pressure sensor calibration table defines a dependency between the actual pressure values (in mBar) and the input voltage (in mV).

The corresponding actual pressure value is calculated using this table when the analog voltage from the setpoint input 1 (SW1) is read in.

The table can contain a maximum of 25 support points, which can be defined using the PTAB command.

The support points are used internally to form a table with 16384 entries by means of linear interpolation. The table shows the voltages -10V...10V.

The PTAB command can be used in the following ways:

- "PTAB number voltage pressure" – definition of a support point
Task Number: Number of the support point (number between 1 and 25)
Voltage: Voltage in mV (-10000 ... 10000)
Pressure: Related pressure value in mBar
- "PTAB number" – display of a support point
Task Number: Number of the support point (number between 1 and 25)
- "PTAB" – output of all defined support points
- "PTAB -1" – deletion of all defined support points

5 Servo pump: ASCII commands

All ASCII commands are described in the ASCII Object Reference. The Object Reference is part of the DriveGUI Online Help.

You can start the ASCII Object Reference online as well:

<http://wiki-kollmorgen.eu/wiki/DanMoBilder/file/s300700help/ASCII.HTML>

6 PROFIBUS expansions

PNU930 new operating mode -7 (Digital speed + servo pump) implemented.

With this operating mode, the process data channel is configured as follows:

PZD1	PZD2	PZD3	PZD4	PZD5	PZD6
STW	Pressure setpoint	Volume-flow setpoint	It is also referred to as Commutation Alignment and Pole Locking.	It is also referred to as Commutation Alignment and Pole Locking.	It is also referred to as Commutation Alignment and Pole Locking.
ZSW	Actual pressure value	Actual volume-flow value	Actual current value	Actual position of bits 16...32	Actual position of bits 0...15

The 16-bit values for the pressure setpoints/actual pressure values are specified in 10 mBar intervals

The 16-bit values for the pressure-flow setpoint/actual pressure-flow value are specified in 0.1 l/min intervals

When operating mode 7 is activated, QENA is automatically set to 1. When switching to an operating mode other than 7, the servo pump is deactivated (QENA=0).

New PNUs 1780...1820 (see ASCII objects)

7 New variables for the Scope recordings

- QFACT volume-flow actual value in l/min (without filter)
- QFACTFILT volume-flow actual value in l/min (with filter)
- QFCMD volume-flow setpoint in l/min (without filter)
- QFCMDFILT volume-flow setpoint in l/min (with filter)
- QPRSET pressure setpoint in bar
- QPRACT actual pressure in bar
- QMCMD torque setpoint in Nm
- QMACT actual torque in Nm
- PCMD power setpoint in Watt
- PACT actual power in Watt
- VQCMD Q-voltage setpoint in Volt
- VDCMD D-voltage setpoint in Volt

8 Format of the Scope file

Data that is used with a Scope recording can be written to an Excel file

(with ending *.csv) under the menu item "Recording/oscillogram → Save oscillogram". The file format is as follows:

Row 1: management information for the GUI Scope page (without significance for external data evaluation)

Row 2: Text "DRIVE S300"

Row 3: Column 1: Number of recorded points "Xcnt"

Row 3: Column 2: Interval between the recorded points (in msec) "Xtime"

Row 4: Column 1...column 10 : name of the recorded channel Xn (n=1...10)

Row 5: Column 1...column 10 : data values for channels 1...10 at time 0

Row 6: Column 1...column 10 : data values for channels 1...10 at time "Xtime"

Row 7: Column 1...column 10 : data values for channels 1...10 at time "2*Xtime"

.....

Row 4+Xcnt: Column 1...column 10: Data values for channels 1...10 at time "(Xcnt-1)*Xtime"

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