Technical Note 131

Sensorless pumping for the ACH580/ACQ580

Pressure control

Introduction

The ACH580 and ACQ580 drives can perform internal flow calculations that allow for controlling the pump speed to match the system load requirements without the use of external feedback sensors. A sensorless flow calculation function uses the pump data to calculate the flow in the system based on measured flow, pressure, and power. By testing the pump and motor combinations, system accuracy is increased by reducing the data tolerance issues created by individual component testing.

The PQ (Power to Flow) data is used to calculate the flow, and the calculated flow is then used in the QH (Flow to Head) data to determine the head of the system. The required information needed to set up the PQ and QH sensorless pump control is the system power, flow, and head. By using up to 10 data points through no flow to full flow conditions, the drive can calculate the flow to head and head to flow without the use of external sensors.

This technical note is to assist an OEM in setting up and testing the “PQ and QH” (power to flow and flow to head) function of the ACH580/ACQ580 drive with drive firmware version of 2.18.2.1 or higher.

Factors influencing the accuracy of the system

By testing the pump/motor combination, more accurate data is obtained. The accuracy of the test data acquired is reflected in the accuracy of the drive's mathematical prediction, allowing for better performance in sensorless pump control modes.

Drive motor control modes:

- Scalar control: Scalar control sets a specific V/Hz according to the data given on the motor nameplate. The actual slip of an asynchronous motor will be dependent on the pump load compared to the motor's capabilities. When a motor and pump are tested as a unit, the actual slip is part of the results.
- Vector control: Vector control uses a model of the motor based on the motor data given and a series of measurements of motor current and voltage to get the right relationship for obtaining the speed required. The uncertainty of the actual shaft speed is reduced by using vector control, which helps to get a better estimate of the actual flow. If independent pump and motor data is being used without testing, the use of vector control may result in more accurate results.

Estimation at low flow is a challenge, and typically the uncertainty increases at lower flow. Therefore, it is not recommended to use flow calculations for systems running at low flow.

The estimate of the flow calculation function is best in systems with constant flow or systems where the flow changes slowly over time. These kinds of systems will have long periods of steady-state operation where the speed is relatively fixed and all input parameters for the flow calculation are relatively constant, giving the best opportunity for a precise calculation.

Motor/Pump Testing

For optimal testing of the motor/pump combination, the setup should include an adjustable flow valve, flow meter, and pressure meter (Diagram 1).

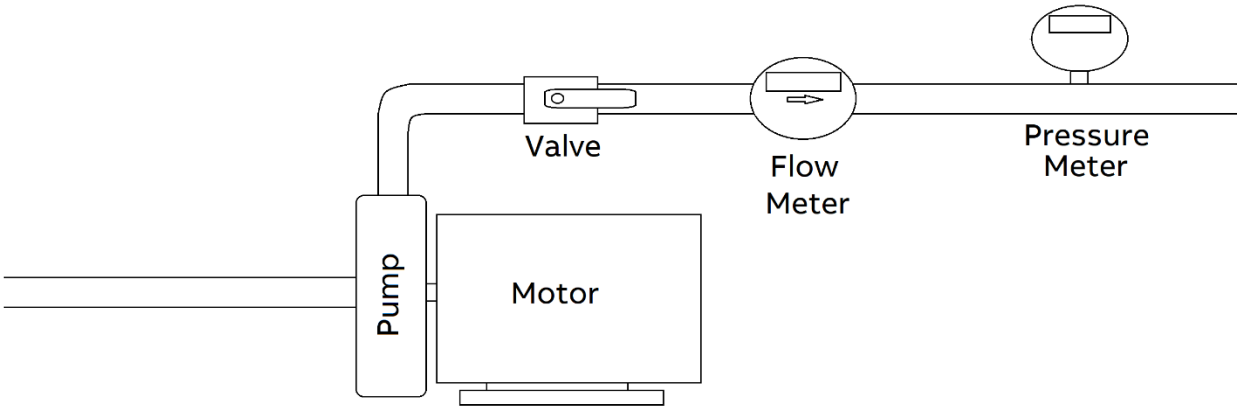


Diagram 1: Lab setup

The drive should be programmed for the desired control mode (parameter 99.04) and the motor data entered.

With the pump at full speed and by controlling the flow through the flow valve from closed to fully open the power, flow, and pressure data is collected (Table 1).

Before performing the final testing points, check for a labile pump curve (Graph 1). If head pressure is increasing as the flow valve is opened, find the peak head-to-flow point and use the point as the base point to start the 10 data points.

The head points in the HQ curve are expected to be in descending order (H1 > H2 > H3 > H4 > H5, …).

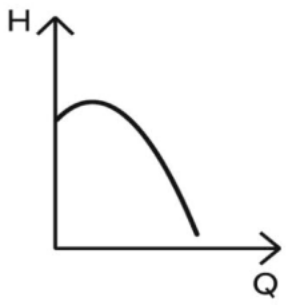
Power point P1 in the PQ curve starts at zero flow or starting head peak flow for systems with a labile pump curve.

Power points in the PQ curve are expected to be in ascending order (P1 < P2 < P3 < P4 < P5, …).

By using the no flow and full flow information, determine 10 collection points to allow for uniform separation of the final data points. If the system has a labile pump curve, start at the peak head point. The flow estimation is not accurate with the flow rates below the first selected point if it is not at zero flow.

Data collection for PQ and HQ functions				
Data Point	Valve Position	Shaft Power - (HP) Pram 01.68	System flow (GPM)	System Pressure (Ft)
1	Closed			
2				
3				
4				
5				
6				
7				
8				
9				
10	Open			
System at full speed drive @ 60 Hz				

Table 1



Graph 1: Labile pump curve

With the pump running at full speed, adjust the flow valve to document the data points for actual shaft power parameter 01.68, metered system flow, and metered system pressure (Table 2).

Data collection for PQ and HQ functions				
Data Point	Valve Position	Shaft Power - (HP) Pram 01.68	System flow (GPM)	System Pressure (Ft)
1	Closed	17.93	0	396
2		22.27	60.75	395.2
3		26.96	119.63	394.5
4		32.19	185.45	390.1
5		37.25	252.84	377.3
6		42.15	324.84	354.4
7		45.82	383.74	331.3
8		50.21	475	287.5
9		52.26	528.87	252.6
10	Open	54.44	600.7	169.5
System at full speed drive @ 60 Hz				

Table 2

Drive Programming

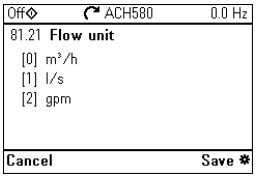
Programming the drive for PQ and QH (power to flow and flow to head) through the following steps:

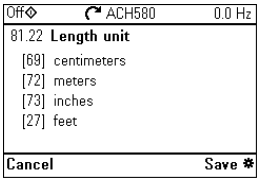
Parameter	Unit options			
81.21 Flow unit	M^3/h	gpm	l/s	
81.22 Length units	meters	feet	inches	centimeters

Program drive units to match data collection units

Menu > Parameters > Complete list > 81 Sensor settings > 81.21 Flow unit = [2] gpm

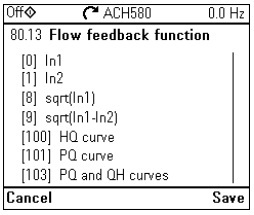
Menu > Parameters > Complete list > 81 Sensor settings > 81.22 Length unit = [27] feet





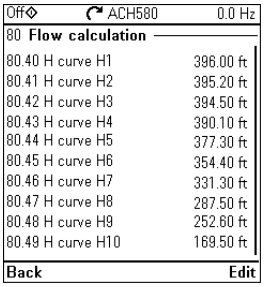
Program drive for PQ and QH mode

Menu > Parameters > Complete list > 80 Flow calculation > 80.13 Flow feedback function = [103] PQ and QH curves

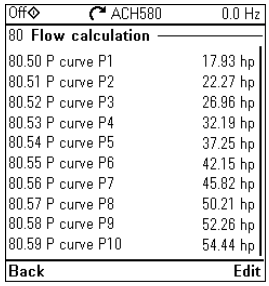


Enter the acquired data in the correct data grouping

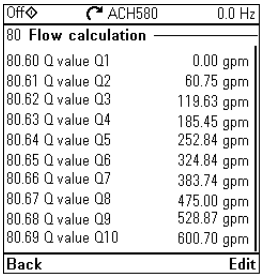
Menu > Parameters > Complete list > 80 Flow calculation > 80.40 to 80.49 H Curve H1 to H10



Menu > Parameters > Complete list > 80 Flow calculation > 80.50 to 80.59 P Curves P1 to P10



Menu > Parameters > Complete list > 80 Flow calculation > 80.60 to 80.69 Q Curves Q1 to Q10



Multiple parameters in group 80 are now accessible and ready to be used in the ACH580 sensorless control.

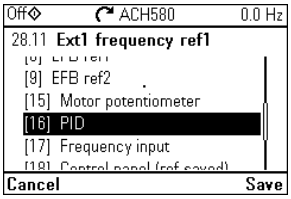
Parameter	Name	Description	Notes
80.01	Actual flow	Actual system flow estimated from the pump curves	Used as set point reference for desired flow in system
80.02	Actual flow percentage	Shows the percentage of parameter 80.01 Actual flow from 80.15 Maximum flow	
80.03	Total flow	Shows cumulative calculated flow.	
80.04	Specific energy	Shows the ratio of pump flow rate and power input.	
80.05	Estimated pump head	Shows the estimated head produced by the pump.	Used as set point reference for desired head pressure in system
80.13	Low feedback function	Selects the source for the flow feedback 1	
80.14	Flow feedback multiplier	Defines the multiplier (k) used with the flow calculation. The output value of 80.13 Flow feedback function is multiplied by this value.	To increase the flow calculation accuracy, a correction factor can be entered.
80.15	Maximum flow	Defines the nominal maximum flow of the system.	Should set to the maximum flow of the system
80.16	Minimum flow	Defines the nominal minimum flow of the system.	Should be set the minimum flow especially if the first test point is not 0 flow
80.17	Maximum flow protection	Selects the action for maximum flow protection function.	
80.18	Minimum flow protection	Selects the action for maximum flow protection function.	
80.19	Flow check delay	Defines the time after motor start when the flow protection is active.	
80.29	Total flow reset	Resets signal 80.02 Total flow.	

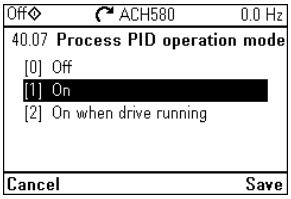
Testing

With the tested data programmed into the drive, the system can be tested for accuracy and to verify the acceptable operation range of the motor/pump combination. The following procedure allows for the use of the internal PID loop to set the desired pressure point and document actual metered flow and head readings to be compared with the drive's calculated data.

Menu > Parameters > Complete list > 28 Frequency reference chain > 28.11 Ext1 frequency ref1 = [16] PID

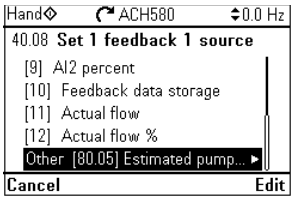
Menu > Parameters > Complete list > 40 Process PID set 1 > 40.07 Process PID operation mode = [1] On

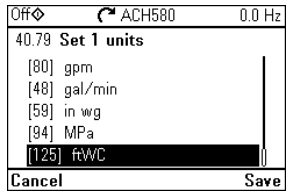




Menu > Parameters > Complete list > 40 Process PID set 1 > 40.08 Set 1 feedback 1 source = Other = [80.05] Estimated pump head

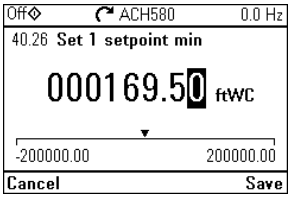
Menu > Parameters > Complete list > 40 Process PID set 1 > 40.79 Set 1 units = [125] ftWC
Note: Set to the entered system pressure units.

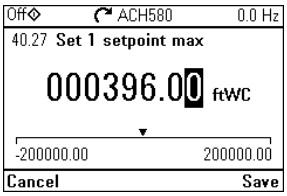




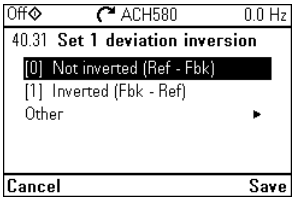
Menu > Parameters > Complete list > 40 Process PID set 1 > 40.26 Set 1 set point min = 169.5 ftWC
Note: Set to the minimum head pressure if required.

Menu > Parameters > Complete list > 40 Process PID set 1 > 40.27 Set 1 setpoint max = 396 ftWC
Note: Set to the maximum head pressure if required.

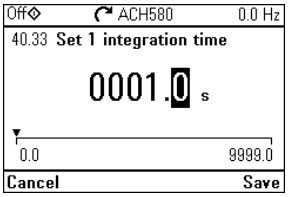




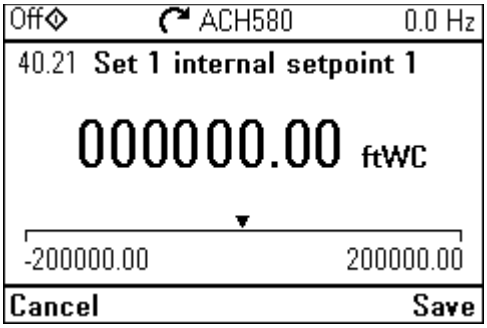
Menu > Parameters > Complete list > 40 Process PID set 1 > 40.31 Set 1 deviation inversion = [0] Not inverted (Ref - Fbk)



Menu > Parameters > Complete list > 40 Process PID set 1 > 40.33 Set 1 integration time = 1.0
Note: Integration time will be dependent on the installed system.



The drive is now programmed to follow the set head pressure entered in parameter 40.21 Set 1 internal setpoint. With the flow valve fully opened, enter a test value for the head pressure within the range of the system. The drive will control the motor speed based on the internal calculation required to support the entered head pressure. As the flow valve is closed, the drive will change the pump speed as necessary to hold the set head pressure. The data from the head and flow meters can be compared to the drive's calculated values.



Notes

- The flow calculation function cannot be used for invoicing purposes.
- The flow calculation function cannot be used outside the normal operating range of the pump.
- Head points in the HQ curve are expected to be in descending order (H1 > H2 > H3 > H4 > H5, …).
- Power points in the PQ curve are expected to be in ascending order (P1 < P2 < P3 < P4 < P5, …).
- PQ/HQ require a minimum of 5 points up to a 10 point pump curve. 10 points allow for higher accuracy.
- Allow the pump system to run at full speed to stabilize for testing before starting testing.
- User error in entering pump curve points results in a zero flow rate.
- The flow estimation is not accurate with flow rates below the first selected point if it is not at zero flow.