Cairo University
Faculty of Engineering
Mech. Power Department

دبلوم تطبيقات التحكم الأوتوماتيكى
فى نظم القوى الميكانيكية

**MEP 599 Diploma Design Project- Summer Term 2015**

# Design of New PLC system to replace existing classical micro-controller of industrial water chiller


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***Abstract:*** **A water chiller is an equipment that cools specific flow rate of water to slightly above freezing temperature ( usually down to 4°C ). Chillers are used in many applications including HVAC , food preserving , petrochemical processes , medical applications .etc. The major problem that encounters the technicians is that all modern chiller uses complex control system that is based on special microprocessors made by the chiller manufacturer. The chiller manufacturer always try to ensure that the consumer won't be able to operate the machine unless he buys manufacturer spare parts , & this is a big problem because price will be too high. Another problem is that electronic cards used in modern chiller control are not designed to work in industrial and hazardous places but in domestic conditions that won't attack control system and causes chiller to be Offline .**

***Project proposal***

**To replace the automatic control system made & supplied by the manufacturer of any selected fereon water chiller , with new control systems based on classic relay interlock & PLC control with a minimum modifications to the chiller mechanical & power circuit components .**

***Contents:***


Part I: Proposal , objectives & activities
Part II: Water chillers - overview
Part III: Control system - overview
Part IV: Proposed chiller
Part V : PLC versus other control systems

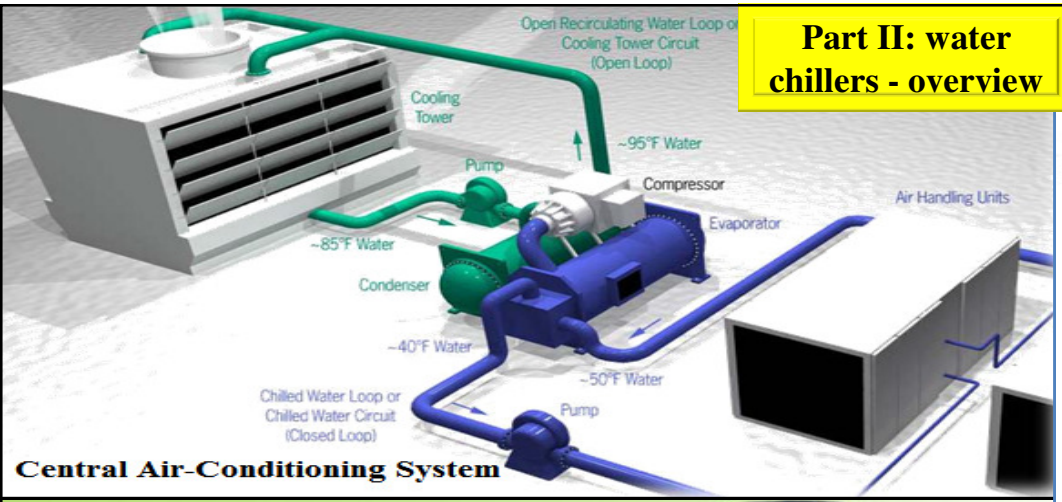

***Project objectives:***

- **Maximize the benefits of diploma courses by applying them to a real industrial application**
- **Revise the studied courses in the undergraduate period .**
- **Share experience with colleges .**
- **Increase experience & productivity in PLC & classic control systems .**
- **Increase the technical writing skills .**
- **Improve usage & search capabilities on the internet .**

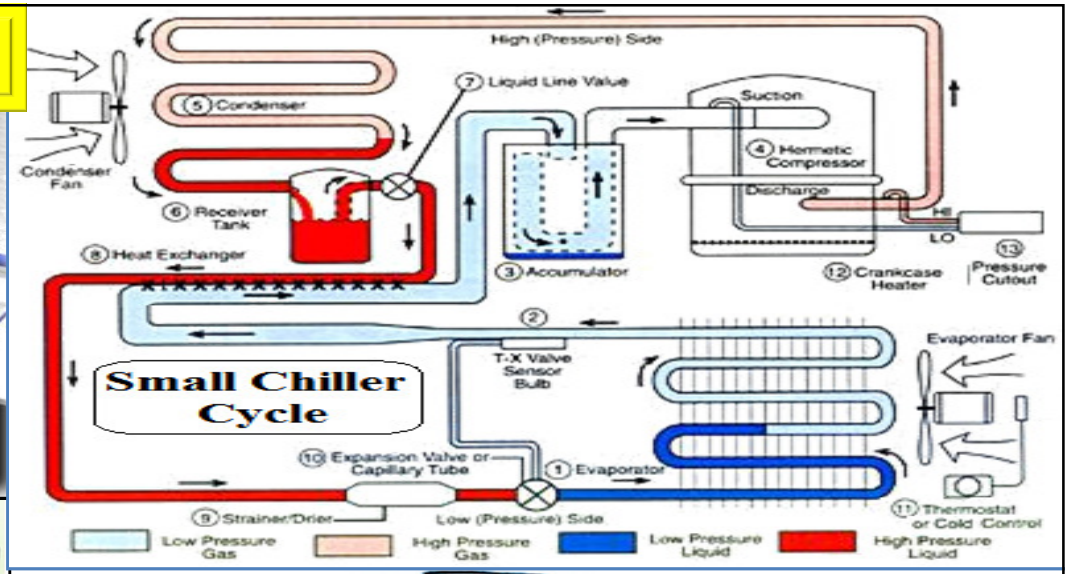
***Project activities***

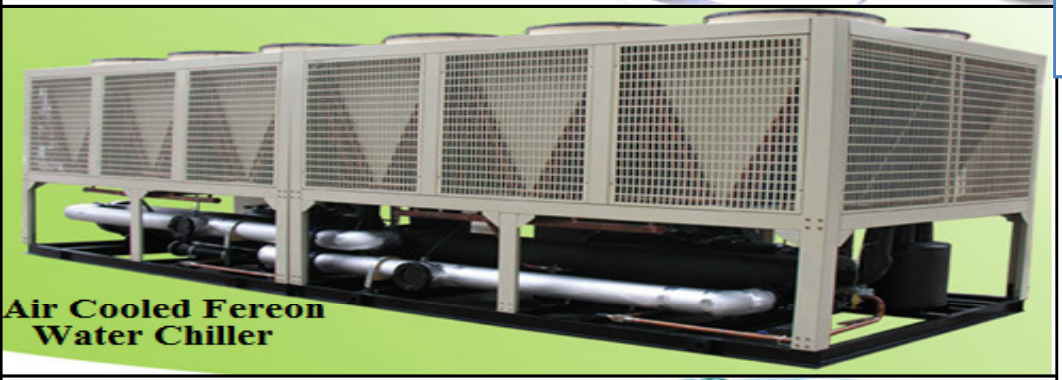
1- **Project proposal .**
2- **Selection of chiller & study provided control system .**
3- **Make thermodynamic analysis of chiller at every loading condition .**
4- **Prepare control requirements + sequential flow chart .**
5- **Build classic control system & prepare a simulation for it .**
6- **Build PLC system & prepare a simulation for it .**
7- **Make comparison between both control systems& when use each one**
8- **Complete project document &presentation .**

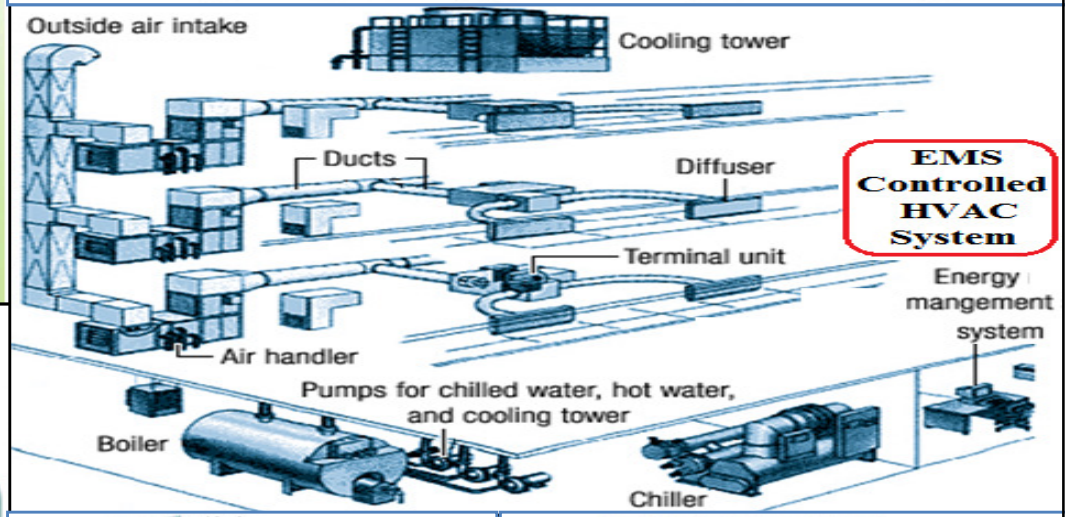
# Part II: water chillers - overview



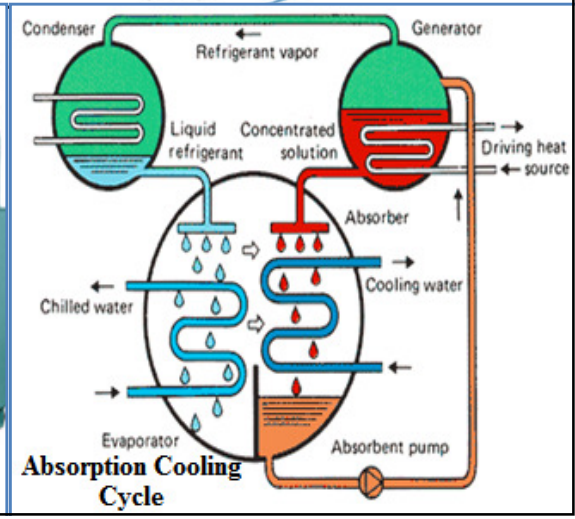
Central Air-Conditioning System



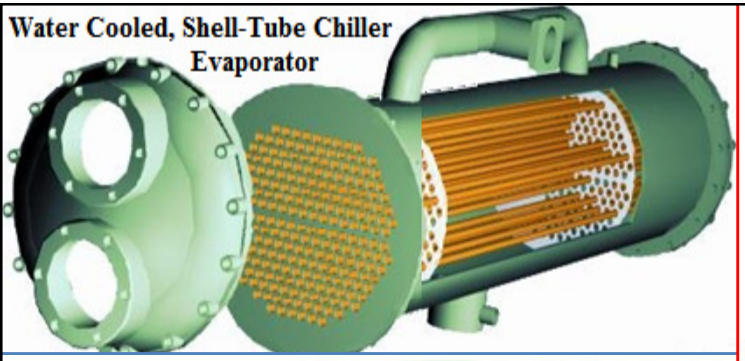


Air Cooled Fereon Water Chiller

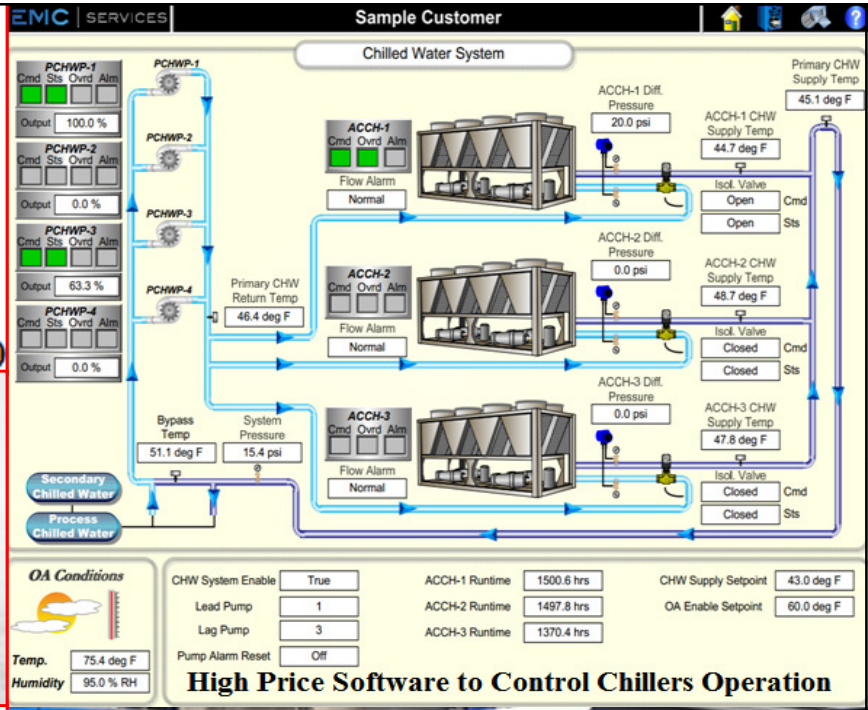


Water cooled Fereon Water Chiller

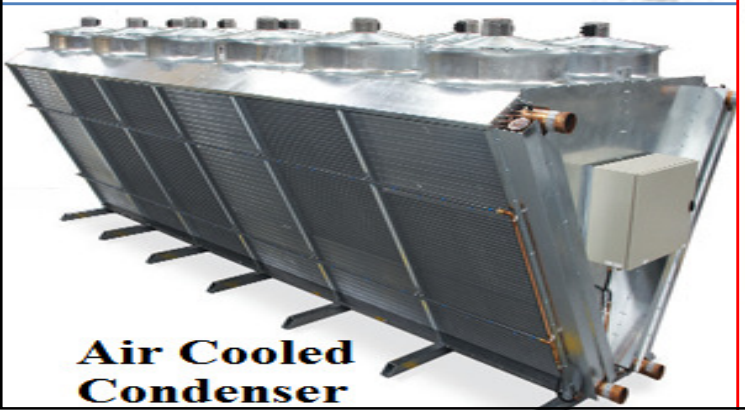


Double Compressors, Water Cooled Chiller

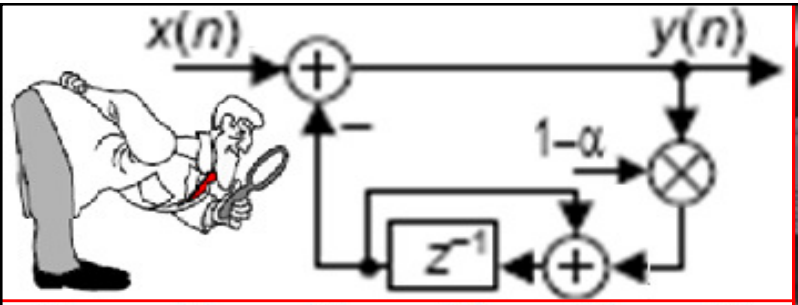


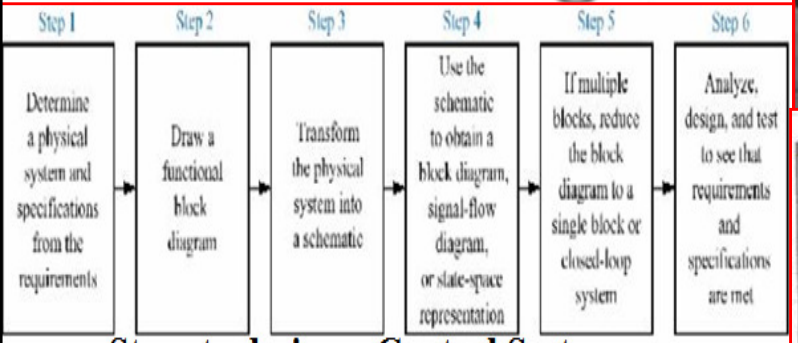


High Price Software to Control Chillers Operation

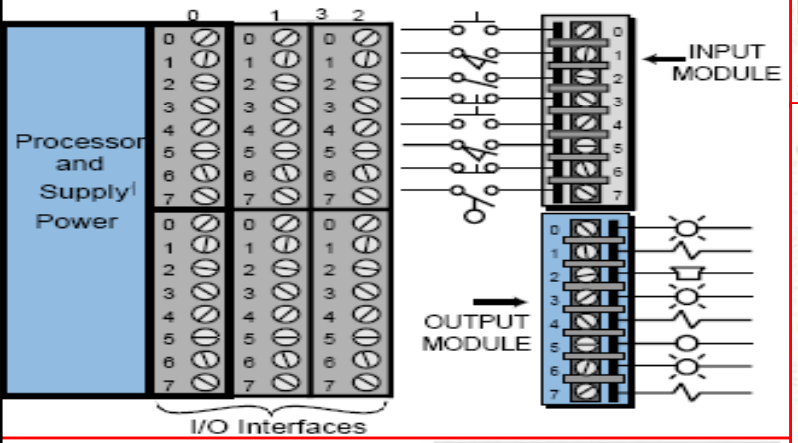


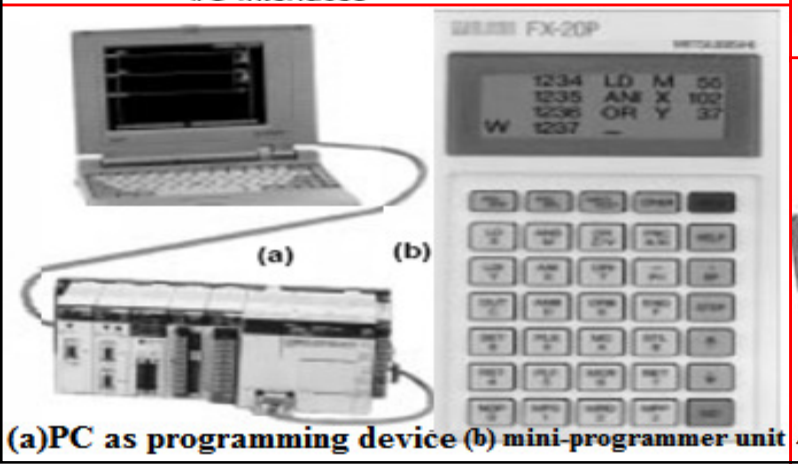
# Part 3: control system-overview



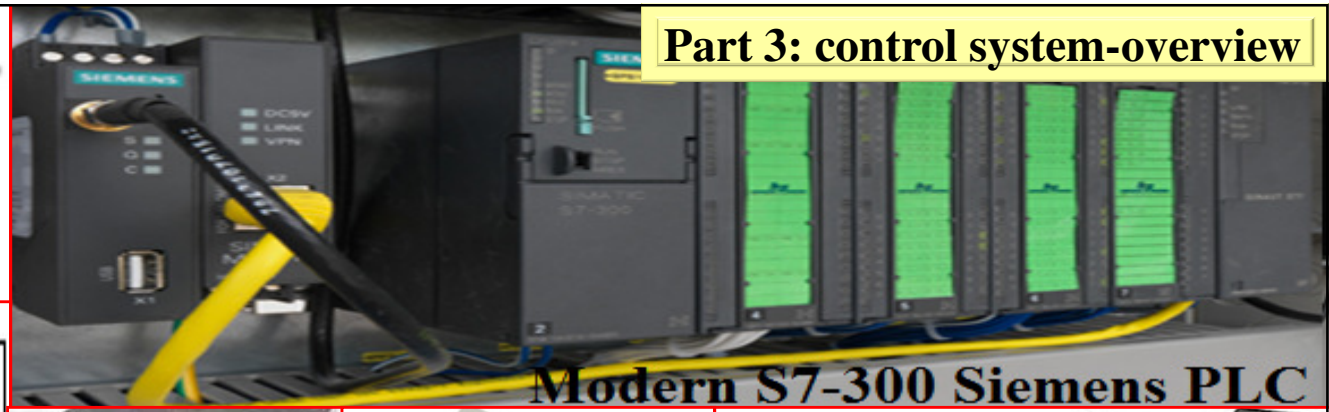




Steps to design a Control System

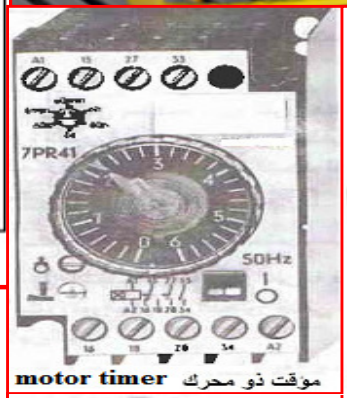



(a)PC as programming device (b) mini-programmer unit



Modern S7-300 Siemens PLC




motor timer موقت ذو محرك

Electronic Timer موقت إلكتروني

Air-Timer موقت هوائي

Physical properties switches

Modern Contactors

5-Compressors Water-Chiller

## Part 4: Proposed Chiller

**is 145 ton air cooled water chiller has specifications :**

- •- manufacturer : Carrier – USA
- •- capacity : 145 TR
- •- type : 30 GTN 150 -- C933 --
- •- condenser coolingis done with forced air cooled using 10 axial flow fans .
- •- refrigerant charge : 130 Kg R22
- •-5 semi-hermetic reciprocating compressors divided in 2 separate circuits with 2 of compressors able to unload one head each .
- •- shell & tube evaporator with separate pass for each circuit .
- •- microprocessor based control system with TD interface .

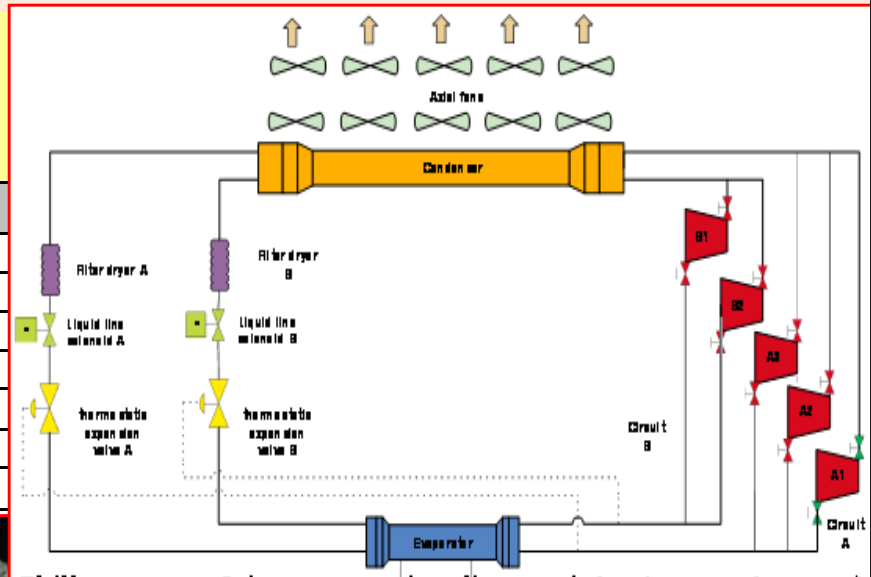
**Compressor specifications :**

- ➢Semi-hermatic , self lubricated , 6 cylinder reciprocating compressor .
- ➢Type : 06EA 299 610 ( carrier type ) 380 V , 50 HZ .
- ➢Compressors A1,B1 are equipped with one head that can be operate unloaded
- ➢compressors operate based on water temp. according with following sequence:

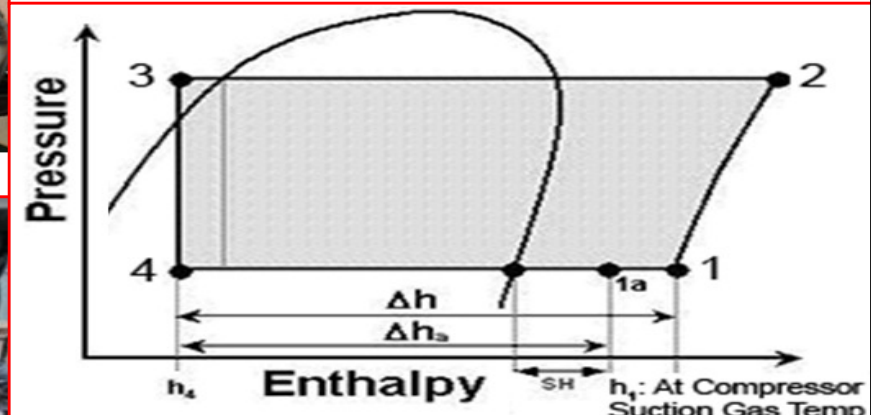
| Circuit | Compressor | % load | Water temp. |
|---|---|---|---|
| A | A1 ( one head unloaded ) | 13.4 | 5 > T |
| | A1 | 20 | 7 > T > 5 |
| | A1 + A2 | 40 | 9 > T > 7 |
| | A1 + A2 + A3 | 60 | 11 > T > 9 |
| B | A1+A2 +A3+B1 ( with one head unloaded ) | 73.4 | 13 > T > 11 |
| | A1 + A2 + A3 + B1 | 80 | 15 > T > 13 |
| | A1 + A2 + A3 + B1 + B2 | 100 | T > 15 |

Compressor Valve Plate equipped with unloading System

Proposed Chiller Evaporator



Chiller process & instrumentation diagram (Classic control system)



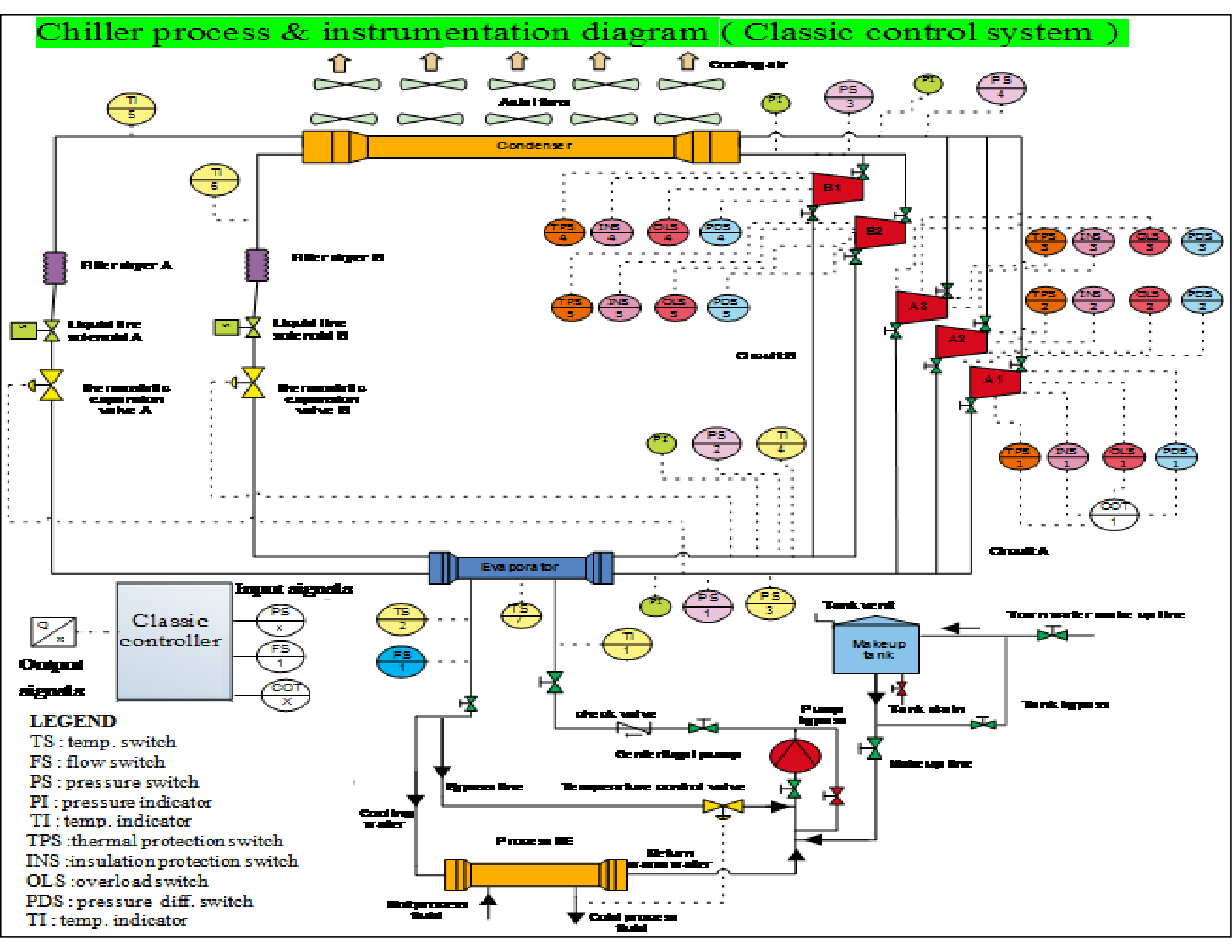
$h_1$: At Compressor Suction Gas Temp

Compressor capacity is based on Δh, 100% useful superheat

Net Refrigeration Effect is based on $\Delta h_s$ SH:Evaporator superheat

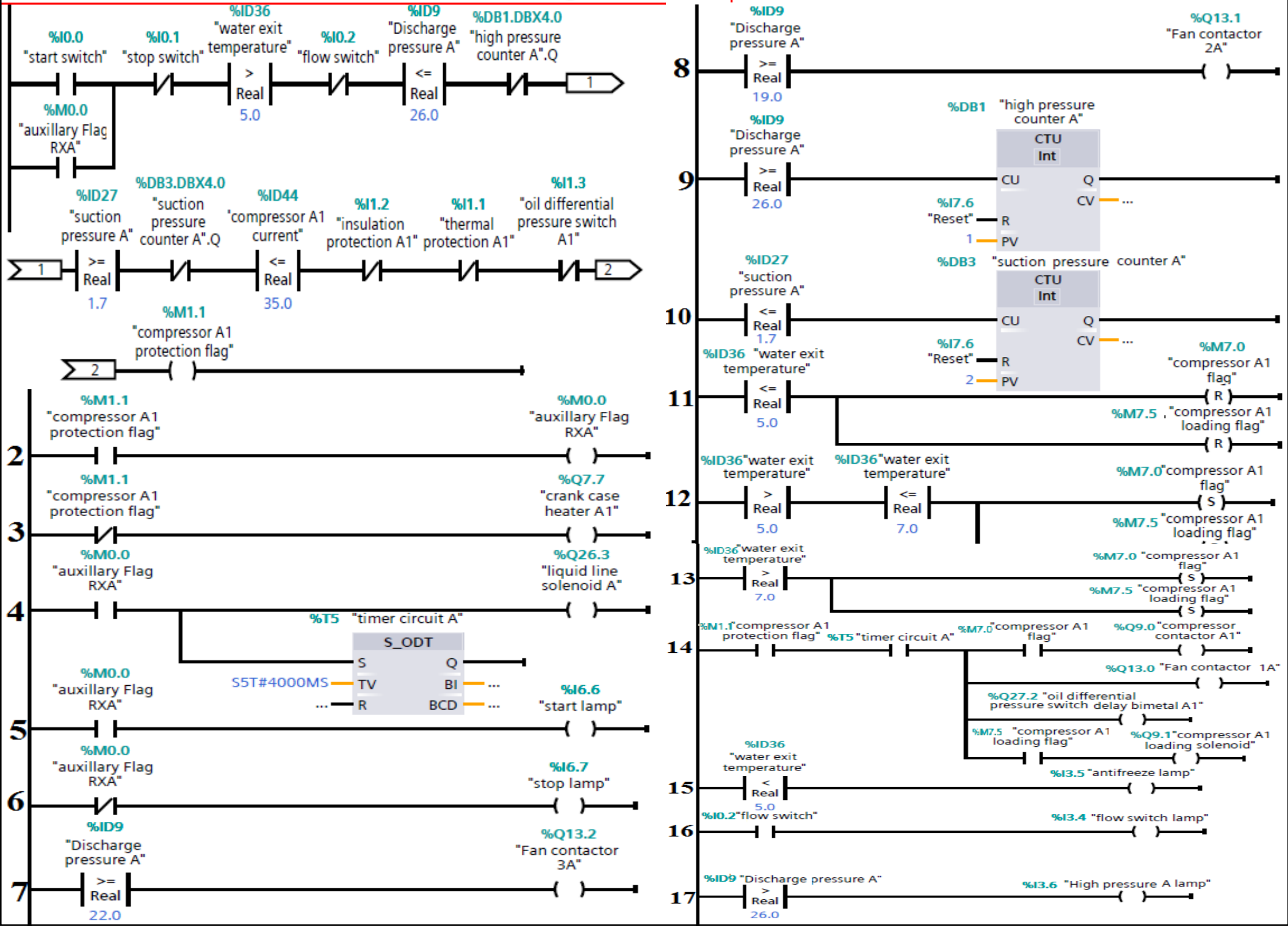
*The Pressure-Enthalpy (PH) Diagram*

# Chiller process & instrumentation diagram ( Classic control system )




**LEGEND**

TS : temp. switch
FS : flow switch
PS : pressure switch
PI : pressure indicator
TI : temp. indicator
TPS :thermal protection switch
INS :insulation protection switch
OLS :overload switch
PDS : pressure diff. switch
TI : temp. indicator


%I0.0 "start switch"
%I0.1 "stop switch"
%ID36 "water exit temperature"
> Real 5.0
%I0.2 "flow switch"
%ID9 "Discharge pressure A"
<= Real 26.0
%DB1.DBX4.0 "high pressure counter A".Q
1
%M0.0 "auxillary Flag RXA"
%ID27 "suction pressure A"
>= Real 1.7
%DB3.DBX4.0 "suction pressure counter A".Q
%ID44 "compressor A1 current"
<= Real 35.0
%I1.2 "insulation protection A1"
%I1.1 "thermal protection A1"
%I1.3 "oil differential pressure switch A1"
2
%M1.1 "compressor A1 protection flag"
2 %M1.1 "compressor A1 protection flag"
%M0.0 "auxillary Flag RXA"
3 %M1.1 "compressor A1 protection flag"
%Q7.7 "crank case heater A1"
4 %M0.0 "auxillary Flag RXA"
%Q26.3 "liquid line solenoid A"
%T5 "timer circuit A"
S_ODT
S
TV
R
Q
BI
BCD
S5T#4000MS
5 %M0.0 "auxillary Flag RXA"
%I6.6 "start lamp"
6 %M0.0 "auxillary Flag RXA"
%I6.7 "stop lamp"
7 %ID9 "Discharge pressure A"
>= Real 22.0
%Q13.2 "Fan contactor 3A"
8 %ID9 "Discharge pressure A"
>= Real 19.0
%Q13.1 "Fan contactor 2A"
9 %ID9 "Discharge pressure A"
>= Real 26.0
%DB1 "high pressure counter A"
CTU Int
CU
Q
CV
%I7.6 "Reset"
R
1
PV
10 %ID27 "suction pressure A"
<= Real 1.7
%DB3 "suction pressure counter A"
CTU Int
%I7.6 "Reset"
2
11 %ID36 "water exit temperature"
<= Real 5.0
%M7.0 "compressor A1 flag"
%M7.5 "compressor A1 loading flag"
12 %ID36 "water exit temperature"
> Real 5.0
%ID36 "water exit temperature"
<= Real 7.0
%M7.0 "compressor A1 flag"
%M7.5 "compressor A1 loading flag"
13 %ID36 "water exit temperature"
> Real 7.0
%M7.0 "compressor A1 flag"
%M7.5 "compressor A1 loading flag"
14 %M1.1 "compressor A1 protection flag"
%T5 "timer circuit A"
%M7.0 "compressor A1 flag"
%Q9.0 "compressor contactor A1"
%Q13.0 "Fan contactor 1A"
%Q27.2 "oil differential pressure switch delay bimetal A1"
%M7.5 "compressor A1 loading flag"
%Q9.1 "compressor A1 loading solenoid"
15 %ID36 "water exit temperature"
< Real 5.0
%I3.5 "antifreeze lamp"
16 %I0.2 "flow switch"
%I3.4 "flow switch lamp"
17 %ID9 "Discharge pressure A"
> Real 26.0
%I3.6 "High pressure A lamp"