Optidrive Applications Support Library

Application Note	**AN-ODV-2-068**
Title	**Using Optiflow Multi Pump Cascade Control**
Related Products	**Optidrive HVAC**
Level **3**	1 – Fundamental - No previous experience necessary 2 – Basic – Some Basic drives knowledge recommended 3 – Advanced – Some Basic drives knowledge required 4 – Expert – Good experience in topic of subject matter recommended

Overview

Optidrive HVAC features a unique Optiflow system, designed to simplify the operation of multiple pump sets, typically in Duty / Standby or Duty / Assist / Standby configurations. The system allows up to five drives, each controlling an individual pump to be connected together, and provides automation of the following functions.

- Automated changeover between Duty and Standby Pumps in the event of a pump fault
- Automated changeover based on time to allow balanced operating time between all pumps
- Automated Staging / Cascade Control of Duty and Assist Pumps in closed loop pressure or flow control applications
- Isolation of any individual pumps is possible whilst maintaining operation with the available pumps

Operating Principle

The Optiflow system operates on the principle that one drive is designated as the Control Master. All other drives operate as Slaves. The Master drive determines which pumps should operate at any given time, to ensure that only the required number of pumps are operating, and operating time is balanced between all pumps.

Control functions are carried out using the on-board RJ45 connector. The Control Master drive must be address 1. The connected Slaves must then have incremental addresses, starting from address 2.

All external control connections, such as feedback transducers, external setpoint and controls are made to the Master drive only. Slave drives simply require an enable input, to allow switching of individual slaves when required. Motor thermistors can also be connected back to each slave drive, and fieldbus connections for remote monitoring can also be made if required.

Installation

Basic installation of the drive, such as incoming mains power and motor connections should be carried out according to information provided in the User Guide.

Any required control connections should then be made to the Master drive, e.g. a pressure feedback transducer can be connected for closed loop pressure control, or an analog signal for direct speed control can be connected.

Each Slave drive requires the inhibit circuit to closed to operate (refer to the User Guide for further information), and an enable signal on digital input 1. A motor thermistor can also be connected and configured if required.

Basic Commissioning

Once installation has been completed, and all drives can be safely powered on, commissioning should be carried out according to the following procedure.

1. Set the drive addresses. Each drive must have a unique individual address, starting with the Control Master drive as address 1, and increasing for each connected slave (e.g. first slave is address 2; second slave is address 3 etc.). The address is set in Parameter P5-01.
2. Configure the motor nameplate details into each drive. For each drive and pump combination, the correct motor nameplate details for the connected motor must be entered into the relevant drive parameters. This ensures that the motor is correctly protected and controlled by the drive. The settings should include

   a. P1-07 Motor Rated Voltage
   b. P1-08 Motor Rated Current
   c. P1-09 Motor Rated Frequency
   d. (Optional) P1-10 Motor Rated Speed
3. Configure the Master drive operating mode. For a closed loop pressure or flow control system, the drive should be set in PID operating mode, P1-12 = 3. Required PID control parameters should then be configured (refer to the product User Guide for further information on setting up the PID control function) and basic operation of the drive and pump can then be tested.
4. On the Master drive only, enable the Multi-Pump Cascade Function. This requires the following parameters to be set
   a. P1-14 = 101 : Enable access to Extended Parameters
   b. P8-14 = 2 : Enable Optiflow Multi Pump Cascade Control
   c. P8-15: Set this parameter to the number of Slave pumps, e.g. for a two pump system, P8-15 = 1.
5. On the Slave drives, select Slave Mode operation by setting P1-12 = 5. When enabled, the drives will now operate under control of the Master drive, and start or stop as required.

Optimising the System Operation

The basic commissioning procedure above along with factory parameter settings should be sufficient to start the operation of the system and allow basic functions to be checked and tested. Further parameter settings are possible to allow optimisation of the operation of the system, as detailed below.

Optiflow Parameters

P8-16 Pump Duty Switch Over Time

This parameter allows adjustment of the changeover time in Duty / Standby applications where balancing of the operating time between pumps is desired. The Master drive stores the operating time of all pumps in the system, and will always operate the pump with the lowest operating time when a pump is started.

The operating time of the pumps can be displayed in P0-19. This contains five indices so that each pump can be displayed.

P0-19 can be reset if desired (e.g. if a new pump is installed) by setting P8-20 = 1

For example, if rotation of the operation between duty and standby pump is desired every 24 hours, then set P8-16 = 24. After 24 hours operation, the Duty Pump will stop and the Standby Pump will start to maintain operation.

P8-17 Assist Pump Start Speed

When Duty / Assist operation is required, this parameter controls the frequency at which an assist pump will be started. In general, a setting slightly below the maximum operating speed of the pump should be used, e.g. if P1-10 = 50.0Hz, P8-17 should be in the 49.0 – 49.9Hz range. In general, this approach will also provide the most efficient pump operation.

With a Duty / Standby pump set, P8-17 should be set to the maximum speed, e.g. P8-17 = P1-01. With this setting, the pumps operate in Duty / Standby mode only, without any Assist function.

Note : If P1-10 is set to match the motor nameplate Rpm, P8-17 will display in Rpm. If P1-10 = 0, P8-17 will display in Hz.

P8-18 Assist Pump Stop Speed

When Duty / Assist operation is used, this parameter defines the operating speed of the pumps at which the assist pump/s are switched off. In general, systems that operate with higher pressure (head) will require a higher setting of this parameter.

In a simple Duty / Assist configuration, the required setting of this parameter can be determined, either by measuring or using the pump curve data to determine the flow produced by a single pump operating at maximum speed and required setpoint, then determining the speed at which two pumps operating in parallel will provide the same pressure and flow. P8-18 should then be set to this speed. See the example below for details on how this point can be estimated.

Where multiple assist pumps are present, e.g. 4 or 5 pump systems with multiple assist pumps, the same technique can be used to determine the optimum switch off point.

Note : If P1-10 is set to match the motor nameplate Rpm, P8-18 will display in Rpm. If P1-10 = 0, P8-18 will display in Hz.

P8-19 Pump Settling Time

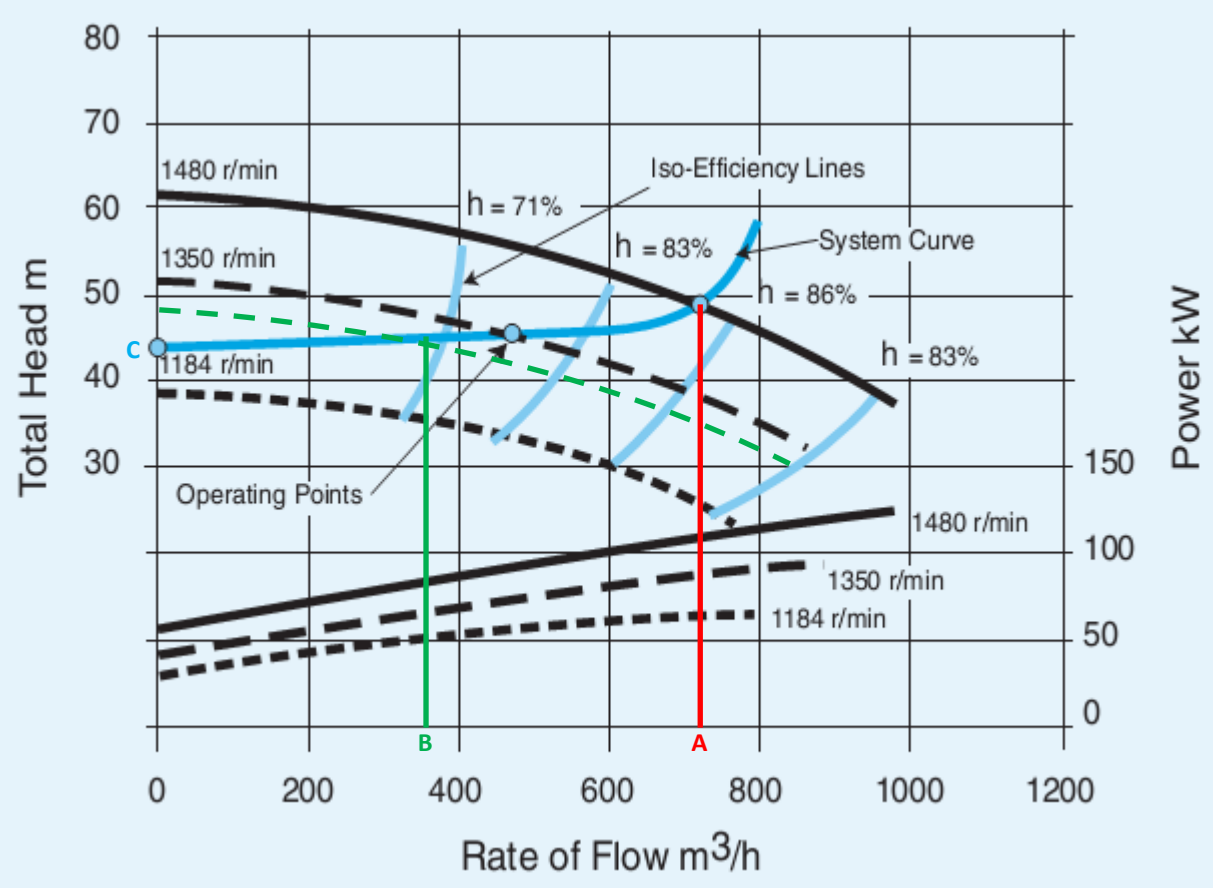
This parameter provides a time limit between the starting and stopping of consecutive pumps. This is to prevent pumps constantly being cycled in and out of operation. When any pump on the system is started, the time set in P8-19 must always elapse before an additional pump is started. Once the time period has elapsed, starting of Assist pumps, or starting of Standby pumps in the event of a fault is carried out immediately.

P8-20 Pump Master Clock Reset

This parameter is used to reset the pump run times stored in P0-20. When P8-20 is set to 1, all values in P0-20 are reset to zero.

Assist Pump Start and Stop Speeds – Example Calculation

Below is an example of a pump flow curve, showing the available head and flow at various speeds, and the relative power consumed. A typical system curve is also shown, representing the required operating range of the pump up to maximum speed, along with the pump efficiency at various points.



From the curve above, we can see that a single pump operating at maximum speed and the chosen system point produces a flow level of around 720m^3/h. This is shown by the Red line A. As this point is closest to the optimum pump efficiency, the best system efficiency will be achieved by operating with only one pump up to the maximum flow of a single pump; hence in this case, the Assist Pump Start Speed parameter P8-17 should be close to maximum speed, e.g. 1475 Rpm / 49.9Hz.

Assuming we now have two identical pumps in parallel, to achieve the same flow demand and system operating point, each pump is required to produce 50% of the flow, 360m^3/h each. This is shown by the Green line B. From this point, we can estimate the pump speed required to produce this flow level, based on the shown Rpm curves. By following the green curve, this point can be estimated as approximately 1320 Rpm. The Assist Pump Stop Speed parameter, P8-18 should therefore be approximately 1320 Rpm / 44.0Hz in this case. These parameter settings can then be optimised during system test and commissioning.

To avoid rapid cycling of pumps, it is always advisable to set P8-18 slightly below the estimated value, to ensure that the final Assist Pump only stops when the flow demand drops below the level where a single pump can meet the demand, and repeated start / stop cycling of assist pumps is avoided.

Using Standby Mode In Multi-Pump Systems

Standby mode can be used to automatically switch off the pumps when there is no flow requirement in the system. If Standby Mode operation is required

- Standby Mode must be enabled on all the drives in the system, by setting P2-27 >0. Refer to the drive User Guide for more information on P2-27. The same value should be used on all drives on the system for consistent operation.
- Standby Mode activates when the output frequency of the drive remains below the threshold value programmed in P3-14 for the time set in P2-27. For Standby Mode to operate correctly, P3-14 must be less than P8-18.
- The PID Error Wake Up Level P3-13 must be set in the Master drive only. This is the % difference allowed between the chosen system setpoint and the measured feedback level at which the drive should restart the first pump.

Example of Standby Mode Parameter Values Calculation

Referring to the pump curves shown earlier, it can be seen that following the Blue Line C, the minimum operating speed for the pump at which the system operating point can be met can be estimated. In this case, the value would be approximately 1250 Rpm. This value can be used for the Standby Mode Activation Speed, P3-14.

For consistent operation, of the system, P2-27 should be equal to or greater than the Pump Settling Time, P8-19. This ensures that Standby Mode is not activated during cascading of the Assist Pumps.

The PID Error Wake Up Level, P3-13 is entered as a % of the transducer range.

For example, in a closed loop pressure control system with a pressure transducer providing feedback, if a 0 – 10 bar feedback transducer is used, and the system is intended to operate at 4 bar working, it may be desired to switch the drive to Standby Mode, and only restart when the system pressure falls below 3.8 Bar. The PID Wake Up Error Level can then be calculated as

(4.0 – 3.8) / Transducer Range = 2.0%

Note : In order for Standby Mode to activate, the Output frequency must remain below the threshold set in P3-14 for the time set in P2-27. This requires the PID settings of the Master drive to be tuned correctly to ensure that the output frequency continues to drop when the system setpoint is held and no flow demand exists.

When Standby Mode is activated on the Master drive, the output of the PID controller will be set to zero. When the PID Error Wake up level exceeds the programmed threshold, the *PID Controller* will restart*. The drive will not recover from Standby until the output of the PID Controller exceeds the Standby Activation Speed*. For this reason, it is advisable to limit the minimum output of the PID Controller, based on the chosen Standby Mode Activation Speed.

PID Low Output Limit, P3-08 = (P3-14 / P1-01)% – 1.0%

E.g. In the example above, where maximum speed = 1500 Rpm, Standby Activation Speed = 1250 Rpm

P3-08 = (1250 / 1500)% - 1.0% = 82.3%

This setting ensures a rapid recovery from Standby Mode when required.

Appendix:

Revision History			
Issue	Comments	Author	Date
01	Document Creation	KB	24/04/13
02	Updated to new format	KB	28/04/14
03	Corrected error on parameter number	KB	22/10/14