Chillers Shut downs caused by sensitivity of Controller to Voltage Sag

(Case Study : HongFha Department Store)

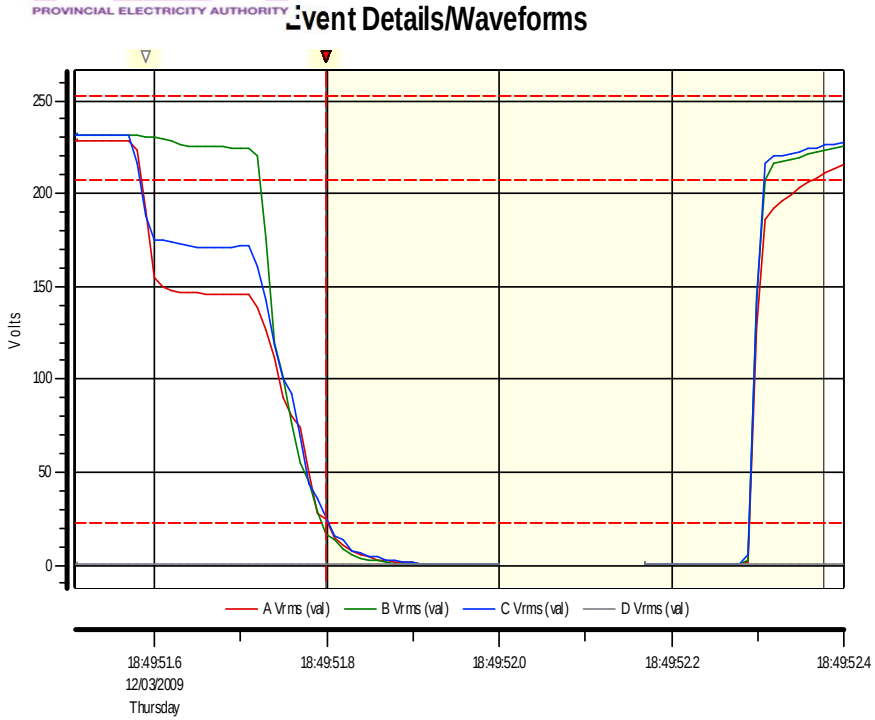
Suwipha Kittitanaphisarn

Chief of Power Quality Section
Engineering & Maintenance Division
Service Department
Provincial Electricity Authority (North Area 1) Chiangmai

Topics

- Theories
- Background
- Power Quality Monitoring Results
- Mitigation Method
- Conclusion

Theory : Voltage Sag Definition

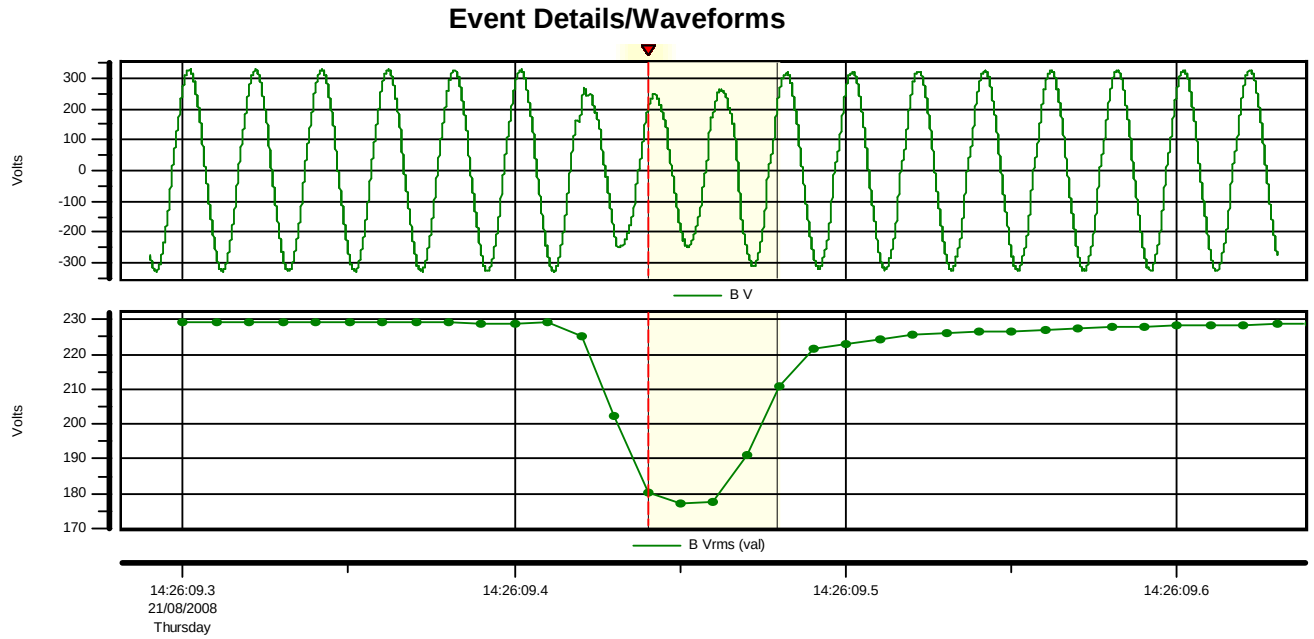


- A Voltage Sag is a reduction in the supply voltage magnitude followed by a voltage Recovery after a short period of time.
- When a voltage magnitude reduction of finite duration can actually be called a “Voltage Sag” (or Voltage Dip in the IEC Standard).
- For the IEEE a voltage drop is only a sag if The during-sag voltage is between 10% and 90% of the nominal voltage.

Voltage sags are mostly caused by short-circuit faults in the system and by starting of large motors.

Theories

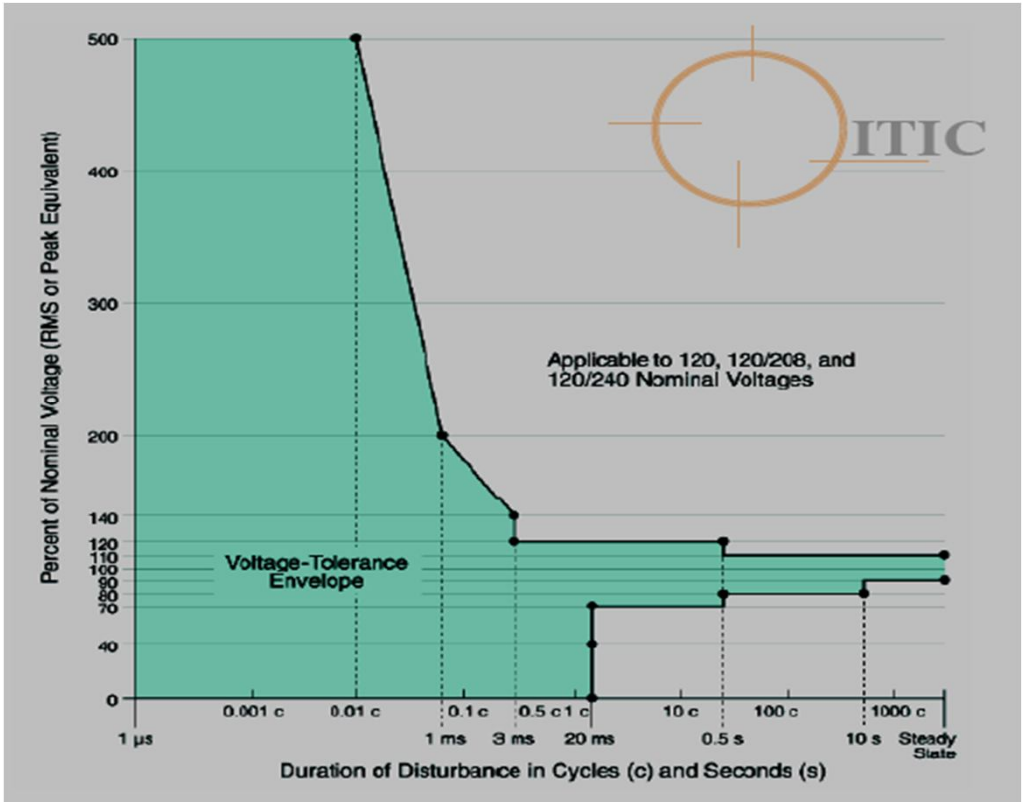
IEEE Standard 1159-1995



- For the IEEE a voltage drop is only a sag if The during-sag voltage is between 10% and 90% of the nominal voltage.

Theories

ITIC Curve : (The Modern Voltage-Tolerance Curve)



This can be understood if one realizes that these figures give the voltage-tolerance performance for one piece of equipment at a time.

Information Technology Industry Council (ITIC)

Minimum voltage sag ride through capability

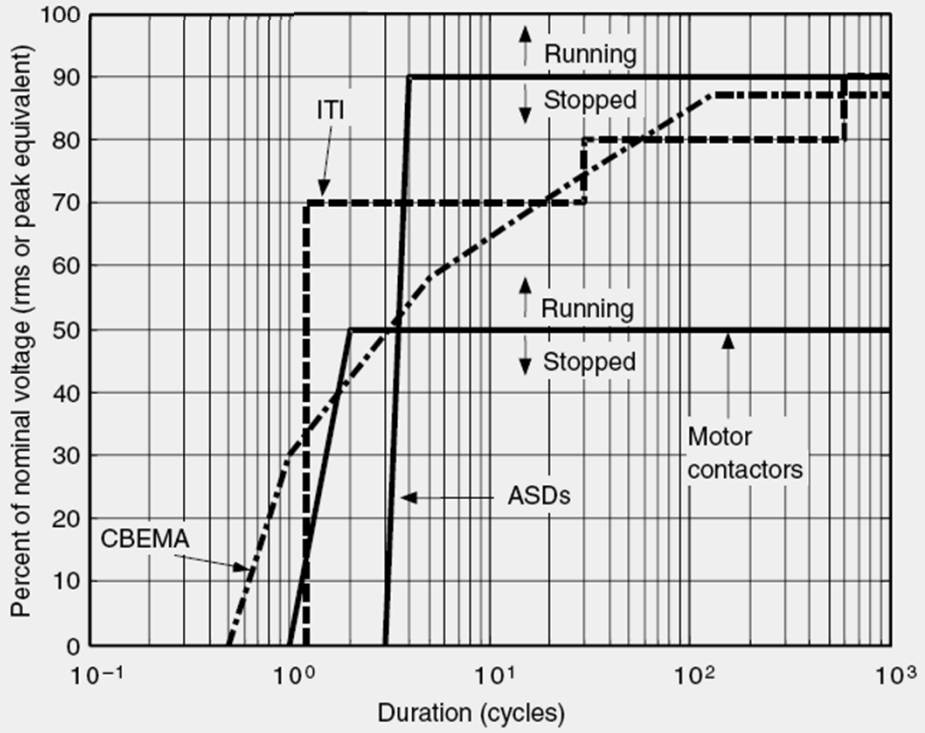


Figure 3.6 Typical equipment voltage sag ride-through capability curves.

The curve labeled CBEMA represents typical equipment sensitivity characteristics.

The curve was developed by the CBEMA and was adopted in IEEE 446 (Orange Book). Since the association reorganized in 1994 and was subsequently renamed the Information Technology Industry Council (ITI), the CBEMA curve was also updated and renamed the ITI curve. Typical loads will likely trip off when the voltage is below the CBEMA, or ITI, curve.

R. C. Dugan, M. F. McGranaghan, S. Santoso, H. W. Beaty, "Electrical Power Systems Quality" McGraw-Hill.,2002

Background

- HongFha Department Store
- Location : Mae-Sai ChiangRai
- Problem : Shutdown of Chiller by sensitivity of voltage sag
- Problem Identification :

Control display by “ SYS1 MOTOR PROTECTION” symptom.

Background

Water-cooled Screw Chiller

YORK® BY JOHNSON CONTROLS YEWS-D

Background

❑SYS1 MOTOR PROTECTION

t imformation

No.	Fault information	Fault reason	Reset method
1	SYS1 COMM.FAULT	Communication disconnection between the centralized controller and 1# main board	Manual
2	SYS1 FLS OPEN	Flow switch open	Auto
3	SYS1 DIS.PRESSURE SW.OPEN	System1 discharge pressure switch open	Manual
4	SYS1 OIL SW.OPEN	[illegible]	Manual
5	SYS1 MOTOR PROTECTION	System1 motor protection switch open	Manual
6	[illegible]	[illegible]	Manual
7	SYS1 Y-△ TRANSITION FAULT	System1 Star-Delta transformation failed	Manual
8	SYS1 AI1 SENSOR FAULT	The leaving cooling water temperature sensor is short circuit or break	Manual
9	SYS1 AI2 SENSOR FAULT	The entering cooling water temperature is short circuit or break	Manual
10	SYS1 AI3 SENSOR FAULT	The leaving chilled water temperature sensor is short circuit or break	Manual
11	SYS1 AI4 SENSOR FAULT	The entering chilled water temperature sensor is short circuit or break	Manual
12	SYS1 AI5 SENSOR FAULT	System1 The discharge temperature sensor is short circuit or break	Manual
13	SYS1 AI13 SENSOR FAULT	System1 The evaporating pressure sensor is short circuit or break	Manual

Background

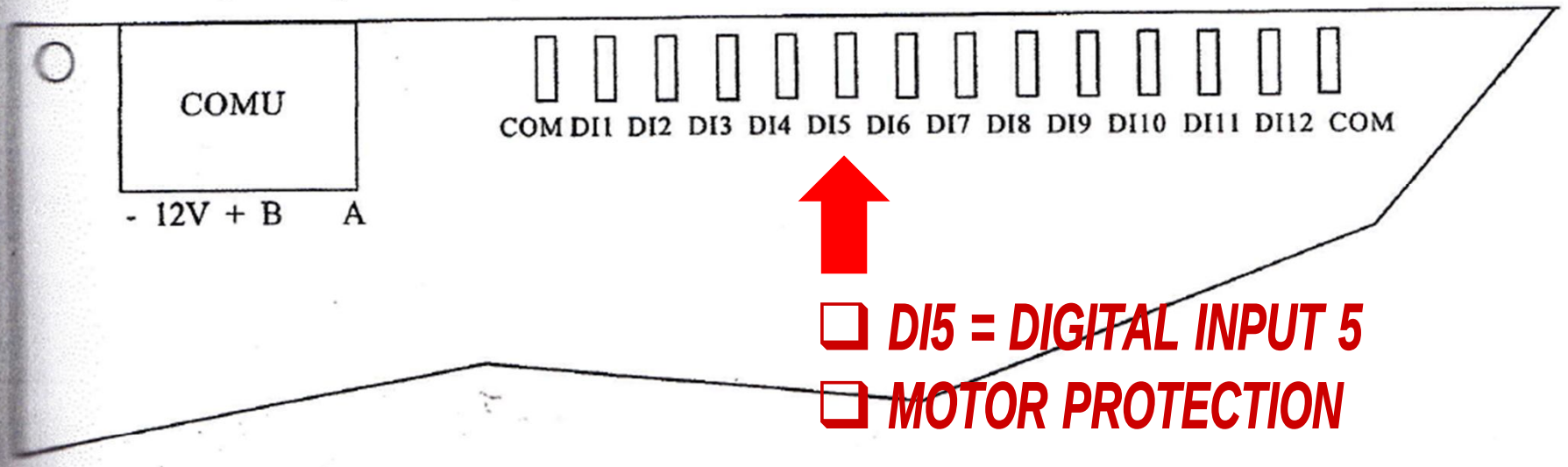
- DI5 = DIGITAL INPUT 5
- MOTOR PROTECTION

(b) Definition of digital input

NO	Switch input	Status description
System 1(YEWS100/130/170/200/210/250)		
DI1	Flow switch	Normal in close, disconnecting means fault
DI2	AC/ITS switch	Open means air-conditioning/Close means ice storage
	AC/HP switch	Open means air-conditioning /Close means heat pump
DI3	Discharge pressure switch	Normal in close, disconnecting means fault
DI4	Oil level switch	Normal in close, disconnecting means fault
DI5	Motor protection	Normal in close, disconnecting means fault
DI6	Ext.interlock	Normal in close, disconnecting means fault
DI7	Start fault	Normal in close, disconnecting means fault
DI8	Remote	Open means shutdown, close means startup
SYSTEM 2(YEWS250)		
DI3	Discharge pressure switch	Normal in close, disconnecting means fault
DI4	Oil level switch	Normal in close, disconnecting means fault
DI5	Motor protection	Normal in close, disconnecting means fault
DI7	Start fault	Normal in close, disconnecting means fault

Background

(c) Connection port diagram of DI open/close quantity and analog signal input



- DI5 = DIGITAL INPUT 5
- MOTOR PROTECTION

Instruction:

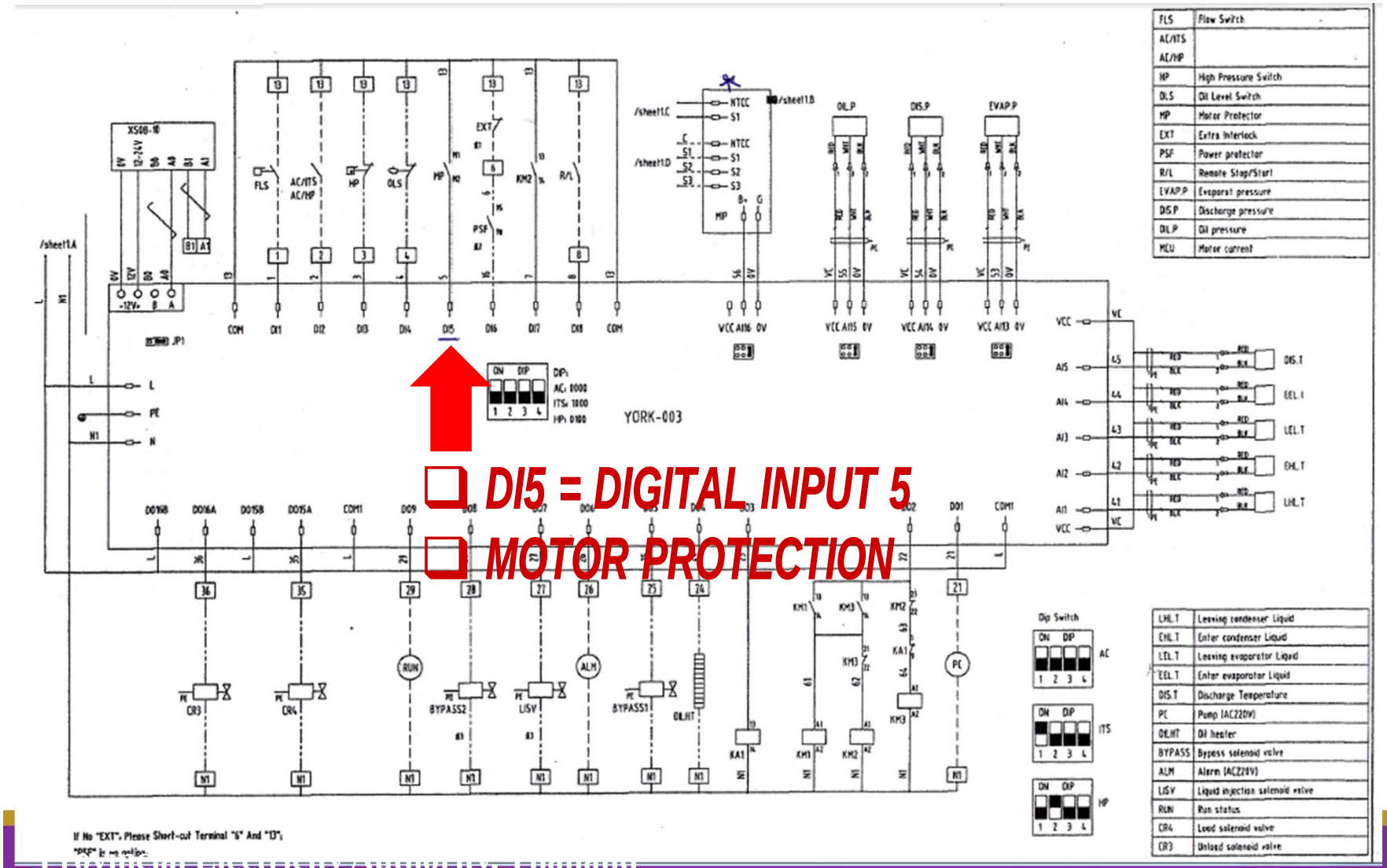
COM: Common port of DI switch input

DI1-DI12: DI switch input

A,B: Communication interface

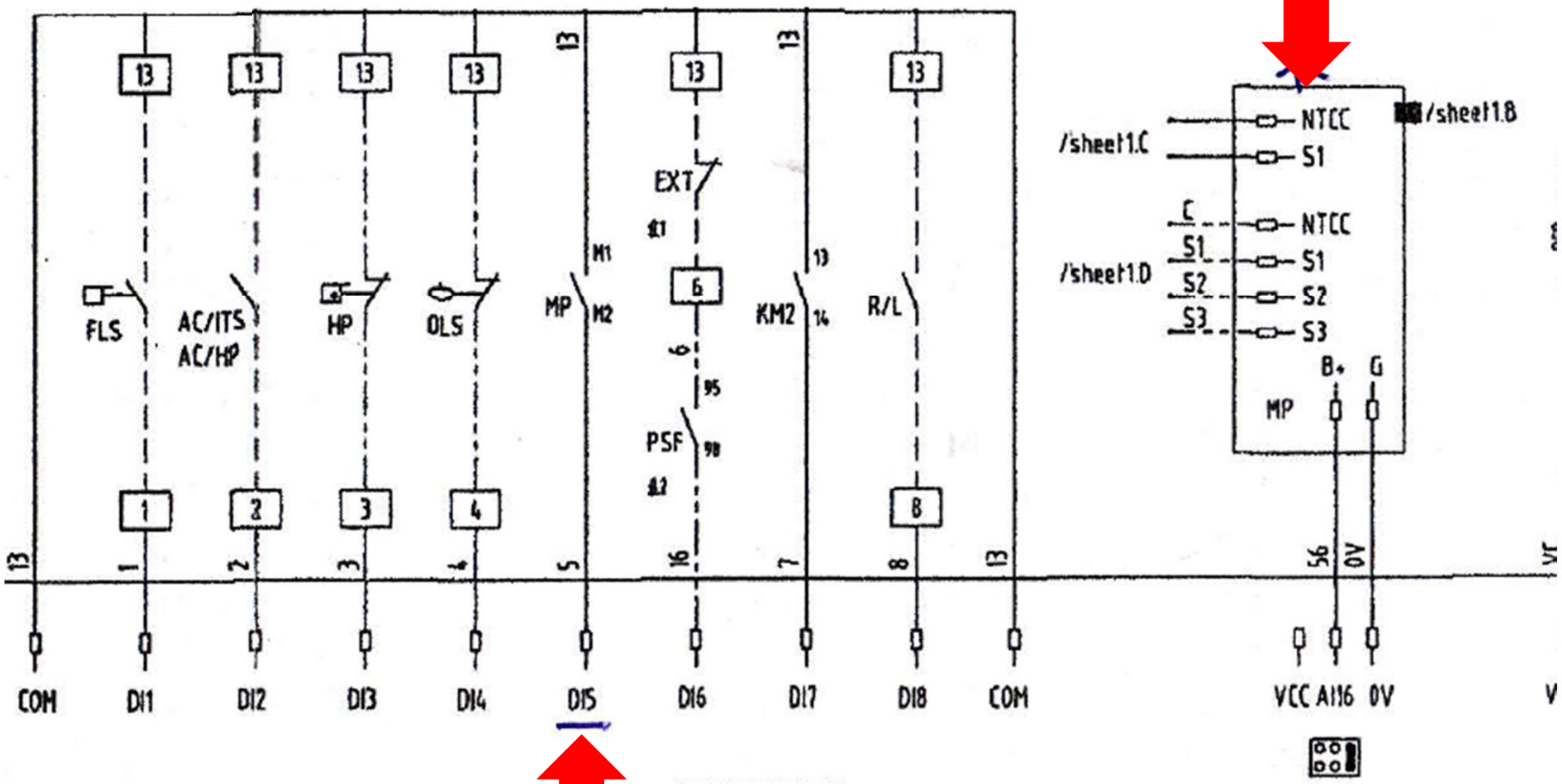
12V: Power supply interface from control panel to outside power

Background

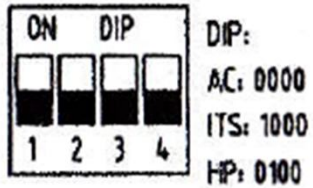

YORK-003
DI5 = DIGITAL INPUT 5
MOTOR PROTECTION
FLS Flow Switch
AC/ITS
AC/HP
HP High Pressure Switch
OLS Oil Level Switch
MP Motor Protector
EXT Extra Interlock
PSF Power protector
R/L Remote Stop/Start
EVAP.P Evaporat pressure
DIS.P Discharge pressure
OIL.P Oil pressure
MCU Motor current
LWL.T Leaving condenser Liquid
EWL.T Enter condenser Liquid
LEL.T Leaving evaporator Liquid
EEL.T Enter evaporator Liquid
DIS.T Discharge Temperature
PC Pump (AC220V)
OIL.HT Oil heater
BYPASS Bypass solenoid valve
ALM Alarm (AC220V)
LISV Liquid injection solenoid valve
RUN Run status
CR4 Load solenoid valve
CR3 Unload solenoid valve
If No "EXT", Please Short-cut Terminal "6" And "13";

Background

- MP : MOTOR PROTECTOR

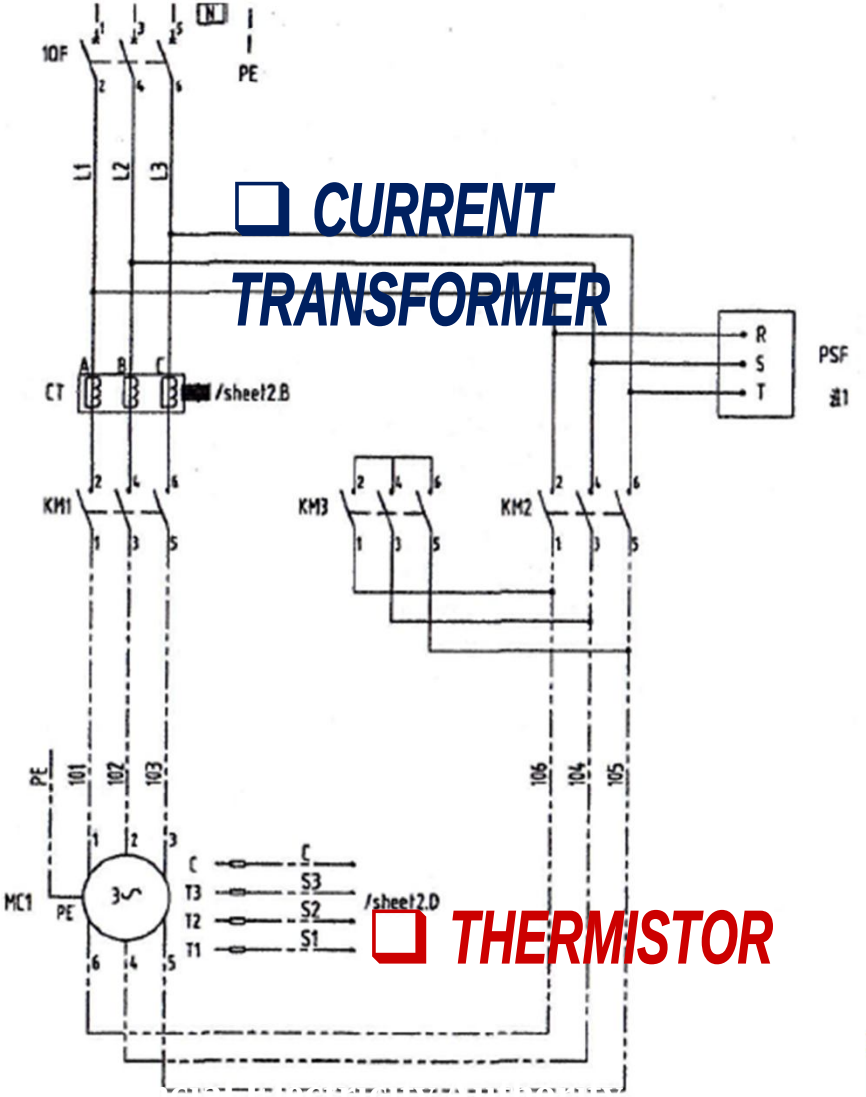


- DI5
- DIGITAL INPUT 5



YORK-003

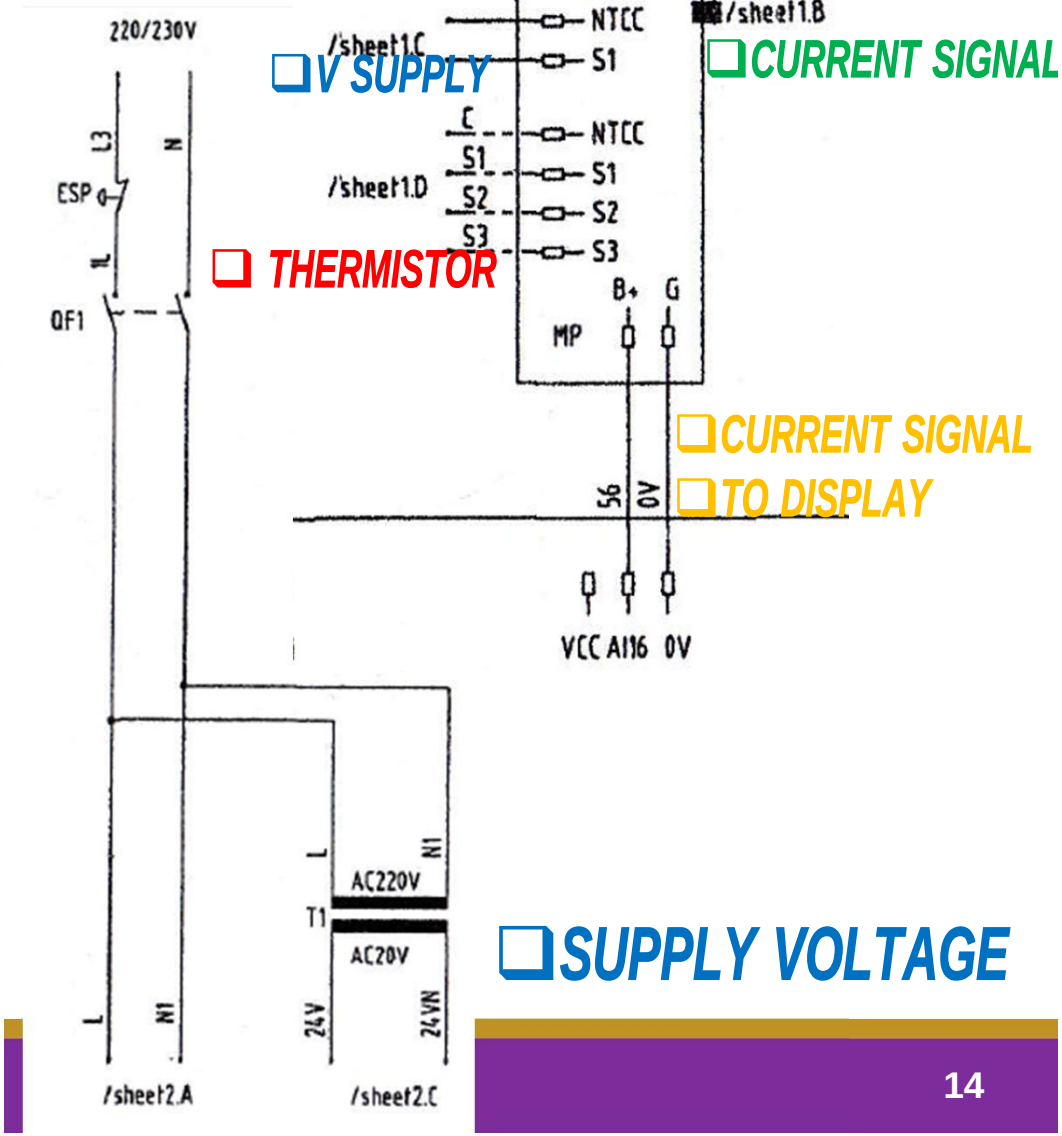
Background



❑ CURRENT TRANSFORMER

❑ THERMISTOR

❑ MP : MOTOR PROTECTOR



❑ V SUPPLY

❑ CURRENT SIGNAL

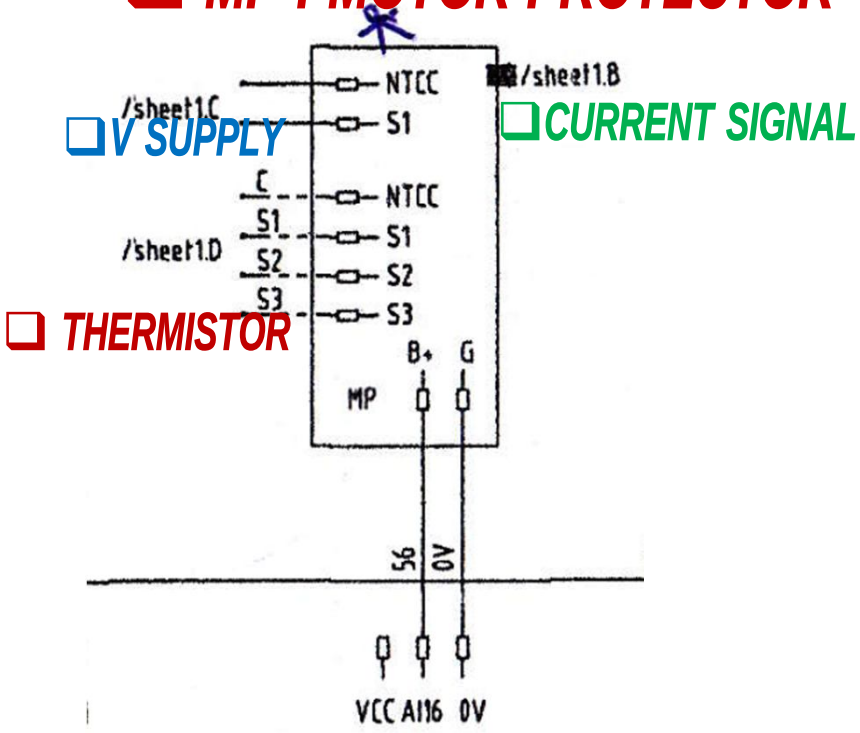
❑ THERMISTOR

❑ CURRENT SIGNAL TO DISPLAY

❑ SUPPLY VOLTAGE

Information

❑ *MP : MOTOR PROTECTOR*



❑ *V SUPPLY*

❑ *CURRENT SIGNAL*

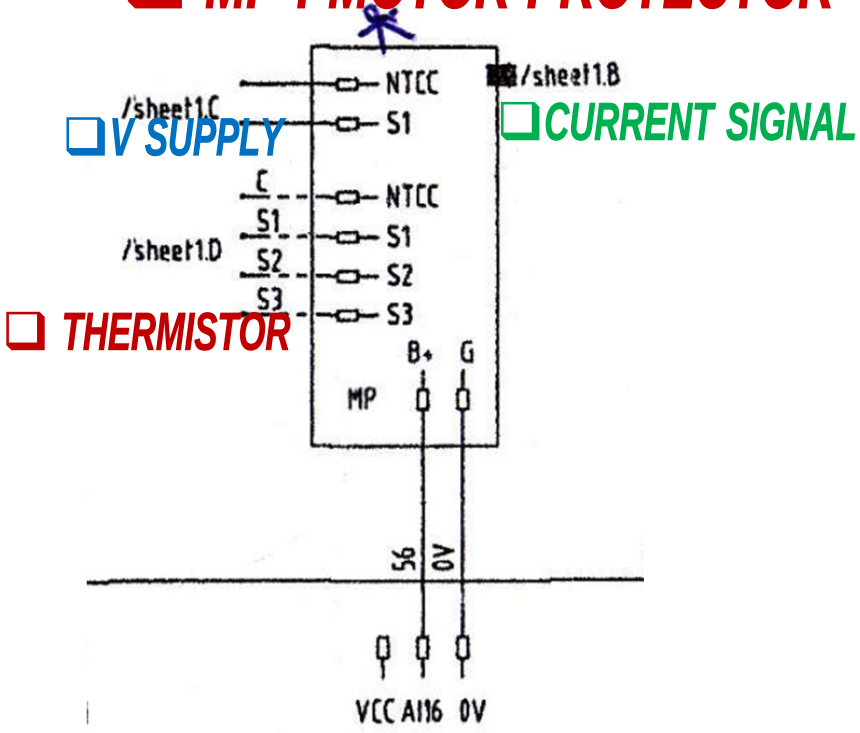
❑ *THERMISTOR*

Operation Condition for MP in normal situation

- ❑ *Overcurrent*
- ❑ *Undercurrent*
- ❑ *High motor winding Temperature*

Information

❑ MP : MOTOR PROTECTOR



❑ V SUPPLY

❑ CURRENT SIGNAL

❑ THERMISTOR

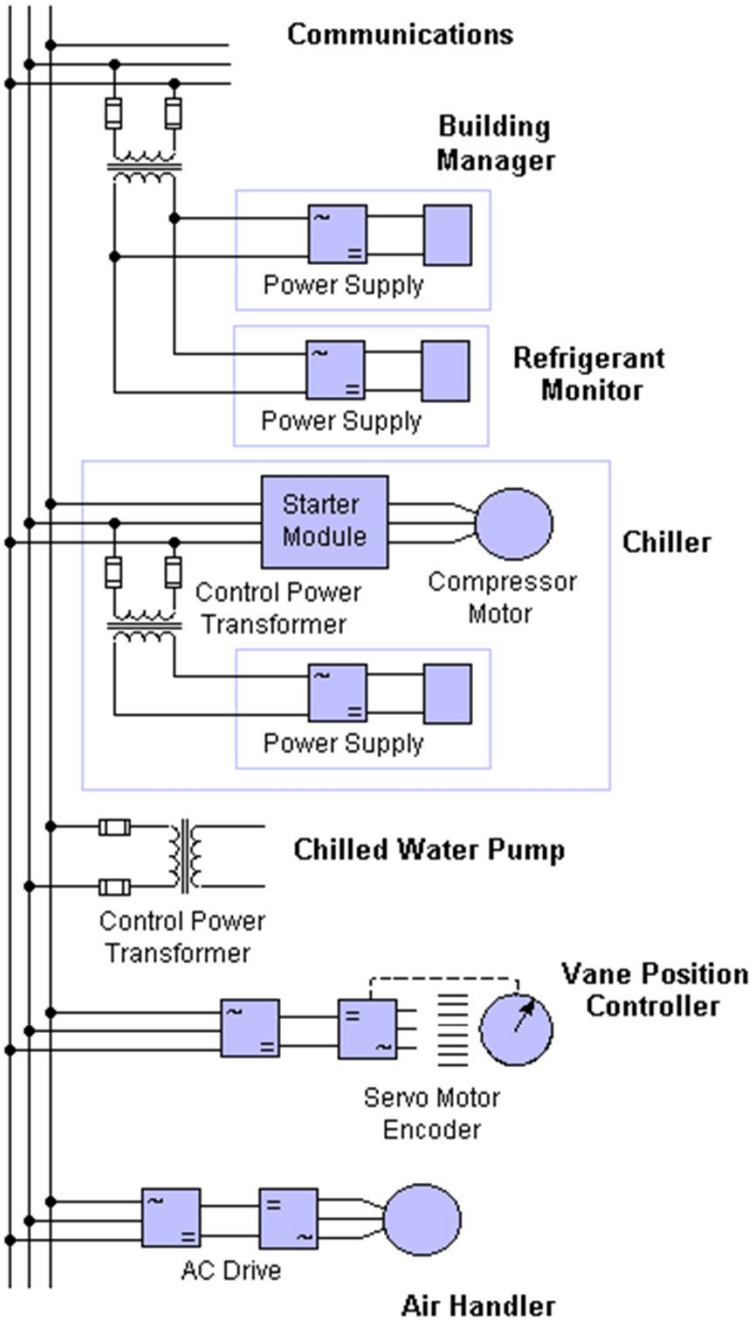
Operation Condition for MP in voltage sag situation

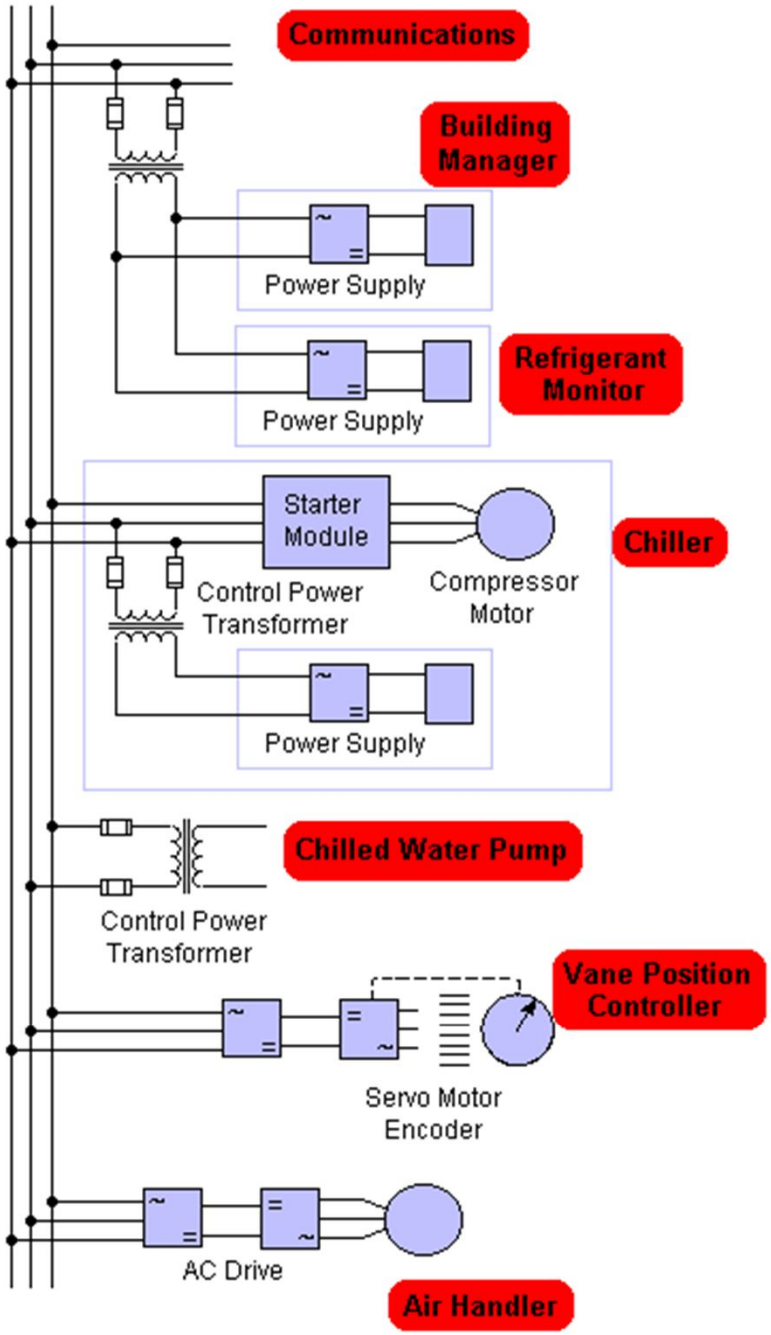
❑ When Control voltage is not in the normal rage makes MP Controller malfunction.

❑ During Voltage sag period, the motor current raise too much. MP Controller doesn't have time-delay function while overcurrent situation appear and make DI5 stop.

❑ Moreover, Thermistor circuit disorder during the voltage sag period.

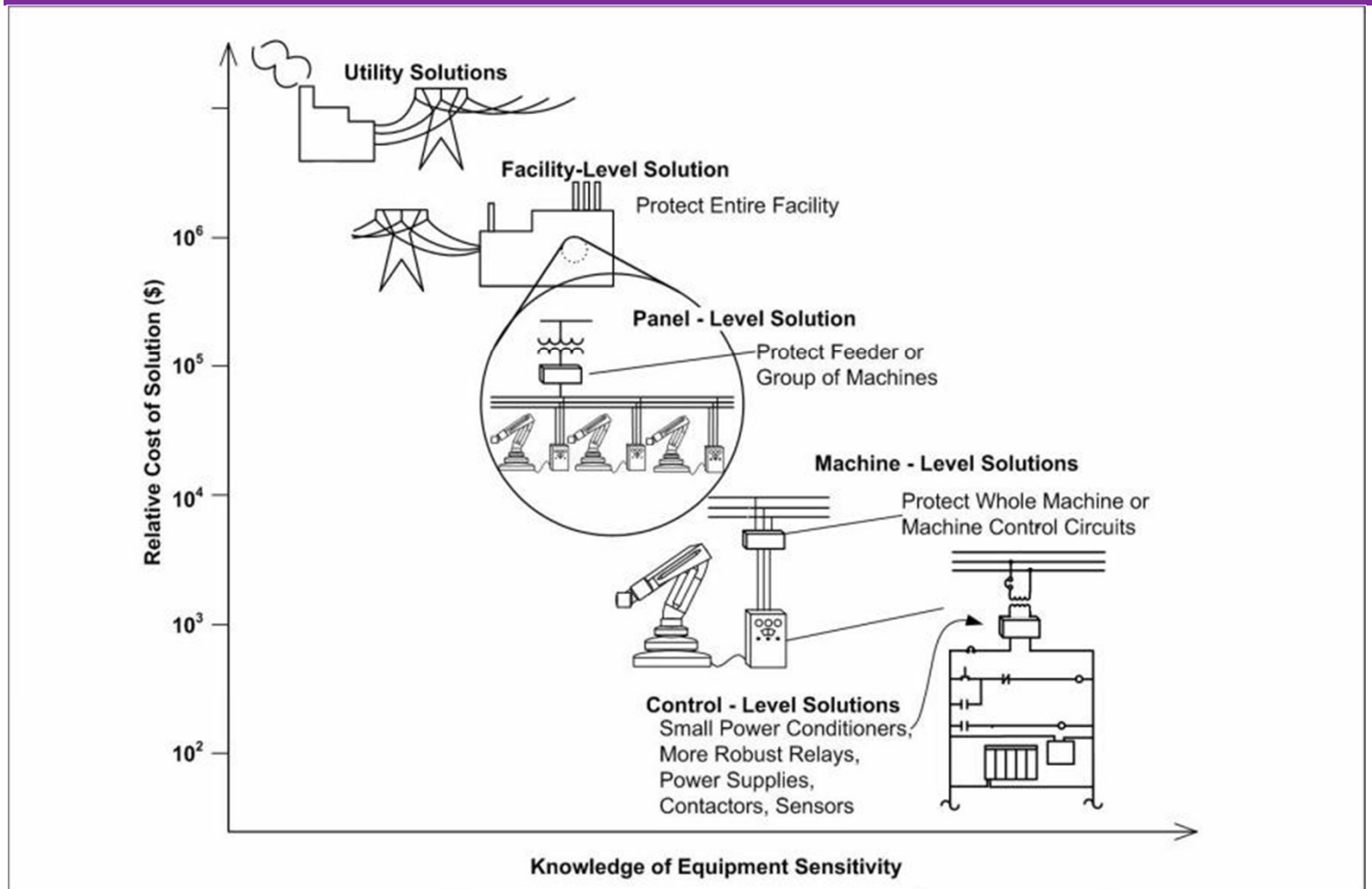
การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY


Communications
Building Manager
Power Supply
Refrigerant Monitor
Power Supply
Starter Module
Chiller
Control Power Transformer
Compressor Motor
Power Supply
Chilled Water Pump
Control Power Transformer
Vane Position Controller
Servo Motor Encoder
AC Drive
Air Handler


Communications
Building Manager
Power Supply
Refrigerant Monitor
Power Supply
Starter Module
Chiller
Control Power Transformer
Compressor Motor
Power Supply
Chilled Water Pump
Control Power Transformer
Vane Position Controller
Servo Motor Encoder
AC Drive
Air Handler

การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY

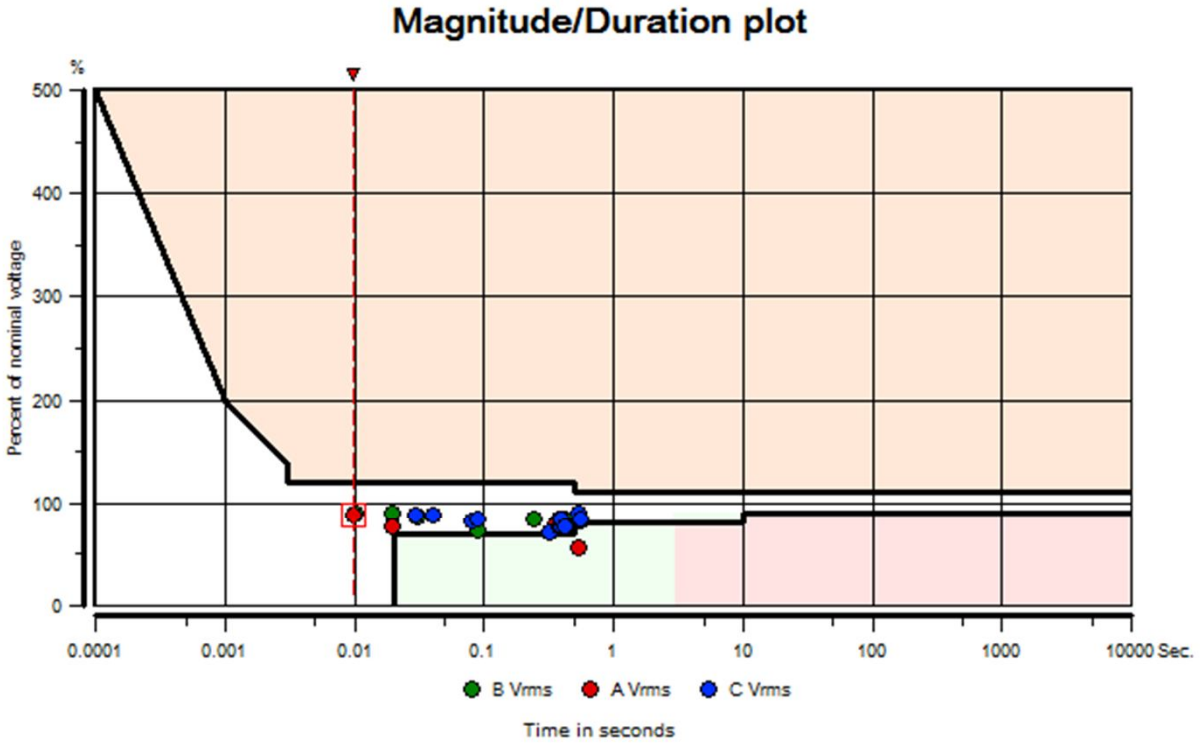
Information



Notes:	This drawing is the property of the Electric Power Research Institute (EPRI). Any use or reproduction in part or in whole is prohibited without the expressed written consent of EPRI.	EPRI ELECTRIC POWER RESEARCH INSTITUTE	Cost Vs. Knowledge Of Equipment Sensitivity To Voltage Sags
1	Copyright © 2008 Electric Power Research Institute, Inc. All rights reserved.	Drawn By: Chuck Thomas	Company: Company; REV; Jan 17, 2008; Drawing Set: XXXXXXXXXX

การไฟฟ้าส่วนภูมิภาค

Power Quality Monitoring Results



TOLERANCE CURVE: ITIC
Nominal voltage (100%) = 230 V
Variations ABOVE tolerance curve 0
Variations BELOW tolerance curve 1

	< 0.01 s	0.01 – 0.02 s	0.02 – 0.1 s	0.1 – 0.2 s	0.2 – 0.5 s	0.5 – 1 s	> 1 s
< 1%							
1 – 40%							
40 – 70%						1	
70 – 90%	1	2	5		9	2	

Number of Voltage sag events.

- Phase A = 9 events
- Phase B = 14 events
- Phase C = 12 events

Phase A (The minimum of voltage sag events)

Total Events :
20 Events

Duration 0.2-0.5 Sec
เกิดจำนวน 9 ครั้ง

การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY

Voltage Sag Mitigation

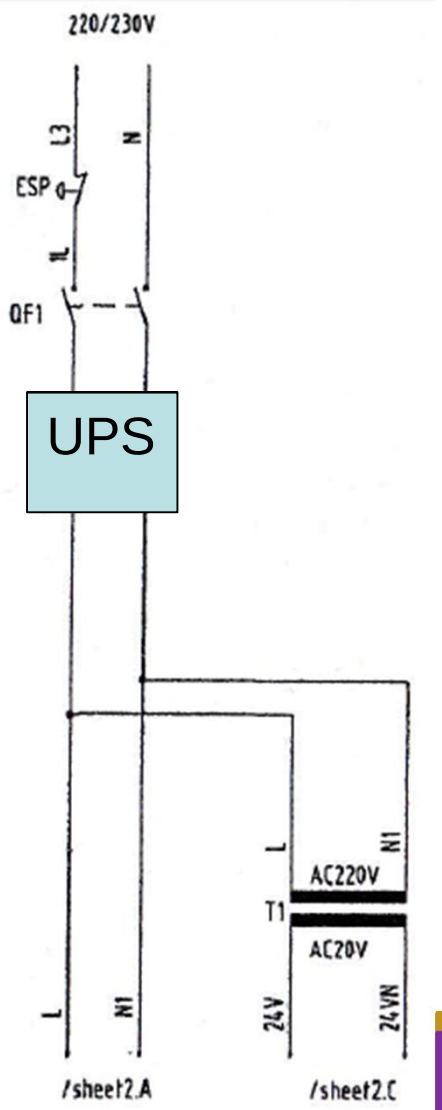
❑ SUPPLY VOLTAGE

❑ *Choose the lowest impact source of sag*

❑ *Use the Control Voltage from External TRUE ONLINE UPS.*

power supply **Phase A**

TRUE ONLINE UPS.



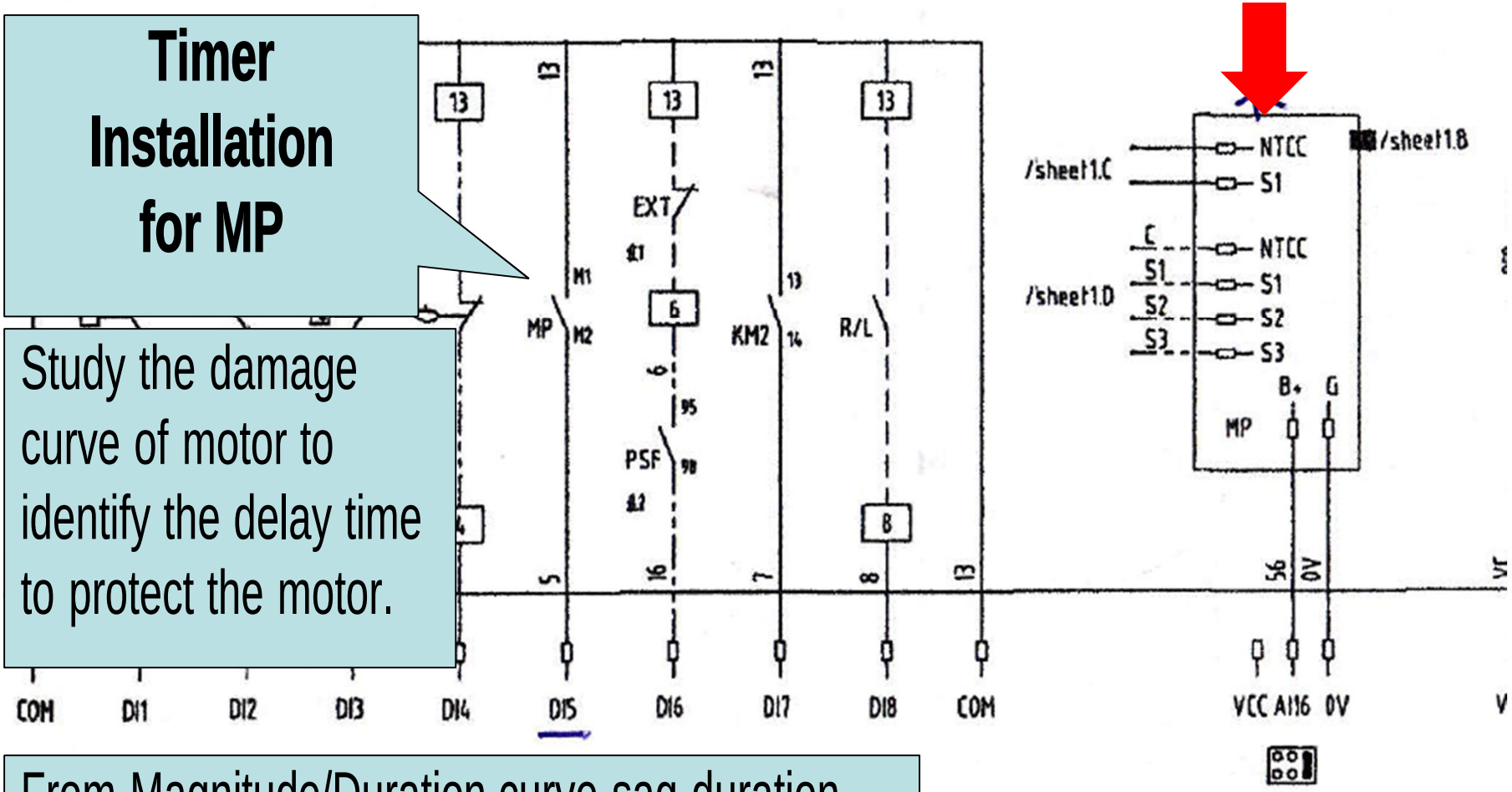
การไฟฟ้าส่วนภูมิภาค
PROVINCIAL ELECTRICITY AUTHORITY

Voltage Sag Mitigation

❑ *MP : MOTOR PROTECTOR*

Timer Installation for MP

Study the damage curve of motor to identify the delay time to protect the motor.



From Magnitude/Duration curve sag duration = 0.01-1 Sec Delay time should be at least 1 sec.

YORK-003

Conclusion:

- Solving the Problem of Voltage Sag in Customer Side
  - Choose the Right Source for Controller in the Least Effect of Voltage Sag or Install True Online UPS for Controller.
  - Setting Delay Time of Motor Protector by inspect Damage Curve of Motor and Duration of Voltage Sag.