



REV	01
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Supersedes	/

**Pump Control**

**Variable Flow**

# Sommario

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## 1. Variable Flow

This document describes all features of Variable Flow option for single chiller applications with Primary or Primary + Backup pumps. For multi-chiller application please contact factory. Three different control modes can be enabled by unit configuration menu:

1. **Fixed Speed**
2. **Variable Primary Flow (VPF)**
3. **Delta-Temperature Control (DT)**

Basic set up of the variable flow control requires to set one simple parameter available in the unit configuration menu.

Notice that, for Web HMI, "Connectivity Kit" is required.

### *HMI EVCO Parameters*

Parameter	Default	Range	Description
[15.03] Pump Cntrl	0	0 = On-Off 1 = Fixed Speed 2 = VPF 3 = DT	On-Off -> Classic On-Off pump management Fixed Speed -> Fixed Speed VPF -> Variable Primary Flow DT -> Evaporator Delta Temperature Control

*HMI Path: Main Menu → Commission Unit → Configure Unit → Options*

Setpoint/Sub Menu	Default	Range	Description
Pump Cntrl	On-Off	On-Off, Fixed Speed, VPF, DT	On-Off -> Classic On-Off pump management Fixed Speed -> Fixed Speed VPF -> Variable Primary Flow DT -> Evaporator Delta Temperature Control

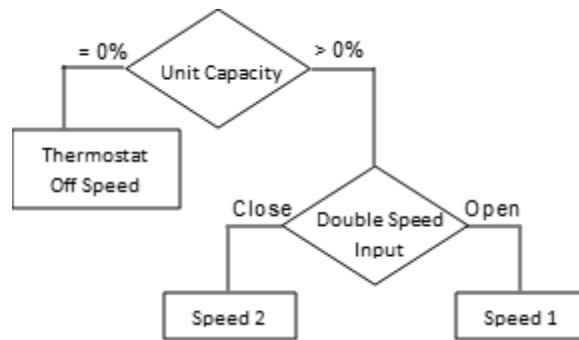
## 2 Fixed Speed

First control mode, Fixed Speed, allows an automatic pump speed variation, between three different speed settings

- *Speed 1*
- *Speed 2*
- *Thermostat Off Speed*

Unit controller switches the pump frequency on the basis of:

1. Actual unit capacity
2. Double Speed digital input state



Referring to the flow chart, if there are no active compressors (Unit Capacity = 0%) pump speed is set to *Thermostat Off Speed*, otherwise *Speed 1* or *Speed 2* is selected depending on the *Double Speed* input state. *Speed 1* and *Speed 2* have to be set in order to ensure the evaporator water flow within the admissible range of the specific chiller. All parameters can be modified through *Variable Flow* menu.

#### HMI EVCO Parameters

Menu	Parameter	Range	Description
[8] Pump	[08.00] Recirculation Time	0-30s	Pump transition time between Start/Run and Off states
	[08.01] Standby Speed	0-100%	Speed when there are no compressors running
	[08.05] Speed 1	0-100%	Speed when the input Double Speed Switch is open
	[08.06] Speed 2	0-100%	Speed when the input Double Speed Switch is close

Web HMI Path: Main Menu → View/Set Unit → Pumps

Setpoint/Sub-Menu	Default	Range	Description
Recirculation Time=	30s	0-300	Pump transition time between Start/Run and Off states
Speed 1=	25%	0 -100%	Speed when the input Double Speed Switch is open
Speed 2=	25%	0 -100%	Speed when the input Double Speed Switch is close
Thermo Off Speed=	25%	0-100%	Speed when there are no compressors running

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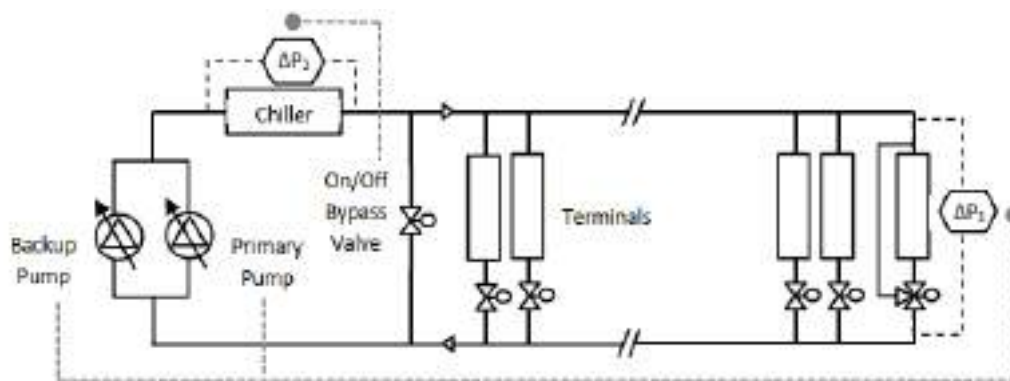
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### 3 Variable Primary Flow (VPF)

In the VPF systems, the pump speed is controlled in order to maintain a minimum pressure drop in a remote location of the plant at a setpoint value determined to ensure the required chilled flow through any terminals or coils. Generally this location is identified as the furthest terminal respect to the chiller pump and it will be indicated in the following as *Load Pressure Drop*.

Before enable this control mode verify if the system comply with main VPF characteristics:

1. Primary only chilled water system
2. Distribution pumps fitted with variable speed drives
3. Terminals or coils regulated with 2 way valve, except for one regulated with a 3 way valve in order to allow water flow if all terminals are off.
4. Bypass pipe with on/off 2 way valve has to be installed near to the pumps in order to ensure a minimum evaporator water flow.



#### 3.1 Pump Speed Control

When the system is enabled, unit controller reads the Load Pressure Drop measure  $\Delta P_1$  and provides a 0-10V signal as reference for variable speed drive. Control signal is generated by a PI algorithm and it is always limited between a minimum and maximum value set by default to 0% and 100%.

#### 3.2 Bypass Control

When there is a low demand for chilled water by coils, the system flow rate may be lower than the minimum flow rate required by the chillers. Unit controller always compares the evaporator pressure drop measure  $\Delta P_2$  with the minimum allowed value and controls the bypass valve state to maintain minimum chiller flow.

Pressure condition	Valve Command
Evaporator Pressure Drop < Minimum Evaporator Pressure Drop Setpoint	Valve Opened
Evaporator Pressure Drop > Minimum Evaporator Pressure Drop Setpoint + Hysteresis	Valve Closed

### 3.3 Sensors

$\Delta P_1$  - Load Pressure Drop transducer can be provided by factory or installed on site. Unit controller receives 0-10V signal and evaluates the pressure value with linear characteristic.

$\Delta P_2$  - Evaporator Pressure Drop transducer is provided by the factory and it is directly installed on unit.

During alarm state of at least one of the two sensors  $\Delta P_1$  or  $\Delta P_2$ , unit controller carries out these actions until normal sensor operation is restored:

- Pump speed fixed to the Maximum value
- Bypass valve opened
- EVCO HMI's alarm icon starts blinking and register [08.14]'s value is set different from 0
- Warnings displayed on the Web HMI alarm page: "EvapPDSen" - "LoadPDSen"
- 

### 3.4 VPF setup menu

Table below reports all parameters available in Variable Flow menu when Variable Primary Flow mode is enabled.

*EVCO HMI Parameters*

Menu	Parameter	Default	Range	Description
[8] Pump	[08.02] Speed	-	0-100	Actual Pump Speed. This value displays the actual pump speed percentage from 0% (minimum inverter pump Hz > 0) and 100% (maximum inverter pump Hz).
	[08.03] Max Speed	100%	0-100	Maximum Pump Speed. This parameter defines the maximum speed value when the pump is on.
	[08.04] Min Speed	0%	0-100	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
	[08.07] LoadPressDropSp	0kPa	0-1000kPa	Plant Pressure Drop set point. This value to defines the set point used to regulate the pump speed.
	[08.08] EvapPressDropSp	0kPa	0-1000kPa	Evaporator Pressure Drop set point. This value defines the set point used to regulate the bypass valve.
	[08.09] BypassValve state	-	0 = Close 1 = Open	Bypass Valve State
	[08.10] LoadPD	-	-	Plant Pressure Drop. This value displays the actual pressure across the furthest terminal $\Delta P_1$ .
	[08.11] EvapPD	-	-	Evaporator Pressure Drop. This value displays the actual pressure drop across the evaporator $\Delta P_2$ .
	[08.12] Pump Ti		0-100	

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Web HMI Path: Main Menu → View/Set Unit → Pumps

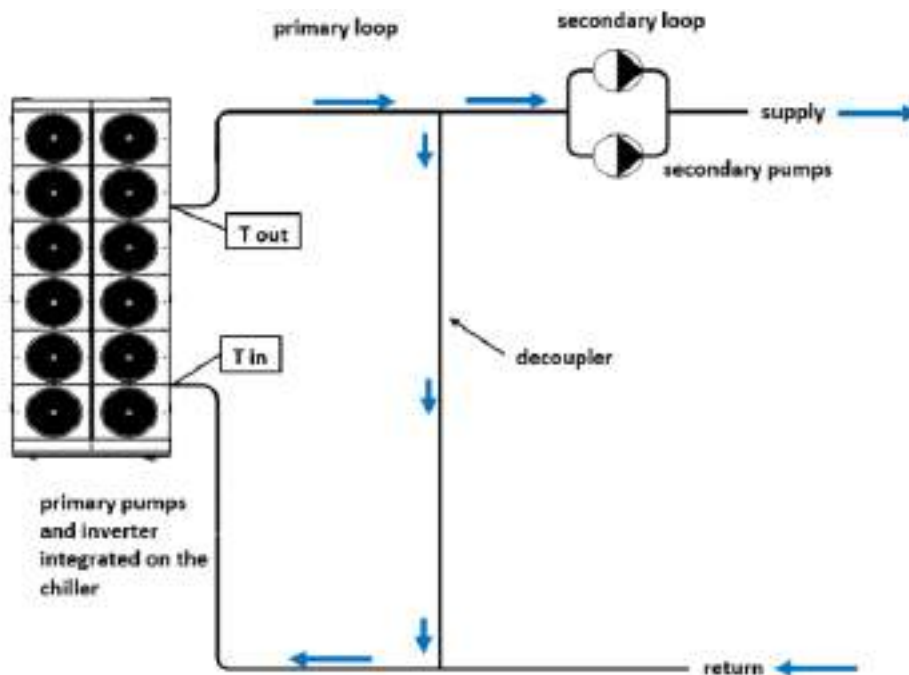
Setpoint/Sub Menu	Default	Range	Description
Plant PD	-	-	Plant Pressure Drop. This value displays the actual pressure across the furthest terminal $\Delta P1$ .
Plant PD Sp	0kPa	0-1000kPa	Plant Pressure Drop set point. This value to defines the set point used to regulate the pump speed.
Evap PD	-	-	Evaporator Pressure Drop. This value displays the actual pressure drop across the evaporator $\Delta P2$ .
Min Evap PD	0kPa	0-1000kPa	Evaporator Pressure Drop set point. This value defines the set point used to regulate the bypass valve.
Pump Speed	-	0-100%	Actual Pump Speed. This value displays the actual pump speed percentage from 0% (minimum inverter pump Hz > 0) and 100% (maximum inverter pump Hz).
Min Speed	0%	0-100%	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
Max Speed	100%	0-100%	Maximum Pump Speed. This parameter defines the maximum speed value when the pump is on.
Bypass	Close	Close-Open	Bypass Valve State
Pump Ti	180	0-1000	Define reaction speed of pump control in VPF and DT

## 4 DT Pump Control

Providing the unit with the inverter kit for the on-board pump it is possible to manage a variable water flow rate for the primary loop. The standard feature is applicable for single unit installation only. In case of multiple chillers installation an additional control is needed. The variable flow control is suitable for primary/secondary plant, cannot be used in primary plant only.

In a Primary-Secondary plant configuration a key component is the decoupler. The decoupler is always open (no valve must be installed). The aim of the decoupler is to allows the primary and secondary pumps to operate at different flow rates. This is necessary because the primary pumps and secondary pumps are managed differently and so the primary and secondary flow rate are practically never the same. Specifically, the primary flow rate is managed based on the chiller delta-T ( $T_{out} - T_{in}$ ), the secondary flow rate is regulated to maintain the necessary pressure differential in the secondary loop. The direction of the water flow through the decoupler must be always from supply to return.

Activating the variable flow control in DT, the chiller will modulate the water flow rate based on the chiller delta. When the secondary loop will reduce the water flow rate (because the plant load decrease), the water flow rate in the decoupler (always from supply to return) increases. The return water temperature mixes with the supply water from the decoupler reducing the water temperature, the inlet temperature and so the delta-T on the chiller. As consequence the chiller control reduce the speed of the pump, reducing the primary flow rate. On the opposite, when the flow rate on secondary flow increases also the water temperature at the chiller inlet increase (increasing the Delta-T); therefore, the chiller control will increase the water flow rate.



## 4.1 The Control Logic

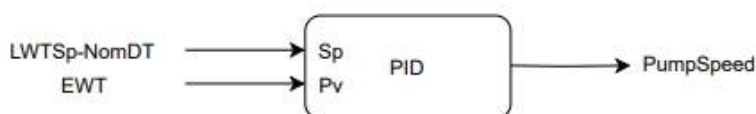
The Logic for DT pump speed control is related mainly on two variables:

- The Evap Nominal DTemp;
- The Entering Water Temp.

The pump is controlled though a PID based on the EWTemp, with a Setpoint defined by the following formula:

*Cooling Mode :  $LWTmpSp + NomEvapDT$ ;*

*Heating Mode :  $LWTmpSp - NomEvapDT$ .*



*Heat Pump Control Case*

So, the desired setpoint of the Leaving WaterTemp and the Nominal Delta Temp of the evaporator, generate a setpoint of the pump speed control, that will regulate on the Entering WaterTemp.

This will guarantee a shorter time to reach the water outlet setpoint, and better control after the transients.

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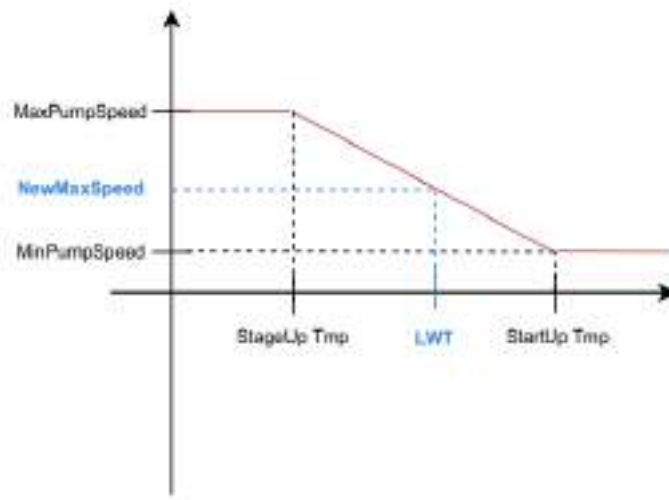
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When the unit is switched on, the control in DT will initially prefer to reach the water outlet setpoint, and to do this it leads the PID to generate an output with a reduced speed, to decrease the flow rate and reach the desired temperature of the LWT in less time. This reduced speed is calculated as:



This means that, as the water moves closer to the setpoint, the maximum speed is reset to the setting value, and the pump starts to regulate the speed with a larger control band.

## 4.2 DT Setup Menu

Table below reports all parameters available in Variable Flow menu when DT Flow mode is enabled.

### EVCO HMI Parameters

Menu	Parameter	Default	Range	Description
[8] Pump	[08.02] Speed	-	0-100	Actual Pump Speed. This value displays the actual pump speed percentage from 0% (minimum inverter pump Hz > 0) and 100% (maximum inverter pump Hz).
	[08.03] Max Speed	100%	0-100	Maximum Pump Speed. This parameter defines the maximum speed value when the pump is on.
	[08.04] Min Speed	0%	0-100	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
	[08.12] Pump Ti	180	0-1000	Define speed reaction of pump control in VPF and DT cases
	[08.13] Evap DTmp Sp	5.8	3.3-8.9	Evaporator nominal delta temperature between EWT and LWT

Web HMI Path: Main Menu → View/Set Unit → Pumps

Setpoint/Sub Menu	Default	Range	Description
Pump Speed	-	0-100%	Actual Pump Speed. This value display the actual pump speed percentage
Evap DTmp Sp	5.8	3.3-8.9	Evaporator nominal delta temperature between EWT and LWT
Min Speed	0%	0-100%	Minimum Pump Speed. This parameter defines the minimum speed value when the pump is on.
Max Speed	100%	0-100%	Maximum Pump Speed. This parameter defines the maximum speed value when the pump is on.
Pump Ti	180	0-1000	Define reaction speed of pump control in VPF and DT cases

## 5 Troubleshooting

In this section are reported all alarm related to the variable flow functions.

### 5.1 VPF Alarm Code

Alarming during On-Off, Fixed Speed and DT pump control is the same reported in unit Operating Manual. VPF operations require a couple of additional sensors. VPF's Alarm Code give information about sensors status.

Notice that, in case of sensors fail during VPF operation, the unit won't stop but pump speed will be set to a standby value (minimum inverter speed).

*EVCO HMI Parameter*

Parameter	Default	Range	Description
[08.14] Alarm Code	-	0..3	VPF Alarm word. Each bit represents: Bit_0 = Load PD Sensor Fault Bit_1 = Evap PD Sensor Fault

*Web HMI Path: Main Menu → View/Set Unit → Pumps*

Setpoint/Sub Menu	Default	Range	Description
Alarm Code	-	0..3	VPF Alarm word. Each bit represents: Bit_0 = Load PD Sensor Fault Bit_1 = Evap PD Sensor Fault

#### 5.1.1 Load PD Sensor Fault

This alarm can occur when the sensor used to measure the pressure drop at load is broken or not properly connected to chiller.

Symptom	Cause	Solution
EVCO HMI's alarm icon is blinking and register [08.14]'s value is different from 0 Bell's led of Web HMI (Connectivity kit required) is blinking String in the alarm list: <i>+LoadPDSen</i> String in the alarm log: <i>± LoadPDSen</i> String in the alarm snapshot: <i>LoadPDSen</i>	Errors in sensor wiring/connection	Check sensor's cabling

#### 5.1.2 Evaporator PD Sensor Fault

This alarm can occur when the sensor used to measure the pressure drop at evaporator is broken or not properly connected to chiller.

Symptom	Cause	Solution
EVCO HMI's alarm icon is blinking and register [08.14]'s value is different from 0 Bell's led of Web HMI (Connectivity kit required) is blinking String in the alarm list: <i>+EvapPDSen</i> String in the alarm log: <i>± EvapPDSen</i> String in the alarm snapshot: <i>EvapPDSen</i>	Errors in sensor wiring/connection	Check sensor's cabling

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