Technical Note 206

Data center chilled water loops and ACH580 drives

Considerations and configuration

Variable frequency drives play a critical role in the management of equipment in data center HVACR applications. HVACR systems are essential to maintain the proper temperature and humidity that servers and supporting equipment are exposed to. VFDs manage the operation of compressors, fans, chilled water pumps, condenser water pumps, cooling towers, air handling units, and CDU pumps. They increase the efficiency of operation, provide control over the speed of their equipment to match design setpoints, and extend the longevity of these systems. The ACH580 drive can support each of these systems. This drive also has standard features that provide redundancy in the control in the event of a PLC failure.

The following technical note will assist with implementation of the ACH580 drive to operate chilled water pumps included in a multi-chiller data center cooling application. It is recommended that the entire technical note be reviewed before commencing. This technical note is written for someone with experience working with VFDs and motors in HVACR applications and is intended as a supplemental document to the existing firmware manual.

There are diverse types of multi-chiller cooling system configurations in data centers, but the examples used are intended to illustrate general considerations involved in the implementation of drive technology in these applications. It will also provide specific drive parameters for the ACH580 involved in the configuration of the drive operation in this application.

Topics to covered:

1. Considerations for control of the loop
2. Commissioning considerations
3. BACnet & Modbus monitoring
4. Creating redundancy in a chiller loop with the ACH580 drive
5. Summary

Considerations for control of the loop
When considering the data center chiller loop, there are both closed loop systems and open loop systems. A closed system does not allow water to leave the system, whereas an open system will involve evaporation in the heat rejection and will have new water introduced to the system. Whether a system is designed to be closed or open is dependent on cooling capacity requirement as well as cost of energy and availability of water in the location of the data center. For the purposes of this drive application example, both a closed and an open system will have similar sensor inputs and system characteristics. Both systems are typically controlled via PLC's (programmed logic controllers), that monitor all the sensors that are positioned to manage the application. When a PLC controls the process, it will activate and deactivate the drive. The control of the drives that operate the chilled water pumps is typically based on sensors monitoring temperature, loop supply/return temperature, and/or differential pressure compared to PID setpoints in the PLC that are defined by the control sequence. Chillers will typically consume the most electricity in both an open and closed system.

Large data centers will typically have redundancy with excess capacity in their chiller loop. This may look like Figure 1 below which reflects a 3-chiller system. In this case, capacity can be increased based on demand. There is also redundancy and the ability to alternate chillers for optimizing equipment life or the ability to remove a chiller from the loop to execute needed maintenance. This additional capacity allows for the above scenarios to continue to operate the loop and maintain the required temperature and humidity of the server rooms in a data center.

When a space temperature is above a setpoint in a server room and creates a call for cooling, the control sequence will have several factors to consider. The chillers are managing the loop temperature. The drives are managing the flow or differential pressure. The valves are changing the amount of volume between the chiller loop and the chilled water loop. Each of these has a control loop that have specific set points.

Additional chillers will be brought into the loop based on the demand for each chiller and the flow required (a predetermined BTU). The PLC will activate another drive managing a chilled water pump, and both drives will operate their chilled water pumps at a predetermined frequency/rpm for a predetermined time. Typically, after a specific amount of time delay, the isolation valve on the lag chiller will open to a predetermined level and start the lag chiller. It will continue to operate based on temperature, cooling capacity, and chiller alternation per the control sequence.

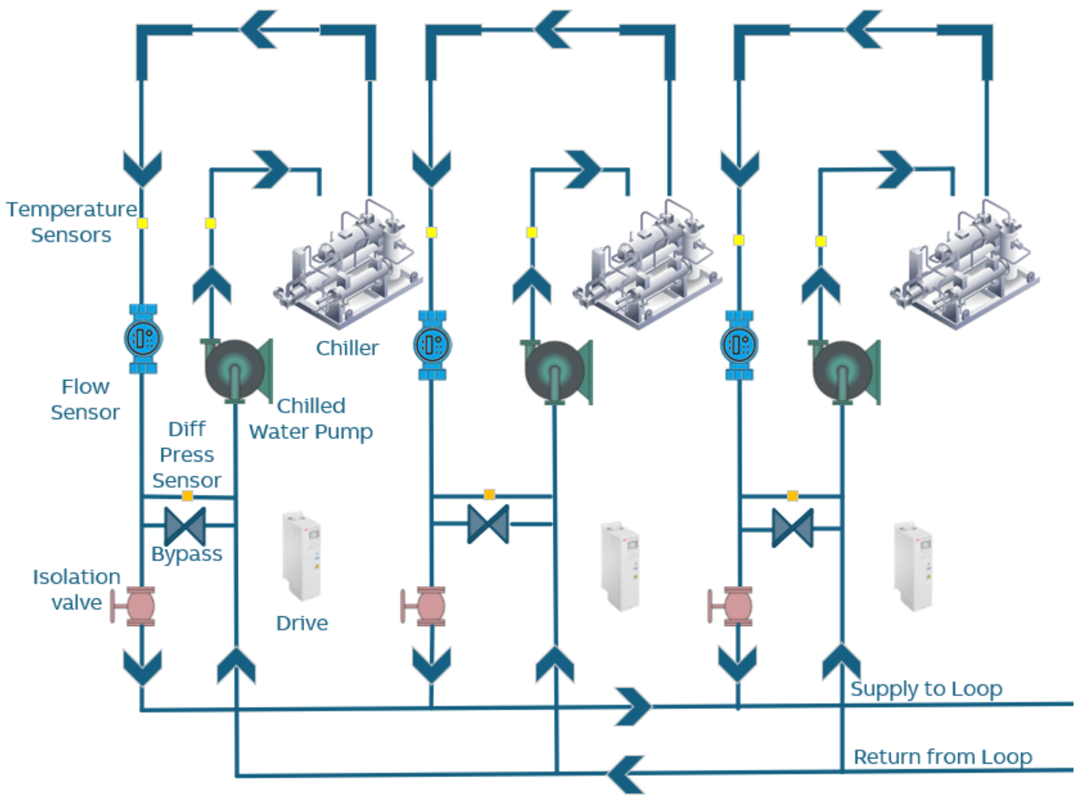

Figure 1 3-Chiller loop layout example

Commissioning considerations

The default configuration for a drive in a pumping application is typically a slow or gradual acceleration or deceleration. But in some loop management conditions, there may be low flow or high differential pressure conditions, which create the need for fast acceleration or deceleration time. The acceleration and deceleration should be evaluated and programmed according to the responsiveness needed to support the sequence of operation.

Selecting the correct start and stop method for the drive will provide the most flexibility to respond when conditions change. The automatic mode should be used to start this application. It supports a start from a stopped or rotating motor condition as well as the ability to automatically restart. The stop mode used in a chilled water pump application should be ramp mode.

In this stop mode, the drive ramps the motor to a stop following the deceleration time. This controlled stop allows pump operation to be coordinated with valve control to manage system pressure. The drives control of the motor also provides the ability to quickly react if there is an additional run command given.

In Table 1 below there is guidance on the parameter settings for the ACH580 drive for start and stop modes as well as the parameters for setting acceleration and deceleration time for a chilled water pump application.

Table 1 – Stop, accel, and decel time

Parameter	Description	Value	Description
21.01	Start mode	[2] Automatic	The drive motor control program identifies the flux as well as the mechanical state of the motor and starts the motor instantly under all conditions.
21.03	Stop mode	[1] Ramp	The drive ramps to a stop along the active deceleration ramp programmed in parameter 28.73.
28.72	Frequency acceleration time	Response time specific	Defines acceleration time one as the time required for the frequency to change from zero to the frequency set in parameter 46.02.
28.73	Frequency deceleration time	Sequence of operation dependent	Defines deceleration time one as the time required for the frequency to change from the frequency set in parameter 46.02 to zero. If there is any doubt about the deceleration time being too short, ensure that DC overvoltage control (30.30 Overvoltage control) is on.

There are times that control loops for the chilled water loop may not have the correct configuration in the PLC. This may result in nuisance faults that impact the drives' ability to operate. Quality manufacturers of variable frequency drives will protect the motor if conditions are created by the control sequence that could potentially damage the motor.

In all cases, the first action should be to coordinate with the controls contractor to address these issues immediately. Understanding the sequence of operation, the control sequence in the PLC, and the parameters in the drive should allow for a quick resolution to the issue.

In some cases, it may be necessary to configure the drive to Autoreset a nuisance fault once it is established that it will not create danger for any individual, system, or process, and there is a timeline to when the controls contractor can evaluate and address the issue.

Once addressed, **Group 31 (Fault Functions)** in an ACH580 drive can be programmed to Autoreset nuisance faults as a temporary solution to avoid manually resetting the fault. Table 2 summarizes the autoreset parameters.

Table 2 - Autoreset parameters in the ACH580 drive

Parameter	Name	Value Examples	Description
31.12	Auto reset selection	Active	Selects which faults are automatically reset.
31.13	Selectable fault	Active	Defines a specific fault that can be automatically reset.
31.14	Number of trials	5	Defines the maximum number of automatic resets that the drive is allowed to attempt in a predetermined time.
31.15	Total trials time	30 sec	Defines a time window for automatic fault reset trials.
31.16	Delay time	5 sec	Defines the time that the drive will wait after a fault before attempting an automatic reset.

BACnet & Modbus monitoring

The two most widely used communication protocols for these applications are BACnet and Modbus. Below in Table 3 are the BACnet object name, type, and number reference for the status and information from the drive typically monitored by the controller managing the application. In Table 4, the Modbus RTU registers for the status and information from the drive typically monitored by the controller managing the application. Additional information is available in the ACH580 firmware manual.

Table 3 – BACnet MS/TP points of interest

BACnet Object Name	Type	Number
HAND-OFF-AUTO Status	MSV	0
Heat sink temperature	AV	7
Output-Speed	AV	31
Output-Freq	AV	1
Output-Current	AV	4
Output-Torque	AV	5
Output-Power	AV	6
Output-Voltage	AV	3
Run-Stop-Monitor	BV	0
Underload-Monitor	BV	26
Warning-Status	BV	5
Fault-Status	BV	2

Table 4 - Modbus RTU registers of interest

Description	16-bit Register Mode 0	32-bit Register Mode 0	16-Bit Register Mode 1	32-Bit Register Mode 2
HAND-OFF-AUTO – HVAC Status	400622	421244	401558	403116
Motor-Temp-Degrees-C (Heat sink temperature)	400131	420262	400287	400574
Output-Speed	400101	420202	400257	400514
Output-Freq	400106	420212	400262	400524
Output-Current	400107	420214	400263	400526
Output-Torque	400110	420202	400257	400514
Output-Power	400114	420228	400270	400540
Output-Voltage	400113	420226	400269	400538
ULC Output-Status Word	403703	427406	409475	418950
HVAC Status Word	400622	421244	401558	403116
Main Status Word	400611	421222	401547	403094

Creating redundancy in a chiller loop with the ACH580 drive

An advantage of using the ACH580 drive is the standard features included in the drive. Besides the ease of use of its integrated control panel and primary settings menu for HVACR applications, there are software features that can provide added redundancy or backup in case the existing control or automation system was to go down.

In the event of a PLC failure, the drive can detect either an analog input loss or a protocol communications loss and operate the drive at the last speed referenced or a predefined safe speed to maintain a minimum flow operation. Table 5 & 6 below identifies these two configuration options.

Table 5 – AI reference loss action in parameter 12.03

Parameter	Description	Value	Description
12.03	AI supervision function	[3] Last speed	If analog input signal is lost or goes outside of range the drive generates a A8A0 AI supervision warning and sets speed to last reference.
12.03	AI supervision function	[4] Speed ref safe	If analog input signal is lost or goes outside of range the drive generates a A8A0 AI supervision warning and set speed at speed defined in parameter 28.41.

Table 6 – Protocol communication loss action in parameter 58.14

Parameter	Description	Value	Description
58.14	Communication loss action	[2] Last speed	If communication loss is detected the drive generates a A7CE EFB comm loss warning and sets speed to last reference.
58.14	Communication loss action	[3] Speed ref safe	If communication loss is detected the drive generates a A7CE EFB comm loss warning and set speed at speed defined in parameter 28.41.

The ACH580 also includes a user load curve function that can provide a redundant method to validate proof-of-flow. This can provide protection for the pump, loop system, and provide redundancy in addition to the existing proof-of-flow devices detailed in the control sequence. The drive can distinguish between a full-speed no-load condition, and a slow speed with load. The differences are minimal since the induction motor's magnetizing current makes up most of the pump motor's current consumption at low speeds. To determine the flow and no-flow conditions, torque data is gathered during commissioning.

Tech Note 120: Proof-of-Flow detection for pumps outlines the process of gathering the points needed to configure this feature as well as how to program them into the drive using Primary settings in the ACH580 keypad. The full set of parameters are available in **Group 37 (User load curve)**.

Summary

Data center cooling and humidity control is a critical requirement in maintaining both the operation and life of the equipment involved. The ACH580 drive can support chilled water pumping applications in any configuration. These drives can fit the sequence of operation and add efficiency while lengthening the life of the equipment that they operate. The ACH580 drive has standard features that can add redundancy to an existing control or automation systems with protection features such as user load curves that can provide proof-of-flow validation, as well standalone operation capabilities in the case of communication loss with a PLC.