INDUSTRIAL POWER AND AUTOMATION
PROCESS AUTOMATION LAB MANUAL

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- Series Compensation
- Shunt Compensation

6. Sudden Load Rejection
7. Operation of OLTC Transformer

b) Experiments on Distribution Module

Local Mode

- Relay Co-ordination
- PF Control/Voltage Regulation
- Transformer Loading

Remote Mode

- Relay Co-ordination
- PF Control/Voltage Regulation
- Transformer Loading
- Demand Side Management

1. PROGRAMMABLE LOGIC CONTROLLER (PLC)

The programmable logic controller (PLC) is a solid state electronic device designed to replace electromechanical relays, timers, counters and sequences, by using a programmable memory for the internal storage of user oriented instructions for implementing specific functions such as logic sequencing timing, country and arithmetic control through digital or analog inputs and outputs, various types of machines or processes.

Major advantages of using PLC are as follows:

1. The PLC is a hardened industrial computer designed to withstand the harsh factory environment.
2. PLCs are reusable they contain a changeable program that eliminators extensive and component changes and that makes them cost effective
3. PLCs offer easy troubleshooting
4. PLCs feature easy installation and small size.
5. Increase productivity.
6. Ease of programming.
7. Ability to communicate with computer.

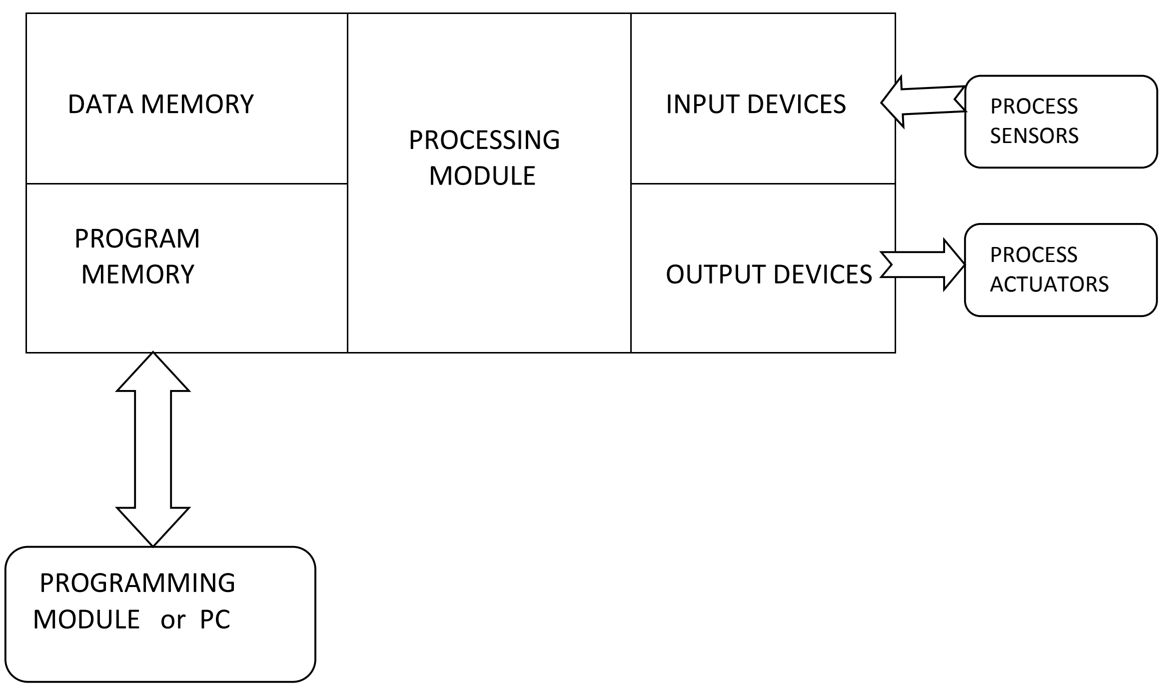


Fig.1.1 ARCHITECHTURE OF PLC

Some of the used Instructions

Bit Instructions

The following instructions are used with fixed, SLC 5/01, SLC 5/02, SLC 5/03, and SLC 5/04 processors.

If you want to:	Use this Instruction:
Examine a bit for an On conditions	XIC
Examine a bit for an Off conditions	XIO
Turn a bit On or Off	OTE
Turn a bit On	OLT
Turn a bit Off	OUT
Trigger a one time event	OSR

Examine if Closed (XIC)

—] [—

Use the XIC instruction in your ladder to determine if a bit is on. When the instruction is executed, if the bit addressed is on (1), then the instruction is evaluated as true. When the instruction is executed, if the bit addressed off (0), then the instruction is evaluated as false.

Examine if Open (XIO)

—]/[—

Use an XIO instruction in your ladder program to determine if a bit is off. When the instruction is executed, if the bit addressed is off (0), then the instruction is evaluated as true. When the instruction is evaluated as false.

Output Energize

( )

Use an OTE instruction in your ladder program to turn on a bit when rung conditions are evaluated as true.

Output Latch (OTL)

(L)

The OTL instruction is a retentive output instruction that can only turn on a bit. It cannot turn off a bit. This instruction is traditionally used in pairs with an Output Unlatch (OUT) instruction, with both instructions addressing the same bit. You can also use this to initialize data values at the bit level.

Output Unlatch (OTU)

(U)

The OTU instruction is a retentive output instruction that can only turn off a bit. If cannot turn on a bit. This instruction is traditionally used in pairs with an Output Latch (OTL) instruction, with both instructions addressing the same bit. You can use this to initialize data values at the bit level.

One Short Rising (OSR)

] OSR [

The OSR instruction is a retentive input instruction that triggers an event to occur one time. Use the OSR instruction when an event must start based on the change of state of the rung from false to true, not on the resulting status. Applications include starting events triggered by a pushbutton switch. An example is freezing rapidly displayed LED values.

Timer and Counter Instructions

Timers and counters are output instructions. Use the following instructions with fixed, SLC 5/01, SLC 5/02, SLC 5/02, SLC 5/03, and SLC 5/04 processors.

If you want to:	**Use this instruction:**
Count time base intervals when the instruction is true	TON
Count time base intervals when the Instruction is false	TOF
Count time base intervals when the instruction is true and retain the accumulated value when the instruction goes false	RTO
Increment the count at each false–to–true transition.	CTU
Decrement the count at each false-to-true transition	CTD
Count high-speed pulses from a fixed Controller High-speed input	HSE
Reset the accumulated value and status bits of a timer or counter. Do not use with TOF timers.	RES

Timer On-Delay (TON)

TON	
TIMER ON DELAY	
Timer	T4: 0
Timer Base	0.01

Use the TON instruction to turn an output on or off after the timer has been on for a preset time interval. The TON instruction begins to count time base intervals when rung conditions become true. As long as rung conditions remain true, the timer adjusts its accumulated value (ACC) each evaluation until it reaches the preset value (PRE). The accumulated value is reset when rung conditions go false, regardless of whether the timer has timed out.

Timer Off-Delay (TOF)

TOF	
TIMER OFF DELAY	
Timer	T4:1
Time base	0.01

Use the TOF instruction to turn an output on or off after is rung has been off for a preset time interval. The TOF instruction begins to count time base intervals when the rung makes a true-to-false transition. As long as rung conditions remain false, the timer increments its accumulated value (ACC) each scan until it reaches the preset value (PRE). The accumulated value is reset when rung conditions go true regardless of whether the timer has timed out.

Retentive Timer (RTO)

RTO	
RETENTIVE TIMER ON	
Timer	T4: 2
Time base	0.01

Use the RTO instruction to turn an output on or off after its timer has been on for a preset time interval. The RTO instruction is a retentive instruction that begins to count time base intervals when rung conditions become true. As long as rung conditions remain true, the timer increments its accumulated value (ACC) until it reaches the preset value (PRE).

<u>Using counters</u>

Counter instructions have three word data file elements. Word 0 is the control word, containing the status bits of the instructions. Word 1 is the preset value; word 2 is the accumulated value.

How Counters Work: The figure below demonstrates how a counter works. The count value must remain in the range of –32768, a counter status overflow (OV) or underflow (UN) bit is set.

Count Up (CTU)

CTU	
COUNT UP	
Counter	C5:0
Preset	120

The CTU is a retentive output instruction that counts false-to-true rung transitions. Rung transitions can be caused by events occurring in the program such as parts traveling past a detector or actuating a limit switch.

Count Down (CTD)

CTD	
COUNT DOWN	
Counter	C5:1
Preset	120

The CTD is a retentive output instruction that counts false-to-true rung transitions Rung transitions can be caused by events occurring in the program such as parts traveling past a detector or actuating a limit switch.

High-Speed Counter (HSC)

HSC	
HIGH SPEED COUNTER	
Counter	C5:0
Preset	120

The High-Speed Counter is a variation of the CTU counter. The HSC instruction is enabled when the rung logic is true and disabled when the rung logic is false.

Reset (RES)

Use a RES instruction to reset a timer or counter. When the RES instruction is enabled, it resets the retentive on-delay timer, count up, or countdown instruction having the same address as the RES instruction.

Math Instruction

The following output instruction allows you to perform computation and math operations on individual words. Use these instructions with fixed. SLC 5/01, SLC 5/02, SLC 5/03, and SLC 5/04 processors, except where noted.

If you want to:	**Use this instruction**
Add two values	ADD
Subtract two values	SUB
Multiply one value from another	MUL
Divide one value by another	DIV
Perform a double divide	DDV
Change the sign of the source value and place it in the destination	NEG
Set all bits of a world to zero	CLR
Convert an integer to BCD	TOD
Convert a BCD value to an integer value	FRD
Multiplex data	DCD
Find the square roof of a value	SQR
Scale a value	SCL

Add (ADD)

ADD
Source A
Source B
Dest

Use the ADD instruction to add one value (source A) to another value (source B) and place the result in the destination.

Subtract (SUB)

SUB
Subtract
Source A
Source B

Use the SUB instruction to subtract one value (Source B) from another (Source A) and place the result in the destination.

Multiply (MUL)

MUL
Multiply
Source A
Source B
Dest

Use the MUL instruction to multiply one value (source A) by another (source B) and place the result in the destination.

Divide (DIV)

DIV
Divide
Source A
Source B
Dest

Use the DIV instruction to divide one value (source A) by another (source B). The rounded quotient is then placed in the destination. If the remainder is 0.5 or greater, round up occurs in the destination. The unrounded quotient is stored in the most significant word of the math register. The remainder is placed in the least significant word of the math register.

Scale Data (SCL)

SCL
Scale
Rate [/10000]
Offset

When this instruction is true, the value at the source address is multiplied by the rate value. The rounded result is added to the offset value and placed in the destination. Use this instruction with SLC 5/02, SLC 5/03, and SLC 5/04 processors.

<u>Comparison Instructions</u>

Following input instructions allow you to compare values of data, Use these instructions with fixed, SLC 5/01, SLC 5/02, SLC 5/03, and SLC 5/04 processors.

If you want to:	**this instruction:**
Test whether two value is not equal	EQU
Test whether one value is not equal to	EQ
Test whether one value is less than a second value	LES

Test whether one value is less than or equal to a second value	LEQ
Test whether one equal to second value is greater than another	GRT
Test whether one value is greater than or equal to a second value	GEQ
Test portions of two values to see whether they are equal	MEQ
Test whether one value is within the limit range of two other values	LIM

Equal (EQU)

EQU
EQUAL
Source A
Source B

Use the EQU instruction to test whether two values are equal. If source A and source B are equal, the instruction is logically true. If these values are not equal, the instruction is logically false.

Not Equal (NEQ)

NEQ
NOT EQUAL
Source A
Source B

Use the NEQ instruction to test whether two values are not equal. If source A and source B are not equal, the instruction is logically true. If the two values are equal, the instruction is logically false.

Less Than (LES)

LES
LESS THAN
Source A
Source B

Use the LES instruction to test whether one value (source A) is less than another (source B). If source A is less than the value at source B the instruction is logically true. If the value at source A is greater than or equal to the value at source B, the instruction is logically false.

Less Than or Equal (LEQ)

LEQ
LESS THAN OR EQUAL
Source A
Source B

Use the LEQ instruction to test whether one value (source A) is less than or equal to another (source B). If the value at source A is less than or equal to the value at source B, the instruction is logically true. If the value at source A is greater than the value at source B, the instruction is logically false.

Greater Than (GRT)

GRT
GREATER THAN
Source A
Source B

Use the GRT instruction to test whether one value (source A) is greater than another (source B). If the value at source A is greater than the value at source B. The instruction is logically true. If the value at source A is less than or equal to the value at source B, the instruction is logically false.

Greater Than or Equal (GEQ)

GEQ
GREATER THAN OR EQUAL
Source A
Source B

Use the GEQ instruction to test whether one value (source A) is greater than or equal to another (source B). If the value at source A is greater than or equal to the value at source B, the instruction is logically true. If the value at source A is less than the value at source B, the instruction is logically false.

Masked Comparison for Equal MEQ)

MEQ
MASKED EQUAL
Source
Mask

Use the MEQ instruction to compare data at a source address with data at a reference address. Use of this instruction allows portions of the data to be masked by a separate word.

Limit Test (LIM)

LIM
LIMIT TEST
Test
High Lim

Use the LIM instruction to test for value within or outside a specified range, depending on how you set the limits. Use this instruction with 5/02 and 5/03 processors.

Move and Logical Instructions

The following output instructions allow you to perform move and logical operations on individual words. Use these instructions with fixed. SLC 5/01, SLC 5/02, SLC 5/03, and SLC 5/04 processors.

If you want to:	**Use this instruction:**
Move the source value to the destination	MOV
Move data from a source location to a selected portion of the destination	MVM
Perform an AND operation	AND
Perform an inclusive OR operation	OR
Perform an Exclusive Or operation	XOR
Perform a NOT operation	NOT

Move (MOV)

MOV

MOVE

Source

This output instruction moves the source value to the destination location.

Masked Move (MVM)

MVM

MASKED MOVE

Source

The masked move instruction is a word instruction that moves data from a source location to a destination, and allows portions of the destination data to be masked by a separate word.

Internal Operation and Signal Processing of PLC

The CPU of the PLC executes the user-program over and over again when it is in the RUN mode. The following figure shows the entire repetitive series of events.

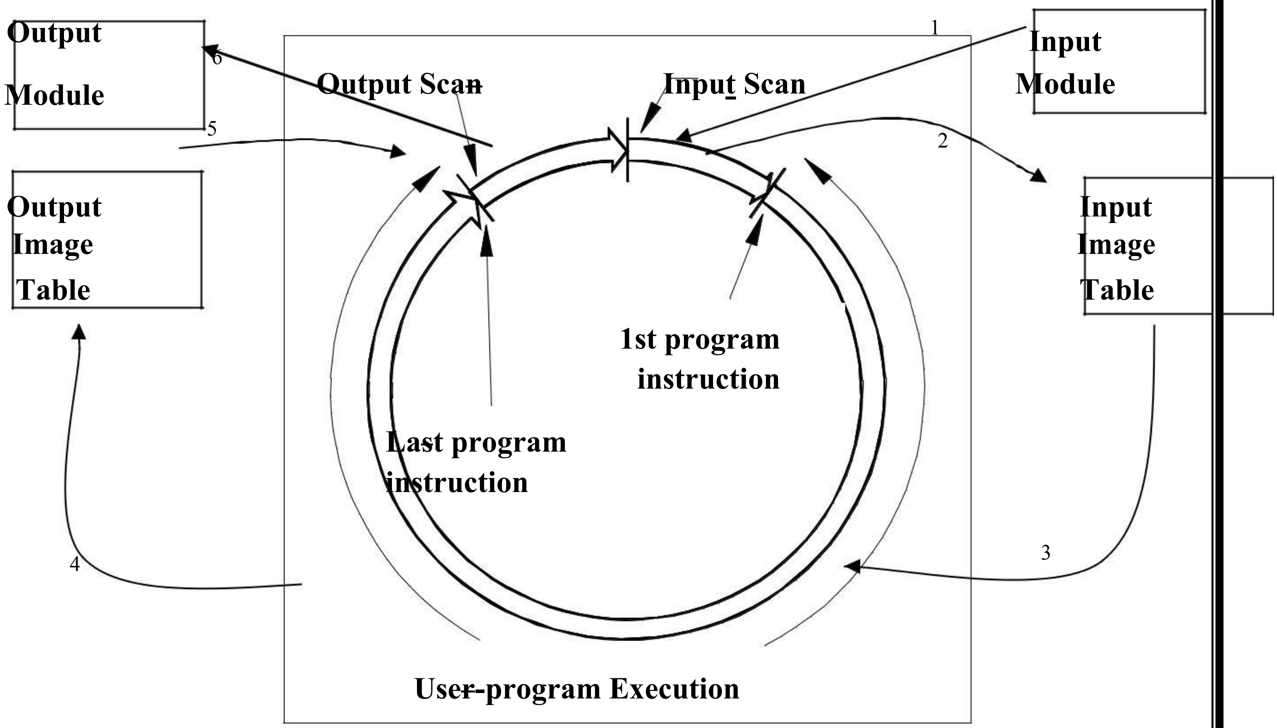


Fig 1.2 PLC scan cycle

(a) Input scan

During the input scan, the current status of every input module is stored in the input image (memory) table, bringing it up-to-date. Thus all the status of the input devices (which in turn is connected to the input module) are updated in the input memory table.

(b) Program scan

Following the input scan, the CPU enters its user program execution, or program scan. The execution involves starting at the program's first instruction, then moving on to the second instruction and carrying out its execution sequence. This continues to the last program instruction. Throughout the user-program execution, the CPU continually keeps its output image (memory) table up-to-date.

(c) Output scan

During program scan, the output modules themselves are not kept continually up to date. Instead, the entire output image table is transferred to the output modules during the output scan which comes after the program execution. Thus the output devices are activated accordingly during the output scan.

Exp No: **WATER LEVEL CONTROLLER USING PROGRAMMABLE LOGIC CONTROLLER** Date:

AIM:

To control the water level of a tank using programmable logic controller.

APPARATUS REQUIRED:

1. Level control trainer kit
2. PLC (Allen Bradley Micrologix 1500 LRP series C)
3. PC with RS Logix Software
4. RS232 cable
5. Patch chords

PROCEDURE:

1. Load the RS logix software to the PC
2. Open the RS logix software
3. Switch On the PLC trainer
4. Connect PLC with level control kit.
5. Open the New folder and draw the ladder logic program
6. Select the correct hardware configuration.
7. Store the Program to PLC
8. Run the program
9. Verify the performance of the water level control using PLC.

PROCESS DESCRIPTION:

Liquid level control is a basic and necessary process for all the process industry. Here the level of liquid is to be maintained inside the tank to a specific height.

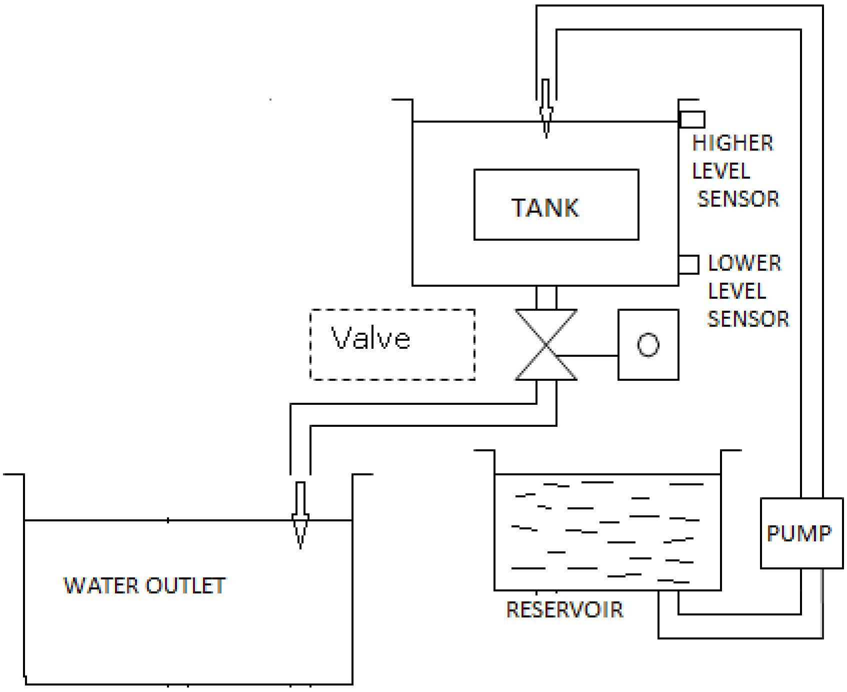
Here there is a water reservoir from which the water needs to be pumped out to the process tank. In the process tank there are two sensors connected around the edges of the tank according to the required heights i.e., one sensor is connected at the near bottom end of the tank called as lower level sensor and another one on the near top edge of the tank called as higher level tank. To let the water out of the tank there is a pipe connected at the bottom of the tank with a valve. This valve is to be used by user for the process application
The level sensor is a magnetic sensor and when the liquid level is above the high level sensor a HL (high level) signal is send to the PLC. When the liquid level goes down the low level sensor LL (low level) signal is send to the PLC. The PLC checks the signals send by these sensors through its input port and give the proper signals through its output port as per the ladder logic program.

Sequence of process control actions done by the PLC:

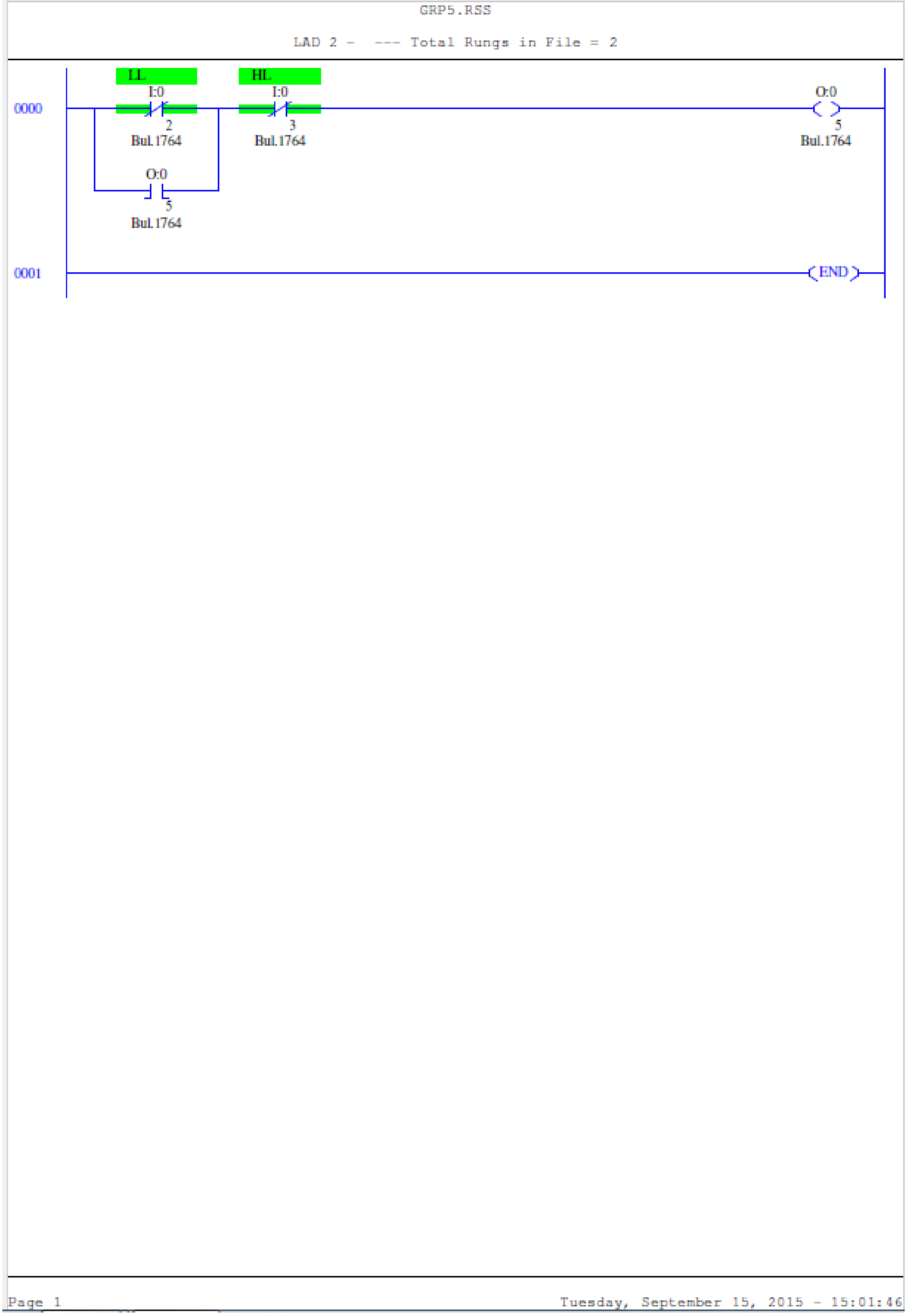
1. When the water level in the tank is less than the lower level then the lower level

sensor senses and turns the motor on to fill the tank.

2. Then the tank is filled up until it reaches the higher level where the higher level sensor senses and makes the motor off and filling of water stops.



[BLOCK DIAGRAM OF LIQUID LEVEL SET UP]



RESULT:

The liquid level trainer kit was set up and liquid level was controlled by using PLC ladder logic program.

Exp No: **BATCH PROCESS REACTOR USING** Date:

PROGRAMMABLE LOGIC CONTROLLER

Aim:

To control the batch process reactor (VPAT 05) using programmable logic controller.

Apparatus required:

6. Batch process trainer kit
7. PLC (Allen Bradley Micrologix 1500 LRP series C)
8. PC with RS Logix Software
9. RS232 cable
10. Patch chords

Procedure:

10. Load the RS Logix software to the PC
11. Open the RS Logix software
12. Switch On the PLC trainer and lift controls system
13. Connect PLC with Batch process control kit.
14. Open the New folder and draw the ladder logic program
15. Select the correct hardware configuration.
16. Store the Program to PLC
17. Run the program
18. Verify the performance to the Batch process control.

Process description:

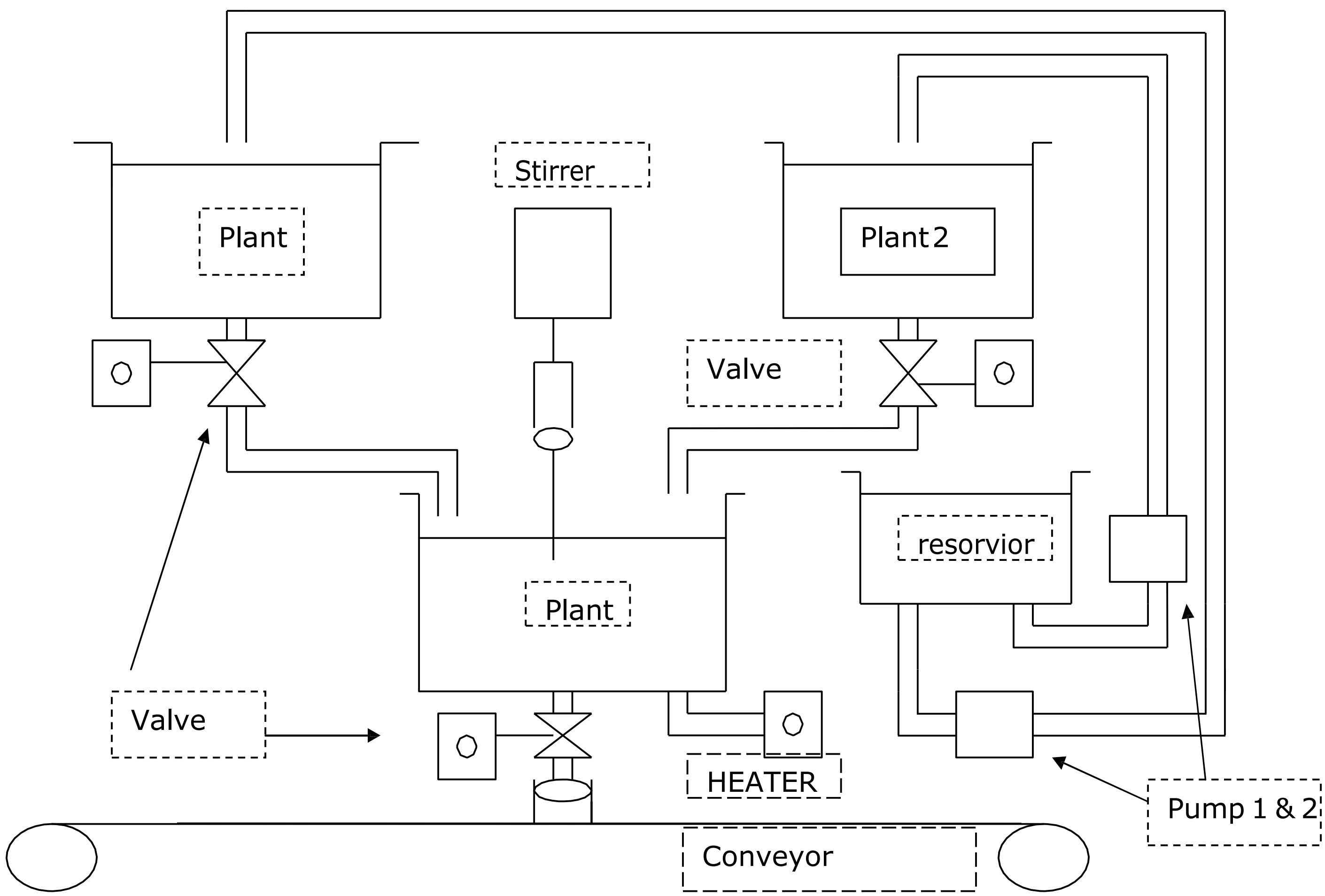
Batch process reactor is a blending process, where two liquids are mixed together to get the output mixture. The programmable logic controller is used to control the whole process. The process tanks 1 & 2 consist of two liquids, which are blended in process tank 3. The process tank 1 & 2 consists of a low liquid level sensor and a high liquid level sensor. The liquids are pumped to the process tanks using respective pumps.

The two liquids are mixed in the process tank 3 using a stirrer. Heater is used to heat the mixture. The solenoid valves provide the liquids to the process tank 3 when the mixture level is low. Solenoid valve 3 is connected to the output of the process tank 3, which feeds mixed liquid to a vessel when it is sensed by the vessel proximity sensor. The container is fed through a conveyor belt run by stepper motor. Two solenoid valves 1 & 2 control the flow of two liquids to the tank 4. The level sensors sense the level in the process tanks 1 and 2. The level sensor is a magnetic sensor and when the liquid level is above the high level sensor a HL (high level) signal is send to the PLC. When the liquid level goes down the low level sensor LL (low level) signal is send to the PLC. The PLC checks the signals send by these sensors through its input port and give the proper signals through its output port as per the ladder logic program.

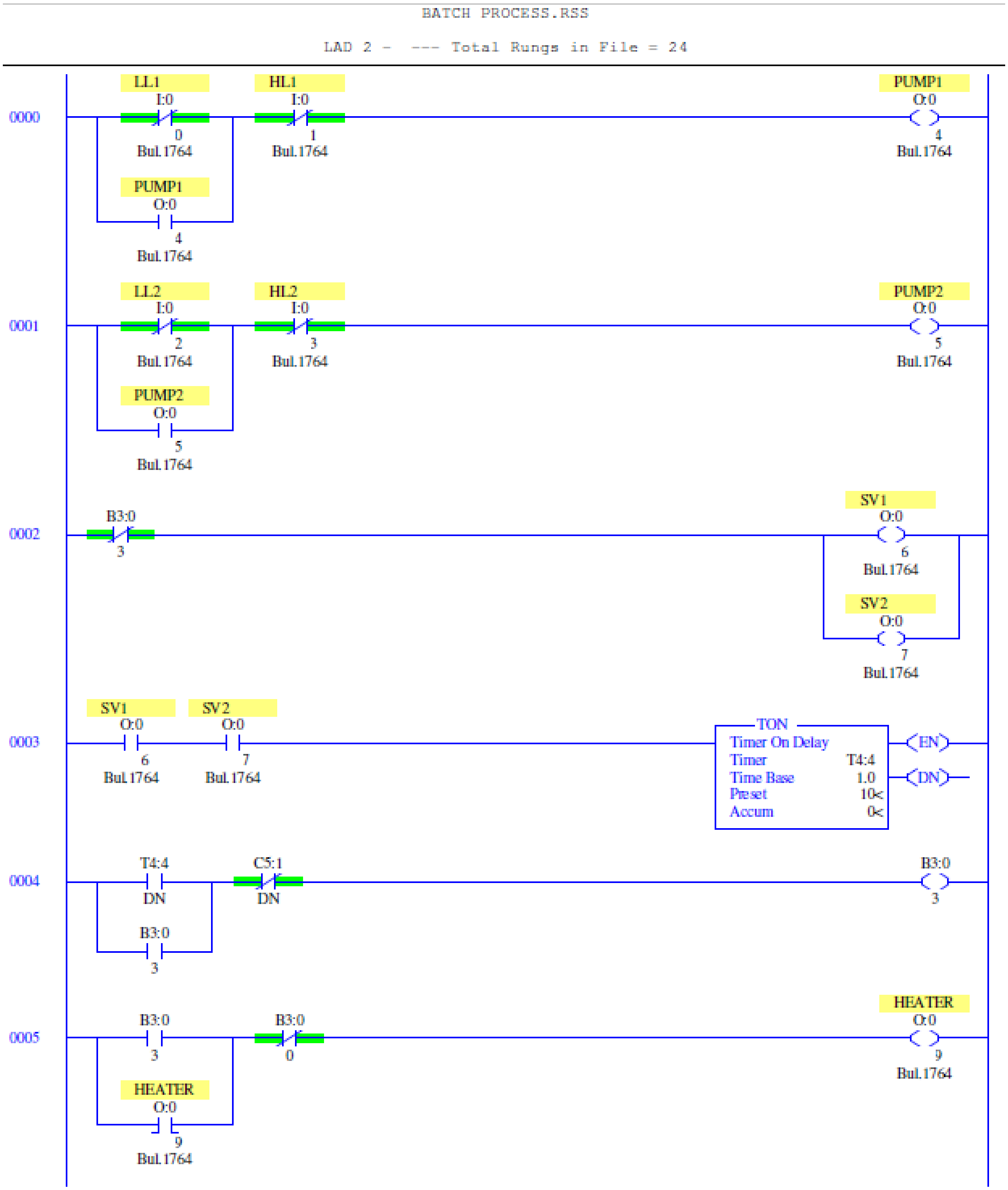
Various process control actions done by the PLC are

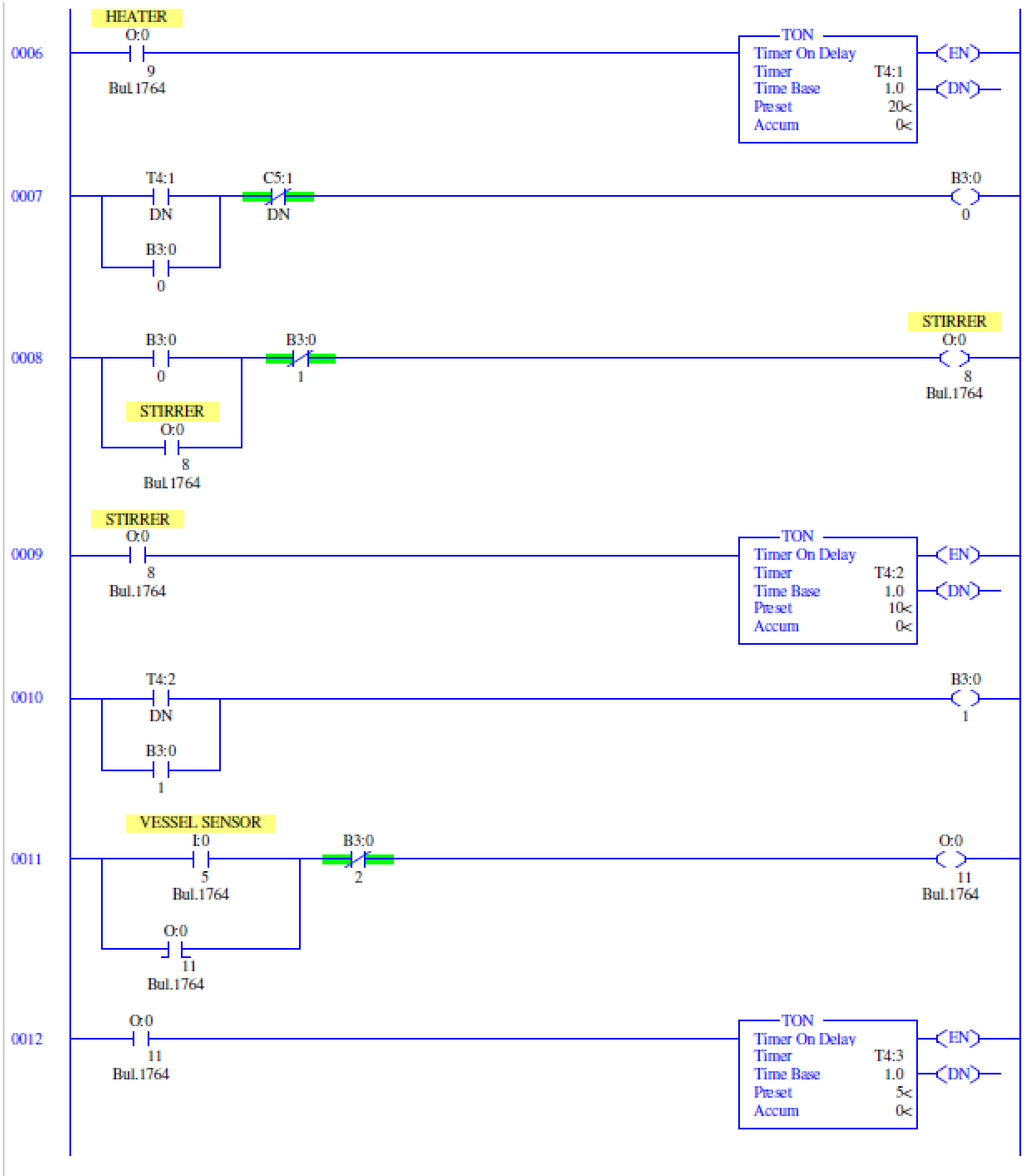
1. When the low level sensor is sensed respective pump is on.
2. When the high level sensor is sensed respective pump is off
3. When both the tanks reached two higher level then the respective solenoids open and allows two liquids two mix in the 3rd one for 10 seconds.
4. Then the heater gets energized and heats the mixture for 10 seconds.
5. Then the stirrer gets on and stirring process continues for next 10 seconds.
6. A stepper motor is made ON to run the conveyor belt
7. When the proximity sensor senses a container, solenoid valve 3 is made on for a particular time as set in the program.
8. This process goes on for filling up of 20 bottles and then the total process starts from the beginning by filling up the two overhead tanks.

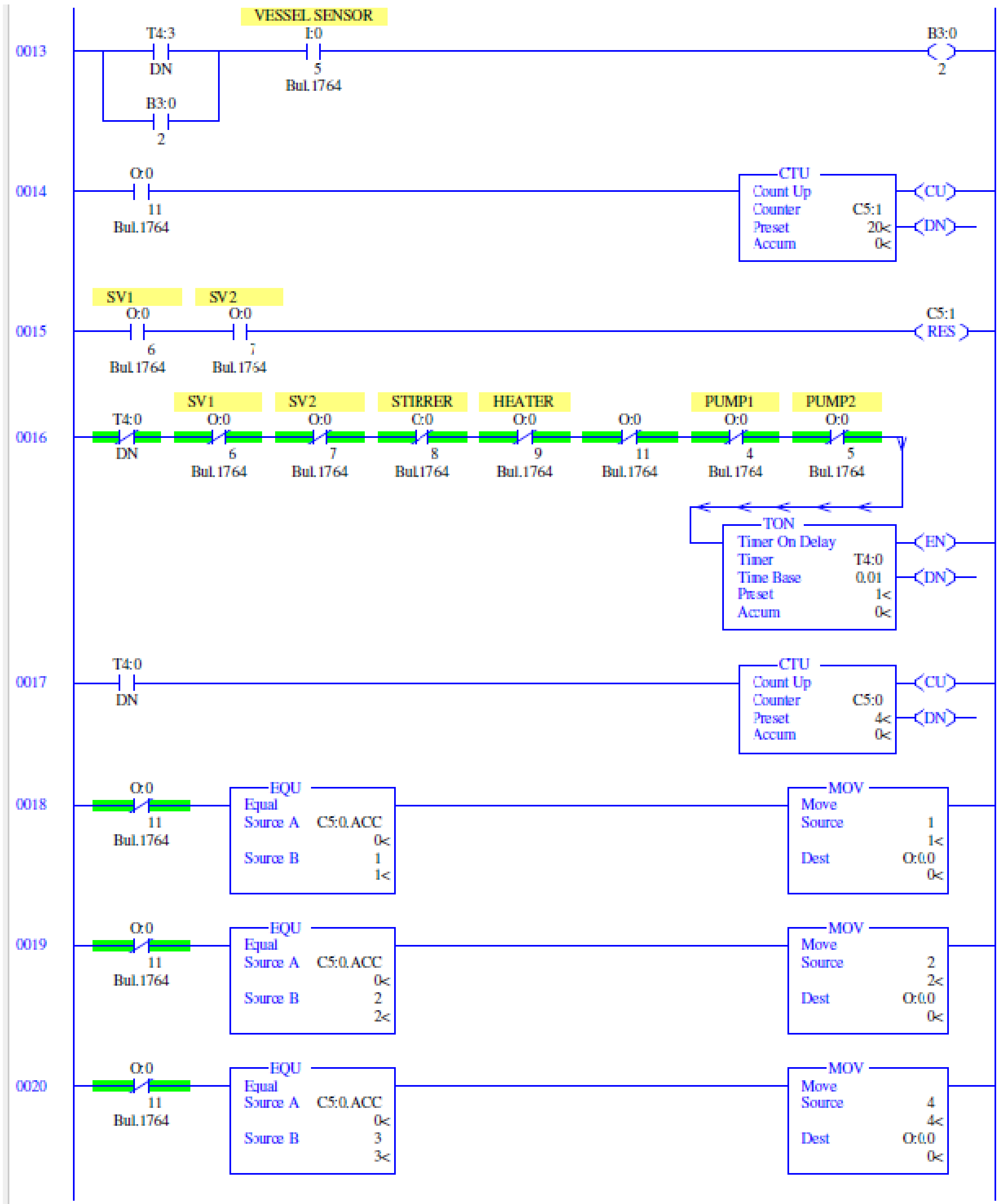
BATCH PROCESS REACTOR T RAINER (VPAT 05)

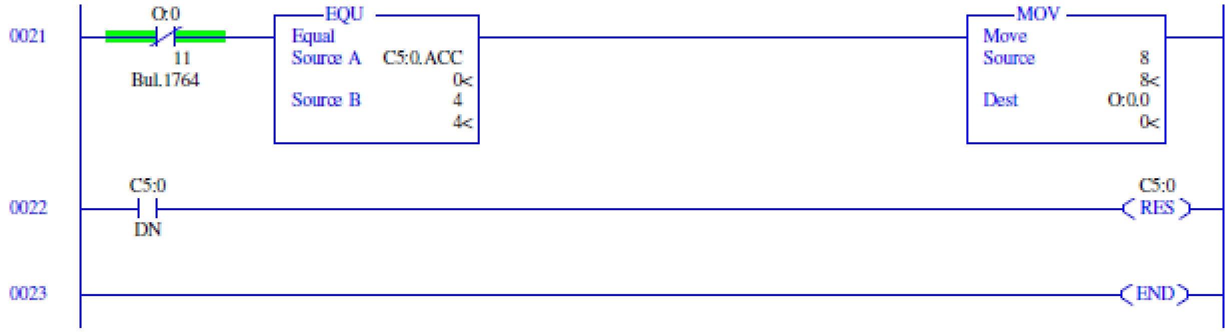


[The block diagram of the batch process reactor]




0006
HEATER
O:0
9
Bul.1764
TON
Timer On Delay
Timer T4:1
Time Base 1.0
Preset 20<
Accum 0<
EN
DN
0007
T4:1
DN
C5:1
DN
B3:0
0
B3:0
0
0008
B3:0
0
B3:0
1
STIRRER
O:0
8
Bul.1764
STIRRER
O:0
8
Bul.1764
0009
STIRRER
O:0
8
Bul.1764
TON
Timer On Delay
Timer T4:2
Time Base 1.0
Preset 10<
Accum 0<
EN
DN
0010
T4:2
DN
B3:0
1
B3:0
1
0011
VESSEL SENSOR
I:0
5
Bul.1764
B3:0
2
O:0
11
Bul.1764
O:0
11
Bul.1764
0012
O:0
11
Bul.1764
TON
Timer On Delay
Timer T4:3
Time Base 1.0
Preset 5<
Accum 0<
EN
DN


0013
T4:3
DN
B3:0
2
VESSEL SENSOR
I:0
5
Bul.1764
B3:0
2
0014
O:0
11
Bul.1764
CTU
Count Up
Counter C5:1
Preset 20<
Accum 0<
CU
DN
0015
SV1
O:0
6
Bul.1764
SV2
O:0
7
Bul.1764
C5:1
RES
0016
T4:0
DN
SV1
O:0
6
Bul.1764
SV2
O:0
7
Bul.1764
STIRRER
O:0
8
Bul.1764
HEATER
O:0
9
Bul.1764
O:0
11
Bul.1764
PUMP1
O:0
4
Bul.1764
PUMP2
O:0
5
Bul.1764
TON
Timer On Delay
Timer T4:0
Time Base 0.01
Preset 1<
Accum 0<
EN
DN
0017
T4:0
DN
CTU
Count Up
Counter C5:0
Preset 4<
Accum 0<
CU
DN
0018
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 1
1<
MOV
Move
Source 1
1<
Dest O:0.0
0<
0019
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 2
2<
MOV
Move
Source 2
2<
Dest O:0.0
0<
0020
O:0
11
Bul.1764
EQU
Equal
Source A C5:0.ACC
0<
Source B 3
3<
MOV
Move
Source 4
4<
Dest O:0.0
0<



RESULT:

The Batch process reactor was set up and controlled by using PLC ladder logic program

Exp No: **Date:**

SPEED CONTROL OF AC SERVO MOTOR USING PROGRAMMABLE LOGIC CONTROLLER

Aim:

To control the speed of an AC servomotor by implementing pi controller using PLC ladder logic program.

Theory:

Proportional Control

The controller is proportional; it will produce a control signal, which is proportional to the input error signal, i.e., signal proportional to the difference between actual level and desired level. When the error is high the controller will send the signal according the error. In the graph we can see the same. When it is in position control, the control signal is almost a straight line and has no relation with error but in P- controller we can see that the controller output is varying according the error. Let the signal be u (t) which is proportional to the input error signal, e (t). Then we can obtain a relation

$$u(t) = k_p e(t)$$

Where Kp proportional gain (or) constant

Hence, we can say that the proportional controller amplifies the error signal by an amount Kp. Also the introduction of the controller on the system increases the loop gain by an amount Kp. The increase in loop gain improves the steady state tracking accuracy, disturbance signal rejection and the relative stability and also makes the system less sensitive to parameter variations. But increasing the gain to very large values may lead to instability of the system. The demerit of P- controller is that it leads to a constant steady state error.

<u>Proportional + Integral Controller</u>

The integral (or) reset action combine with proportional control gives us a controller which will always act to maintain the control variable as its desired value (set point). The proportional mode provides a stabilizing influence while the integral mode will help to overcome the OFFSET. Integral controller will provide corrective action as long as there is a deviation in the controlled variable from the set point value. Integral control has a phase lag of 900 proportional controls. This lagging feature of reset will result in a slow responses & oscillation will come in to picture. The proportional &

integral controller produce an output signal consisting of 2-terms, one is proportional to error signal & the other proportional to the integral of the error signal.

The advantage of both P & I controller are combined in P-I controller, the proportional action increased the loop gain & makes the system less sensitive to variations of system parameters. The integral action eliminates (or) reduces the steady state error. The integral action is adjusted by varying the integral time. The inverse of integral timeT is called the reset value

Proportional + Integral + Derivative Control
When the all three control effects are combined together we obtain the benefits of each control action & more over the effect duplicates the action of good human operator on a control application. A three controller contains the stability of P- controller and the ability to eliminate offset because of reset control and ability to provide an immediate corrective action for the
magnitude of a disturbance because of rate control.

Apparatus required:
1. AC servomotor kit
2. PLC (Allen Bradley Micrologix 1500 LRP series C)
3. PC with RXlogix Software
4. RS232 cable
5. Patch chords

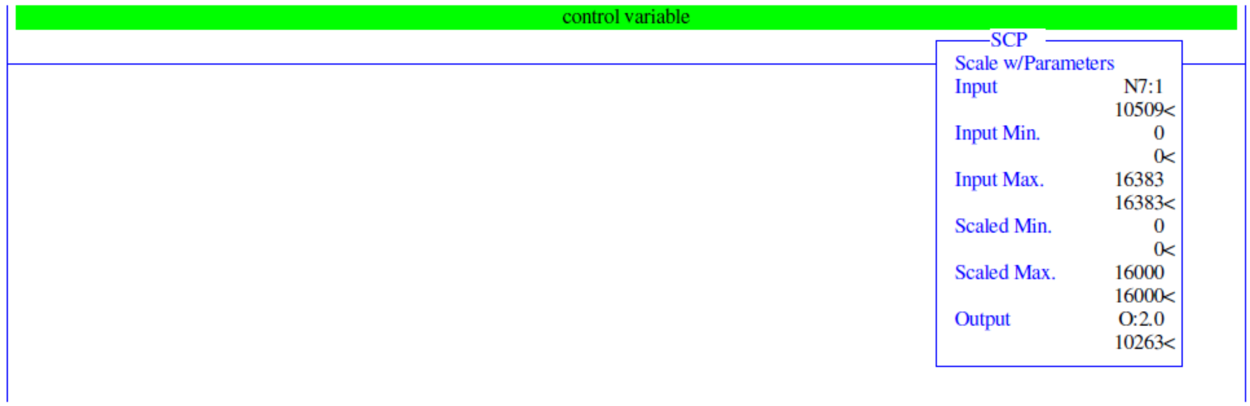
Procedure:

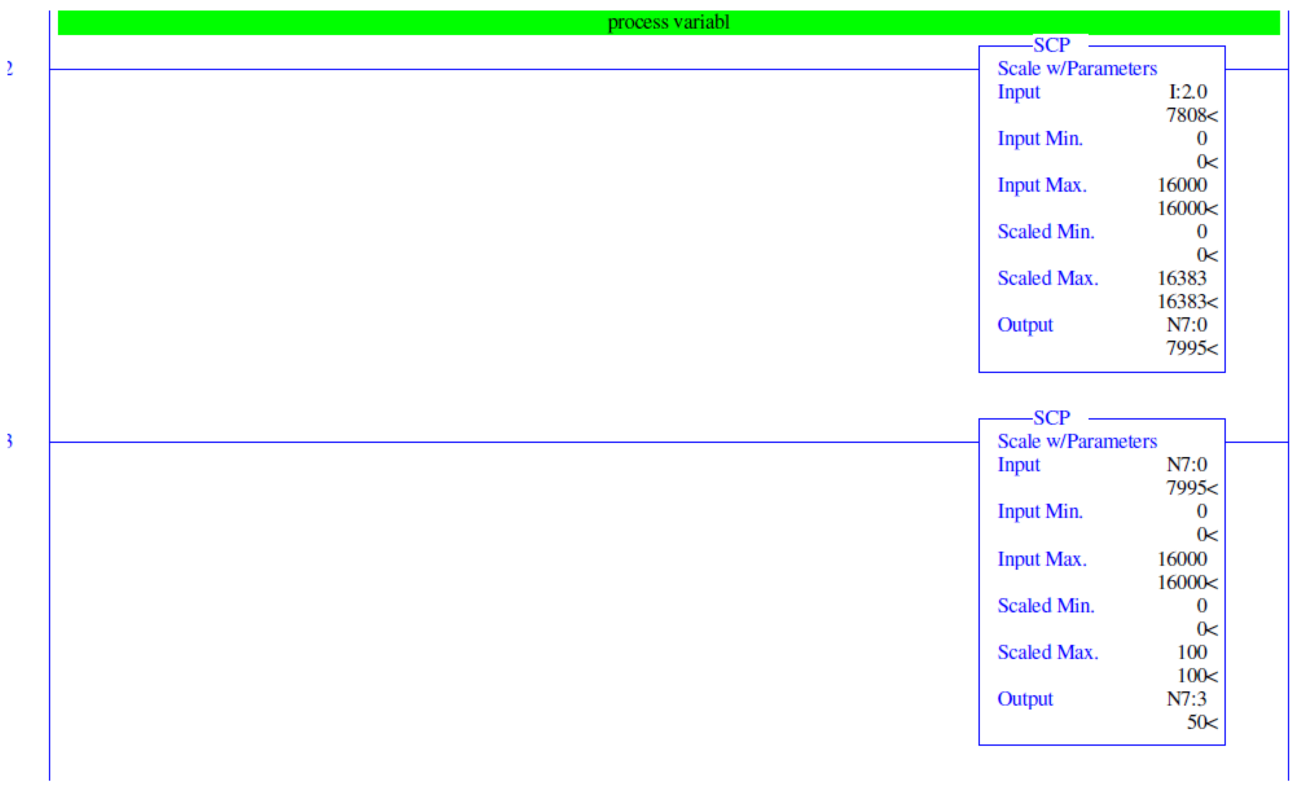
1. Load the RXlogix software to the PC
2. Open the RXlogix software
3. Switch on the PLC trainer and lift controls system
4. Connect PLC with AC servomotor kit.
5. Open the New folder and draw the ladder logic program
6. Select the correct hardware configuration.
7. Store the Program to PLC
8. Run the program
9. Verify the performance to the control AC servomotor.

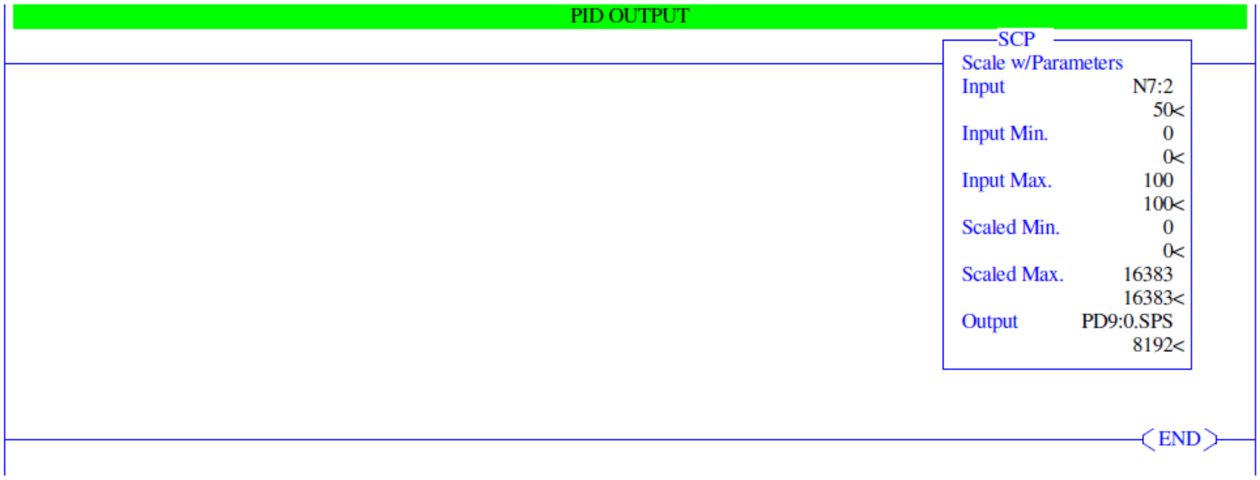
Description:
Applying different voltages can control speed of the AC servomotor. For this purpose AC voltage controller has been used. Accordingly triggering angle control for this circuit has accomplished by plc ladder logic program. For measurement of speed an optocoupler is used in conjunction with a square geared wheel connected to the shaft of the motor. The optocoupler measures speed of motor by noting the number of tooth that it encountered in a fixed time. The optocoupler output is given to the analog input port of plc kit. Then control algorithm will compare this value with the default set point value, which give an error signal. This error signal is used in manipulating the firing angle of thyristor circuit to control applied voltage to the servomotor. Ladder logic program also facilitates

the user to tune the controller parameters to change the performance of the controller and to set desired speed value.

Program







Observations:

What do you infer from the controller output oscillations? By varying the proportional gain, integral gain, what would be the merits and demerits?

What do you infer from the controller output oscillations? By varying the proportional gain, integral gain, what would be the merits and demerits?

Exp No: **Date:**

LIFT CONTROL SYSTEM using PLC

Aim:

To control the lift plant model using programmable logic controller.

Apparatus required:

1. Lift control system
2. PLC (Allen Bradley micrologix 1500 LRP series C)
3. PC with RXlogix Software
4. RS232 cable
5. Patch chords

Procedure:

1. Load the RXlogix software to the PC
2. Open the RXlogix software
3. Switch on the PLC trainer and lift controls system
4. Connect PLC with Lift control system kit.
5. Open the New folder and draw the ladder logic program
6. Select the correct hardware configuration.
7. Store the Program to PLC
8. Run the program
9. Verify the performance to the lift control system

Program description:

I1, I2, I3 - Requisition switch.

I4, I5, I6 - Sensor Inputs.

Q2, Q3, Q4, Q5 - Output for stepper motor.

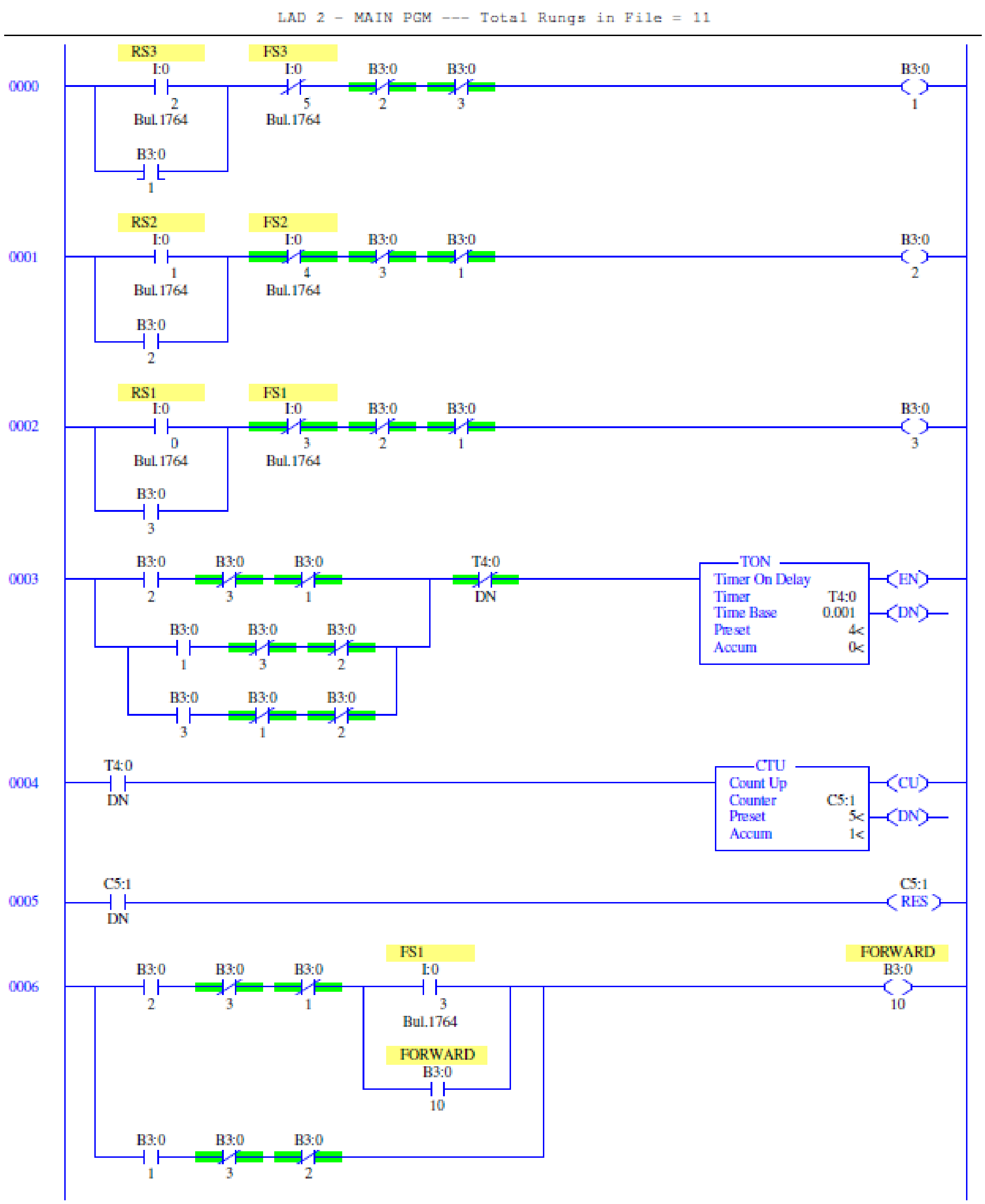
1. I1, I2, I3 are requisition switches I4, I5, I6 are the sensor placed in each floor. The other coils used in the program are the set coil, reset coil, positive transition coil, negative transition coil are in memory location.
2. The timer functions are used to produce the required time delay.
3. Bit sequence functions used to drive the stepper motor.
4. Whenever the requirement switch I1, is pressed the set coil M1 is energized and bit sequence outputs are enabled then the stepper motor rotates.
5. When the motor reaches the respective floor, the switch I4 gets closed and energizes both positive transition coil & negative transition coil.
6. The positive transition coil energizes one more set coil, which is used to enable the timer.
7. This is used to give time delay for the lift in each floor.

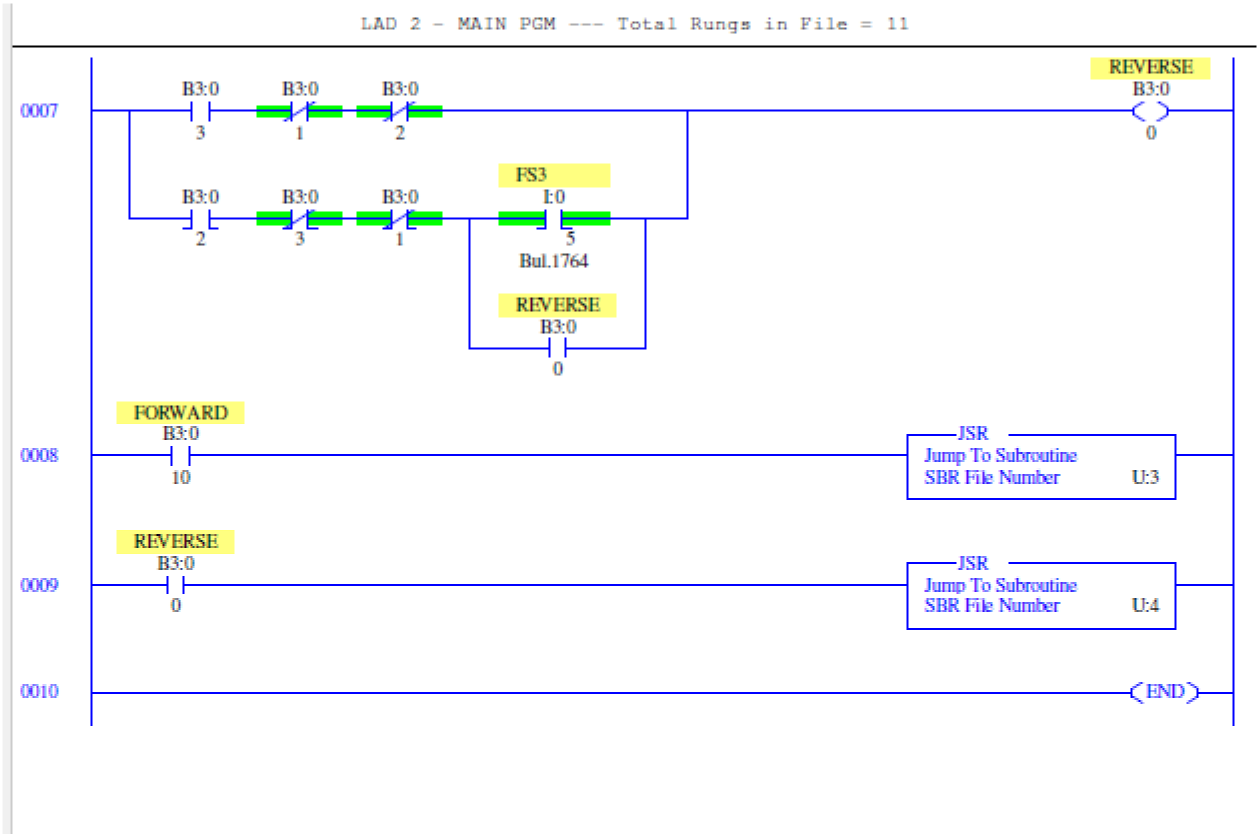
8. The negative transition coil, which was energized, is used to reset the requisition.
9. The above functions are repeated in each floor.

Conditions for rotation of Motor:

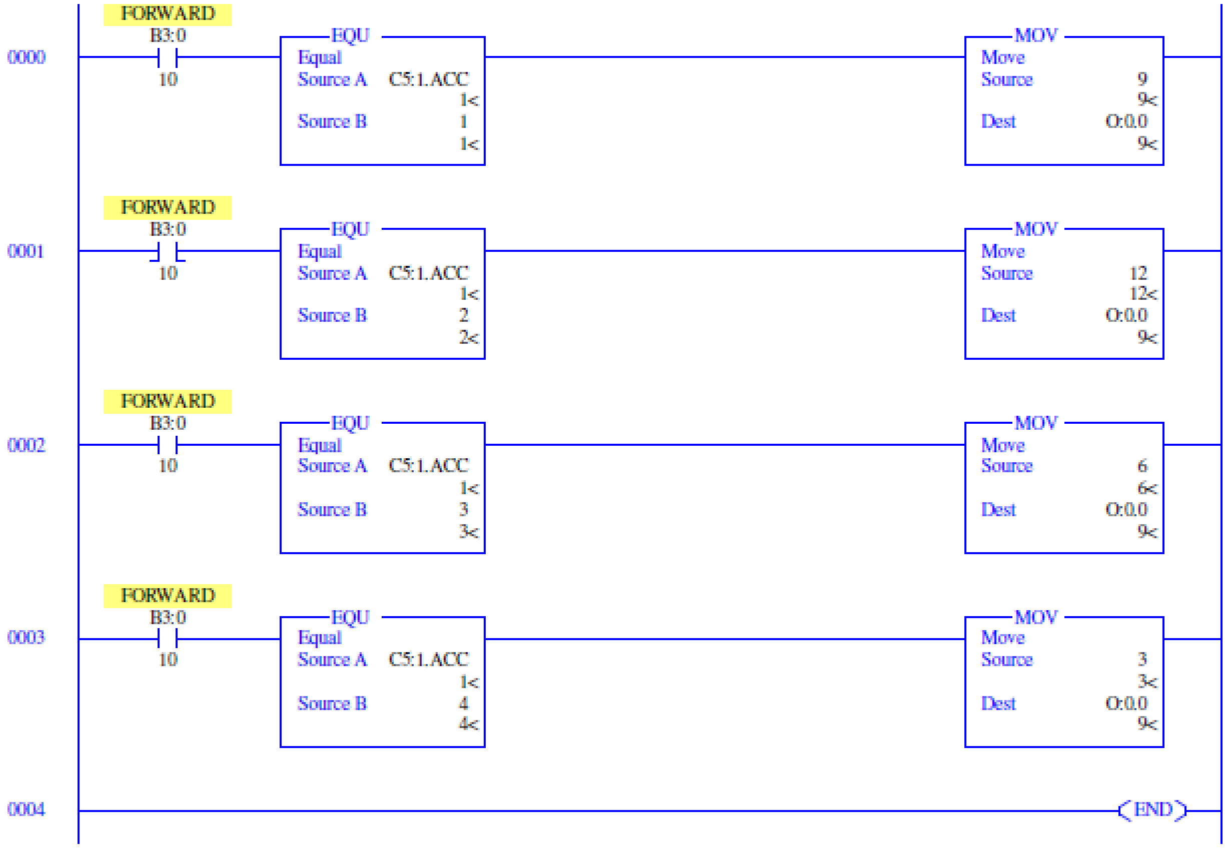
1. **C**onsider the lift is in ground floor, when the requisition is given from first floor or second floor the motor has to move forward.
2. If the lift is in top floor then it has to move in the reverse direction.
3. If the lift is in middle floor then according to the requisition, lift will move in forward orreverse direction.

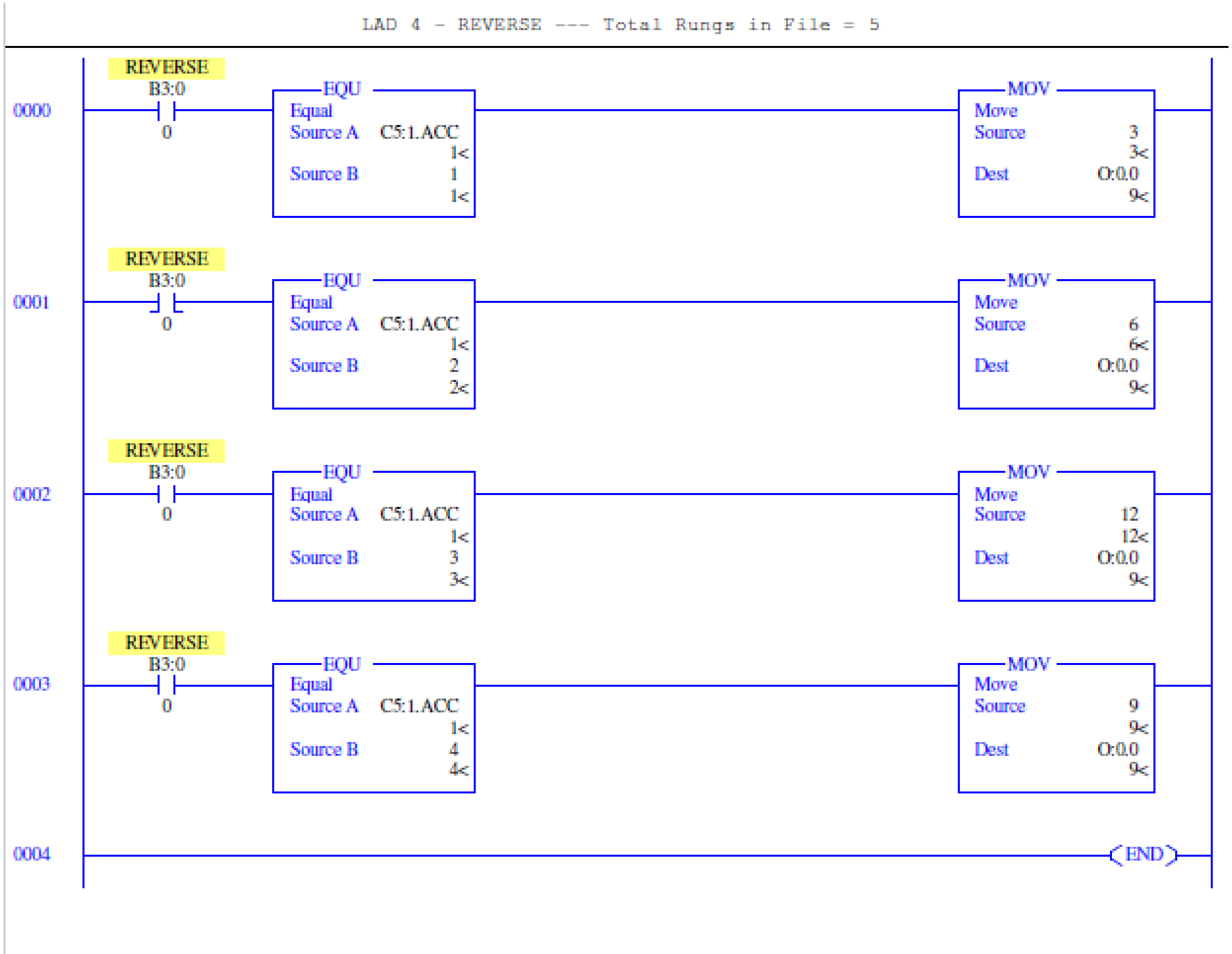
Program




LAD 2 - MAIN PGM --- Total Rungs in File = 11
0007
B3:0
3
B3:0
1
B3:0
2
REVERSE
B3:0
0
B3:0
2
B3:0
3
B3:0
1
FS3
I:0
5
Bul.1764
REVERSE
B3:0
0
0008
FORWARD
B3:0
10
JSR
Jump To Subroutine
SBR File Number U:3
0009
REVERSE
B3:0
0
JSR
Jump To Subroutine
SBR File Number U:4
0010
END

LAD 3 - FORWARD --- Total Rungs in File = 5





Result:

It is observed that lift is controlled smoothly by using programmable logic controller.

Exp No: **Date:**

STAR DELTA STARTER using PLC

AIM:

The objective of the product is to start a 3・ squirrel cage induction motor in star-delta method using PLC.

APPARATUS REQUIRED:

1. Personal computer
2. PLC.
3. PLC programming software
4. RS 232 communication cable
5. PLC based star to delta star starter module (VPAT-15).
6. Power supply -220 volt 3Φ AC 50 Hz.
7. 3Φ variable transformer.
8. Patch Chords.

STAR-DELTA STARTER

The Star/Delta starter is probably the most commonly used reduced voltage starter. The Star/Delta starter requires a six terminal motor that is delta connected at the supply voltage. The Star Delta starter employs three contactors to initially start the motor in a star connections, then after a period of time, to reconnect the motor to the supply in a delta connection. While in the star connection, the voltage across each winding is reduced by a factor of the square root of 3. This results in a start current reduction to one third of the DOL start current and a start torque reduction to one third of the DOL start torque. If there is insufficient torque available while connected in star, the motor can only accelerate to partial speed. When the timer operates (Set normally from 5 - 10 seconds), the motor is disconnected from the supply and then reconnected in Delta resulting in full voltage start currents and torque. The transition from star connection to delta connection requires that the current flow through the motor is interrupted. This is termed “Open Transition Switching” and with an induction motor operating at partial speed (or full load speed), there is a large current and torque transient produced at the point of reconnection. This transient is gar worse than any produced by the DOL starter and can cause severe damage to equipment and the supply. If there is insufficient torque produced by the motor in star, there is no way to accelerate the load to dull speed without switching to delta and causing those severe current and torque transients. These must be allowed-for in the design of the motor and its starting system if they are to have an economic useful life.

This type of starter is used in the case of motors which are built to run normally with a delta connected stator winding. It consists of a two - way switch which connects the motor in star for starting and then in delta for running. The usual connections are shown. When star-connected, the applied voltage over each motor phase is reduced by a factor of 1/ $\sqrt{3}$ and hence the torque developed becomes 1/

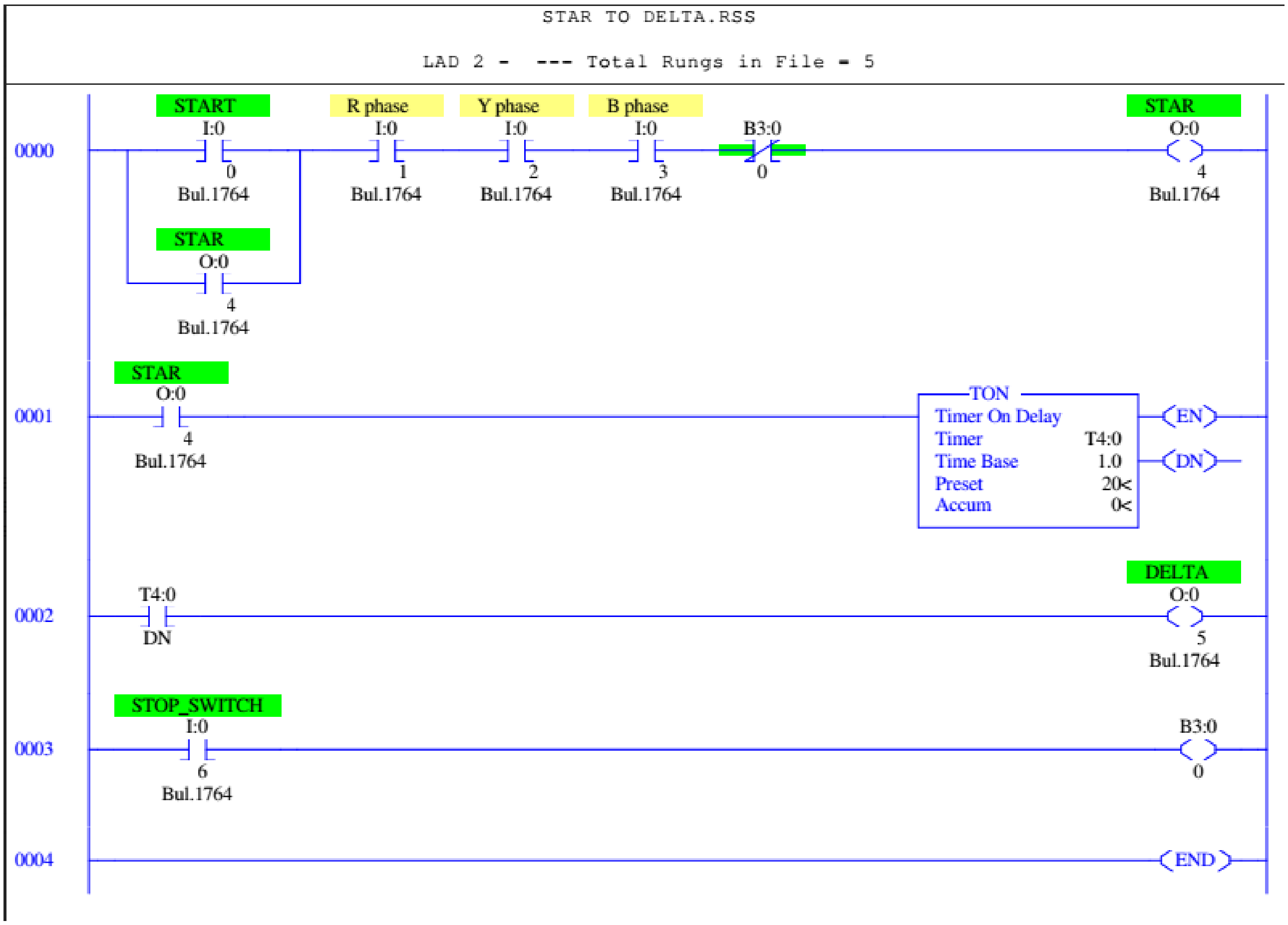
$\sqrt{3}$ of that which would have been developed if motor were directly connected in delta. The line current is reduced to 1/ $\sqrt{3}$. Hence, during starting period when motor is Y-connected, it takes 1/3rd as much stating current and develops 1/3rd as much torque as would have been developed were it directly connected in delta.

It is clear that the star-delta switch is equivalent to an auto-transformer of ratio 1/$\sqrt{3}$ .or 58% approximately. This method is cheap and effective provided the starting torque is required not to be more than 1.5 times the full-load torque. Hence, it is used for machine tools, pumps and motor-generators etc.

PROCEDURE:

1. First program the ladder logic for star-delta starter with required protection sequence.
2. Connect the personal computer & PLC by RS 232 communication cable.
3. Clear the PLC content using clear command.
4. Download the ladder logic program from PC to PLC.
5. Make proper connection to PLC, motor & starter.
6. By selecting the run mode the PLC is ready for action.
7. Output of the PLC is given to PLC based starter & Motor starts to run in star connection.
8. After a preset time the motor winding change into delta connections.
9. Now the motor take high current compared to star.
10. After any fault like single phasing, over current comes the PLC starter automatically sense & cut off the power supply to the motor.
11. After the power supply cut off we have to reset the starter for next starting action.

PROGRAM



PROGRAM EXPLANATION:

1. The first rung consists of Start and Stop switch, R, Y and B phase and Memory contact. Start or Stop Switch is used for Emergency OFF purpose. When switch is ON start switch Enable, switch is OFF stop switch Enable.
2. When the power supply is given, R, Y and B phase in normally open and Memory contact is normally closed. At the time motor will start rotate in Star connection.
3. In second rung, the output of Star is given to the TIMER. At particular time delay, it will give output.
4. In third rung, output of the Timer s given to Delta, Now, the motor start to rotate in delta connection.
5. In fourth rung, CURRENT SENSOR is used to sense the current. When the actual current reaches above the set current, it will set the memory contact and motor stop.
6. In fifth rung, RESET switch is used to return to the normal position.
7. In sixth rung, END is used to stop the operation.

Result:

SCADA Experiments

Introduction

ELECTRICAL power is one of the most important infrastructure inputs necessary for the rapid economic development of a country. The ever-rising demand of electrical energy has led to the installation and incorporation of a large number of electrical power generation units, with increased capacities in a common power grid, making the operation of the entire system sensitive to the prevailing conditions. Therefore, the extensive and complex power systems have become unmanageable using the conventional instrumentation and control schemes. Intelligent systems based on microprocessors and computers have been employed for online monitoring and control of modern large-scale power systems, in generation, transmission and distribution, thereby overcoming the complexities and drawbacks of the conventional instrumentation schemes.

The term “Automation”

Automation is the use of scientific and technological principles in the manufacture of machines that take over work normally done by humans. This definition has been disputed by professional scientists and engineers, but in any case, the term is derived from the longer term “automatization” or from the phrase “automatic operation”. Delmar S. Harder, a plant manager for General Motors, is credited with first having used the term in 1935.

History of Automation

Ideas for ways of automating tasks have been in existence since the time of the ancient Greeks. The Greek inventor Hero (fl. about A.D. 50), for example, is credited with having developed an automated system that would open a temple door when a priest lit a fire on the temple altar. The real impetus for the development of automation came, however, during the Industrial Revolution of the early eighteenth century. Many of the steam-powered devices built by James Watt, Richard Trevithick, Richard Arkwright, Thomas Savery, Thomas Newcomen, and their contemporaries were simple examples of machines capable of taking over the work of humans. One of the most elaborate examples of automated machinery developed during this period was the draw loom designed by the French inventor Basile Bouchon in 1725. The instructions for the operation of the Bouchon loom were recorded on sheets of paper in the form of holes. The needles that carried thread through the loom to make cloth were guided by the presence or absence of those holes. The manual process of weaving a pattern into a piece of cloth through the work of an individual was transformed by the Bouch on process into an operation that could be performed mindlessly by merely stepping on a pedal.

Automation Applications

Manufacturing companies in virtually every industry are achieving rapid increases in productivity by taking advantage of automation technologies. When one thinks of automation in manufacturing, robots usually come to mind. The automotive industry was the early adopter of robotics, using these automated machines for material handling, processing operations, and assembly and inspection. Donald A. Vincent, executive vice president, Robotic Industries Association, predicts a greater use of robots for assembly, paint systems, final trim, and parts transfer will be seen in the near future. One can break down automation in production into basically three categories: fixed automation, programmable automation, and flexible automation. The automotive industry primarily uses fixed automation. Also known as "hard automation," this refers to an automated production facility in which the sequence of processing operations is fixed by the equipment layout. A good example of this would be an automated production line where a series of workstations are connected by a transfer system to move parts between the stations. What starts as a piece of sheet metal in the beginning of the process, becomes a car at the end. Programmable automation is a form of automation for producing products in batches. The products are made in batch quantities ranging from several dozen to several thousand units at a time. For each new batch, the production equipment must be reprogrammed and changed over to accommodate the new product style. Flexible automation is an extension of programmable automation. Here, the variety of products is sufficiently limited so that the changeover of the equipment can be done very quickly and automatically. The reprogramming of the equipment in flexible automation is done off-line; that is, the programming is accomplished at a computer terminal without using the production equipment itself. Computer numerical control (CNC) is a form of programmable automation in which a machine is controlled by numbers (and other symbols) that have been coded into a computer. The program is actuated from the computer's memory. The machine tool industry was the first to use numerical control to control the position of a cutting tool relative to the work part being machined. The CNC part program represents the set of machining instructions for the particular part, while the coded numbers in the sequenced program specifies x-y-z coordinates in a Cartesian axis system, defining the various positions of the cutting tool in relation to the work part.

SCADA

SCADA is an acronym that stands for Supervisory Control and Data Acquisition. SCADA refers to a system that collects data from various sensors at a factory, plant or in other remote locations and then sends this data to a central computer which then manages and controls the data. SCADA is a term that is used broadly to portray control and management solutions in a wide range of industries. SCADA generally refers to an industrial control system: a computer system monitoring and controlling a process. The process can be industrial, infrastructure or facility based as described below:

- Industrial processes include those of manufacturing, production, power generation, fabrication, and refining, and may run in continuous, batch, repetitive, or discrete modes.
- Infrastructure processes may be public or private, and include water treatment and distribution, wastewater collection and treatment, oil and gas pipelines, electrical power transmission and distribution, civil defence siren systems, and large communication systems.
- Facility processes occur both in public facilities and private ones, including buildings, airports, ships, and space stations. They monitor and control HVAC, access, and energy consumption.

SCADA as a System

There are many parts of a working SCADA system. A SCADA system usually includes signal hardware (input and output), controllers, networks, user interface (HMI), communications equipment and software. All together, the term SCADA refers to the entire central system. The central system usually monitors data from various sensors that are either in close proximity or off site (sometimes miles away).

For the most part, the brains of a SCADA system are performed by the Remote Terminal Units (sometimes referred to as the RTU). The Remote Terminal Units consists of a programmable logic converter. The RTU are usually set to specific requirements, however, most RTU allow human intervention, for instance, in a factory setting, the RTU might control the setting of a conveyer belt, and the speed can be changed or overridden at any time by human intervention. In addition, any changes or errors are usually automatically logged for and/or displayed. Most often, a SCADA system will monitor and make slight changes to function optimally; SCADA systems are considered closed loop systems and run with relatively little human intervention. One of key processes of SCADA is the ability to monitor an entire system in real time. This is facilitated by data acquisitions including meter reading, checking statuses of sensors, etc that are communicated at regular intervals depending on the system. Besides the data being used by the RTU, it is also displayed to a human that is able to interface with the system to override settings or make changes when necessary. SCADA can be seen as a system with many data elements called points. Usually each point is a monitor or sensor. Usually points can be either hard or soft. A hard data point can be an actual monitor; a soft point can be seen as an application or software calculation. Data elements from hard and soft points are usually always recorded and logged to create a time stamp or history. A SCADA System usually consists of the following subsystems:

- A Human-Machine Interface or HMI is the apparatus which presents process data to a human operator, and through this, the human operator monitors and controls the process.

-A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process.

- Remote Terminal Units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.

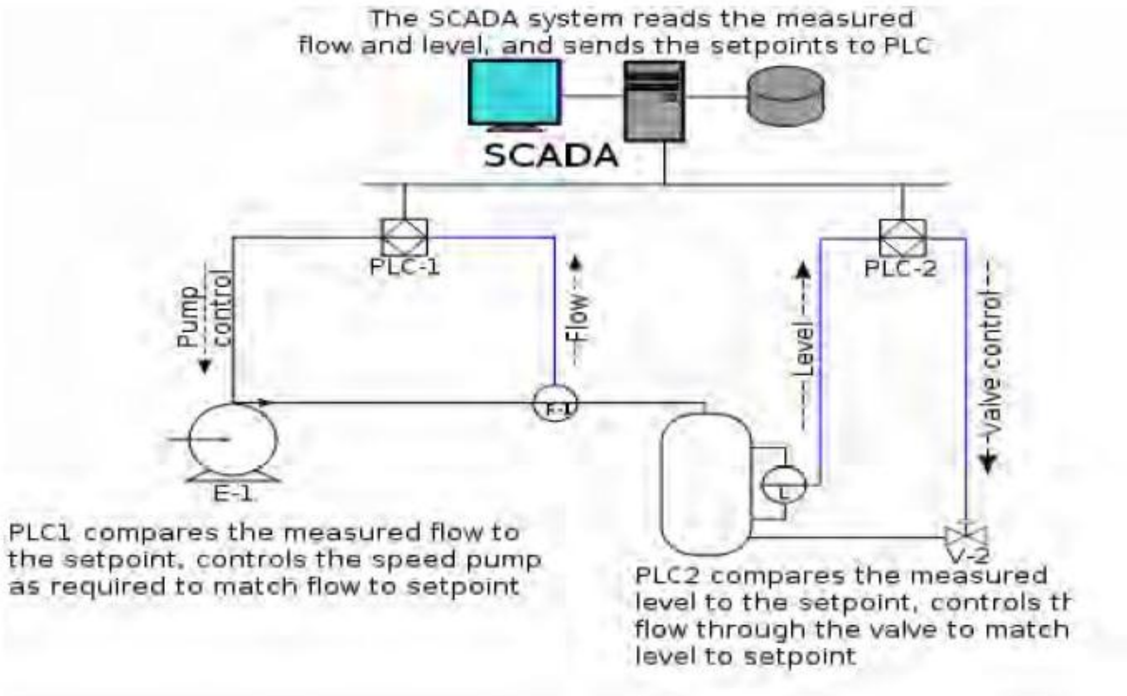
- Programmable Logic Controller (PLCs) used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs.

- Communication infrastructure connecting the supervisory system to the Remote Terminal Units

There is, in several industries, considerable confusion over the differences between SCADA systems and Distributed control systems (DCS). Generally speaking, a SCADA system usually refers to a system that **coordinates**, but does not **control** processes in real time. The discussion on real-time control is muddied somewhat by newer telecommunications technology, enabling reliable, low latency, high speed communications over wide areas. Most differences between SCADA and DCS are culturally determined and can usually be ignored. As communication infrastructures with higher capacity become available, the difference between SCADA and DCS will fade.

System Concept

The term SCADA usually refers to centralized systems which monitor and control entire sites, or complexes of systems spread out over large areas (anything between an industrial plant and a country). Most control actions are performed automatically by remote terminal units ("RTUs") or by programmable logic controllers ("PLCs"). Host control functions are usually restricted to basic overriding or *supervisory* level intervention. For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow operators to change the set points for the flow, and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors the overall performance of the loop.



Data acquisition begins at the RTU or PLC level and includes meter readings and equipment status reports that are communicated to SCADA as required. Data is then compiled and formatted in such a way that a control room operator using the HMI can make supervisory decisions to adjust or override normal RTU (PLC) controls. Data may also be fed to a Historian, often built on a commodity Database Management System, to allow trending and other analytical auditing. SCADA systems typically implement a distributed database, commonly referred to as a *tag database*, which contains data elements called *tags* or *points*. A point represents a single input or output value monitored or controlled by the system. Points can be either "hard" or "soft". A hard point represents an actual input or output within the system, while a soft point results from logic and math operations applied to other points. (Most implementations conceptually remove the distinction by making every property a "soft" point expression, which may, in the simplest case, equal a single hard point.) Points are normally stored as value-timestamp pairs: a value, and the timestamp when it was recorded or calculated. A series of value-timestamp pairs gives the history of that point. It's also common to store additional data with tags, such as the path to a field device or PLC register, design time comments, and alarm information.

Substation Automation with SCADA

The substation SCADA system provides a common interface for various types of equipments/devices used in the substation. Display & Database tools are used to configure the interfaces used for controlling & monitoring the different equipment and the settings required for protection, regulation or loading limits. The usage of alarm management systems prompts various warning tags, control interlock logics relating to the current/past operations. The graphical screens provide current information on all critical parameters. All the equipments can be controlled & monitored through a single computer. Parameters such as actual & reactive power, Energy, transformer temperature, Tap positions, Voltage, Current, Frequency, Power factor, relay status & protection settings etc are collected and displayed in a user friendly graphical format. Substation automation can give adequate self checking, diagnostic features which helps in providing proactive measures to establish a healthy system. The functions like Voltage regulation, load management are implemented in substation software which reduces the usage of complex components.

SCADA Lab Setup

The SCADA lab setup comprises of the following

Transmission Model (400/220 kV)

1. **Panel 1: Station Model** (415 V/110 V 3- transformer 1 KVA, Protection Relay Class-1, 3- Energy Meters , PLC)
2. **Panel 2: Transmission Line Model** (Resistors, Inductors & Capacitors), Series Compensators.
3. **Panel 3: Load Model for Transmission Line** (Dimmer, Resistors & Inductors) Shunt Compensators, 3- Energy Meter

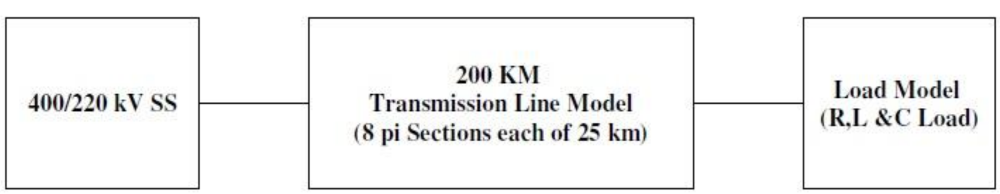
Distribution Model (11 kV)

4. **Panel 4: Distribution Model** (415 V/110 V 1- transformer 1 KVA, Protection Relay Class-1, 3- Energy Meters , PLC, Dimmers, Resistors, Inductors & Capacitors).

The system consists of 400/220 kV transmission model & 11kV distribution substation model, metering, protection and control devices, and a multi-tier SCADA system with scalable distributed architecture. The proposed solution is based on the latest international standards in substation communication and automation such as IEC 61850 and IEC 60870-5. The module consists of RTU, protection relay, circuit breakers and energy meter for control, protection and metering functions. PC based SCADA server/workstation is provided for local operation, data logging, metering and sequence of events. The substation automation system is built on IEC 61850 open standard communication architecture. The software supplied is flexible and
compatible with above system to control entire substation modules and interfaces, simulate power system distribution and network with single line diagrams. The SCADA software monitors, communicates and operate RTUs, breakers and relays. Display for KWH, KVA, V, I, Hz, Pf and kVAR is provided. The Control center consists of remote SCADA system for operation, training & monitoring of the electrical network. The system communicates with Transmission model in IEC 870-5-101 standard protocol.

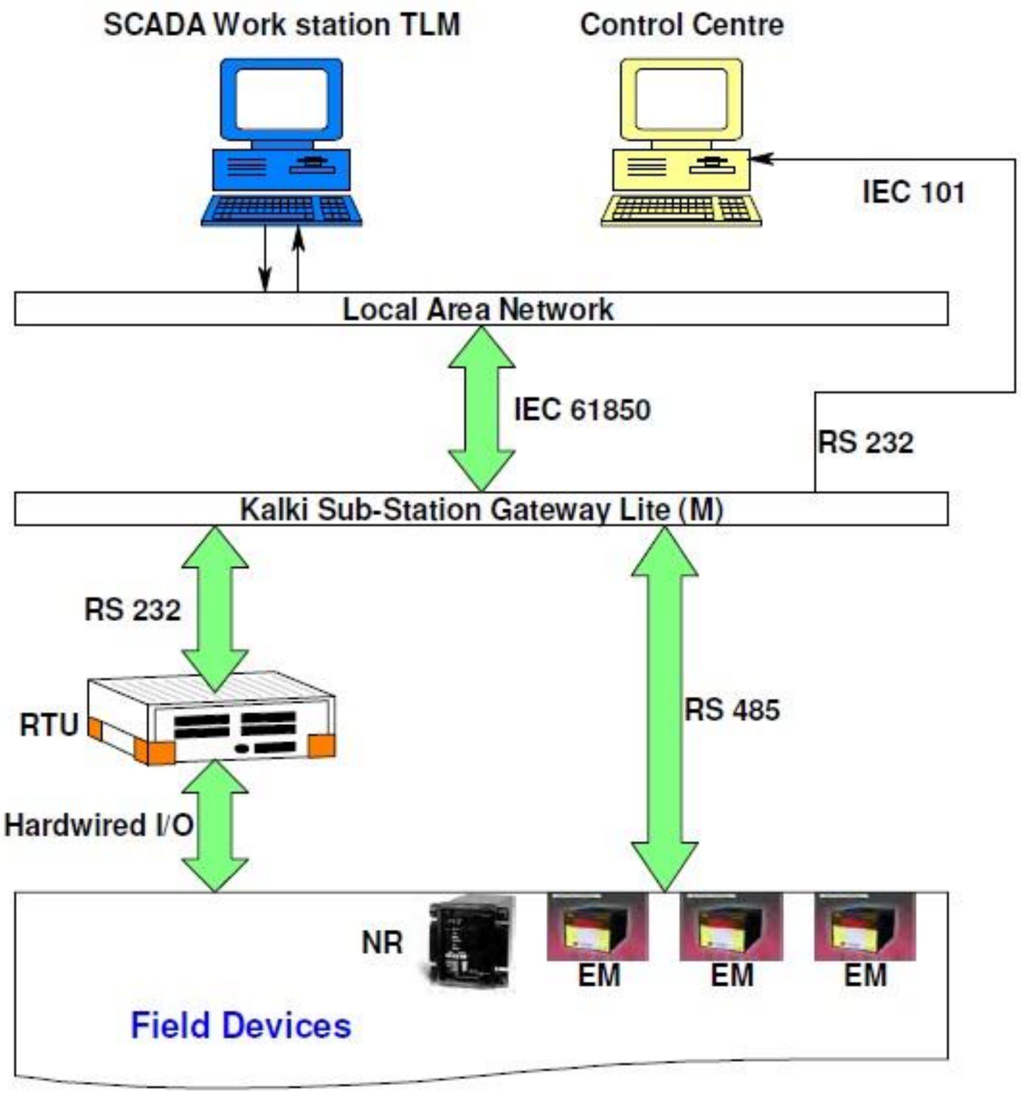
Transmission Line Model

1) The model consists of 400/220 kV receiving substation with a 220 kV out going line.
2) One typical 220 kV transmission line also is modeled for a distance of 200 km.
3) The Communication System is built on the newest substation CommunicationArchitecture of IEC 61850.



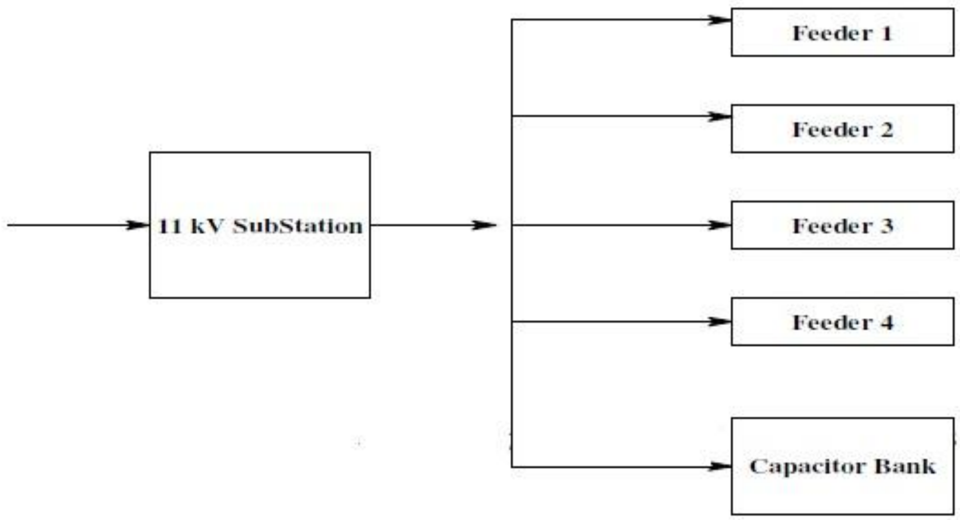
Single Line Diagram:

Communication Architecture:



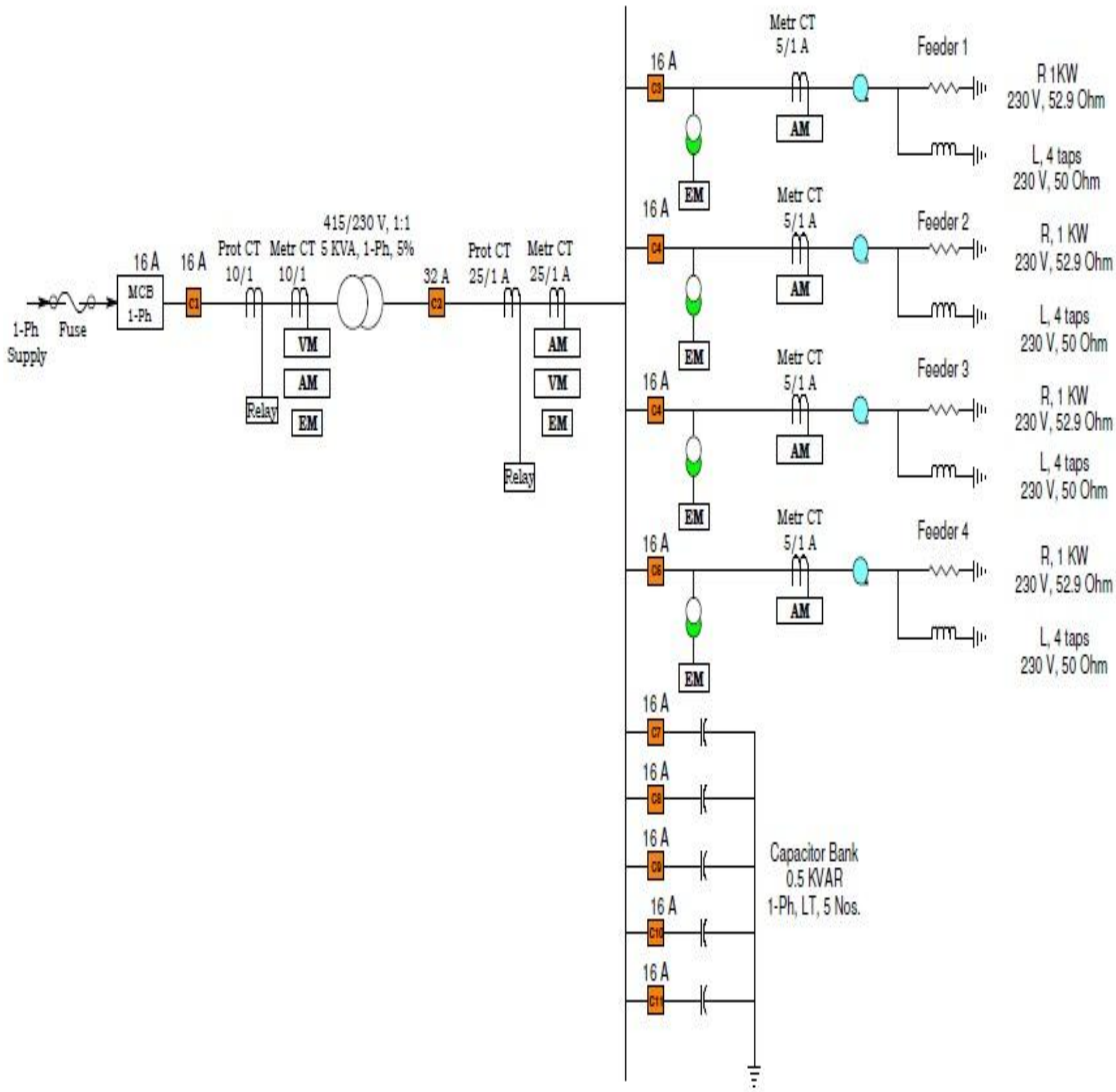
Distribution Model

The model consists of 11 kV substations with four outgoing feeders and a capacitor bank, each feeder is designed as RL load. The Communication System is built on the newest substation Communication Architecture of IEC 61850.



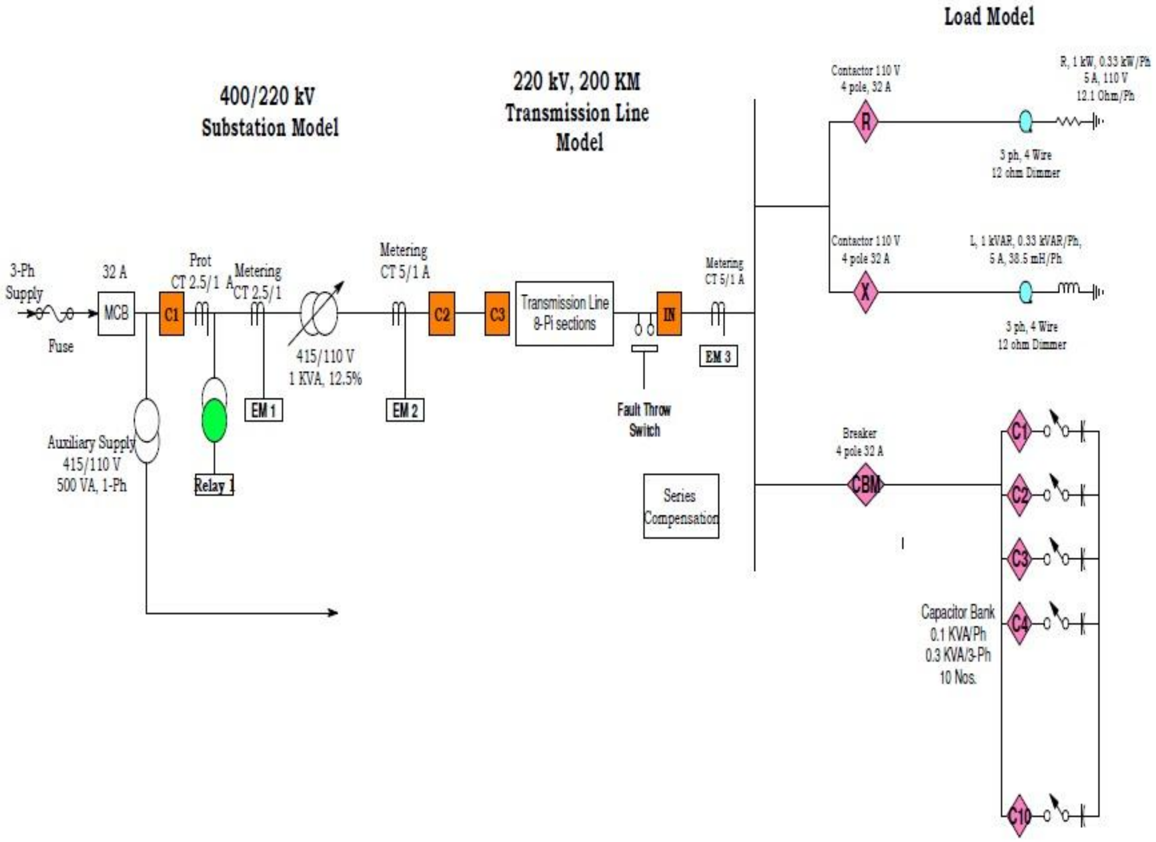
Single Line Diagram:

11 KV Distribution Model:



EXPERIMENTS ON TRANSMISSION MODULE

Experiment Setup - Transmission Module:



Precautions:

1. Once an experiment is selected in the SCADA system until it is completed and stopped by clicking the stop button we shouldn't click the main screen.
2. While closing the Circuit breaker make sure that the status of the breaker icon is updated before going to close the next breaker (Vertical line on the breaker will be changed to horizontal line)
3. Whenever a question mark (?) appears on the breaker icons, wait till the status is updated without disturbing it, because it's the problem of communication.
4. Always click the STOP button before going to the next experiment.

Experiments overview – Transmission Model

The following experiments can be done using the Transmission Model both in Local and Remote mode.

1. Fault Test
a. Line to Line Faults (LL)
b. Line to Ground Faults (LG)
c. Line to Line to Line Fault (LLL)
d. Line to Line to Ground Faults (LLG)
2. Ferranti Effect
3. Transmission Line Loading

a. Resistive Loading (R Load)
b. Inductive Loading (L load)
c. Resistive & inductive Loading (R & L Load)
4. Transformer Loading
a. Resistive Loading (R Load)
b. Inductive Loading (I load)
c. Resistive & Inductive Loading (R & L Load)
5. VAR Compensation
a. Shunt Compensation
b. Series compensation
i. Mid Point Compensation
ii. Sending End Compensation
iii. Receiving End Compensation
6. Operation of OLTC (Tap changing of transformer)
7. Sudden Load rejection

Common Procedure to All Experiments

1. Assemble S/S panel, Station Model, Transmission model & Load model.
2. Keep the Local/Remote selector in proper Position.
3. Keep all the Emergency Push buttons in released condition.
4. In the station model connect the energy meter & relay through the cables provided to the corresponding pins.
5. Interconnect Station model & Transmission model using power cable
6. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins of pin no. 4(4th pie section) & connect the O/p of 4th Pie to 5th pie & so on up to 8th Pie O/p to the end pins of the pie section using cables provided. (Note: Phase lines should not be interchanged).
7. Connect the transmission model & load Model using the power cable.
8. Change the phase current setting of the relay based on the load
9. Switch on the SCADA system & enter your login ID
10. Click ON the experiments screen.

Local Mode Experiments

Simulation of Faults (Local mode)

L-G Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Close the Incomer C1 by pressing the ON push button.
2. Configure the relay for the earth current settings, time multiplier for earth current & curve number.
3. Close the Breaker C2 by pressing the ON push button.
4. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions.
5. Select the system for simulating fault in the particular distance (100th KM, 150th KM, and 175th KM) by closing the contactors 100th KM, 150th KM, 175th KM by pressing the corresponding ON push button.
6. Create the particular fault (R-G, Y-G, B-G) by pressing the ON push buttons of L1, L2, L3 and G
7. The relay will trip the Line depending on the phase current setting and the time setting set on the relay.
8. Once the system is tripped reset the relay manually.
9. Click the back button & select the test results.
10. The test results will display the details regarding the fault current & Nature of fault.
11. Repeat the experiment for various phase currents and the time settings in the relay.
12. Note the Fault current, Voltage & time to trip for various settings.
13. Plot the current vs. time graph.

After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:

It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

L-L Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Close the Incomer C1 by pressing the ON push button.
2. Configure the relay for the earth current settings, time multiplier for earth current & curve number
3. Close the Breaker C2 by pressing the ON push button.
4. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
5. Select the system for simulating fault in the particular distance (100th KM, 150th KM, and 175th KM) by closing the contactors 100th KM, 150th KM, 175th KM by pressing the corresponding ON push button.
6. Create the particular fault (R-Y, Y-B, R-B) by pressing the ON push buttons of L1, L2, L3
7. Click the experiments screen & select the L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
8. The relay will trip the Line depending on the time setting set on the relay
9. Once the system is tripped reset the relay manually
10. Click the back button & select the test results
11. The test results will display the details regarding the fault current & Nature of fault
12. Repeat the experiment for various time settings in the relay
13. Note the Fault current, Voltage & time to trip for various settings
14. Plot the current vs. time graph.

After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:

It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

L-L-L Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Close the Incomer C1 by pressing the ON push button.
2. Configure the relay for the earth current settings, time multiplier for earth current & curve number.
3. Close the Breaker C2 by pressing the ON push button.
4. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions.
5. Select the system for simulating fault in the particular distance (100th KM, 150th KM, and 175th KM) by closing the contactors 100th KM, 150th KM, 175th KM by pressing the corresponding ON push button.
6. Create the particular fault (R-Y, Y-B, R-B) by pressing the ON push buttons of L1, L2, L3
7. Click the experiments screen & select the L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
8. The relay will trip the Line depending on the time setting set on the relay
9. Once the system is tripped reset the relay manually
10. Click the back button & select the test results
11. The test results will display the details regarding the fault current & Nature of fault
12. Repeat the experiment for various time settings in the relay
13. Note the Fault current, Voltage & time to trip for various settings
14. Plot the current vs. time graph

After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:

It is observed that relay tripping is based on the current setting and time multiplier setting. It tookdifferent time for different current values.

L-L-G Fault
Aim:
Relay sensing and tripping and observe the fault current
Procedure:
1. Close the Incomer C1 by pressing the ON push button.
2. Configure the relay for the earth current settings, time multiplier for earth current & curve number
3. Close the Breaker C2 by pressing the ON push button.
4. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
5. Select the system for simulating fault in the particular distance (100th KM, 150th KM, and 175th KM) by closing the contactors 100th KM, 150th KM, 175th KM by pressing the corresponding ON push button.
6. Create the particular fault (R-Y, Y-B, R-B) by pressing the ON push buttons of L1, L2, L3 and G
7. Click the experiments screen & select the L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
8. The relay will trip the Line depending on the time setting set on the relay
9. Once the system is tripped reset the relay manually
10. Click the back button & select the test results
11. The test results will display the details regarding the fault current & Nature of fault.
12. Repeat the experiment for various time settings in the relay
13. Note the Fault current, Voltage & time to trip for various settings
14. Plot the current vs. time graph
After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:
It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

L-L-L-G Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Close the Incomer C1 by pressing the ON push button.
2. Configure the relay for the earth current settings, time multiplier for earth current & curve number
3. Close the Breaker C2 by pressing the ON push button.
4. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
5. Select the system for simulating fault in the particular distance (100th KM, 150th KM, and 175th KM) by closing the contactors 100th KM, 150th KM, 175th KM by pressing the corresponding ON push button.
6. Create the particular fault (R-Y, Y-B, R-B) by pressing the ON push buttons of L1, L2, L3 and G
7. Click the experiments screen & select the L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
8. The relay will trip the Line depending on the time setting set on the relay
9. Once the system is tripped reset the relay manually
10. Click the back button & select the test results
11. The test results will display the details regarding the fault current & Nature of fault
12. Repeat the experiment for various time settings in the relay
13. Note the Fault current, Voltage & time to trip for various settings
14. Plot the current vs. time graph

After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:

It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

Ferranti Effect (Local mode)

Aim: Simulating Ferranti effect in SCADA setup and observe the results

Procedure:
1. Close the Incomer C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 incomer for transmission line model by pressing the ON push button
4. Close the Breaker C3 for load model by pressing the ON push button
5. Check the Energy meter voltage of Energy meter 2 & Energy Meter 3.
6. Observe the Voltage at receiving end (EM3) and sending end (EM2) of the transmission line.
7. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Energy Meter 2	Energy Meter 3
1	Voltage (V)		
	Current (A)		
2	Voltage (V)		
	Current (A)		
3	Voltage (V)		
	Current (A)		

Result:
Ferranti effect is observed in the experiment.

Transmission Line Loading (Local mode)

Resistive Loading

Aim:

Load the transmission line by a resistive load and observe voltage and current profile.

Procedure:

1. Close the Incomer C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 for transmission line model by pressing the ON push button
4. Close the Breaker C3 of the load model by pressing the ON push button
5. Close the breaker R by pressing the ON push button of the variable resistance.
6. Increase the load by rotating the dimmer check the current value in the screen and in the EM3 for the receiving end parameters.
7. Click the test results & note the values as shown in the tabular column
8. Repeat the experiment for various current values. (Max up to 3A)
9. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Energy Meter 2	Energy Meter 3
1	Voltage (V)		
	Current (A)		
2	Voltage (V)		
	Current (A)		
3	Voltage (V)		
	Current (A)		

Result:

Resistive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transmission Line Loading (Local mode)

Inductive Loading
Aim:
Load the transmission line by an inductive load and observe voltage and current profile.

Procedure:
1. Close the Incomer C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 for transmission line model by pressing the ON push button
4. Close the Breaker C3 of the load model by pressing the ON push button
5. Close the breaker X by pressing the ON push button of the variable Inductance.
6. Increase the load by rotating the dimmer for inductance & check the current value in the screen for the receiving end energy meter
7. Click the test results & note the values as shown in the tabular column
8. Repeat the experiment for various current values. (Max up to 3 A)
9. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:
Inductive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transmission Line Loading (Local mode)

Resistive and Inductive Loading

Aim:

Load the transmission line by resistive and inductive loads and observe voltage and current profile.

Procedure:

1. Close the Incomer C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 for transmission line model by pressing the ON push button
4. Close the Breaker C3 of the load model by pressing the ON push button
5. Close the breaker R by pressing the ON push button of a variable Resistance.
6. Close the breaker X by pressing the ON push button of a variable Inductance
7. Increase the load by rotating the dimmer for inductance & resistance, check the current value in the screen for the receiving end energy meter
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values. (Max up to 3 A)
10. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Inductive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transmission Line Loading (Local mode)

Resistive and Inductive Loading

Aim:

Load the transmission line by resistive and inductive loads and observe voltage and current profile

Procedure:

1. Close the Incomer C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 for transmission line model by pressing the ON push button
4. Close the Breaker C3 of the load model by pressing the ON push button
5. Close the breaker R by pressing the ON push button of a variable Resistance.
6. Close the breaker X by pressing the ON push button of a variable Inductance
7. Increase the load by rotating the dimmer for inductance & resistance, check the current value in the screen for the receiving end energy meter
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values. (Max up to 3 A)
10. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive and inductive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transformer Loading (Local mode)

Resistive Loading

Aim:

Load the transformer by a resistive load and observe voltage and current profile

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker R by pressing the ON push button of the variable resistance
5. Increase the load by varying the dimmer positions, check the current value in the screen for the receiving end energy meter
6. Click the test results & note the values as shown in the tabular column
7. Repeat the experiment for various current values. (Max up to 3 A)
8. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive loading of transformer is conducted and observed the voltage and current profiles.

Transformer Loading (Local mode)

Inductive Loading

Aim:

Load the transformer by an inductive load and observe voltage and current profile

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker X by pressing the ON push button of the variable Inductance
5. Increase the load by varying the dimmer positions, check the current value in the screen for the receiving end energy meter
6. Click the test results & note the values as shown in the tabular column
7. Repeat the experiment for various current values. (Max up to 3 A)
8. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Incomer Measurements	Sending end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Inductive loading of transformer is conducted and observed the voltage and current profiles.

Transformer Loading (Local mode)

Resistive and Inductive Loading

Aim:

Load the transmission line by resistive and inductive loads and observe voltage and current profile

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker R by pressing the ON push button of the variable resistance.
5. Close the breaker X by pressing the ON push button of the variable Inductance
6. Increase the load by varying both the dimmer positions (resistance & inductance), check the current value in the screen for the receiving end energy meter
7. Click the test results & note the values as shown in the tabular column
8. Repeat the experiment for various current values. (Max up to 3A at the receiving end)
9. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Sl No.	Description	Incomer Measurements	Sending end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive and inductive loading of transformer is conducted and observed the voltage and current profiles.

VAR Compensation (Local mode)

Series Compensation

Aim:

Study of series Var compensation at different points of transmission network and observe the comparison

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker R by pressing the ON push button of the variable resistance.
5. Close the breaker X by pressing the ON push button of the variable Inductance
6. Increase the load by rotating the dimmer for inductance & resistance, check the current value in the screen for the receiving end energy meter
7. Click the test results & note the values as shown in the tabular column
8. Open the Breaker C3 for Transmission line model by pressing the ON push button

For Sending End compensation

9. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to the input pins of the 1st pie section using cables provided. (Note: Phase lines should not be interchanged) *For Receiving End compensation*
10. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins of 1st pie section & connect the O/p of 4th Pie to 5th Pie I/p & so on up to 8th Pie O/P. Connect the 8th Pie O/p to input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to the 3 Phase output pins of the PI section using cables provided. (Note: Phase lines should not be interchanged) *For Mid Point compensation*
11. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins of 1st PI section & connect the O/p of 4th Pie to input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to 5th Pie I/p and all other PI sections should be connected in series & so on up to 8th Pie O/P & to the end pins of the pie section using cables provided. (Note: Phase lines should not be interchanged)
12. Close the Breaker C3 of the transmission line model by pressing the ON push button.
13. Compare the values for different compensations without changing the load.
14. Click the test results & note the values as shown in the tabular column
15. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

Observations:

S No.	Description	Before Compensation		Sending end Compensation		Mid point Compensation		Receiving End compensation	
		Sending	Receiving	Sending	Receiving	Sending	Receiving	Sending	Receiving
1	Voltage (V)								
2	Current (A)								
3	Power (W)								
4	VAR								
5	Power Factor								

Result:
Var compensation at different of transmission line is simulated and observed the voltage and current profiles.

VAR Compensation (Local mode)

Shunt Compensation (Regulation of bus voltage)

Aim:

Study of shunt Var compensation at different points of transmission network and observe the bus voltage.

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker R by pressing the ON push button of the variable resistance.
5. Close the breaker X by pressing the ON push button of the variable Inductance and vary the corresponding dimmer so that the energy meter shows a lagging PF (i.e. 0.8 and less)
6. Close the breaker Capacitor Bank main of the capacitor bank main by pressing the ON push button
7. Close the breakers CB1, CB2 in the branch carefully one by one until the power factor is compensated for a value up to .99 lagging (i.e. unity power factor) (Note: Don't close all the capacitance breakers simultaneously as it will imbalance the complete system).
8. Click the test results & note the values as shown in the tabular column. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

S No.	Description	Receiving end Measurements	
		Before	After
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Shunt Var compensation is simulated in the system and bus voltage profile is observed.

Sudden Load Rejection (Local mode)

Aim:

Apply the sudden load rejection to the transmission network and observe the voltage profiles.

Procedure:

1. Close the Breaker C1 by pressing the ON push button
2. Close the Breaker C2 by pressing the ON push button
3. Close the Breaker C3 of the load model by pressing the ON push button
4. Close the breaker R by pressing the ON push button of the variable resistance.
5. Close the breaker X by pressing the ON push button of the variable inductance.
6. Increase the load by varying the dimmer positions for inductance & resistance, check the current value in the screen for the receiving end energy meter
7. Open the Breaker C3 by pressing the OFF push button.
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values. (Max up to 2 A)
10. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding contactors.

S No.	Description	Receiving end Measurements	
		Before c3 open	After c3 open
1	Voltage (V)		
	Current (A)		
2	Voltage (V)		
	Current (A)		

Result:

Sudden load rejection is applied to the transmission network and the voltage profile is observed.

Remote Mode Experiments

Simulation of Faults (Remote mode)
L-G Fault
Aim:
Relay sensing and tripping and observe the fault current
Procedure:
1. Click the experiments screen & select the L-G Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Configure the relay for the earth current settings, time multiplier for earth current & curve number
5. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker P2 by clicking the Breaker icon in the SLD & follow the instructions
7. Click on the Pie section in SLD screen
8. A screen showing the connections of Pie section will appear, Click the create fault screen
9. Select the particular fault (R-G, Y-G, B-G) by clicking the radio button & click apply
10. The relay will trip the Line depending on the phase current setting and the time setting set on the relay.
11. Once the system is tripped reset the relay manually
12. Click the back button & select the test results
13. The test results will display the details regarding the fault current & Nature of fault
14. Repeat the experiment for various phase currents and the time settings in the relay

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result: It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

Simulation of Faults (Remote mode)

L-L Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Click the experiments screen & select the L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Configure the relay for the Phase current settings, time multiplier for Phase current & curve number
5. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker P2 by clicking the Breaker icon in the SLD & follow the instructions
7. Click on the Pie section in SLD screen
8. A screen showing the connections of Pie section will appear, Click the create fault screen
9. Select the particular fault (R-Y, Y-B, R-B) by clicking the radio button & click apply
10. The relay will trip the Line depending on the time setting set on the relay
11. Once the system is tripped reset the relay manually
12. Click the back button & select the test results
13. The test results will display the details regarding the fault current & Nature of fault.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result: It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

Simulation of Faults (Remote mode)

Aim:
Relay sensing and tripping and observe the fault current
Procedure:
1. Click the experiments screen & select the L-L-L Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Configure the relay for the earth current settings, time multiplier for Phase current & curve number
5. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker P2 by clicking the Breaker icon in the SLD & follow the instructions
7. Click on the Pie section in SLD screen
8. A screen showing the connections of Pie section will appear, Click the create fault screen
9. Select the particular fault (R-Y-B) by clicking the radio button & click apply
10. The relay will trip the Line depending on the time setting set on the relay
11. Once the system is tripped reset the relay manually
12. Click the back button & select the test results
13. The test results will display the details regarding the fault current & Nature of fault
14. Repeat the experiment for various time settings in the relay
15. Note the Fault current, Voltage & time to trip for various settings
16. Plot the current vs. time graph
17. After completing the experiment please click close button to close the experiment

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:
It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

Simulation of Faults (Remote mode)

L-L-G Fault

Aim:

Relay sensing and tripping and observe the fault current

Procedure:

1. Click the experiments screen & select the L-L-G Fault button, Configure the system for the particular distance (100th KM, 150th KM, 175th KM)
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Configure the relay for the Phase current setting, time multiplier for Phase current, curve number, Earth current setting, Time multiplier for earth current & curve number
5. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker P2 by clicking the Breaker icon in the SLD & follow the instructions
7. Click on the Pie section in SLD screen
8. A screen showing the connections of Pie section will appear, Click the create fault screen
9. Select the particular fault (R-Y-G, Y-B-G, R-B-G) by clicking the radio button & click apply
10. The relay will trip the Line depending on the time setting set on the relay
11. Once the system is tripped reset the relay manually
12. Click the back button & select the test results
13. The test results will display the details regarding the fault current & Nature of fault
14. Note the Fault current, for various settings

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:

It is observed that relay tripping is based on the current setting and time multiplier setting. It took different time for different current values.

Ferranti Effect (Remote mode)

Aim:

Simulating Ferranti effect in SCADA setup and observe the results

Procedure:

1. Click the experiments screen & select the Ferranti effect button
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Check the Energy meter voltage of Energy meter 2 & Energy Meter 3.
8. Observe the Voltage at receiving end (EM3) and sending end (EM2) of the transmission line.

Observations:

Sl No.	Description	Energy Meter 2	Energy Meter 3
1	Voltage (V)		
	Current (A)		
2	Voltage (V)		
	Current (A)		
3	Voltage (V)		
	Current (A)		

Result:

Ferranti effect is observed in the experiment.

Transmission Line Loading (Remote mode)

Resistive Loading

Aim:

Load the transmission line by a resistive load and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transmission line loading button & select the resistive load button
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 of the load model by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD which shows a variable resistance.
8. Increase the load by rotating the dimmer check the current value in the screen for the receiving end energy meter
9. Click the test results & note the values as shown in the tabular column
10. Repeat the experiment for various current values.

Observations:

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transmission Line Loading (Remote mode)

Inductive Loading

Aim:

Load the transmission line by an inductive load and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transmission line loading button & select the inductive loading button
2. Click the back button after configuring & go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 of the load model by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C5 in the SLD, which shows a variable Inductance.
8. Increase the load by rotating the dimmer for inductance & check the current value in the screen for the receiving end energy meter
9. Click the test results & note the values as shown in the tabular column
10. Repeat the experiment for various current values.

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Inductive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transmission Line Loading (Remote mode)

Resistive and Inductive Loading

Aim:

Load the transmission line by resistive and inductive loads and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transmission line loading button & select the R & L button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD, which shows a variable Resistance.
8. Close the breaker C5 in the SLD which shows a variable Inductance
9. Increase the load by rotating the dimmer for inductance & resistance, check the current value in the screen for the receiving end energy meter
10. Click the test results & note the values as shown in the tabular column
11. Repeat the experiment for various current values. (Max up to 3 A)

Observations:

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive and inductive loading of transmission line for 200km is conducted and observed the voltage and current profiles.

Transformer Loading (Remote mode)

Resistive Loading

Aim:

Load the transformer by a resistive load and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transformer loading button & select the R load button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker C3 of the load model by clicking the Breaker icon in the SLD & follow the instructions
6. Close the breaker C4 in the SLD, which shows a variable Resistance.
7. Increase the load by varying the dimmer positions, check the current value in the screen for the receiving end energy meter
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values. (Max up to 3 A)

Observations:

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive loading of transformer is conducted and observed the voltage and current profiles.

Transformer Loading (Remote mode)

Inductive Loading

Aim:

Load the transformer by an inductive load and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transformer loading button & select the Inductive load button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker C3 of the load model by clicking the Breaker icon in the SLD & follow the instructions
6. Close the breaker C5 in the SLD, which shows a variable inductance.
7. Increase the load by varying the dimmer positions, check the current value in the screen for the receiving end energy meter
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values.

Observations:

Sl No.	Description	Sending end Measurements	Receiving end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Inductive loading of transformer is conducted and observed the voltage and current profiles.

Transformer Loading (Remote mode)

Resistive and Inductive Loading

Aim:

Load the transmission line by resistive and inductive loads and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transformer loading button & select the R & L button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker C3 of the load model by clicking the Breaker icon in the SLD & follow the instructions
6. Close the breaker C4 in the SLD, which shows a variable resistance.
7. Close the breaker C5 in the SLD, which shows a variable inductance.
8. Increase the load by varying both the dimmer positions (resistance & inductance), check the current value in the screen for the receiving end energy meter
9. Click the test results & note the values as shown in the tabular column
10. Repeat the experiment for various current values. (Max up to 3A at the receiving end)

Observations:

Sl No.	Description	Incomer Measurements	Sending end Measurements
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Resistive and inductive loading of transformer is conducted and observed the voltage and current profiles.

VAR Compensation (Remote mode)

Series Compensation

Aim:

Study of series Var compensation at different points of transmission network and observe the comparison

Procedure:

1. Click the experiments screen & select the VAR compensation button & select the Series compensation
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD, which shows a variable Resistance.
8. Close the breaker C5 in the SLD which shows a variable Inductance
9. Increase the load by rotating the dimmer for inductance & resistance, check the current value in the screen for the receiving end energy meter
10. Click the test results & note the values as shown in the tabular column
11. Open the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions

For Sending End compensation

12. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to the input pins of the 1st pie section using cables provided. (Note: Phase lines should not be interchanged) *For Receiving End compensation*
13. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins of 1st pie section & connect the O/p of 4th Pie to 5th Pie I/p & so on up to 8th Pie O/P. Connect the 8th Pie O/p to input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to the 3 Phase output pins of the PI section using cables provided. (Note: Phase lines should not be interchanged)

For Mid Point compensation

14. In the transmission model Connect the 3 Phase supply (R-Y-B) to the corresponding Input pins of 1st PI section & connect the O/p of 4th Pie to input pins I1, I2, I3 respectively & connect the O/p O1, O2, O3 to 5th Pie I/p and all other PI sections should be connected in series & so on up to 8th Pie O/P & to the end pins of the pie section using cables provided. (Note: Phase lines should not be interchanged)
15. Close the Breaker P2 by clicking the Breaker icon in the SLD & follow the instructions after connecting the cables by selecting any of the compensations
16. Compare the values for different compensations with out changing the load.
17. Click the test results & note the values as shown in the tabular column.

Observations:

S No.	Description	Before Compensation		Sending end Compensation		Mid point Compensation		Receiving End compensation	
		Sending	Receiving	Sending	Receiving	Sending	Receiving	Sending	Receiving
1	Voltage (V)								
2	Current (A)								
3	Power (W)								
4	VAR								
5	Power Factor								

Result:
Var compensation at different of transmission line is simulated and observed the voltage and current profiles.

Shunt Compensation (Regulation of bus voltage)

Aim:

Study of shunt Var compensation at different points of transmission network and observe the bus voltage.

Procedure:

1. Click the experiments screen & select the VAR Compensation button & select the Shunt Compensation
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD, which shows a variable Resistance.
8. Close the breaker C5 in the SLD which shows a variable Inductance and vary the corresponding dimmer so that the energy meter shows a lagging PF
9. Close the breaker C6 in the SLD which shows a mains capacitance branch with 10 breakers
10. Close the breakers in the branch carefully one by one until the power factor is compensated for a value up to .99 lagging (ie. unity power factor) (Note: Don't close all the capacitance breakers simultaneously as it will imbalance the complete system)
11. Click the test results & note the values as shown in the tabular column
12. Repeat the experiment for various current values. (Max up to 3 A)

S No.	Description	Receiving end Measurements	
		Before	After
1	Voltage (V)		
2	Current (A)		
3	Power (W)		
4	VAR		
5	Power Factor		

Result:

Shunt Var compensation is simulated in the system and bus voltage profile is observed.

Sudden Load Rejection (Remote mode)

Aim:

Apply the sudden load rejection to the transmission network and observe the voltage profiles.

Procedure:

1. Click the experiments screen & select the Transmission line loading button & select the R & L button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD, which shows a variable Resistance.
8. Close the breaker C5 in the SLD which shows a variable Inductance
9. Increase the load by varying the dimmer positions for inductance & resistance, check the current value in the screen for the receiving end energy meter
10. Open the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
11. Click the test results & note the values as shown in the tabular column
12. Repeat the experiment for various current values. (Max up to 2 A)

Observations:

S No.	Description	Receiving end Measurements	
		Before c3 open	After c3 open
1	Voltage (V)		
	Current (A)		
2	Voltage (V)		
	Current (A)		

Result:

Sudden load rejection is applied to the transmission network and the voltage profile is observed.

Operation of OLTC Transformer (Remote mode)

Aim:

Study the operation of OLTC transformer and observe the voltage regulation at sending end

Procedure:

1. Click the experiments screen & select the OLTC button
2. Click the back button & after configuring go to the main screen
3. Close the Incomer C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Breaker C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Breaker P2 for panel 2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Breaker C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the breaker C4 in the SLD, which shows a variable Resistance.
8. Close the breaker C5 in the SLD which shows a variable Inductance
9. Increase the load by varying the dimmer positions for inductance & resistance, check the current value in the screen for the receiving end energy meter
10. Once the load current is increased, the voltage will decrease then increase voltage by changing the tap position of the transformer. Click the tap button above the transformer symbol. A popup screen will appear, Raise the tap to increase the voltage/tap position or lower it to reduce the voltage at lower loads
11. Click the test results & note the values as shown in the tabular column

Observations:

Sl.No.	Tap position	Sending end voltage (v)
1		
2		
3		
4		
5		

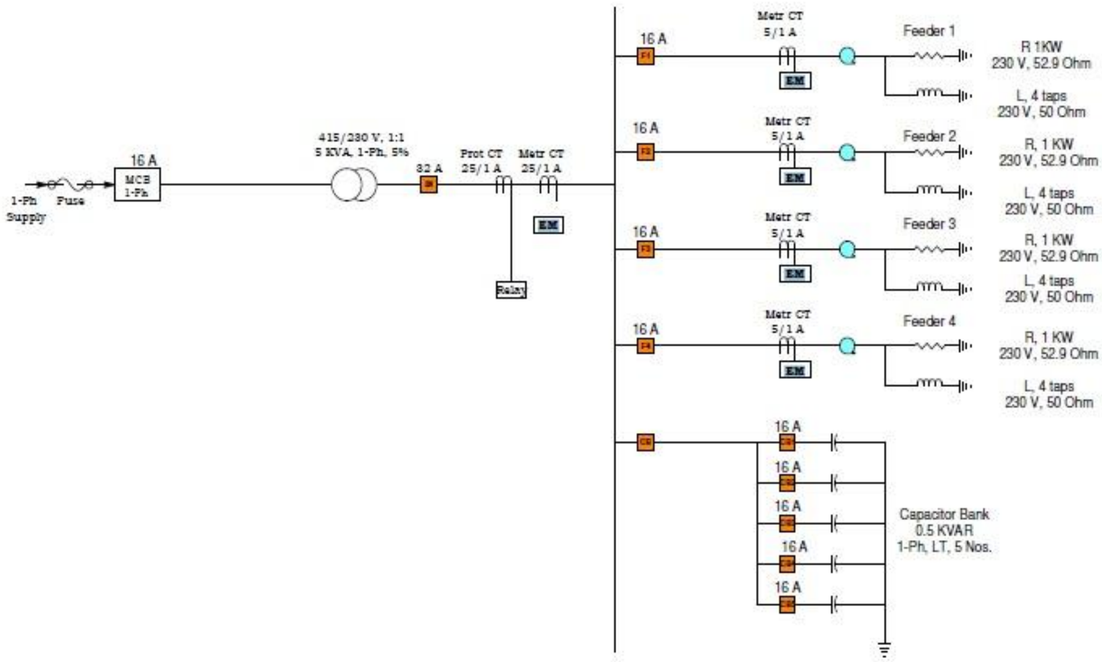
Result:

Operation of OLTC transformer is studied and voltage regulation at the sending end is observed

EXPERIMENTS ON DISTRIBUTION MODULE

Experiment Setup - Distribution Module

11 KV Distribution Model



overview- Distribution Model

The following experiments can be done using the Distribution Model

1. Relay Coordination
2. PF Control\Voltage Regulation
3. Transformer Loading
4. Demand side management

These experiments can be done in two modes i.e., Remote Mode and Local Mode.

Common Procedure to All Experiments:

1. Assemble Distribution Model.
2. Keep the Local/Remote selector in Local Position.
3. Keep the Emergency Push buttons in released condition.
4. Switch on the supply to the module by closing the MCB
5. Configure the Incomer relay for the current setting, time multiplier and curve number for Phase current & Earth fault current.

6. Configure the Feeder relay for the current setting, time multiplier and curve number for Phase current & Earth fault current
7. Switch on the SCADA system & enter your login ID for observing the real Trends
8. Click the real trend icon on the main screen and select the parameters to observe with the select pen option provided at the right side of the screen.

Precautions:

1. Once an experiment is selected in the SCADA system until it is completed and stopped by clicking the stop button we shouldn't click the main screen.
2. While closing the Circuit breaker make sure that the status of the breaker icon is updated before going to close the next breaker (Vertical line on the breaker will be changed to horizontal line)
3. Whenever a question mark (?) appears on the breaker icons, wait till the status is updated without disturbing it, because it's the problem of communication.
4. Always click the STOP button before going to the next experiment.

Local Mode Experiments

Relay Co-ordination (Local mode)

Aim:
Configure the protection relays to trip the circuit during overloading
Procedure:
1. Close the Sec contactor C1 (main incomer) by pressing the ON push button (Green)
2. Close the Feeder contactor F1 by pressing the ON push button.
3. Close the Feeder contactor F2 by pressing the ON push button.
4. Close the Feeder contactor F3 by pressing the ON push button.
5. Close the Feeder contactor F4 by pressing the ON push button.
6. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter as well as in the SCADA.
7. The relay will trip the Line depending on the time setting set on the relay & the overload.
8. The relay which have the lower current setting will trip first
9. The time settings can be synchronized in such a way that the feeder relay will pick up for over load & the secondary relay will trip based on the overload condition
10. The test results will display the details regarding the fault current & Nature of fault
11. Repeat the experiment for various time settings in the relay
12. Note the Fault current, Voltage & time to trip for various settings
13. Plot the current vs. time graph
14. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding breakers provided on the module.

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:
Relay co-ordination is simulated and observed.

PF Control/Voltage Regulation

Aim:

Observe the voltage profile & PF at incomer and feeder side

Procedure:

1. Close the Sec contactor C1 (main incomer) by pressing the ON push button.
2. Close the Feeder contactor F1 by pressing the ON push button.
3. Close the Feeder contactor F2 by pressing the ON push button.
4. Close the Feeder contactor F3 by pressing the ON push button.
5. Close the Feeder contactor F4 by pressing the ON push button.
6. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter as well as in the SCADA.
7. Close the Capacitor Bank Contactor by pressing the ON push button of Capacitor bank main
8. Note the PF & Voltage of the secondary side energy meter & the feeders
9. Close the Capacitor Bank branch Contactor one by one by pressing the ON push button of CB1, CB2, CB3, CB4, and CB5. (Note: don't switch on all the capacitor banks, check the Pf profile accordingly switch on the capacitor banks based on the load)
10. The test results will display the details regarding Current, Voltage & PF
11. Repeat the experiment for various Load currents
12. Click the test results & note the values as shown in the tabular column
13. Repeat the experiment for various current values. (Max up to 3 A)
14. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding breakers.

Observations:

S No.	Description	Incomer Measurements	Feeder (1,2,3,4) Measurements	Remarks
1	Voltage (V)			
2	Current (A)			
3	Power (W)			
4	VAR			
5	Power Factor			
6	VA			

Result:

By using capacitor banks, pf can be adjusted and voltage regulation can be obtained.

Transformer Loading (Local mode)

Aim:

Load the transformer by increasing the feeder loads and observe voltage and current profile

Procedure:

1. Close the Sec contactor C1 by pressing the ON push button.
2. Close the Feeder contactor F1 by pressing the ON push button.
3. Close the Feeder contactor F2 by pressing the ON push button.
4. Close the Feeder contactor F3 by pressing the ON push button.
5. Close the Feeder contactor F4 by pressing the ON push button.
6. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter as well as in the SCADA.
7. Repeat the experiment for various Load currents
8. Click the test results & note the values as shown in the tabular column
9. Repeat the experiment for various current values. (Max up to 3 A)
10. After completing the experiment please de-energize/open all the breakers by pressing the OFF push button of the corresponding breakers.

Observations:

S No.	Description	Incomer Measurements	Feeder Measurements	Remarks
1	Voltage (V)			
2	Current (A)			
3	Power (W)			
4	VAR			
5	Power Factor			
6	VA			

Result:

Transformer is loaded with the feeder and voltage and current profiles are observed.

Remote Mode Experiments

Relay Co-ordination (Remote mode)

Aim:
Configure the protection relays to trip the circuit during overloading
Procedure:
1. Click the experiments screen & select the Relay coordination, Configure the system
2. Click the back button after configuring & click the start button
3. Close the Sec contactor C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Feeder contactor C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Feeder contactor C3 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Feeder contactor C4 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the Feeder contactor C5 by clicking the Breaker icon in the SLD & follow the instructions
8. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter.
9. The relay will trip the Line depending on the time setting set on the relay & the overload.
10. The relay which have the lower current setting will trip first
11. The time settings can be synchronized in such a way that the feeder relay will pick up for over load & the secondary relay will trip based on the overload condition
12. The test results will display the details regarding the fault current & Nature of fault
13. Repeat the experiment for various time settings in the relay.
14. Note the Fault current, Voltage & time to trip for various settings
15. Plot the current vs. time graph
16. After completing the experiment, click close button to close the experiment

Observations:

Sl No	Current (%)	Time(sec)	Voltage
1			
2			
3			

Result:
Relay co-ordination is simulated and observed.

PF Control/Voltage Regulation (Remote mode)

Aim:

Observe the voltage profile & PF at incomer and feeder side

Procedure:

1. Click the experiments screen & select the PF\ Voltage Regulation, Configure the system
2. Click the back button after configuring & click the start button.
3. Close the Sec contactor C2 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Feeder contactor C3 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Feeder contactor C4 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Feeder contactor C5 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the Feeder contactor C6 by clicking the Breaker icon in the SLD & follow the instructions
8. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter
9. Close the Capacitor Bank Contactor by clicking the Breaker icon in the SLD & follow the instructions
10. Note the PF & Voltage of the secondary side energy meter & the feeders
11. Close the Capacitor Bank branch Contactor one by one by clicking the Breaker icon in the SLD & follow the instructions. The test results will display the details regarding Current, Voltage & PF. Click the test
12. Repeat the experiment for various current values. (Max up to 3 A)

Observations:

S No.	Description	Incomer Measurements	Feeder (1,2,3,4) Measurements	Remarks
1	Voltage (V)			
2	Current (A)			
3	Power (W)			
4	VAR			
5	Power Factor			
6	VA			

Result:

By using capacitor banks, pf can be adjusted and voltage regulation can be obtained.

Transformer Loading (Remote mode)

Aim:

Load the transformer by increasing the feeder loads and observe voltage and current profile

Procedure:

1. Click the experiments screen & select the Transformer loading, Configure the system
2. Click the back button after configuring & click the start button.
3. Close the Sec contactor C1 by clicking the Breaker icon in the SLD & follow the instructions
4. Close the Feeder 1 contactor C2 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Feeder 2 contactor C3 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Feeder 3 contactor C4 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the Feeder 4 contactor C5 by clicking the Breaker icon in the SLD & follow the instructions
8. Increase the load by varying the dimmer positions slowly for all the feeders & monitor the load current in the energy meter
9. Repeat the experiment for various Load currents
10. Click the test results & note the values as shown in the tabular column
11. Repeat the experiment for various current values. (Max up to 3 A)
12. After completing the experiment please click close button to close the experiment

Observations:

S No.	Description	Incomer Measurements	Feeder (1,2,3,4) Measurements	Remarks
1	Voltage (V)			
2	Current (A)			
3	Power (W)			
4	VAR			
5	Power Factor			
6	VA			

Result:

Transformer is loaded with the feeder and voltage and current profiles are observed.

Demand Side Management (Remote mode)

Aim:

Apply demand side management in the present system and observe the load management results

Procedure:

1. Click the experiments screen & select the Demand side Management (Load management), Configure the system
2. In the configuration screen select the different priorities for different feeders (1- 4).
3. Click the back button after configuring & click the start button.
4. Close the Sec contactor C1 by clicking the Breaker icon in the SLD & follow the instructions
5. Close the Feeder 1 contactor C2 by clicking the Breaker icon in the SLD & follow the instructions
6. Close the Feeder 2 contactor C3 by clicking the Breaker icon in the SLD & follow the instructions
7. Close the Feeder 3 contactor C4 by clicking the Breaker icon in the SLD & follow the instructions
8. Close the Feeder 4 contactor C5 by clicking the Breaker icon in the SLD & follow the instructions
9. Rotate the dimmer slowly for all the feeders & monitor the load current in the energy meter
10. Once the load is increased greater than the secondary feeder the least priority feeder will tripto c ompensate the overload.
11. Repeat the experiment for various Load currents
12. Click the test results & note the values as shown in the tabular column
13. Repeat the experiment for various current values. (Max up to 3 A)
14. After completing the experiment please click close button to close the experiment

Observations:

S No.	Description	Incomer Measurements	Feeder (1,2,3,4) Measurements	Remarks
1	Voltage (V)			
2	Current (A)			
3	Power (W)			
4	VAR			
5	Power Factor			
6	VA			

Results:

Demand side load management strategy is observed.