Controller for operation of evaporator on water chiller

EKC 316A

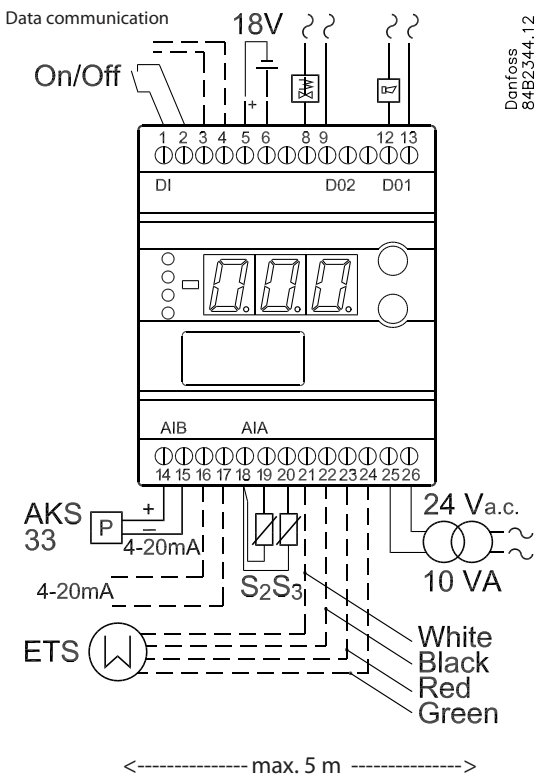
REFRIGERATION AND
AIR CONDITIONING

Reference manual

Contents

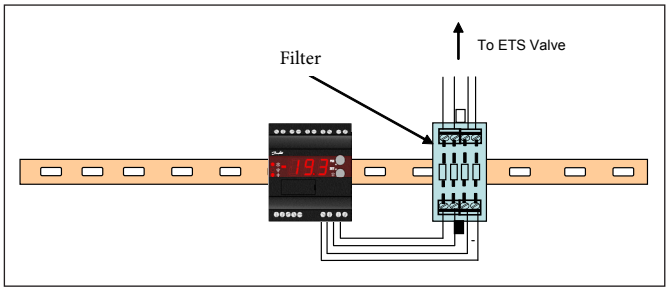
Installation

The EKC 316A is normally mounted on a DIN rail, and the necessary connections are shown in the diagram. If the sensor S3 is not used to measure air temperature in connection with thermostat function or as part of the controlling loop, then it is not necessary to connect the S3 sensor. The 18Volt battery input at terminals 5 and 6 is not required if battery back-up is not needed.



Communication to controller is an option and can only be achieved by inserting the data communication module EKA 174 or EKA 175 in the EKC 316A controller.

The maximum length of cable between EKC 316A and the ETS valve is five meters. If cable lengths are in excess of this value then it is recommended to use an inductive filter.



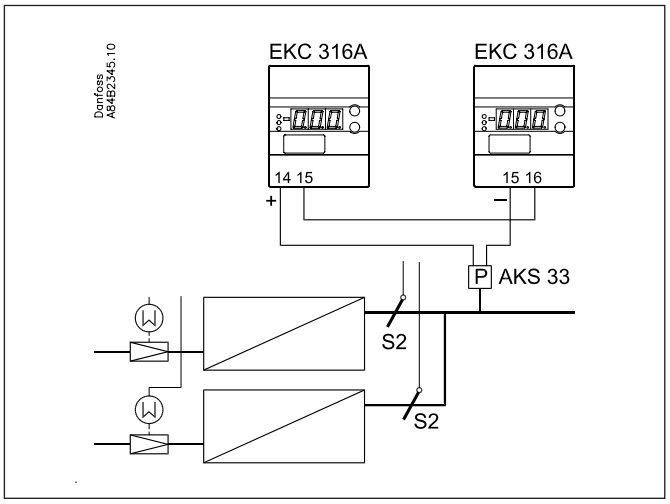
AKS 33 Pressure transmitter connected to two EKC 316A controllers

An AKS33 pressure transmitter can be connected up to two EKC 316A controllers.
In case of problems the following checks can be made:

1) Ensure that the voltage between terminals 14 and 16 is approximately 14.5 Volts.

2) Check that the resistance between terminals 15 and 16 is 100 Ohms.

3) If there are problems in connecting the AKS 33 and EKC316A controllers as shown above, disconnect the controller to the right and place a 100 Ohms resistor between the wires that were previously connected at terminals 15 and 16. Check that the pressure reading in the controller to the right is correct. If there are still problems and assuming that checks 1) and 2) have been carried out, check the connections to the AKS 33.



Stepper motor Output

After installation the following checks can be made to the connection between the EKC316A controller and the stepper motor of the ETS valve.

1) With the power off, check that resistance between terminals 21 and 22 and terminals 23 and 24 is approximately 53 Ohms. Make slight allowances for cable resistance.

2) With the power on and parameter o18 set to 1, measure the phase current from terminals 21 (or 22) and terminals 23 (or 24) with a true RMS multimeter when the valve is operating. The valve can be driven from 0% to 100% and vice versa by changing valve opening percent in parameter o45. The phase current should be 70 mA rms when operating.
Remember to set o18 back to 0 after checks.

3) If the checks 1) and 2) are not correct, ensure that motor cable corrections are correct and the cable length is less than five meters (see section 1)

Output relay contacts

The two output relays in the controller are respectively the relay for starting refrigeration and alarm relay. Ensure the following action:

1) The contact for refrigeration will be made when the superheat regulation in the controller starts operating. The contact will be broken if the regulation cannot start or is stopped.

2) The contact of the alarm relay will be made when there is an alarm.

Setting and checks to be made before start

Basic Settings

Before using the EKC 316A controller, there are settings that have to be made for each individual application. These are the refrigerant type, the pressure transducer range and the total number of steps for the ETS valve. It is good practice and some cases necessary to set the Main Switch r12 to OFF when making these changes.

Refrigerant Type.
It is possible to choose from a list of 28 different refrigerants in the controller. If refrigerant is not found on the list, it is possible using AKM and setting o30 to 13 to plug in the Antione constants for the unlisted refrigerant.

Refrigerant setting Before refrigeration can be started, the refrigerant must be defined. You can select the following refrigerants: 1=R12. 2=R22. 3=R134a. 4=R502. 5=R717. 6=R13. 7=R13b1. 8=R23. 9=R500. 10=R503. 11=R114. 12=R142b. 13=User defined. 14=R32. 15=R227. 16=R401A. 17=R507. 18=R402A. 19=R404A. 20=R407C. 21=R407A. 22=R407B. 23=R410A. 24=R170. 25=R290. 26=R600. 27=R600a. 28=R744. 29=R1270. *(Warning: Wrong selection of refrigerant may cause damage to the compressor).*	o30	Refrigerant

ETS Valve type
Each ETS valve has a specified number of steps as given below:

Total steps	ETS 50: 2625 [+160 / -0] steps ETS 100: 3530 [+160 / -0] steps ETS 250 and 400: 3810 [+160 / -0] steps

The number of steps can be set in the controller at address n37:

The parameters "n37" to "n42" are settings for step motor ETS 100. The settings in n37 must be changed when another valve is used. The other settings should not be changed.		
Number of steps from 0% to 100% open	n37	Max. steps (0 - 5000 step)

In practise, the EKC316A display can only manage 3 digits.
Therefore the set value at address n37 is always 10 times greater i.e. if n37 is set to 263 then the true value is 2630. The same applies to the n37 address in the AKM system.

"n37" to "n42" are adapted to valve type ETS 100 and should only be changed through the use of another valve.				
Number of steps from 0-100% opening degree (x10) (ETS = 262. ETS 100 = 353)	n37	000 stp**	5000 stp **	263

The range of the pressure transmitter can be set by entering the transmitter's minimum value at address o20 and maximum value at address o21.

Working range for pressure transmitter Depending on the application a pressure transmitter with a given working range is used. This working range (say, -1 to 12 bar) must be set in the controller. The min. value is set.	o20	MinTransPres.
The max. value is set	o21	MaxTransPres.

Backlash Compensation

The controller includes a procedure for compensating for backlash on the ETS valve spindle. The parameters involved in this procedure are listed below

Compensation value for spindle play at valve's closing point (number of steps)	n39	Start bcklsh (Menu=Danfoss only)
Compensation value for spindle play during operation (number of steps)	n40	Backlash (Menu=Danfoss only)
Valve definition 1=Valve must open when more capacity is required (NC function) 2=Valve must close when more capacity is required (NO function)	n41	Valve type (Menu=Danfoss only)
Compensation direction 1=Compensation takes place when the valve opens (normal setting) 2=Compensation takes place when the valve closes	n42	Comp.dir. (Menu=Danfoss only)

These parameters should not be changed and the reason the parameters are accessible is only historical, and at some point will be withdrawn from the menu.

Finding the optimum settings

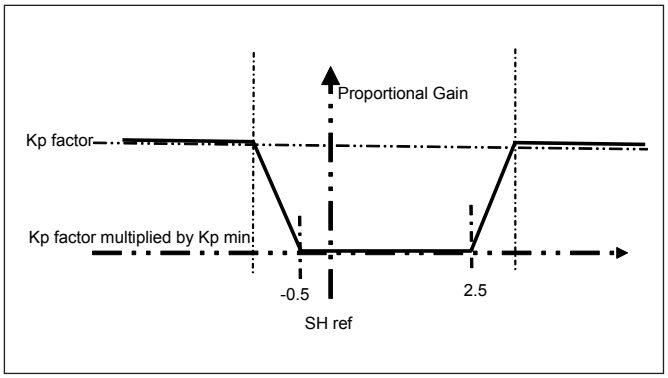
Details on the controller algorithm and settings

Kp factor and Kp min

The Proportional Gain is dependant on the value of the measured superheat SH relative to Reference superheat SH ref. The Proportional Gain has the following values relative superheat SH:

If SH is more than 2.5K greater than SH ref then Gain equals Kp factor.
If SH is within the range 2.5K and -0.5K from SH ref, then Gain equals Kp factor times Kp min.

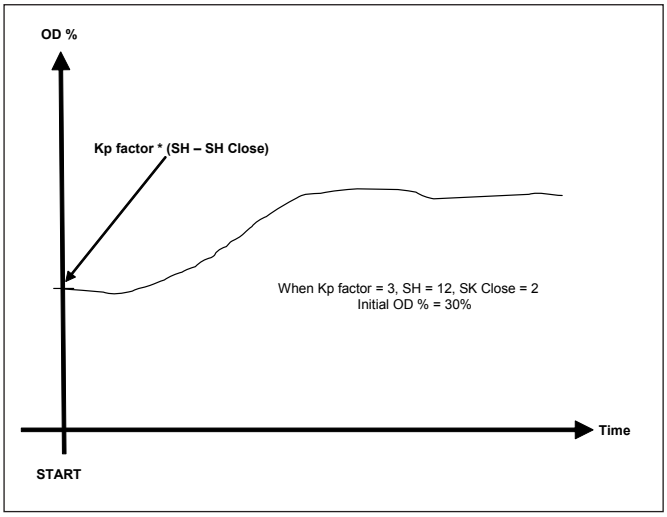
The reason for this variable Gain is to give stabile superheat for values near the superheat reference.
Note the value of Gain does not change suddenly but gradually when SH gets close to SH ref.



Initial start-up "Kick start"

In general the valve opening degree is controlled by the measured value of the superheat SH. This means that during certain situations during start up, the valve will be slow to open due to the built of superheat from a small value. To prevent this happening, the valve is given an initial opening degree dependant on the Kp factor, the measured superheat SH and SH closes as given in the following relationship:

Initial OD% = kp factor*(SH – SH close)



The regulation modes for controlling superheat

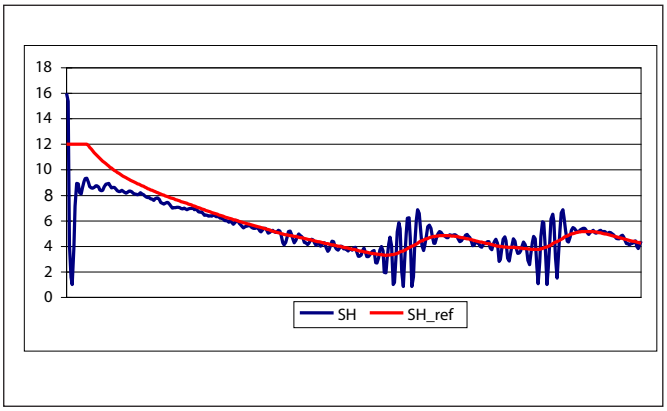
There two different ways of controlling superheat i.e. controlling according to the minimum stable superheat (MSS) and Load Defined superheat.
The parameter SH mode selects the controlling form where it can be set to MSS when set to 1, or Load Defined superheat when set to 2.

SH mode = 1

The superheat reference SH ref is adaptive adjusted

The diagram shows how the SH ref is decreased 0.1 K every 30 seconds until instability in SH is detected. The SH ref will continue increase at 0.1 K every 30 seconds until stability is achieved again. More less the same behaviour will continue as shown where the operation is attempting to find the minimum stable superheat.

When using this form of control, there are three settings that have major affect on this mode of control



Max SH – The maximum limit of SH ref.

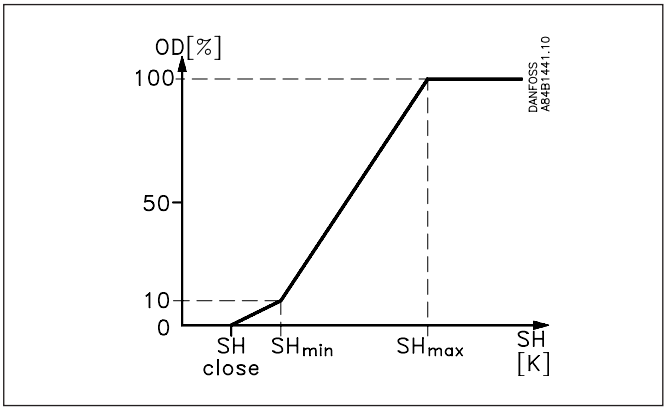
Min SH – The minimum limit of SH ref. Care should be taken not to set value too low in order to avoid flooding back in the compressor.

Stability – This factor determines how much instability can be accepted. Small values will cause the SH ref to increase if the slightest instability in SH is detected. Conversely, higher values will accept a higher degree of instability.

SH mode = 2

SH ref follows a defined curve as shown below. This curve is defined by three values: SH close SH max and SH min.

This form of regulation is similar to the *thermostatic* valve where the spring force can be adjusted to keep the SH (superheat) in the stable region to the right of the curve.
The advantage over the *thermostatic* valve is that there are three settings to define the operating curve.

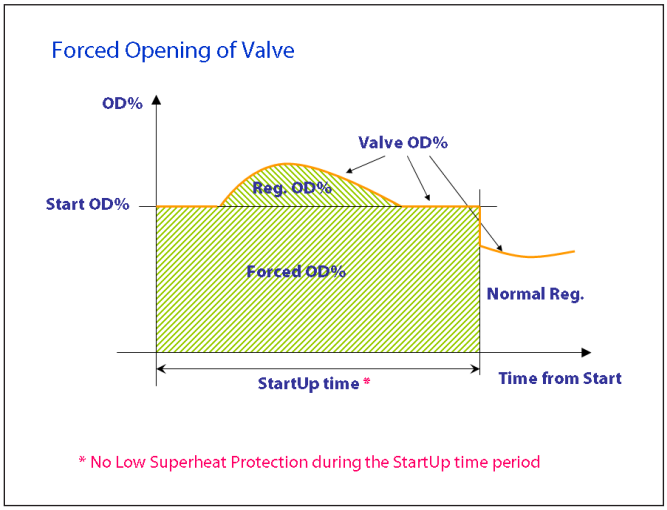


Problems of start up

Sometimes in one to one applications, the valve does not open sufficiently on start-up, and troublesome low pressure trips happen. This problem is typical when using the single loop control where the only the SH controls the opening of valve.

The *force opening of valve* function has been implemented in the EKC 316A controller. This is not stated in the controller manual, but please be aware that this function will give after start up, a constant set minimum opening degree during a set time period, without any regard to the superheat value. The setting parameters are called *Start OD%* (n17) and *StartUp time* (n15), and are found in the *For Danfoss only* menu in AKM and also in the EKC 316A controller.

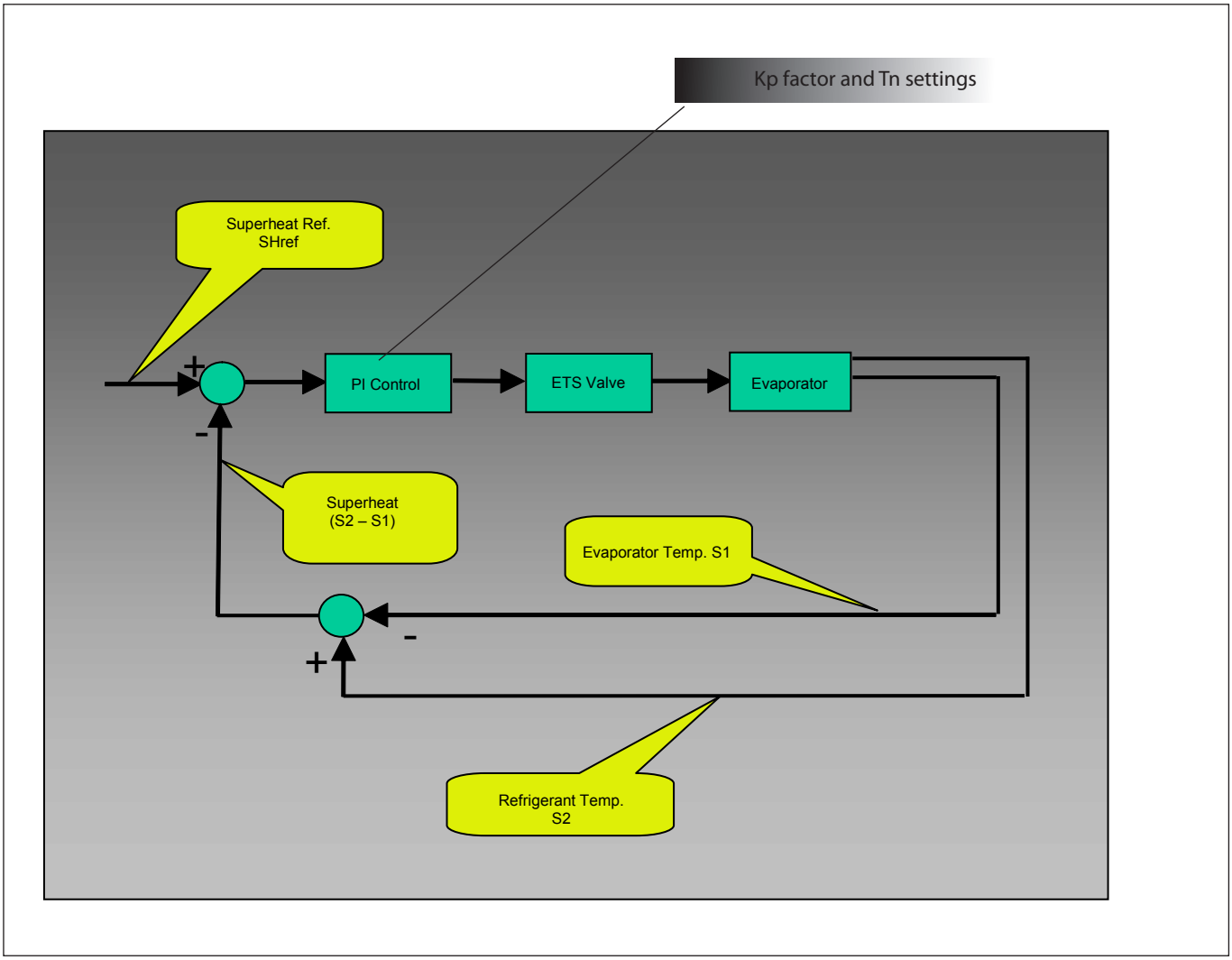
Please observe that the *Start OD%* is a minimum value after start up and if the measured superheat (u21) produces a value greater than *Start OD%* then this value will be valve opening degree (u24) - see diagram.



Types of regulation

Single Loop (address o56 Reg.type = 1)

The EKC 316A has the *traditional* PI controlling function with the Kp factor for Proportional Gain and Tn for Integration Time in seconds. This also is known as the Single loop control with only one PI block as shown in the diagram below.



Instability cause by too much Proportional Gain can be corrected by reducing to value of the Kp factor. This should be done reducing with small steps at a time and observing the results before making further reductions.

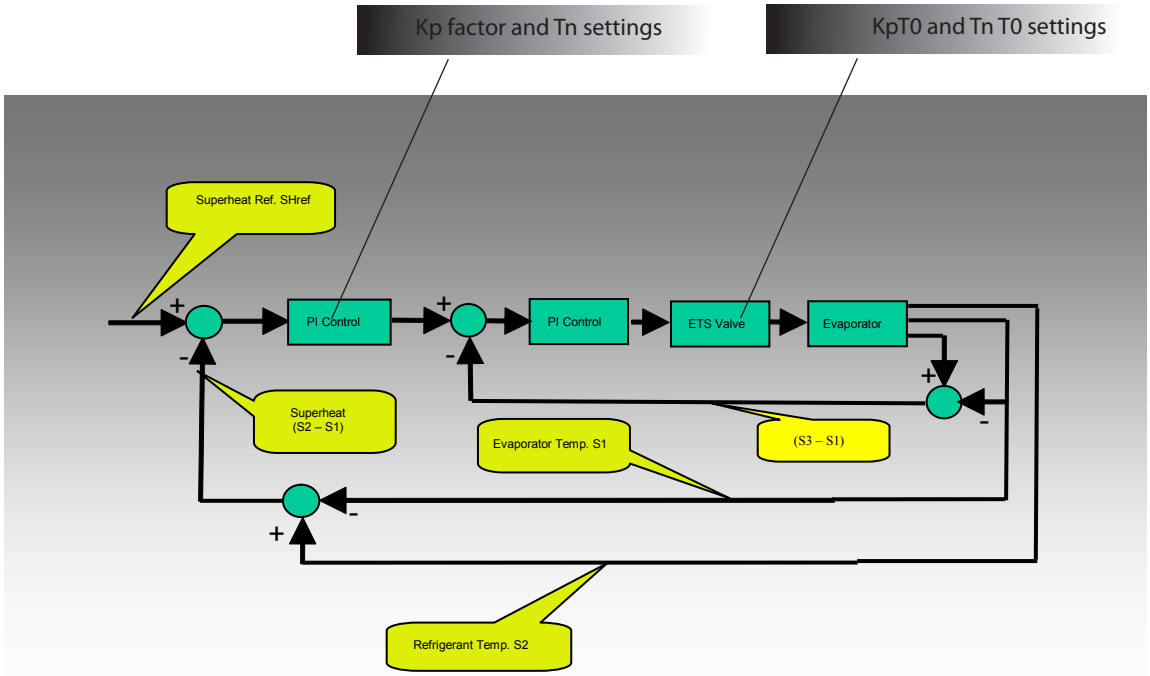
If the superheat response is slow to changes, it can be increased by reducing the value of the Integration Time Tn.

When tuning the superheat stability, it is good practise to have a fixed superheat reference by making SH max the same as SH min.

Double Loop (address o56 Reg.type = 3)

The controller can regulate the superheat using a double loop system. The so called outer loop is really the same as in the single loop system except output of PI block is the reference for the inner loop.
The inner loop also has also PI block with Proportional Gain factor is KpT0 and the Integration Time is TnT0.

The double loop control system is shown in the diagram below.



The feedback of the inner loop is temperature difference between media temperature S3 and S1. This value represents the load on the evaporator and large values will tend to increase the opening degree OD% of the valve.
The tuning of the double loop is more complicated than the single loop and it is advisable not change to many parameters at the same time. The starting point should be to use the following settings.

Parameter	Value	Address
Kp factor	0.7	n04
Tn sec	120	n05
KpT0	3	n20
TnT0 sec	30	n44

If the superheat is unstable, the KpT0 parameter should be slightly reduced. The value parameter Kp factor is not large so little is gain by reducing this parameter.

When to use Single or Double loop
In most applications and especially air coolers, the single loop is the best option because of simplicity and easier to tune.
In water chillers where the S3 sensor is located at the leaving water outlet, the double loop gives some advantages in terms of being less susceptible to compressor or fan step changes. Further, it gives a quicker opening of the valve during start up. However the double loop is less advantages on air coolers of slower response of the media temperature.

NOTE
The settings Atten.factor (address n43) and Min.Lim.Ref (address n45) should not be changed without the help of trained staff.

The S3 sensor has to be connected when Reg.type = 3, or else an alarm is given.

Recommended control loop type and settings for some applications

From the experience of using single loop and double regulation, the following recommendations are given for the applications that EKC 316A has been used in. These are only recommendations and the final choice is made by the end user.

Application	Reg. type	Kp factor	Tn sec	Kp T0	TnT0 sec
	address n56	address n04	address n05	address n20	address n44
Air cooler	1 (Single loop)	3.0	120	0.4	-
Water chiller	3 (Double loop)	0.7	120	2.0	30

Manually operating the valve

There are three modes for operating the valve manually and are described in the following sections.

Operating the valve manually from the EKC 316A controller

The opening degree of the ETS can be operated manually by setting parameter o18 to 1 and then setting parameter o45 to required opening degree from 0 to 100%
Note, relay outputs can also be checked using parameter o18 as shown in extract from manual.

Manual control of outputs For service purposes the individual relay outputs and the ETS-output can be forced However only when regulation has been stopped. OFF: No override 1: Relay to the solenoid valve is ON. 2: Relay to the solenoid valve is OFF 3: Alarm relay is activated (connection established between terminals 12 and 13). After 600 seconds the manual control will be interrupted, and the setting will return to "0". In settings 1-3, "o45" will become active and the ETS output can be set manually.	o18	Manual ctrl

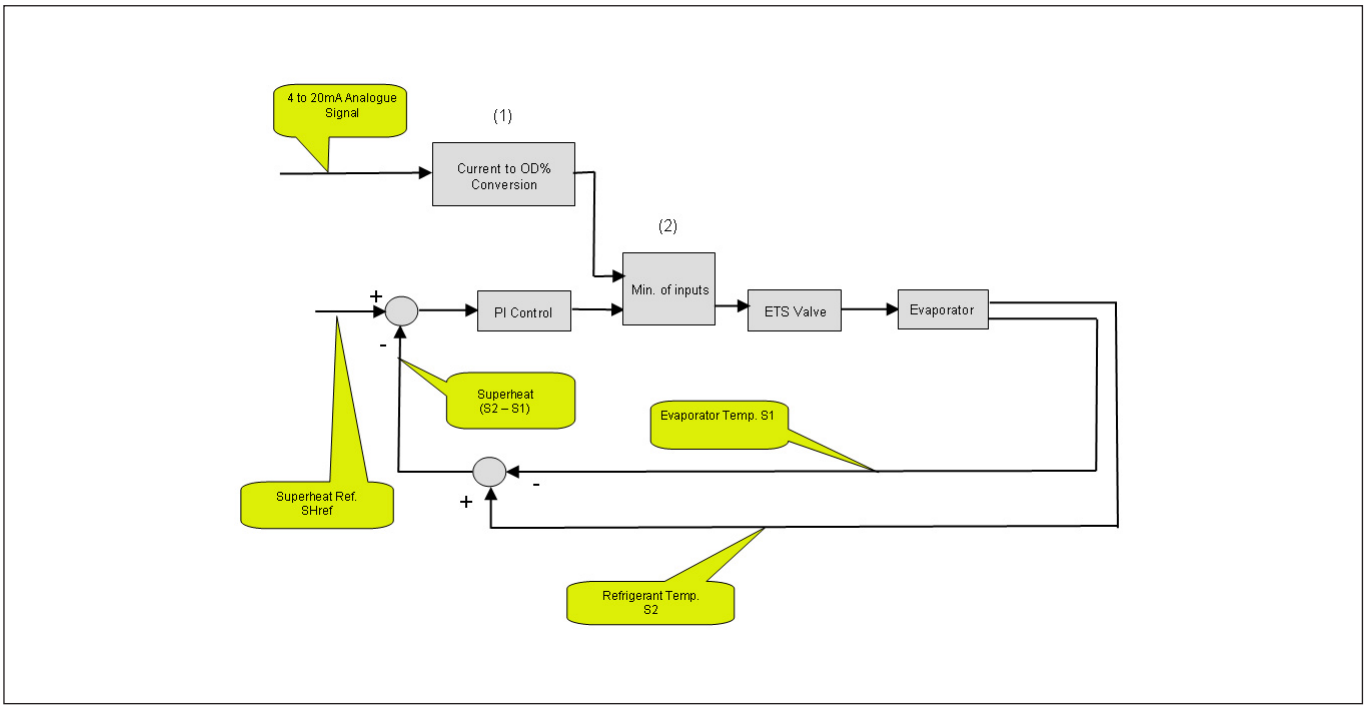
Operating the valve manually by an extern analogue signal

The opening degree of the ETS valve can operated manually with 0 to 20 mA or 4 to 20 mA external analogue signal connected to terminals 16 (-) and 17 (+) of the controller. This can be done by setting parameter o18 to 4 for 0 to 20 mA signal or 5 for 4 to 20 mA signal. The analogue input 0 or 4 mA will correspond to a valve open of 0% and 20 mA will correspond to 100%.
Note this is not shown in the manual.

Operating the valve manually by an extern analogue signal with MOP active

The opening degree of the ETS valve can operated manually with 0 to 20 mA or 4 to 20 mA external analogue signal connected to terminals 16 (-) and 17 (+) of the controller in the same way as Section 5.2. The difference is that the superheat controlling function is still with transmitter and sensors connected. The signal operating the ETS comes from the external signal or superheats controlling function and will always be controlled by the smallest value of these two sources

Input signal for reference displacement Definition of function and signal range. 0: No signal 1: Displacement of temperature reference with 0-20 mA 2: Displacement of temperature reference with 4-20 mA 3: Displacement of superheat reference with 0-20 mA 4: Displacement of superheat reference with 4-20 mA 5: Forced control of valves opening degree with 0-20 mA 6: Forced control of valves opening degree with 4-20 mA (4 or 0 mA will not give a displacement. 20 mA will displace the reference by the value set in menu r06)	o10	AI A type



The diagram is a simplified form of the EKC 316A algorithm, where sections (1) and (2) have been added in connection with modifications made in software version 1.24.
Sections (1) and (2) are active when parameter o10 is set to 5 or 6, and in this situation, the analogue current signal applied to terminals 16 and 17 in certain circumstances can control the opening degree OD% of the valve. With o10 set to 5, a current signal 0 to 20mA can be applied to terminals 16 and 17. Similarly a 4 to 20mA signal can be used when o10 is set to 6.

When the sections (1) and (2) are active, the function in section (2) will choose the lowest value of OD%, that comes from either sections (1) or the PI Control.
This means that the valve can be manually controlled by the external analogue voltage as long as the output of section (1) is smaller than the output from the PI Control section. If output of the PI Control section is smaller than the output from section (1), then the valve opening degree OD% will regulated according to superheat values and MOP setting. This prevents excessive values of opening degree OD% that might cause low superheat values or high suction pressure.

The opening degree OD% will go to zero if there is a fault in any of the sensors.

Battery Back-up

A battery back-up can be connected to terminals 5 (+) and 6 (-).
The voltage should be at least 18 Volts and this can be achieved by using two 9 Volt 100 mAh batteries in series.
The back-up voltage can also come from UPS giving 24 Volts.

Note: In the case where no battery back-up is used, the valve will always close correctly even when the valve is fully open before the power is interrupted.
The valve will be driven 110% of the steps during start up.

Troubleshooting

Symptom	Possible Cause	Remedy
Suction pressure too low	Pressure drop across the evaporator too high	
	Lack of subcooling ahead of expansion valve	Check refrigerant ahead of expansion valve. If the valve is placed much higher than condenser outlet, check pressure difference
	Evaporator superheat too high	1. Check superheat performance, the settings SH min and SH max. 2. Check valve capacity. 3. Check that the maximum number of steps of valve is same as parameter n37
	Pressure drop across the expansion valve less than valve is sized for	Check pressure drop across expansion valve. Replace with larger valve.
	Expansion valve too small	Check refrigeration system capacity and compare with expansion valve capacity. Replace with larger valve if necessary.
	Expansion valve block with foreign material	
	Evaporator wholly or partly iced up	De-ice evaporator
Liquid hammer in compressor	Superheat of expansion valve too low	Increase the values of SH close and SH min.
	Superheat reference set too low	Increase the value of SH min
	The S2 sensor not in good contact with the suction line	Ensure that S2 sensor is secured on suction line. Insulate sensor.

Alarms

Symptom	Possible Cause	Fault Message	Remedy
All Light emitting diodes flashing	S2 sensor cut-out.	E15	Check connections at terminals 18-19 and sensor.
	S2 sensor short-circuited	E16	Check connections at terminals 18-19 and sensor.
	S3 sensor cut-out	E17	Check connections at terminals 18-20 and sensor.
	S3 sensor short-circuited	E18	Check connections at terminals 18-20 and sensor.
	Analogue input outside range.	E19	
	Pressure transmitter outside range.	E20	Check pressure transmitter, connections at 14-15 and pressure.
	High Temperature alarm	A1	Check cooling is effective. Check thermo-stat relay at terminals 8-9
	Low Temperature alarm	A2	Check ETS valve is full open and relay at terminals 8-9
	No refrigerant selected	A11	Select refrigerant
	Supply to stepper motor	A43	Check connections from EKC316A to ETS valve.
	Battery alarm	A44	Check the battery voltage is the nominal voltage.

Notes:

1) Only one alarm is displayed at a time in the controller display and are shown in the order given above i.e. E15 will be displayed if S2 is not connected. If S2 is connected successfully then the next alarm will be E17 if S3 is not connected. All alarms are displayed in the AKM system.
2) The alarm E19 will only be active if address o10 is set to 1 or more.
3) The alarm E17 and E18 will be only active if the Therm.Mode address r14 is set to 1 or Reg.type address o56 is set to 3.
4) The battery alarm A44 is only active when Batt.alarm address A34 is set to ON.

References

[1] Controller for operation of evaporator on water chillers
EKC316A Manual RS8CX502.

[2] Electrically operated expansion valves type ETS
ETS Technical Leaflet DKRCC.PD.VD1.A1.02 (tidligere RD1TA302)

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