CONTROL SYSTEMS

LAB

List of experiments

1. Characteristics Magnetic Amplifier
2. DC position control systems
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4. Synchro Transmitter Receiver
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`Magnetic Amplifier

Experiment

Objective:-

To study Self exited, Series, Parallel, and Bridge type Magnetic amplifier.

Apparatus Required:-

a) Magnetic amplifier study unit.

b) 250 0hms/1A Rheostat

Technical Description:-

1.	ON/OFF	:	Power ON/OFF switch to the circuit with indicator.
2.	Fuse	:	2A glass fuse for Bias Voltage source protection.
3	Saturable Reactor	:	500mA max current.
	a) CW	:	Control Winding.
	b) FW	:	Feed back winding.
	c) BW	:	Bias Winding.
	d) LW_1	:	Load Winding 1.
	e) LW_2	:	Load Winding 2.
4.	Input Transformer	:	230V/50-100V @ 500mA step down transformer for AC supply.230V/5V @ 500mA step down transformer for AC supply to load winding for preliminary test at low voltage.
5	D_1, D_2, D_3 & D_4 ,D_5,D_6	:	6A/600V Diodes.
6.	I_C (mA)DC	:	3 ½ digit DC Ammeter to measure control winding current.
7.	I_L (mA)AC	:	3 ½ digit AC Ammeter to measure Load Current.
8.	V_C – Control Voltage	:	0-24 V @200mA variable DC supply to vary the control current.
	a) ON	:	ON/OFF switch for control supply.
	b) +VE -VE	:	Switch to change the polarity of control supply.
9.	V_B – Bias Voltage	:	1.5V to 15V @ 250mA variable DC supply to vary the Bias Current.
	a) ON	:	ON/OFF Switch for Bias Voltage supply.

Operation instruction for magnetic amplifier

I. Applications:

The Magnetic Amplifier and its similar version the saturable reactor have been in use as control devices for the past three decades on account of the following advantages:

a) Rugged and simple constructions.

b) No warm up time required.

c) High Efficiency.

d) Isolation between the input and output.

e) No heavy DC power source is required.

f) They can be designed to deliver enormous power outputs.

g) Magnetizing of signals is possible with complete isolation between source. They find numerous applications in devices such

(a) Measurement of large DC currents;

(b) Controlled drive of AC and DC motor;

(c) Alternator Voltage Regulators;

(d) Relay Amplifier:

(e) Measurement of low DC current;

(f) Servo Amplifiers.

II. Introductions:

The Basic unit which goes into a Magnetic Amplifier is the saturable reactor. The saturable reactor carries a Load Winding which is excited with an AC Voltage.

The Excited level is adjusted such that the variation in flux in the core taken its boundaries between the knees of the BH curve. The second winding is the control winding to which DC is supplied causing the core to saturable during part of the half cycle due to additional magnetizations. When no DC is applied to the second winding the core flux variation are within saturations limits and hence the

current drawn from AC supply by the load winding will only be the magnetizing current, since DC voltage is applied at a particular instance in the half cycle. Under these conditions, the importance of the AC winding reduces almost zero.

Hence, when a load is connected in series with load winding the entire supply voltage appears across the load. The shape of the current is chopped since wave, it can be readily reckoned with the higher DC current in the control winding. The core will saturate earlier in the half cycle delivered to the load is possible in the above arrangements, it suffers from the disadvantages with the EMF is introduced in the control winding due to transformer motion. The second advantage is that the output is delivered only during one half cycle.

To overcome these advantages, the two core constructions is adopted such that the load winding when connected in either series or in parallel cause no EMF to be induced in the control winding by transformer.

Description :

Small electron tube and transistors, by themselves are not sufficient to control larger AC circuits. Using a magnetic device such as saturable reactor in association with these active components, a large AC load (of upto hundred of amperes and kilowatts) may be controlled by a small direct current (part of an ampere).

The saturable reactor is the connecting link and acts as a large power amplifier, and by itself can serve as a low gain amplifier of large loads. The usefulness of this magnetic device can be greatly increased by the addition of rectifiers in the output circuit; and this combination for saturable reactor with rectifiers is called a half saturable amplifier of magnetic Amplifier.

The part played by a saturable reactor in a circuit, when it is connected in series with a load across an AC power supply, is that of a variable inductance. It consists of two or more windings around a core of steel, one of these windings received a small direct current which acts as an input signal that controls the amount of AC that can flow through the other winding and the load. The reactor can have a single core and only on AC winding or load winding in which case the alternating current in the load winding produces an objectionable AC voltage in the control winding that may disturb or damage the DC control circuit. Also, the output will be delivered only during one half cycle. To overcome these drawbacks, most saturable reactors include two identical steel cores. Each core has its own winding, while the DC coil surrounds on leg of each core. Here the two load windings can be connected in Parallel or in series; but the connections to one of the coils reversed to meet the above objections. When the gate winding of the reactor is excited with an AC voltage during one half cycle varying flux cycle is caused in the upper core. This excitation is adjusted such that the core flux variation is within the upper knee ofthe RR curve (i.e. Within the saturation limits) and hence the current drawn by the gate winding will only be the magnetizing current.

If now a small direct current is passed through the control winding, a steady amount of flux will be added to the above varying flux.

And the total flux in the upper core varies along with flat portion of the magnetization curve during the entire half cycle, the core is almost completely

saturated. Such a small change of flux causes no little inductance in the steel core that nearly all the supply voltage appears across the load and the load current approaches its largest value. At the same time the lower core which is in parallel with the upper core is not saturated during this same half cycle. By increasing the DC control signal further one can force each core to be saturated during both half cycles. Since both cores are now saturated at all time, the load current becomes maximum. Thus, as the DC control current is increased from a low value, the core will saturate earlier in the half cycle thus delivering more current to the load.

Saturable Reactor Modified Into Magnetic Amplifier

The above saturable reactor is modified by adding a silicon diode in series with each of its gate winding on upper core, current now can flow in the gate winding and through the load only when a particular supply terminal is positive. Current flows inthe lower core gate winding and the load only when the other terminal is negative. Thus the load received both half cycle of alternative currents but each core is magnetizing by only half a cycle of current. When AC power is connected to the circuit the initial flux produced in the upper core during the one half cycle, due to small magnetizing current, will not be reset during the opposite half cycle because rectifier diode blocks the current. The action continues in the first few cycles and the flux in the upper coregents added up and will be so high that it operates along the flat portion of the magnetizing curve through out the entire half cycle. Then the upper core will be saturated so that the coil inductance had decreased greatly; the saturable reactor now has such low impedance that a large AC flows through the load. Meanwhile, similar action during the alternate half cycle has saturated the lower core. Thus the saturable reactor in combination with the rectifiers had become self saturated without the influence of direct current in the control winding.

Dc Control : When the reactor is in this self saturated condition the load may be receiving a specific amount of alternating current.This amount can be varied by passing a small direct current through the control winding. If the direction of this DC is such that it produces a flux that assists the flux produced by the gate winding then the combined flux drives the cores into more complete saturation, there by increasing the load current to its largest value. Instead, as generally employed if the DC direction is such that, the

DC flux produced opposite the gate winding fluxes, the amount of direct current in the control winding is increased, the resultant flux is decreased and the core is less saturated. The important point is this: where as in a saturable reactor, a large control current can drive the core into saturation, in a self saturated amplifier only a few milliamps are needed to drive the same core out of saturation. Thus the gain produced by this self saturated reactor is much greater than the gain of the saturable reactor alone.

Bias Winding : It is observed in the above case that the DC input must decrease to cause greater load current. Both the load current and the control signal can be made to increase together by making use of an additional winding called as base winding provided in the Truohm Magnetic Amplifier. A separate DC supply is given to bias winding such that the direct flux due to this winding oppose the flux due to a DC winding to such an extent that the whole reactor becomes unsaturated. Now if the polarity of the direct current to the control winding is reversed that the direct flux produced in the core assists the gate winding flux, then the load can be increased from its minimum by the amperes turns of the bias winding, the zero current point of the control winding can be moved to any desired point on the curve of AC load current.

Feedback Winding*:* Feedback winding has been included in the Truohm Magnetic Amplifier to provide whether positive or negative feedback. When the feedback winding is connected into the load circuit such that flux produced by the load current passing through the feedback winding assists the flux of the control winding due to DC through

it, so that the total flux becomes larger than further increasing the load current this action is called positive feedback. The effect of positive feedback is to increase the value of load current at a particular value of control current from the without feedback. Also, it is seen that the positive feedback causes the characteristics curve to become steeper, thus providing increased gain but less linearity decreases stability and slower response. If the feedback winding connections are reserved, then the flux due to this winding opposes the flux of the control winding. Thus as the control current increases there by increasing the load current, the feedback flux offsets or prevents some of this action is called negative feedback. The effect of negative feedback is to increase the value of the load current at a particular value of control current from that without feedback. The characteristics curve shows that the current gain of a Megamp has been decreased because of the negative feedback. Negative feedback provided a more linear output greater stability and faster response.

The above facts can be observed in the ideal graph enclosed.

Abbreviations:

Abbreviations used on the front panel:

LW : Load Winding CW : Control Winding BW : Bias Winding

FW : Feedback Winding

Polarity Marking:

Polarity Marking of all windings are clearly indicated on the front panel. Circuit connections for the various circuits are given in the drawings. If connections are according to the diagram, the polarities of the CW, BW, FW are such that the DC current will aid auto excitation when passing from positive terminals to negative terminal.

Caution:

- Use the AC voltage available on the panel to excite the megamp. A Step down transformer is provided on the megamp to furnish the desired Ac voltage.
- Make use of the voltage of 5V to check the connections of the load winding. The voltage induced in the control winding should be small.
- Do not exceed the output rating and the maximum current permissible in the control winding (100mA) load winding is rated at approximately 2A.
- Ensure that the load impedance is not less that the limit permissible. The limit permissible is defined by the limits on current as stated above.

Experiment

Objective:-

Several experiments can be performed by the students using the Magnetic Amplifier.

These include the following experiments:

Series Connected Magnetic amplifier Parallel connected Magnetic amplifier Self excited

Bridge type DC output without feedback, with negative feedback and with positive feedback.

Apparatus:-

The Magnetic amplifier experiments require a load resistance. AC voltage as already stated are furnished on the front panel. To the control current requires a DC ammeter, IL the load current required an AC ammeter for all experiments.

Procedure : -

a) **Procedure for Self exited MAGNETIC AMPLIFIER :-**

1. Connect the circuit as shown in fig. Externally with the help of patch cords. Take care of the polarity of the windings.
2. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
3. Connect the load resistor (250 Ohms rheostat) and load current meter. (0-2A AC) as shown in fig.
4. Vary control winding current IC in steps and record corresponding load current I_L.
5. Reverse the polarity (+ to -) in the DC power supply to the control winding and Vary control winding current IC in steps of -1ma and record corresponding load current IL.
6. Plot the graph of I_C v/s I_L in each case.
7. Repeat the above procedure for different values of R_L.
8. Connect V_B- bias voltage in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and polarity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current .

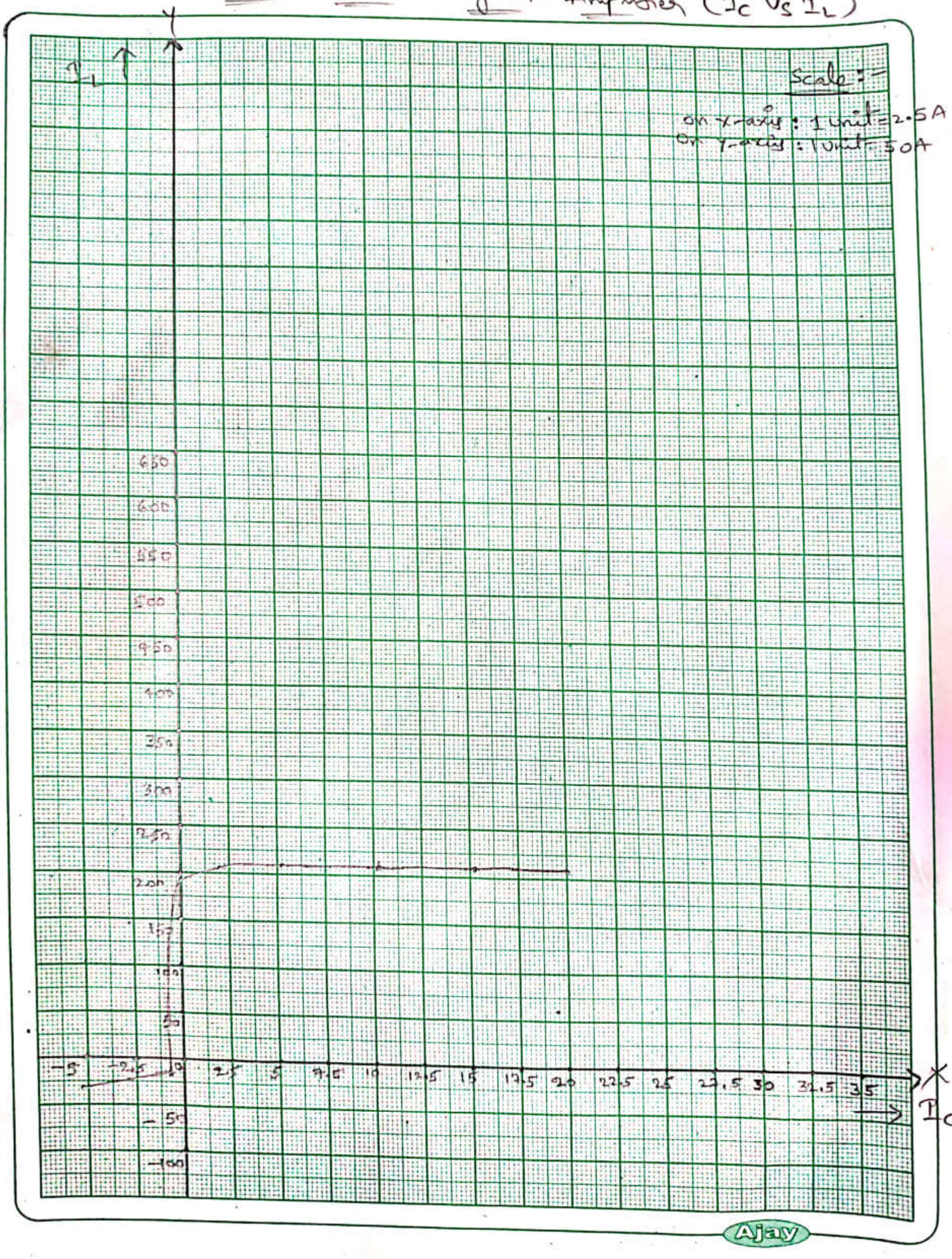
Tabular column for self exited Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliamps
1	0	193
2	2	204
3	5	206
4	10	208
5	15	208
6	20	208
7	25	209
8	-0.6	14
9	-5	30
10	-6	34
11	-10	51

Note: At 208mA the core is saturated. That value will be repated.

MODEL GRAPH:

Self-Excited Magnetic Amplifier (I_C Vs I_L)



b) Procedure for Series Connected MAGNETIC AMPLIFIER for AC output:-

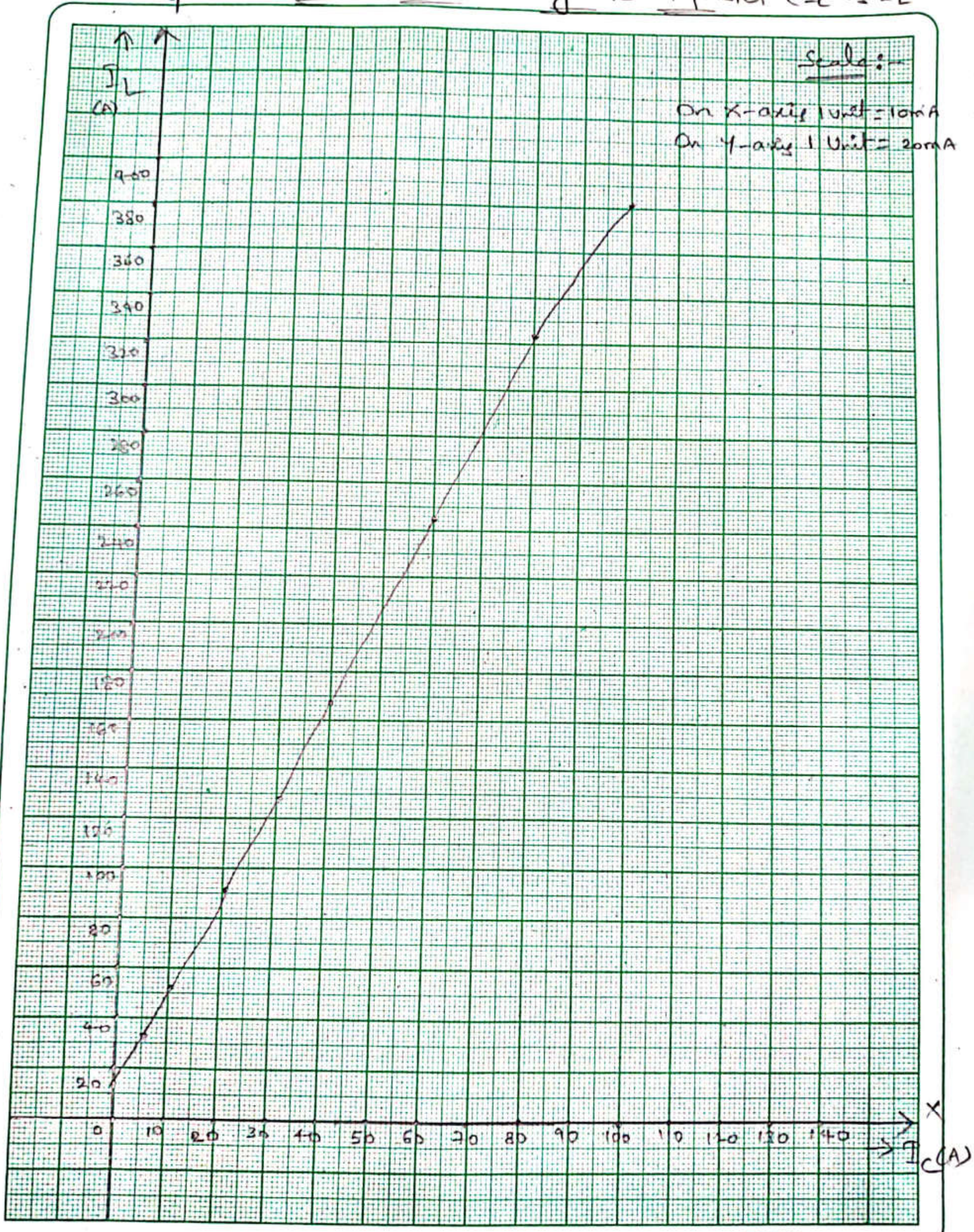
1. Connect the circuit as shown in the fig externally with the help of patch cords. Take care of the polarity of the winding.
2. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
3. Connect the load resistor ((250 Ohms rheostat) and load current meter (0-2A AC) as shown in fig.
4. Vary control winding current I_C in steps and record corresponding load current I_L.
5. Plot a graph of I_C v/s I_L in each case.
6. Repeat the above procedure for different values of R_L.
7. Connect V_B-Bias voltage in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and polarity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current .

Tabular column for series connected Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliAmps
1	0	14
2	5	30
3	10	52
4	20	91
5	30	128
6	40	167
7	60	245
8	80	324
9	100	382

MODEL GRAPH:

Series Excited Magnetic Amplifier (I_C Vs I_L



c) **Procedure for Parallel Connected MAGNETIC AMPLIFIER:-**

1. Connect the circuit as shown in the fig externally with the help of patch cords. Take care of the polarity of the winding.
2. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
3. Connect the load resister ((250 Ohms rheostat) and load current meter (0-2A AC) as shown in fig.
4. Vary control winding current I_C in steps and record corresponding load current I_L.
5. Plot a graph of I_C v/s I_L in each case.
6. Repeat the above procedure for different values of R_L.
7. Connect V_B-Bias voltage in series with the bias winding vary the bias voltage and that by the adjustment of bias voltage and polarity the zero current point of the control winding can be moved to any desired point on the curve of the AC load current .

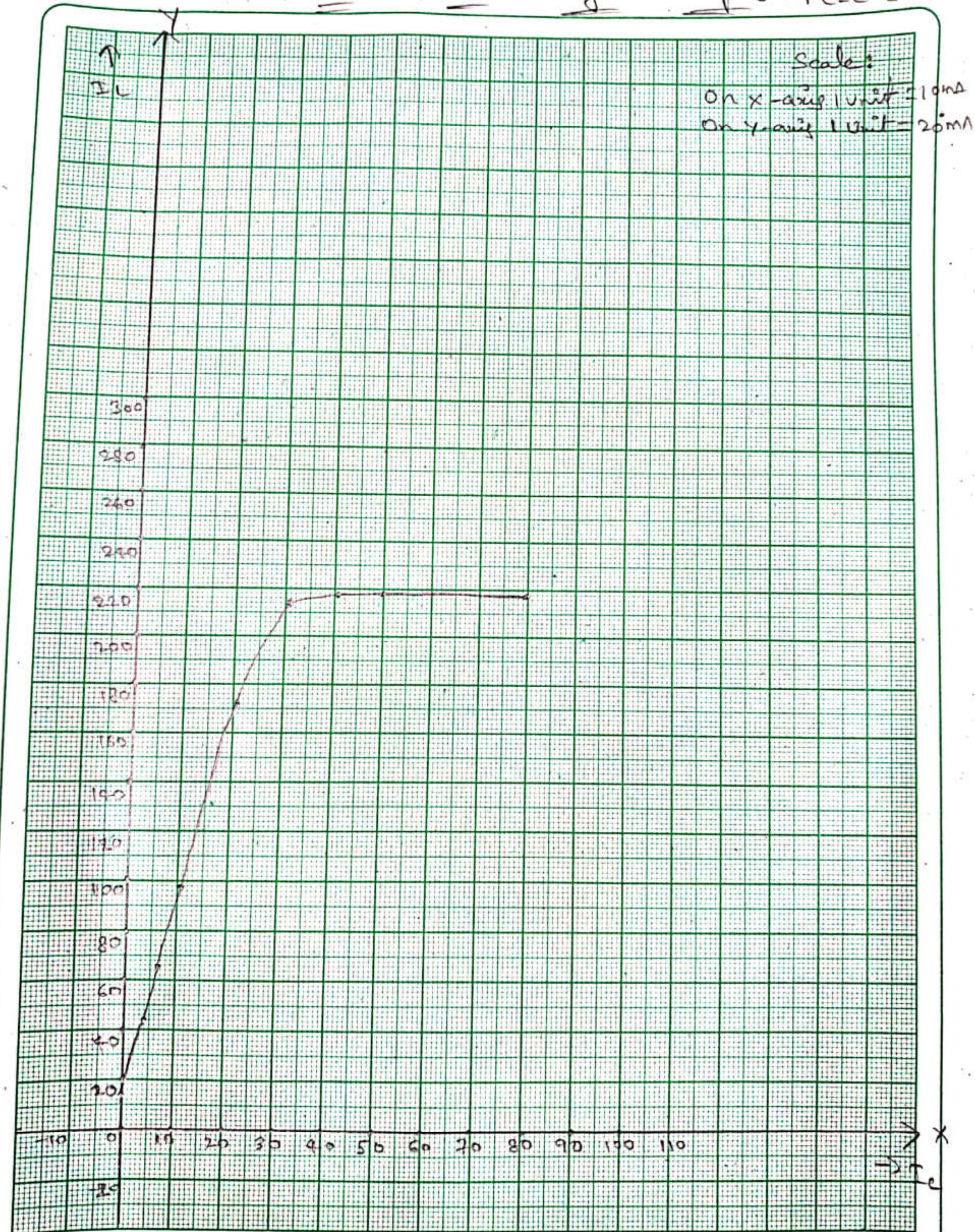
Tabular column for Parallel connected Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliAmps
1	0	14
2	4	44
3	6	65
4	10	98
5	20	173
6	30	214
7	40	216
8	50	218
9	80	218

Note: At 218mA The core is saturate

MODEL GRAPH: .

Parallel Excited magnetic Amplifier (I_c Vs I_L)



d) Procedure for Bridge type connected magnetic amplifier with out feed back:-

1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding. Connect the diodes as in circuit diagram.
2. Do not connect Feed back winding in the circuit.
3. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
4. Connect the load resister ((250 Ohms rheostat) and load current meter (0-2A AC) as shown in fig.
5. Vary control winding current I_C in steps and record corresponding load current I_L.
6. Reverse the polarity (+ to -)in the DC power supply to the control winding and Vary control winding current IC in steps of -1ma and record corresponding load current I_L.
7. Plot a graph of I_C v/s I_L in each case.
8. Repeat the above procedure for different values of R_L.

Tabular column for Bridge type connected magnetic amplifier with out feed back Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliAmps
1	0	390
2	1.5	410
3	2.5	413
4	5	415
5	10	417
6	-1.5	32
7	-5.5	68
8	-8	85
9	-11	113

e) **Procedure for Bridge type connected magnetic amplifier with Positive feed back:-**

1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding. Connect the diodes as in circuit diagram.
2. Connect Feed back winding in the circuit as shown in circuit diagram.
3. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
4. Connect the load resister ((250 Ohms rheostat) and load current meter (0-2A AC) as shown in fig.
5. Vary control winding current I_C in steps and record corresponding load current I_L. 6.Reverse the polarity (+to-)in the DC power supply to the control winding and Vary control winding current IC in steps of -1ma and record corresponding load current IL.
7. Plot a graph of I_C v/s I_L in each case.
8. Repeat the above procedure for different values of R_L.

Tabular column for Bridge type connected magnetic amplifier with positive feed back Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliamps
1	0	409
2	1	410
3	4.5	413
4	6	414
5	10	414
6	-1.5	31
7	-2	36
8	-5	59
9	-7.5	80
10	-10	96

f) Procedure for Bridge type connected magnetic amplifier with Negative feed back:-

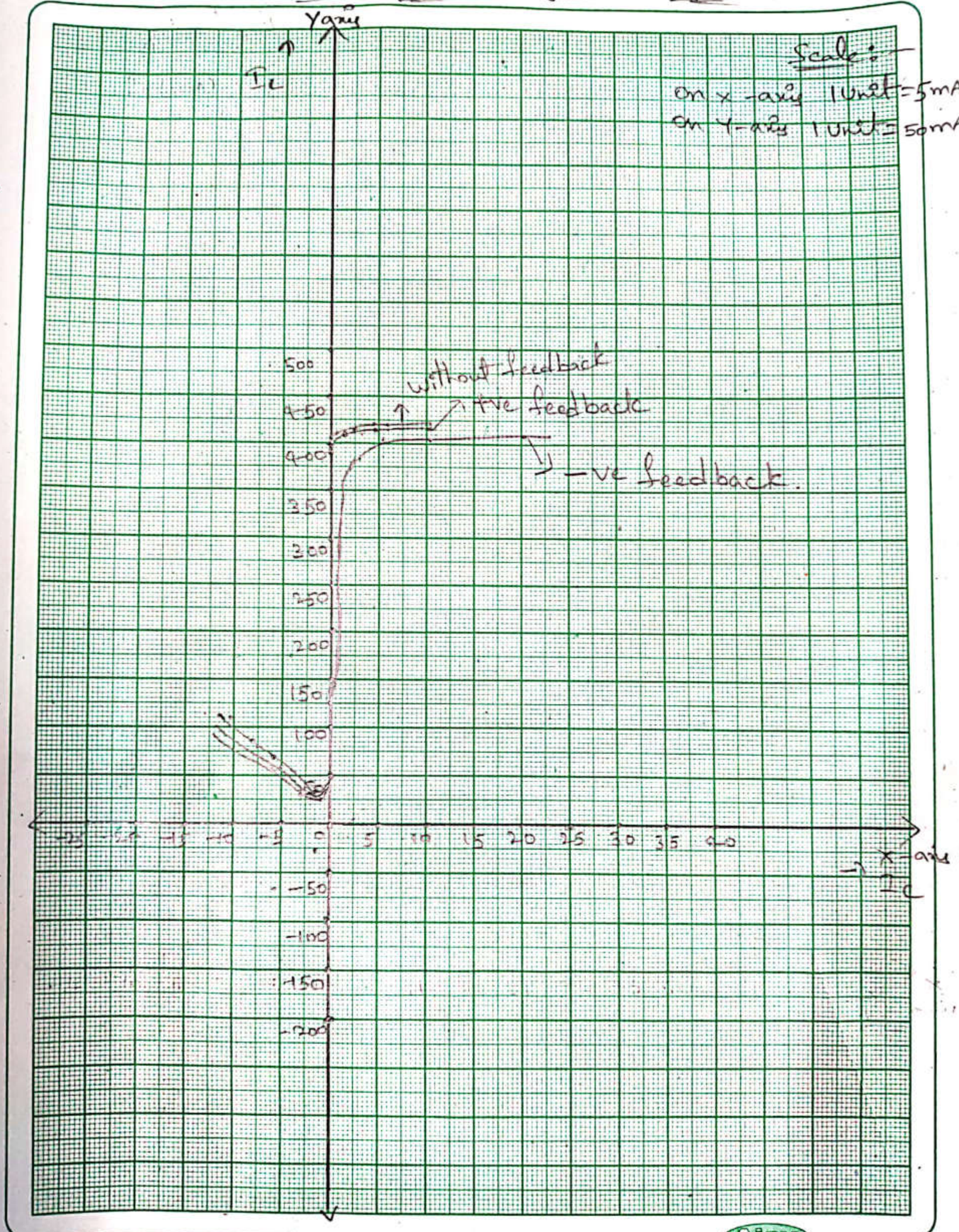
1. Connect the circuit as shown in the fig. externally with the help of patch cords. Take care of the polarity of the winding. Connect the diodes as in circuit diagram.
2. Interchange the polarity of Feed back winding in the circuit as shown in circuit diagram for negative feedback.
3. Connect V_c –Control voltage supply with DC current meter (0-200mA) in series with the control winding.
4. Connect the load resister ((250 Ohms rheostat) and load current meter (0-2A AC) as shown in fig.
5. Vary control winding current IC in steps and record
6. corresponding load current I_L. 6.Reverse the polarity (+ to -)in the DC power supply to the control winding and Vary control winding current IC in steps of -1ma and record corresponding load current I_L.
7. Plot a graph of I_C v/s I_L in each case.
8. Repeat the above procedure for different values of R_L.

Tabular column for Bridge type connected magnetic amplifier with negative feed back Magnetic amplifier:-

Sl No.	I_c (Control winding current) DC in milliamps	I_L(Load winding current) AC in milliAmps
1	0	125
2	2.5	376
3	3	385
4	5.5	407
5	10.5	411
6	20.5	412
7	-0.5	25
9	-2.5	45
10	-5.5	70
11	-10	111

MODEL GRAPH:

Bridge type magnetic Amplifier



Result:- Performance of magnetic amplifier is studied experimentally.

DC POSITION CONTROL SYSTEM

Experiment

Objective:-
To study the performance characteristics of a DC motor angular position Control system.

Introduction:
Angular position control using a D.C motor forms a fine example of feed back controlled system. A D.C. motor whose speed can be varied by application of various voltages is used through an appropriate gear drive to rotate a shaft. The angular position of the shaft is sensed using an . appropriate sensor, and depending on the set value and the measured value of the angular position, an error voltage is obtained which is amplified and fed back to control the motor. when in equilibrium,
the shaft position will correspond to the angular position dictated by the set value. However, in this simple feedback system, the performance of the system will be highly under damped, and as a result, the system will take a long time to come to stable shaft position. As theory shows, it is advantageous to use either tachometric feedback or derivative feedback to increase the damping of the system to acceptable limits

PRINCIPAL OF OPERATION:-
In its simplest form, The output (Controlled) and derived (reference) position θ1 and θ2 are respectively measured and compared by a potentiometer pair whose output voltage is proportional to the error in angular position θE= θ1- θ2. The error voltage is amplified and applied to servomotor which positions the load and output such that the error is reduced to zero. Please refer to the figures 1 and 2 before go through the following. Assume SW! in upward position(Tachoout) P1 is output potentiometer and P2 is output position sensing potentiometer, the control problem is to position the mechanical load J in accordance with the input command from input pot P1. Assume that system is in equilibrium i.e. θ1 = θ2.
If Pl is disturbed and wiper is moved in the upward Direction (move + ve) then the error detector IC1 gets a +ve error Signal. This signal is amplified and then power is amplified by the Servo amplifier, making the D.C. servomotor terminal A +ve w.r.t. the ground. This sets the motor into rotation and through the gear train the output shaft (Ø2) is also set into rotation along with the Load J. This will take the wiper contact of P2 in upward position, thus increasing the positive potential available on it. This voltage is inverted by the op amp and the output of Error amplifier becomes more -ve than its previous value. Note that the error detector is working a summation amplifier and hence, effectively the net input i.e. error signal for error detector becomes zero and the motor comes to a rest. The entire system is again in equilibrium position.
If Pl wiper contact is moved in the downward direction the servo amplifier output terminal A is made -ve & the D.C. motor rotated in the opposite direction and P2 wiper contact to the downward position until the motor stops again. The output angle θ2 again becomes equal to the desired input θ1. As soon as P1 becomes equal to P2, the motor stops. That is now any variation in the desired input θ 1 is transferred to the output position θ 2 along with the load.
In accordance with the input changes θ 1 the load is also positioned suitably. This constitutes the basic closed loop control system.

NEED FOR STABILIZATILON:-

With tachogain pot in zero position, the step change in input shaft, output exhibits an oscillating behavior. This happens because of the system elements which are capable of storing energy i.e. capacitance, inductance, inertia of moving components like rotor of motor load gear train etc..

Once the system is excited by a change in the input signal the various elements begin to store energy and even if the error voltage falls to zero, the stored energy causes the output shaft to move in the same direction. This creates an error of opposite polarity and the system again is instructed to work in the opposite direction. In this way energy storing elements tend to produce over shoots and under shoots in the system. For avoiding this various stabilizing techniques are used. In this set up 'DERIVATIVE FEEDBACK' is used for stabilization of the output.

The tachogenerator which is coupled to the motor generates an output voltage which is proportional to the rate of change of θ2 i.e.. V-tach = dθ2 This voltage is coupled to the dt

Input Error amplifier in regenerative mode or Degenerative mode by adjusting tachogain pot, the amount of derivative feedback can be adjusted while the DPDT switch is meant for selection of the mode of stabilizing feedback.

HOW DERIVATIVE FEEDBACK WORKS

When SW1 is in downward position (i.n, in tachoin position),and SW2 also in down ward position , and the Degenerative (-ve) feedback is suitably adjusted we observe that the output shaft follows the input shaft in a smooth fashion without any unwanted oscillations.

If the mode of feedback is regenerative (+ve) then the output never reaches a stable state, instead it keeps on oscillating around the desired position. In short for degenerative feedback the damping factor of the system is increased, this resulting in braking action on the moving components prior to their final desired position. Hence, there are no oscillations. For a greater amount of feed back voltage, damping becomes excessive and system exhibits a very sluggish response.

For regenerative feedback the damping of the system. is reduced and energy stored in. the moving elements cannot be readily dissipated. This increases the tendency for oscillation and the system becomes unstable. **Please note that this is never a desirable way of operation.**

OPERATING INSTRUCTIONS:

(1). Before switching on the mains, see that the switches SW3,SW4(On the LHS panel) are in down ward position i.e.ON position.

(2) Keep the input potentiometer P1 in 10 degree position.

(3)Adjust the Potentiometer P3 (amplifier gain Adj.) in mid position.

(4)Now switch ON the main unit LED ‘R’and LED “G” should glow.

OPERATION WITHOUT STABILIZING FEEDBACK or Open loop
(SW1 in off position i.e.Tacho out.)

1) Now slowly advance the input potentiometer P1 in clockwise direction. The output potentiometer along with load will be seen to be following the change in the input potentiometer.

2) When the input is disturbed ,the null indicator will be showing some indication but when it may be noted that when input pot is moved in anticlockwise Direction, the output pot P2 also moves in the reverse direction.

STEP CHANGE INPUT :

Keep the pot P1 at around 180 degree position. Pot P2 also will be in the same position. Now change the input pot in a step fashion by about 60 to 80 degrees (in fact approximating step input) , The output will be observed to change in oscillatory mode before it settles to a final position. The tendency for oscillations is found to be dependent on the amplifier gain setting. For high gain there are too many oscillations where as low gain oscillations are reduced but with static error.

OPERATION WITH STABILIZING FEEDBACK(Closed loop):

1) Now put the SW1 switch in lower position .i.e, **Tacho in** position .SW2 must be in down ward position i.e, degenerative mode. Keep P4 in fully anti clock wise direction ,output again indicates oscillations.

2) Now take the pot P1(input potentiometer) to 180° position, effect the step input change in one of the direction, output again indicates oscillations.

3) Now advance the tachogain pot (P4) in clockwise direction the output now is observed to follow the input in a smooth fashion without oscillation. If the tacho gain pot (P4)is too much advanced, the output now follows input in a sluggish fashion indicating over damped system. Now take the pot P1 to 180 degree position.

4) Now the switch SW2 in upward position i.e. regenerative mode. Now if the pot P1 is disturbed, the output pot P2 is found to oscillate continuously around desired position As the amount of feed back is adjusted the frequency and amplitude of output is observed to vary.

5) Warning :- Do not operate the DC position control in the regenerative mode for long time. This can damage the potentiometers.

6) Bring the switch SW2 in down ward position.

OBSERVATIONS:-

1. Plot the output angle versus input for both system i.e. with out and with stabilizing feed back by looking to the nature of rotation of the output potentiometer and disc mounted on it.

TABULAR COLUMN FOR WITH OUT TACHO FEEDBACK(open loop) Without stabilizing Feedback (open loop) SW1 up ward (Tacho out)

K_D	Kp	Θr	Θo	%Error= [(Θo- Θr)/ Θr]	Remarks
0	20	50 100 200	41 94 191	-18 -6 -4.5	No oscillations
0	40	50 100 200	47 96 204	-6 -4 2	No oscillations
0	60	50 100 200	47 97 204	-6 -3 2	Little oscillations
0	80	50 100 200	30-60 80-120 -	-40 to -20 -20 to +20 -	More oscillations

Note that these are typical readings and there can be piece to piece variation because the servomotor pots are having linearity of +/- 1% . it is better to operate in the region of 15 degrees to 330 degrees to avoid zero crossing and possible damage of potentiometers.

TABULAR COLUMN FOR WITH DEGENERATIVE (-Ve) TACHO

FEEDBACK (closed loop) SW1 down ward (Tacho in)

K_D	Kp	Ɵr	Ɵo	%Error= [(Ɵo- Ɵr)/ Ɵr]	Remarks
20	20	50 100 200	41 91 194	-18 -9 -3	No Oscillations
20	40	50 100 200	46 96 198	-8 -4 -1	No Oscillations
20	60	50 100 200	47 99 199	-6 -1 -0.5	No Oscillations
20	80	50 100 200	48 98 199	-4 -2 -.05	No Oscillations
20	100	50 100 200	48 99 200	-4 -1 0	No Oscillations
40	20	50 100 200	41 93 194	-18 -7 -3	No Oscillations
40	40	50 100 200	45 95 198	-10 -5 -1	No Oscillations
40	60	50 100 200	47 98 200	-6 -2 0	No Oscillations
60	20	50 100 200	41 90 194	-18 -10 -3	No Oscillations
60	40	50 100 200	45 96 198	-10 -4 -3	No Oscillations
60	60	50 100 200	47 96 199	-6 -4 -0.5	No Oscillations
60	80	50 100 200	47 99 199	-6 -1 -0.5	No Oscillations
80	20	50 100 200	41 91 193	-18 -9 -3.5	No Oscillations
80	40	50 100 200	45 99 198	-10 -10 -1	No Oscillations
80	60	50 100 200	47 97 198	-6 -3 -1	No Oscillations
80	80	50 100 200	47 97 200	-6 -3 0	No Oscillations

TABULAR COLUMN FOR WITH REGENERATIVE (+Ve)TACHO FEEDBACK(closed loop) SW1 down ward (Tacho in)

K_D	Kp	Ѳr	Ѳo	%Error= [(Ѳo- Ѳr)/ Ѳr]	Remarks
20	20	50 100 200	55 93 200	+10 -7 +6	Little Oscillations
40	20	50 100 200	- - -		Continuously Oscillations
60	20	50 100 200	- - -		Increasing Oscillations

Precautions:-

1) Please do not cross zero degree position by moving pot P1 i.e. do not operate between 330 degrees and 10degrees.
2) Do not try to rotate output potentiometer by hand. This may damage the potentiometer.
3) Students should note the following : Try to understand the function of output potentiometer.
4) The null indicator indicates a small deviation from zero indication at various positions of angle ø1 and ø2.This is so because of backlash in the gear, friction and the fact that some definite torque is required to be produced by the motor, so that the system can be set in to rotation. More over this torque goes on changing from position to position. Hence this error.
5. Observe the effect of change in amplifier gain. Higher the gain ,smaller is the error.
6. when system is not using ,keep Sw3 & Sw4 in off position.(Upward position) to avoid heating and possible damage of the power stage.
Do not operate this mode for long time.
Observe the waveforms at various test points TP1 to TP5 at the side panel of the unit. This will help in understanding the system in a better fashion. This test points are also useful for trouble shooting.

TEST POINT DESCRIPTION:-
TP1:- Output of input potentiometer.(max 5VDC)
TP2:- Output of output potentiometer.(max 5VDC)
TP3:- Output of inverter stage (Max – 5V)
TP4:- Amplifier output (Range +/- 10V)
TP5 :- output voltage of driver amplifier (+/-12V)

Maintenance instructions for D.C. Position control system

1. Check for loose or broken connections, transformer voltages and fuse.
2. Check for condition of servo pots. When separately tested, they should give a variable resistance of 5 kilo ohms over their entire travel.
3. Check for plus or minus 12 volt D.C.: supply available at pin no. 7 and 4 of ic741 on -the amplifier card respectively.
4. An excitation voltage of +5 volts (from 7805) should be present across each of servo pots.
5. Replace all 741 op AMPS on * amplifier card and null indicator card one by ore.
6. The test point'tp4 should give an amplifier voltage foutput for disturbing the input position and it should change polarity for null crossing. this ensures' that amplifier is in good working condition.
7. The test point tp5 is input to servo amplifier .power amplifier components hl100, hk100, 2n3055 should be checked.
8. Servo amplifier transistors, -ecp055 and ecn055 should-have -20 and +20 volts on their collectors respectively.(with respect to ground). These transistor^ hay also be checked.
9. Check for loose screws effecting load and motor coupling.

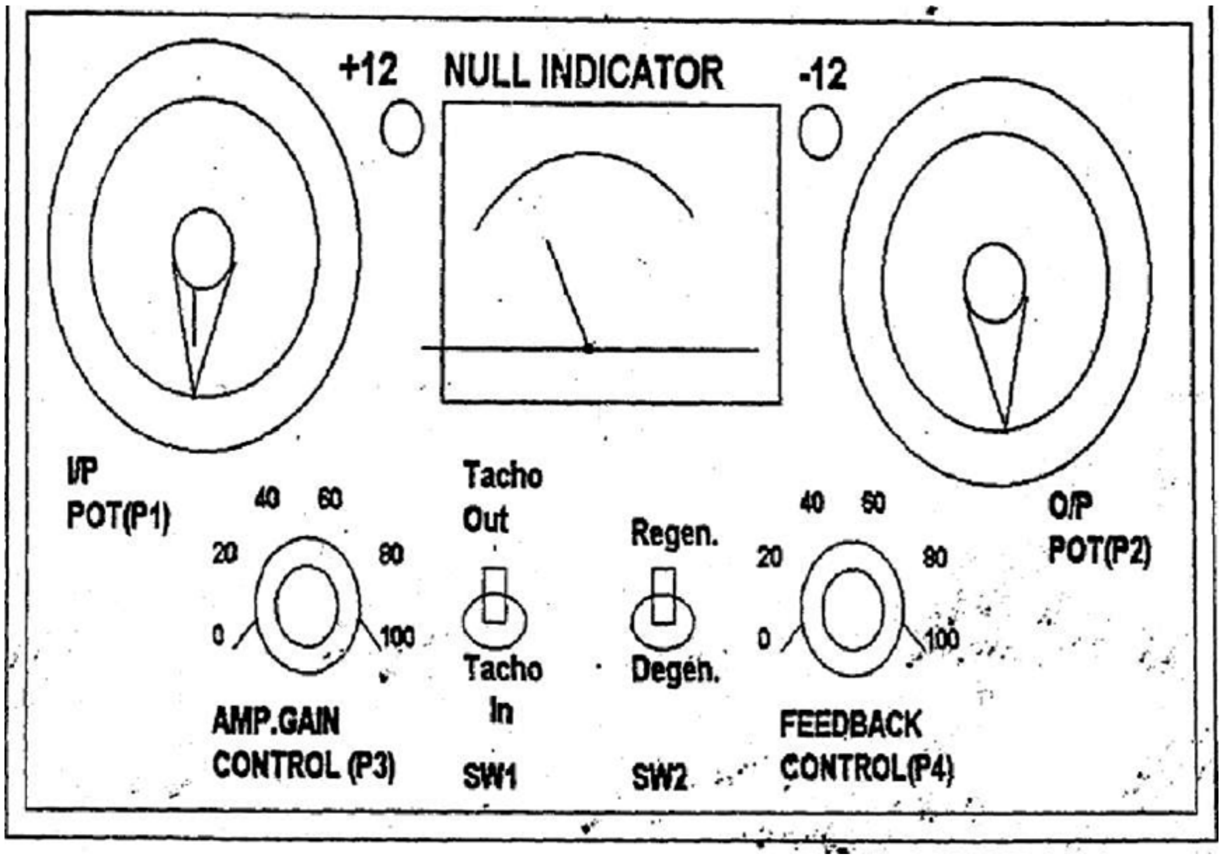
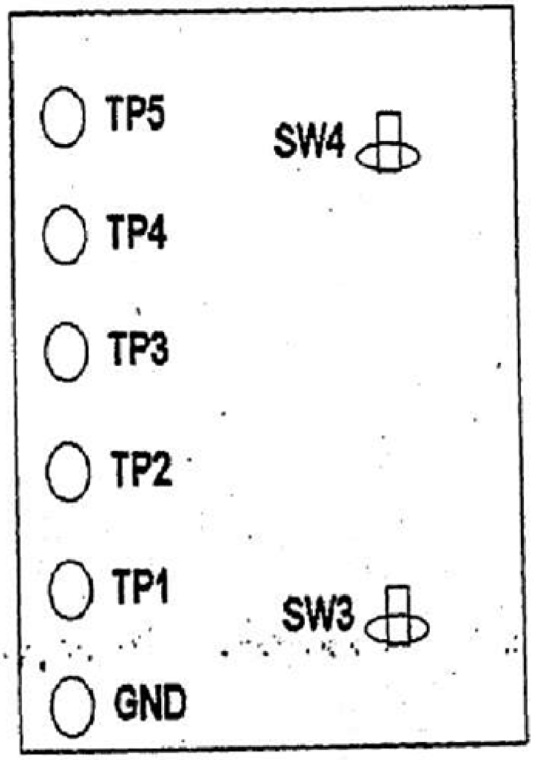
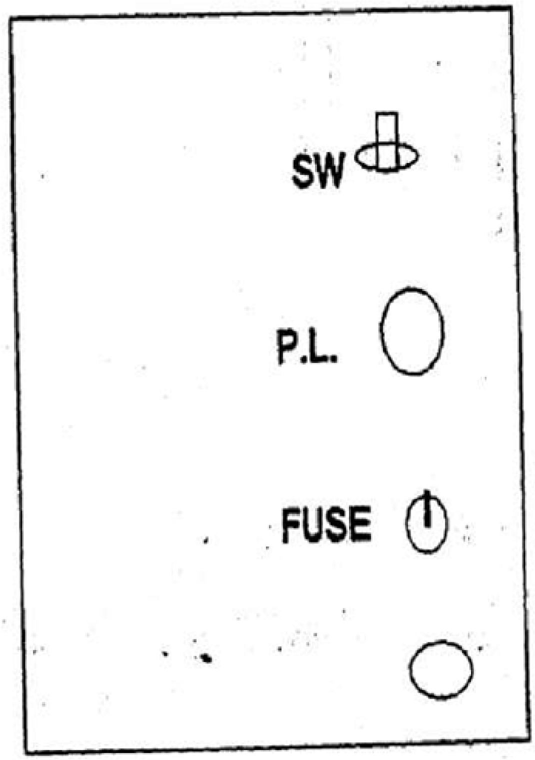


Figure No.1 Front panel layout for D.C Posrtion control



LEFT SIDE VIEW



RIGHT SIDE VIEW

FIGURE NO.1B
SIDE VIEW OF D.C. POSITION CONTROL SYSTEM

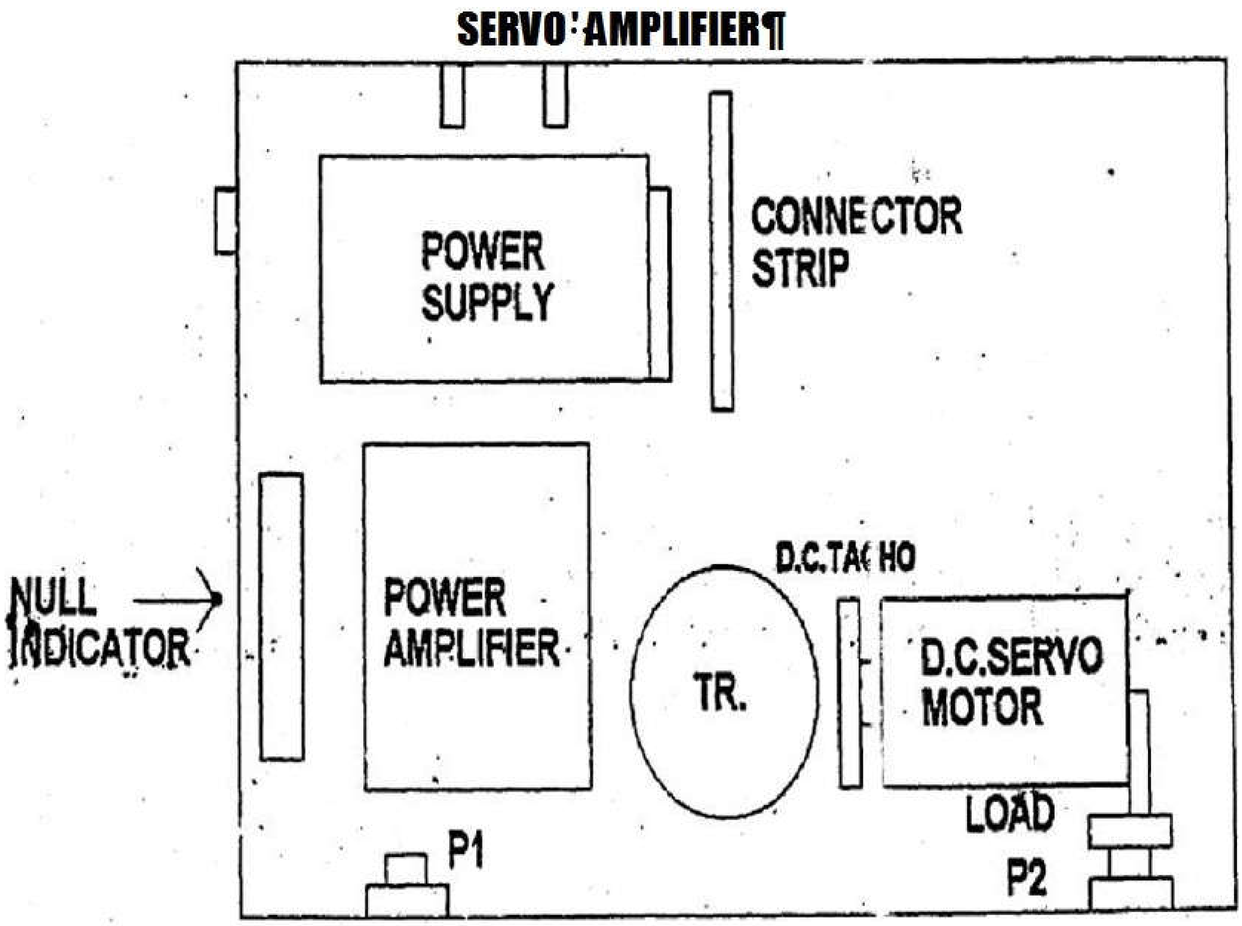


FIGURE TOP VIEW OF D.C. POSITION CONTROL SYSTE

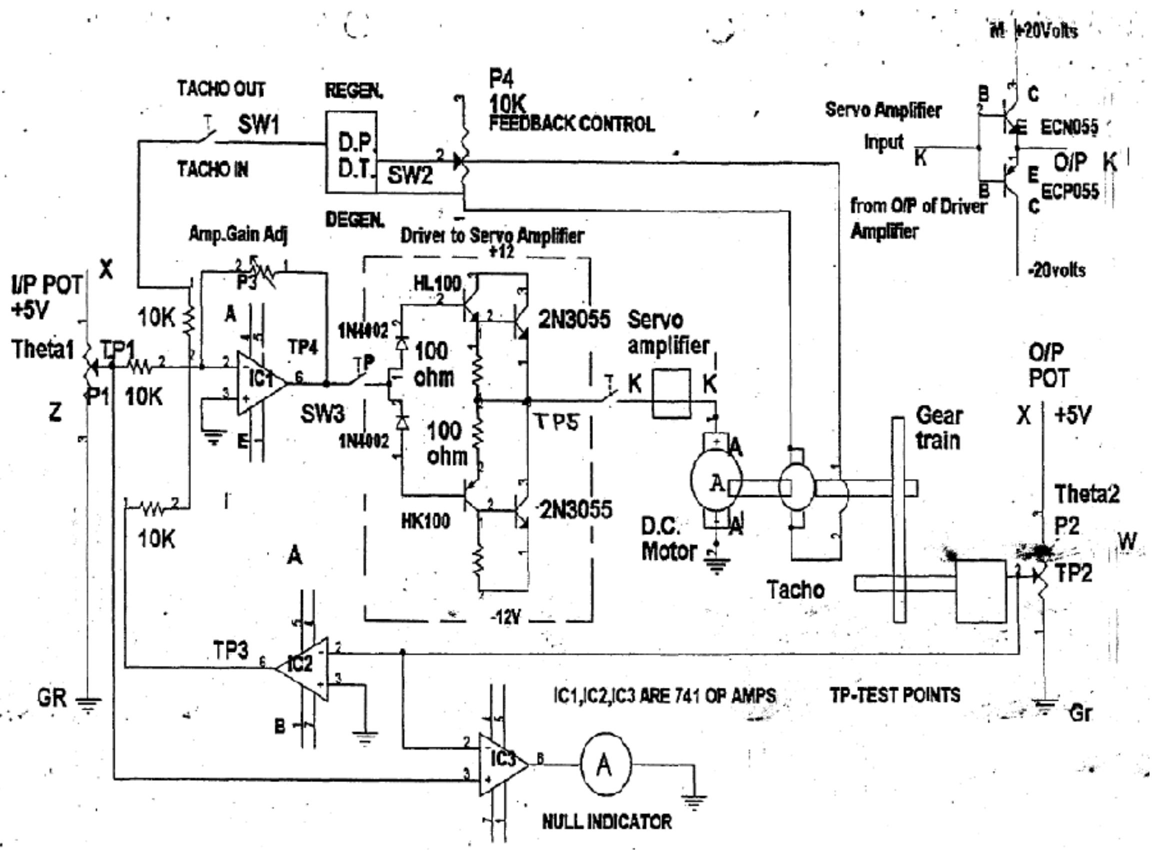
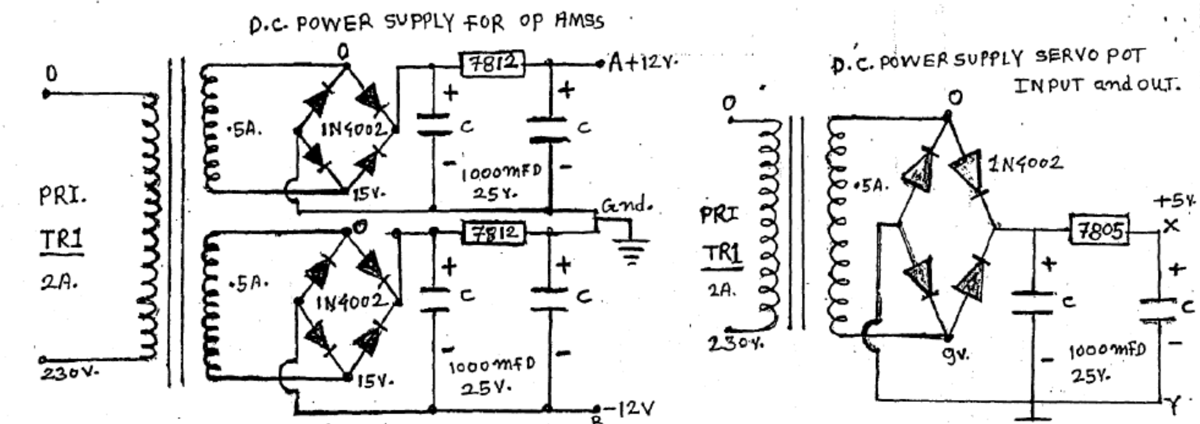
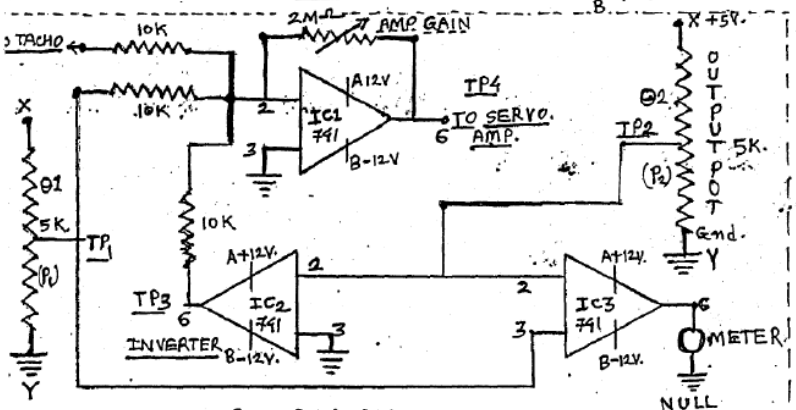


FIGURE NO.3
CIRCUIT DIAGRAM FOR D.C. POSITION CONTROL SYSTEM

D.C. POSITION CONTROL SYSTEM-1





DRIVER CIRCUIT.

TP → Test POINTS.

TRANSFORMER RATING.

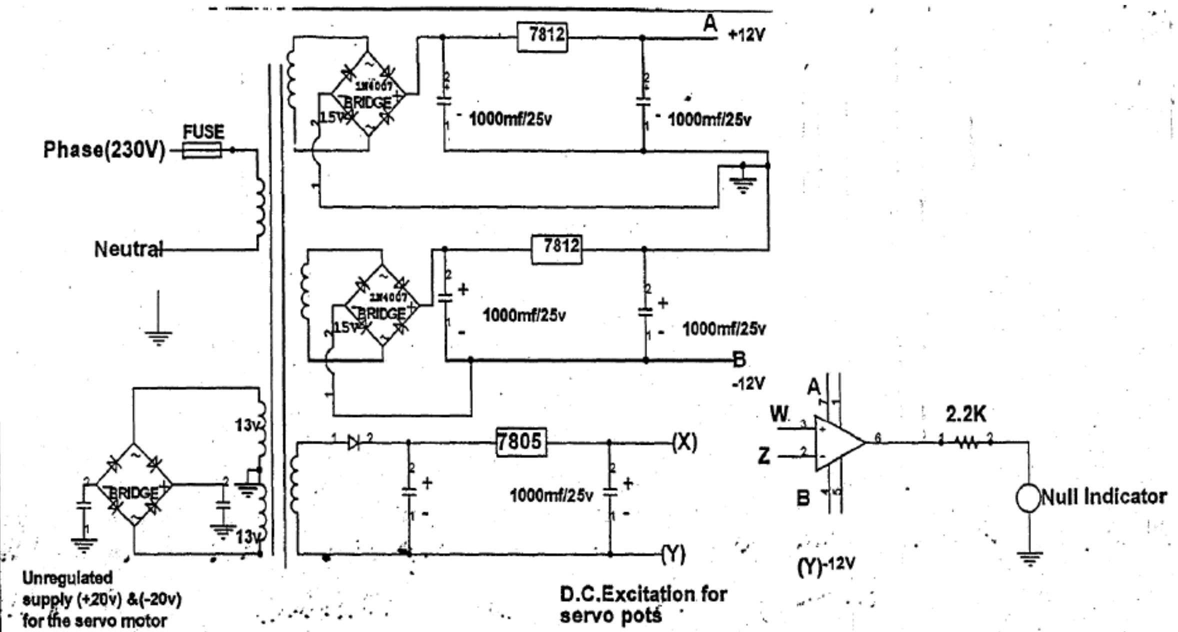
PRIMARY — 230V. 50HZ
2 AMPS.

SECONDARY—

0-15V. 0-15V. SUPPLY OP AMPS.

0-9V. SERVO Pot SUPPLY.

15-0-15V. Servo and power Amplifier SUPPLY.



Circuit diagram for Power supply ,
Null Indicator &Reference supply for
potentiometers and servoamplifiers.
Z&W are wiper contacts of P1&P2

D.C. POSITION CONTROL SYSTEM
FIGURE NO.6

D.C.POSITION CONTROL SYSTEM / CE-2 / 15

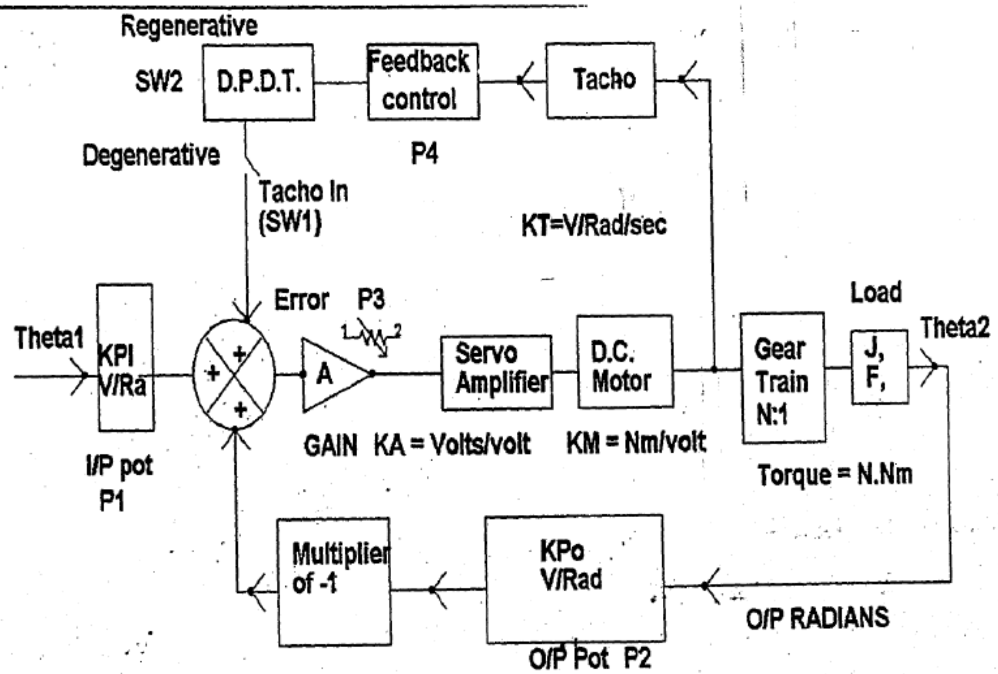


FIGURE NO.5

BLOCK DIAGRAM SHOWING TRANSFER FUNCTIONS OF VARIOUS COMPONENTS FOR D.C.POSITION CONTROL SYSTEM

RESULT:-Performance of DC position control system is studied**.**

SPEED TORQUE CHARACTERISTICS
OF TWO PHASE AC SERVO MOTOR

INTRODUCTION:-

An AC servo motor is basically a two phase induction motor except for certain special design features. A two phase induction motor consisting of two stator windings oriented 90 degrees electrically apart in space excited by AC voltages which differ in time phase by 90 degrees. Generally voltages of equal magnitude & 90 degrees phase difference is applied to the two stator phases thus making their respective fields 90 degrees apart in both & space at the synchronous speed. As there field sweeps over a rotor, voltages are induced in it producing current in the short circuited rotor. The rotating magnetic field interacts with these currents producing a torque on the rotor in the direction of the field rotation.

The shape of the characteristics depends upon the ratio of the rotor reactance (x) to the rotor resistance **(R)** In normal induction motors **X/R** ratio is generally kept high so as to obtain the maximum torque close to operating region which is usually around 5% slip.

A two phase servo motor differ in two ways from normal induction motor.

1. The rotor of the servo motor is built with high resistance so that its **X/R** ratio is small & the torque speed characteristics is as shown in the figure **(2).** Curve **(B)** is nearly linear in contrast to the non linear characteristics with large x/r. It must be emphasized that if a conventional induction motor with high x/r is used for servo application, then because of the positive slope for the part of the characteristics, the system using such a motor becomes unstable. The motor construction is usually squirrel cage or drag cup type. The diameter of the rotor is kept small in order to reduce inertia & thus to obtain good accelerating characteristics. Drag sup construction is used for a very low inertia operation.

2. In servo applications, the voltages applied to the two stator windings are seldom balanced. One of the phases known as the reference phase is excited by constant voltage & the other phase is excited by constant voltage supplied to the reference windings & it has a variable magnitude & polarity. The control winding voltage is supplied from a servo amplifier. For low power application, AC servo motors are preferred because they are light weight, rugged & there are no brush contacts to maintain.

Both the control and reference windings are similar and we can interchange them. During forward direction the control winding is taken as control winding and reference winding as reference winding and during reverse direction control winding is taken as reference winding and reference winding as control winding.

DESCRIPTION OF THE SETUP:-

This setup consists of a AC servomotor whose speed –torque characteristics to be studied. The AC servomotor is coupled to DC servo motor .DC motor is used to load the AC servomotor.

A DC supply is provided to load the AC servomotor by load potentiometer 'R'. The servomotor is fitted with Photo reflective sensor to sense the speed of A.C servomotor.

A micro controller based tachometer is provided with LCD display to read the motor speed in RPM. Arrangement is made to apply the fixed voltage to reference winding and variable voltage to control winding by variable auto transformer. An ammeter is provided to read the armature current I_a of the DC motor.

Description of tachometer:-

The servomotor is fitted with Photo reflective sensor to sense the speed of A.C servomotor. The Photo reflective sensor generates pulses whose frequency is proportional to the speed of

D.C. servomotor. In this unit, the frequency of the Photo reflective sensor is taken as the reference for speed sensing. This signal is fed to a signal conditioner and then to a micro controller. The micro controller is programmed to display the speed in rpm directly.

TORQUE MEASUREMENT:-

To measure the torque produced by the AC servomotor, We have an arrangement to load the AC servomotor. The shaft of the AC servomotor is coupled to DC servo motor. When the AC servomotor is rotating the DC motor is made to rotate in the opposite direction. Then the AC Servomotor is loaded. The amount of load on AC servomotor is proportional to the current in the DC servomotor , the current of DC servomotor is displayed by digital ammeter provided on the front panel.

Technical Specifications

1.	**POWER**	:	Mains ON/OFF switch to the unit with built-in indicator.
2.	**RPM**	:	Tachometer to display the RPM on LCD display.
3.	**AMMETER**	:	Digital Ammeter to measure the DC motor armature current.
4.	**SERVOMOTOR ON/OFF**	:	AC supply ON/OFF switch to the servomotor.
5.	**LOAD ON/OFF**	:	ON/OFF Switch to load the motor.
6.	**R**	:	Potentiometer to vary the Load-500 Ohms/100 Watts.
7.	**V_{DC}**	:	12 V unregulated DC supply to DC motor.
8.	**E_b**	:	Terminals to measure the Back EMF.
9.	**CONTROL WINDING**	:	Control winding terminals of AC Servomotor.
10.	**REFERENCE WINDING**	**:**	Reference winding of AC servo motor with supply 230 V.
11.	**CONTROL VOLTAGE-V_C**	:	Auto transformer to vary the AC supply to theControl winding from 0-230V.

Motor Specifications:-

1.	Reference winding Voltage	- 230V AC
2.	Control winding Voltage	- 0-230V AC
3.	Rated Speed	- 2000 RPM
4.	Rated Power	- 20 Watts

PROCEDURE:-

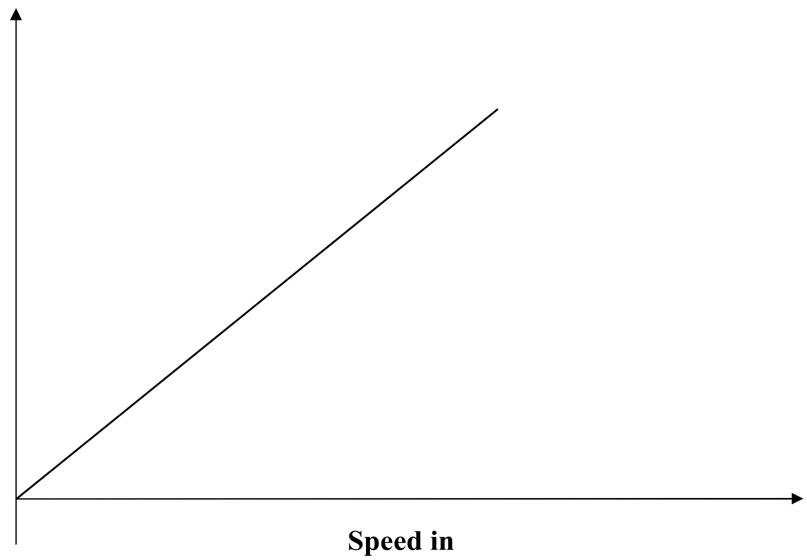
1. Study all the controls carefully on the front panel.
2. Initially keep load control switch at OFF position, indicating that the armature circuit of dc machine is not connected to auxiliary dc supply – 12 V dc. Keep servomotor supply switch also at OFF position.
3. Ensure load potentiometer and control voltage auto transformer at minimum position.
4. Now switch ON mains supply to the unit and also AC servomotor supply switch. Vary the control voltage transformer. You can observe that the ac servomotor will starts rotating and the speed will be indicated by the tachometer in the front panel.
5. With load switch in OFF position, vary the speed of the AC servomotor by moving the control voltage and note down back emf generated by the dc machine (Now working as dc generator or tacho). Enter the results in the Table.

TABLE TO PLOT SPEED Vs BACK EMF:-

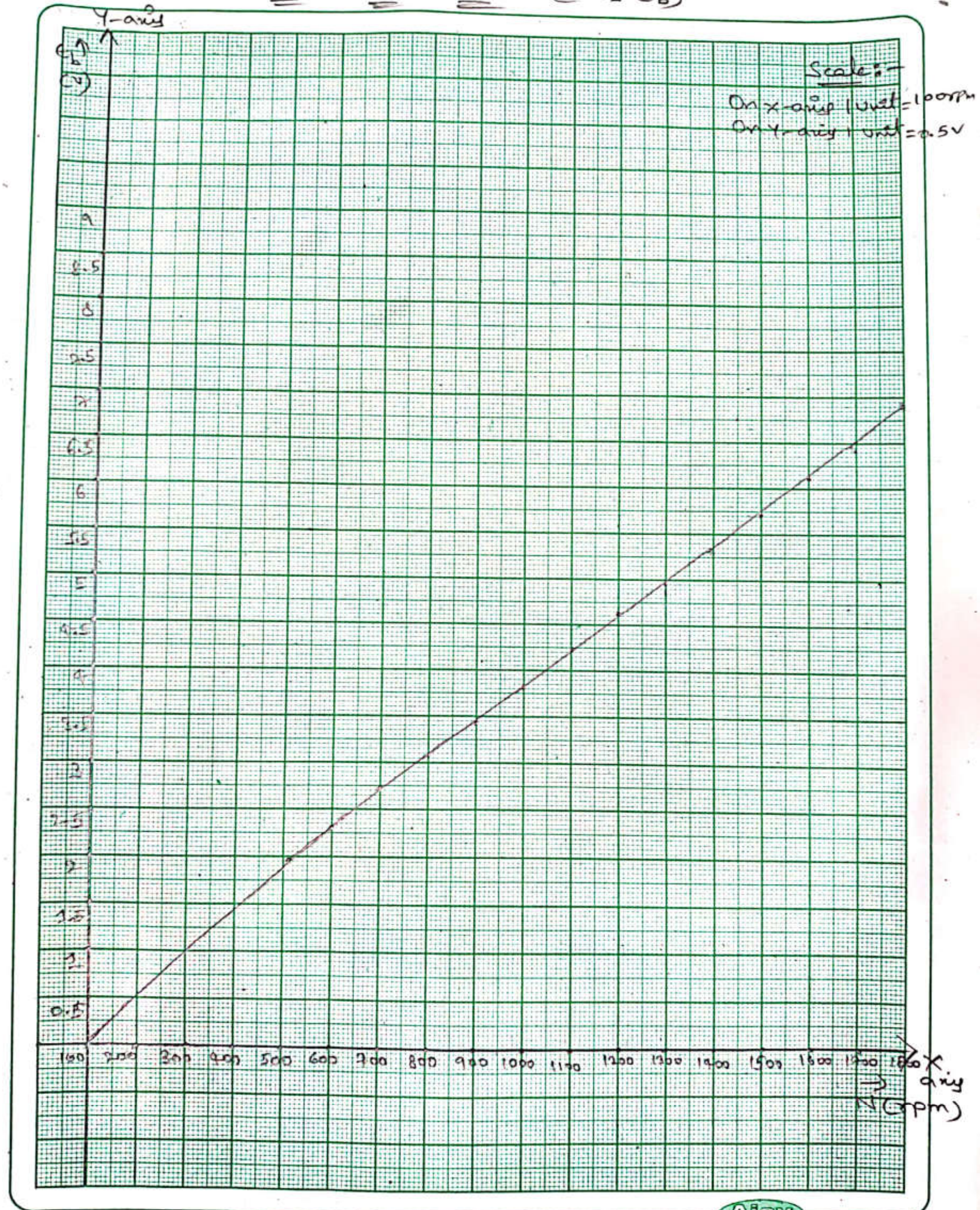
Table-1

Sl.no.	Speed - N Rpm	Back Emf – E_b in volts
1	500	1.95
2	600	2.3
3	700	2.73
4	800	3.08
5	900	3.42
6	1000	3.82
7	1100	4.22
8	1200	4.66
9	1300	4.83
10	1400	5.30
11	1500	5.73
12	1600	6.17
13	1700	6.4
14	1800	6.9

MODEL GRAPH:


Speed in

A.C. Servo Motor (N Vs E_b)



6. Now with load switch at OFF position, switch ON AC servomotor and keep the speed in the minimum position. Now vary the control winding voltage by varying the auto transformer(230V) .You can observe that the AC servomotor

starts moving with speed being indicated by the tachometer and set the speed for maximum speed. Now switch ON the load switch and start loading AC servomotor by varying the load potentiometer slowly. Note down the corresponding values of I_A and speed and enter these readings in the table. And also enter the back emf for different speed from table to plot speed V/s back emf.

7. Repeat the above procedure for different control voltage 200V,180V also and plot the graph of speed V/s Torque.

Speed torque characteristics table:-

V_C –Control winding voltage: 210VAC Table-2

Sl.No.	I_A mA	N rpm	Eb-Back emf (From table-1)	P-watts	T-Torque(Gm-cm)
1	0	1800	6.9	0	0
2	0.06	1700	6.4	0.384	21.39
3	0.091	1600	6.17	0.561	33.62
4	0.125	1500	5.73	0.716	45.85
5	0.162	1400	5.30	0.858	59.102
6	0.2	1300	4.83	0.966	72.34
7	0.228	1200	4.66	1.061	85.59
8	0.254	1100	4.22	1.071	93.74
9	0.281	1000	3.82	1.1073	103.93
10	0.311	900	3.42	1.061	114.12

V_C –Control winding voltage: 180VAC Table-3

Sl.No.	I_A mA	N rpm	Eb-Back emf (From table-1)	P-watts	T-Torque(Gm-cm)
1	0	1700	6.4	0	0
2	0.05	1600	6.17	0.3085	18.76
3	0.07	1500	5.73	0.4011	25.47
4	0.108	1400	5.30	0.572	39.79
5	0.137	1300	4.83	0.6617	48.91
6	0.165	1200	4.66	0.768	62.15
7	0.193	1100	4.22	0.814	72.34
8	0.211	1000	3.82	0.810	78.46
9	0.242	900	3.42	0.827	88.65
10	0.271	800	3.08	0.834	100.88

V_C –Control winding voltage: 150VAC Table-4

Sl.No.	I_A mA	N rpm	Eb-Back emf (From table-1)	P-watts	T-Torque(Gm-cm)
1	0	1500	5.73	0	0
2	0.057	1380	5.25	0.299	20.38
3	0.077	1300	4.83	0.371	27.51
4	0.103	1200	4.66	0.479	38.72
5	0.13	1100	4.22	0.548	47.85
6	0.154	1000	3.382	0.588	57.06
7	0.175	900	3.42	0.598	64.19
8	0.207	800	3.08	0.637	77.44
9	0.221	700	2.73	0.603	83.55
10	0.238	600	2.3	0.547	88.65

I_A is measured by ammeter which is connected in series with the power supply & variable resistance (LOAD CONTROL). From the product of Eb (back e. m. f. developed by the motor) and the armature current take, we can find the mechanical power developed at the motor shaft. Again we must use the formula.

$$P = \frac{2\pi NT}{60} \text{ N-mts}$$

$$\text{Torque} = \frac{P \times 1.019 \times 10^4 \times 60}{2\pi N} \text{ gm-cm}$$

P in watts

$P = I_A \; V_A$ in watts
T=Torque in Gm-Cm

Repeat the above experiment for control winding voltage 200V,180V,& 150V. The above readings are not standard.

Torque calculation for a sample data:

Ia= 0.381 A

Control voltage-230V Speed N= 1000 rpm.

For speed 1000 rpm -Eb = 3.33 volts.

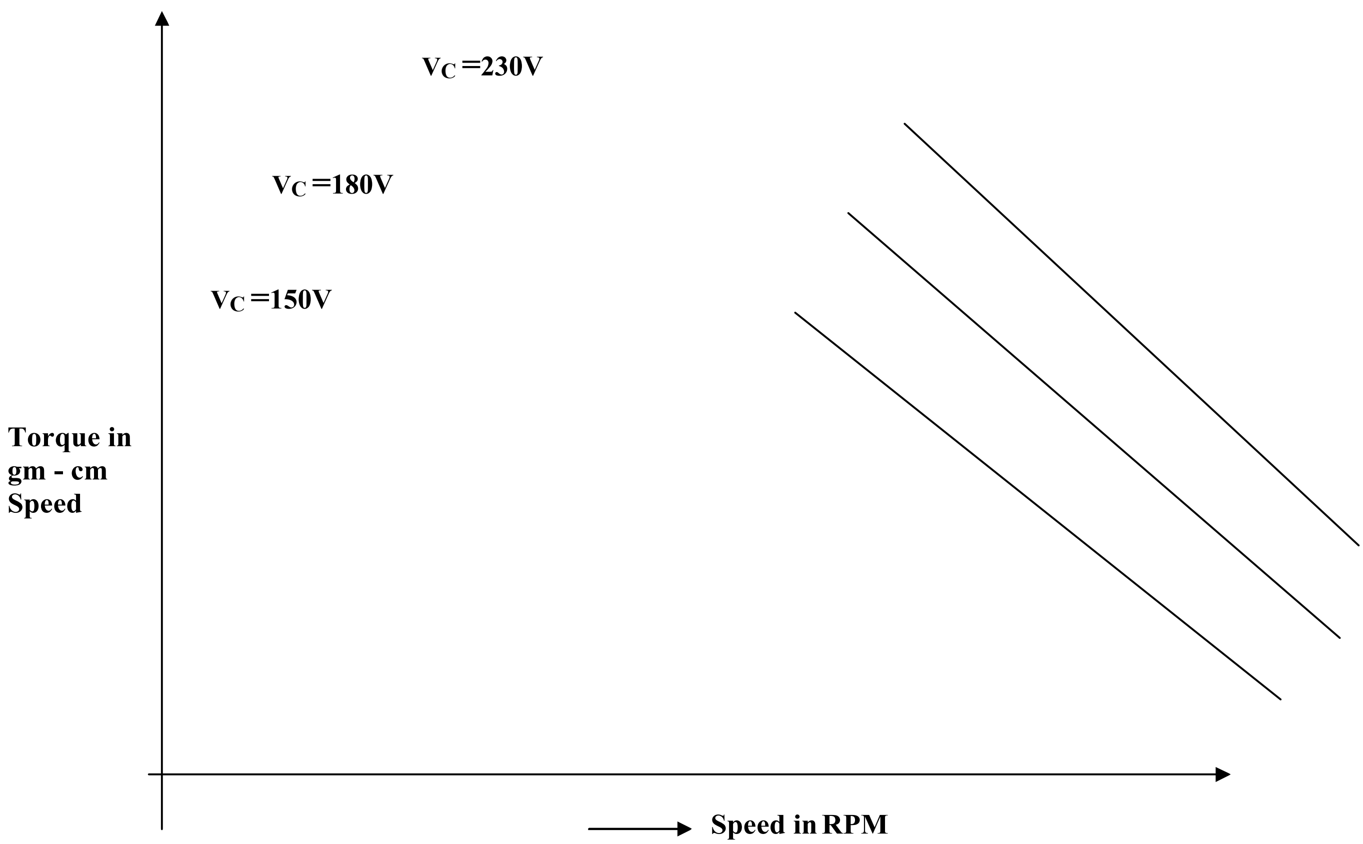
Therefore power P= Eb × Ia = 0.96 × 0.17 = 1.268 watts

$$P = \frac{2\pi NT}{60} \text{ N-mts}$$

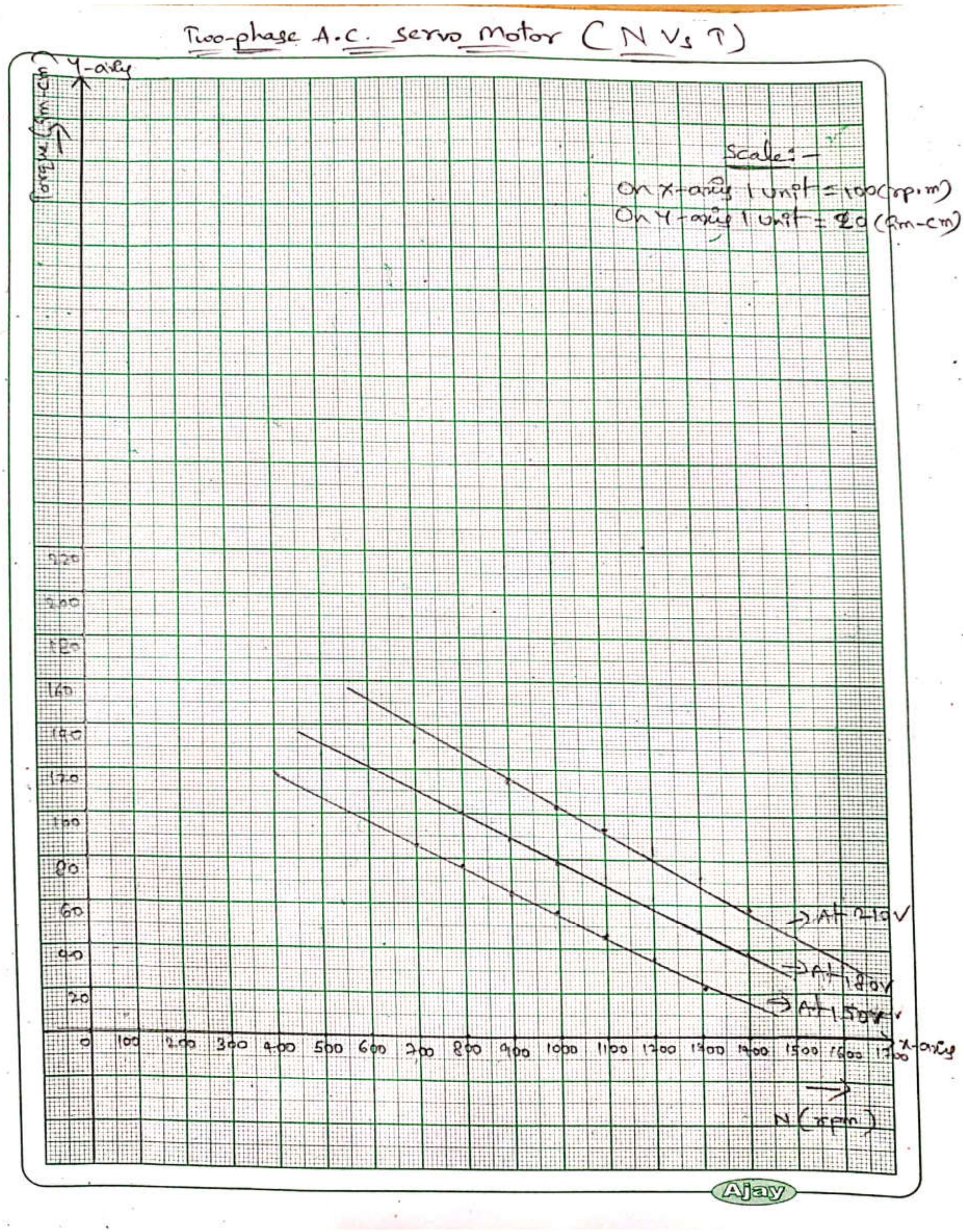
$$\text{Torque} = \frac{P \times 1.019 \times 10^4 \times 60}{2\pi N} \text{ gm-cm} \longrightarrow$$

T= 123.44 Gm-Cm

Torque V/S Speed



MODEL GRAPH:



Two-phase A.C. servo Motor (N Vs T)
Y-axis
Torque (gm-cm)
Scale:-
On X-axis 1 unit = 100 (rpm)
On Y-axis 1 unit = 20 (gm-cm)
220
200
180
160
140
120
100
80
60
40
20
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
X-axis
N (rpm)
At 210V
At 180V
At 150V

RESULT:- Speed torque characteristics of AC servomotor determined experimentally.

Synchro Transmitter Receiver
Scientech 2455

Synchro Transmitter and Receiver

Scientech 2455

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to it.

Do not operate the instrument if you suspect any damage within.

The instrument should be serviced by qualified personnel only

For your safety:

Use proper Mains cord **:** Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument **:** This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

Use only the proper Fuse **:** Use the fuse type and rating specified for this instrument.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

- **Do not operate in wet / damp conditions.**
- **Do not operate in an explosive atmosphere.**
- **Keep the product dust free, clean and dry.**

Introduction

Scientech 2455 Synchro Transmitter Reciever helps the user to gain invaluable knowledge about the working principal and operating of Synchro motors. It also contains onboard AC voltmeter to measure the voltages between rotor and stator windings.

Features

- **Calibrated dials for reference and output position**
- **Switch for transmitter and Receiver rotor supply**
- **Synchro Transmitter and Receiver rotor terminals onboard**
- **Synchro Transmitter and Receiver stator terminals onboard**
- **AC Voltmeter to measure stator and rotor voltages**
- **On/Off Touch Switch**
- **Sensitive, linear, stable and accurate**
- **Easy to operate**

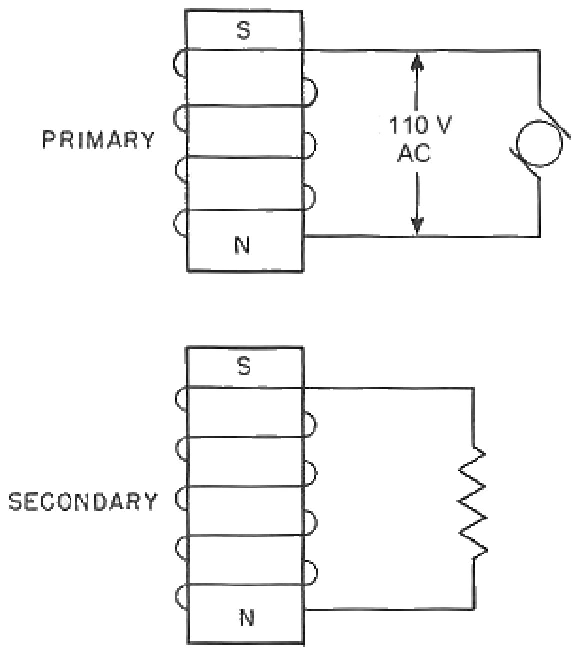
Technical Specification

Transformer Rating	:	100V AC, 1 amp (Rotor winding Supply)
Digital Voltmeter	:	0-400 V AC max.
Power Supply	:	230V ± 10%, 50Hz
Dimension	:	W 430 X D 260 X H 100
Weight	:	4500gm (Approximately)

Theory

Synchro Transmitter

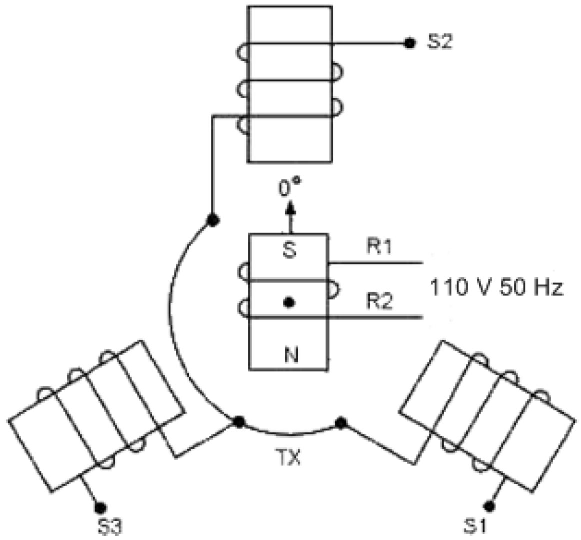
To understand how a synchro functions, think of it for the moment as a transformer in which the primary and secondary are wound on separate cores (fig. 1). When a current flows in the primary, it forms a magnetic field in its core. As the current changes and reverses (which it does constantly, being an alternating current) so does the magnetic field. The changes in the field induce current in the secondary (whose circuit is closed through a load). The currents in the secondary produce their own magnetic field. At any instant, the induced or secondary field opposes in direction that produced by the primary. Figure 1 shows the field at a selected instant. At some other instant the fields might be of opposite polarity, but the primary and secondary fields are always opposed, whatever the instantaneous polarity.



Instantaneous Magnetic Fields in Transformer

Figure 1

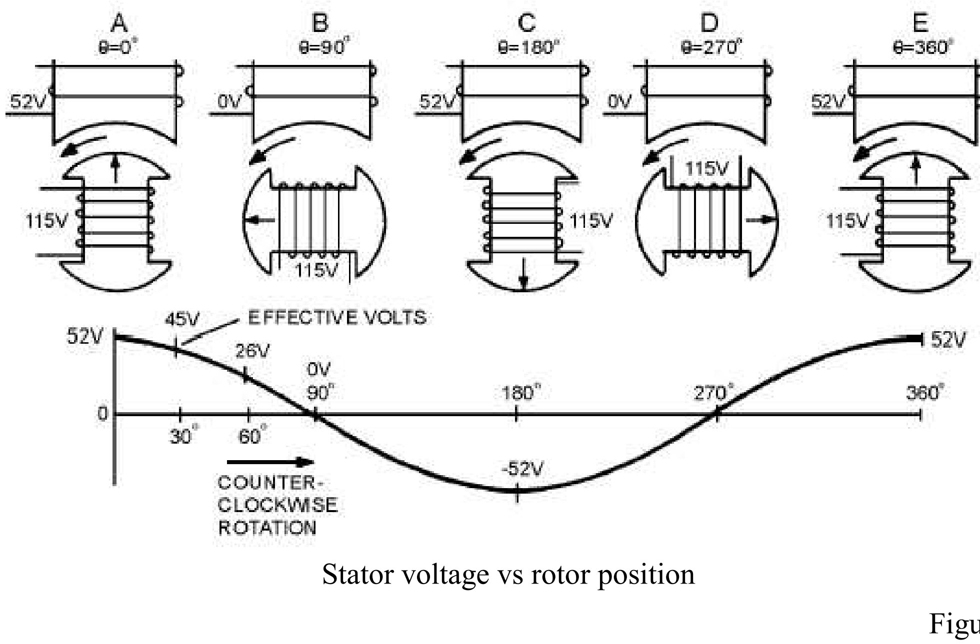
The synchro transmitter converts the angular position of its rotor (mechanical input) into an electrical output signal. When a 110-volt ac (Approximately) excitation voltage is applied to the rotor of a synchro transmitter, such as the one shown in figure 2, the resultant current produces an ac magnetic field around the rotor winding. The lines of force cut through the turns of the three stator windings and, by transformer action, induce voltage into the stator coils. The effective voltage induced in any stator coil depends upon the angular position of that coil's axis with respect to the rotor axis. When the maximum effective coil voltage is known, the effective voltage induced into a stator coil at any angular displacement can be determined.



Synchro transmitter

Figure 2

Figure 3 illustrates a cross section of a synchro transmitter and shows the effective voltage induced in one stator coil as the rotor is turned to different positions. 110volts is applied to the rotor coil. The maximum induced voltage occurs each time there is maximum magnetic coupling between the rotor and the stator coil (views A, C, and E). The effective voltage induced in the secondary winding is approximately equal to the product of the effective voltage on the primary; the secondary-to-primary turns ratio, and the magnetic coupling between primary and secondary. Therefore, because the primary voltage and the turns ratio are constant, it is commonly said that the secondary voltage varies with the angle between the rotor and the stator.



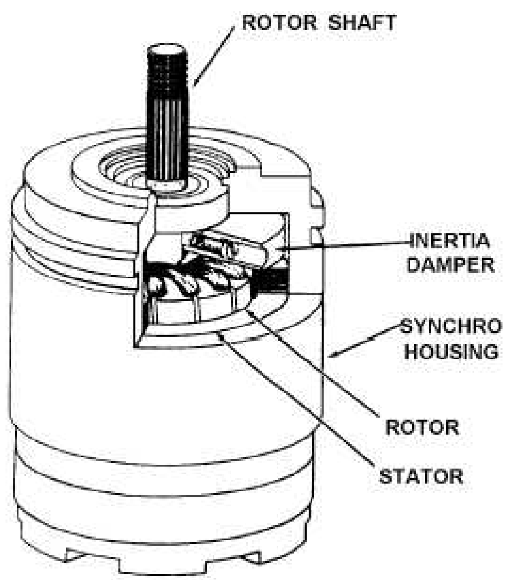
Stator voltage vs rotor position

Figure 3

When stator voltages are measured, reference is always made to terminal-to-terminal voltages (voltage induced between two stator terminals) instead of to a single coil's voltage. This is because the voltage induced in one stator winding cannot be measured because the common connection between the stator coils is not physically accessible.

Synchro Receiver

Synchro torque receivers, commonly called synchro receivers, are electrically identical to transmitters of the same size except for the addition of some form of damping. Unlike the transmitter, the receiver has an electrical input to its stator and a mechanical output from its rotor. The synchro receiver's function is to convert the electrical data supplied to its stator from the transmitter, back to a mechanical angular position through the movement of its rotor. This function is accomplished when the rotor is connected to the same ac source as the transmitter and assumes a position determined by the interaction of its magnetic field with the magnetic field of the stator. Normally, the receiver rotor is unrestrained in movement except for brush and bearing friction. When power is first applied to a system, the transmitter position changes quickly; or if the receiver is switched into the system, the receiver rotor turns to correspond to the position of the transmitter rotor.



Cutaway view of torque receiver with inertia damper

Figure 4

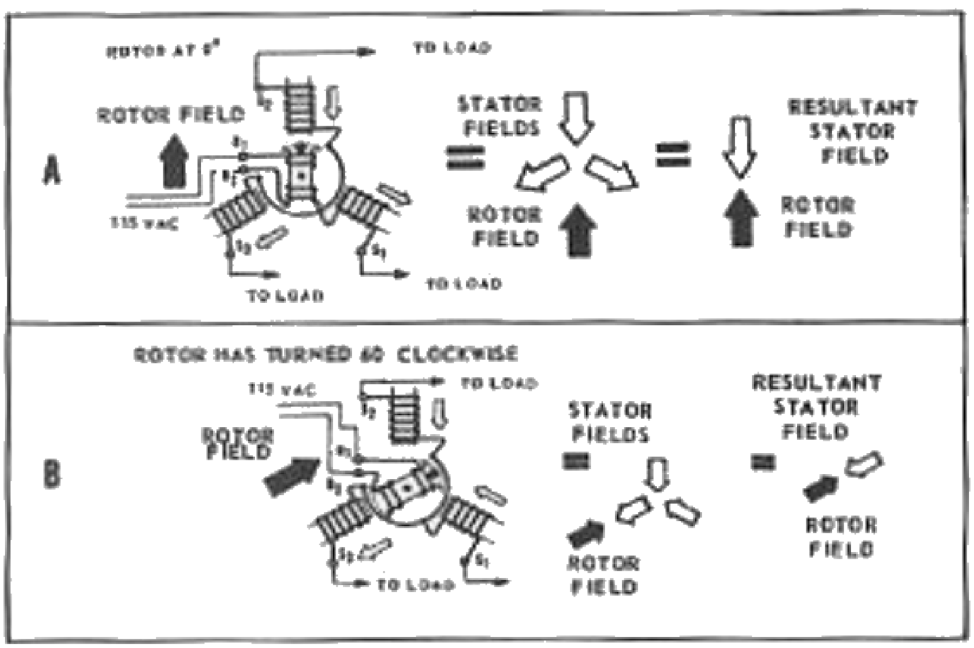
Synchro System

A transmitter (TX) and a receiver (TR) make up a simple synchro system. Basically, the electrical construction of synchro transmitters and receivers is similar, but their intended functions are different. The rotor of a synchro transmitter is usually geared to a manual or mechanical input. This gearing may drive a visual indicator showing the value or quantity being transmitted. The rotor of the receiver synchronizes itself electrically with the position of the rotor of the transmitter and thus responds to the quantity being transmitted.

Synchro System Operation

Now consider what happens in a synchro transmitter. Let 110-volt AC flow through the rotor. As shown in figure 4 (A), the rotor will produce a changing magnetic field. Its direction at some selected instant is shown by the black arrow. At that instant, the rotor field induces currents in the three stator fields, which are connected to a load. This transformer action produces in the three stator windings three fields (white arrows) which, when added to produce a resultant (symbolized by a large white arrow), exactly oppose the field in the (primary) rotor winding. If the rotor is now turned, say, 60 degrees clockwise, as in figure 4 (B), the rotor field, shown by the black arrow, will produce in the 3 stator coils 3 fields which will again add up to a resultant directly opposed to the rotor field.

In each of the cases illustrated in figure 4, the rotor will induce in the stator coils currents corresponding to that position of the rotor, and to that one only. This is true for all positions of the rotor.

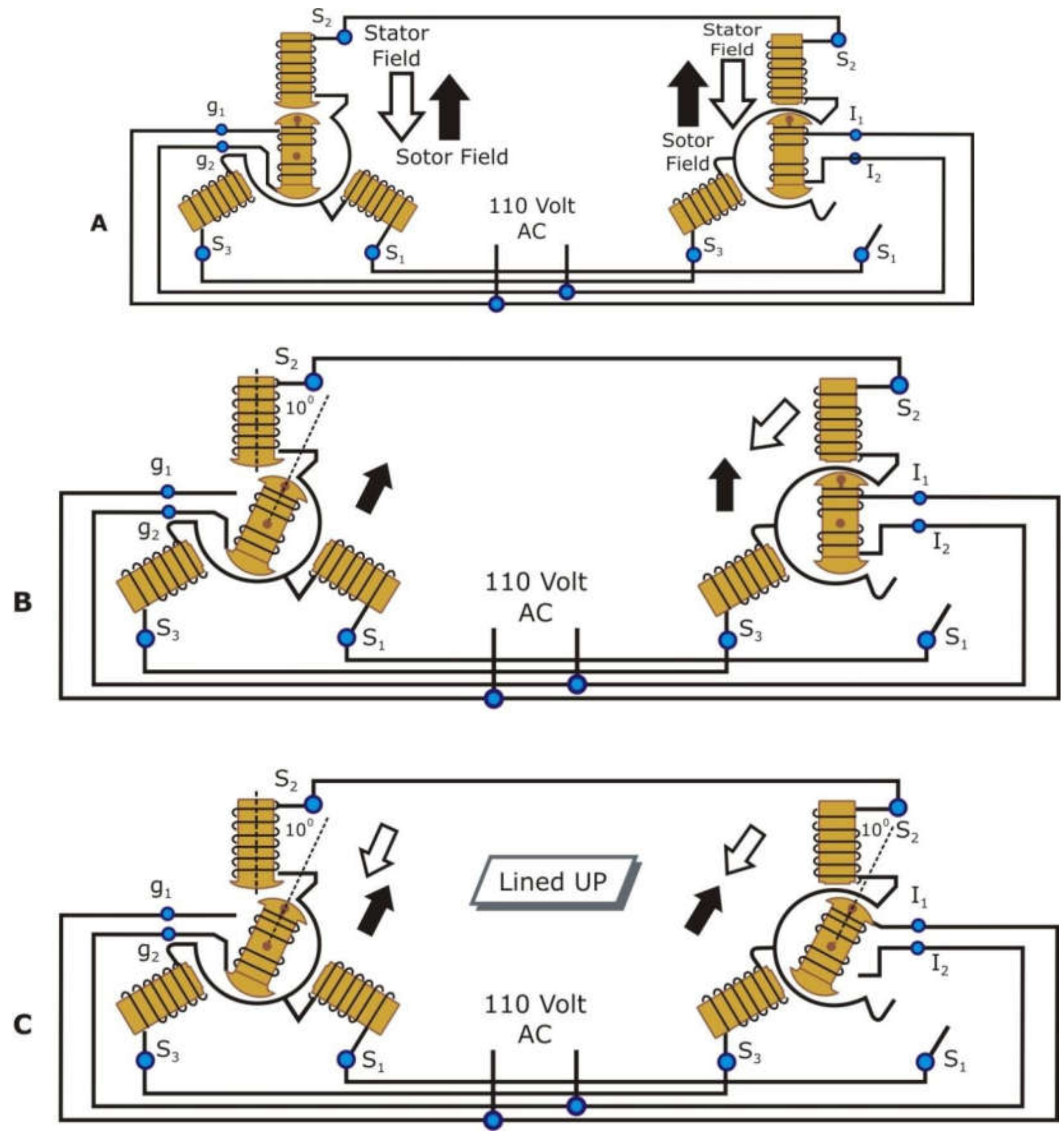


Transformer action in a Synchro Transmitter

Figure 5

Now consider a synchro transmitter connected to a receiver as in figure 6 (A), so that the rotors are fed by the same AC line and the stator coils of the receiver load the corresponding coils of the transmitter. The currents induced in the transmitter stator flow also in the receiver, and produce the resultant stator fields shown by the white arrows. Thus the receiver rotor, which produces a magnetic field similar to that of the transmitter rotor (because it is excited by the same AC line) always, because it is free to rotate, assumes exactly the same angular position (relative to the stator) as does the transmitter rotor.

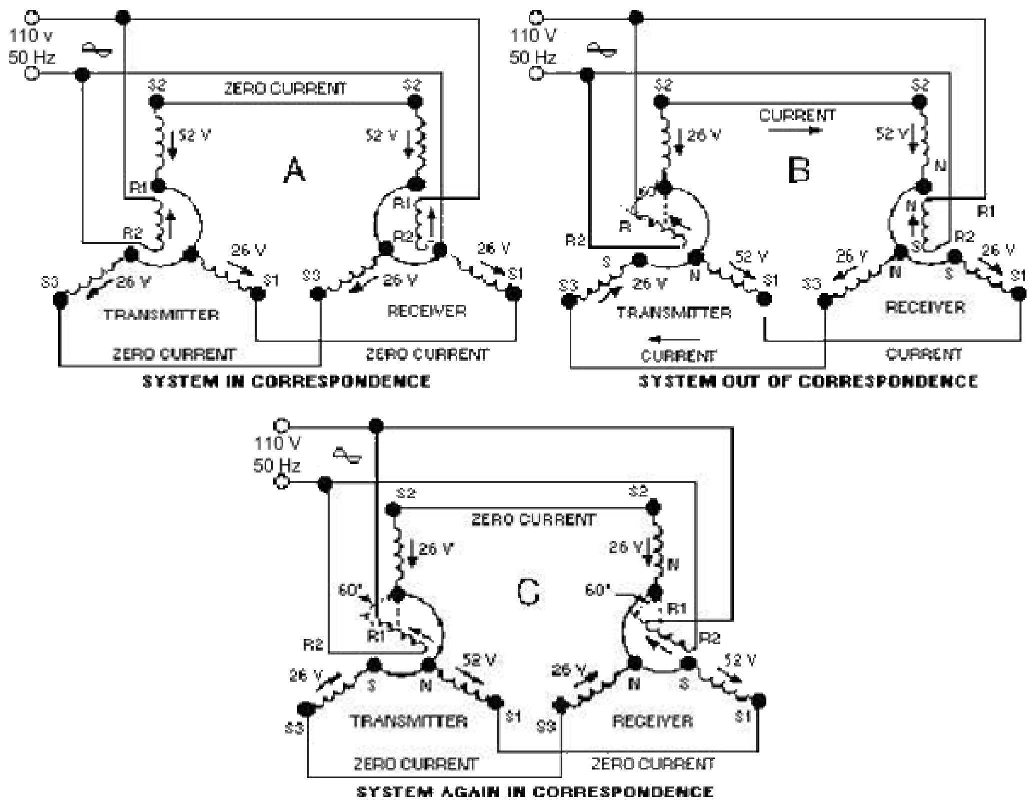
When the transmitter rotor is turned-say 30 degrees, as in figure 6 (B)-the resultant field produced by the stator turns too, as it did in figure 5; so does the receiver stator field. And the transmitter rotor, being free to follow, does. See figure 6 (C).



Syncro System (Transmitter connected to receiver)

Figure 6

A simple synchro transmission system consisting of a torque transmitter connected to a torque receiver (TX-TR) is illustrated in figure 7. As you can see, in this system the rotors are connected in parallel across the ac line. The stators of both synchros have their leads connected S1 to S1, S2 to S2, and S3 to S3, so the voltage in each of the transmitter stator coils opposes the voltage in the corresponding coils of the receiver. The voltage directions are indicated by arrows for the instant of time shown by the dot on the ac line voltage.



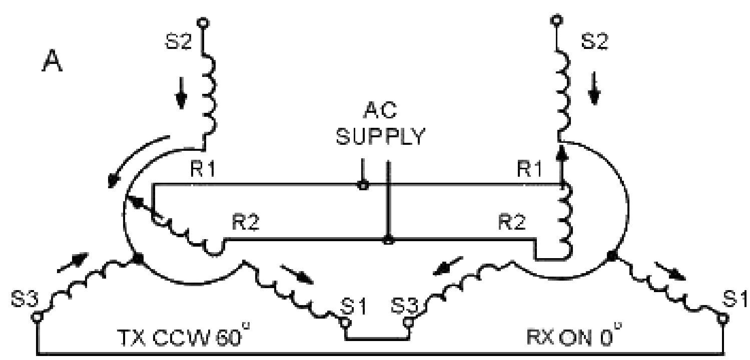
A simple synchro transmission system

Figure 7

When both transmitter and receiver rotors in a synchro system are on zero or displaced from zero by the same angle, a condition known as CORRESPONDENCE exists. In view A of figure 7, the transmitter and receiver are shown in correspondence. In this condition, the rotor of the TR induces voltages in its stator coils that are equal to and opposite the voltages induced into the TX stator coils. This causes the voltages to cancel and reduces the stator currents to zero. With zero current through the coils, the receiver torque is zero and the system remains in correspondence. The angle through which a transmitter rotor is mechanically rotated is called a SIGNAL. In view B of figure 7, the signal is 60º. Now, consider what happens to the two synchros in correspondence when this signal is generated. When the transmitter's rotor is turned; the rotor field follows and the magnetic coupling between the rotor and stator windings changes. This results in the transmitter decreasing S2 coil's voltage, reversing of the S3 coil voltage, and increasing the S1 coil's voltage. This imbalance in voltages, between the transmitter and receiver, causes current to flow in the stator coils in the direction of the stronger voltages. The current flow in the receiver produces a resultant magnetic field in the receiver stator in the same direction as the rotor field in the transmitter. A force (torque) is now exerted on the receiver rotor by the interaction between its resultant stator field and the magnetic field around its rotor. This force causes the rotor to turn through the same angle as the rotor of the transmitter. As the receiver approaches correspondence, the stator voltages of the transmitter and receiver approach equality. This action decreases the stator currents and produces a decreasing torque on the receiver. When the receiver and the transmitter are again in correspondence, as shown in view C, the stator voltages between the two synchros are equal and opposite, the rotor torque is zero, and the rotors are displaced from zero by the same angle (60º). This sequence of events causes the transmitter and receiver to stay in correspondence. In the system we just explained, the receiver reproduced the signal from the transmitter. As you can see, a synchro system such as this could provide a continuous, accurate, visual reproduction of important information to remote locations.

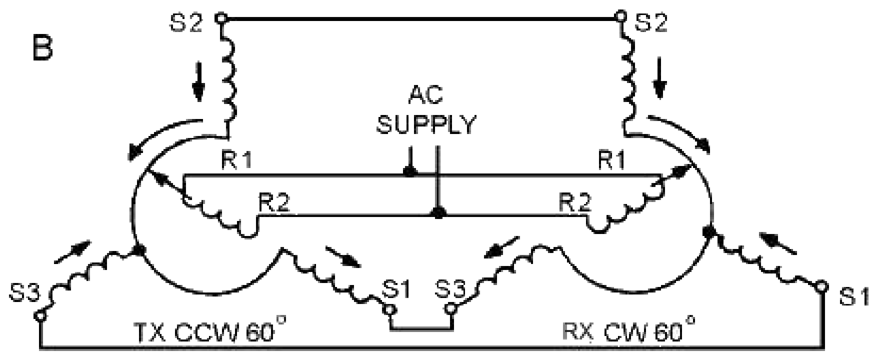
Receiver Rotation

When the teeth of two mechanical gears are meshed and a turning force is applied, the gears turn in opposite directions. If a third gear is added, the original second gear turns in the same direction as the first. This is an important concept, because the output of a synchro receiver is often connected to the device it operates through a train of mechanical gears. Whether or not the direction of the force applied to the device and the direction in which the receiver rotor turns are the same depends on whether the number of gears in the train is odd or even. The important thing, of course, is to move the dial or other device in the proper direction. Even when there are no gears involved, the receiver rotor may turn in the direction opposite to the direction you desire. To correct this problem, some method must be used to reverse the receiver's direction of rotation. In the transmitter-receiver system, this is done by reversing the S1 and S3 connections so that SI of the transmitter is connected to S3 of the receiver and vice versa (fig. 8), view (A) and view (B).



Effect of reversing the S1 and S3 connections between the transmitter and the receiver.

Figure 8(a)



Effect of reversing the S1 and S3 connections between the transmitter and the receiver

Figure 8(b)

Even when the S1 and S3 connections are reversed, the system at 0º acts the same as the basic synchro system we previously described at 0º. This is because the voltages induced in the S1 and S3 stator windings are still equal and oppose each other. This causes a canceling effect, which results in zero stator current and no torque. Without the torque required to move the receiver rotor, the system remains in correspondence and the reversing of the stator connections has no noticeable effect on the system at 0º. Suppose the transmitter rotor is turned counterclockwise 60º, as shown in view A of figure 8. The TX rotor is now aligned with S1. This results in maximum magnetic coupling between the TX rotor and the S1 winding. This maximum coupling induces maximum voltage in S1. Because S1 is connected to S3 of the RX, a voltage imbalance occurs between them. As a result of this voltage imbalance, maximum current flows through the S3 winding of the RX causing it to have the strongest magnetic field. Because the other two fields around S2 and S1 decrease proportionately, the S3 field has the greatest effect on the resultant RX stator field. The strong S3 stator field forces the rotor to turn 60º clockwise into alignment with itself, as shown in view B. At this point, the rotor of the RX induces canceling voltages in its own stator coils and causes the rotor to stop. The system is now in correspondence. Notice that by reversing S1 and S3, both synchro rotors turn the same amount, but in Opposite Directions. We must emphasize that the only stator leads ever interchanged, for the purpose of reversing receiver rotation, are S1 and S3. S2 cannot be reversed with any other lead since it represents the electrical zero position of the synchro. As you know, the stator leads in a synchro are 120º apart. Therefore, any change in the S2 lead causes a 120º error in the synchro system and also reverses the direction of rotation. In new or modified synchro systems, a common problem is the accidental reversal of the R1 and R2 leads on either the transmitter or receiver. This causes a 180º error between the two synchros, but the direction of rotation remains the same.

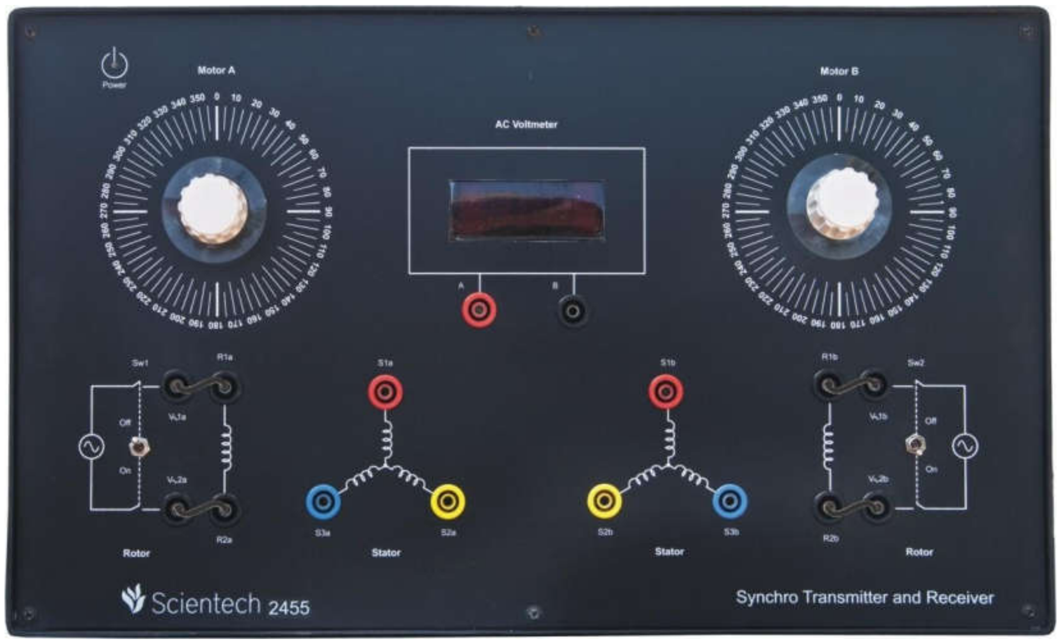
Experiment 1

Objective: Study of Synchro Transmitter

Equipments Needed:

- Scientech 2455 Synchro Transmitter Receiver
- Patch Cords

Connection Diagram



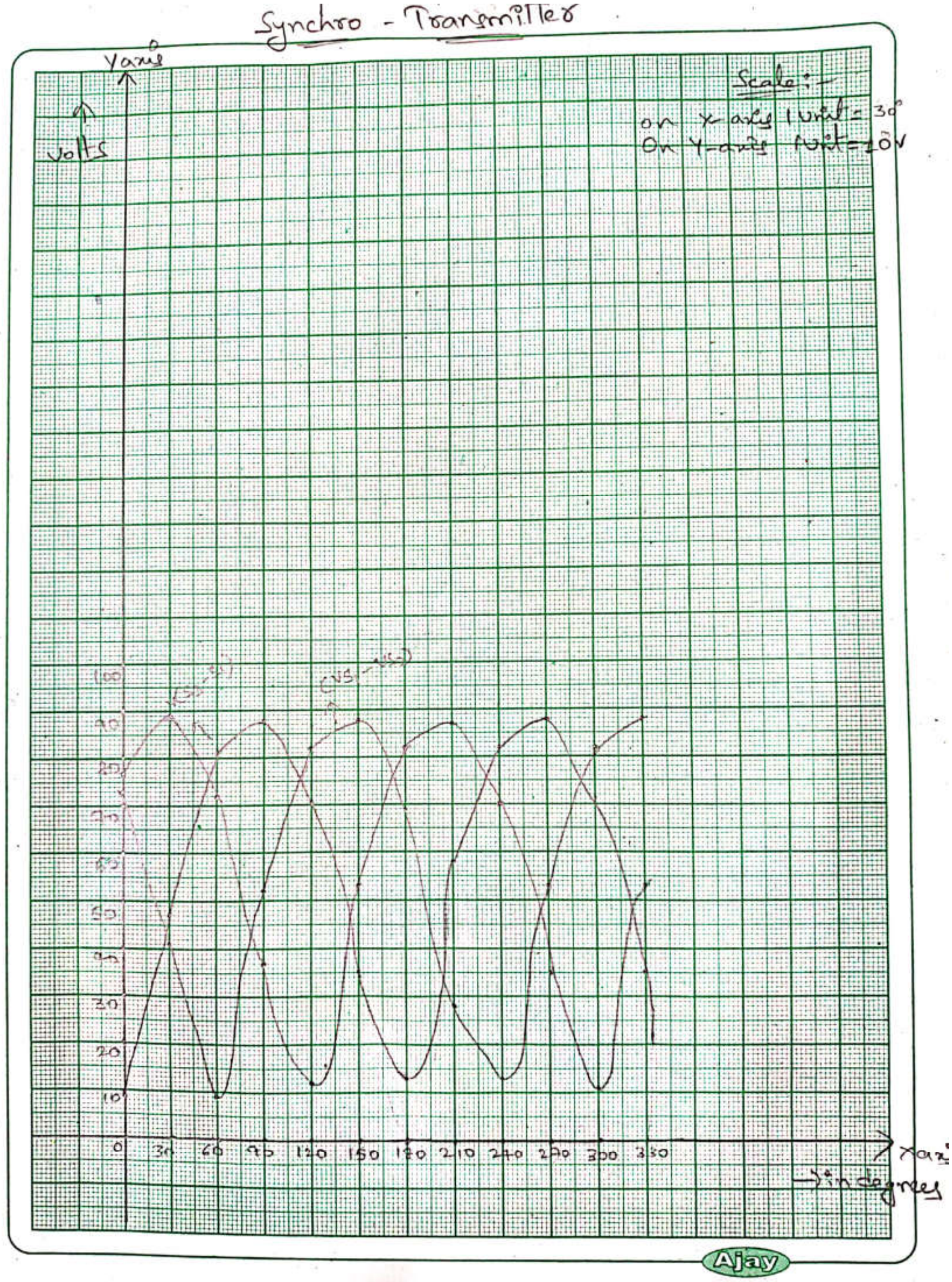
Procedure:

- Connect the mains supply to the system with the help of cable provided.
- Switch on mains supply for the unit.
- Connect patch cord from V~1a to R1a.
- Connect patch cord from V~2a to R2a.
- Switch on Sw1 and set the dial of Motor A in Zero Position.
- Starting from Zero Position, note down the voltage between stator winding terminals i.e. V(S3a-S1a), V(S1a-S2a) and V(S2a-S3a) with the help of AC Voltmeter in a sequential manner. Enter readings in a tabula form and plot a graph of angular position of rotor voltages for all three phases.
- The same procedure will follow for Motor2.
- Note that the zero position of the transmitter rotor coincides with V (S3a-S1a) voltage equal to zero voltage. Do not disturb this condition.

Observation Table

S.No.	Rotor Position Degrees	Vrms for Stator Terminal V(S3a-S1a)	Vrms for Stator Terminal V(S1a-S2a)	Vrms for Stator Terminal V(S2a-S3a)
1	00	9	73	77
2	30	47	41	89
3	60	81	9	72
4	90	88	52	37
5	120	70	82	12
6	150	35	88	53
7	180	13	69	82
8	210	58	28	87
9	240	82	13	70
10	270	88	53	35
11	300	71	82	11
12	330	35	88	53

MODEL GRAPH:


Synchro - Transmitter
Y axis
volts
Scale:-
On X-axis 1 unit = 30°
On Y-axis 1 unit = 10V
100
90
80
70
60
50
40
30
20
10
0
30
60
90
120
150
180
210
240
270
300
330
X axis
→ in degrees
Ajay

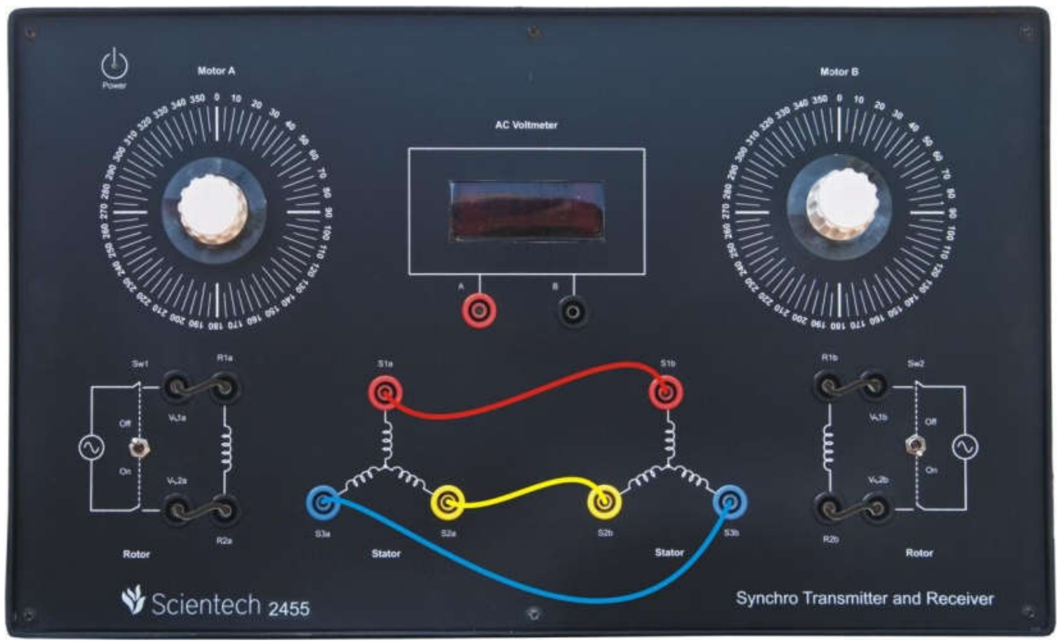
Experiment 2

Objective: Study of Synchro Transmitter and Receiver pair

Equipments Needed:

- Scientech 2455 Synchro Transmitter Receiver
- Patch Cords

Connection Diagram:



Procedure:

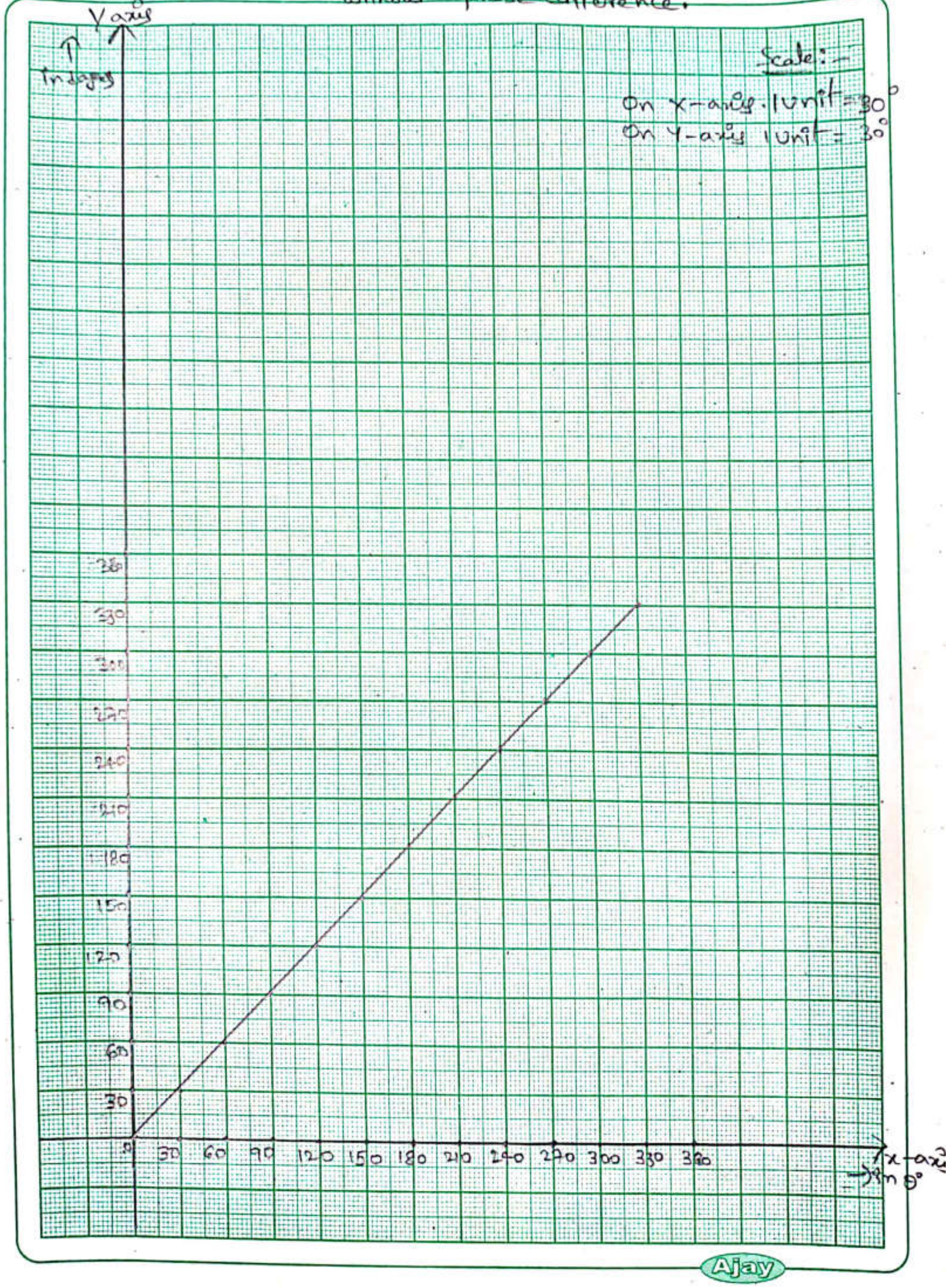
- Connect the mains supply to system with the help of cable provided.
- Connect s1a, s2a and s3a terminals of synchro transmitter Motor A to s1a, s2a and s3a of synchro receiver Motor B by patch cords provided respectively.
- Connect patch cord from V~1a to R1a.
- Connect patch cord from V~2a to R2a.
- Connect patch cord from V~1b to R1b.
- Connect patch cord from V~2b to R2b.
- Switch on Sw1 and Sw2 and switch on the mains supply.
- Move the pointer i.e. rotor position of synchro transmitter Motor A in steps of 30°and observe the new rotor position. Observe that whenever Motor A is rotated, the rotor of Motor B follows it for both the direction of rotations and their positions are in good agreement.
- Enter the input angular position in the tabular form and plot the graph.

Observation Table

S.No.	Angular Position in Degrees Synchro Transmitter Motor A	Angular Position in Degrees Synchro Receiver Motor B
1	0	0
2	30	30
3	60	60
4	90	90
5	120	120
6	150	150
7	180	180
8	210	210
9	240	240
10	270	270
11	300	300
12	330	330

MODEL GRAPH:

Synchro - Transmitter and Receiver pair without phase difference.



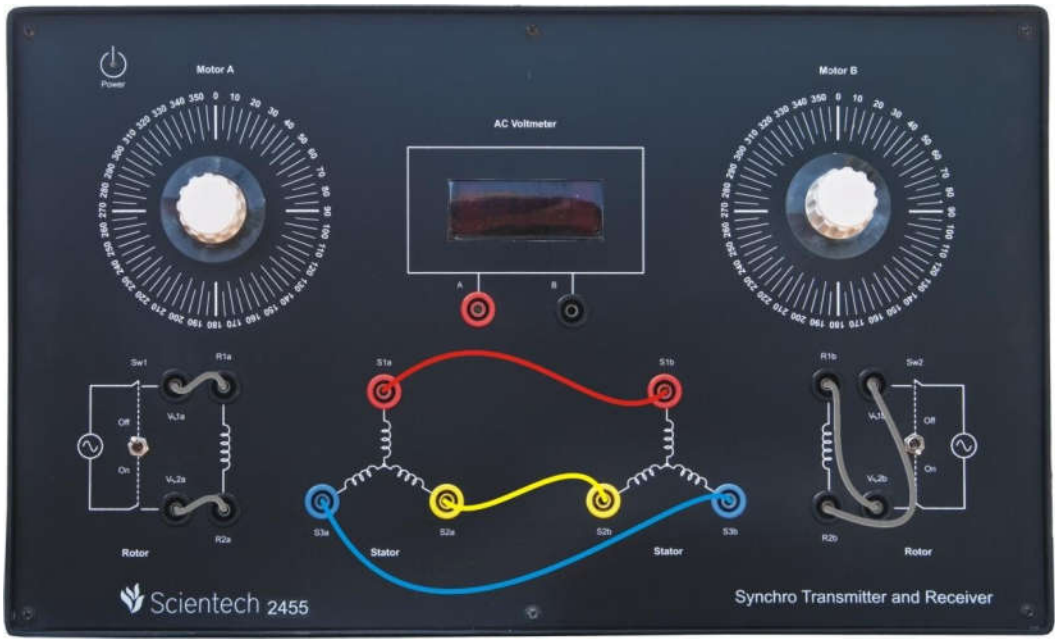
Experiment 3

Objective: Study of Synchro Transmitter and Receiver pair with phase difference

Equipments Needed:

- Scientech 2455 Synchro Transmitter Receiver
- Patch Cords

Connection Diagram:



Procedure:

- Connect the mains supply to system with the help of cable provided.
- Connect s1a, s2a and s3a terminals of synchro transmitter Motor A to s1a, s2a and s3a of synchro receiver Motor B by patch cords provided respectively.
- Connect patch cord from V~1a to R2a.
- Connect patch cord from V~2a to R1a.
- Connect patch cord from V~1b to R1b.
- Connect patch cord from V~2b to R2b.
- Switch on Sw1 and Sw2 and switch on the mains supply.
- Move the pointer i.e. rotor position of synchro transmitter Motor A in steps of 30°and observe the new rotor position. Observe that whenever Motor A is rotated, the rotor of Motor B follows it for both the direction of rotations but in 180° out of phase and their positions are in good agreement.
- Enter the input angular position in the tabular form and plot the graph.

Observation Table:

S.No.	Angular Position in Degrees Synchro Transmitter Motor A	Angular Position in Degrees Synchro Receiver Motor B
1	0	180
2	30	210
3	60	240
4	90	270
5	120	300
6	150	330
7	180	0
8	210	30
9	240	60
10	270	90
11	300	120
12	330	150

RESULT: The performance characteristics of synchro transmitter and receiver studied.

TIME RESPONSE CHARACTERISTICS OF A SECOND ORDER SYSTEM

FRONT PANEL DETAILS:

1. Power : Mains ON/OFF switch with builtin indicator
2. AC output : Square wave output w. r. t. GND for the experiment
3. Frequancy : Varies from 100 Hz to 500 Hz in Hz Range
4. Amplitude : Varies up to 10 V
5. R1 : 1 k Ω
6. R2 : 6.32 k Ω
7. R3 : 10 k Ω
8. L : 100 mH
9. C : 0.01 μF
10. C_V : 560 pF

TIME RESPONSE CHARACTERISTICS OF A SECOND ORDER SYSTEM

THEORY:

TIME RESPONSE:

The time response of the system is the output of the closed loop system as a function of time. It is denoted by C(t). The time response can be obtained by solving the differential equation governing the system. Alternatevely, the response C(t) can be obtained from the transfer function of the system and the input to the system.The output in s-domain, C(s) is given by the product of the transfer function and the input R(s). On taking inverse Laplace transform of this product the time domain response, C(t) can be obtained.

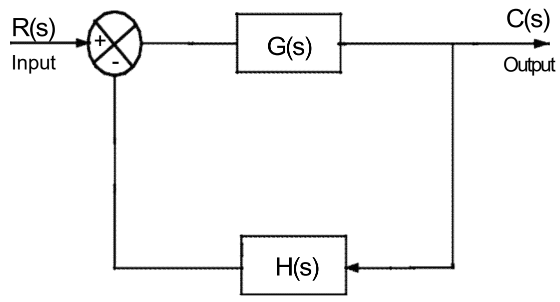


Fig.1. Closed loop system.

The closed loop transfer function, C(s)/R(s) = G(s)/[1+G(s).H(s)] …… (1)

Response in s-domain, C(s)=[R(s).G(s)]/[1+G(s).H(s)] ……(2)

Response in time domain, $C(t) = L^{-1}[C(s)] = L^{-1}$ {[R(s).G(s)]/[1+G(s)H(s)]} ..….(3)

The time response of a control system consists of two parts: the transient and steady state response. The transient response shows the response of the system when the input changes from one state to another. The steady state response shows the response as time, t approaches infinity.

The standard test signals is

STEP SIGNAL: The step signal is a signal whose value changes from zero to A at t=0 and remains constant at A for t >0. A special case of step signal is unit step in which A is unity.

$r(t) = A\,u(t).$

Where, $u(t) = 1;\ t > 0.$

$u(t) = 0;\ t < 0.$

SECOND ORDER SYSTEM:

The standard form of closed loop transfer function of second order system is given by

$$C(s)/R(s) = \omega_n^2 / s^2 + 2\delta\omega_n s + \omega_n^2. \quad \text{.......(4)}$$

Where ω_n = undamped natural frequency, rad/sec.

δ = damping ratio.

Case 1: Undamped system, $\delta = 0$,

Case 2: Underdamped system, $0 < \delta < 1$,

Case 3: Critically damped system, $\delta = 1$,

Case 4: Over damped system, $\delta > 1$.

The characteristics equation of second order system is

$$s^2 + 2\delta\omega_n s + \omega_n^2 = 0. \quad \text{.......(5)}$$

It is a quadratic equation and the roots are ginen by

$$s1, s2 = \frac{-2\delta\omega_n \pm \sqrt{(4\delta^2\omega_n^2 - 4\omega_n^2)}}{2} \quad \text{.......(6)}$$

$$= \frac{-2\delta\omega_n \pm \sqrt{(4\omega_n^2(\delta^2-1))}}{2} \quad \text{.......(7)}$$

$$= -\delta\omega_n \pm \omega_n^2\sqrt{(\delta^2-1)} \quad \text{.......(8)}$$

when $\delta = 0$, $s1, s2 = \pm j\omega_n$; roots are purely imaginary and the system is undamped.

When $\delta = 1$, $s1, s2 = -\omega_n$; roots are real and equal and the system is Critically damped.

When $\delta > 1$, $s1, s2 = -\delta\omega_n \pm \omega_n^2\sqrt{(\delta^2-1)}$;

roots are real and unequal and the system is over damped.

When $0 < \delta < 1$, $s1, s2 = -\delta\omega_n \pm \omega_n\sqrt{(\delta^2-1)}$

$= -\delta\omega_n \pm \omega_n\sqrt{(-1)}\ (1-\delta^2)$

$= -\delta\omega_n \pm j\omega_n\sqrt{(1-\delta^2)}$

$= -\delta\omega_n \pm \omega_d$;

roots are complex conjugate and the system is underdamped.

Where $\omega_d = \omega_n\sqrt{(1-\delta^2)}$

Here ω_d is called damped frequency of oscillation of the system and its unit is rad/sec.

Unit step response of Second Order systems

$r(t) = A\ u(t)$.

Where, $u(t) = 1$; $t > 0$.

$u(t) = 0$; $t < 0$.

Which has Laplace transform as given by

$R(s) = 1/s$.

From equation (4)

$$C(s) = \{\omega_n^2/[s^2+2\delta\omega_n s+\omega_n^2]\}\ R(s) \qquad \text{.....(9)}$$

$$C(s) = \{\omega_n^2/[s^2+2\delta\omega_n s+\omega_n^2]\}\,[1/s]$$

Refering to the table of inverse Laplace transforms, we have the response of the system given by

$$C(t)=1-\frac{e^{-\delta\omega_n t}}{\sqrt{(1-\delta^2)}}\sin[\omega_d t+\tan^{-1}\frac{\sqrt{(1-\delta^2)}}{\delta}] \qquad \text{.....(10)}$$

Where δ = damping ratio.

ω_n = undamped natural frequency of the system

ω_d = damped frequency of oscillations of the system

and $\omega_d = \omega_n\sqrt{(1-\delta^2)}$

From equation (10), it can be seen that the frequency of transient oscillations is the damped natural frequency w_d and thus varies with the damping ratio.

I. Typical response of undamped second order system with step input [δ=0]

$$C(s)/R(s) = \omega_n^2 / [s^2+2\delta\omega_n s+\omega_n^2] \qquad \text{….(11)}$$

For step input

$$R(s) = 1/s.$$

The time domine response is

$$C(t) = 1- \cos \omega_n t. \qquad \text{….(12)}$$

The response of undamped second order system for unit step input is completely oscillatory.

II. Typical response of under-damped second order system with step input [0 < δ <1]

The time domine response is

$$C(t) = 1- \frac{e^{-\delta\omega_n t}}{\sqrt{(1-\delta^2)}} (\sin \omega_d t \cos\theta+\cos\omega_d t \sin\theta)$$

$$= 1- \frac{e^{-\delta\omega_n t} \sin (\omega_d t + \theta)}{\sqrt{(1-\delta^2)}} \qquad \text{….(13)}$$

Where $\theta = \tan^{-1} \left(\frac{\sqrt{(1-\delta^2)}}{\delta}\right)$

The response of underdamped second order system oscillates before settling to a final value. The oscillation depends on value of the damping ratio.

III. Typical response of critically damped second order system with step Input [δ=1].

The time domine response is

$$C(t) = 1-e^{-\omega_n t}(1+\omega_n t). \qquad \text{….(14)}$$

The response of critically damped second order system has no oscillations.

IV. Typical response of overdamped second order system with step input [δ>1].

The time domine response is

$$C(t)= 1 - \frac{\omega_n}{2\sqrt{(\delta^2-1)}}\left[\frac{e^{-s_1 t}}{s1} - \frac{e^{-s2t}}{s2}\right] \quad ....(15)$$

$$S1= \delta\omega_n - \omega_n\sqrt{(\delta^2-1)}$$

$$S2= \delta\omega_n + \omega_n\sqrt{(\delta^2-1)}$$

The response of overdamped second order system has no oscillations but it takes longer time for response to reach the final steady value.

Time domine specifications

The desired performance characteristics of control systems are specified in terms of time domine specifications. Systems with energy storage elements cannot respond instantaneously and will exihibit transient responses, wherever they are subjected to input or disturbances.

The desired performance characteristics of a system of any order may be specified in terms of the transient response to a unit step input signal. The response of a second order system for unit-step input with various values of damping ratio is shown in fig.2.

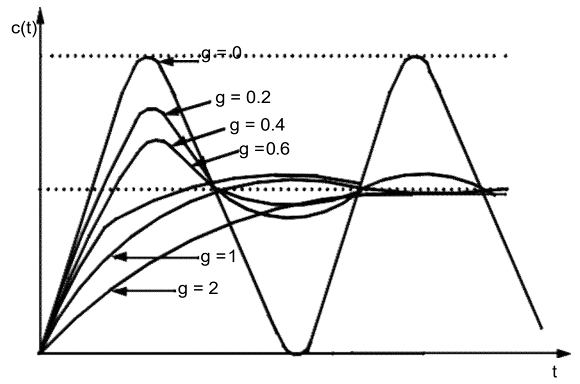


Fig.2. The time response of II order system for various values of δ.

The transient response of a practical control system often exhibits damped oscillations before reaching steady state. A typical oscillatory response of the second order system shown fig.3.

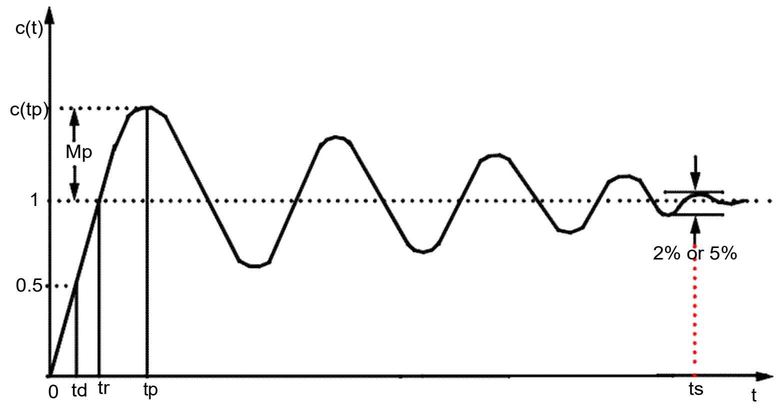


Fig.3. The time response of II order system for under damped case

TIME DOMAIN SPECIFICATION:

In specifying the transient response characteristics of a control system to a unit-step input, we usually specify the following.

1). **Delay time (t_d):** It is time taken for response to reach 50% of the final value, for the very first time.

$$t_d = [1+ 0.7\delta] /\omega_n \text{ seconds.}$$

2). **Rise time (t_r):** It is the time taken for response to raise from 0 to 100% for the very first time. For underdamped system, the rise time is calculated from 0 to 100%. But for overdamped system, it is the time taken by the responase to raise from 10% to 90%. For critically damped system it is the time taken for response to raise from 5% to 95%.

$$t_r = \frac{\Pi - \theta}{\omega_d}$$

3). **Peak time (t_p):** It is the time taken for the response to reach the peak value for the very first time, or it is the time taken for the response to reach the peak overshoot, Mp.

$$t_p = \Pi /\omega_d.$$

4). **Peak overshoot (Mp):** It is defined as he ratio of the maximum peak value measured from final value to the Mp.

% peak overshoot Mp = $[e^{-\delta\Pi/(\sqrt{(1-\delta)})}]$ x100.

5). **Settling time (t_s):** It is the time taken by the response to reach & stay within a specified error. i.e., either 2% or 5% of the final value.

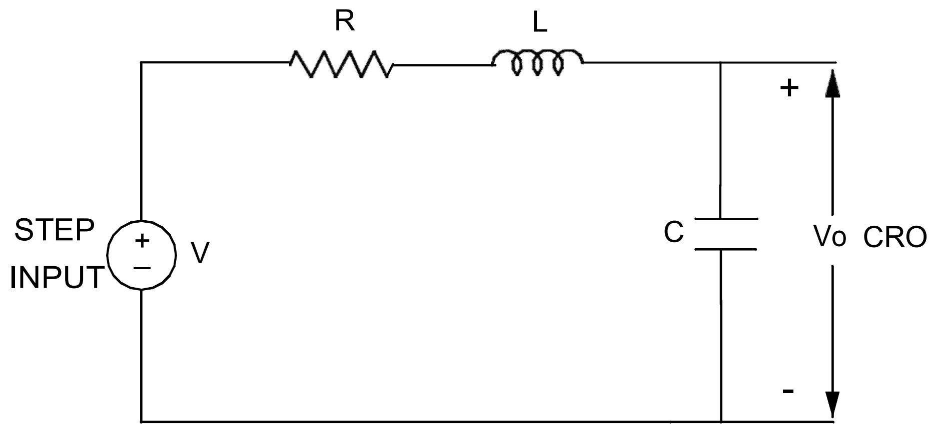
$t_s = 4/\ \delta\omega_n$ for ± 2% tolerance.
$t_s = 3/\ \delta\omega_n$ for ± 5% tolerance.

Analysis of Second Order System

The characteristics equation of second order system is

$$s^2 + 2\delta\omega_n s + \omega_n^2 = 0. \qquad \text{.......(16)}$$

Where $\omega_n = \dfrac{1}{\sqrt{(LC)}}$



For series RLC circuit,
Ri + L di/dt +1/C idt =V

d^2i/dt^2 + R/L [di/dt] +i/LC = 0

$$m^2 + R/L\ m + 1/LC = 0 \qquad \text{.......(17)}$$

on comparing equation (16) & (17), we get,

$R/L = 2\delta\omega_n$

$$\mathbf{R = \frac{2\delta}{\sqrt{(C/L)}}} \qquad \text{.......(18)}$$

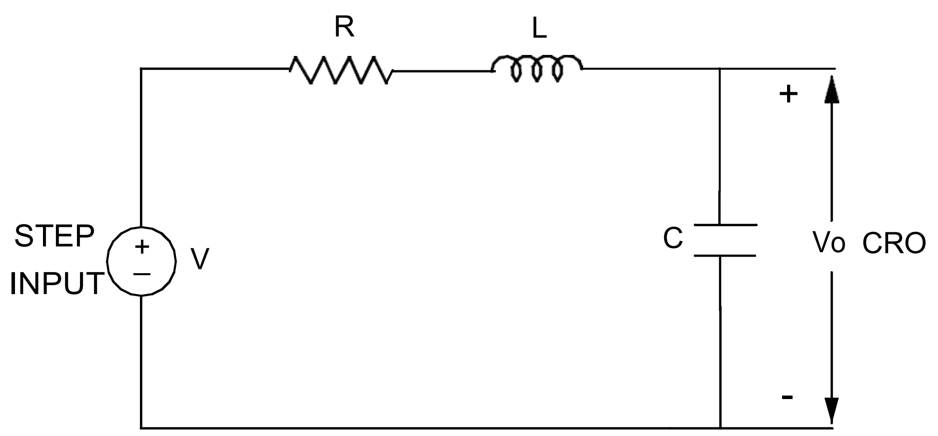
EXPERIMENTAL

AIM: Determination of time response characteristics of a second order system.

APPARATUS: Time response characteristics apparatus, CRO, patch chords etc.,

PROCEDURE

Circuit diagram



I Under damped case [0 < δ <1]

Let δ = 0.158

C = 0.01 uF
L = 100 mH

$$R = \frac{2\delta}{\sqrt{(C/L)}} = \frac{2 \times 0.158}{\sqrt{(0.01 \times 10^{-6} / 100 \times 10^{-3})}} = 1\ k\,\Omega$$

Therefore Choose R1

II Critically damped case [δ=1]

Let δ = 1.0

C = 0.01 uF
L = 100 mH

$$R = \frac{2\delta}{\sqrt{(C/L)}} = \frac{2 \times 1.0}{\sqrt{(0.01 \times 10^{-6} / 100 \times 10^{-3})}} = 6.32\ k\ \Omega$$

Therefore Choose R2

III Over damped case [δ>1]

Let δ = 1.58

C = 0.01 uF
L = 100 mH

$$R = \frac{2\delta}{\sqrt{C/L}} = \frac{2 \times 1.58}{\sqrt{(0.01 \times 10^{-6} / 100 \times 10^{-3})}} = 10\ k\ \Omega$$

Therefore Choose R3

Calculations:

For under damped case:

$$\omega_n = 1/\sqrt{(LC)} = 1/\sqrt{(100 \times 10^{-3} \times 0.01 \times 10^{-6})}$$
$$= 31622 \text{ rad/sec}$$
$$\omega_d = \omega_n \sqrt{(1-\delta^2)} = 31622 \sqrt{(1- 0.158^2)}$$
$$= 31224 \text{ rad/sec}$$

1). Delay time (t_d):

$$t_d = [1+ 0.7\delta] / \omega_n \quad \text{Sec.}$$

$t_d = [1+ 0.7 \times 0.158] /31622$
$= 35.12\ \mu S$

2). <u>Rise time (t_r):</u>

$$t_r = \frac{\Pi - \theta}{\omega_d}$$

$$\theta = \tan^{-1}\left(\frac{\sqrt{1-\delta^2}}{\delta}\right) = \tan^{-1}\left(\frac{\sqrt{1-0.158^2}}{0.158}\right) \ \mathbf{= 80.90^0 = 1.42\ rad}$$

$$t_r = \frac{\Pi - \theta}{\omega_d} = \frac{3.142 - 1.42}{31224} = 55.14\ \mu S$$

3). <u>Peak time (t_p):</u>

$$t_p = \Pi / \omega_d = 3.142/31224 = 100.62\ \mu S$$

4). <u>Peak overshoot (Mp):</u>

$$\%\text{ peak overshoot } Mp = [e^{-\delta\Pi /(\sqrt{(1-\delta)})}] \times 100$$

$$= [e^{-0.158\Pi / (\sqrt{(1-0.158)})}] \times 100$$
$$= 66.33\ \%$$

5). <u>Settling time (t_s):</u>

$t_s = 4/ \delta\omega_n$ for $\pm$ 2% tolerance.
$t_s = 4/ 0.158 \times 31622$
$= 0.8$ mS
$t_s = 3/ \delta\omega_n$ for $\pm$ 5% tolerance.
$t_s = 3/ 0.158 \times 31622$
$= 0.6$ mS

Tabular Coloum:

Time	Theoretical values	Practical values
t_d	35.12 µS	35 µs
t_r	55.14 µS	55 µS
t_p	100.62 µS	100 µS
M_p	66.33 %	63.52 % or 40%
t_s	0. 8 mS for ± 2%	0.6 mS for ± 2%
	0. 6 mS for ± 5%	0.5 mS for ± 5%

1. Connections are made for under damped case.
2. For $\delta = 0.158$ (less than 1) ($R = 1k\Omega$, $L = 100$ mH, $C = 0.01$ uF) & find the values of t_d, t_r, t_p, M_p, & t_s theoretically for under damped case.
3. Give the square input say (10 Volts) by using signal source.
4. Take the output across the capacitor and observe the output waveforms in the CRO.
5. Find t_r, t_p, m_p, & t_s practically from the waveforms for the underdamped conditions.
6. Connections are made for critically damped case note down rise time t_r using CRO.
7. Connections are made for over damped case note down rise time t_r using CRO.
8. Draw all the three wave forms on the graph sheet for different δ .

RESULT: the characteristics of time response of second order system studied.

TRANSFER FUNCTION OF DC MOTOR

CONTENTS

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CONTROLLER FOR DC MOTOR – GENERATOR 0.5HP/180V (TRANSFER FUNCTION STUDY MODULE)

This unit consists of DC/AC supplies, digital AC/DC voltmeter and a digital AC/DC Ammeter for DC motor – Generator set to find its transfer function.

This unit consists of

- 0-220V @ 3 Amps variable DC supply for Armature of DC motor for speed control of DC motor using single phase half controlled bridge rectifier.
- A variable DC supply from 100V – 220V @ 2Amps for field of DC motor for speed control of DC motor by field control and also for field of DC generator for variable DC generator output.
- A fixed supply of 220V ± 10% for field of DC motor using 1-ph Diode Bridge Rectifier.
- A variable AC supply of 0-230volts + @ 2 Amps to find inductance of armature and field of DC motor / Generator.
- A digital voltmeter to measure AC and DC voltages with AC/DC selector switch.
- A digital Ammeter to measure AC/DC current with AC/DC selector switch.
- Neon indicators are provided for all AC/DC supplies.
- Fuse Protection is provided for the power supplies.
- 6A / 1 pole MCB is provided to switch ON/OFF the AC supply to the unit and also for protection.
- From this unit we can do the following experiments to find out Transfer Function of:

- Armature controlled DC motor.
- Field controlled DC motor.
- Separately excited DC generator.
- Self Excited DC generator.

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CONTROLLER FOR DC MOTOR – GENERATOR 0.5HP/180V (TRANSFER FUNCTION STUDY MODULE)

FRONT PANEL DETAILS :

AC IN **:** Transfer to connect 230volts AC mains supply.
MCB **:** 2 pole / 6A MCB to turn OFF / ON AC supply to the controller.

ARMATURE
VA : Potentiometer to vary the armature voltage from 0-220V.
OFF : ON/OFF switch for armature voltage with soft start.
ON
0-220V DC **:** 0-220V variable DC supply for armature 1-phase Half controlled bridge rectifier with neon lamp indicator.
0-230V AC **:** 0-230V variable AC supply to find inductance of Field coil with Neon Lamp (AC voltage controller).

FIELD
VF : Potentiometer to vary the field voltage from 100V to 200V.
100-220V DC: Variable DC supply from 100V to 200V approximately with Neon Lamp indicator for field.
220V DC **:** 220V ± 10% @ @A rectified DC supply for field supply of DC motor or generator with Neon Lamp indicator.

DIGITAL VOLTMETER: 3 ½ digit voltmeter to measure AC/DC voltage with AC/DC selector switch.
DIGITAL AMMETER **:** 3 ½ digit ammeter to measure AC/DC current with AC/DC selector switch.

TRANSFER FUNCTION OF ARMATURE CONTROLLED DC MOTOR:

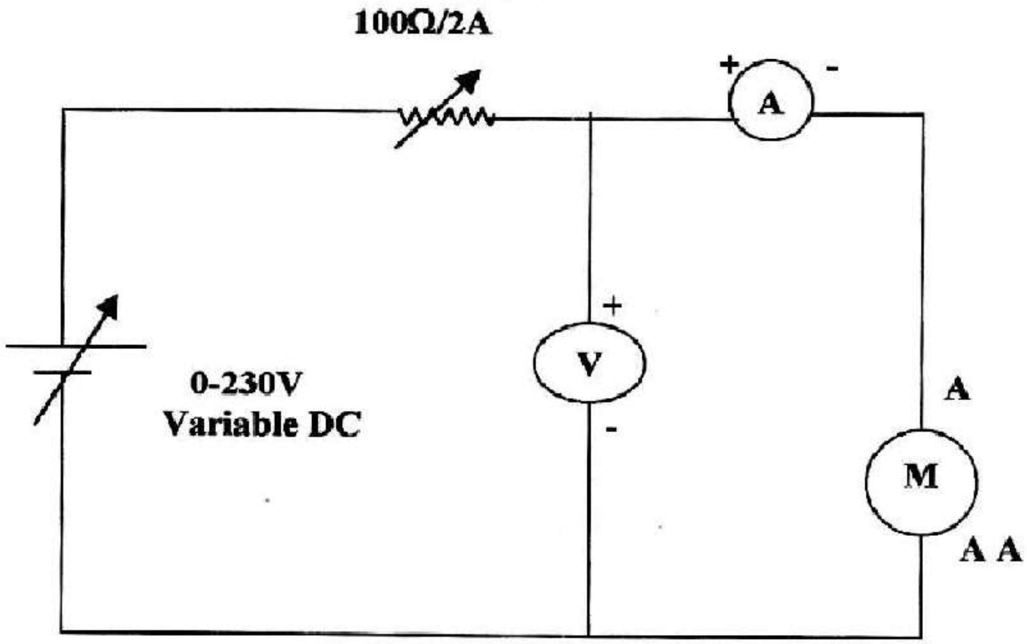
This setup consists of the following units to conduct the above experiments:

a. DC motor – 0.5HP/180V/1500 rpm with mechanical loading arrangement.
b. Controller unit suitable for the above motor to vary the armature voltage and field voltage with Digital meters.
c. Tachometer : Digital contact Tachometer to measure the speed of DC motor.

DC motor – 0.5HP/180V/1500 rpm

- ✓ Armature Resistance – Ra = 15 ohms
- ✓ Armature Inductance – La = 135 mH
- ✓ Field Resistance - Rf = 400 ohms
- ✓ Field Inductance - Lf = 21 H
- ✓ Moment of Inertia - J = 0.024 Kg – m^2
- ✓ Friction Co-efficient - B = 0.8

MEASUREMENT OF ARMATURE RESISTANCE



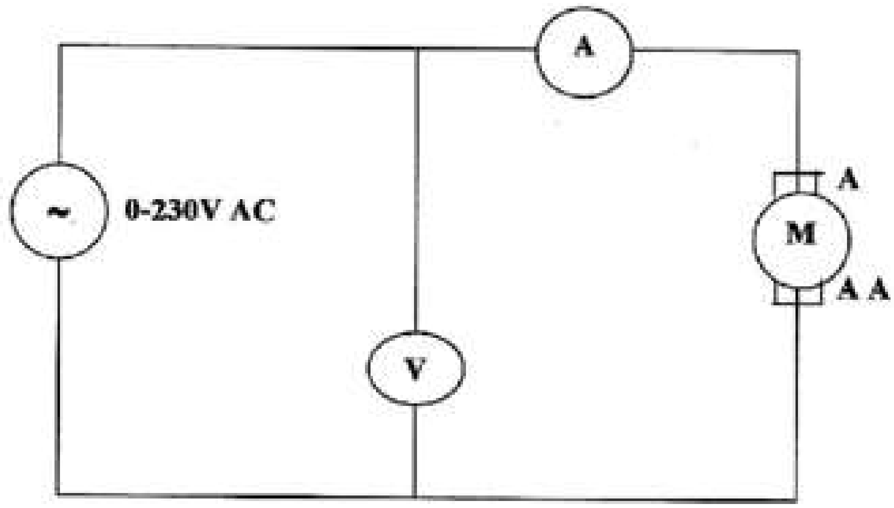
1. Connect circuit as shown in figure.Keeping the field circuit open.
2. Motor shaft should not be rotate.
3. Vary the input voltage slowly from (0-20)V & armature current should not exceed the rated current, and note down the ammeter and voltmeter readings in the tabular column.
4. Calculate the resistance (R_a)=V/I.
5. Repeat the same for different input voltages.
6. The average resistance value gives the Armature Resistance.

Tabular column

Sl.No.	Va (Volts)	Ia (Amps)	Ra=Va/Ia (ohms)
1	5	0.55	9.09
2	9	1.01	8.91
3	13	1.51	8.60
4	18	2.06	8.73
5	20	2.3	8.7

Ravg=8.821 oh

MEASUREMENT OF ARMATURE INDUCTANCE



1. Make the connections as given in the circuit diagram. Keep field circuit open.
2. Vary the input AC Voltage from the controller and note down voltmeter and Ammeter readings and enter in the tabular column.
3. Calculate za, xa and La
4. Repeat the same for different input voltages
5. The average Value gives the La

f = 50Hz

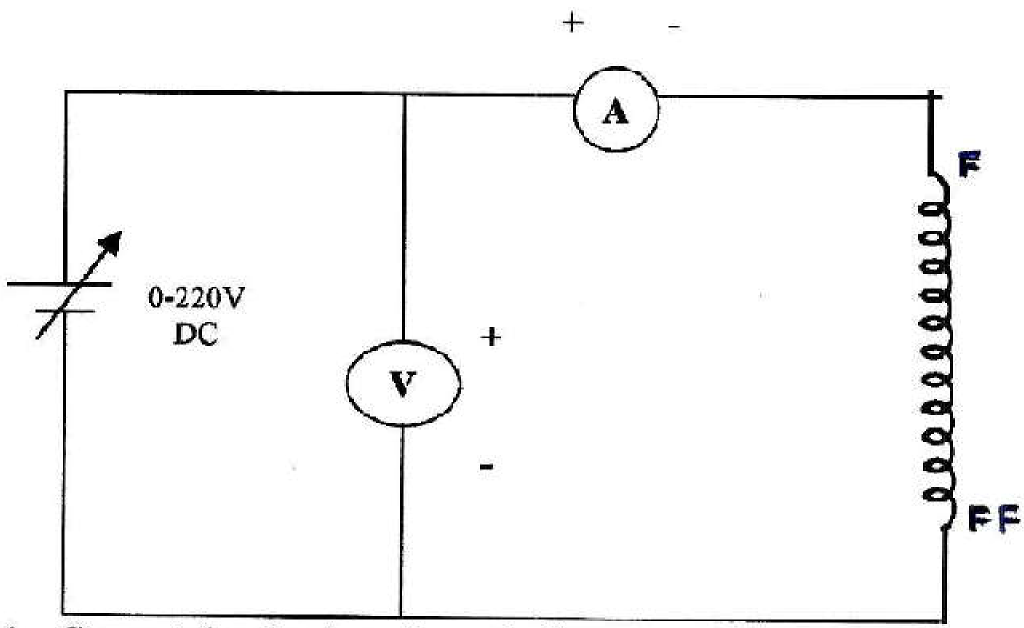
Ra - ohms

Tabular column:

S.NO	V_A	I_A	Z_A	X_A	L_A
1	20	0.15	133.33	133.02	0.423
2	40	0.28	142.85	142.6	0.453
3	60	0.45	133.33	133.05	0.4233
4	80	0.65	123.07	122.75	0.391
5	100	0.94	106.38	106.02	0.337

Lavg=405.4mH

MEASUREMENT OF FIELD RESISTANCE



1. Connect the circuit as shown in figure.

2. Keep the armature winding open.

3. Vary the input D.C. supply from the controller and note down voltmeter and Ammeter readings.

   V/I ratio will give the field resistance.

4. Repeat the same for different input voltage and find out Rf.

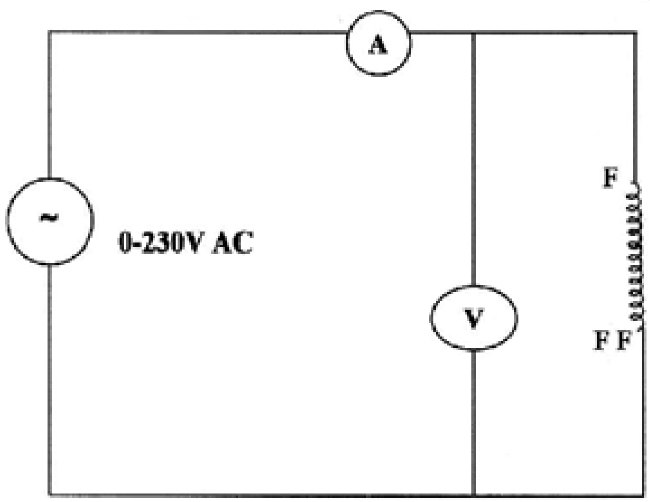
5. The average value gives Rf.

Tabular column

S. no.	Vf	If	Rf=Vf/If
1	10	0.01	1000
2	30	0.05	600
3	50	0.08	625
4	70	0.12	583.33
5	90	0.16	562.5
6	110	0.19	578.94

Rf avg=658.295 ohms.

MEASUREMENT OF FIELD INDUCTANCE



1. Connect the circuit as shown in the figure
2. Keep the armature winding open
3. Vary the input AC supply from the controller and note down voltmeter and ammeter readings and enter in the tabular column.
4. Calculate Z_f, Xf and Lf
5. Repeat the same for different input voltages.

TABLE:

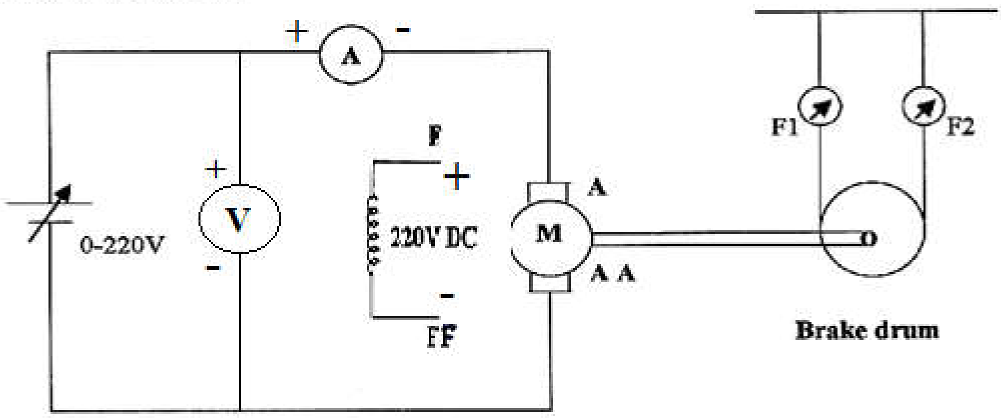
S NO	V_A	I_A	Z_A	X_A	L_A
1	18	0.07	257.14	30.56	0.097
2	50	0.08	625	175	0.557
3	100	0.08	1250	1082.53	3.445
4	150	0.09	1666.67	1561.25	4.97
5	200	0.1	2000	1919.26	6.109

Lf avg=3.71H

PROCEDURE TO FIND KT (Torque Constant)

ARMATURE CONTROLLED DC MOTOR

Load Test on DC Motor:-

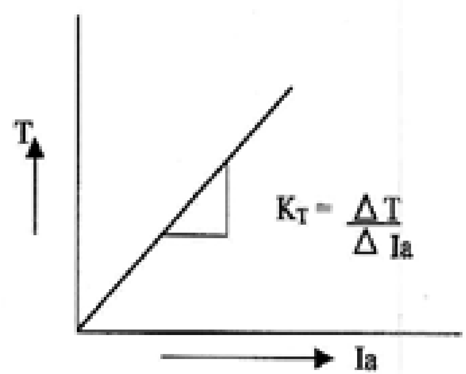


1. Circuit connections are make as per the circuit diagram.
2. Connect 220V fixed DC supply to the field of DC motor and Brake drum belt should be loosened.
3. Start the motor by applying 0-220V variable DC supply from the controller till the motor rotates at its rated speed.
4. Note down meter readings which indicates no load reading.
5. Apply load in steps upto rated current of the motor and note down corresponding I_L, N, F_1 and F_2 readings.

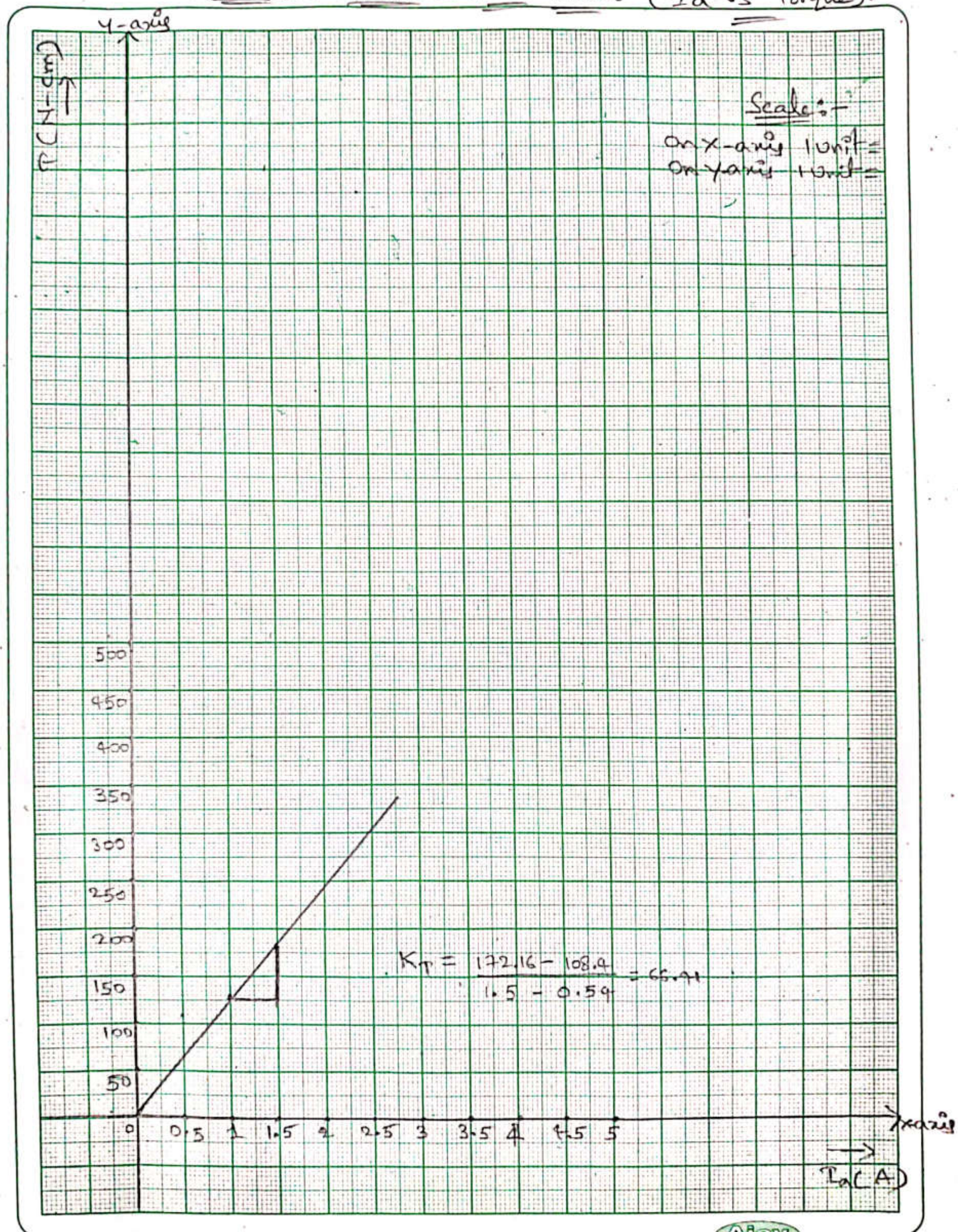
TABLE:

S NO	I_L =Ia	F_1	F_2	SPEED (N) rpm	TORQUE (T)=(F_1-F_2)*6.5*9.81NM
1	0.54	2	0.3	1048	108.4
2	0.85	2.3	0.8	770	95.64
3	1.1	3	1	600	127.53
4	1.5	3.8	1.1	465	172.16
5	2	4.2	1	410	204.04
6	2.5	5	1	370	255.06

MODAL GRAPH:

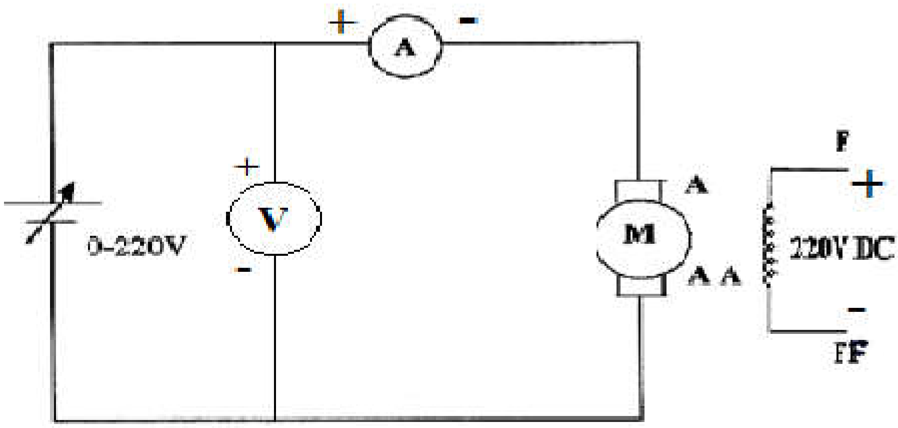


Armature Controlled D.C. Motor (Ia Vs Torque).



PROCEDURE TO FIND Kb (Back EMF Constant):-

Speed Control by Armature Voltage Method:

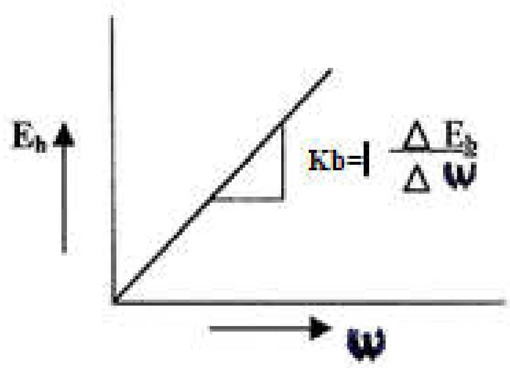


1. Circuit connections are made as per circuit diagram.
2. Connect 220V fixed DC supply to the motor Field keep the Armature controller point at its minimum position and switch at OFF position.
3. Switch ON the MCB, Switch ON the Armature control switch. Vary the Armature voltage and note down the Speed and corresponding meter readings.
4. Repeat the same for Different Armature Voltages.

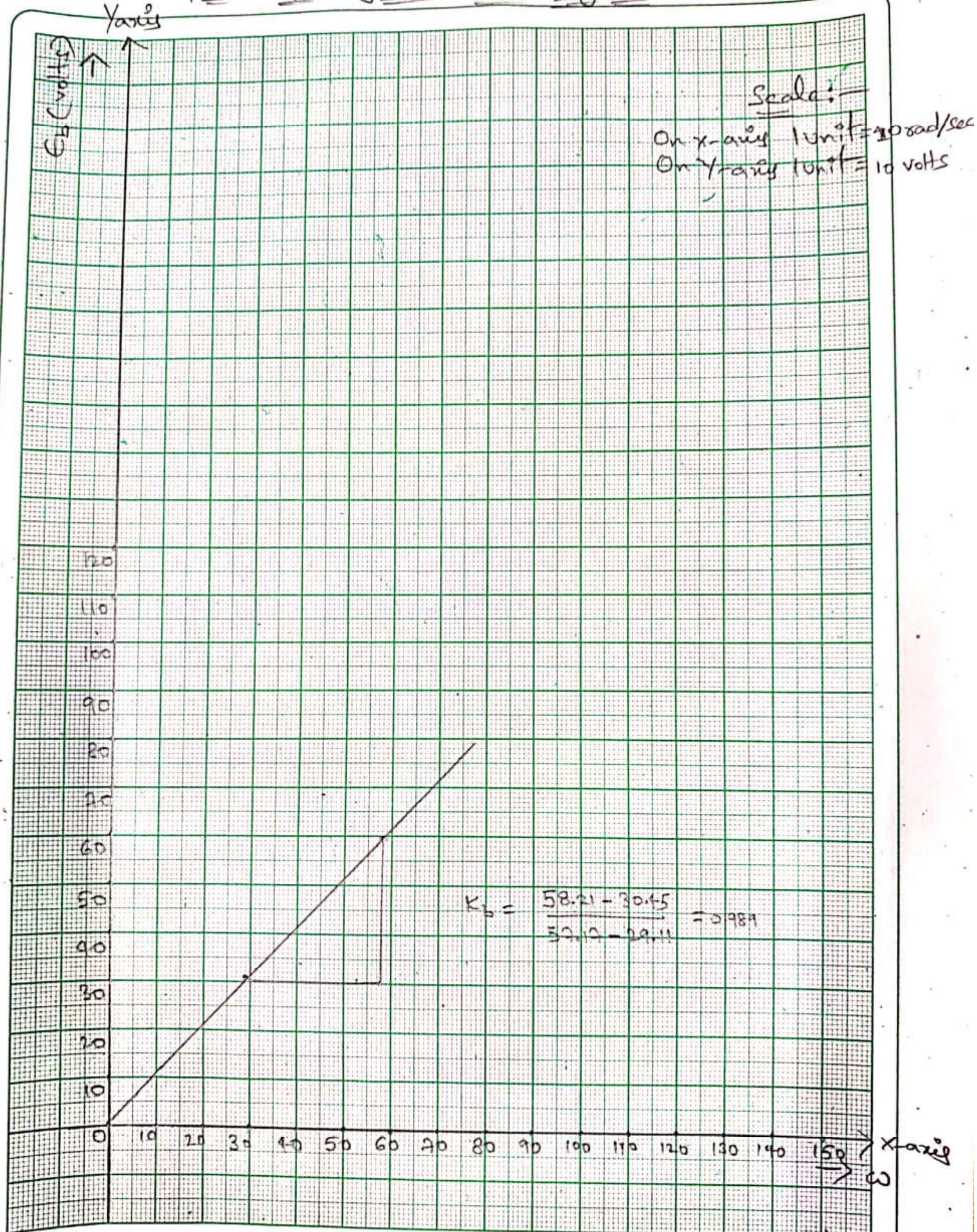
TABLE:

S NO	I_a	V	N rpm	E_b=V-I_aR_a	ω=2πN/60
1	0.17	32	278	30.54	29.11
2	0.2	60	546	58.21	57.17
3	0.21	90	832	88.19	87.12
4	0.22	120	1088	118.07	113.93
5	0.23	150	1362	147.97	142.62
6	0.25	165	1504	162.8	157.49

MODEL GRAPH:



Speed Control by Armature Voltage method (ω vs E_b)



Transfer Function of Armature Controlled DC Motor = $\dfrac{K_T}{S\left[[R_a + SL_a]\,[SJ_m + f_m] + K_T K_b\right]}$

R_a	=	Armature Resistance
L_a	=	Armature Inductance
I_a	=	Armature Current
E_b	=	Back emf
T	=	Torque developed
J	=	Moment of Inertia = 0.024 $Kg\text{-}m^2$
(fm) B	=	Frictional Co-efficient – 0.8
K_b	=	Back emf constant
K_T	=	Torque Constant

By Kirchoff's law

$$Ia\,Ra + La\,\frac{d\,Ia}{dt} + Eb = Va$$

Since flux is constant

Torque is proportional to Ia.

$$T_m \alpha\, Ia$$
$$T_m \alpha\, K_T\, Ia$$

Also for Mechanical System

$$J \frac{d\theta m^2}{dt^2} + B \frac{d\theta m}{dt} = Tm$$

Also Back emf Eb α to angular velocity of shaft

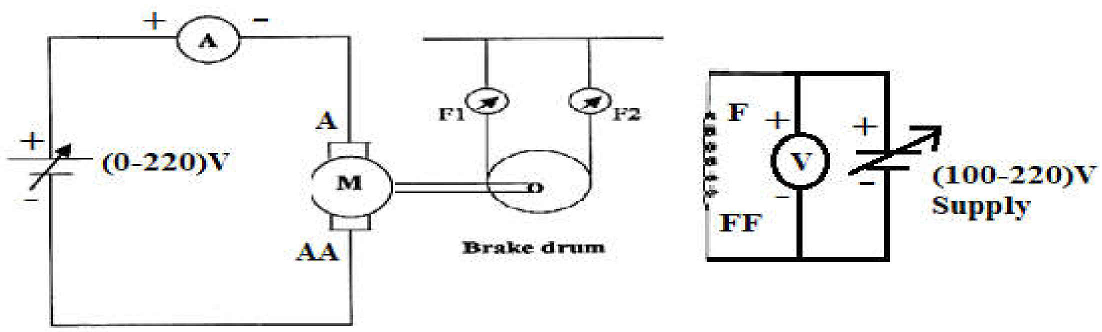
$$Eb = Kb \frac{d\theta m}{dt}$$

Dynamic Equation	**Laplace Equipment**
$Tm = K_T\, Ia$ $Eb = Kb\, Wm$ $Va - Eb = Ra\, Ia + La \frac{dIa}{dt}$ $Tm = Jm \frac{d^2\theta_m}{dt2} + f_m \frac{d\theta m}{dt}$	$Tm\,(s) = K_T\, Ia\,(s)$ $Eb\,(S) = Kb\, Wm\,(s)$ $Va(s) - Eb(s) = Ra\, Ia\,(s) + Sl_a\, Ia\,(s)$ $T_m(s) = JmS^2\, \theta_m\,(s) + Sfm\, \theta_m(s)$

By solving the Laplace equation we obtain the transfer function as $\frac{\theta(s)}{V(s)}$

$$= \frac{K_T}{S\,(\,[Ra + SL_a]\,[SJ_m + f_m) + K_T\, Kb])}$$

<u>Transfer Function of Field controlled of DC motor :</u>



Procedure:

1. Connections are made as per circuit diagram.
2. To bring the motor at rated speed apply load .
3. To maintain the Ia as constant and vary the field knob.
4. Remove / apply load by maintain the Ia as constant.
5. Note down the readings .

TABULAR COLUMN:

S.NO.	Ia(A)	Speed(N) in RPM	Vf(V)	F_1	F_2	$T=(F_1-F_2)6.5*9.81$(N-cm)
1	0.24	1500	200	0	0	0
2	0.75	860	198	0.6	2.5	121.15
3	0.75	895	170	0.6	2.1	95.65
4	0.75	920	150	0.6	2.1	95.65
5	0.75	970	135	0.6	2	89.27
6	0.75	1020	120	0.5	2.1	102.02

RESULT: Transfer function dc motor experimentally studied.

Transfer Function of DC Generator

CONTENTS

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CONTROLLER FOR DC MOTOR – GENERATOR 0.5HP/180V
(TRANSFER FUNCTION STUDY MODULE)

This unit consists of DC/AC supplies, digital AC/DC voltmeter and a digital AC/DC Ammeter for DC motor – Generator set to find its transfer function.

This unit consists of

1. 0-220V @ 3 Amps variable DC supply for Armature of DC motor for speed control of DC motor using single phase half controlled bridge rectifier.
2. A variable DC supply from 100V – 220V @ 2Amps for field of DC motor for speed control of DC motor by field control and also for field of DC generator for variable DC generator output.
3. A fixed supply of 220V ± 10% for field of DC motor using 1-ph Diode Bridge Rectifier.
4. A variable AC supply of 0-230volts + @ 2 Amps to find inductance of armature and field of DC motor / Generator.
5. A digital voltmeter to measure AC and DC voltages with AC/DC selector switch.
6. A digital Ammeter to measure AC/DC current with AC/DC selector switch.
7. Neon indicators are provided for all AC/DC supplies.
8. Fuse Protection is provided for the power supplies.
9. 6A / 1 pole MCB is provided to switch ON/OFF the AC supply to the unit and also for protection.
10. From this unit we can do the following experiments to find out Transfer Function of:

- ✓ Armature controlled DC motor.
- ✓ Field controlled DC motor.
- ✓ Separately excited DC generator.
- ✓ Self Excited DC generator.

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CONTROLLER FOR DC MOTOR – GENERATOR 0.5HP/180V
(TRANSFER FUNCTION STUDY MODULE)

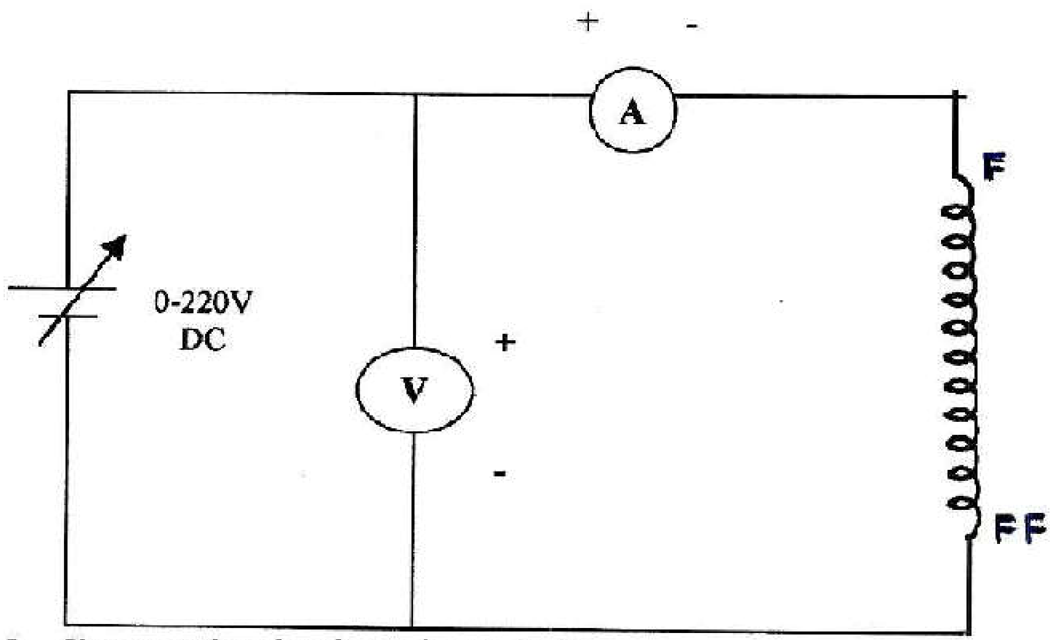
FRONT PANEL DETAILS :

1. **AC IN** : Transfer to connect 230volts AC mains supply.
2. **MCB** : 2 pole / 6A MCB to turn OFF / ON AC supply to the controller.
3. **ARMATURE**
   - **VA** : Potentiometer to vary the armature voltage from 0-220V.
   - **OFF ON** : ON/OFF switch for armature voltage with soft start.
   - **0-220V DC** : 0-220V variable DC supply for armature 1-phase Half controlled bridge rectifier with neon lamp indicator.
   - **0-230V AC** : 0-230V variable AC supply to find inductance of Field coil with Neon Lamp (AC voltage controller).
4. **FIELD**
   - **VF** : Potentiometer to vary the field voltage from 100V to 200V.
   - **100-220V DC**: Variable DC supply from 100V to 200V approximately with Neon Lamp indicator for field.
   - **220V DC** : 220V ± 10% @ @A rectified DC supply for field supply of DC motor or generator with Neon Lamp indicator.

DIGITAL VOLTMETER: 3 ½ digit voltmeter to measure AC/DC voltage with AC/DC selector switch.

DIGITAL AMMETER : 3 ½ digit ammeter to measure AC/DC current with AC/DC selector switch.

MEASUREMENT OF FIELD RESISTANCE



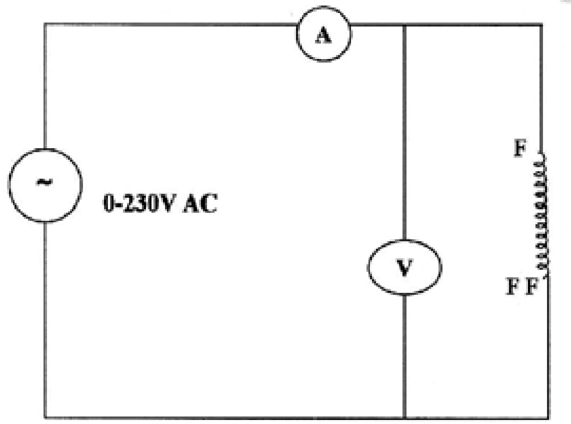
1. Connect the circuit as shown in figure.
2. Keep the armature winding open.
3. Vary the input D.C supply from the controller (0-150)V and field current should not exceed the rated current. Note down voltmeter and ammeter readings. V/I ratio will give the field ressistance.
4. Repeat the same for different input voltage and find out Rf.
5. The average value gives Rf.

TABLE:

S. NO.	Vf (volts)	If (Amps)	Rf=Vf/If(ohms)
1	20	0.04	500
2	50	0.08	625
3	80	0.14	571.42
4	100	0.17	588.23
5	130	0.23	565.21
6	160	0.28	571.42

Rf avg= 570.21 ohms.

MEASUREMENT OF FIELD INDUCTANCE



1. Connect the circuit as shown in the figure
2. Keep the armature winding open
3. Vary the input AC supply from the controller and note down voltmeter and ammeter readings and enter in the tabular column.
4. Calculate Z_f, Xf and Lf
5. Repeat the same for different input voltages.

TABLE:

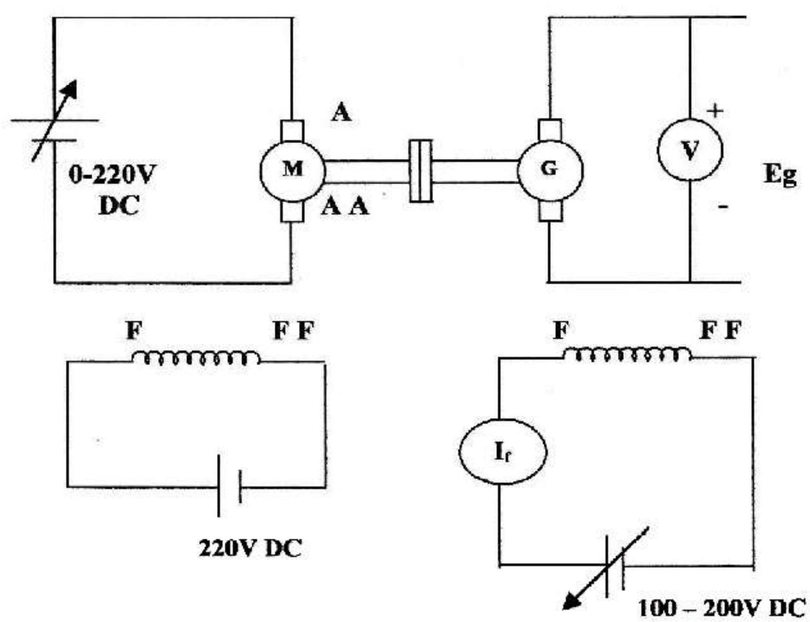
S NO	V_F	I_F	Z_F Ω	X_F Ω	L_A in henrey
1	20	0.05	400	300	0.955
2	40	0.05	800	499.37	1.589
3	80	0.06	1333.33	1204.67	3.834
4	130	0.06	2166.67	2085.29	6.637
5	180	0.06	3000	2946.27	9.378
6	220	0.07	3142.85	3090.46	9.646

Lf avg = 5.33H

Procedure to find Kg

TRANSFER FUNCTION OF DC GENERATOR

(Separately Excited)



1. Make the connections as given in the circuit diagram
2. Connect 220V fixed DC supply to the Motor field
3. Connect 100-220V Variable DC supply to the Generator field
4. Connect 0-220V Variable DC supply to the armature.
5. Switch on the MCB keeping armature voltage control pot at its minimum position & ON/OFF switch at OFF position and also variable field voltage pot at its maximum position
6. Now switch ON the Armature control switch and vary the armature control potentiometer till the motor rotates at its rated speed.

7. Note down If and Eg and entered in the tabular column.

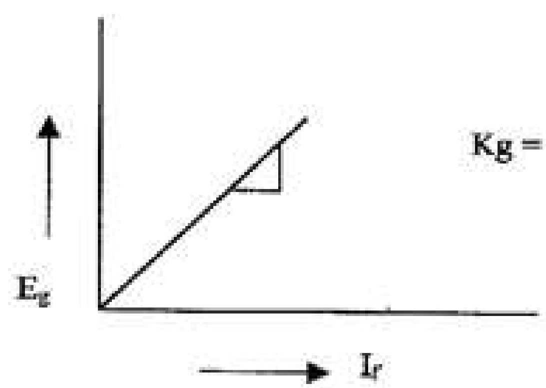
8. Now vary the generator field supply and note down Eg for different Igs and entered in the tabular column.

9. Draw the graph of Eg volts v/s I_f.

TABLE:

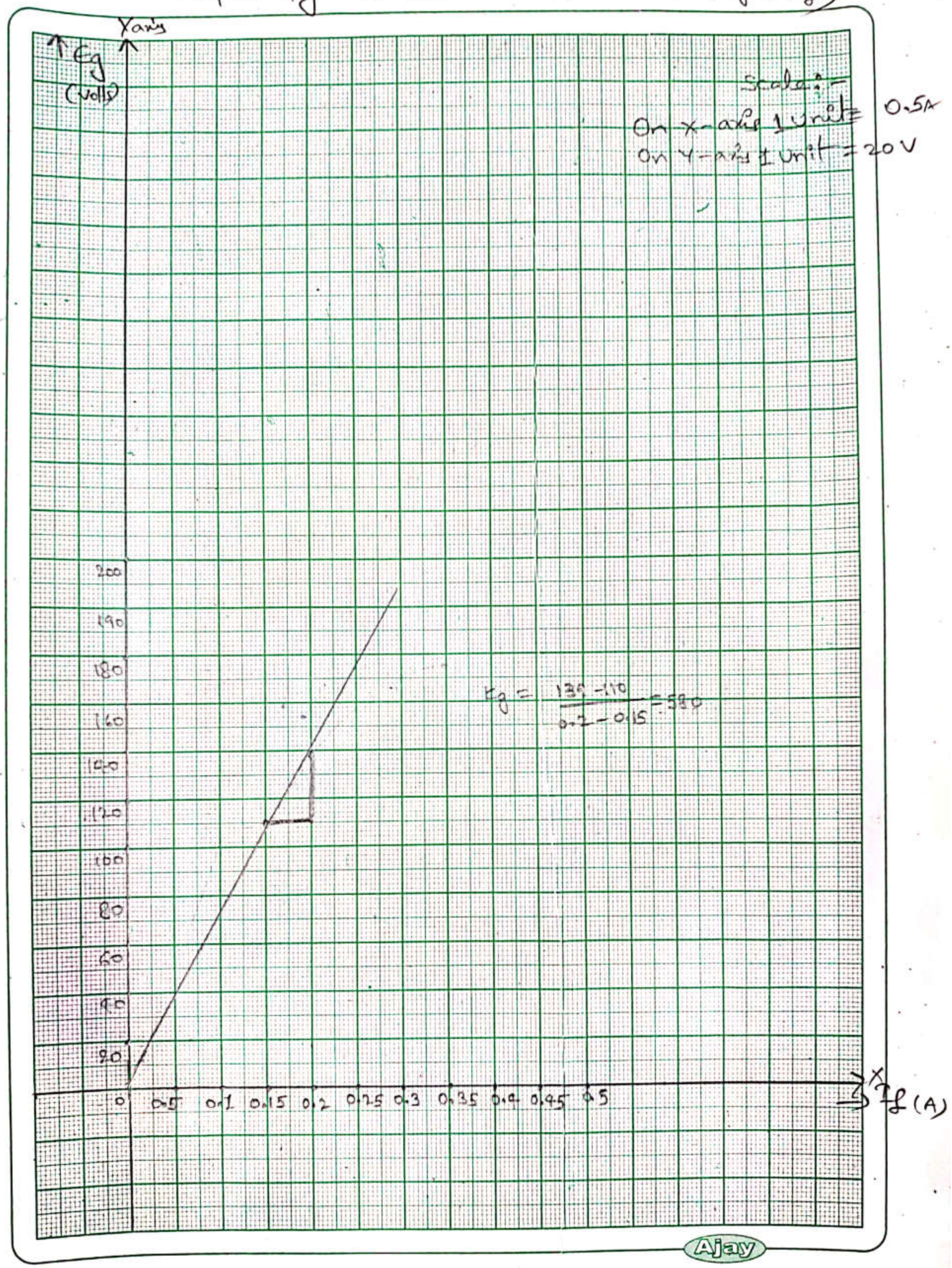
S NO	I_F AMPS	V_F VOLTS
1	0.1	103
2	0.15	110
3	0.2	139
4	0.25	157
5	0.28	165
6	0.3	170
7	0.34	175

MODEL GRAPH:

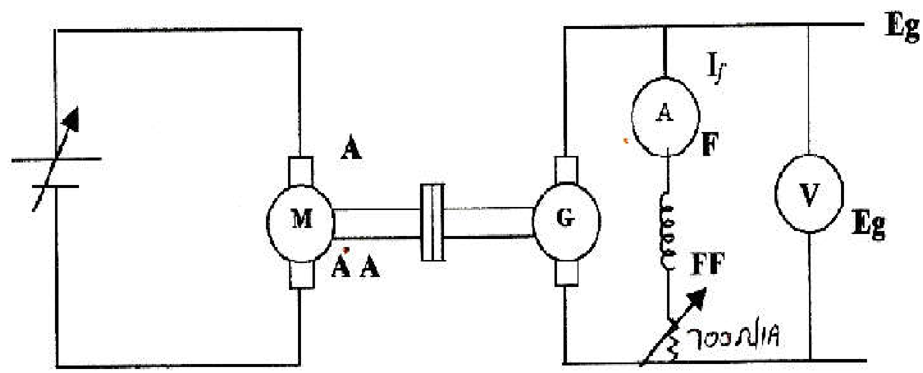


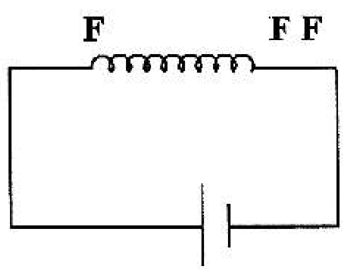
$$Kg = \frac{\Delta Eg}{\Delta I_f}$$

Separately Excited D.C. Generator (Eg Vs If)



TRANSFER FUNCTION OF SELF EXCITED DC GENERATOR





PROCEDURE is same as Separately excited DC generator.

PROCEDURE FOR SELF EXITED DC GENERATOR:-

1. Make the connections as given in the circuit diagram.
2. Connect 220V fixed DC supply to the Motor field.
3. Connect O-220V Variable DC supply to the armature of Motor.
4. Connect Rheostat 0f 700 Ohms/1A in series with the field of generator.
5. Switch on the MCB keeping armature voltage control pot at its minimum position & ON/OFF switch at OFF position.
6. Now switch ON the Armature control switch and vary the armature control potentiometer till the motor rotates at its rated speed.
7. Note down If and Eg and entered in the tabular column.
8. Now vary the generator field supply by varying Rheostat and note down Eg for different Igs and entered in the tabular column.
9. Draw the graph of Eg volts v/s If.

Tabular column:-

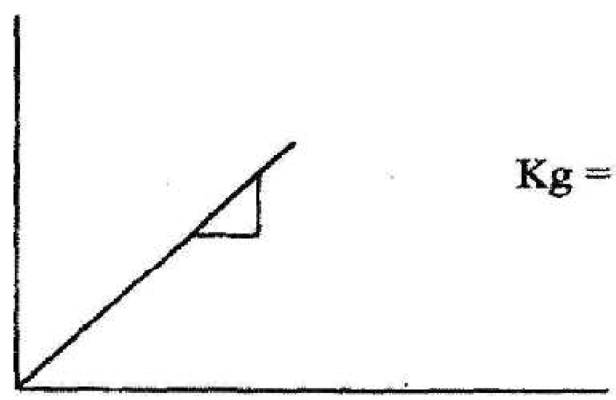
Sl No. If Amps Eg Volts

Transfer function = $(K_g/L_f)/(S_f R_f/ L_f)$

$$=(K_g/L_f)/(S+ R_f / L_f)$$

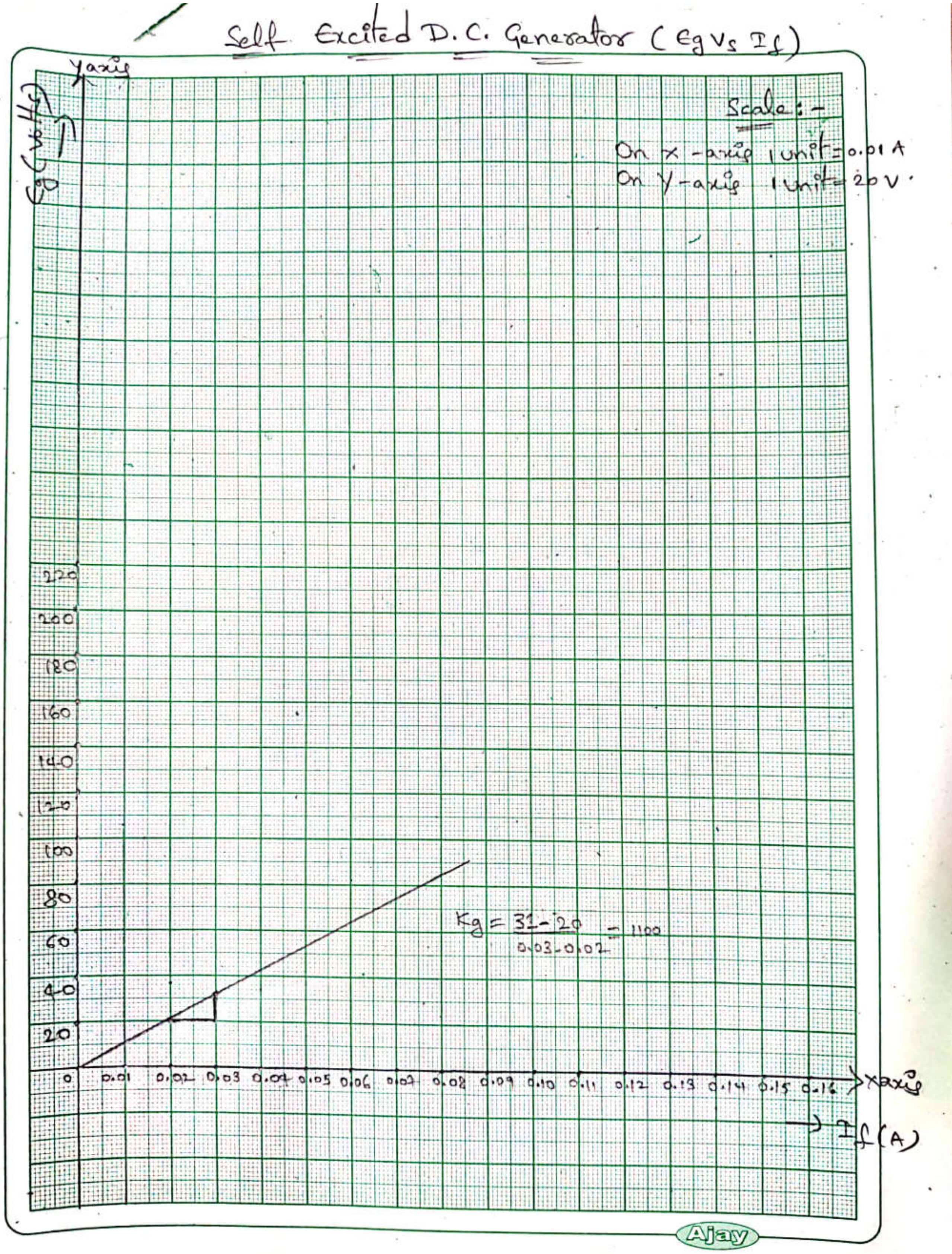
Eg

↑



⟶ If

$K_g = \Delta E_g/\Delta I_f$



RESULT: transfer function of dc generator experimentally studied.

Scientech 2428

Bottle Filling Plant control by PLC

Scientech 2428

Bottle Filling Plant control by PLC

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to it.

Do not operate the instrument if suspect any damage to it.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

Use only the proper Fuse : Use the fuse type and rating specified for this instrument.

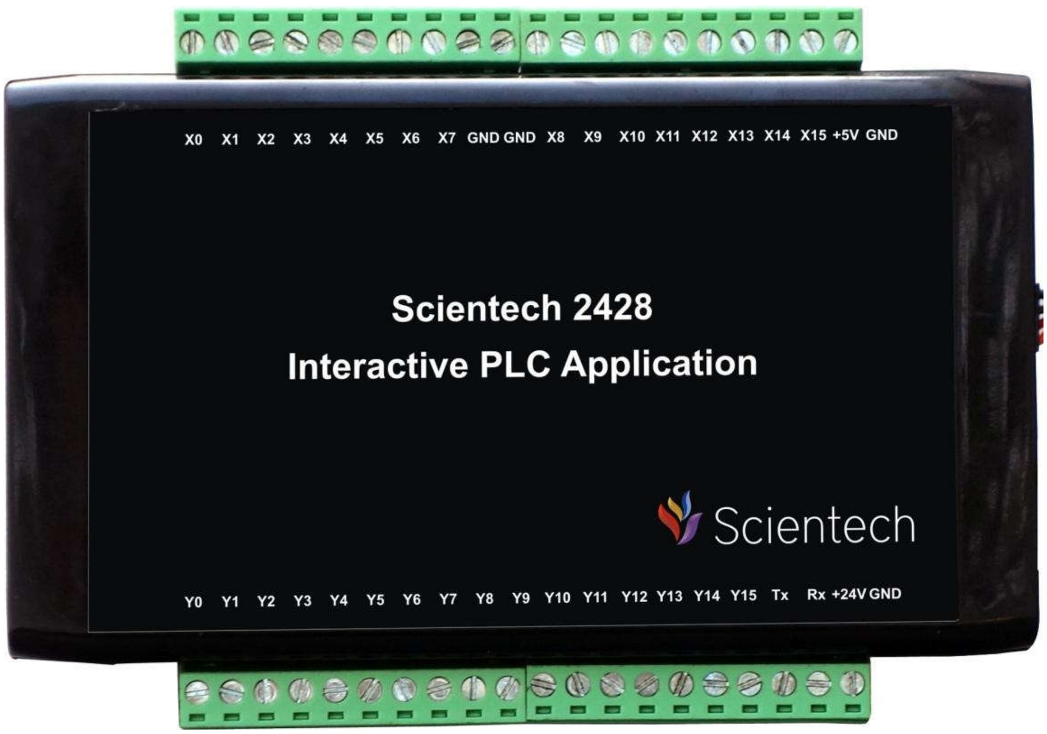
Use in proper Atmosphere : Please refer to operating conditions given in the manual.

- **Do not operate in wet / damp conditions.**
- **Do not operate in an explosive atmosphere.**
- **Keep the product dust free, clean and dry.**

Introduction

Normally the users who learn PLC, they just write small ladder programs and test them by using some LEDs and Switches. But when practitioner goes to real world and observes the big processes running with PLC he find himself in big trouble and loses confidence to understand and to do such heavy programming for PLC and if he is allowed to do programming for big processes then it can become dangerous because in industries machine are costly and wrong programming machines can do injury to machine as well as man power.

Scientech 2428 Bottle Filling Plant provide virtual environment using real time graphics , physics and total interactivity which you can do with your any real PLC and practice real world programming of PLC. Scientech 2428 give your real component which are used in industry and by using DAQ card you can work them according to your need. So the user who has learned PLC programming with Scientech 2428 be able to do real world programming directly.



Features

- Total interactivity with the system
- Friendly user interface
- Easy and fast to setup
- Space saving
- Easy to Operate

Technical Specifications

Isolated Digital Input

Channels	:	16
Input Voltage Logic 0	:	2 V max.
Logic 1	:	5 V min. (60 V max.) or dry contact

Isolated Digital Output

Channels	:	16
Output Type	:	Sink (NPN)
Output Voltage	:	5 ~ 40 VDC

Isolated Counter

Channels	:	3
Resolution	:	32-bit

General

Bus Type	:	USB for Scientech 2428
I/O Connectors	:	screw terminals
Dimensions	:	150x 85 x 32 mm
Weight	:	200g (approximately)
Power	:	5Vdc/200mA (Nvis 631 is USB powered)

Theory

Sensors:

A **Sensor** is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example, a mercury-in-glass thermometer converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. A thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, most sensors are calibrated against known standards.

Example

- Optical
- Mechanical
- Electrical

Need for Sensors

Sensors are omnipresent. They embedded in our bodies' automobiles, airplane, cellular telephone, radio, chemical plant, industrial plant and countless other application.

Proximity sensor:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Actuator:

An **Actuator** is a mechanical device for moving or controlling a mechanism or system. It is operated by a source of energy, usually in the form of an electric current, hydraulic fluid pressure or pneumatic pressure, and converts that energy into some kind of motion.

Conveyor system

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries. Many kinds of conveying systems are available, and are used according to the various needs of different industries.

The relation between ITS PLC Input/output and the DAQ card

Bottle Filling Plant	DAQ Board
Sensor 0	X0
Sensor 1	X1
Sensor 2	X2
Sensor 3	X3
Sensor 4	X4
Sensor 5	X5
Sensor 6	X6
Sensor 7	X7
Sensor 8	X8
Sensor 9	X9
Start	X10
Actuator 0	Y0
Actuator 1	Y1
Actuator 2	Y2
Actuator 3	Y3
Actuator 4	Y4
Actuator 5	Y5
Actuator 6	Y6
Actuator 7	Y7

Bit Number	Input Bit	Types of contact
8	Sensor 0	NO (Normally Open)
9	Sensor 1	NO (Normally Open)
10	Sensor 2	NO (Normally Open)
11	Sensor 3	NO (Normally Open)
12	Sensor 4	NO (Normally Open)
13	Sensor 5	NO (Normally Open)
14	Sensor 6	NO (Normally Open)
15	Sensor 7	NO (Normally Open)
16	Sensor 8	NO (Normally Open)
17	Sensor 9	NO (Normally Open)
18	Start	NO (Normally Open)
	Not Connected	NC (Normally Close)

Bit Number	Input Bit
0	Actuator 0
1	Actuator 1
2	Actuator 2
3	Actuator 3
4	Actuator 4
5	Actuator 5
6	Actuator 6
7	Actuator 7

Bottle Filling Plant

Sensors:

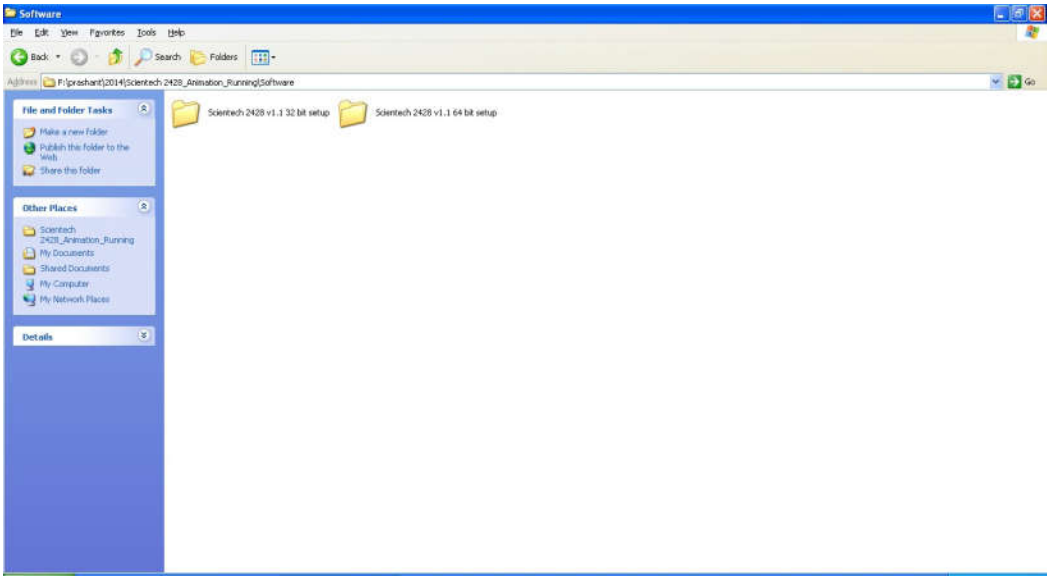
Sensor	Description
0	Bottle entry detector
1	Bottle detector
2	Bottle Level detector
3	Bottle detector
4	Bottle Level detector
5	Bottle detector
6	Cap position detector
7	Bottle detector
8	Cap pressing detector
9	Bottle detector

Actuator:

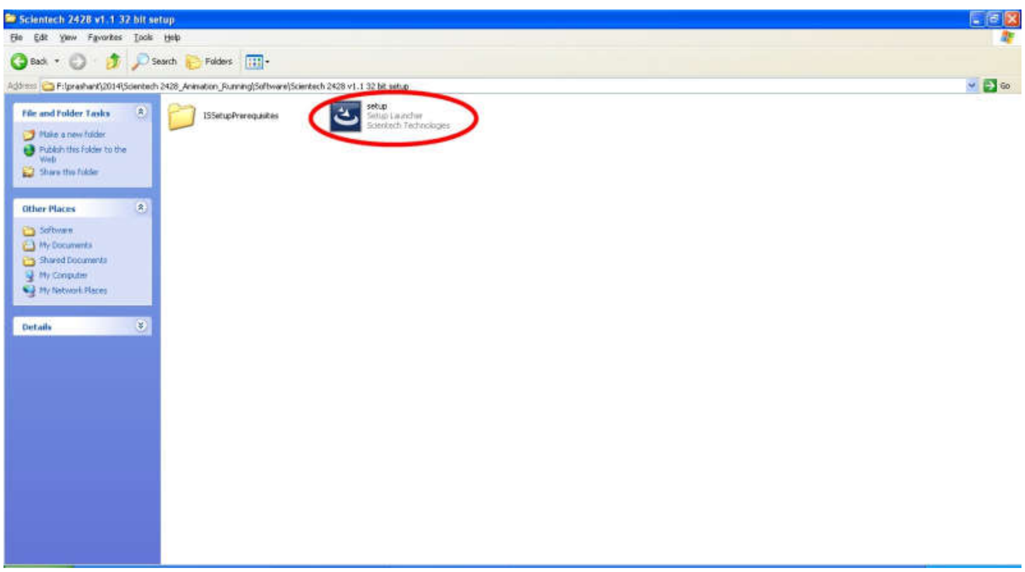
Actuator	Description
0	Conveyor belt
1	Red liquid Filling
2	Yellow liquid filling
3	Cap fitting
4	Cap pressing
5	Label
6	Holder
7	Roller

Scientech 2428 Software Installation

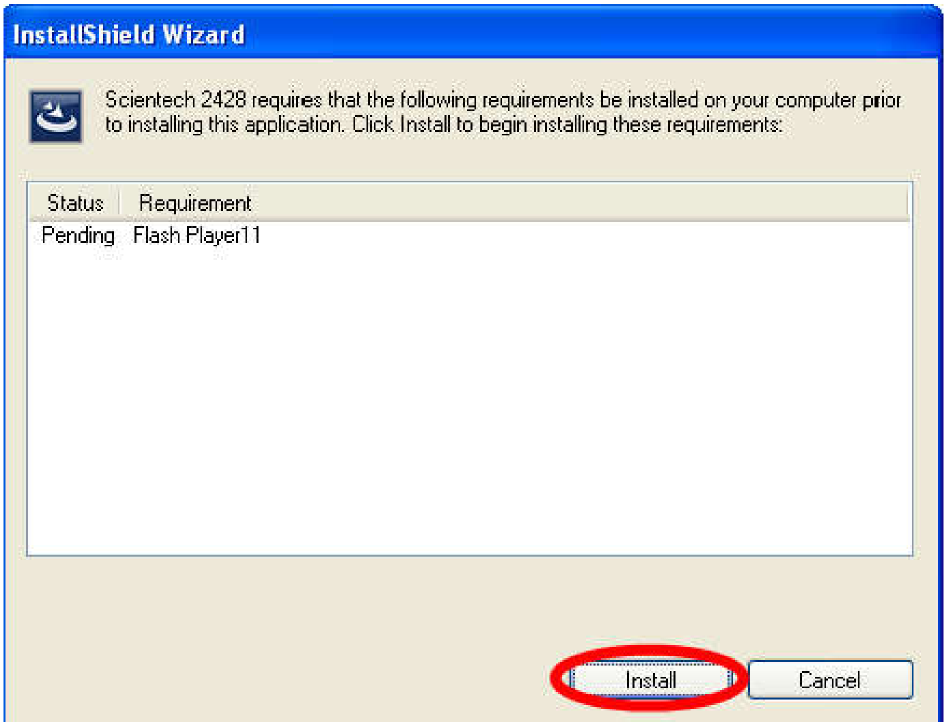
- Open Scientech 2428 CD and Open Scientech 2428 Software. Then Click on Scientech 2428 V1.1 32 Bit setup folder as shown below.



- Double click on Setup icon as shown below.

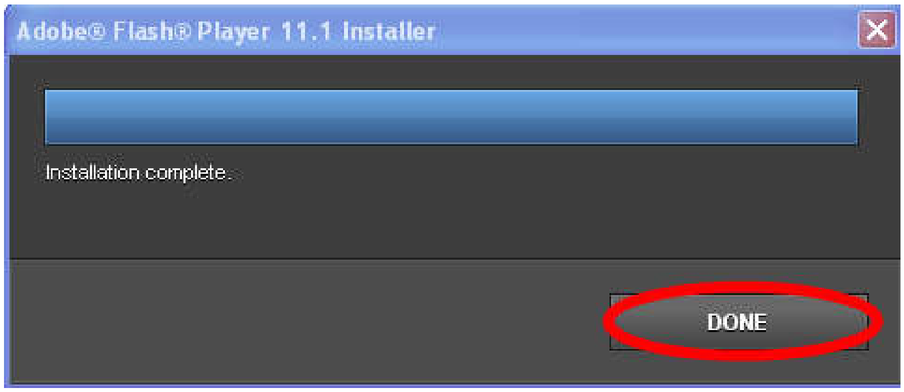


- InstallShied Wizard window will open then click on Install button as shown below.

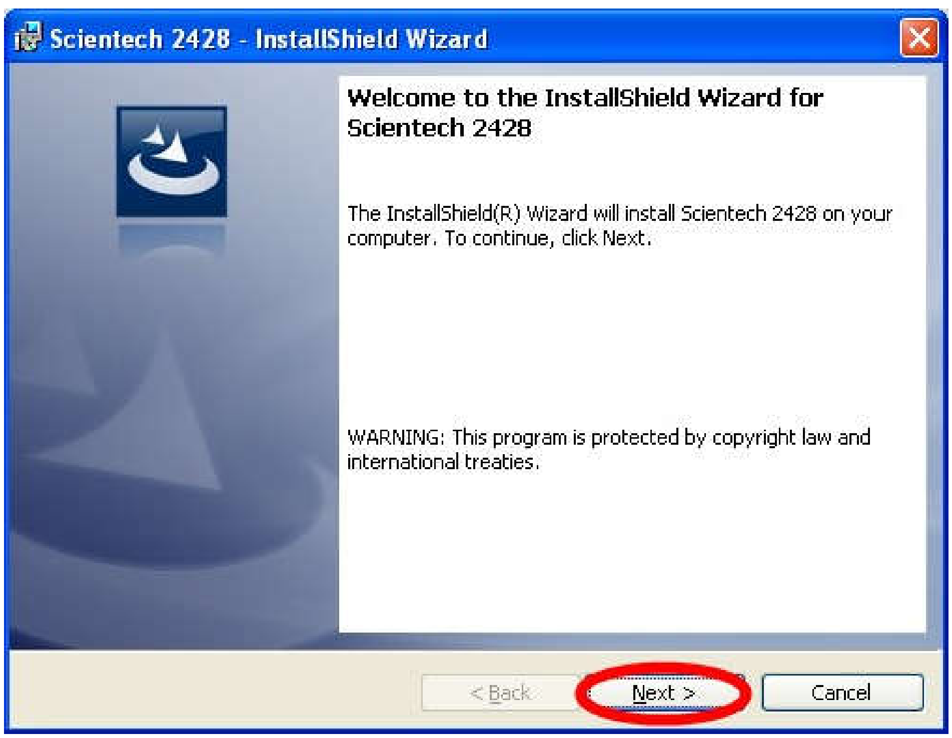


- For Flash player installation , click on Install button as shown below.

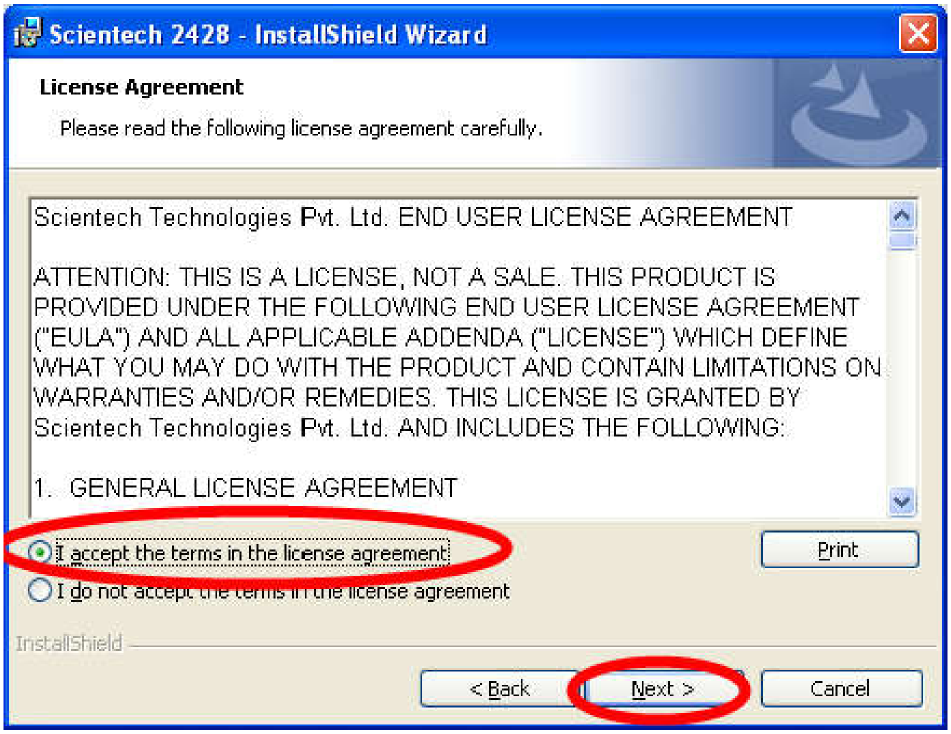
- When Flash Player installation will done then click on Done button as shown below.



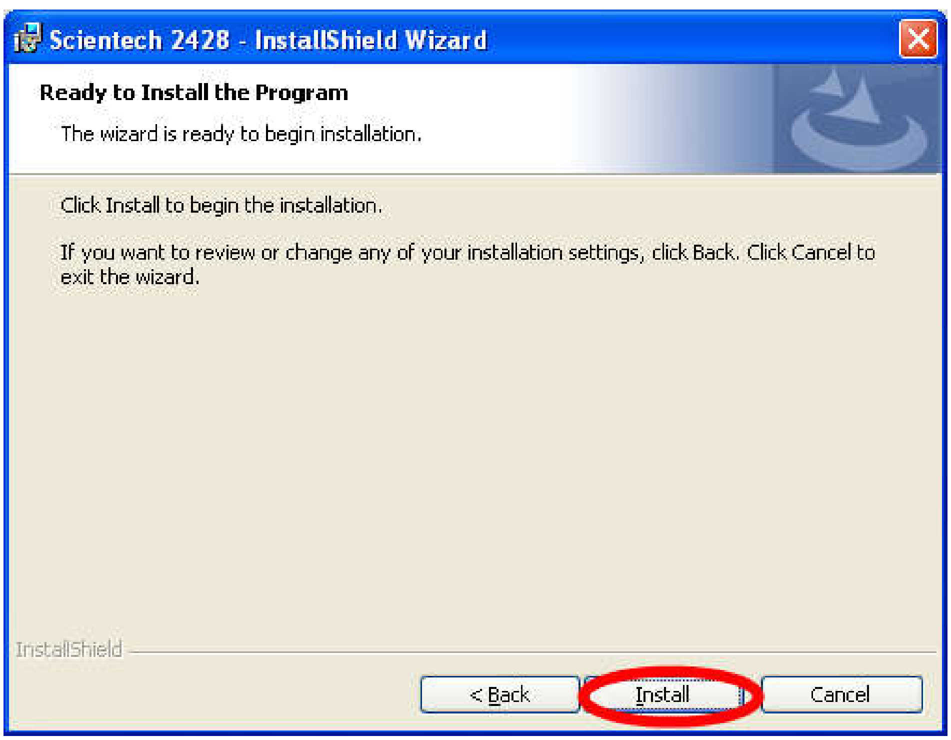
- Scientech 2428 Install Shield window will opoen then click on Next button as shown below.



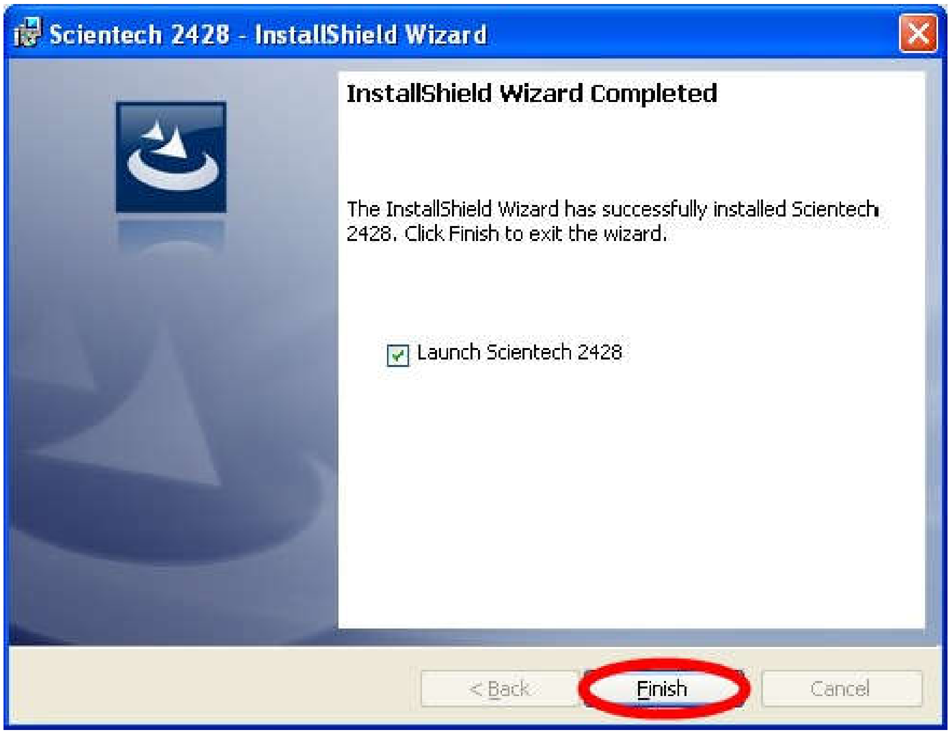
- Click on " I Accept the terms in license agrrement" then click on Next button as shown below.



- Ready to Install the Program window will open then click on install button as shown below.



- When Scientech 2428 Setup installation will complet then click on Finish button as shown below.



Note:

Note_1 : Before Using a Scientech 2428 DAQ please install FT232 Driver_Setup in your PC.

Note_2 : Before Performing a Experiment please check all connection diagram according to Scientech 2428 manual.

Note _3: Before Performing a Experiment please remove 3 pin female connector of IR Sensor.

Experiment 1

Objective: Study and programming of Bottle filling plant for Red liquid.

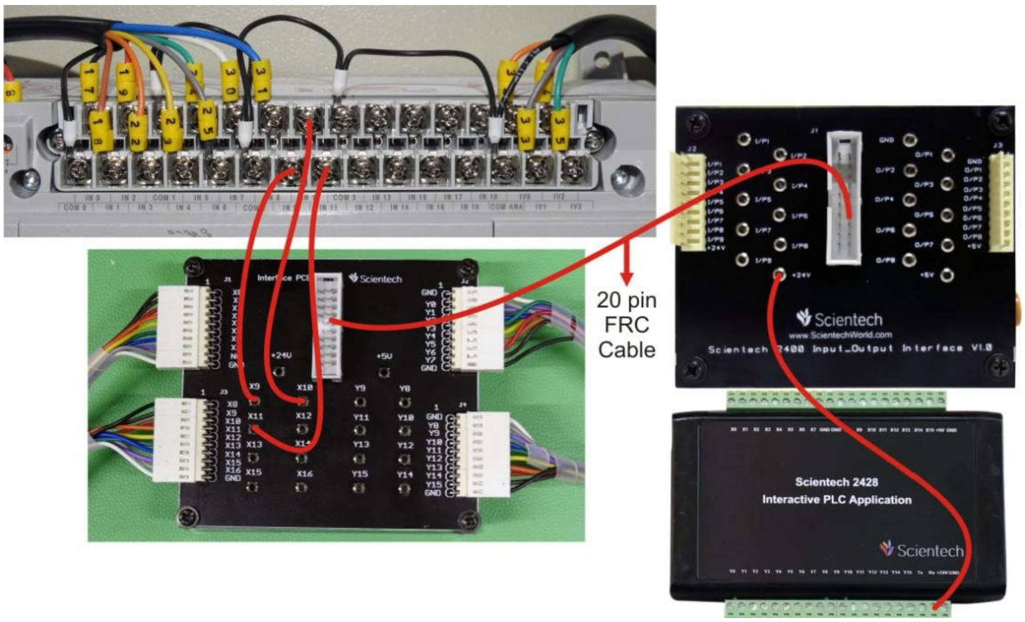
Equipment required:

- Scientech 2400EH Universal PLC Platform
- Scientech 2428 Interactive PLC Application
- A to B TYPE USB cable
- Interfacing PCB
- 2mm patch cords
- 20 pin FRC cable

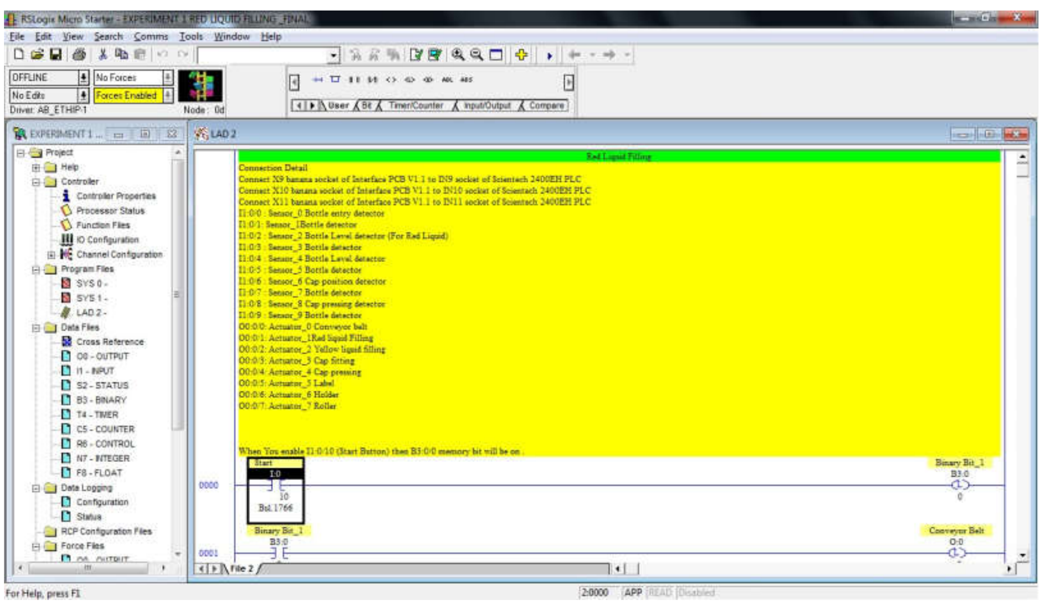
Procedure:

- Made connection between DAQ card and Interfacing PCB ver. 1.1 is shown in below figure

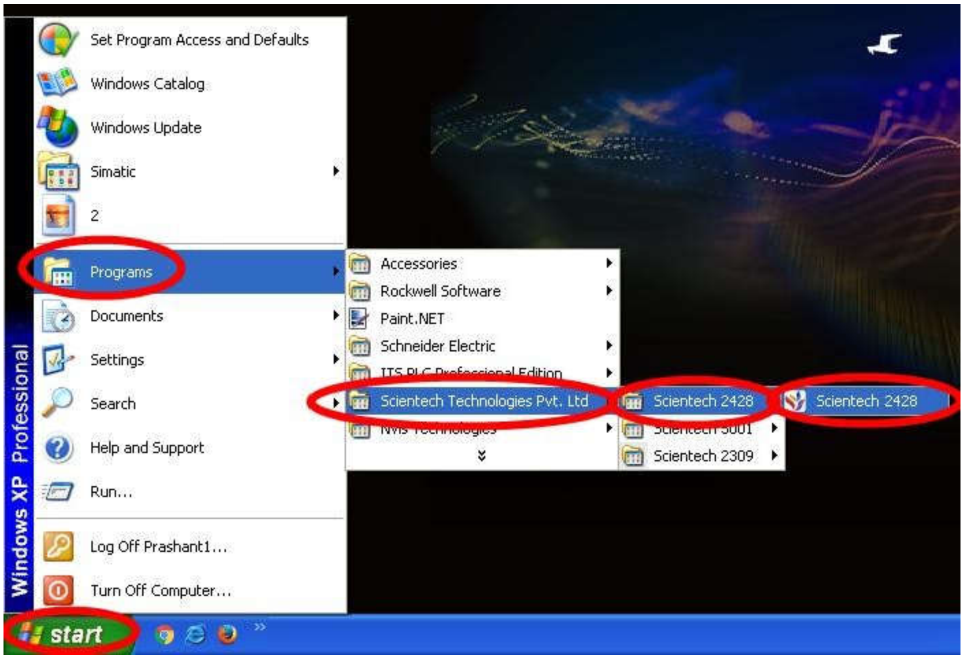
- Connect IN9 (Scientech 2400EH) to Interfacing PCB X9 banana socket Connect IN10 (Scientech 2400EH) to Interfacing PCB) X10 banana socket. Connect IN11 (Scientech 2400EH) to Interfacing PCB) X11 banana socket.



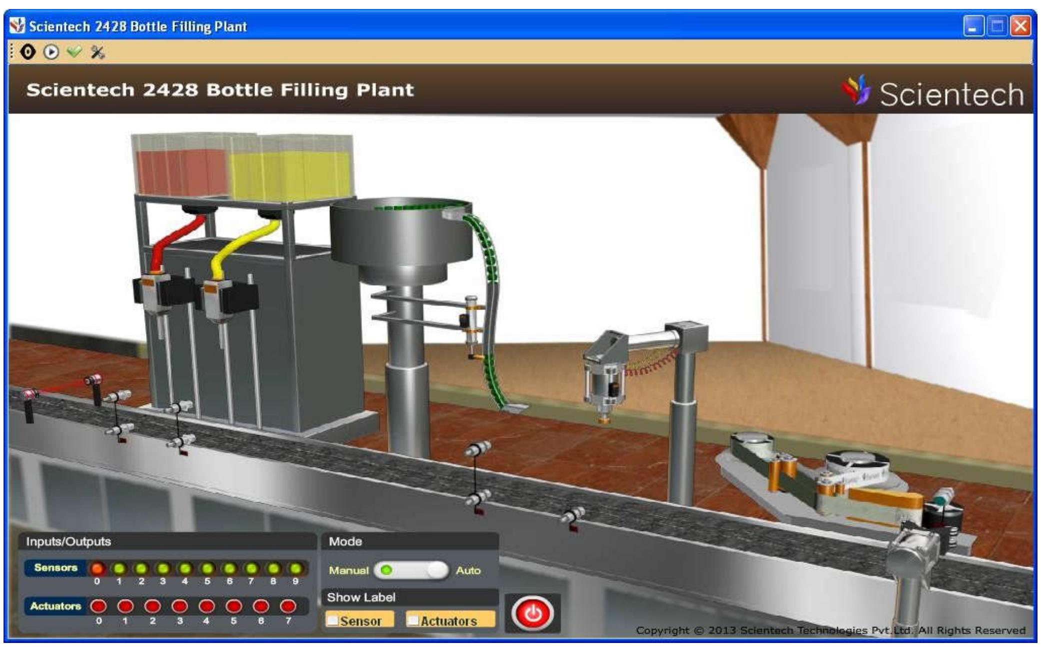
- Open the Scientech 2428 CD. Open Sample Program folder and Double click on Experiment 1.



- Connect A to USB Cable between Scientech 2428 DAQ USB Socket and PC USB Port.
- Open Scientech 2428 Software.

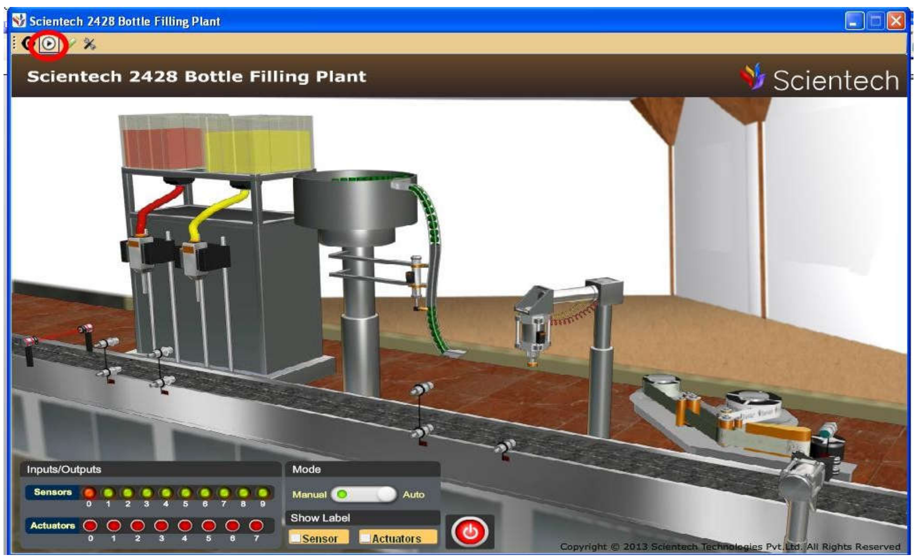


- Scientech 2428 Software will open .

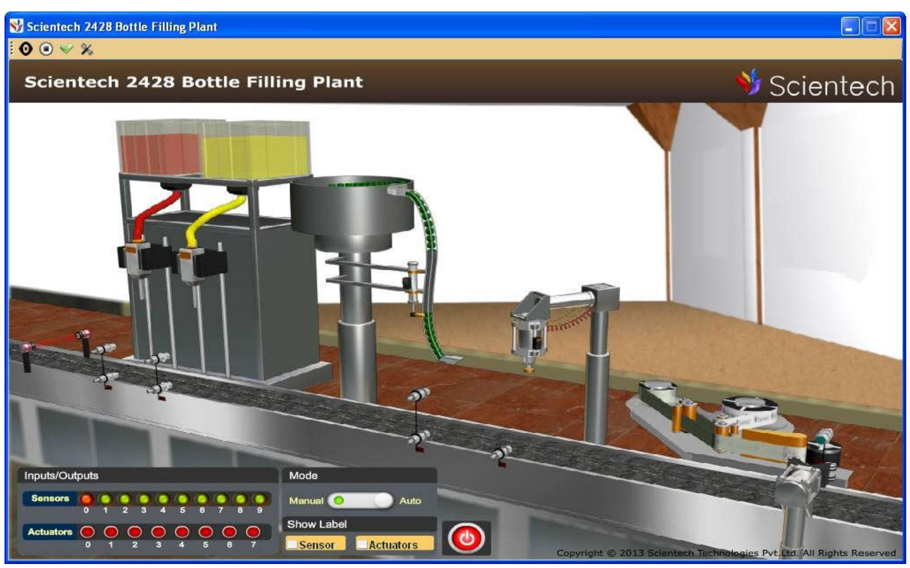


- When USB is Properly connect to PC then Hardware Found message will comes as shown below.

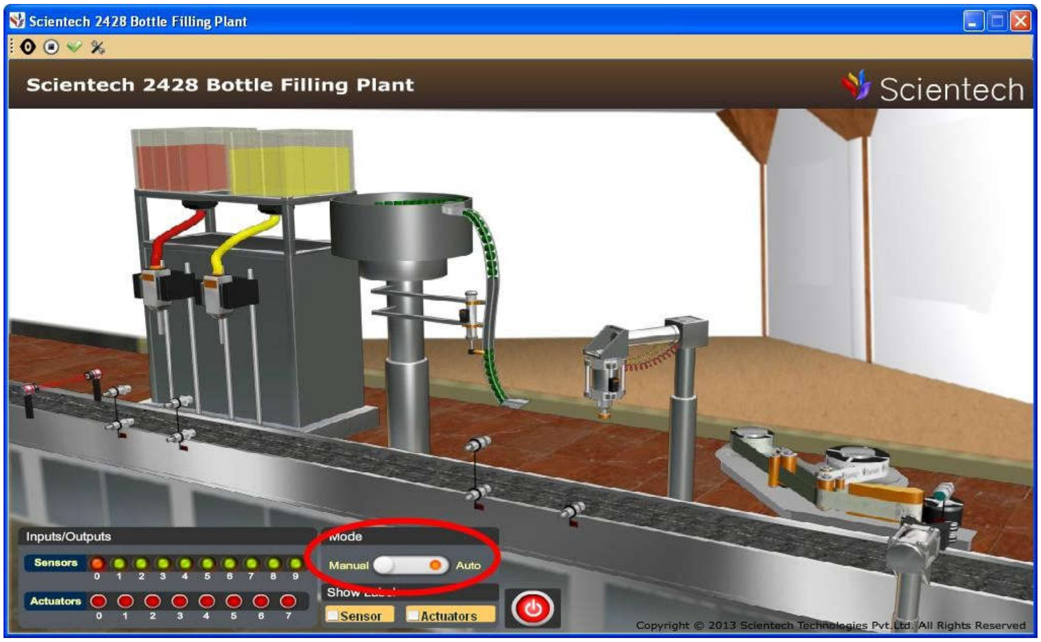
- Click on Start button as shown below.



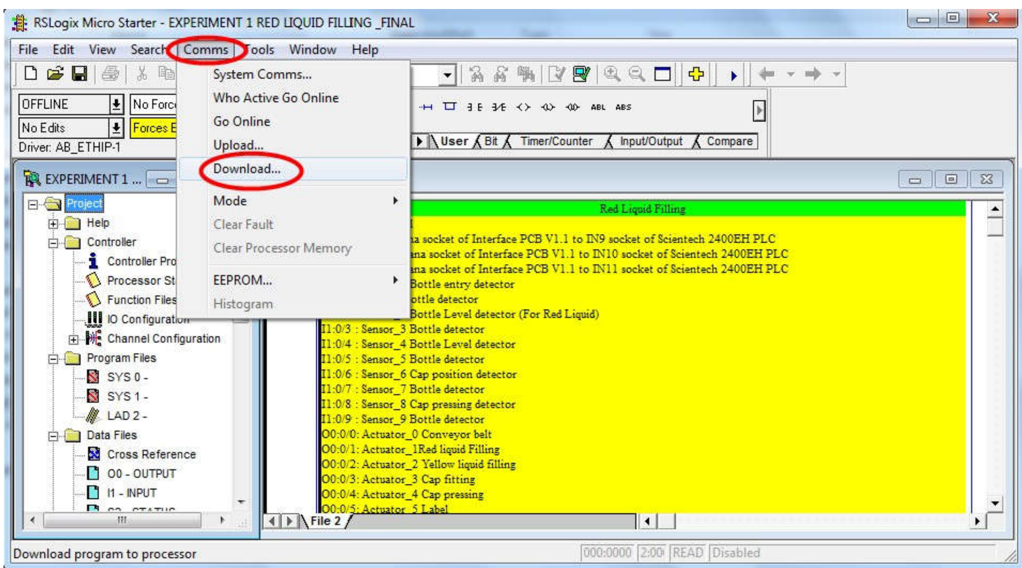
- After above step Start button icon change in Stop button icon as shown below.



- Change the Manual mode to Auto mode as shown below.

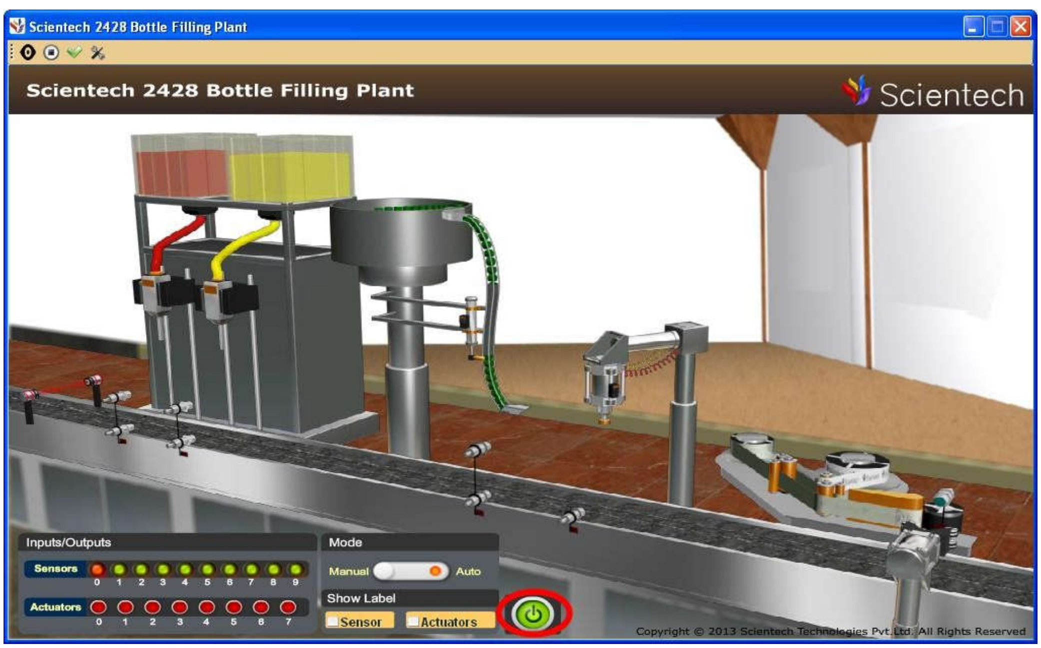


- For download the program in PLC go to the **Comms** button then click on **Download** button as shown below.

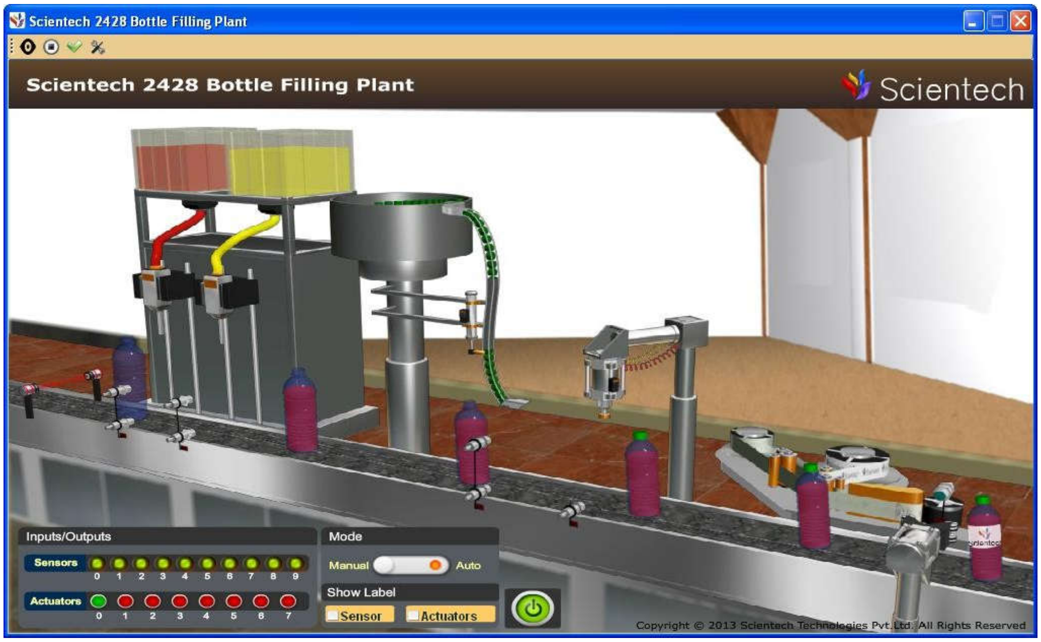


- After Download a program in PLC then put the PLC in Run mode using RSLogix Micro Strater Software.
- Click on Start/ Stop button as shown below.

- Stop icon (Red) in Start icon (Green) as shown below.



- Red Bottle Filling Process will start as shown below.



Experiment 2

Objective: Study and programming of Bottle filling plant for Yellow liquid.

Equipment required:

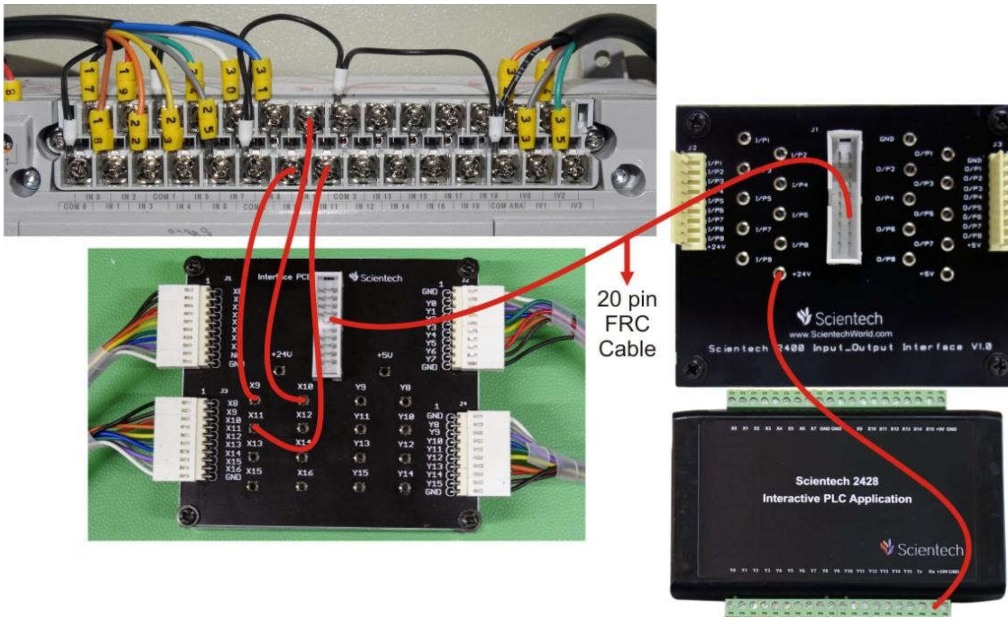
- Scientech 2400EH Universal PLC Platform
- Scientech 2428 Interactive PLC Application
- A to B TYPE USB cable
- Interfacing PCB
- 2mm patch cords
- 20 pin FRC cable

Procedure:

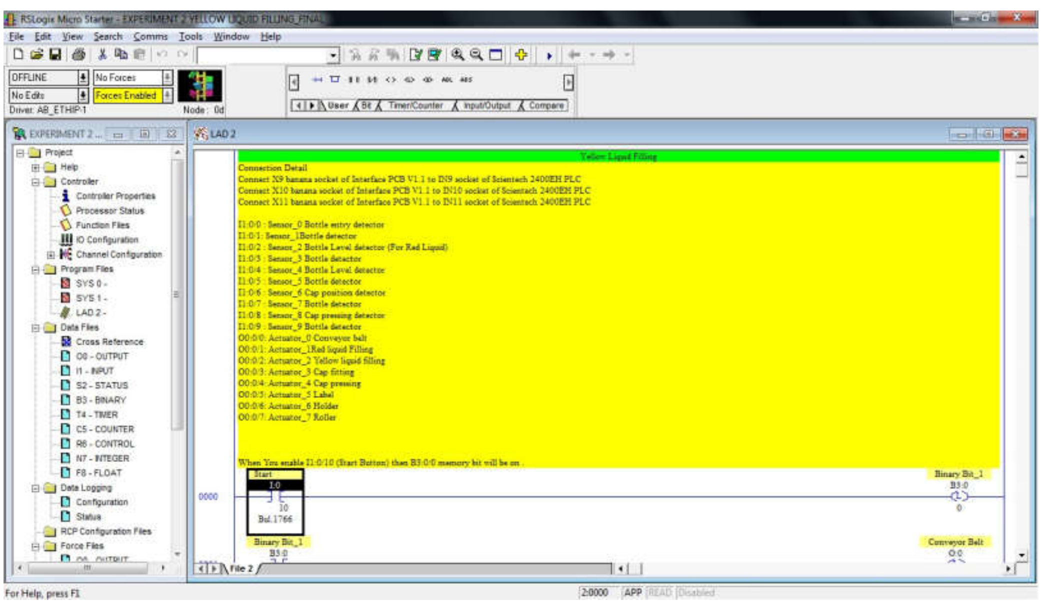
- Made connection between DAQ card and Module PCB ver. 1.1 is shown in figure 1.0.

Figure1.0

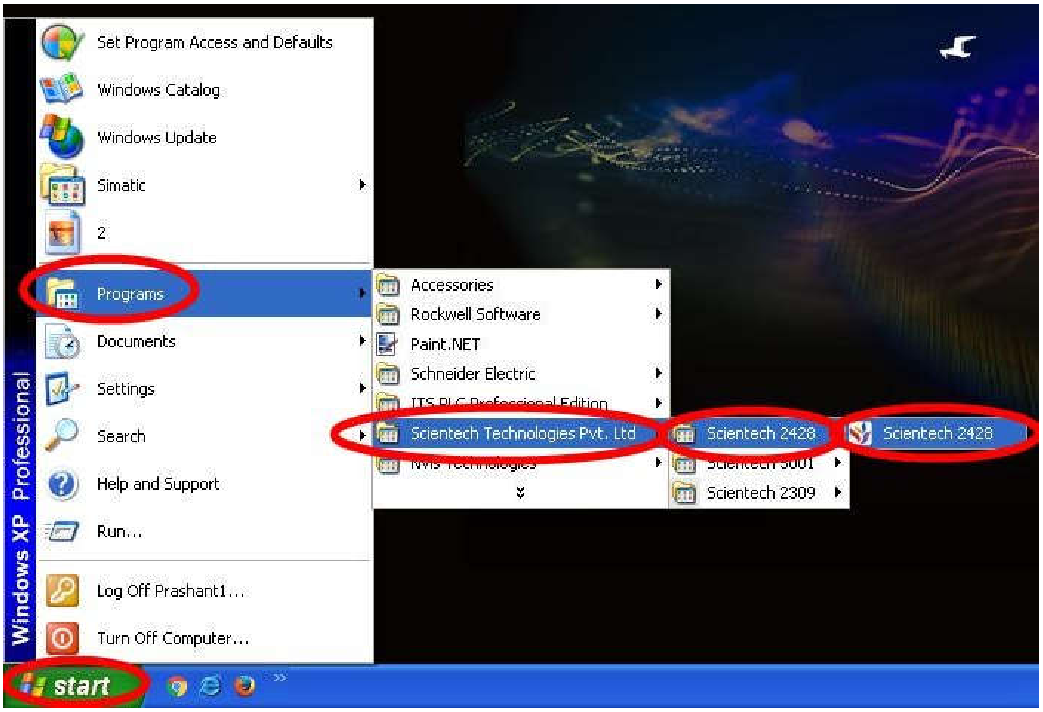
- Connect IN9 (Scientech 2400EH) to Interfacing PCB X9 banana socket .Connect IN10 (Scientech 2400EH) to Interfacing PCB) X10 banana socket .Connect IN11 (Scientech 2400EH) to Interfacing PCB) X11 banana socket .



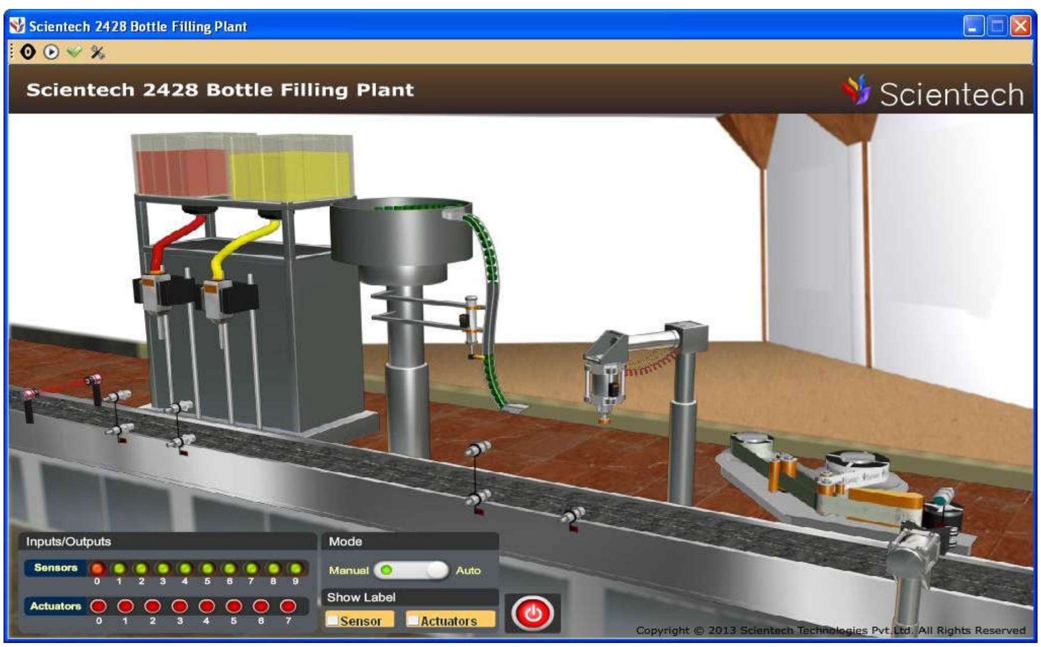
- Open the Scientech 2428 CD. Open Sample Program folder and Double click on Experiment 2.



- Connect A to USB Cable between Scientech 2428 DAQ USB Socket and PC USB Port.
- Open Scientech 2428 Software.



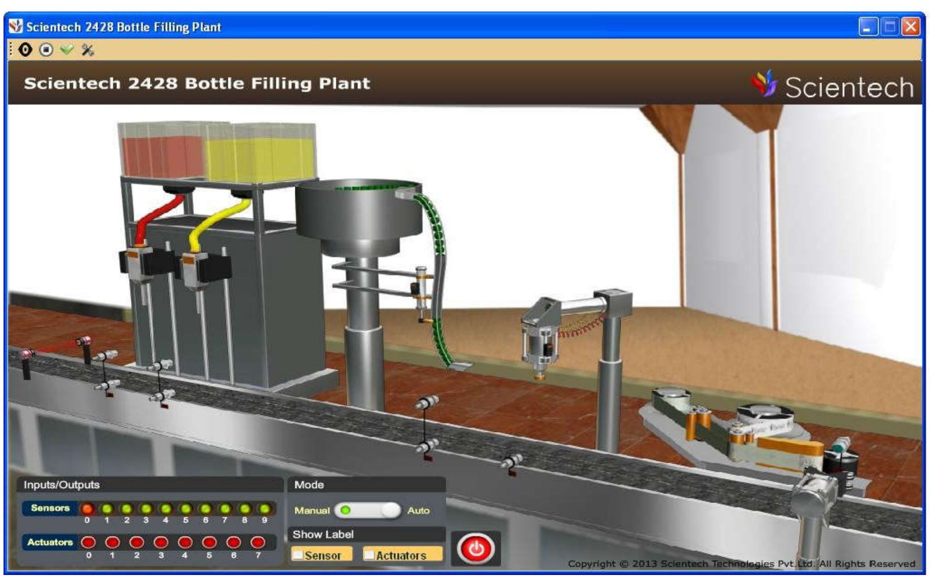
- Scientech 2428 Software will open .



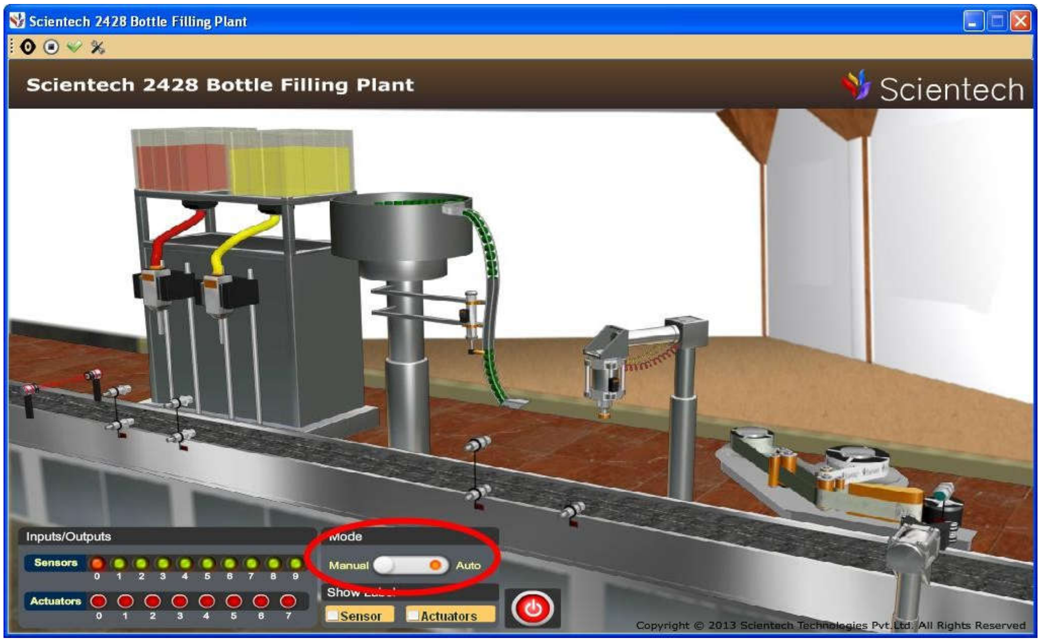
- When USB is Properly connect to PC then Hardware Found message will comes as shown below.

- Click on Start button as shown below.

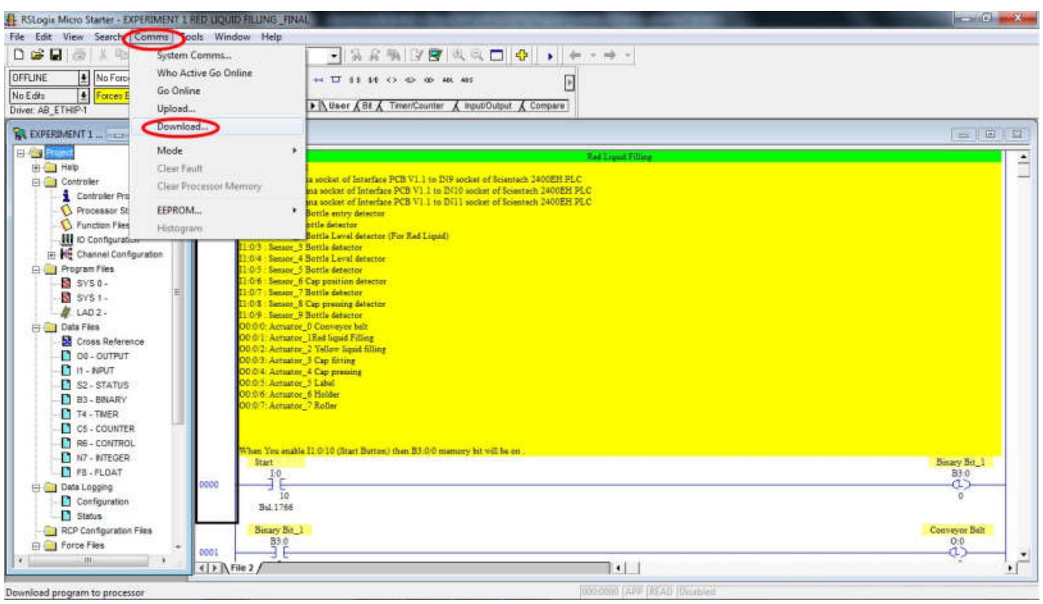
- After above step Start button icon change in Stop button icon as shown below.



- Change the Manual mode to Auto mode as shown below.

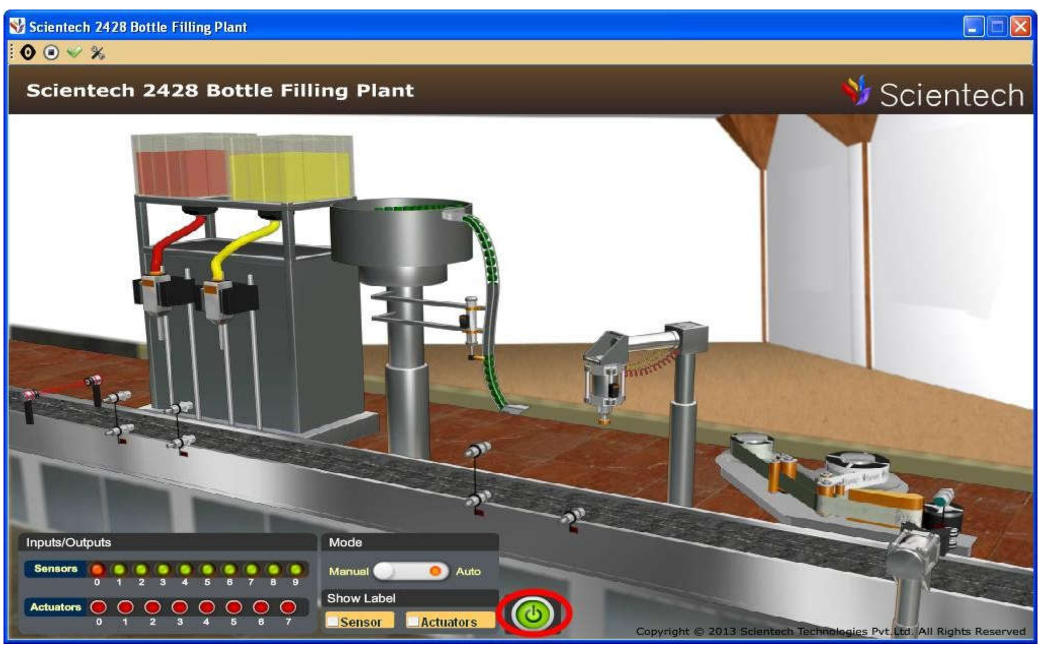


- For download the program in PLC go to the **Comms** button then click on **Download** button as shown below.



- After Download a program in PLC then put the PLC in Run mode using RSLogix Micro Strater Software.
- Click on Start/ Stop button as shown below.

- Stop icon (Red) in Start icon (Green) as shown below.



- Red Bottle Filling Process will start as shown below.

Experiment 3

Objective: Study and programming of Bottle filling plant for Red and yellow liquid filling .

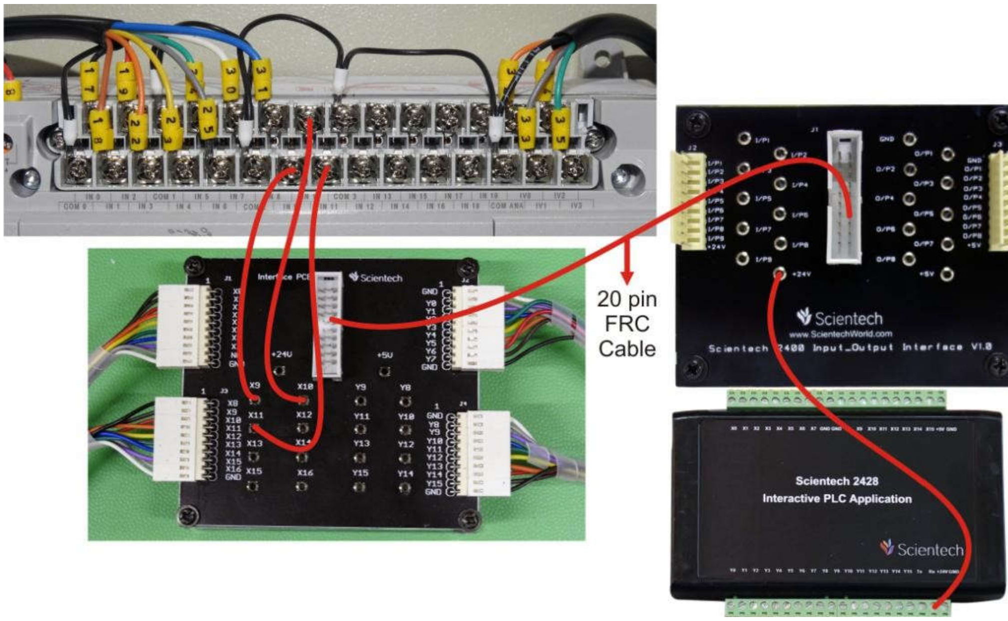
Equipment required:

- Scientech 2400EH Universal PLC Platform
- Scientech 2428 Interactive PLC Application
- A to B TYPE USB cable
- 2mm patch cords
- 20 pin FRC cable

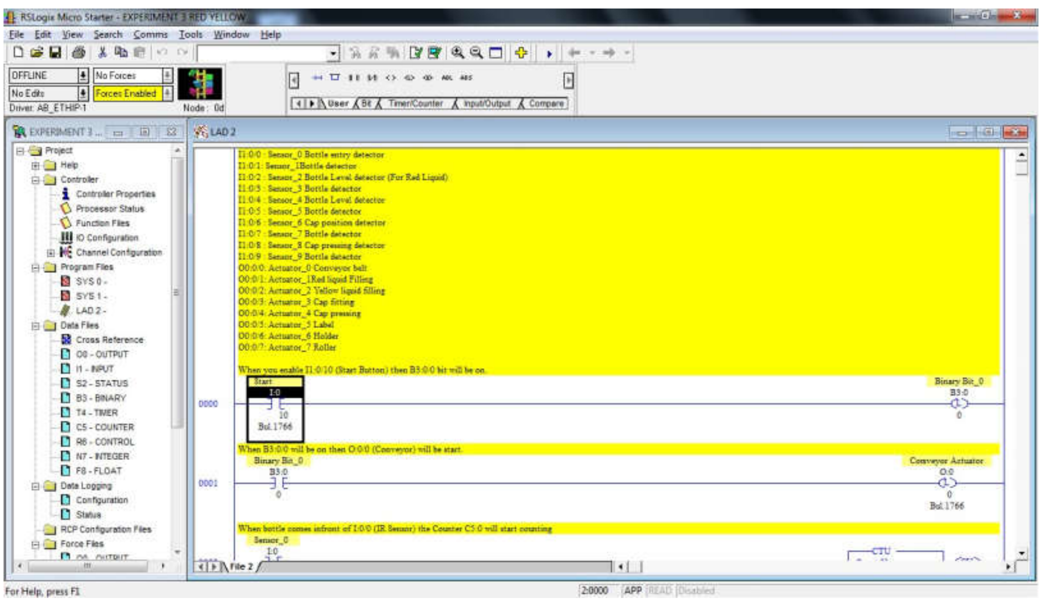
Procedure:

- Made connection between DAQ card and Module PCB ver. 1.1 is shown in figure 1.0.

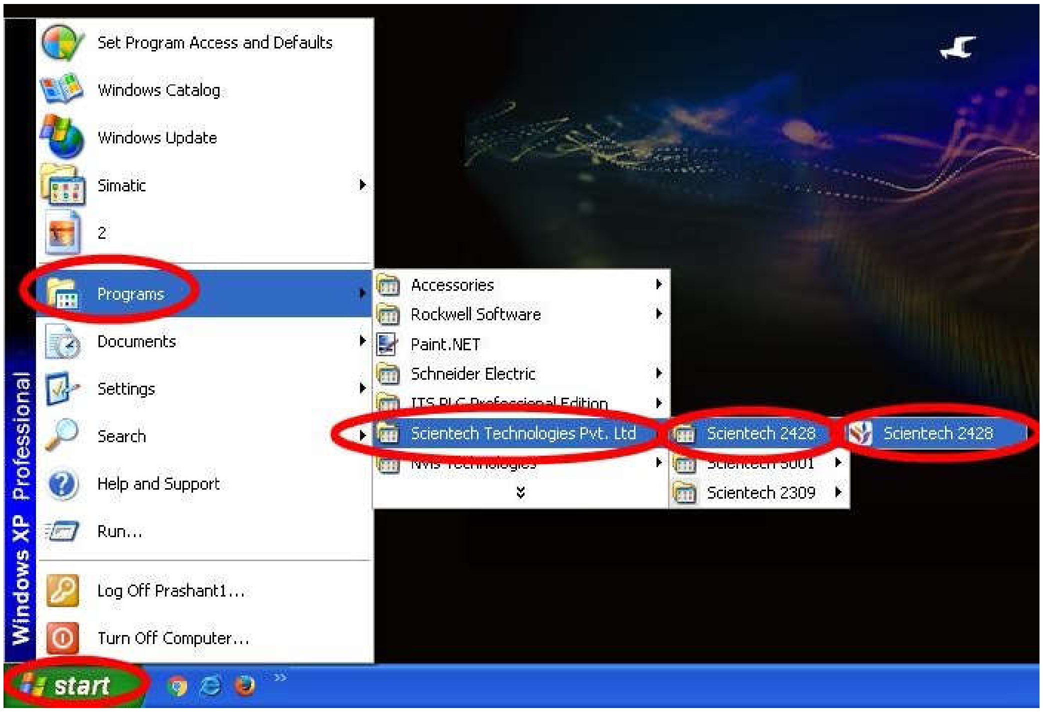
- Connect IN9 (Scientech 2400EH) to Interfacing PCB X9 banana socket Connect IN10 (Scientech 2400EH) to Interfacing PCB) X10 banana socket. Connect IN11 (Scientech 2400EH) to Interfacing PCB) X11 banana socket .



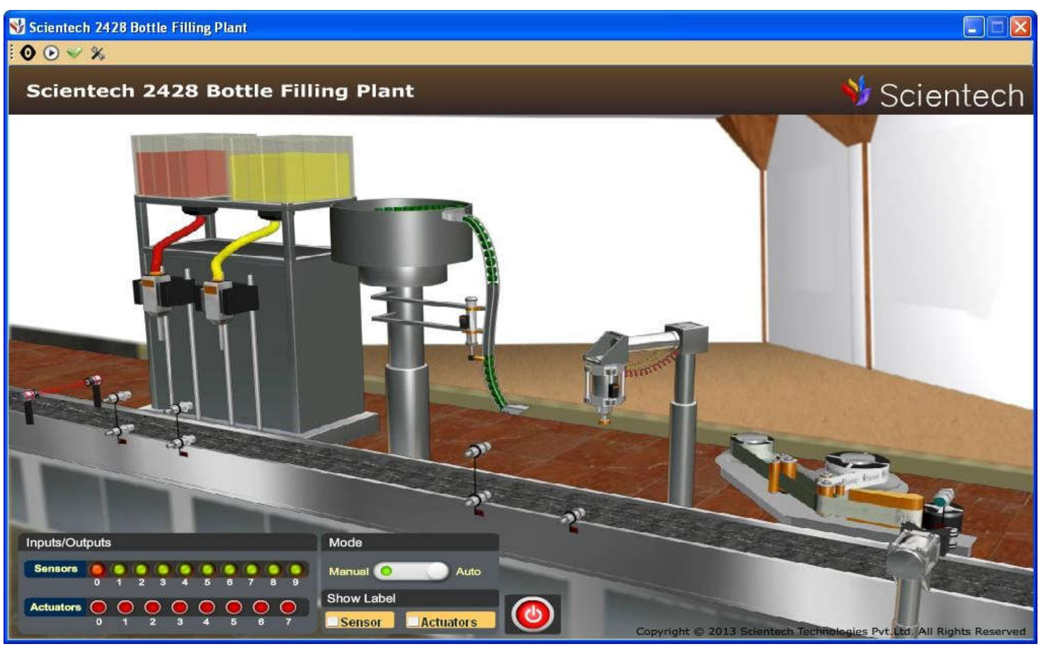
- Open the Scientech 2428 CD. Open Sample Program folder and Double click on Experiment 3.



- Connect A to USB Cable between Scientech 2428 DAQ USB Socket and PC USB Port.
- Open Scientech 2428 Software.

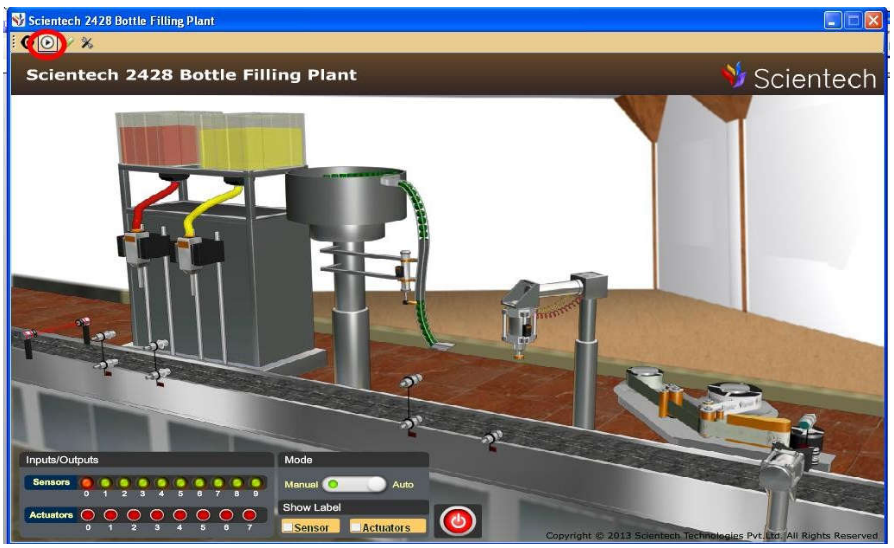


- Scientech 2428 Software will open .

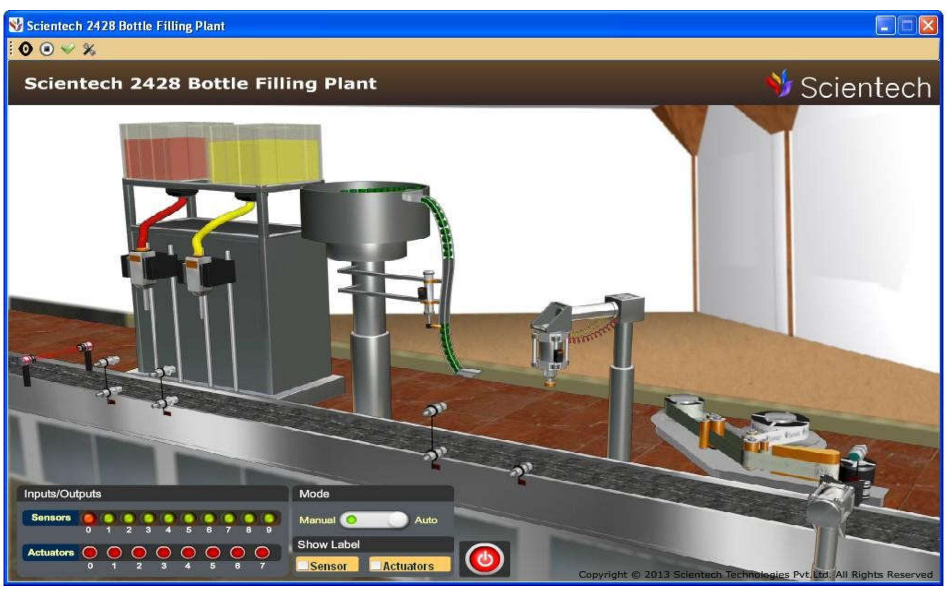


- When USB is Properly connect to PC then Hardware Found message will comes as shown below.

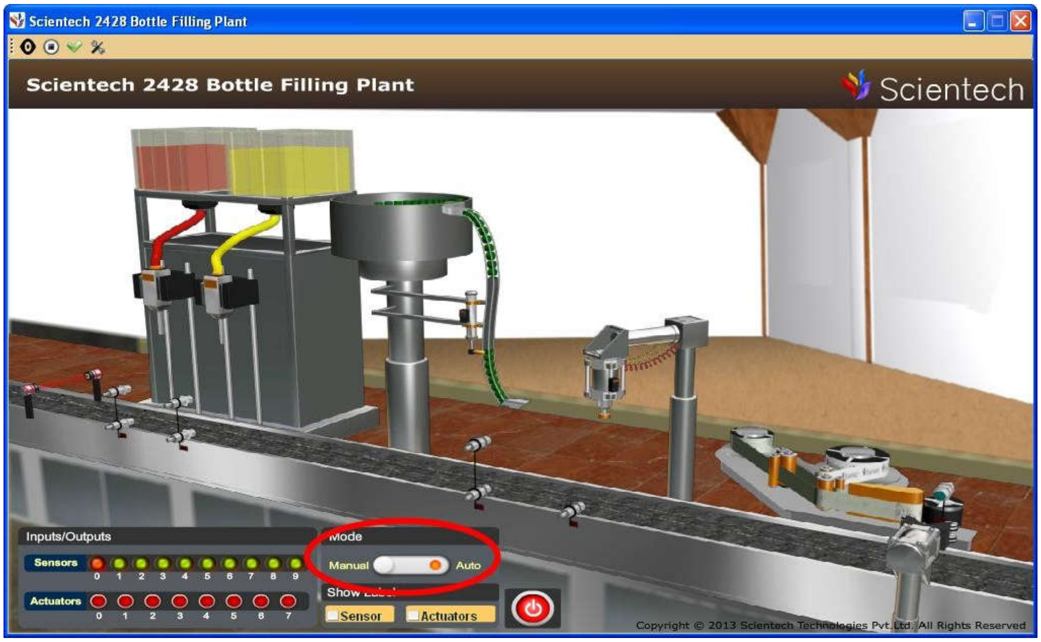
- Click on Start button as shown below.



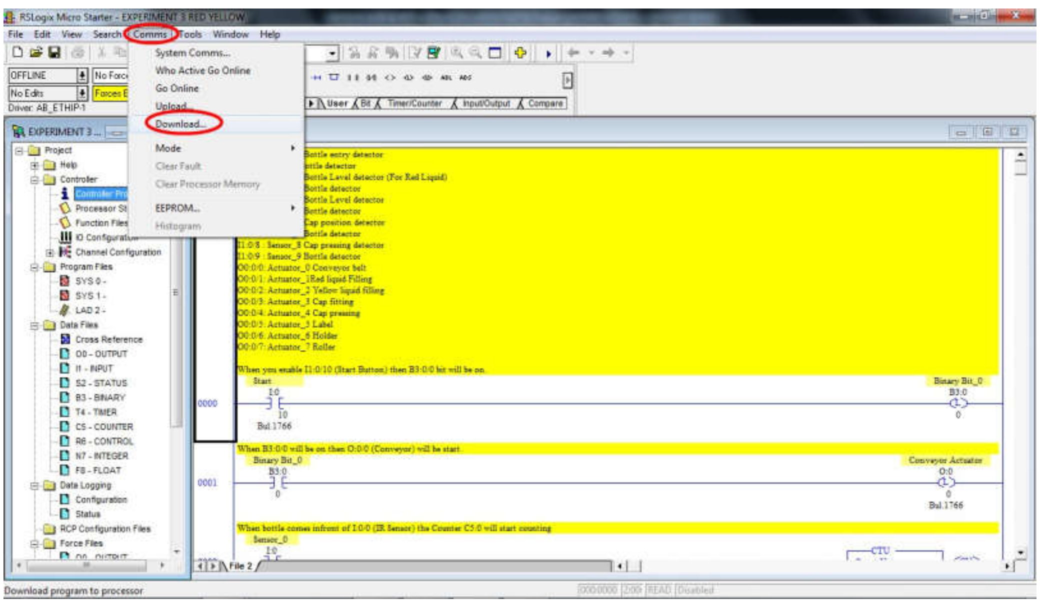
- After above step Start button icon change in Stop button icon as shown below.



- Change the Manual mode to Auto mode as shown below.



- For download the program in PLC go to the **Comms** button then click on **Download** button as shown below.



- After Download a program in PLC then put the PLC in Run mode using RSLogix Micro Strater Software.
- Click on Start/ Stop button as shown below.

- Stop icon (Red) in Start icon (Green) as shown below.

- Red and Yellow Bottle Filling Process will start as shown below.

List of Contents

1. A to B type USB cable.. 1 No.
2. 16” (2 mm) Patch Cord ....10Nos.
3. Interfacing PCB.. 1No.

Industrial PID Controller Training System

Scientech 2003A

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the Scientech 2003A. To avoid any personal injury or damage to the instrument or any product connected to the instrument.

Do not operate the instrument if suspect any damage to it.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock, the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Introduction

Scientech 2003A **Industrial PID Controller Training System** is a complete setup to control process through two point (ON/OFF) and three point (PID) controller. It has two processes Temperature and Liquid level which we can control through an Ethernet based Data Acquisition System which has 24 bit ADC and digital input/output. Scientech 2003A also gives us the exposure to the industrial components like Level Transmitter, Temperature Transmitter, Valves, DAQ, PID controller and sensors. User can learn how to calibrate, install, operate and tune the instruments for controlling the process. All electrical components are connected to the control panel to allow students to measure signals and connect the devices in wide variety of control configuration including open loop (manual control) and close loop (PID control, ON/OFF control).

Scientech 2003A also has versatile software through which we can control it from any PC which is in the local area network, software has features like logging of the process data, live and store Graph which can be printed when needed, alarm can be set for different points, animated real time view of complete process, easy IP configuration.

Features

- Use of Industrial Process Control elements
- Heavy duty bench workstation
- Electrical Control Panel
- Capacitive Level Sensor
- Temperature Transmitter
- Interface with Ethernet based DAQ
- 8 Channel 24 bit ADC
- Din rail mounting for DAQ
- Process Control concept
- RTD Sensor
- Thermocouple Sensor
- Start , Stop , Emergency Stop button , Indicators for Pump ,Heater , Stirrer, Solenoid Valve, Audio Indicator, Visual Indicator
- 2 Types of Controller: PID Control , DAQ Control
- Process Loop Tuning & Stable Process
- Real-time DAQ interface with ADC & Digital input/output
- Process Control by ON/OFF Controller
- Process Control by PID with Auto tuning
- Process Control loops
- Temperature Measurement and Control
- Automatic and Manual Control
- Leak proof Safety measures, sturdy piping
- Enhanced Electrical Safety considerations
- Heat Transfer concepts
- Transducer/Transmitter Calibration
- Piping and instrumentation diagram
- Built-In Instrumentation
- Sump tank for inlet and outlet of water
- User Friendly Software
- Robust construction
- Platform with Caster wheel arrangement for ease in movement
- Online Product Tutorial

Technical Specifications

Push to On Switch	:	6
Toggle Switch	:	5
Indicator Lamp	:	5
Emergency Stop Switch	:	1
Audio Indicator	:	1
Process (Measuring) Tank	:	**1**
Capacity	:	15 Litres
Material	:	Stainless Steel (SS304)
Dimension	:	300 X 315 X 250 mm
Supply (Sump) Tank	:	1
Capacity	:	30 Litres
Material	:	Stainless Steel (SS304)
Dimension	:	500 X 315 X 250 mm
Temperature Sensor	:	1
Type	:	RTD (PT100)
Wire	:	3 Wire
Rod Length	:	9"
Temperature Range	:	(-99 to 850°C)
Thermocouple Sensor	:	1
Type	:	K Type
Wire	:	2 Wire
Rod Length	:	9"
Temperature Range	:	(-200 to1250°C)
Heater	:	1
Supply	:	230 V AC (1000Watt)
Ammeter	:	1
Range	:	0 to 5A, 0.2% resolution
Solenoid Valve	:	1
Supply Voltage	:	+230V AC
Type	:	2/2
Port size	:	1/2"
2 Pressure range	:	0-10kg/cm

Stirrer	:	1
Supply	:	12 V DC
Level Transmitter	**:**	1
Supply Voltage	:	+24V DC
Output Voltage	:	4ma to 20ma
Cable Entry	:	2 X 1/2" BSP, SC gland brass
User Interface	:	4 digit display+4 Keys
Read out	:	0 - 100%, 4-20mA LED (red), Digital, 2-1/2
Outputs	:	4-20 mA PNP output (3 wire) or galvanic ally isolated (4 wire loop) (User selectable) 4 - 20 mA output is over current safe and compatible with PLC
		Measurement Range: 10-50000 pF.
	:	Calibration: Cali ratable over measurement range.
	:	Calibration method: Easy (Using DIP Switches)
Sensing rod material	:	Stainless steel (SS304)
Insulation	:	Full PTFE
Mains	:	+24V DC @25mA (reverse polarity safe)
Probe Length	:	250mm
Temperature Transmitter	**:**	**1**
Input RTD	:	Pt100 3 wire
Output	:	4 - 20 mA, two wire
Accuracy	:	±0.1% of the calibrated span
Loop Supply	:	24V DC nominal (12 to 36)V DC
Electrical Control panel	**:**	-MS Powder coated panel with switches, indicator, Test Points, PID and DAQ , Ammeter on front facia, DAQ Mounted on DIN rail channel, multistrand wire with proper insulated ,lugs, ferruling & neat wire dressing & clamping

Industrial PID Controller	**:**	1
Input	:	RTD (PT100), K type Thermocouple
Display	:	7 segment LED, dual display
Control Action	:	PID & ON/OFF
Supply Voltage	:	230V AC
Relay Action	:	Forward for cooling and reverse for heating
Water Pump	**:**	1
Flow Rate	:	500L/h
Operating Voltage	:	165 -230 V AC
Piping	**:**	1/2" PVC
Drain valve	**:**	1
Size	:	½”
Size	:	½”
Computer Interface	**:**	Ethernet
Caster Wheel	:	4 nos
Dimension (mm)	:	W 3850 X D 1400 X H 1400
Weight	:	75Kgs (Approximately).
Power Supply	:	230V ± 10%, 50 / 60 Hz

Data Acquisition System (DAQ)

Analog input	:	8
Analog output	:	2
Digital input	:	8
Digital Output	:	8
ADC Resolution (In Bit)	:	24
Unity gain amplifier (Buffer)	:	2 (0-5V)
USB	:	Yes
Ethernet	:	Yes
Data Login (PC based)	:	Yes
UART Interface	:	Yes
Software	:	Yes

List of Accessories

Mains Cord	:	1
Ethernet Cable	:	1
Panel Gate Key	:	1
Drawer Lock Key	:	1
Flexible Pipe	:	1 meter
Product Tutorial	:	Online

Theory

Introduction to Process Control

Process control is a statistics and engineering discipline that deals with architectures, mechanisms, and algorithms for controlling the output of a specific process.

For example, heating up the temperature in a room is a process that has the specific, desired outcome to reach and maintain a defined temperature (e.g. 20°C), kept constant over time. Here, the temperature is the controlled variable. At the same time, it is the input variable since it is measured by a thermometer and used to decide whether to heat or not to heat. The desired temperature (20°C) is the set-point. The state of the heater (e.g. the setting of the valve allowing hot water to flow through it) is called the manipulated variable since it is subject to control actions.

In practice, process control systems can be characterized as one or more of the following forms:

Discrete: Found in many manufacturing, motion and packaging applications. Robotic assembly, such as that found in automotive production, can be characterized as discrete process control. Most discrete manufacturing involves the production of discrete pieces of product, such as metal stamping.

Batch: Some applications require that specific quantities of raw materials be combined in specific ways for particular durations to produce an intermediate or end result. One example is the production of adhesives and glues, which normally require the mixing of raw materials in a heated vessel for a period of time to form a quantity of end product. Other important examples are the production of food, beverages and medicine. Batch processes are generally used to produce a relatively low to intermediate quantity of product per year (a few pounds to millions of pounds).

Continuous: Often, a physical system is represented though variables that are smooth and uninterrupted in time. The control of the water temperature in a heating jacket, for example, is an example of continuous process control. Some important continuous processes are the production of fuels, chemicals and plastics. Continuous processes, in manufacturing, are used to produce very large quantities of product per year (millions to billions of pounds).

Applications having elements of discrete, batch and continuous process control are often called hybrid applications.

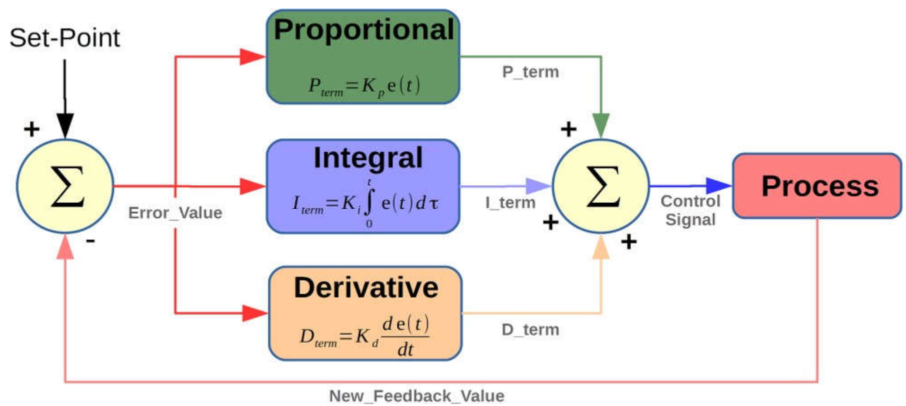
Terminology:

Bi-Modal Control: A control arrangement that provides both direct acting and reverse acting control.

Closed loop: A signal path (includes a final control element for the process) and a process feedback (compared to the set-point to determine the deviation). A deviation signal addresses the final control element and provides automatic control of the process, called the Auto mode.

Introduction of PID Controllers

Proportional–Integral–Derivative controller is a control loop feedback mechanism widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired set-point by calculating and then outputting a corrective action that can adjust the process accordingly.



The PID controller calculation (algorithm) involves three separate parameters; the Proportional, the Integral and Derivative values. The Proportional value determines the reaction to the current error, the Integral determines the reaction based on the sum of recent errors and the Derivative determines the reaction to the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element.

By "tuning" the three constants in the PID controller algorithm the PID can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the set-point and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system.

Some applications may require using only one or two modes to provide the appropriate system control. This is achieved by setting the gain of undesired control outputs to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are particularly common, since derivative action is very sensitive to measurement noise, and the absence of an integral value prevents the system from reaching its target value due to the control action.

The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). Hence:

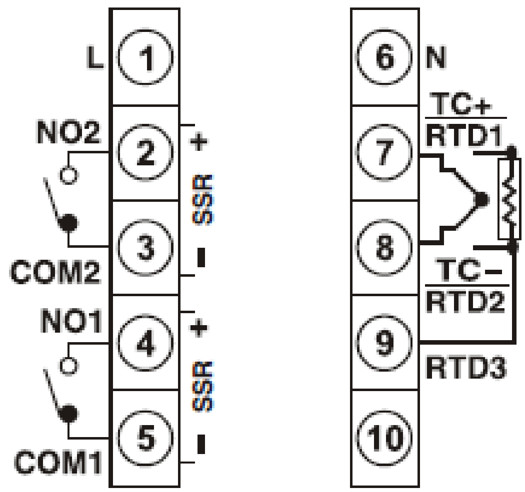
$$MV(t) = Pout + Iout + Dout$$

where, *P*out, *I*out, and *D*out are the contributions to the output from the PID controller from each of the three terms, as defined below.

Industrial PID Controller

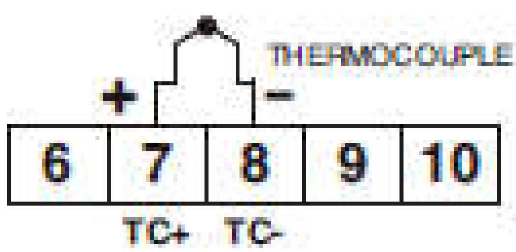
A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an error value as the difference between a measured process variable and a desired set point.

Terminal Connection detail



Connection Diagram

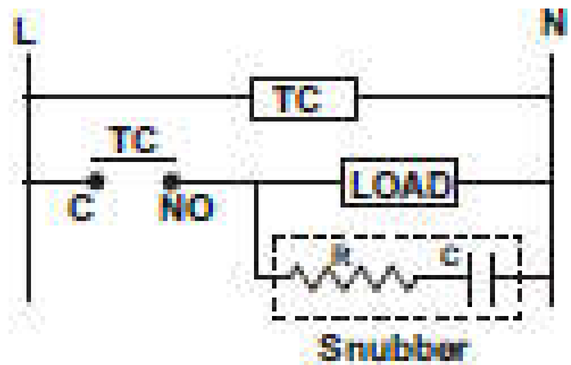
For Thermocouple



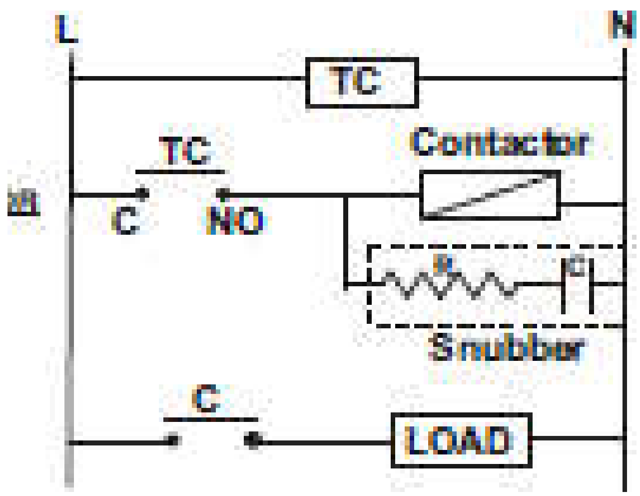
Connector Thermocouple (T/C) according to polarity shown .Positive of T/C at terminal no. 7 and negative of T/C at terminal no. 8

Typical Connection for Loads

1. For Load Current less than 0.5A



2. For bigger load interposing relay/contactor



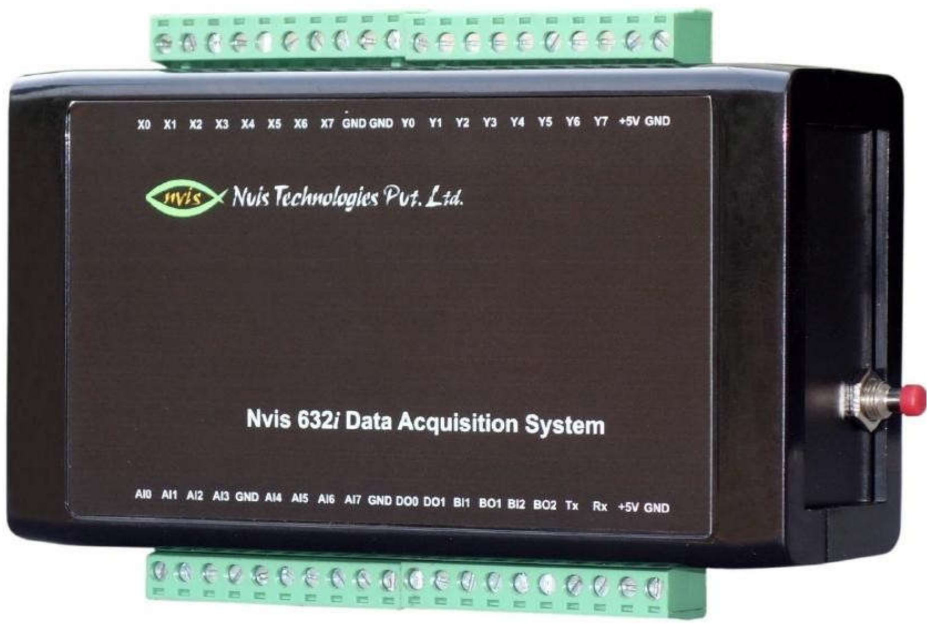
Configuration Scheme (Parameter Setting)

Configuration Scheme (Parameter Setting) **To Enter configuration: Press & for 3 seconds**				
Key Press	**Display**		**Name**	**Description**
	Upper	**Lower**		
Press + for 3 sec	SEt2	0000	Set point 2	-99 to max. Range of sensor for 1^0C resi -99.9 ti 999.9 for 0.1^0C resl
Press	tUnE	OFF	* Tuning mode	Autotune: To tune the instrument select Tune **00** and come out of config. Tune LED will blink indicating tune is in progress
Press	mnL	00	* Manual Reset	Programmable form -99.1 to 99.9 for 0.1^0C
Press	InPt	k	Input Sensor	Select input sensor type options: J (J)/K (K)/t (t)/R (r)/S (s)/RTD(rtd)
Press	rESL	1	Display Resolution	Resolution 0.1 or 1^0C [Valid only for J (j)/K (k)/RTD (rtd)]
Press	rLY1	Fd	Output mode of Relay1	Select reverse **rE** for Heating & forward **Fd** for cooling Application
Press	rLY2	rE	Output mode of Relay2	Select reverse **rE** for Heating & forward **Fd** for cooling application
Press	SEt2	AbS	Set point 2	Absolute/Deviation toggle between **AbS/dEV** mode by pressing of +keys

Press	HYS2	01.0	Hysteresis of Set2	Programmable from 0.1 to 99.9^{0}C
Press	Pb	000	Proportional Band	Proportional band programmable from 0.0 to 400.0^{0}C
Note: To operate in ON/OFF mode make Pb=00				
Press	Int.t	0120	Integral Time	Integral time (reset) programmable from 0 to 3600 sec. This parameter is prompted only in PID mode. i.e. When PB>0
Press	dEr.t	030	Derivative Time	Derivative time (rate) Programmable from 0 to 200 sec. This parameter is prompted only in PID mode. i.e. when PB>0
Press	CYC	020	Cycle Time	Range 1 to 100 sec
Press	HIGH	1350	High Level Limit	Select the maximum limit of setpoint
Press	LSP1	no	Lock set point	Lock setpoint1 Toggle between **no** **/Yes** with each press of + keys
Press	LSP2	no	Lock set point	Lock setpoint1 Toggle between **no** **/Yes** with each press of + keys
Press	rSEt	no	Reset	Reset all parameters to default values. Toggle between **no** **/Yes** with each press of + keys
Press + for 3 Sec. To come of programming				

Data Acquisition System (DAQ)

Scientech 632*i* Data Acquisition System is very useful for sensing and controlling digital and analog signals of any process. It makes easy and interesting to interface real world signals with PC through Ethernet. For easy connection screw terminals are provided. It comes with very versatile software which uses simple USB and Ethernet communication protocol so that user can use or design own software according to its need.

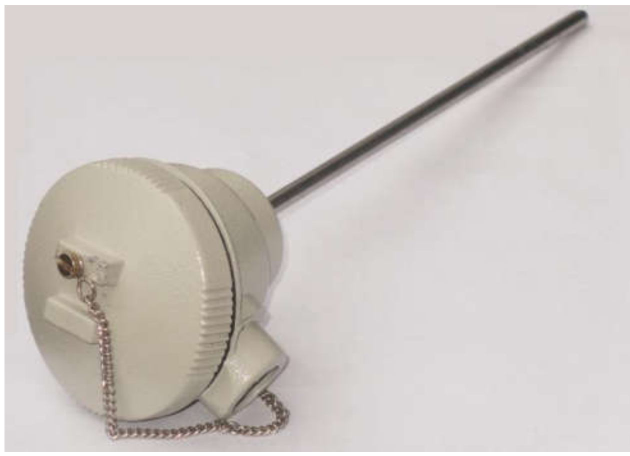


Data acquisition systems, as the name implies, are products and/or processes used to collect information to document or analyze some phenomenon. In the simplest form, a technician logging the temperature of an oven on a piece of paper is performing data acquisition.

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current with a computer.

Resistance Temperature Dependent (RTD)

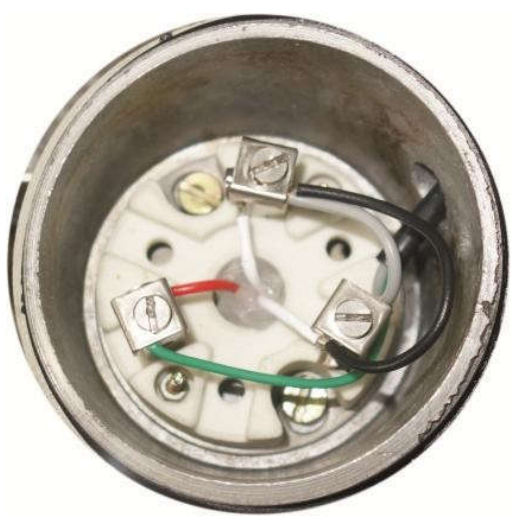
Resistance temperature detectors or RTD’s as they are more commonly known, are another common way to measure temperature. RTD’s were developed in Europe about a century ago but have only become popular in the United States in the last 25 years. RTD’s are very similar in appearance to thermocouples but they function completely different.



As you may remember, thermocouples produce a very small voltage when heated. An RTD does not produce any voltage and so it relies on an instrument for power.

RTD’s are electrical resistors that change resistance as temperature changes. With all common types of RTD’s, the resistance increases as the temperature increases. This is referred to as a positive temperature coefficient.

Sensor Inner structure

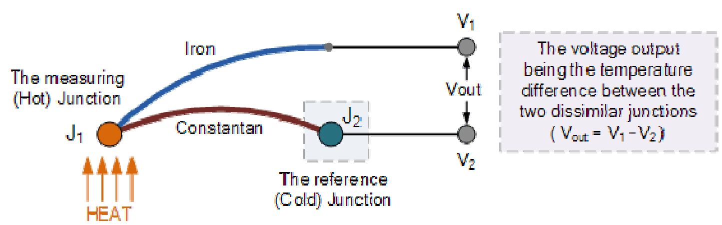


Thermocouples

A thermocouple is a sensor for measuring temperature. This sensor consists of two dissimilar metal wires, joined at one end, and connected to a thermocouple thermometer or other thermocouple-capable device at the other end. When properly configured, thermocouples can provide temperature measurements over wide range of temperatures. The **Thermocouple** is by far the most commonly used type of all the temperature sensor types. Thermocouples are popular due to its simplicity, ease of use and their speed of response to changes in temperature, due mainly to their small size. Thermocouples also have the widest temperature range of all the temperature sensors from below -200^{o}C to well over 2000^{o}C.

Thermocouples are thermoelectric sensors that basically consists of two junctions of dissimilar metals, such as copper and constantan that are welded or crimped together. One junction is kept at a constant temperature called the reference (Cold) junction, while the other the measuring (Hot) junction. When the two junctions are at different temperatures, a voltage is developed across the junction which is used to measure the temperature sensor as shown below.

Thermocouple Construction



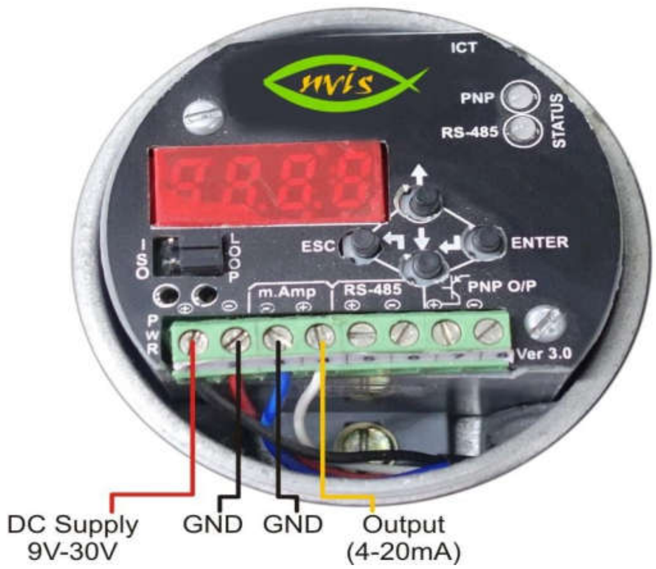
The operating principal of a thermocouple is very simple and basic. When fused together the junction of the two dissimilar metals such as copper and constantan produces a "thermo-electric" effect which gives a constant potential difference of only a few millivolts (mV) between them. The voltage difference between the two junctions is called the "Seebeck effect" as a temperature gradient is generated along the conducting wires producing an emf. Then the output voltage from a thermocouple is a function of the temperature changes.

If both the junctions are at the same temperature the potential difference across the two junctions is zero in other words, no voltage output as $V_1 = V_2$. However, when the junctions are connected within a circuit and are both at different temperatures a voltage output will be detected relative to the difference in temperature between the two junctions, $V_1 - V_2$. This difference in voltage will increase with temperature until the junctions peak voltage level is reached and this is determined by the characteristics of the two dissimilar metals used.

Thermocouples can be made from a variety of different materials enabling extreme temperatures of between -200^{o}C to over + 2000^{o}C to be measured. With such a large choice of materials and temperature range, internationally recognised standards have been developed complete with thermocouple colour codes to allow the user to choose the correct thermocouple sensor for a particular application. The British colour code for standard thermocouples is given below.

Level Transmitter

A Level Transmitter is simply an instrument that provides continuous level measurement. Level transmitters can be used to determine the level of a given liquid or bulk-solid at any given time.



Working Principle:

A capacitor is formed when a level sensing electrode is installed in a vessel. The metal rod of the electrode acts as one plate of the capacitor and the tank wall (or reference electrode in a non-metallic vessel) acts as the other plate. As level rises, the air or gas normally surrounding the electrode is displaced by material having a different dielectric constant. A change in the value of the capacitor takes place because the dielectric between the plates has changed. RF (radio frequency) capacitance instruments detect this change and convert it into a relay actuation or a proportional output signal. The capacitance relationship is illustrated with the following equation:

$$C = 0.225\ K\ \left(\frac{A}{D}\right)$$

Where:

C = Capacitance in pico Farads

K = Dielectric constant of material

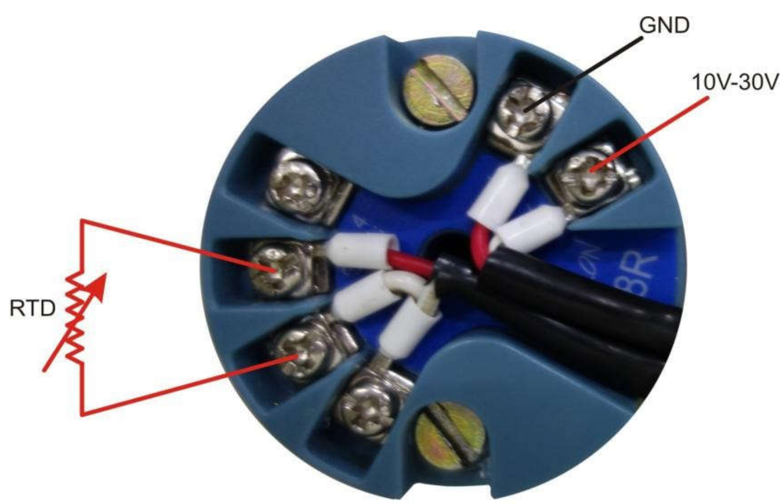
A = Area of plates in square inches

D = Distance between the plates in inches

Temperature Transmitter

Temperature transmitter is an electrical instrument that interfaces a temperature sensor (e.g. thermocouple, RTD, or thermistor) to a measurement or control device (e.g. PLC, DCS, PC, loop controller, data logger, display, recorder, etc.).

A temperature transmitter combine a temperature sensor RTD or Thermocouple and transmitter in same instrument. The sensor measure the temperature while transmitter amplies and transmit the signal to monitoring system or a control room. A temperature transmitter measure temperature and convert it into a current signal 4 to 20ma that is proportional to the temperature measured.



Software Installation

Unpacking

After receiving your Scientech 2003A package, please inspect its contents first. The package should contain the following

Scientech 2003A Industrial PID Controller Training System (Measuring tank ,Sump Tank , Control Panel , PVC Pipes , Sensor Unit (RTD , Thermocouple , Stirrer , Level Transmitter) and CPVC Pipes and Flexible

List of Accessories

Ethernet Cable, Mains Cord, Flexible Pipe (2 Meter),Panel Gate Key, Drawer Key Product CD Contains , Manual, Software setups folder

- Mysql _essential5.1.43win32
- Mysqlguitools5.0r17win32•

Scientech 2003A setup

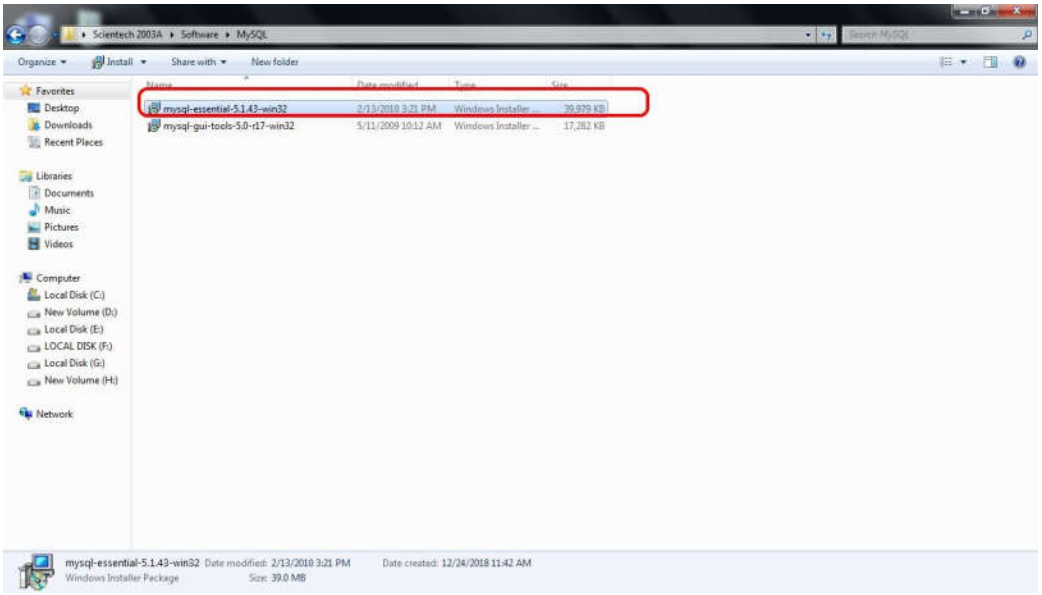
- ISSetup Prerequisites

Scientech 2003A DAQ needs MySQL for data base system installed in user PC/Laptop

MySQL Installation

Insert the CD into the CD drive of your computer and go to Software folder.

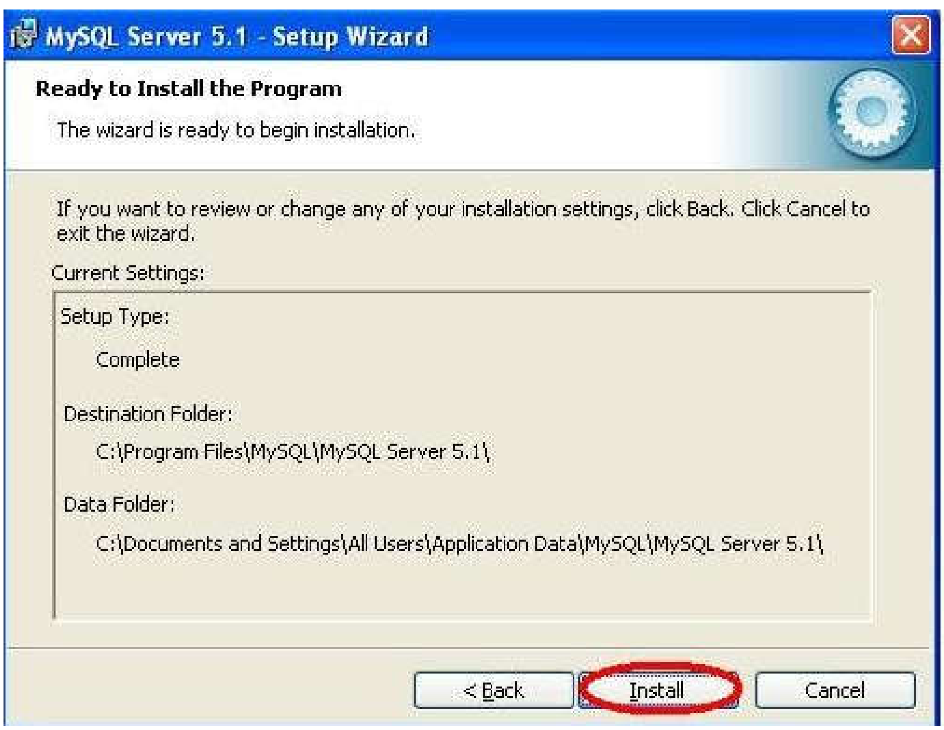
Step 1: CD Contains>**Software setups**> **Mysql - essential5.1.43-win32** then Double click on icon shown below



Step 2: Click on **Next** tab shown below.

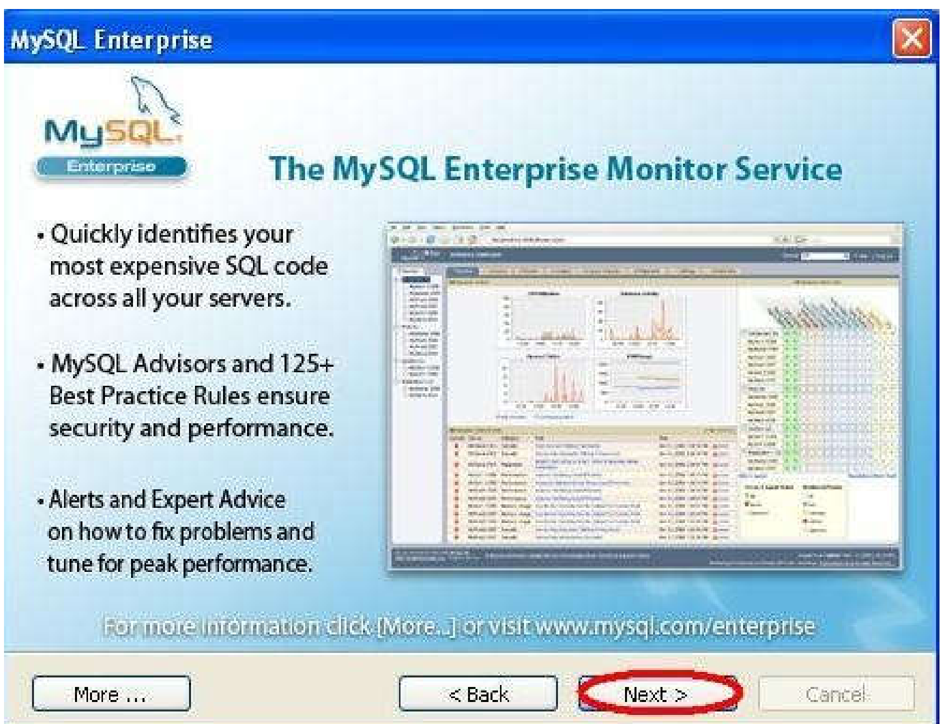
Step 3: Click on **Complete** Check box then click on **NEXT tab shown below.**

Step 4: Ready to Install the Program window will be open then Click on **Install** tab shown below.



Step 5: Click on **Next** tab shown below.

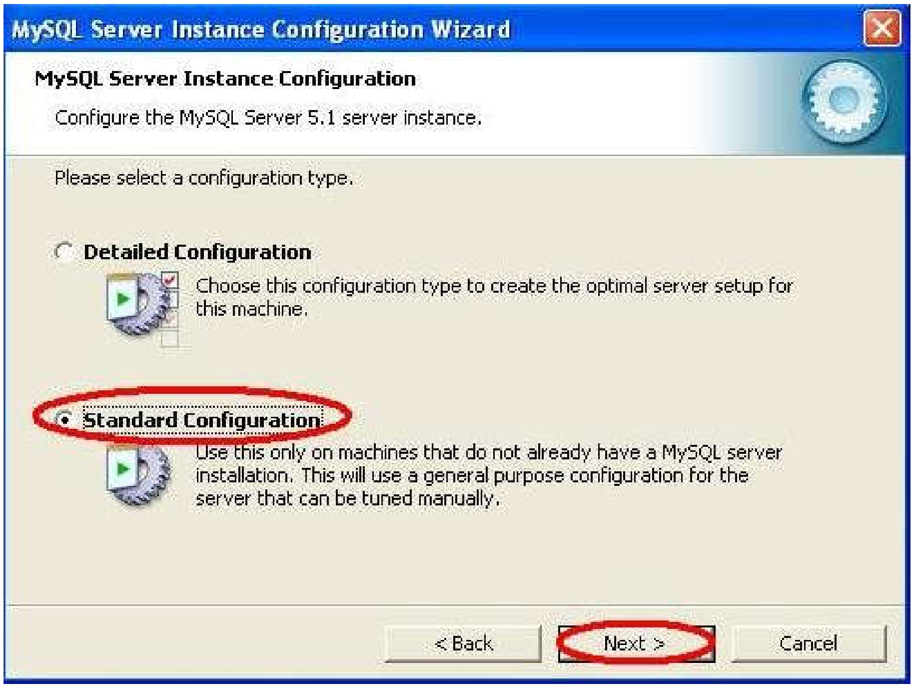
Step 6: Click on **Next** tab shown below.



Step 7: Wizard complete window will be open , click on Configure the MySQL Server now check box and Click on **Finish** tab shown below.

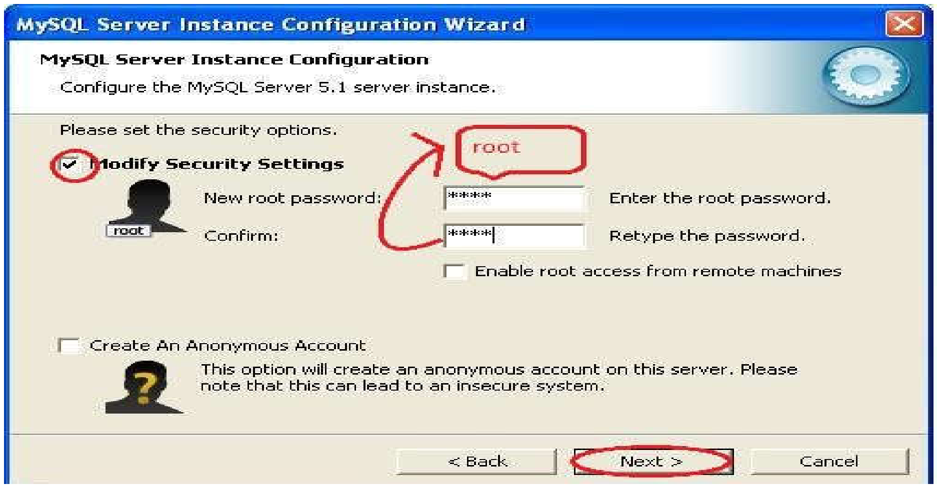
Step 8: Welcome to the MySQL Server Instance Configuration Wizard 1.0.16.0 Window will be open then click on **Next** tab shown below.

Step 9: MySQL Server Instance Configuration window will be open, click on Standard Configuration check box and Click on **Next** tab shown below.

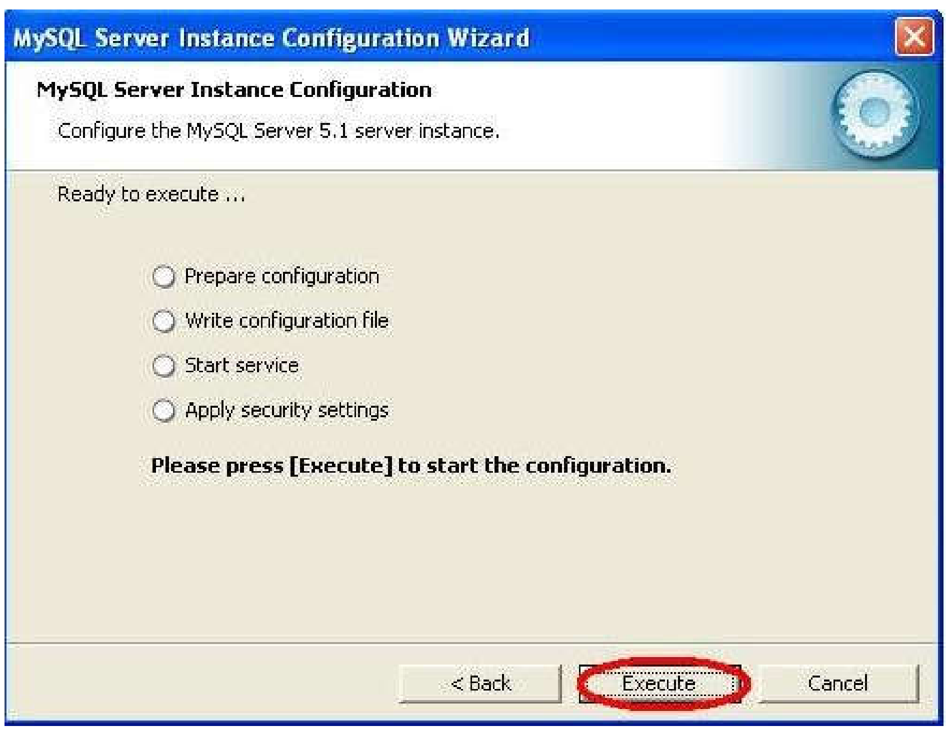


Step 10: MySQL Server Instance Configuration window will be open, click on Install as Windows Services then click on **Next** tab shown below.

Step 11: MySQL Server Instance Configuration window will be open, click on Modify Security Settings then click on **Next** tab shown below.



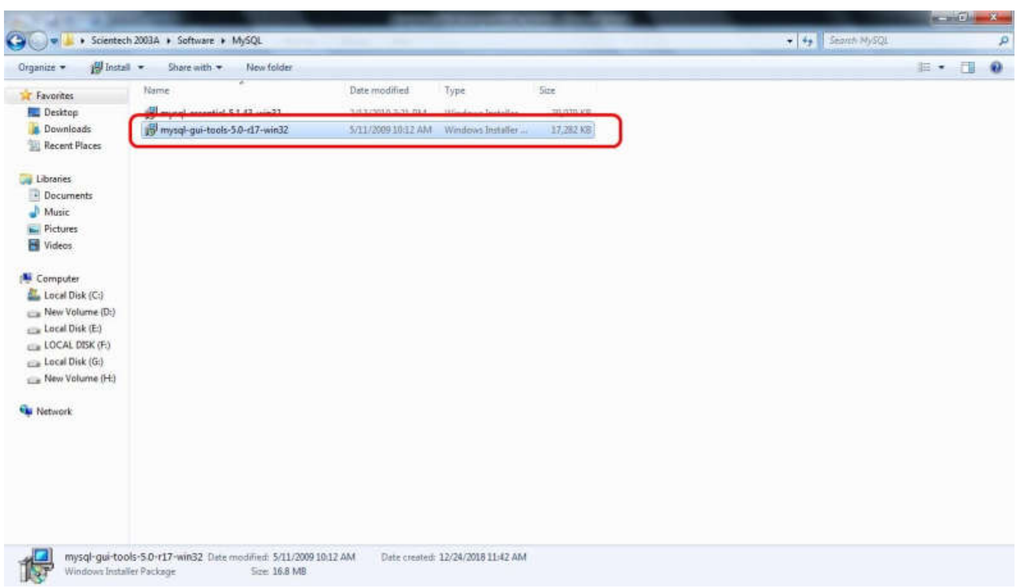
Step 12: MySQL Server Instance Configuration window will be open then click on Execute tab shown below.



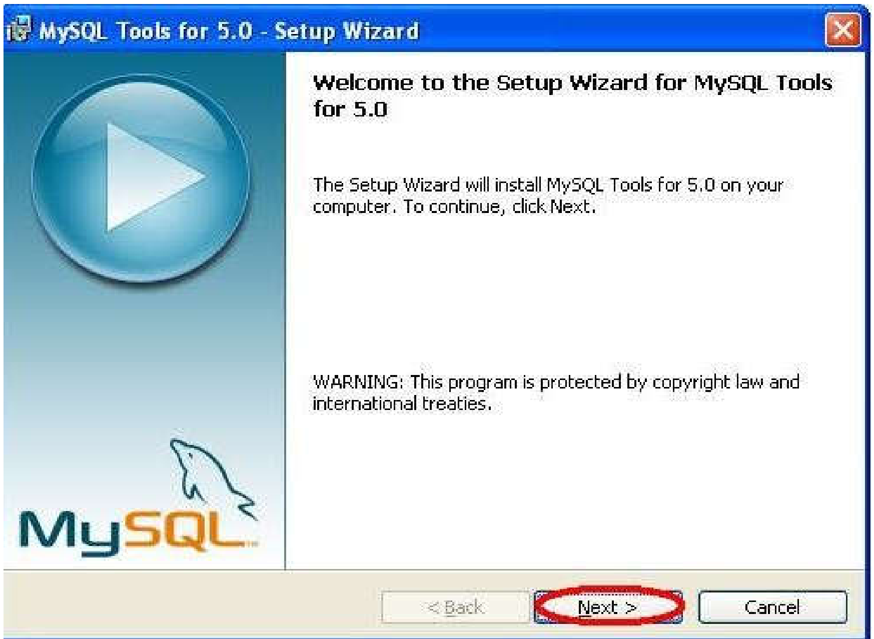
Step 13: MySQL Server Instance Configuration window will be open then click on Finish tab shown below.

User must install Mysql-gui-tools5.0-r17-win32

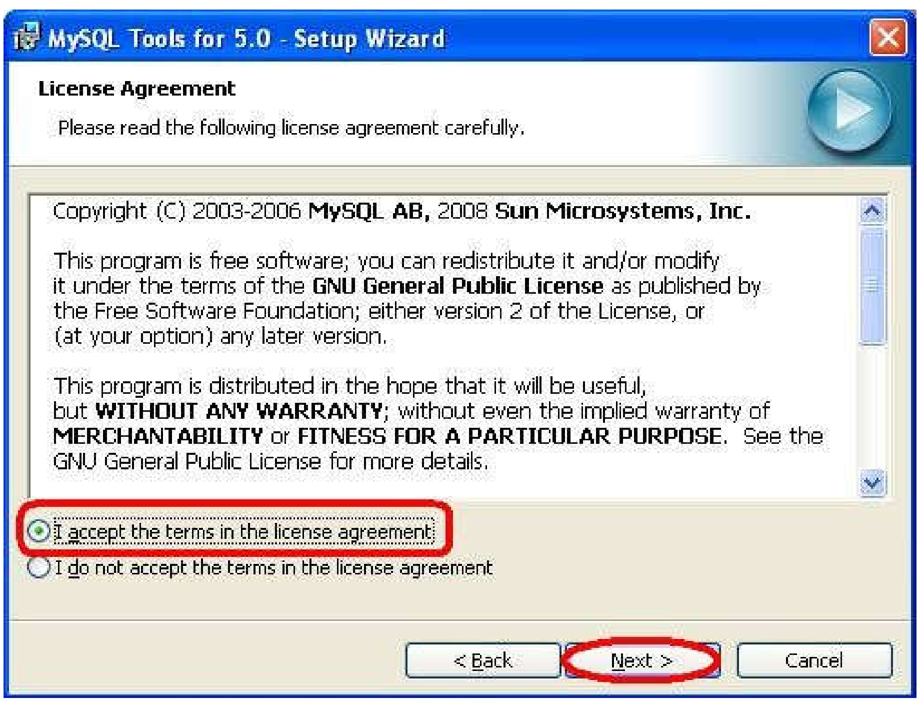
Step 14: Go to the CD Contains>Software setups> Mysqlguitools5.0r17win32 and double click on mysql gui tools 5.0r17win32 shown below.



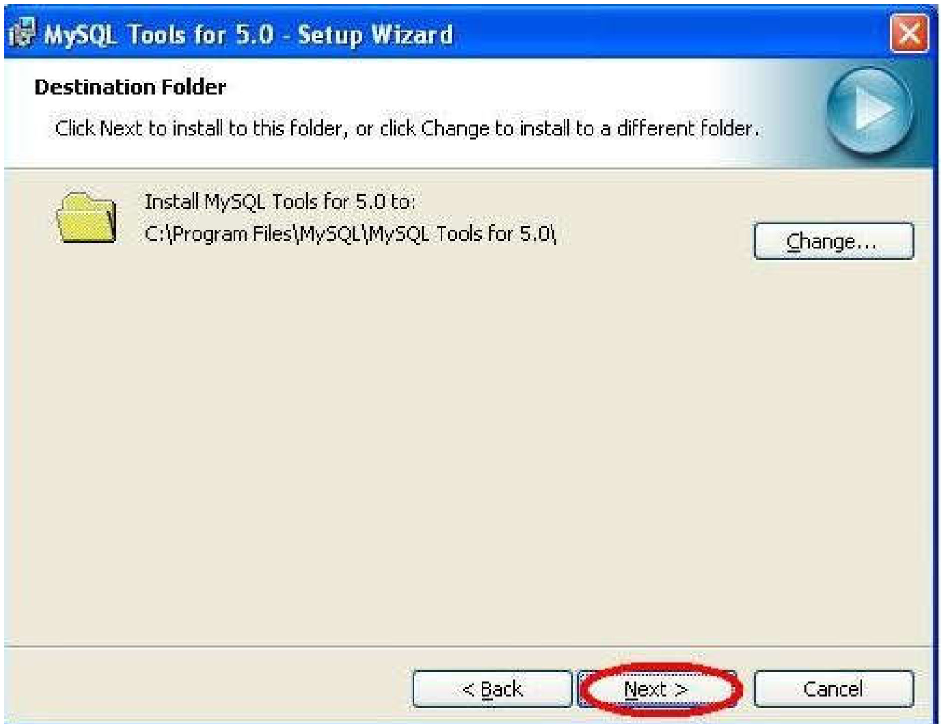
Step 15: Welcome to the Setup Wizard for MySQL Tools for 5.0 Window will be open then click on **Next** tab shown below.



Step 16: License Agreement Widow will be open, Click on Accept the terms in license agreement check box and click on Next tab shown below.



Step 17: Setup Type Window will be open , Click on Complete Check box and click on Next tab shown below.



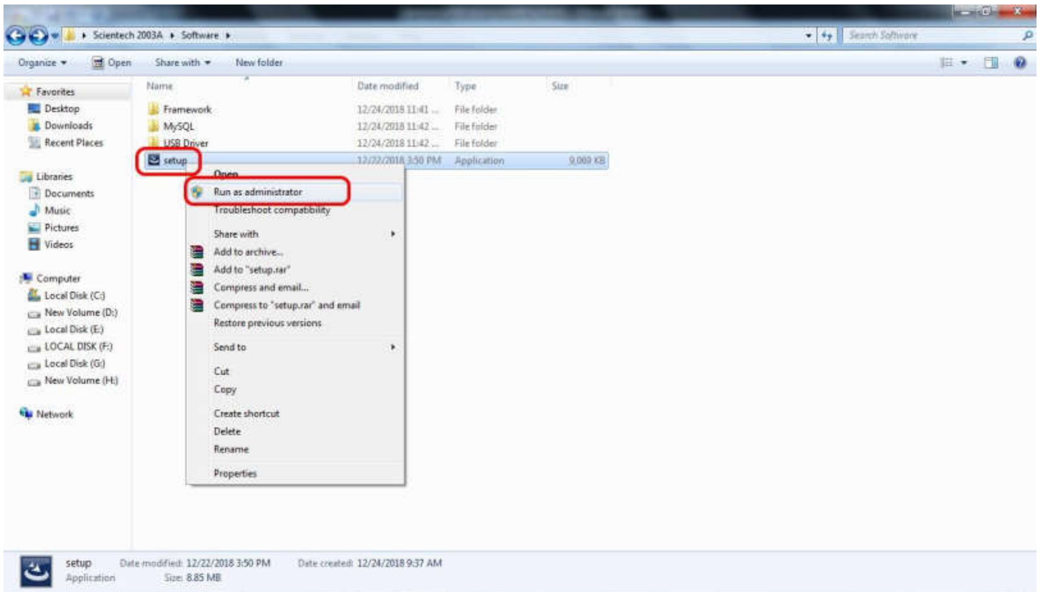
Step 18: Select a Destination Folder for MySQL Tools and click on Next tab shown below.

Step 19: Ready to Install the Program, click on Install tab shown below**.**

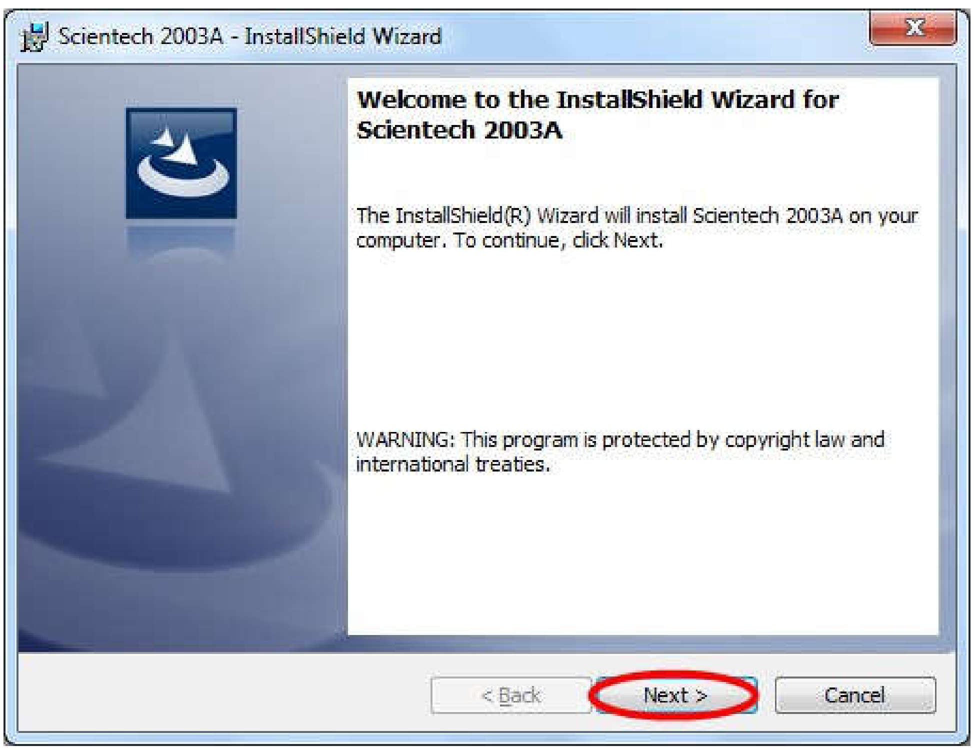
Step 20: MySQL Tools Setup will install completely then click on **Finish** tab.

Scientech 2003A Setup Installation

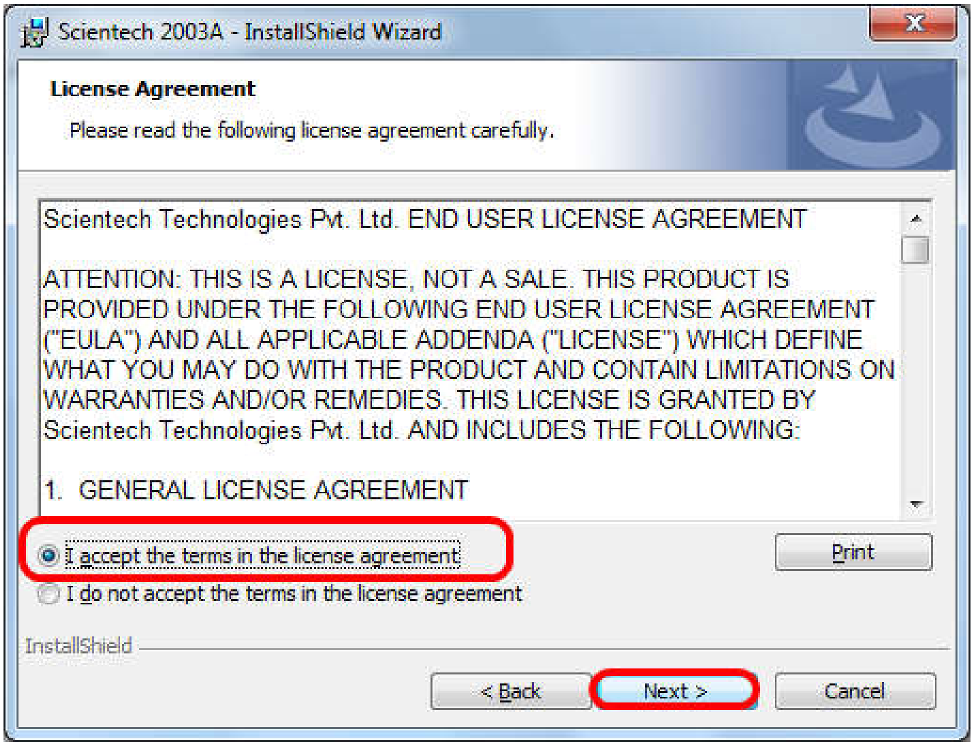
Step1: Double click on Scientech 2003A Setup.



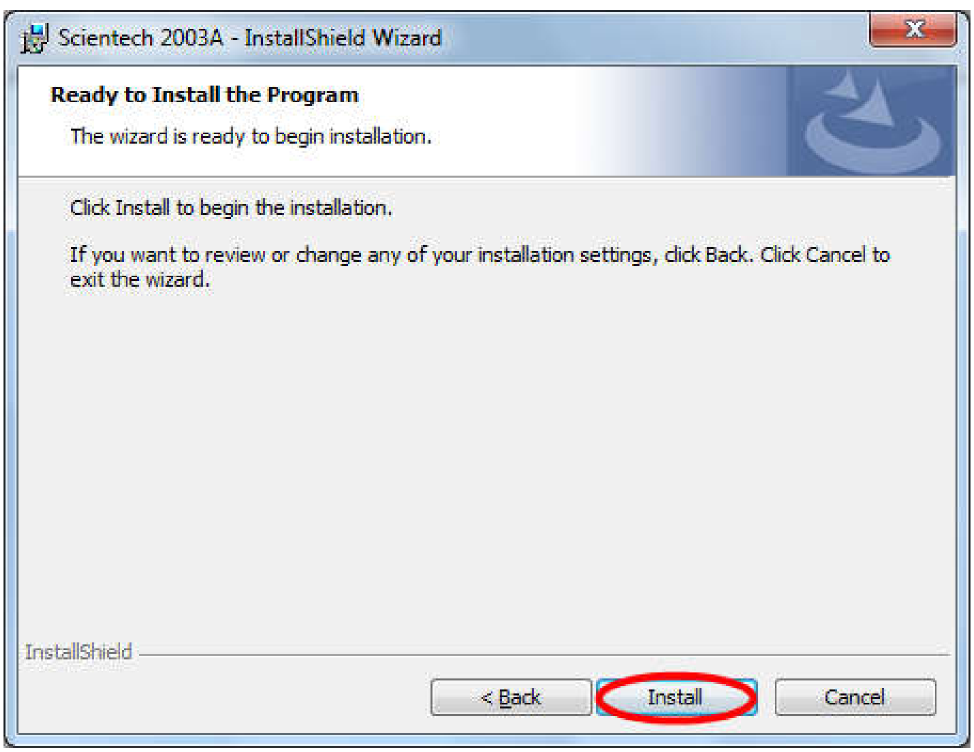
Step2: Click on Next tab shown below.



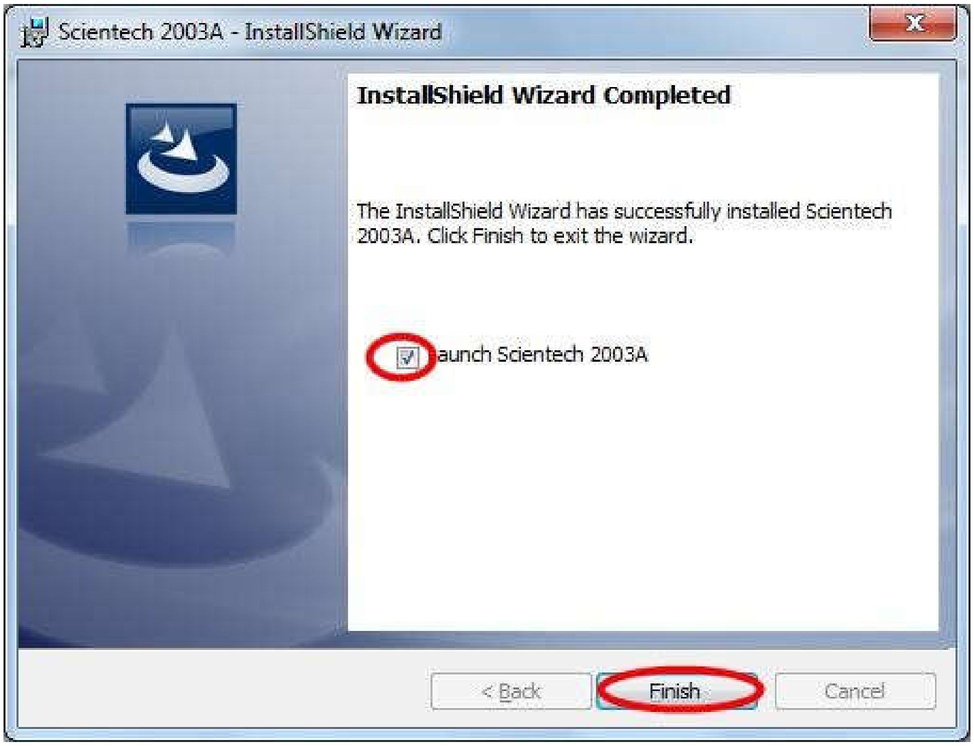
Step3: Accept the license agreement and click Next tab shown below.



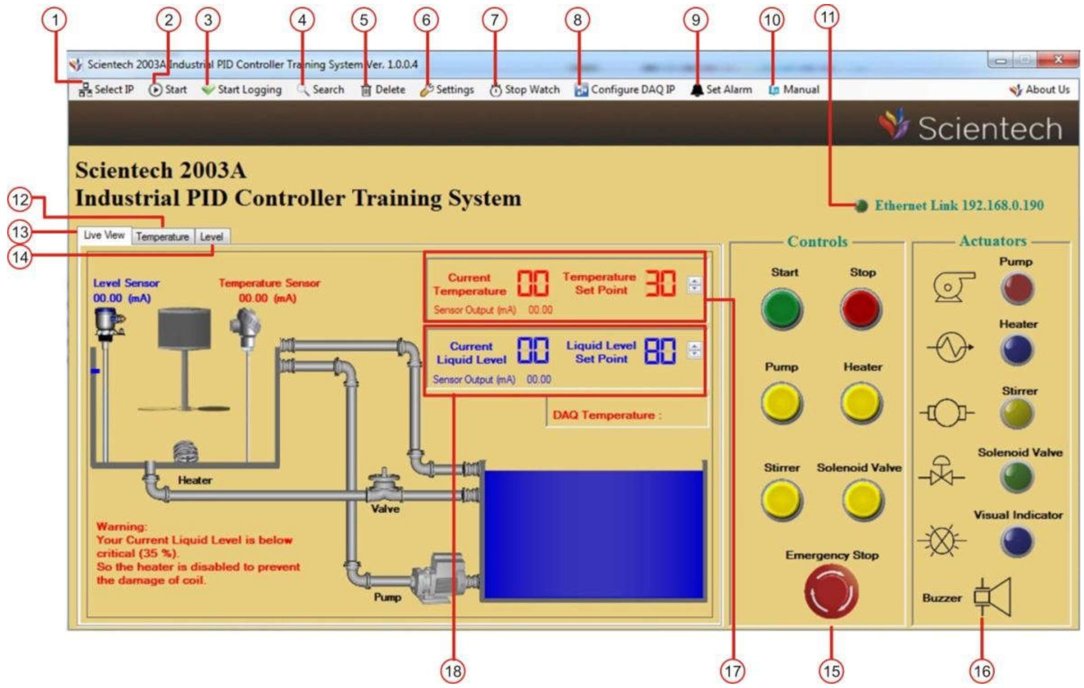
Step4: Click on Install tab. Installation gets start shown below.



Step5: Click on Finish tab shown below.

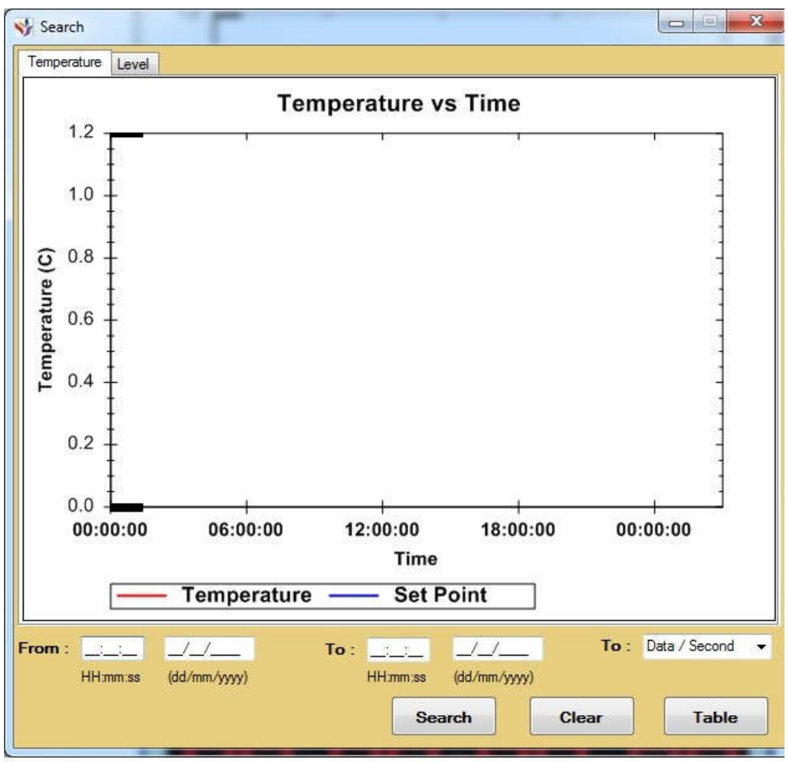


Scientech 2003A Software Detail

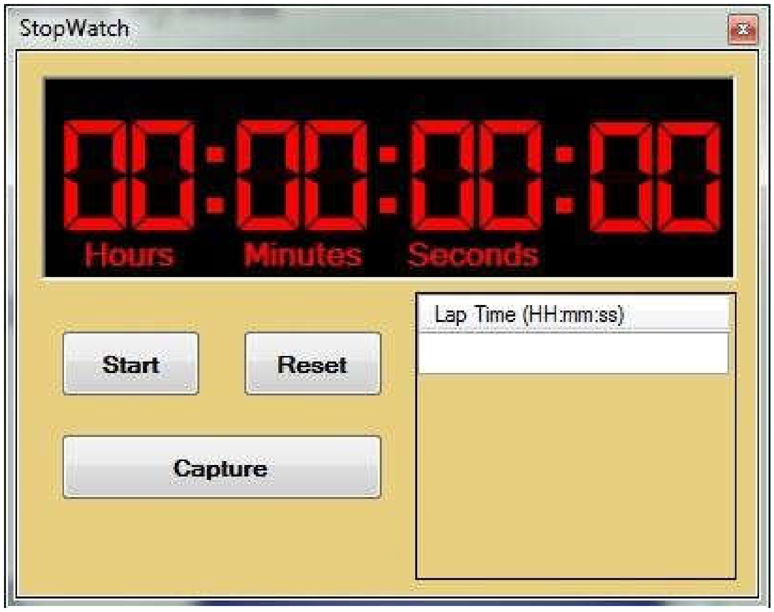


1. **Enter IP:** Enter IP Tab is used for Enter the IP of DAQ in software.

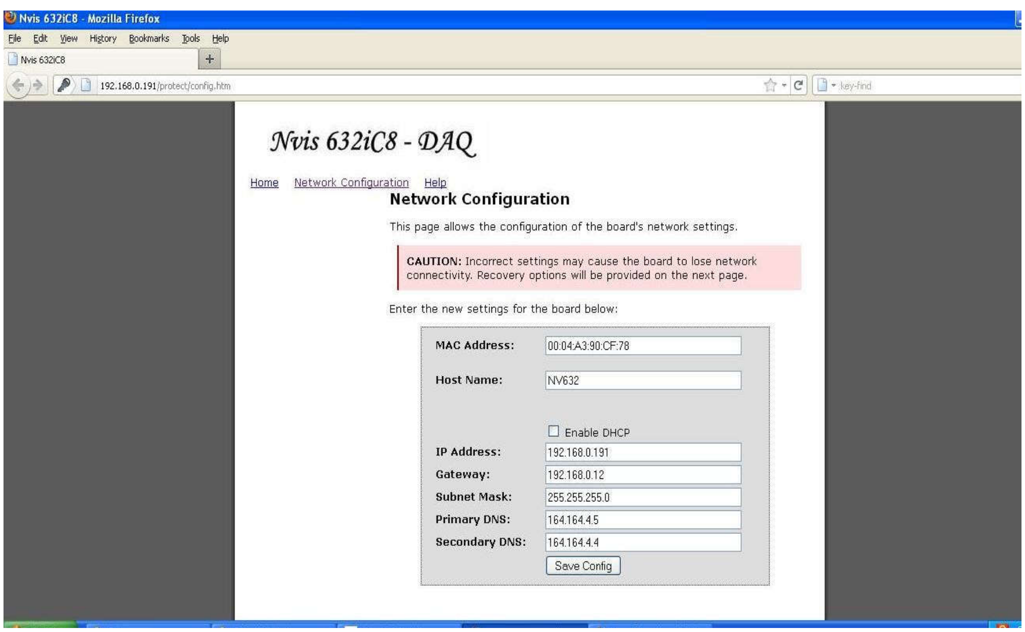
2. **Start:** Start tab is used for Start a DAQ.
3. **Start Logging:** This tab is used for logging of Data like Temperature and Level output graph.
4. **Search:** This tab is used for see the logging data.



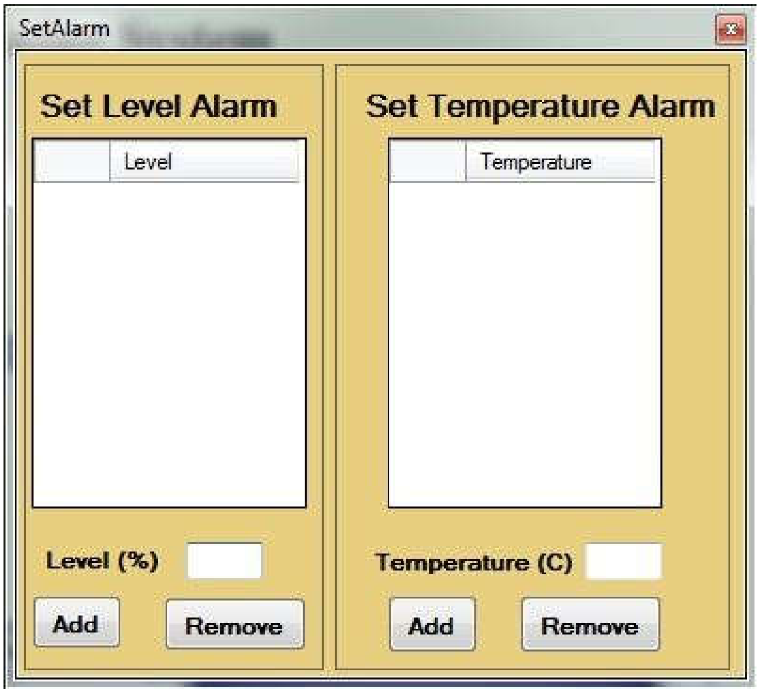
5. **Delete:** This tab is used for delete the logging data.
6. **Setting:** This tab is used for Selecting a Temperature PID & Level PID.
7. **Stop Watch:** This tab is used to see the time of Industrial PID Controller heating process.



8. **Configure IP:** If you want to Configure Scientech632i according to your network, you change the IP Address, Gateway, Subnet Mask, Primary DNS, and Secondary DNS according to your system network. If you configured Ethernet according to your system network is complete, click on to Save Configure button.



9. **Set Alarm:** This tab is used for set a alarm for Temperature and level at different set points.



10. **Manual:** When you click on ts the manual button then manual of Scientech 2003A will open.

11. **Ethernet Link:** This tab indicates whether the hardware is connected to LAN or not.

12. **Temperature:** This tab is used for see the graph between RTD Temperature and Time.

13. **Live View:** This tab is used for control and see a real time change in the Process.

14. **Level:** This tab is used for see the graph between water level % and Time.

Controls: This tab is used for control (like start, stop, Emergency Stop, Heater, pump, solenoid valve, Stirrer).

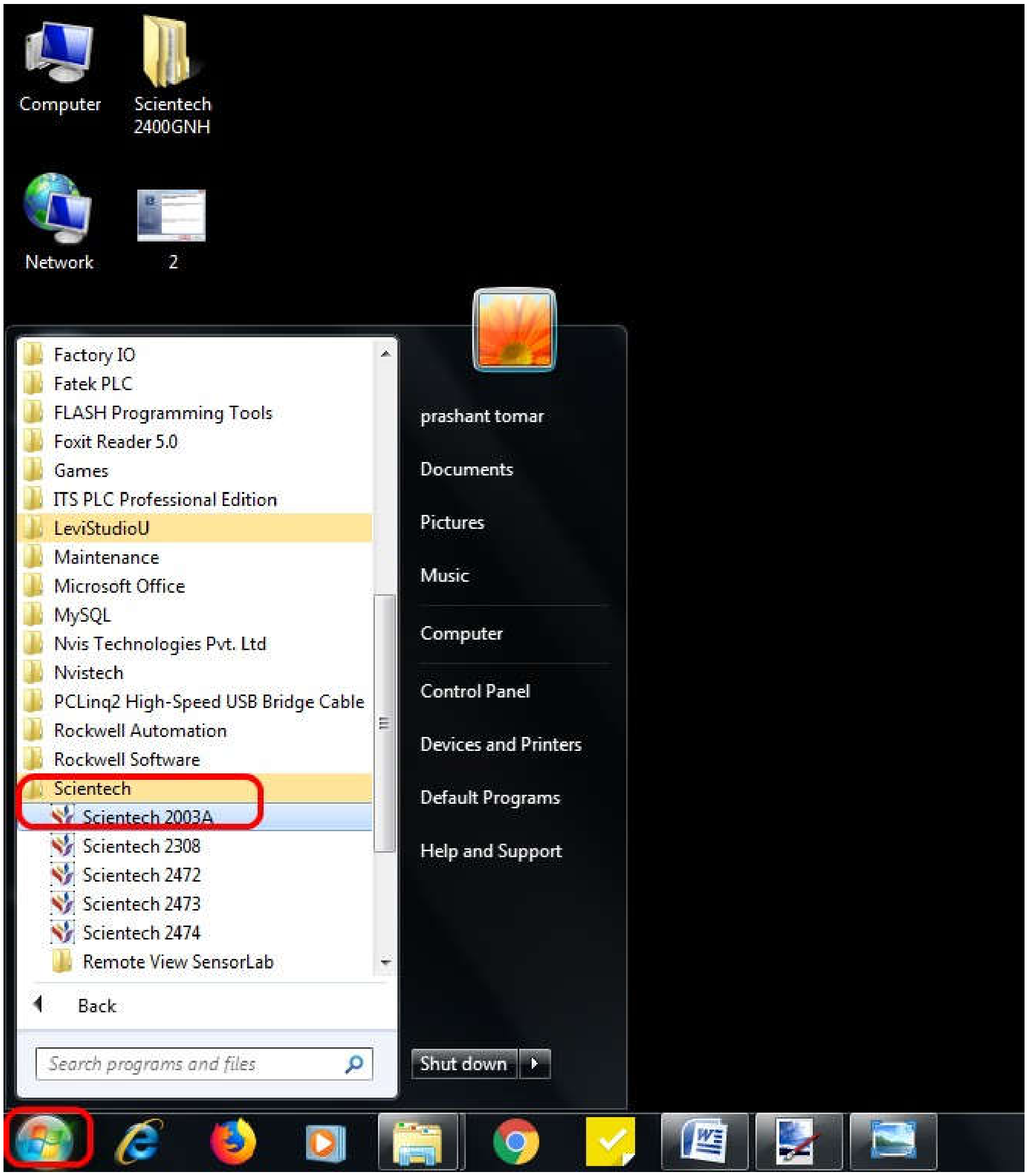
Actuator: This tab is used for see a status of Actuator (Pump , Heater , Stirrer , Solenoid valve, Visual Indicator, Audio Indicator)

Temperature: This tab is used for See a current temperature of RTD and set the setpoint for Temperature.

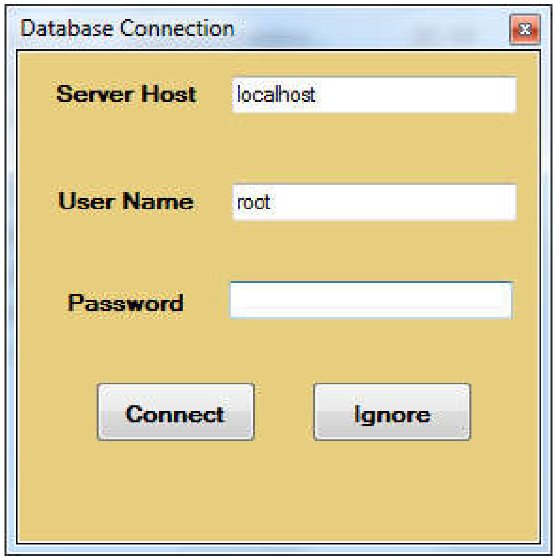
Level: This tab is used for see a current level of water and set the setpoint for Level.

How to open Scientech 2003A Software

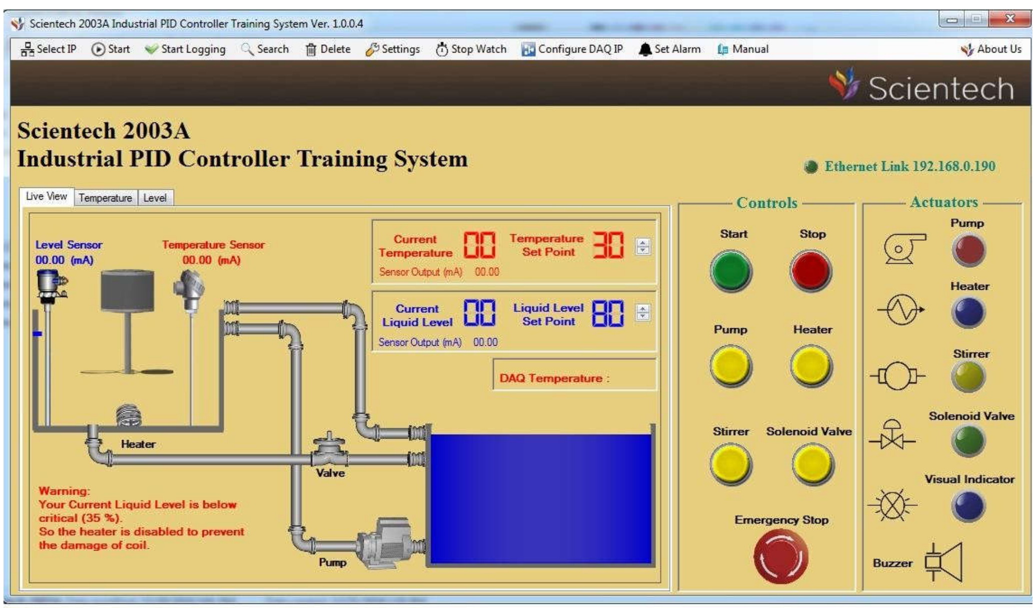
Step6: For open a Scientech 2003A software follow below given path.



Step7: After above step Database Connection window will open. Enter “root” in Password window and click on Connect window as shown below.

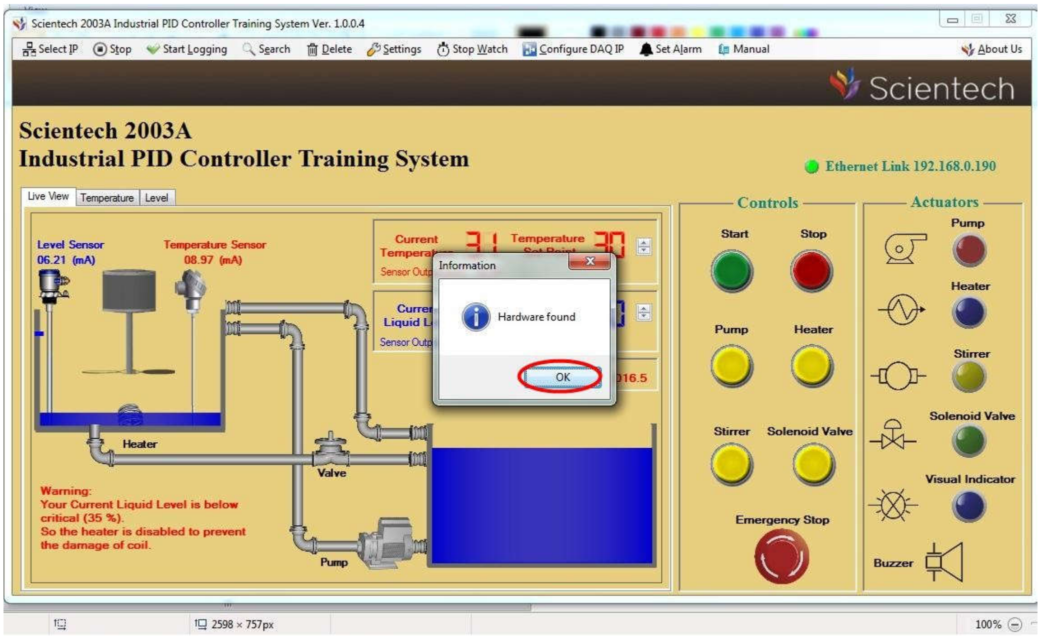


Step8: Scientech 2003A Software window will open as shown below.

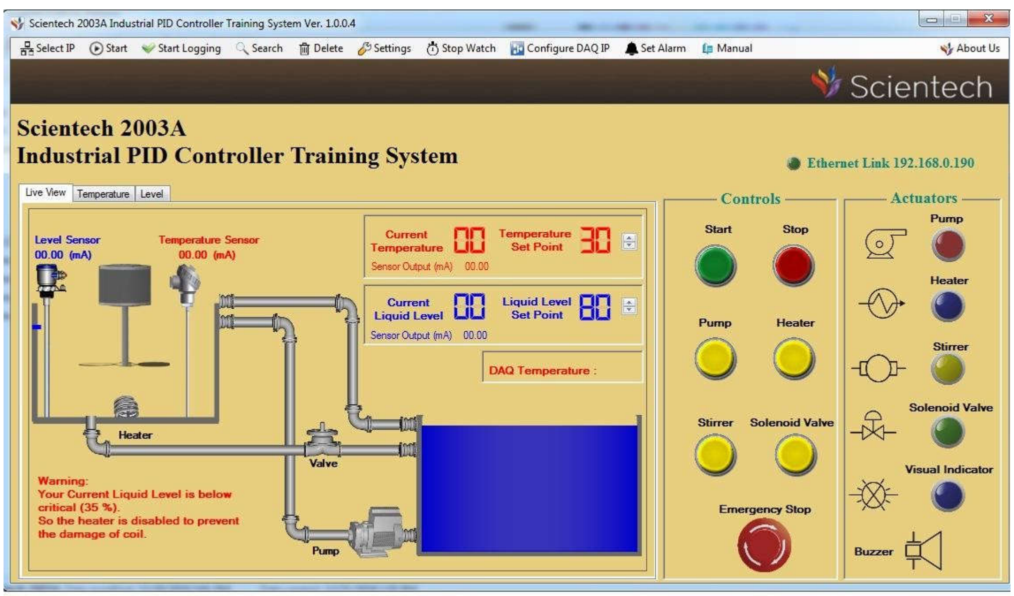


Step9: Enter the DAQ IP and click on OK tab as shown below.

Step10: Hardware Found" message will comes then click on "OK" Tab as shown below.



Step11: After above step this window will be open as shown below.



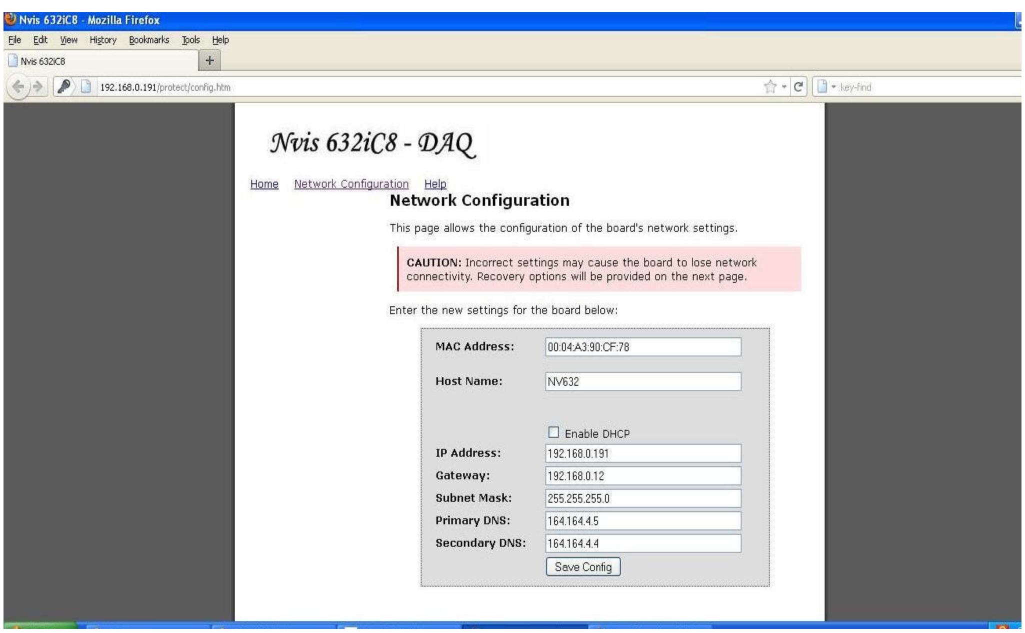
Step12: When you click on to the Config. DAQ button Authentication Required window will open.

Step13: Enter User Name " admin" and Password "stpl" and click on OK Button is shown below.

Step 14: After above step Scientech632i – DAQ window will be open. Please do not change the Mac Address and Host Name. If you want to Configure Scientech632i according to your network, you change the IP Address, Gateway, Subnet Mask, Primary DNS, and Secondary DNS according to your system network. If you configured Ethernet according to your system network is complete, click on to Save Configure button.

Note: If user want to reset all Network Configuration into default Configuration.

Please press reset switch and restart DAQ, release switch after 10 second.



Addressing Detail

DAQ Input Addressing Detail

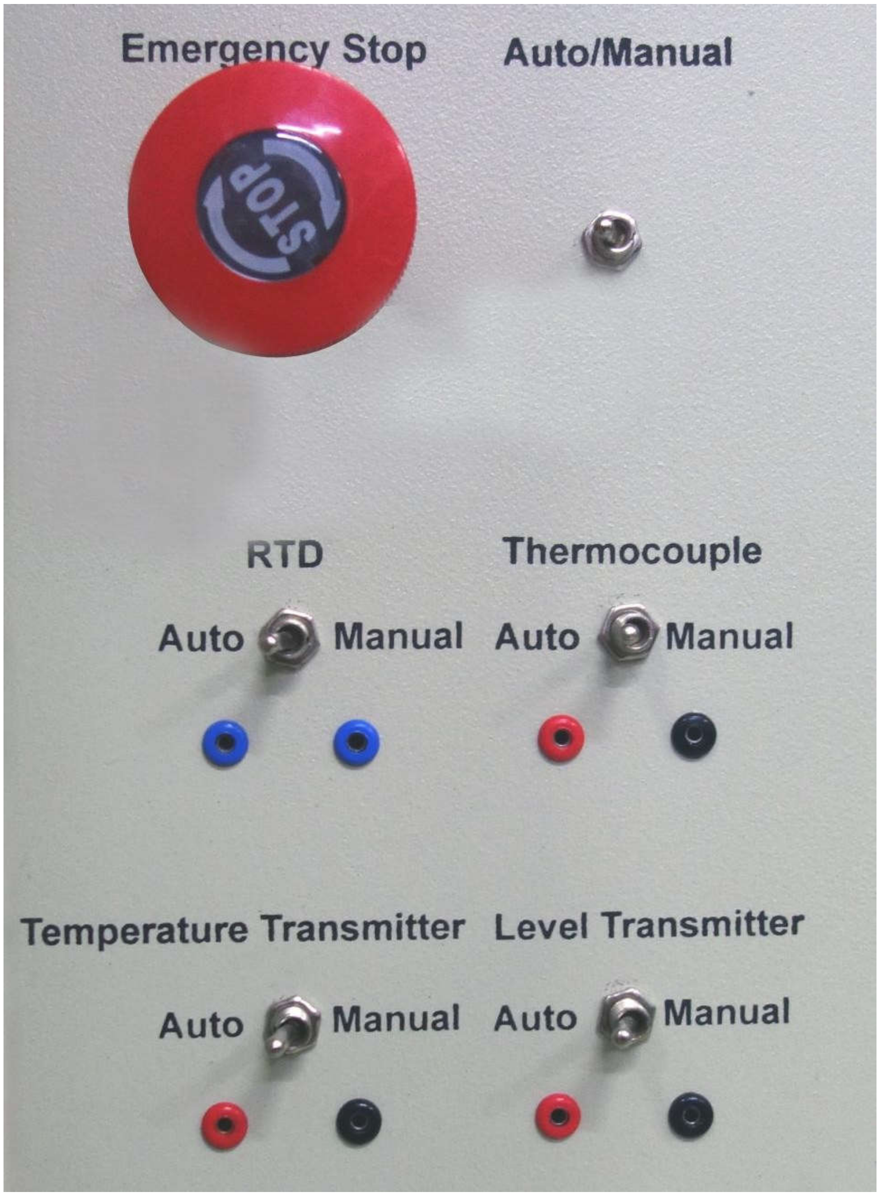
Ferrule no.	DAQ Input Addressing	Component
0	X0 (Digital Input_1)	Start Button
1	X1 (Digital Input_2)	Stop Button
2	X2 (Digital Input_3)	Pump Button
3	X3 (Digital Input_4)	Heater Button
4	X4 (Digital Input_5)	Stirrer Button
5	X5 (Digital Input_6)	Solenoid Valve Button
6	X6 (Digital Input_7)	Emergency Stop Button

DAQ Output Addressing Detail

Ferrule No.	DAQ Output Addressing	Component
10	Y0 (Digital Output_1)	Pump & Its indicator
11	Y1 (Digital Output_2)	Heater Indicator
12	Y2 (Digital Output_3)	Stirrer Indicator
13	Y3 (Digital Output_4)	Solenoid Valve & Its indicator
14	Y4 (Digital Output_5)	Visual Indicator
15	Y5 (Digital Output_6)	Audio Indicator
16	Y6 (Digital Output_7)	Stirrer
17	Y7 (Digital Output_8)	Heater

Switch Setting for PID Experiment

Note1: When you perform PID Experiment please keep all toggle switches at below given position.



Switch Setting for DAQ Experiment

Note1: When you perform DAQ Experiment please keep all toggle switches at below given position.

Note: Before Starting a experiment Fill the Measuring tank to 35%

Experiment 1

Objective: Study of P- control action using the software for Temperature.

Equipments Needed:

- **Scientech 2003A Industrial PID Controller Training System**
- **Scientech 2003A Software V1.1**
- Ethernet Cable
- Mains cord

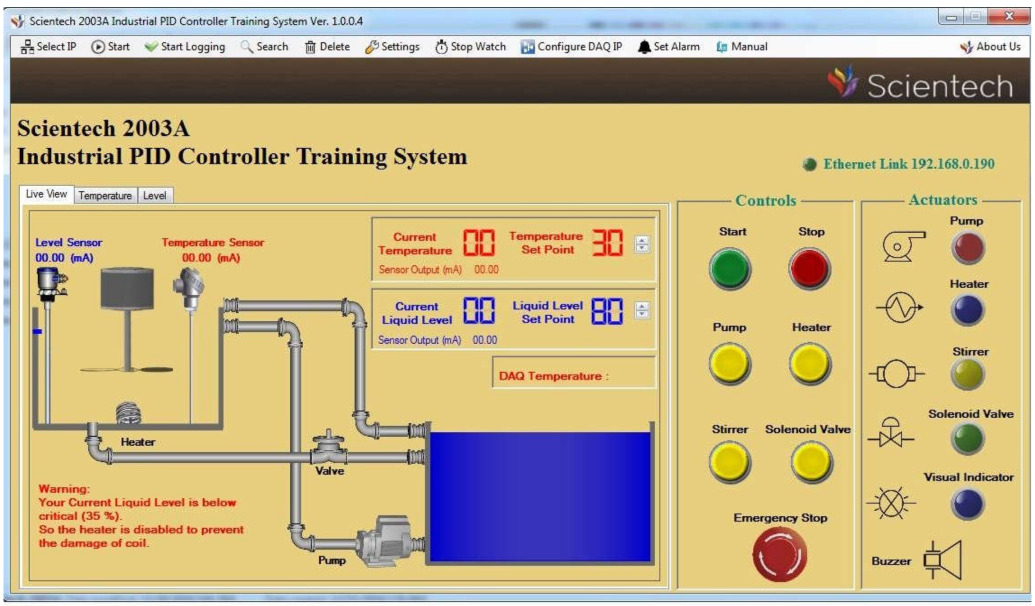
Note: Before Starting a experiment Fill the Measuring tank to 35%.

Procedure:

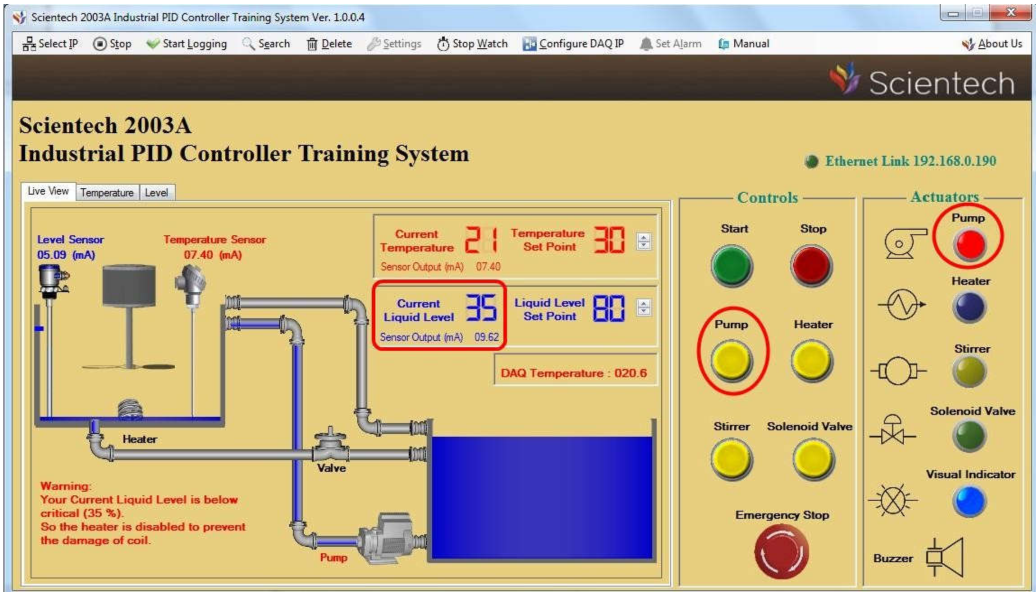
- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below

- Open the Scientech 2003A Software , **select IP** and click on **Start tab**.
- **“Hardware Found”** message will comes then click on “**OK”** Tab as shown below.

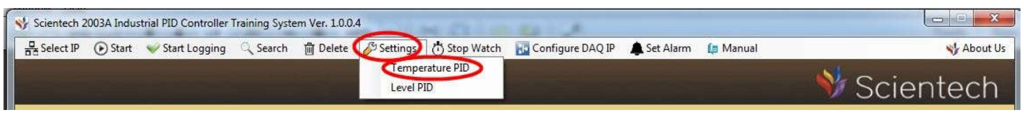
- After above step this window will be open as shown below.



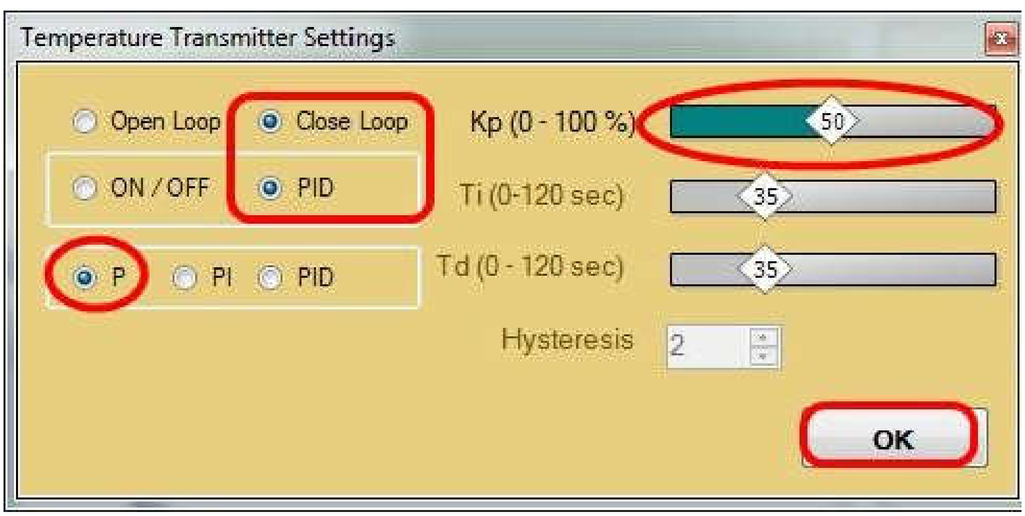
- Before Starting a experiment Fill the Measuring tank to 35%. Press or Click on (**Start tab (X0)** then **Visual Indicator (Y4)** will be 'ON'. **Pump tab (X2)** and see the Level Sensor reading on Scientech 2003A Software. When Level Sensor Reading is 35% then you again click or press on **Stop tab (X1)** or **Pump tab (X3)** for Stop a Pump.



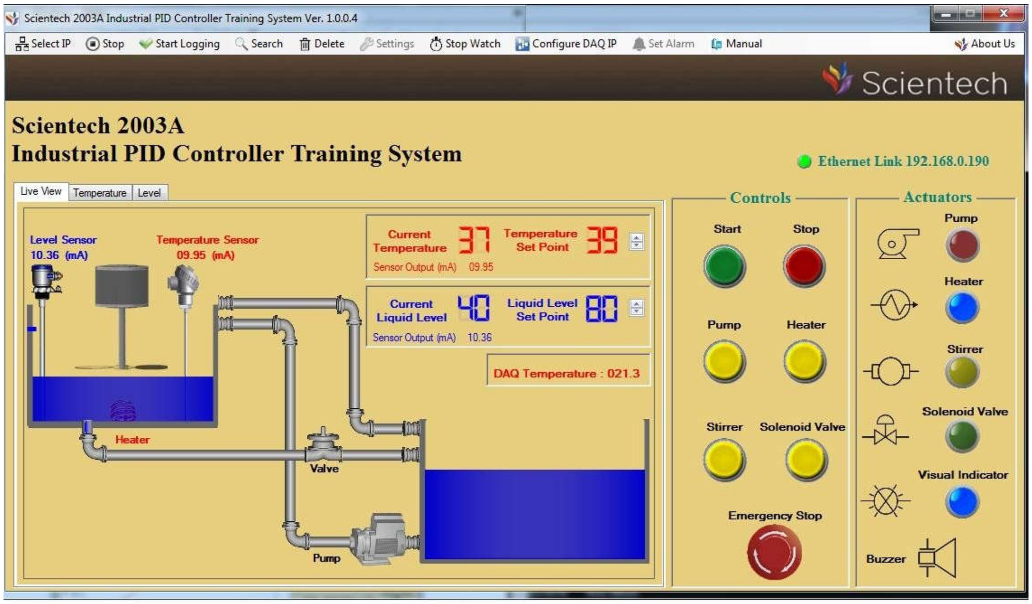
- Go to Menu bar and click on Setting tab then Temperature PID and Level PID tab will be open . Click on Temperature PID tab as shown below.



- When you Click on Temperature PID option then Temperature Transmitter Setting Window will open. You click on to Close loop>P>Select Hysterisis >OK as shown below

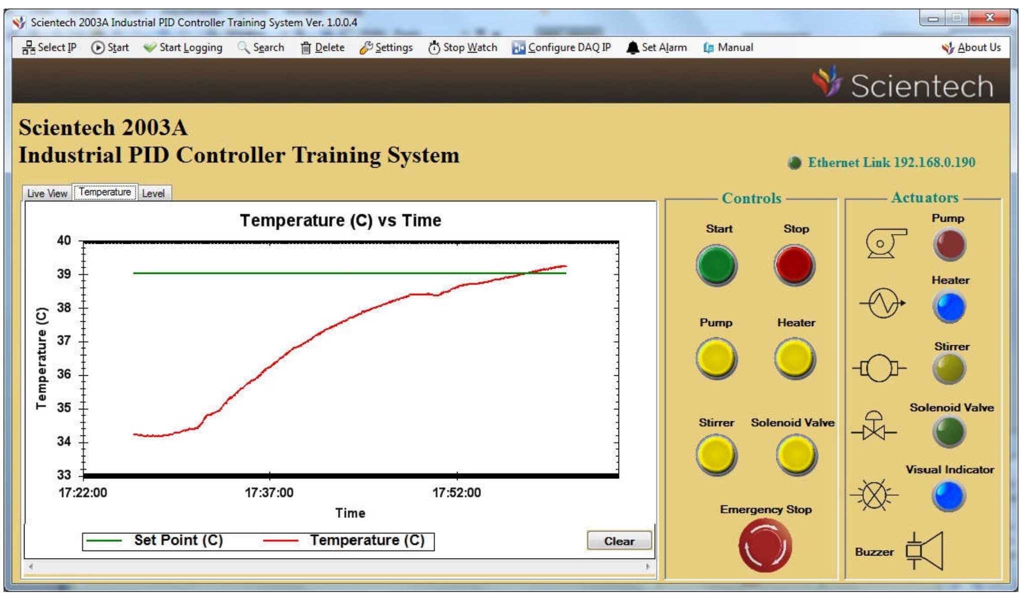


- Set the Set point of On/Off Controller as shown below . Click on Start TAB (X0) . When the set point is below the Current temperature then Heater (Y1) will be 'ON' as shown below.



- When temperature reach its set point then Heater (Y1) will be off after some time.

- If you want to see a graph between RTD Temperature Vs Time , click on Temperature TAB as shown below.



Experiment 2

Objective: Study of PI-control action using the software for Temperature.

Equipments Needed:

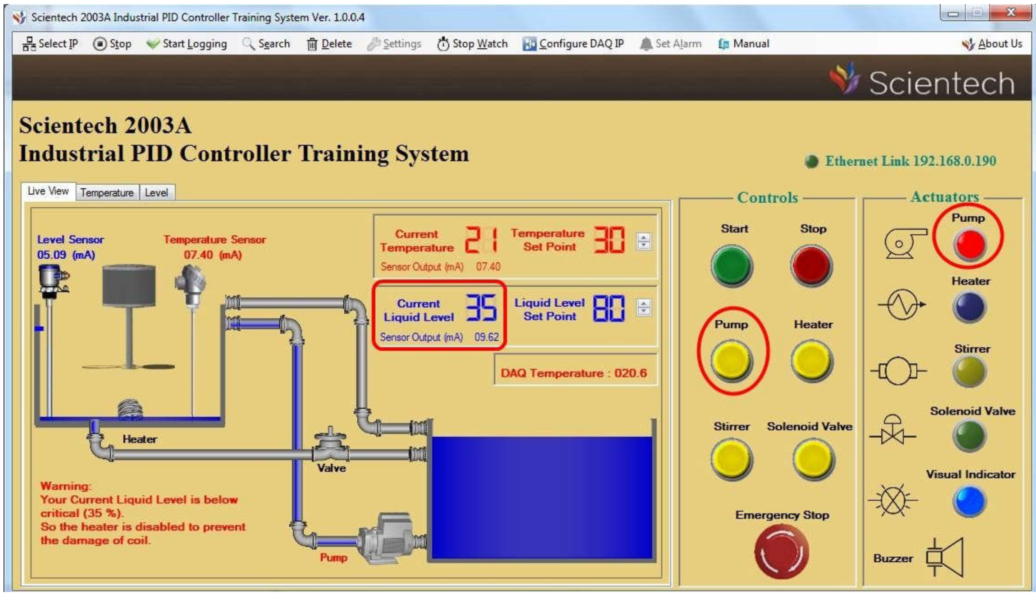
- Scientech 2003A Industrial PID Controller Training System
- Scientech 2003A Software V1.1
- Ethernet Cable
- Mains cord

Note: Before Starting a experiment Fill the Measuring tank to 35%.

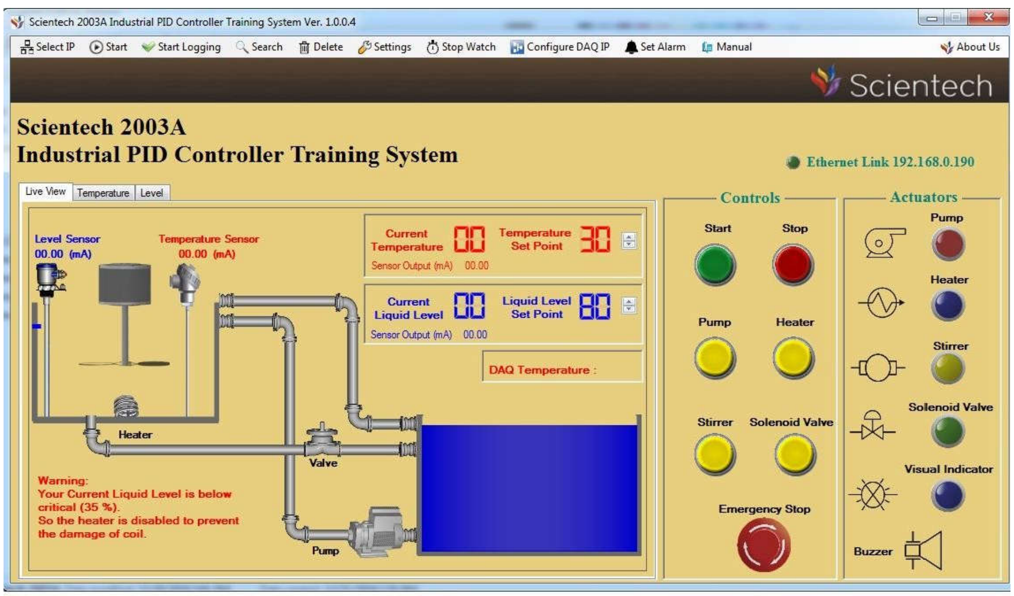
Procedure:

- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below

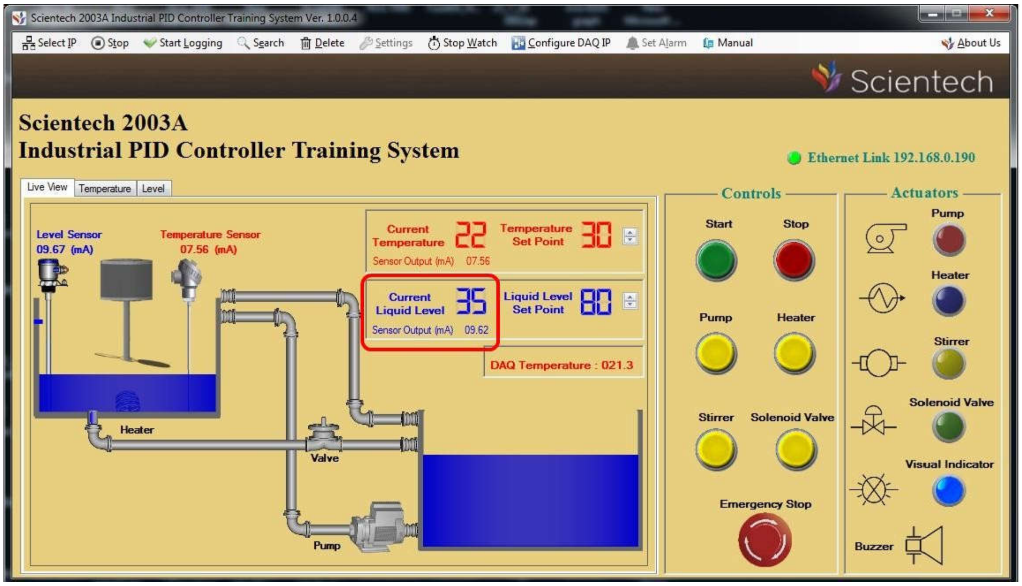
- Open the Scientech 2003A Software , select IP and click on Start tab.
- “Hardware Found” message will comes then click on “OK” Tab as shown below.



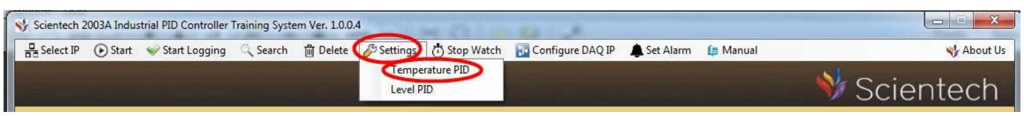
- After above step this window will be open as shown below.



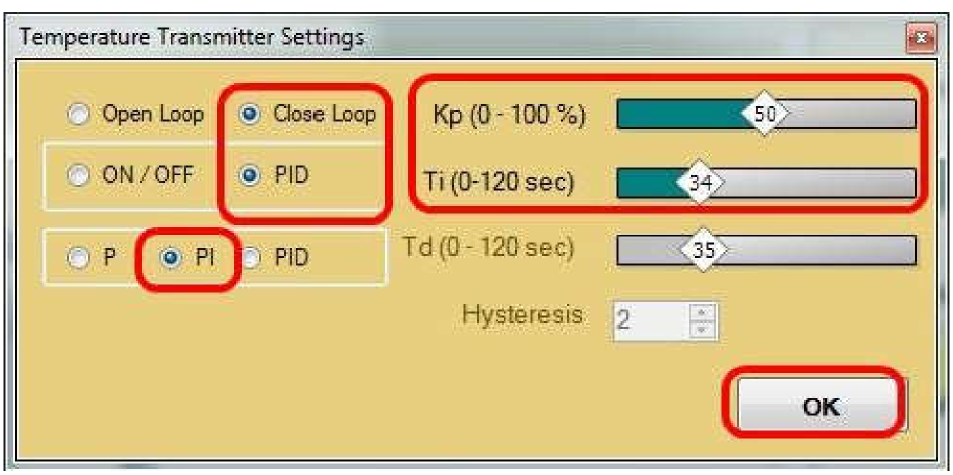
- Before Starting a experiment Fill the Measuring tank to 35%. Press or Click on (**Start tab (X0)** then **Visual Indicator (Y4)** will be 'ON'. **Pump tab (X2)** and see the Level Sensor reading on Scientech 2003A Software. When Level Sensor Reading is 35% then you again click or press on **Stop tab (X1)** or **Pump tab (X3)** for Stop a Pump.

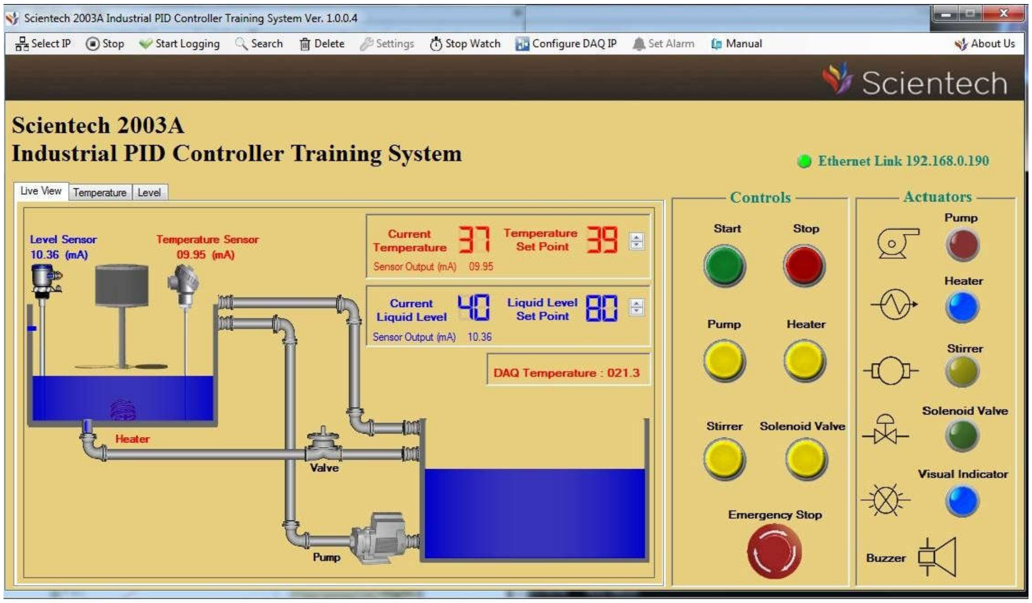


- Go to Menu bar and click on Setting tab then Temperature PID and Level PID tab will be open . Click on Temperature PID tab as shown below.

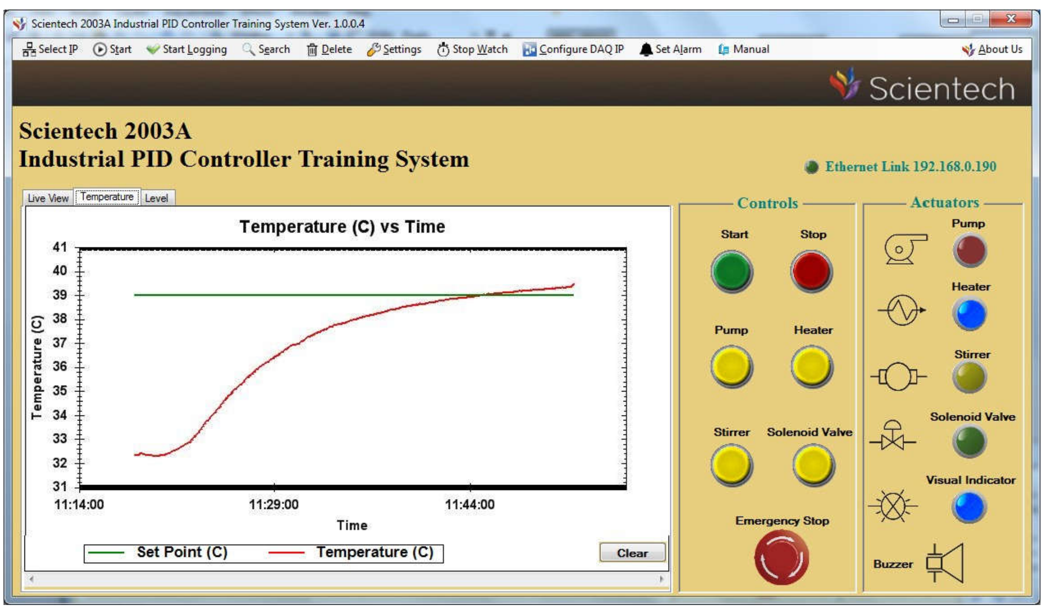


- When you Click on Temperature PID option then Temperature Transmitter Setting Window will open. You click on to Close loop>PI>Select Hysterisis >**OK** as shown below





- Set the Set point of On/Off Controller as shown below . Click on Start TAB (X0) . When the set point is below the Current temperature then Heater (Y1) will be 'ON' as shown below.
- When current temperature is reach the set point then heater will be off after some time.



- If you want to see the graph between RTD Temperature Vs Time click on Temperature tab.

Experiment 3

Objective: Study of PID - control action using the software for Temperature.

Equipments Needed:

- Scientech 2003A Industrial PID Controller Training System
- Scientech 2003A Software V1.1
- Ethernet Cable
- Mains cord

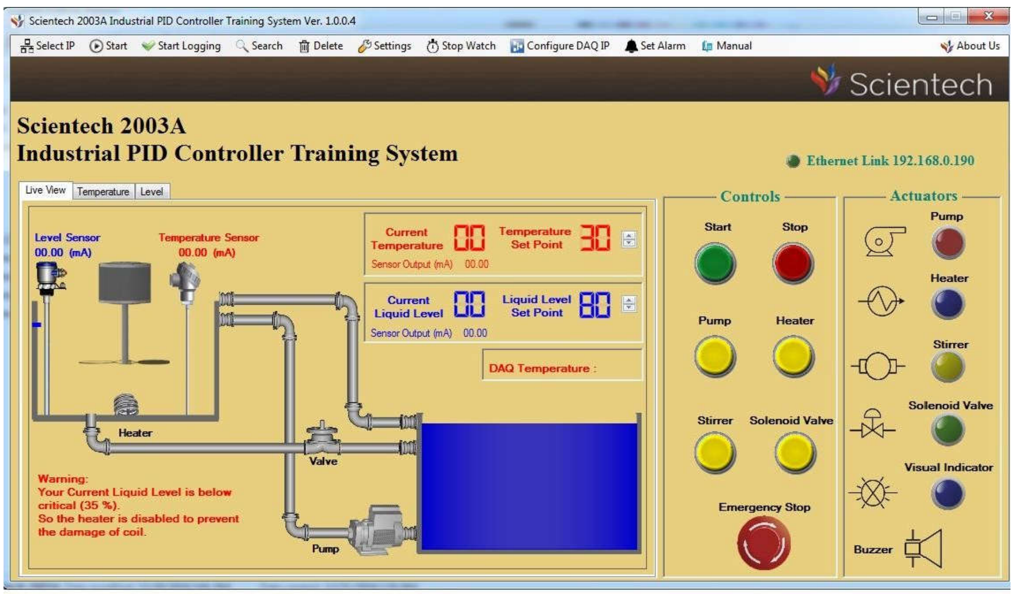
Note: Before Starting a experiment Fill the Measuring tank to 35%.

Procedure:

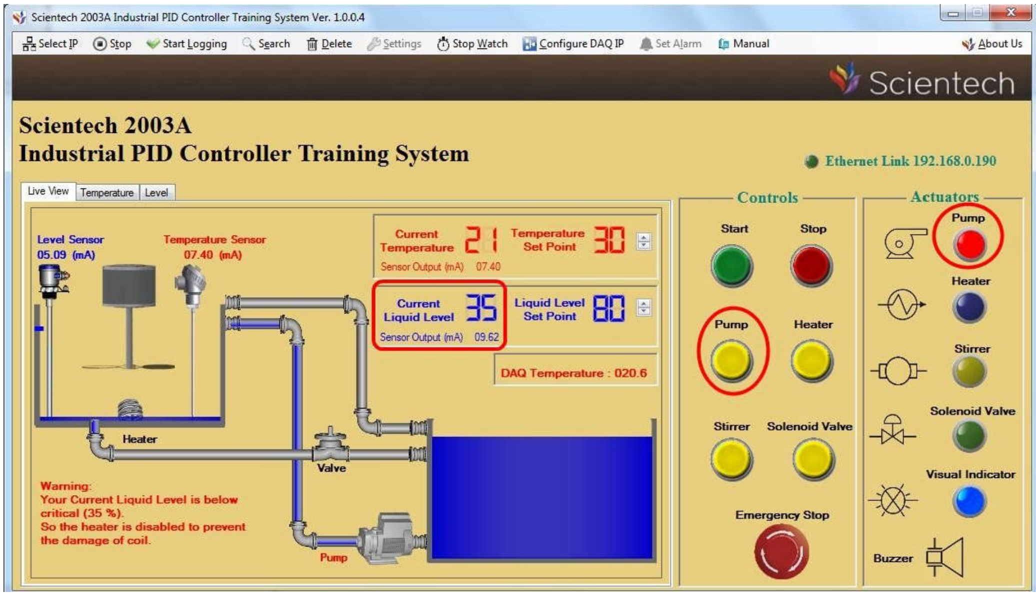
- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below

- Open the Scientech 2003A Software , select IP and click on Start tab.
- “Hardware Found” message will comes then click on “OK” Tab as shown below.

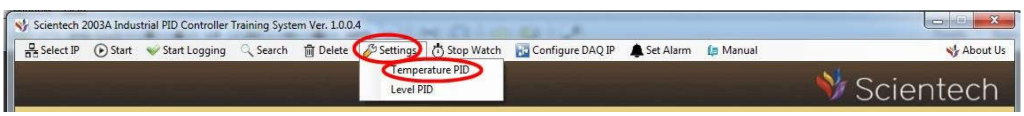
- After above step this window will be open as shown below.



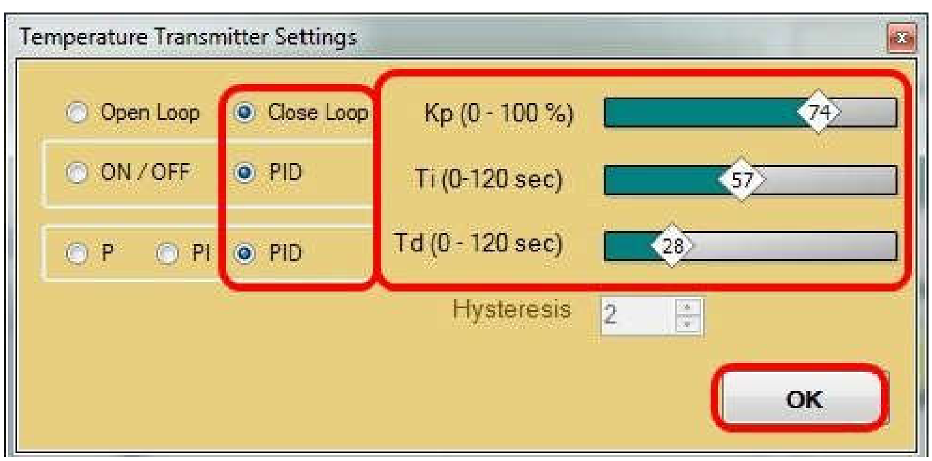
- Before Starting a experiment Fill the Measuring tank to 35%. Press or Click on (Start tab (X0) then Visual Indicator (Y4) will be 'ON'. Pump tab (X2) and see the Level Sensor reading on Scientech 2003A Software. When Level Sensor Reading is 35% then you again click or press on Stop tab (X1) or Pump tab (X3) for Stop a Pump.

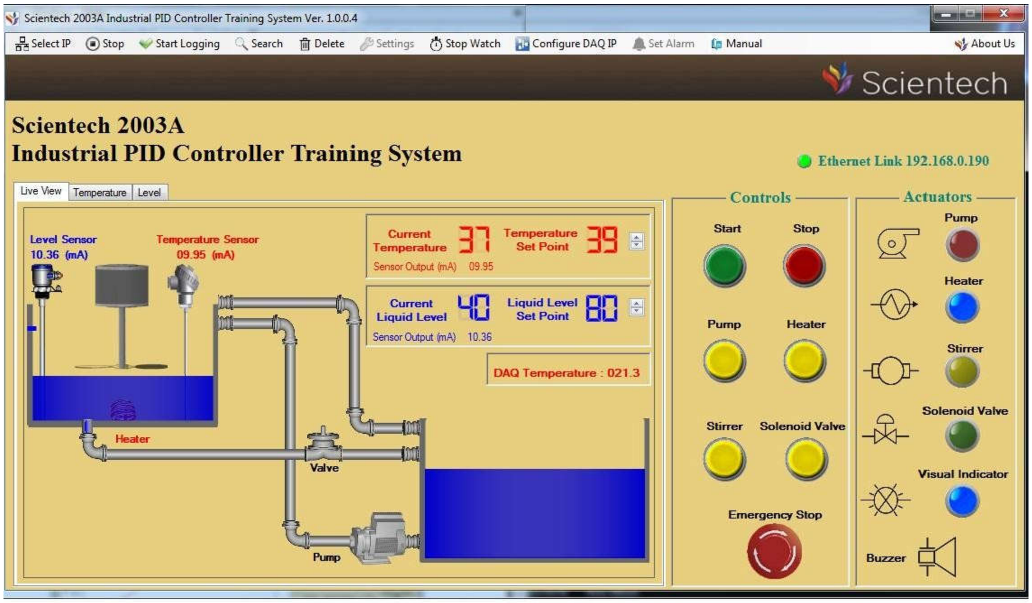


- Go to Menu bar and click on Setting tab then Temperature PID and Level PID tab will be open . Click on Temperature PID tab as shown below.

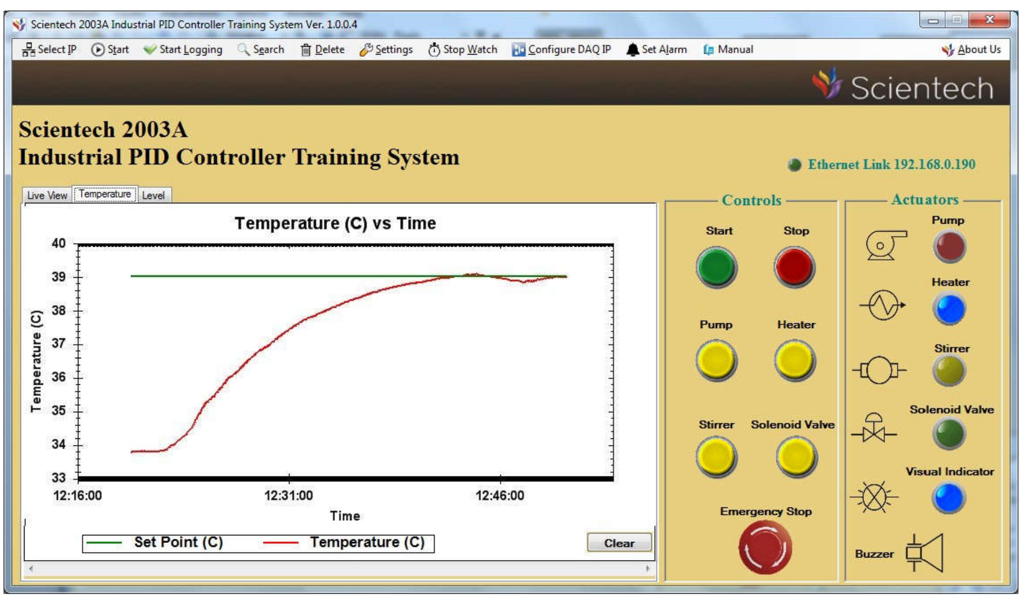


- When you Click on Temperature PID option then Temperature Transmitter Setting Window will open. You click on to Close loop>PID>Select Hysterisis >OK as shown below





- Set the Set point of On/Off Controller as shown below . Click on Start TAB (X0). When the set point is below the Current temperature then Heater (Y1) will be 'ON' as shown below.
- When current temperature is reach the set point then heater will be off after some time.
- If you want to see the graph between RTD Temperature Vs Time click on Temperature tab.



Experiment 4

Objective: Study and use of Level P Control action using Software.

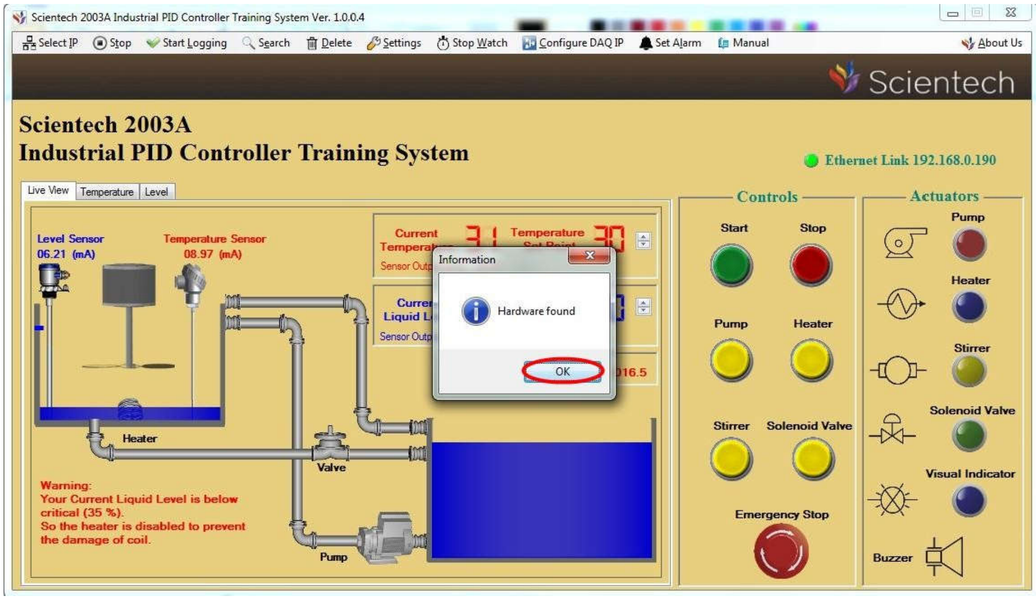
Equipments Needed:

- Scientech 2003A Industrial PID Controller Training System
- Scientech 2003A Software V1.1
- Ethernet Cable
- Mains cord

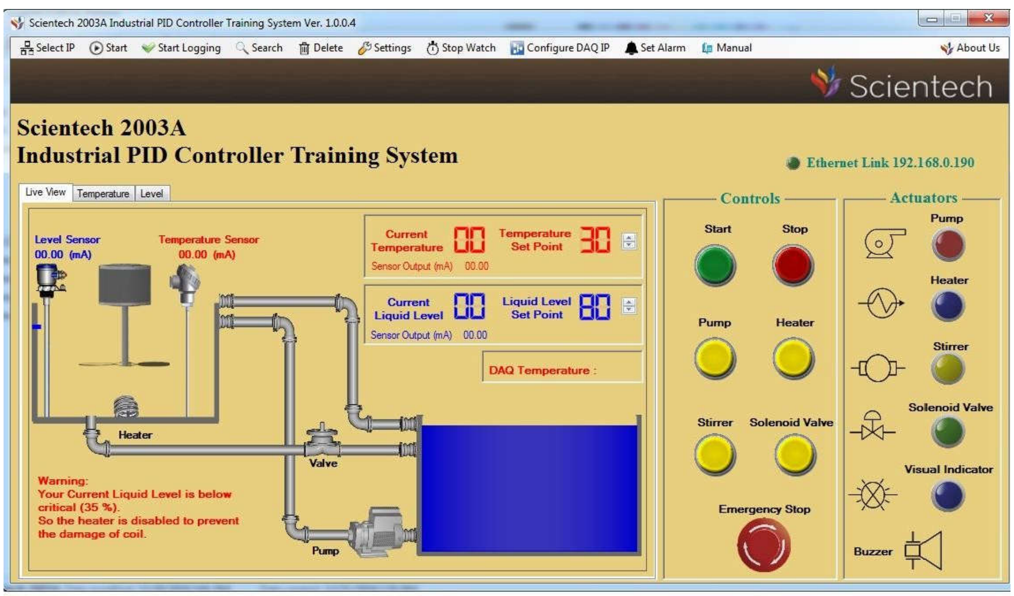
Procedure:

- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below.

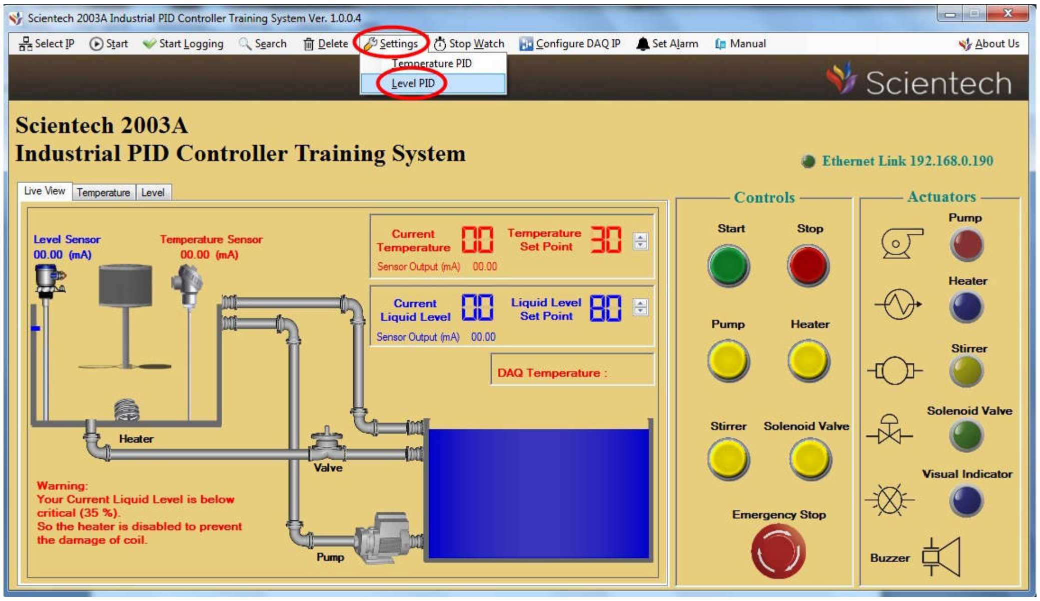
- Open the Scientech 2003A Software , Select IP and click on Start tab.
- “Hardware Found” message will comes then click on “OK” Tab as shown below.



- After above step this window will be open as shown below.

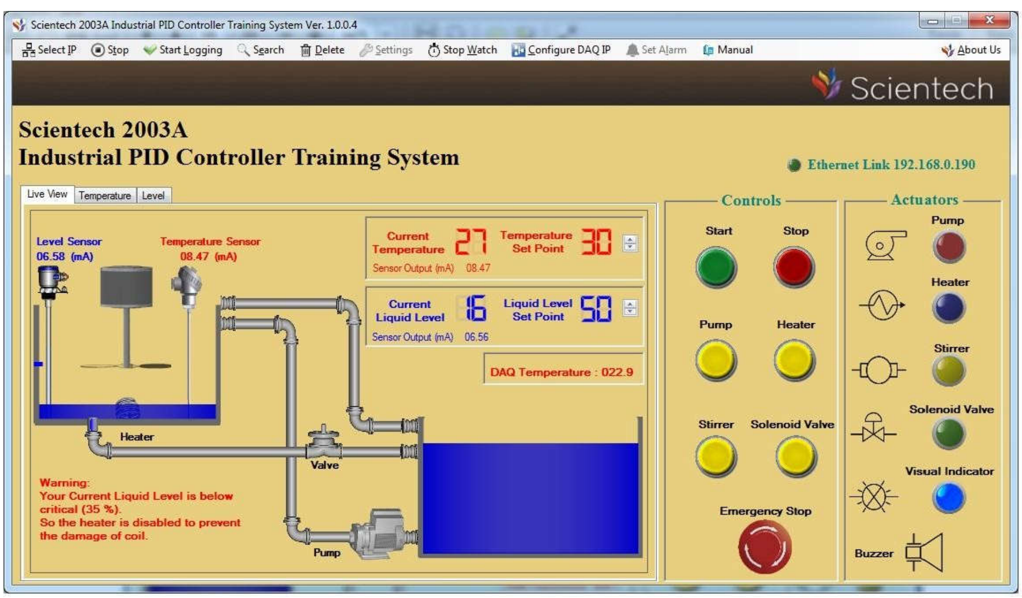


- Go to **Setting** TAB (in menu bar) then click on Level PID tab as shown below.

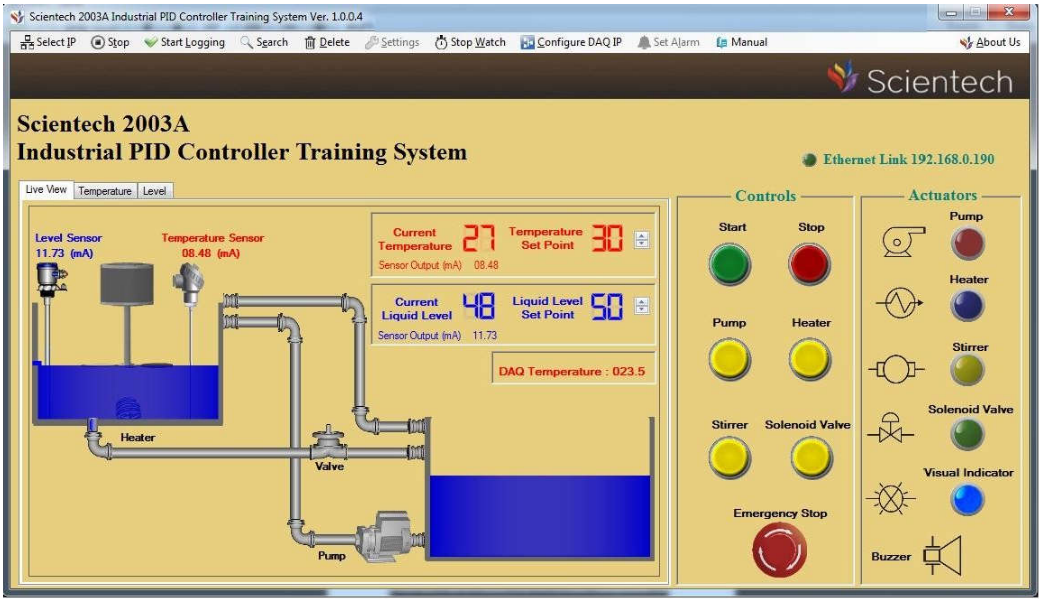


- Level Transmitter Setting window will open then Click on Open Loop check box and click on OK tab as shown below.

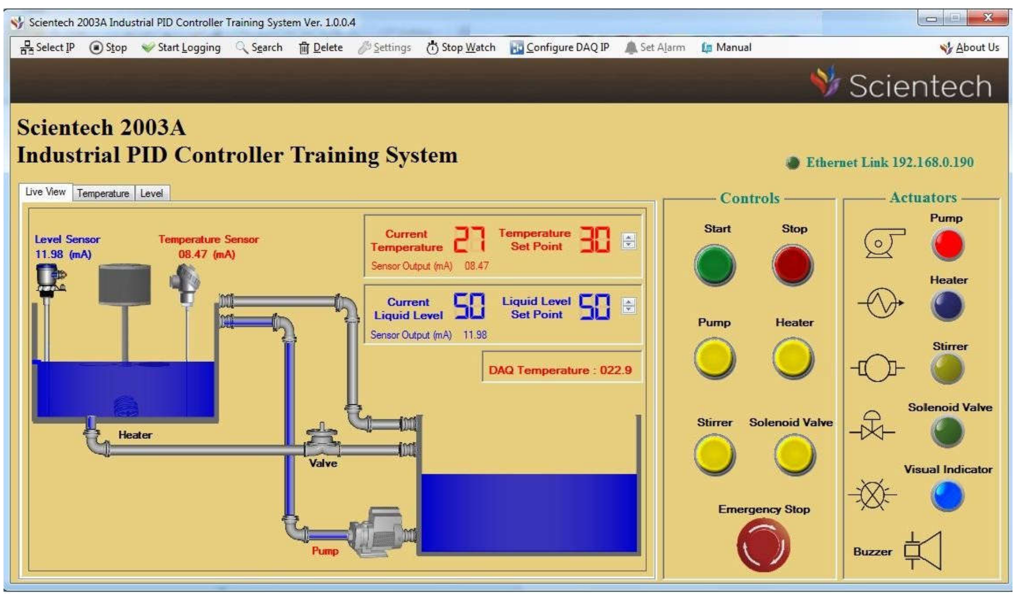
- Set the set point using UP/Down TAB.



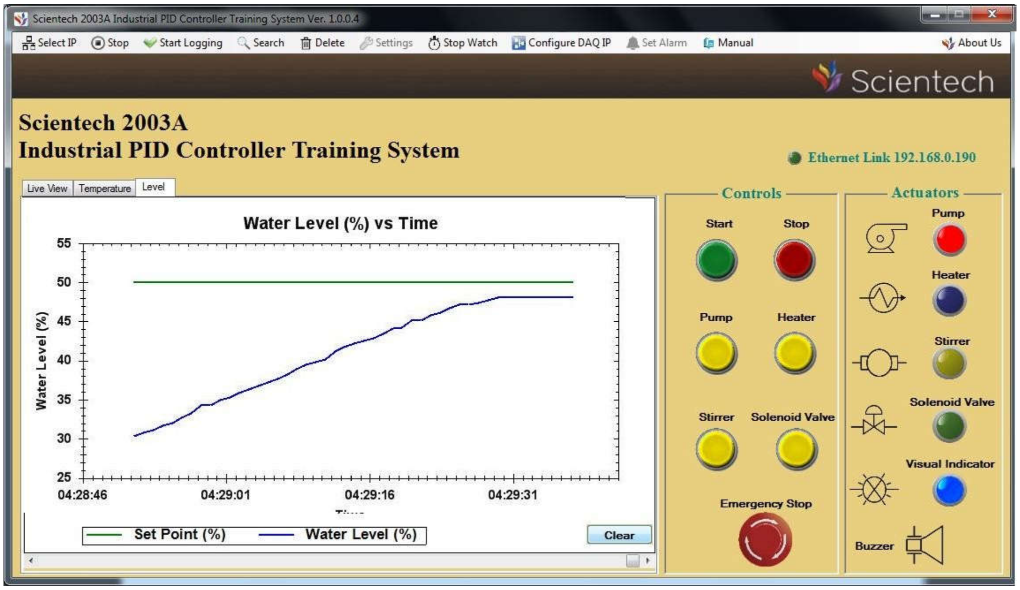
- When you click or press Start TAB (X0) then Pump (Y0) will be 'ON'. When pump will be on then level of water in measuring tank will increase as shown below.



- When Current liquid level is reach the set point then pump (Y0) will be 'OFF' as shown below.



- If you want to see a graph between Water level % Vs Time , click on Level TAB.



Experiment 5

Objective: Study and use of Level PI Control action using Software.

Equipments Needed:

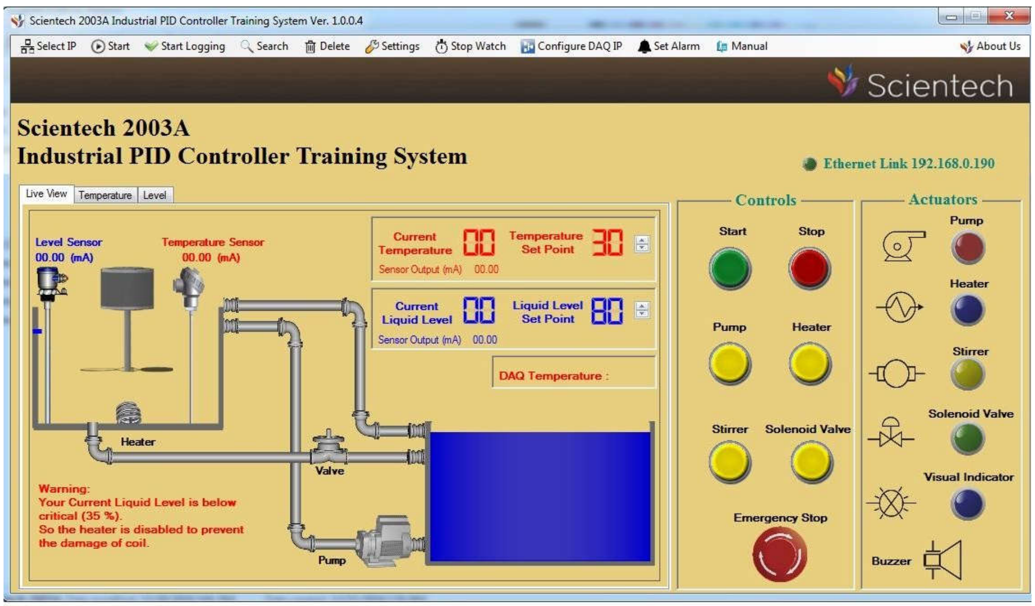
- Scientech 2003A Industrial PID Controller Training System
- Scientech 2003A Software V1.1
- Ethernet Cable
- Mains cord

Procedure:

- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below

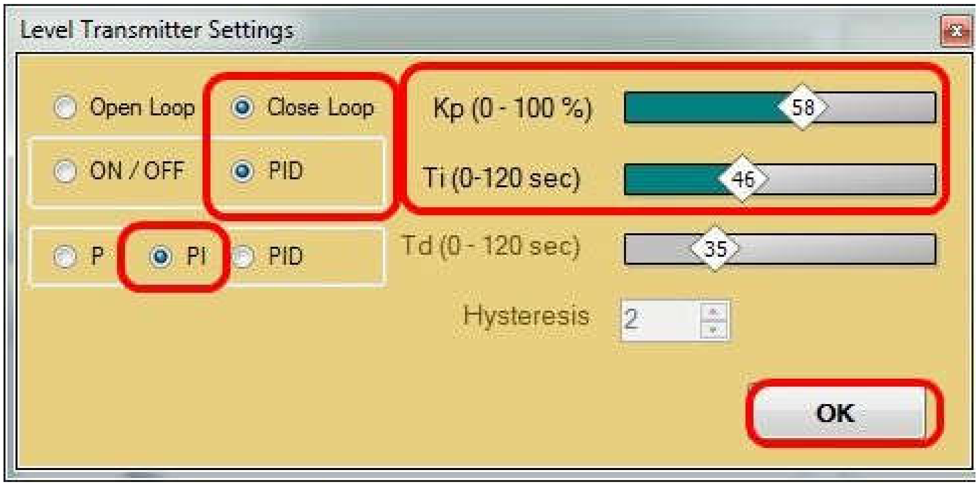
- Open the Scientech 2003A Software, Select IP and click on Start tab.
- “Hardware Found” message will comes then click on “OK” Tab as shown below.

- After above step this window will be open as shown below.

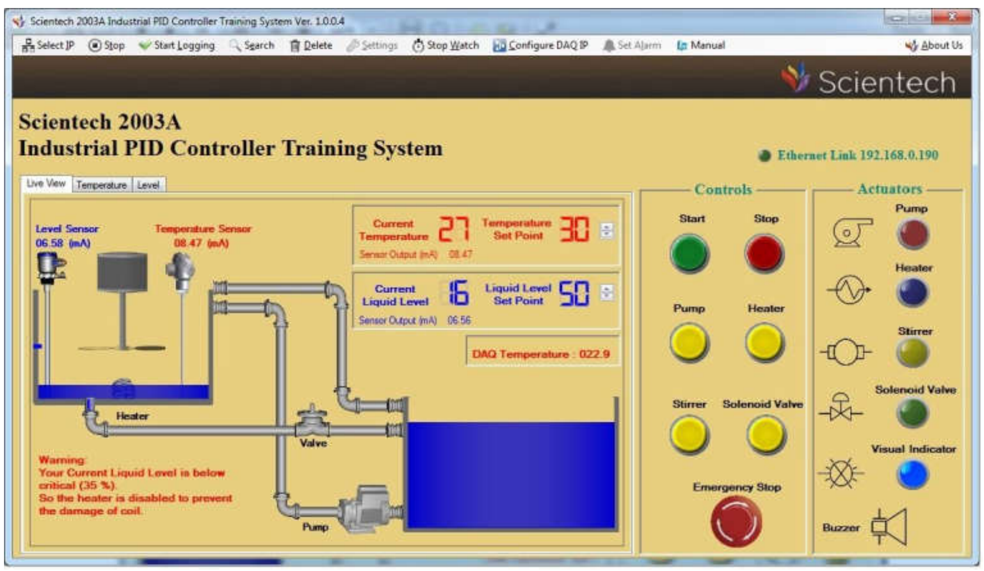


- Go to Setting TAB (in menu bar) then click on Level PID tab as shown below.

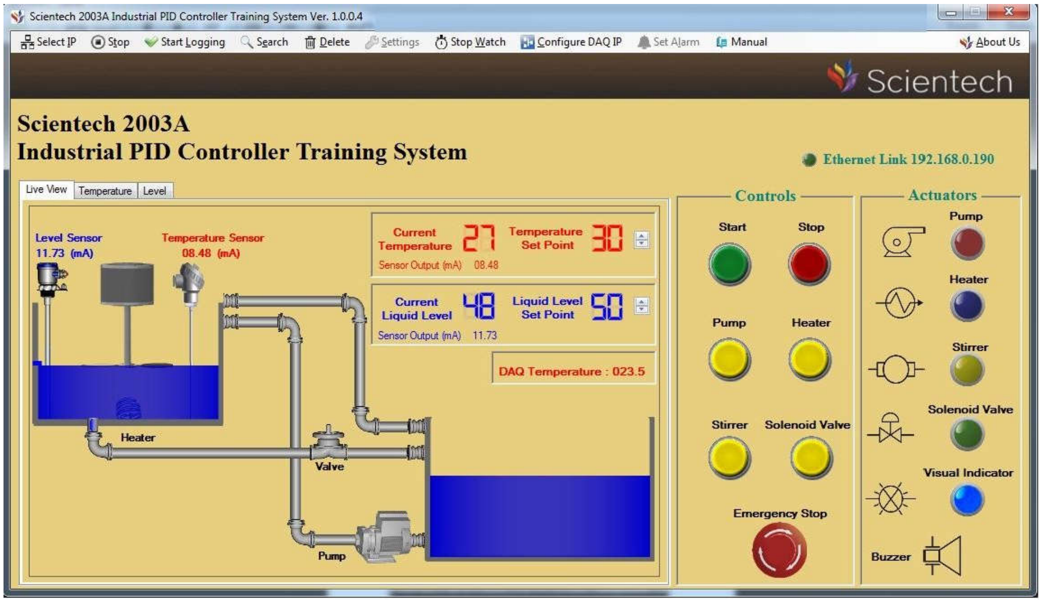
- **Level Transmitter Setting** window will open then Click on **Open Loop** check box and click on **OK** tab as shown below.



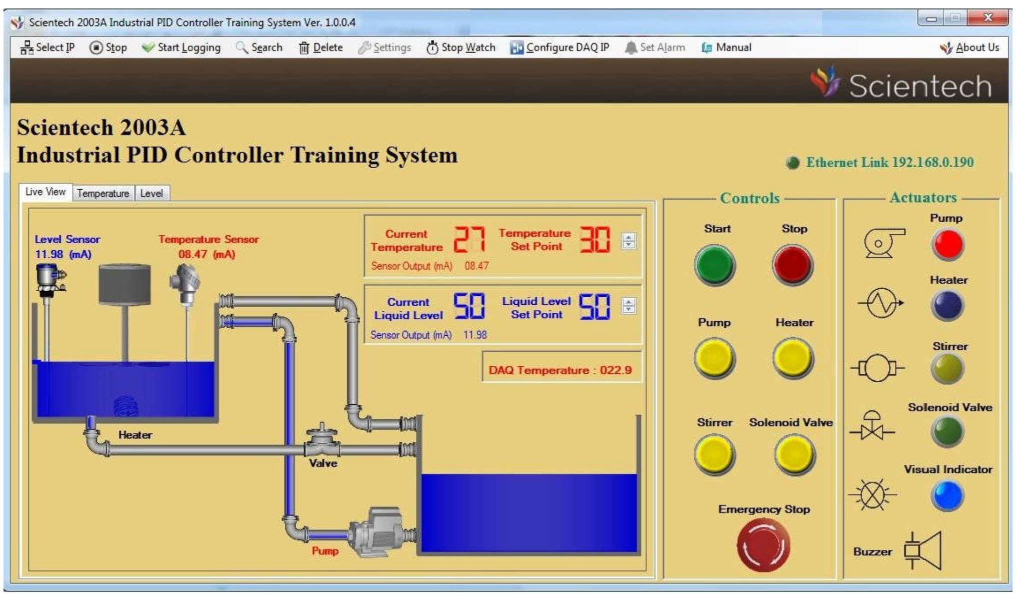
- Set the set point using **UP/Down** TAB.



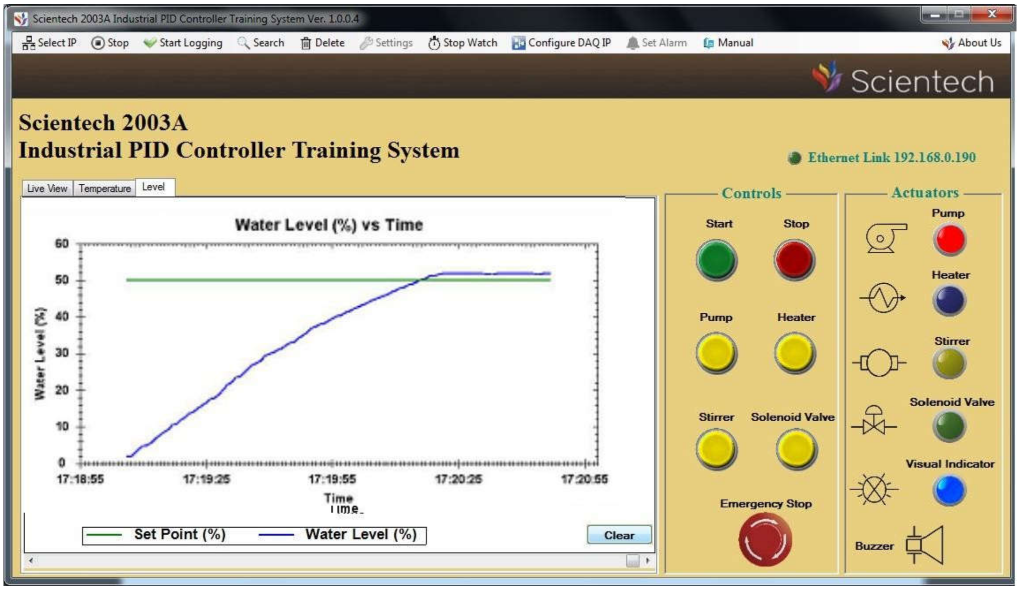
- When you click or press Start TAB (X0) then Pump (Y0) will be 'ON'. When pump will be on then level of water in measuring tank will increase as shown below.



- When Current liquid level is reach the set point then **pump (Y0)** will be 'OFF' as shown below.



- If you want to see a graph between **Water Level % Vs time** , click on Level TAB as shown below.



Experiment 6

Objective: Study and use of Level PID Control action using Software.

Equipments Needed:

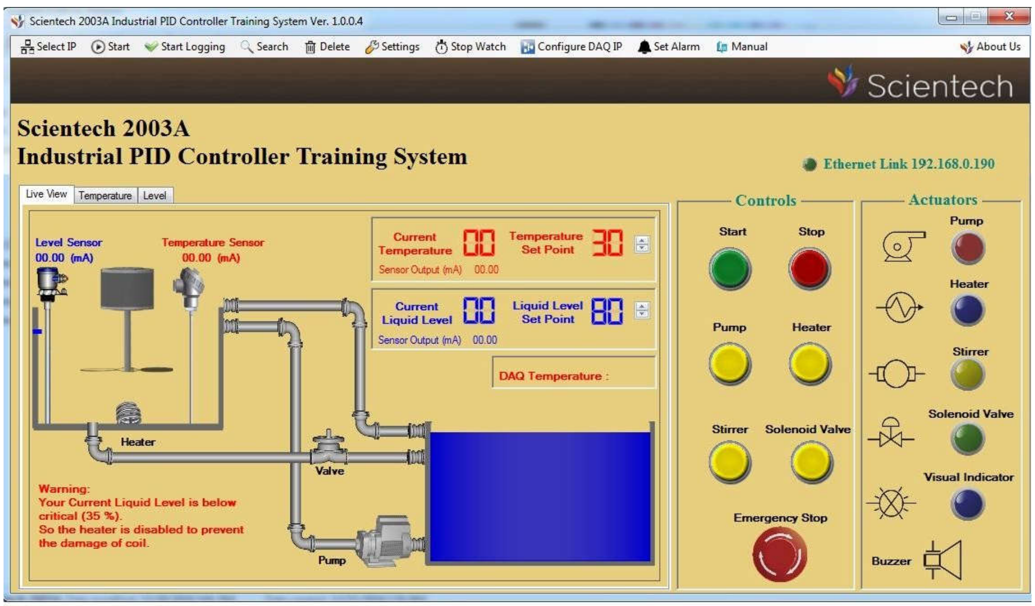
- Scientech 2003A Industrial PID Controller Training System
- Scientech 2003A Software V1.1
- Ethernet Cable
- Mains cord

Procedure:

- Connect Mains cord to Mains socket of Scientech 2003A.
- Turn on the Rocker (Power) Switch.
- Connect Ethernet Cable between PC/Laptop Ethernet Socket and Scientech 2003A Ethernet Socket.
- Put the switches in the position as shown in the image below.

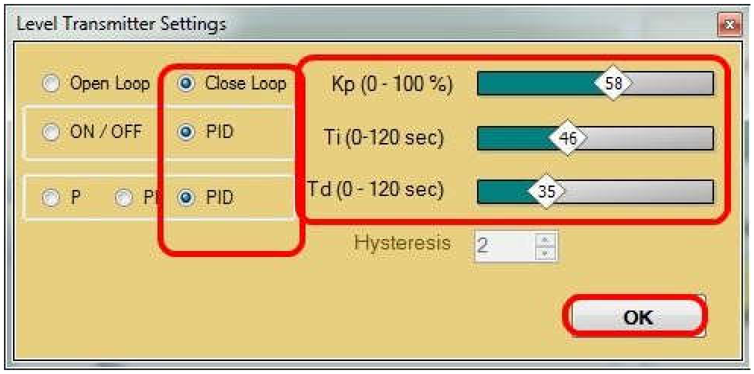
- Open the Scientech 2003A Software , Select IP and click on Start tab.
- “Hardware Found” message will comes then click on “OK” Tab as shown below.

- After above step this window will be open as shown below.

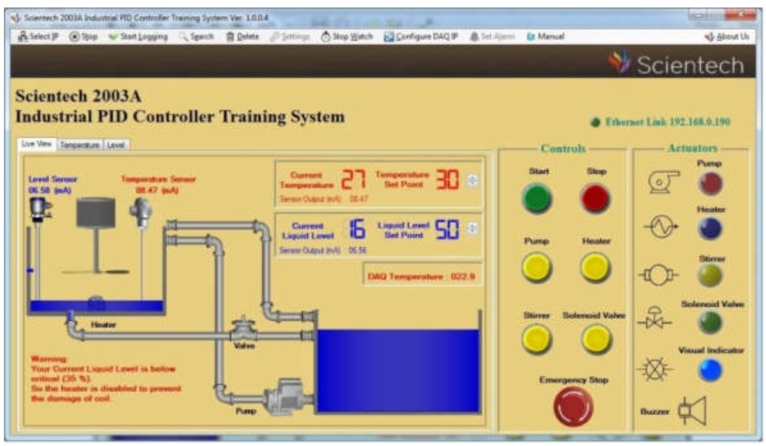


- Go to Setting TAB (in menu bar) then click on Level PID tab as shown below.

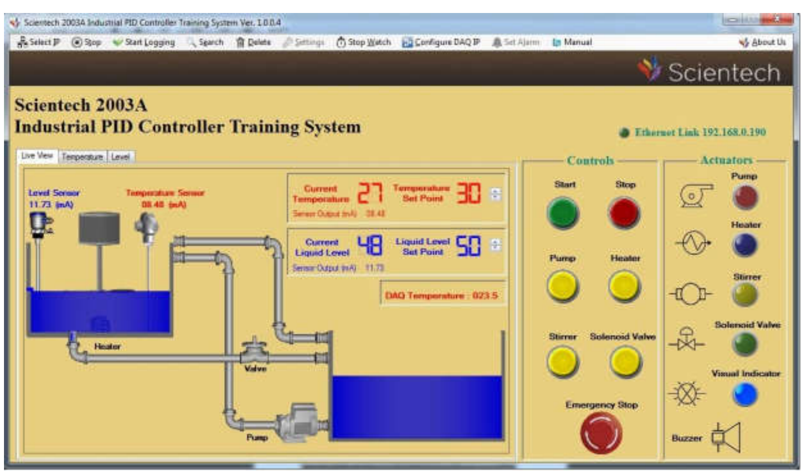
- Level Transmitter Setting window will open then Click on Open Loop check box and click on OK tab as shown below. Click on Close Loop check box and PID Check box and PID check box and click on OK TAB as shown below.



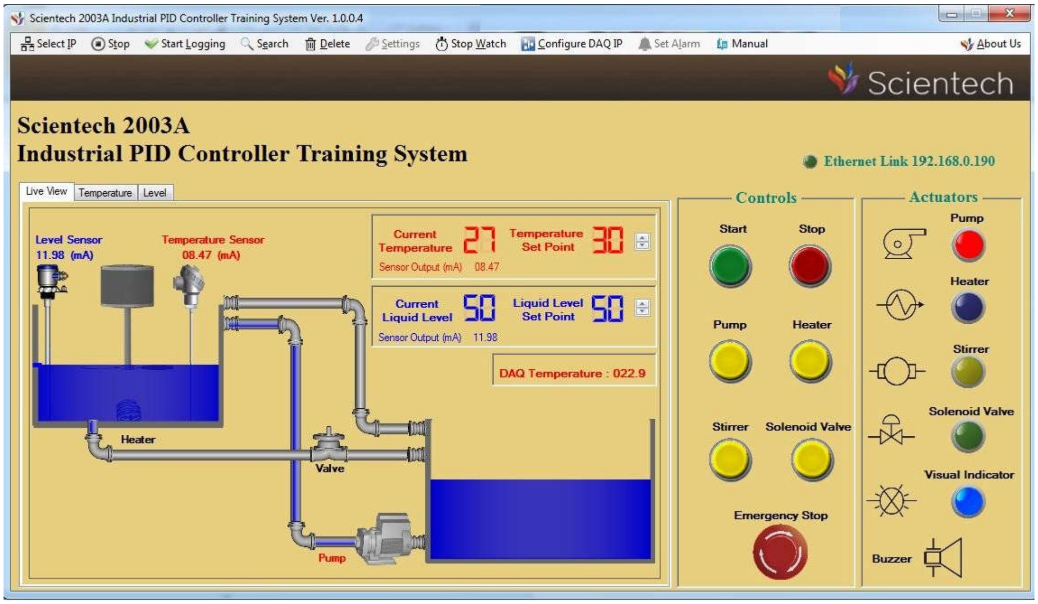
- Set the set point using UP/Down TAB.



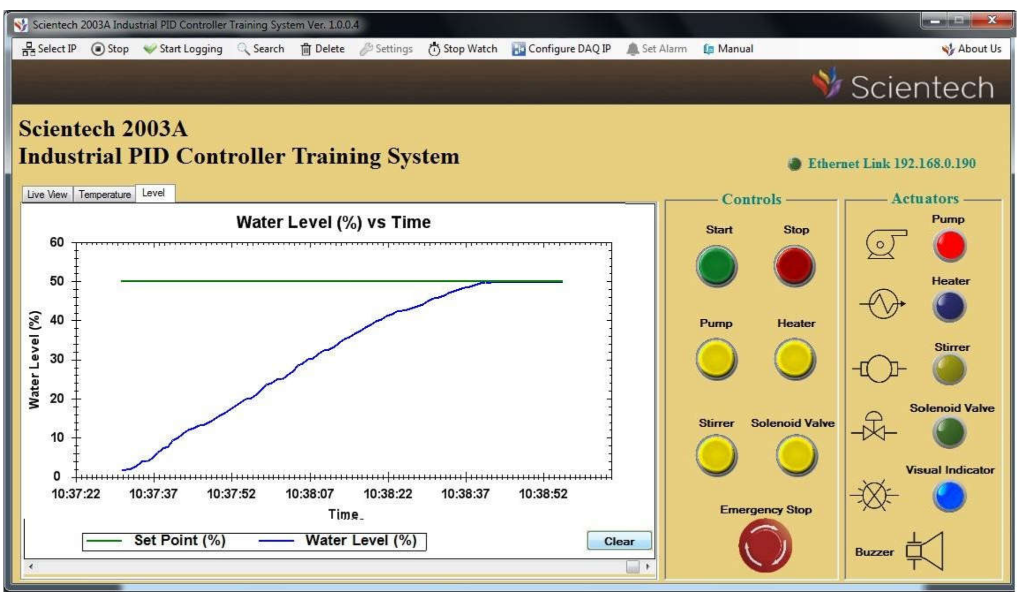
- When you click or press Start TAB (X0) then Y0 (Pump) will be on. When pump will be 'ON' then level of water in measuring tank will increase as shown below.



- When Current liquid level is reach the set point then pump (Y0) will be 'OFF' as shown below.



- If you want to see a graph between Water Level % Vs time , click on Level TAB as shown below.



RESULT: studied of PID controller by using scientech2003A software.

Lead-Lag Compensation Network
Scientech 2452

Lead-Lag Compensation Network
Scientech 2452

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to the instrument.

Do not operate the instrument if suspect any damage to it.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

Use only the proper Fuse : Use the fuse type and rating specified for this instrument.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Introduction

Scientech TechBooks are compact and user friendly learning platforms to provide a modern, portable, comprehensive and practical way to learn Technology. Each TechBook is provided with detailed Multimedia learning material which covers basic theory, step by step procedure to conduct the experiment and other useful information.

Scientech 2452 is a Lead Lag Compensation Network which helps the user to gain invaluable practical experience of the principles and application of Leading Lagging of a signal applied to any active network.

Scientech 2452 is helpful used to study Lead, Lag and Lag-Lead in the network, networks as a filter, analysis through Bode plots and compensation of the same.

Figure 1

Features

- **Digital Frequency Counter**
- **Square Wave Generator**
- **Precise Signal Conditioning**
- **Sensitive, linear, stable and accurate**
- **Easy to operate**
- **Rugged and compact**
- **Functional Blocks indicated on board mimic**
- **2 mm socket for interconnection**
- **Test points at various blocks to measure and observe the signals**
- **eManual describing working of TechBook along with detailed**
- **experiment descriptions**
- **On Board Touch Switch**

Technical Specifications

Frequency Counter	**:**	100 Hz – 50 kHz.
Square Wave Generator	**:**	250 Hz – 5 kHz
2 mm interconnection sockets	**:**	16
Power Consumption	**:**	1.6 VA (Approximately)
Test Points	**:**	17 nos (Gold plated)
Dimensions (mm)	**:**	W 326 x D 252 x H 52
Power Supply	**:**	110V - 260V AC, 50/60Hz
Weight	**:**	1.5Kg (Approximately)
Operating Conditions	**:**	0-40^0 C, 80% RH
Learning Material	**:**	CD (Theory, procedure, reference results etc), Online (optional)

Theory

The primary objective of this techbook is to study the design and compensation of the single input single output linear time invariant control systems. Compensation is the modifications of the system dynamics to satisfy the given specification.

Series Compensation and feedback (or parallel) compensation, the choice between series compensation and feedback compensation depends on the nature f the signals in the system, the power levels at various points, available components, the designer's experience, economic considerations, and so on.

In general, series compensation may be simpler than feedback compensation; however, series compensation frequently requires additional amplifiers to increase the gain and/or to provide isolation. To avoid power dissipation, the series compensator is inserted at the lowest energy point in the feed forward path. In general, the number of components required in feedback compensation will be less than the number of components required in series compensation, provided a suitable signal is available, because the energy transfer is from a higher power level to a lower power level. This means that the additional amplifiers may not be necessary.

In discussing compensators, we frequently use lead network lag network and lag-lead network. If a sinusoidal input e_i is applied to the input of the network and steady state output e_o which is also sinusoidal has a phase lead then the network is called lead network. If the steady-state output e_o has a phase lag, then the network is called as a lag network. In a lag-lead network both phase lag and phase lead occur in the output but in different frequency regions. A compensator having a characteristic of a lead network, lag network and lag-lead network is called a lead compensator, lag compensator and lag-lead compensator. In practice a system may indicate that the desired performance cannot be achieved just by the adjustment of the gain. In fact in some cases, the system may not be stable for all values of gain.

The addition of the pole to the open loop transfer function tending to lower the system's relative stability and to slow down the settling response. Remember the addition of integral control adds a pole at the origin, thus making the system less stable.

The addition of a zero to the open loop transfer function has the effect to make the system more stable and to speed up the settling of the response. Physically the addition of a zero in feed forward transfer function means the addition of derivative control to the system. The effect of such control is to introduce a degree of anticipation into the system and speed up the transient response.

There are many ways to realize continuous time or analog lead compensator, such as electronic networks using operational amplifiers, electrical RC networks, and mechanical spring dashpot systems.

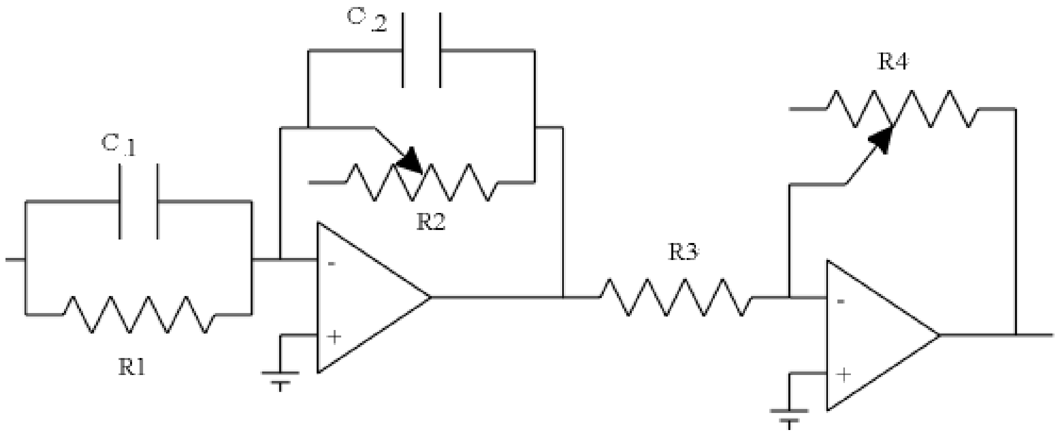


Figure 2

$E_o(s)/E_i(s) = K_c\,\alpha\,(Ts+1)/(\alpha Ts+1)$

Where,

T = R1C1,

αT= R2C2,

K_c = R4C1/R3C2.

Network is a lead network if R1C1>R2C2 or α<1. It is a lag network if R1C1<R2C2.

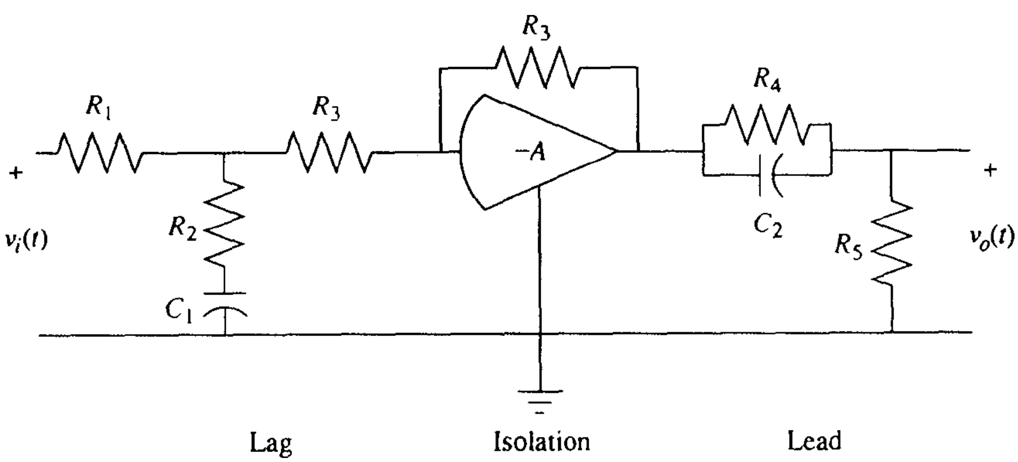


Figure 3

A lead–lag compensator is a component in a control system that improves an undesirable frequency response in a feedback and control system. It is a fundamental building block in classical control theory. Typically, there is also a specification on gain crossover frequency or closed-loop bandwidth. A phase margin specification can represent a requirement on relative stability due to pure time delay in the system, or it can represent desired transient response characteristics that have been translated from the time domain into the frequency domain. A specification on bandwidth or crossover frequency can represent a requirement on speed of response in the time domain or a frequency-domain requirement on which sinusoidal frequencies will be passed by the system without significant attenuation. The overall philosophy in the design procedure presented here is for the lead part of the compensator to adjust the system's Bode phase curve to establish the required phase margin at a specified frequency, without reducing the zero-frequency magnitude value. The lag part of the compensator is used to drop the magnitude curve down to 0 db at that specified frequency. The lag compensator must attenuate the magnitude of the series combination of the lead compensator Gc lead (s) and the plant Gp(s) at the chosen frequency. Thus, in the procedure presented here, the lead compensator is designed first. In order for lag-lead compensation to work in this context, the following two characteristics are needed: The uncompensated phase shift at the chosen gain crossover frequency must be more negative than the value needed to satisfy the phase margin specification otherwise, no lead compensation is needed;

The Bode magnitude curve after the lead compensator has been designed) must be above 0 db at the frequency chosen for the gain crossover frequency otherwise no lag compensation is needed, just additional gain.

The basic lag-lead compensator has two stages, one each of lag and lead compensation. If the compensator is to have a single-stage lead compensator, then the amount that the phase curve needs to be moved up at the gain crossover frequency in order to satisfy the phase margin specification must be less than 90,

If the compensator is to have a single-stage lag compensator, then it must be possible to drop the magnitude curve down to 0 db at the gain crossover frequency.

The gain crossover frequency and bandwidth for the lag-lead-compensated system may be higher or lower than for the plant itself or for the plant after the steady-state error specification is satisfied.

A lag compensator is a device that provides phase lag in its' frequency response.

lead: improves the transient response.

lag: improves the steady-state performance at the expense of slower settling time.

lead-lag: combines both

Lead compensator approximates derivative plus proportional control. It Increases the gain crossover frequency and it increases bandwidth.

Lag compensator approximates integral plus proportional control. It moves the gain-crossover frequency lower and it Reduces bandwidth.

As with phase lag and phase lead compensation, the purpose of lag-lead compensator design in the frequency domain generally is to satisfy specifications on steady-state accuracy and phase margin.

Bode Plot

A Bode diagram consists of two graphs:

a plot of 20 log jG(jw)j (in dB) versus frequency w, and

a plot of phase angle = G(jw) versus frequency w.

Advantages of Bode plot:

An approximate bode plot can always be drawn with hand.

Multiplications of magnitudes get converted into addition.

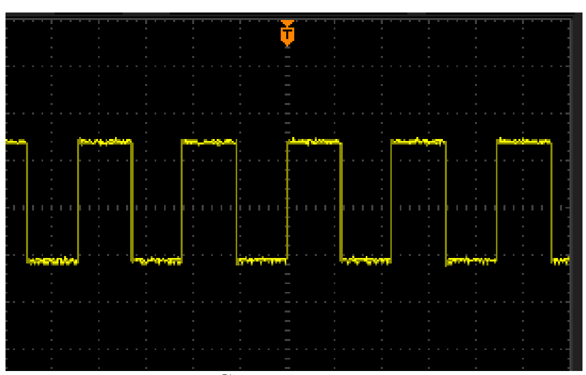
Phase-angle curves can easily be drawn if a template for phase-angle curves of

(1 + jw) is available.

The lead compensator provides phase lead at high frequencies. This shifts the poles to the left, which enhances the responsiveness and stability of the system. The lag compensator provides phase lag at low frequencies which reduces the steady state error.

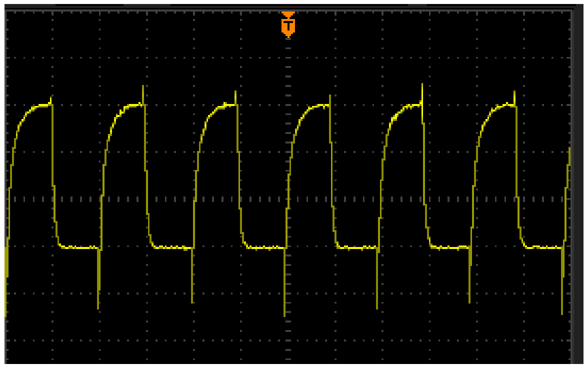
The precise locations of the poles and zeros depend on both the desired characteristics of the closed loop response and the characteristics of the system being controlled. However, the pole and zero of the lag compensator should be close together so as not to cause the poles to shift right, which could cause instability or slow convergence. Since their purpose is to affect the low frequency behavior, they should be near the origin.

If the phase angle is negative for all signal frequencies in the network then the network is classified as a "lag network". If the phase angle is positive for all signal frequencies in the network then the network is classified as a "lead network". If the total network phase angle has a combination of positive and negative phase as a function of frequency then it is a "lead-lag network". A compensator is an additional component or circuit that is inserted into a control system to compensate for a deficient performance.



Square wave

Figure 4

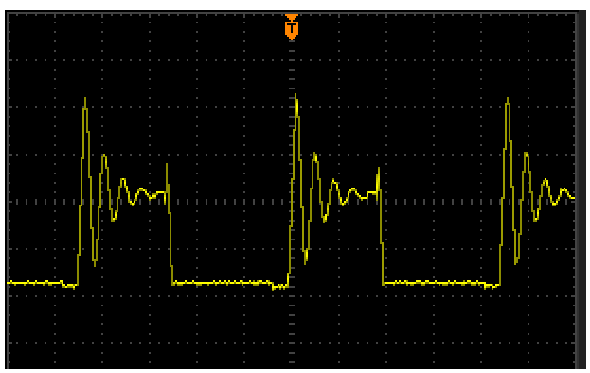


Uncompensated

Figure 5

Compensated

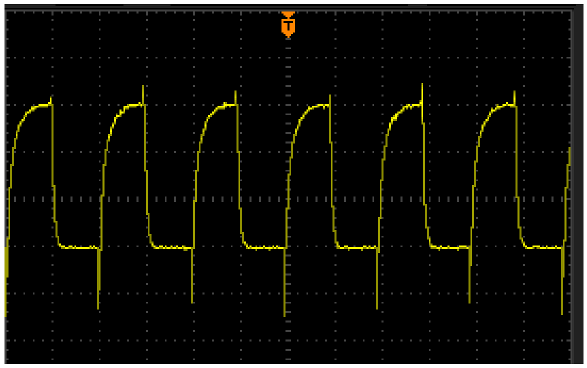
Figure 6



Lag

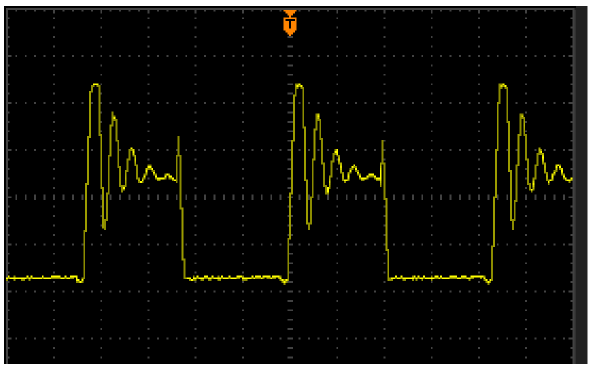
Figure 7

Scientech 2452



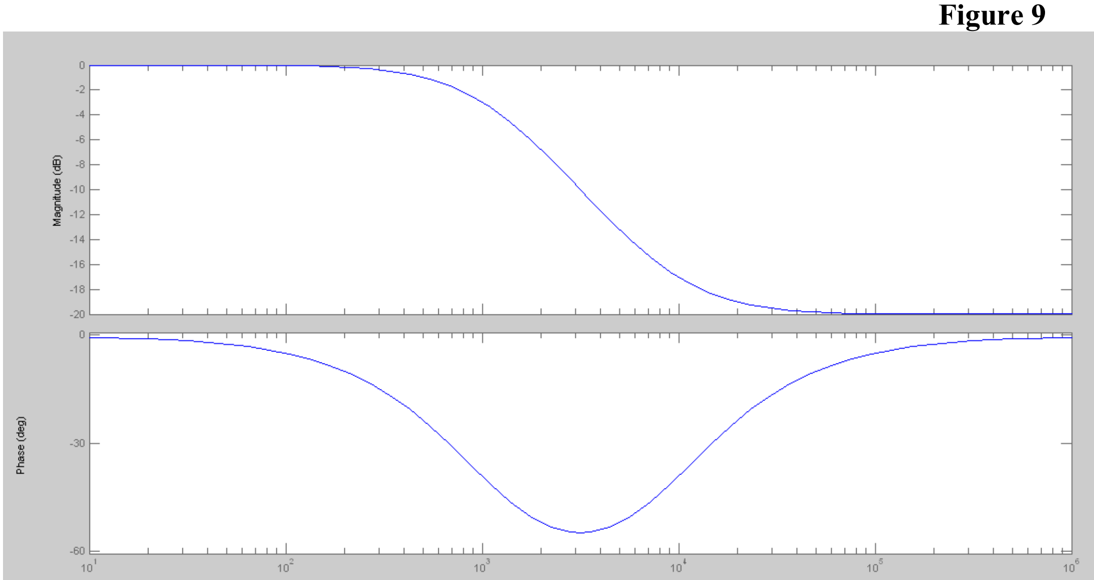
Lead

Figure 8



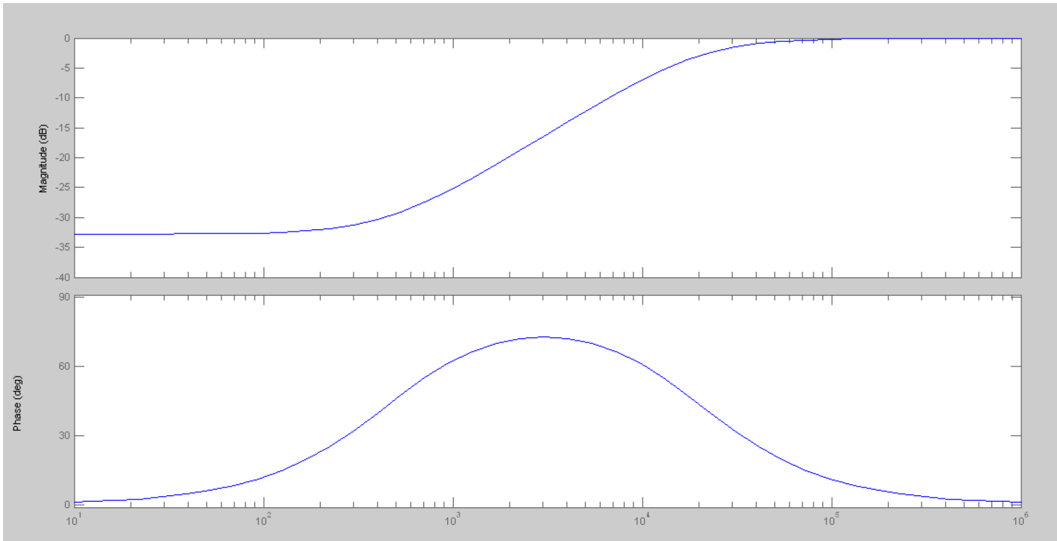
Lag-Lead

Figure 9



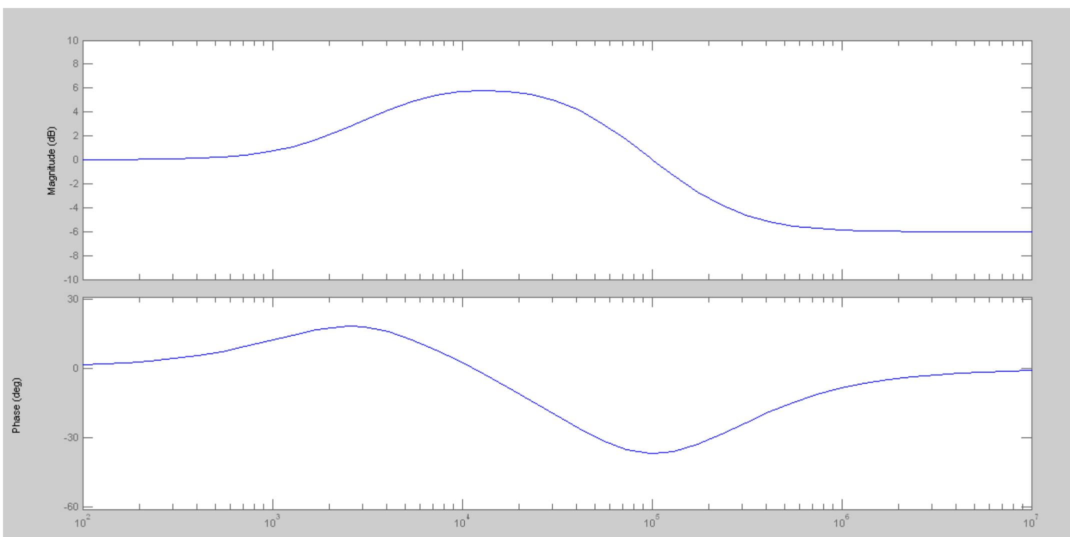
Lag Compensator

Figure 10



Lead Compensator

Figure 11



Lag-Lead Compensator

Figure 12

Experiment 1

Objective: To study Lead compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network.**
2. Patch Chords.
3. BNC Cable.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to uncompensated circuit (2).
7. Uncompensated circuit (4) to Lead (7).
8. Select the toggle switch to down position that is at lead position.
9. Connect lead (8) to gain (11).
10. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
11. Switch ON the techbook.
12. Now observe the waveform on CRO.
13. Now adjust the knob provided in lead block to compensate the lead.

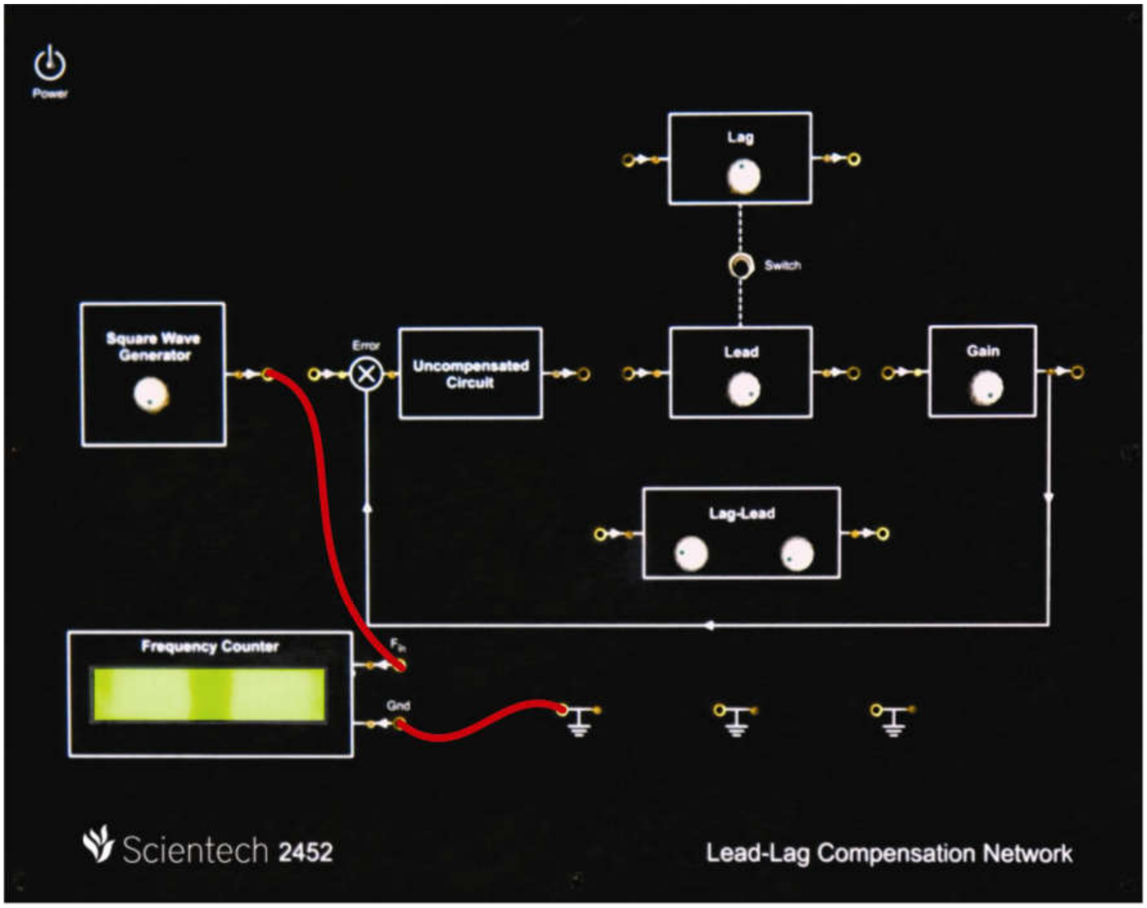

Power
Lag
Switch
Square Wave Generator
Error
Uncompensated Circuit
Lead
Gain
Lag-Lead
Frequency Counter
Gnd
Scientech 2452
Lead-Lag Compensation Network

Figure 13

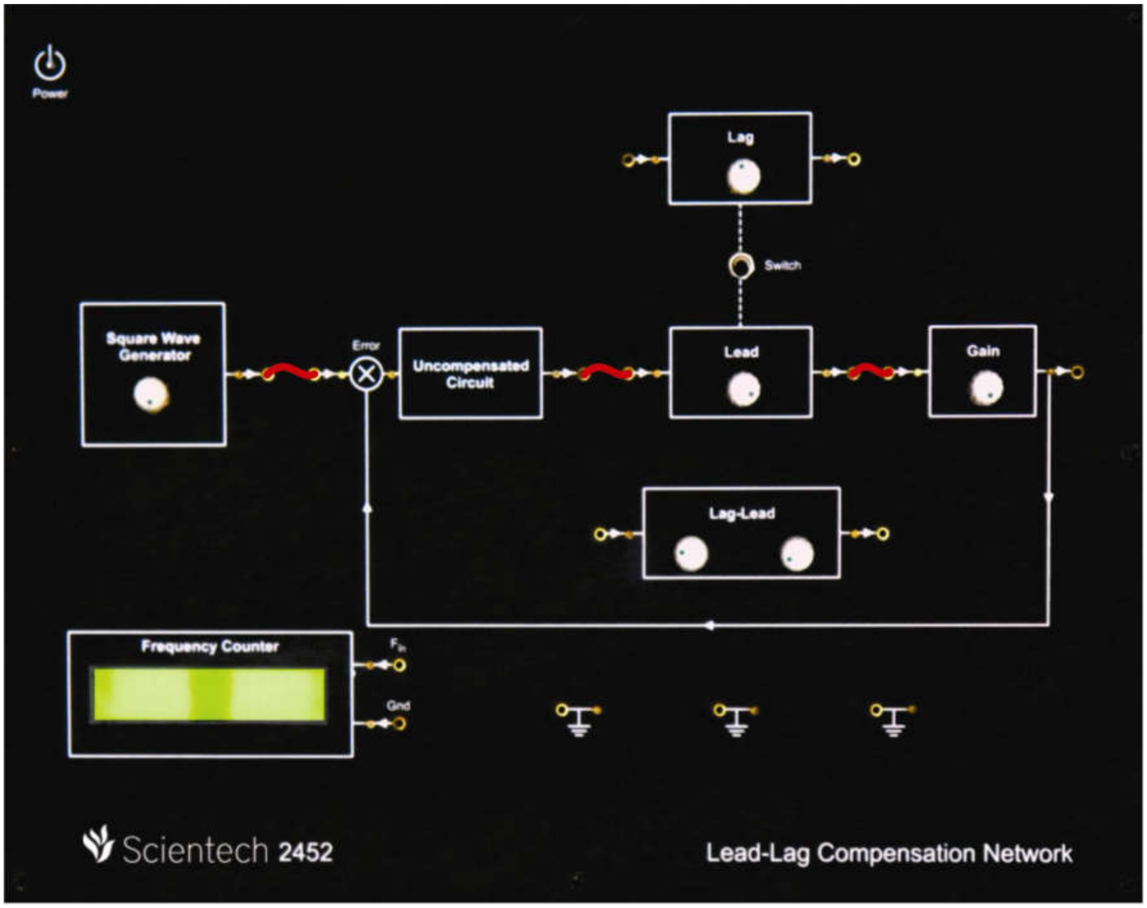

Power
Lag
Switch
Square Wave Generator
Error
Uncompensated Circuit
Lead
Gain
Lag-Lead
Frequency Counter
Gnd
Scientech 2452
Lead-Lag Compensation Network

Figure 14

Experiment 2

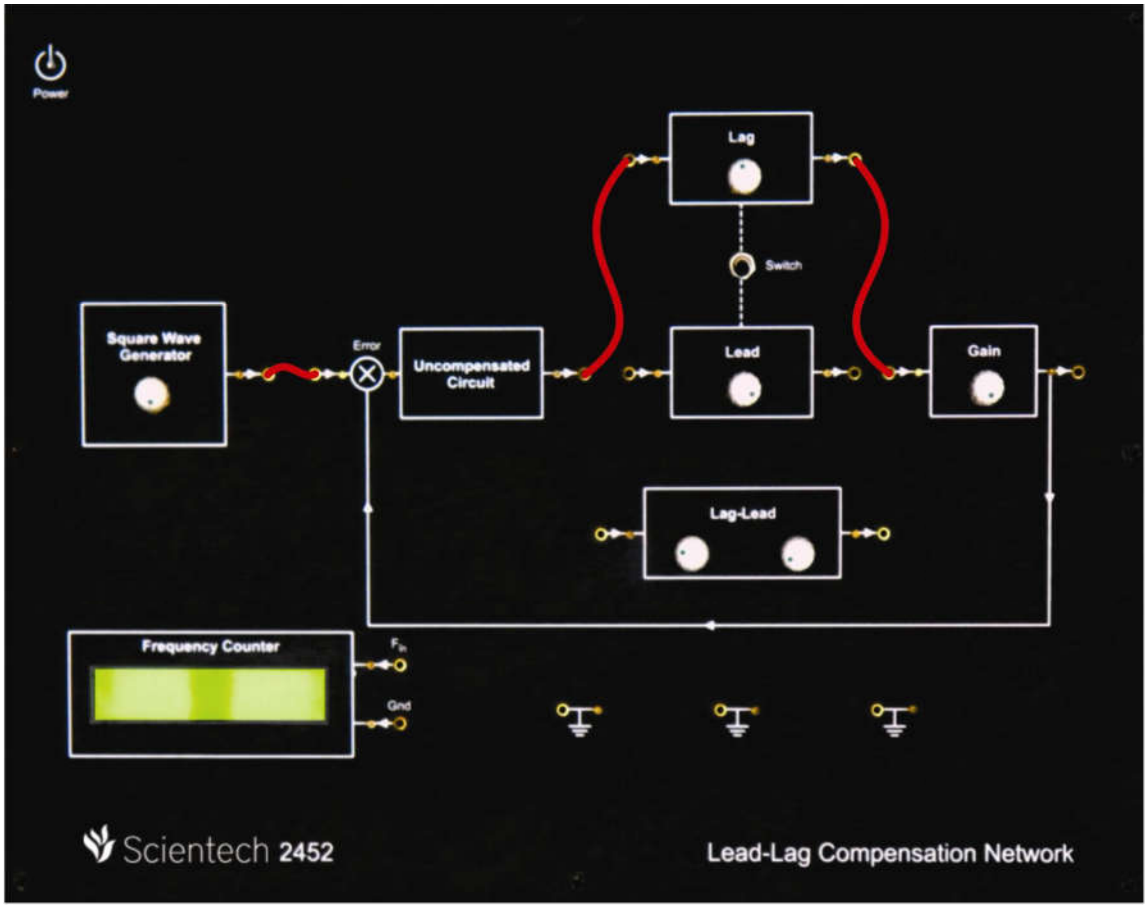
Objective: To study Lag compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network.**
2. Patch Chords.
3. BNC Cable.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to uncompensated circuit (2).
7. Uncompensated circuit (4) to Lag (5).
8. Select the toggle switch to upper position that is at lag position.
9. Connect lag (6) to gain (11).
10. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
11. Switch ON the techbook.
12. Now observe the waveform on CRO.
13. Now adjust the knob provided in Lag circuit block to compensate the lag.



Power
Square Wave Generator
Error
Uncompensated Circuit
Lag
Switch
Lead
Gain
Lag-Lead
Frequency Counter
Gnd
Scientech 2452
Lead-Lag Compensation Network

Figure 15

Experiment 3

Objective: To study Lag-Lead compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network.**
2. Patch Chords.
3. BNC Cable.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to uncompensated circuit (2).
7. Uncompensated circuit (4) to Lag- Lead (9).
8. Connect lag-lead block (10) to gain (11).
9. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
10. Switch ON the techbook.
11. Now observe the waveform on CRO.
12. Now adjust the knob provided in Lag-Lead block to compensate the Lag-Lead.

E

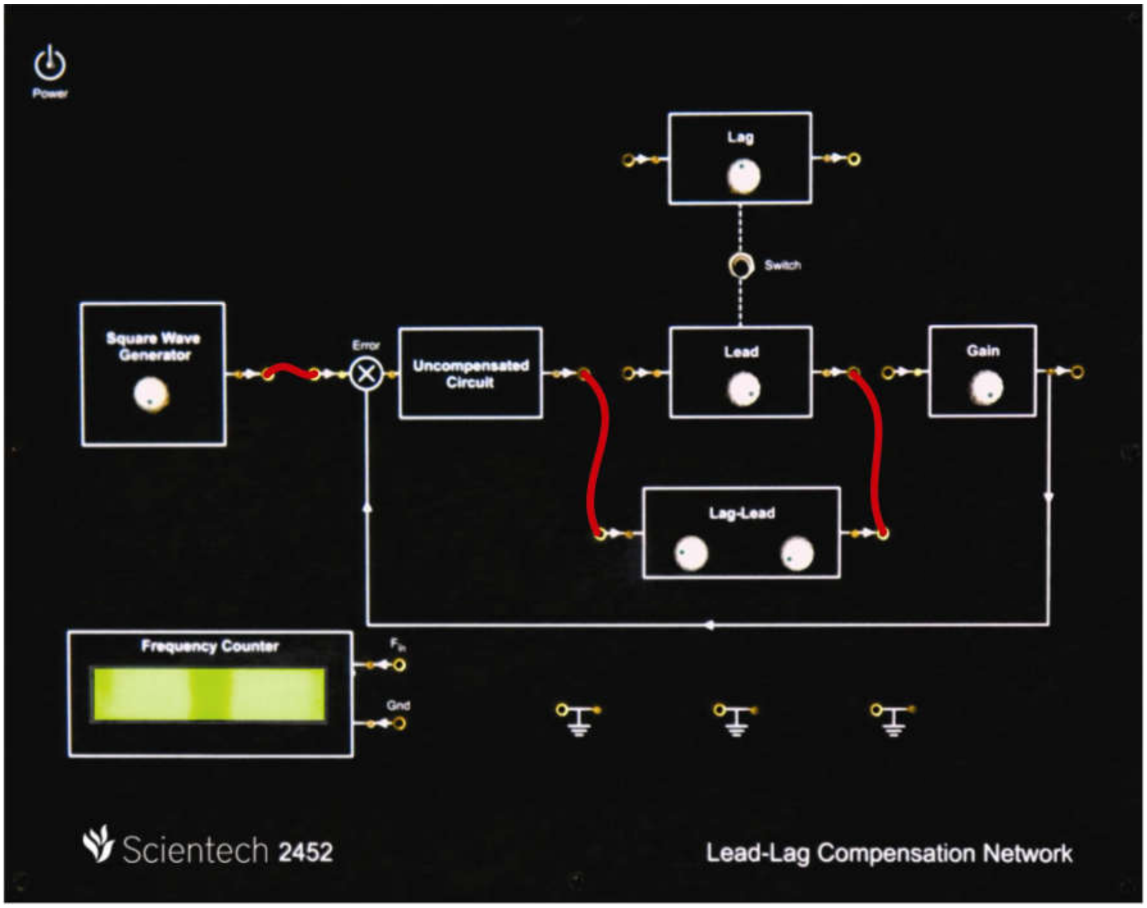

Power
Lag
Switch
Square Wave Generator
Error
Uncompensated Circuit
Lead
Gain
Lag-Lead
Frequency Counter
Gnd
Scientech 2452
Lead-Lag Compensation Network

Figure 16

Experiment 4

Objective: To draw Bode plot of Lead compensator by using MATLAB.

Procedure:

1. The transfer function of the given Lead Compensator is $\frac{R_2[10^{-5}s+4.5x10^{-5}]}{R_2 10^{-5}s+1}$
2. The variable value R2 can be varied from 500Ω to 50KΩ.
3. Now substitute the value of R2 from the above given range (500Ω -50KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

   num = [a b c];

   den = [d e f];

   bode(num,den)

   subplot(2,1,1);

   title (‘Bode Diagram of Lead compensator’)

Experiment 5

Objective: To draw Bode plot of Lag compensator by using MATLAB.

Procedure:

1. The transfer function of the given Lag Compensator is $\frac{R_2[22*10^{-4}s+1]}{R_2\,22*10^{-6}s+1}$
2. The variable value R2 can be varied from 100Ω to 10KΩ.
3. Now substitute the value of R2 from the above given range (100Ω -10KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

   num = [a b c];

   den = [d e f];

   bode(num,den)

   subplot(2,1,1);

   title (‘Bode Diagram of Lag compensator’)

Experiment 6

Objective: To draw Bode plot of Lag-Lead compensator by using MATLAB.

Procedure:

1. The transfer function of the given Lag-Lead Compensator is

$$\frac{[0.25+2.5\times10^{-6}R_2 s][1+R_1\times10^{-7}s]}{[1+5\times10^{-6}R_2 s][0.5+R_1\times10^{-7}s]}$$

2. The variable value R1 can be varied from 10Ω to 1KΩ and R2 can be varied from 50 Ω to 5KΩ.
3. Now substitute the value of R1 and R2 from the above given range (10Ω-1KΩ and 50 Ω to 5KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

```
num = [a b c];
den = [ d e f];
bode(num,den)
subplot(2,1,1);
title ('Bode Diagram of Lag-Lead compensator')
```

Experiment 7

Objective: To study Bode plot of Lead compensator by using MATLAB.

Procedure:

1. The transfer function of the given Lead Compensator is $\frac{R_2[10^{-5}s+4.5x10^{-5}]}{R_2 10^{-5}s+1}$
2. The variable value R2 can be varied from 500Ω to 50KΩ.
3. Now substitute the value of R2 from the above given range (500Ω -50KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

   num = [a b c];

   den = [d e f];

   bode(num,den)

   subplot(2,1,1);

   title (‘Bode Diagram of Lead compensator’)
6. Study the Gain v/s Frequency curve and compare it with High Pass Filter curve as it blocks lower frequency and allows higher frequency to pass through it.

Experiment 8

Objective: To study Bode plot of Lag compensator by using MATLAB.

Procedure:

1. The transfer function of the given Lag Compensator is $\frac{R_2[22*10^{-9}s+1]}{R_2\,22\times10^{-8}s+1}$
2. The variable value R2 can be varied from 100Ω to 10KΩ.
3. Now substitute the value of R2 from the above given range (100Ω - 10KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

   num = [a b c];

   den = [d e f];

   bode(num,den)

   subplot(2,1,1);

   title (‘Bode Diagram of Lag compensator’)
6. Study the Gain v/s Frequency curve and compare it with Low Pass Filter curve as it allows lower frequency and blocks higher frequency to pass through it.

Experiment 9

Objective: To study Lag-Lead compensator as a filter.

Procedure:

1. The transfer function of the given Lag-Lead Compensator is
   $$\frac{[0.25+2.5\times10^{-6}R_2s][1+R_1\times10^{-7}s]}{[1+5\times10^{-8}R_2s][0.5+R_1\times10^{-7}s]}$$
2. The variable value R1 can be varied from 10Ω to 1KΩ and R2 can be varied from 50Ω to 5KΩ.
3. Now substitute the value of R1 and R2 from the above given range (10Ω - 1KΩ and 50Ω to 5KΩ) in the above given Transfer Function (given in point1).
4. Transfer Function = $\frac{num(s)}{den(s)}$

   num(s) = as2 + bs + c and den(s) = ds2 + es + f

   Where,

   a, b, c are the coefficients of s2, s and constant term of the numerator respectively.

   d, e, f are the coefficients of s2, s and constant term of the denominator respectively.
5. MATLAB program :

   num = [a b c];

   den = [d e f];

   bode(num,den)

   subplot(2,1,1);

   title (‘Bode Diagram of Lag-Lead compensator’)
6. Study the Gain v/s Frequency curve and compare it with Band Pass Filter curve as it allows lower frequency and blocks higher frequency to pass through it.

Additional Experiment 10

Objective: To study your various uncompensated circuit modules Lead Compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network**.
2. Patch Chords.
3. BNC Cable.
4. Bread Board and components used in uncompensated circuit.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to your uncompensated circuit.
7. Uncompensated circuit to Lead (7).
8. Select the toggle switch to down position that is at lead position.
9. Connect lead (8) to gain (11).
10. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
11. Switch ON the techbook.
12. Now observe the waveform on CRO.
13. Now adjust the knob provided in lead block to compensate the lead.

Experiment 11

Objective: To study your various uncompensated circuit modules Lag Compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network**.
2. Patch Chords.
3. BNC Cable.
4. Bread Board and components used in uncompensated circuit.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to your uncompensated circuit.
7. Uncompensated circuit to Lag (5).
8. Select the toggle switch to down position that is at lead position.
9. Connect Lag (6) to gain (11).
10. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
11. Switch ON the techbook.
12. Now observe the waveform on CRO.
13. Now adjust the knob provided in lead block to compensate the lag.

Experiment 12

Objective: To study your various uncompensated circuit modules Lead Lag Compensator.

Equipments Needed:

1. **Scientech 2452 Lead-Lag Compensation Network**.
2. Patch Chords.
3. BNC Cable.
4. Bread Board and components used in uncompensated circuit.

Procedure:

1. Connect the Square Wave Generator to the upper point of LCD provided and connect lower point of LCD to ground.
2. Now switch ON the Techbook.
3. Set the frequency of input Square Wave through knob provided in the square wave generator block to 1KHz.
4. Switch OFF the techbook.
5. Make the circuit through patch chords.
6. Connect Square Wave Generator (1) to your uncompensated circuit.
7. Uncompensated circuit to Lead-Lag (9).
8. Select the toggle switch to down position that is at lead position.
9. Connect Lead-Lag (10) to gain (11).
10. Feed the output of gain (12) to CRO through a crocodile to BNC cable..
11. Switch ON the techbook.
12. Now observe the waveform on CRO.
13. Now adjust the knob provided in lead block to compensate the Lead - Lag.

RESULT: the characteristics of LEAD LAG compensator studied**.**

Overview of P I D Controller
Scientech 2451

Scientech 2451 Overview of P I D Controller

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to the instrument.

Do not operate the instrument if you suspect any damage within.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

Use only the proper Fuse : Use the fuse type and rating specified for this instrument.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

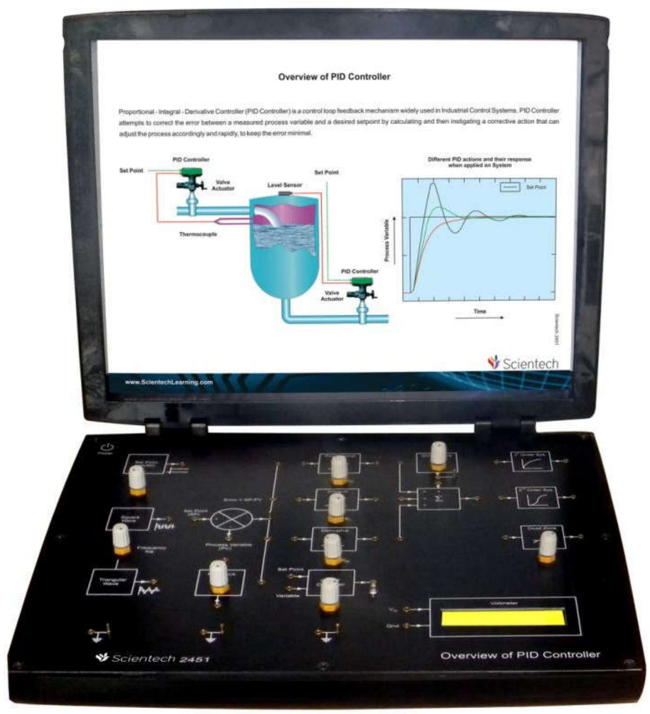
1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Introduction

Scientech TechBooks are compact and user friendly learning platforms to provide a modern, portable, comprehensive and practical way to learn Technology. Each TechBook is provided with detailed Multimedia learning material which covers basic theory, step by step procedure to conduct the experiment and other useful information.

In Control System there are different types of Controllers. Study of two position mode as ON/OFF Controller and continuous Controller modes as PID controller is a very important part of control engineering. To have a basic idea and practical hands on Controllers PID Techbook has been designed to be used by students to investigate the principles of PID by applying different signals.

With Scientech TechBook 2451 Overview of PID Controller Students can study two-position mode as ON/OFF Controller and continuous Controller modes as P-control mode, I-control mode, D-control mode, PI-control mode, PD-control mode and PID control mode. These modes of Controller can be performed individually and also with different combinations in open loop and close loop system. Users can easily understand the difference between the different modes of Controllers used. Square wave, triangular wave generator variable DC supply as set point and disturbance generator are provided on board. Effect of PID can be seen on first order system and second order system in open loop and close loop .



Features

- **Proportional, Integral and Derivative functions can be checked on same Board (configurable as P, I, D, PI, PD, PID)**
- **'On/Off' controller**
- **Square and triangular wave with variable frequency for testing P I D**
- **Variable DC for set point**
- **Error detector**
- **Ist order system & IInd order system**
- **In built power supply**
- **Dead zone and disturbances generator**
- **Voltmeter for DC measurement**
- **Signals can be observed and measured at various blocks**
- **Learning Material describing working of trainer along with detailed experiment descriptions**
- **On board Touch Switch**

Technical Specifications

Proportional Band	:	5% to 55%.
Integrator	:	10msec to 11msec
‘On/Off’ controller	:	‘On‟ = 12V, „Off‟ =-12V
On board Generator	:	Square wave & triangular wave Generator of 0-156Hz, Two Variables DC ±6V & ±10V.
Power Consumption	:	1.6VA (approximately)
Interconnections	:	2 mm socket
Power Supply	:	100-240VA AC, 50/60Hz
Dimensions (mm)	:	W 340 x H 252 x D 52
Weight	:	1.5 Kg (approximately)
Operating Conditions	:	0-40^0 C, 85% RH
Product Tutorials	:	Online (Theory, procedure, reference results etc),

Theory

'On/Off' Controller:

The „On/Off" or two position controller is the most widely used. It is the kind used in domestic heating systems, refrigerators, and water tanks. When the controller is below the set point, the controller is on and the o/p signal has the maximum values. When the measured value is above the set point, the controller is off and the o/p is zero. Due to mechanical friction or arcing at electrical contacts, the controller actually goes ON slightly below the Set Point and „Off" slightly above the set point. This differential gap in the controller output may deliberately increased to give decreased frequency of operation and reduce wear

Open Loop Systems:

Those systems in which the output has no effect on the control action are called open loop control systems. In other words, in an open loop control system the output is neither measured nor fed back for comparison with the input. Thus, to each reference input there corresponds a fixed operating condition; as a result, accuracy of the system depends upon calibration. In the presence of disturbances, an open loop control system will not perform desired task. Open loop system can be used only if the relationship between input and output is known and if there are neither internal nor external disturbances. Note that any system that operates on time basis is open loop.

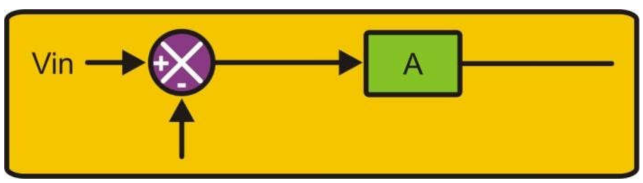


Figure 1

Closed-loop systems:

Feedback control systems are often referred to as closed loop control systems. In practice, the terms feedback control and close loop control are used interchangeable.

Let us start with the concept of a closed-loop feedback system. An amplifier is presented with signals from a summing junction. Output voltage is modified by a factor B, subtracted from the input voltage, and the result is the signal that the amplifier is given to amplify.

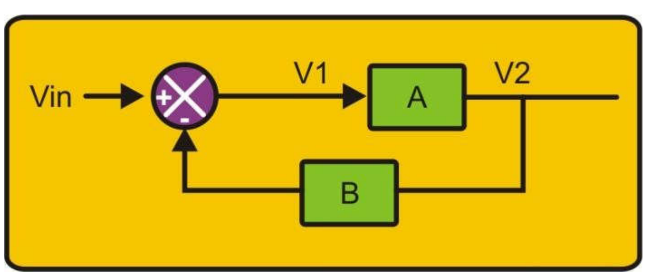


Figure 2

Then:

$V_2 = AV_1$
$V_1 = Vin - BV_2$

Substituting,

$$V_2 = A\,(Vin - BV_2)$$

Rearranging,

$$V_2\,(1+BA) = Avin$$

$$V_2 = V_{in}\ \frac{A}{BA+1}$$

Or

$$\frac{V_2}{V_{10}} = \frac{A}{BA+1}$$

or

Op amp gains (A) are typically 50,000 to 100,000, at least at DC. Note, therefore, that the gain of this block is quite insensitive to A. For B = .01,

A=10,000 $\frac{V_1}{V_{in}} = \frac{10000}{100+1} = 99.01$ If A=100,000, $\frac{V_1}{V_{in}} = 99.90$ The term A (which could include other terms in addition to the gain of the amplifier as will be shown) changed by a factor of 10 but the overall gain changed by 0.9%

This is the fundamental relationship for feedback control systems, and it's very powerful. Note that in general, A and B are differential equations or LaPlace transforms that describe the behavior of these functions with frequency and time. Because the transfer function above is a ratio of polynomials, (A could be in series with some function G rather than just a gain block) and since the time and frequency nature of networks can similarly be described as ratios of polynomials in s (LaPlace transforms), many functions can be realized with this structure. Oscillators, filters, amplifiers, impedance changers, negative-impedance blocks comprise just a few. For now we'll confine ourselves to a simple DC case.

Because A is large and BA is therefore large compared to 1, the transfer function can often be simplified to

$$\frac{V_1}{V_{in}} \approx \frac{1}{B}$$

Note that if other functions are in series with A, their transfer functions could be lumped with A and would cancel out as they did above. This means that you can cancel or minimize the effects of functions you cannot control simply by including them "inside the loop" - i.e., in series with A.

The Proportional-Integral-Derivative (PID):

PID stands for Proportional, Integral, and Derivative. Controllers are designed to eliminate the need for continuous operator attention. Cruise control in a car and a house thermostat are common examples of how controllers are used to automatically adjust some variable to hold the measurement (or process variable) at the set point. The set point is where you would like the measurement to be. Error is defined as the difference between set point and measurement.

(Error) = (set-point) - (measurement) The variable being adjusted is called the manipulated variable, which usually is equal to the output of the controller. The output of PID controllers will change in response to a change in measurement or set point. Manufacturers of PID controllers use different names to identify the three modes

Proportional Band:

With proportional band, the controller output is proportional to the error or a change in measurement (depending on the controller).

(Controller output) = (error)*100/ (proportional band)

With a proportional controller offset (deviation from set point) is present. Increasing the controller gain will make the loop go unstable. To reduce un-stability integral action included in controllers to eliminate this offset.

The mathematical representation is,

$$\frac{mv}{e(s)} = k_c \text{ (Laplace domain)}$$

Or

$$mv(t) \; mv_{ss} \; k_c e(t) \text{ (time domain)}$$

The proportional mode adjusts the output signal in direct proportion to the controller input (which is the error signal, e). The adjustable parameter to be specified is the controller gain, kc. This is not to be confused with the process gain, Kp. The larger kc the more the controller output will change for a given error. For instance, with a gain of 1 an error of 10% of scale will change the controller output by 10% of scale. Many instrument manufacturers use Proportional Band (PB) instead of kc.1

Integral:

With integral action, the controller output is proportional to the amount of time the error is present. Integral action eliminates offset.

Controller Output = (1/Integral) (Integral of) e (t) d (t)

Notice that the offset (deviation from set-point) in the time response plots is now gone. Integral action has eliminated the offset. The response is somewhat oscillatory and can be stabilized some by adding derivative action.

Integral action gives the controller a large gain at low frequencies that results in eliminating offset and "beating down" load disturbances. The controller phase starts out at ° and increases to near 0 ° at the break frequency. This additional phase lag is what you give up by adding integral action. Derivative action adds phase lead and used to compensate for the lag introduced by integral action.

Derivative:

With derivative action, the controller output is proportional to the rate of change of the measurement or error. The controller output is calculated by the rate of change of the measurement with time.

Controller Output = Derivative dm / dt

Where *m* is the measurement at time *t*.

Some manufacturers use the term rate or pre-act instead of derivative. Derivative, rate, and pre-act are the same thing.

Derivative = Rate = PRE ACT

Derivative action can compensate for a changing measurement. Thus, derivative takes action to inhibit more rapid changes of the measurement than proportional action. When a load or set point change occurs, the derivative action causes the controller gain to move the "wrong" way when the measurement gets near the set point. Derivative is often used to avoid overshoot.

Derivative action can stabilize loops since it adds phase lead. Generally, if you use derivative action, more controller gain and reset can be used.

A proportional + integral:

The integral action corrects for the offset that characterizes the proportional action. The effective result of the composite P+I action is equivalent to manual adjustment or resetting of set point after each load change.

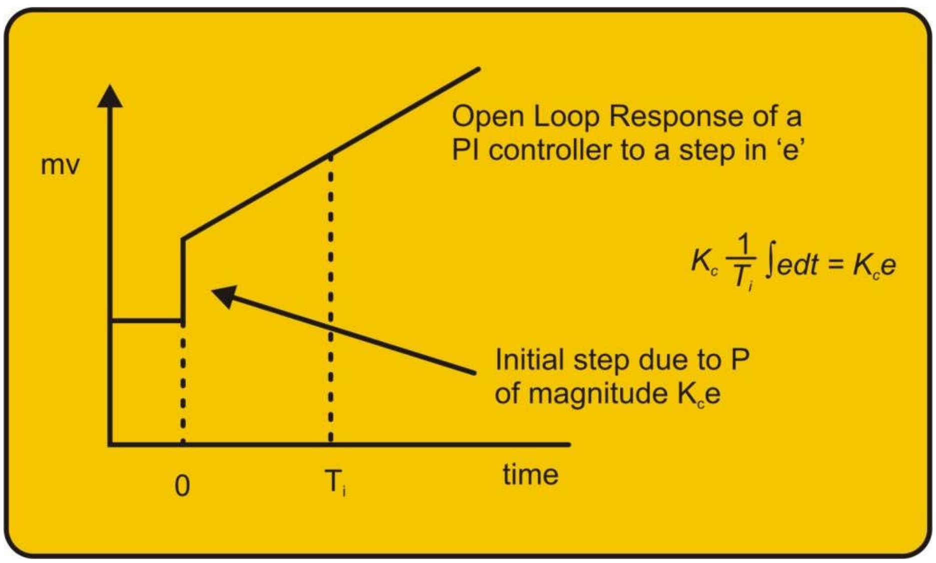
The mathematical representation is,

$$\frac{mv(s)}{e(s)} = k_c\left[1 + \frac{1}{T_i s}\right] \text{or } mv(t)\ mv_{ss} + k_c\left[e(t) + \frac{1}{T_i}\int e(t)dt\right]$$

The additional integral mode (often referred to as reset) corrects for any offset (error) that may occur between the desired value (set point) and the process output automatically over time2. The adjustable parameter to be specified is the integral time (Ti) of the controller.

Where does the term reset come from?

Reset is often used to describe the integral mode. Reset is the time it takes for the integral action to produce the same change in mv as the P modes initial (static) change. Consider the following Figure.



The response of a PI algorithm to a step in error

Figure 3

(Figure 3) shows the output that would be obtained from a PI controller given a step change in error. The output immediately steps due to the P mode. The magnitude of the step up is Kce . The integral mode then causes the mv to „ramp". Over the period 'time 0 to time TI' the mv again increases by Kce.

Integral wind-up:

When a controller that possesses integral action receives an error signal for significant periods of time the integral term of the controller will increase at a rate governed by the integral time of the controller. This will eventually cause the manipulated variable to reach 100% (or 0%) of its scale, i.e. its maximum or minimum limits. This is known as integral wind-up. A sustained error can occur due to a number of scenarios, one of the more common being control system „override‟. Override occurs when another controller takes over control of a particular loop, e.g. because of safety reasons. The original controller is not switched off, so it still receives an error signal, which through time, „winds-up‟ the integral component unless something is done to stop this occurring. There are many techniques that may be used to stop this happening. One method is known as „external reset feedback. Here, the signal of the control valve is also sent to the controller. The controller possesses logic that enables it to integrate the error when its signal is going to the control value, but breaks the loop if the override controller is manipulating the valve.

Proportional + Derivative:

Proportional Integral Derivative algorithm

The mathematical representation is,

$$\frac{mv(s)}{e(s)} = k_c\left[1+\frac{1}{T_i s}+T_D s\right] \text{ or } mv(t)\ mv_{ss} + k_c\left[e(t)+\frac{1}{T_i}\int e(t)dt + T_D\frac{de(t)}{dt}\right]$$

Derivative action (also called rate or pre-act) anticipates where the process is heading by looking at the time rate of change of the controlled variable (its derivative). TD is the *'rate time'* and this characterizes the derivative action (with units of minutes). In theory, derivative action should always improve dynamic response and it does in many loops. In others, however, the problem of noisy signals makes the use of derivative action undesirable (differentiating noisy signals can translate into excessive mv movement).

Derivative action depends on the slope of the error, unlike P and I. If the error is constant, derivative action has no effect.

PID algorithms can be different:

Not all manufactures produce PID‟s that conform to the ideal 'textbook' structure. So before commencing tuning it is important to know the configuration of the PID algorithm! The majority of „text-book‟ tuning rules are only valid for the ideal architecture. If the algorithm is different then the controller parameters suggested by a particular tuning methodology will have to be altered.

Ideal PID:

The mathematical representation of this algorithm is:

$$\frac{mv(s)}{e(s)} = k_c\left[1+\frac{1}{T_i s}+T_D s\right]$$

One disadvantage of this ideal 'textbook' configuration is that a sudden change in set point (and hence e) will cause the derivative term to become very large and thus provide a “derivative kick” to the final control element this is undesirable. An alternative implementation is

$$mv(s) = k_c\left[1+\frac{1}{T_i s}\right]e(s) + T_D scv\ (s)$$

The derivative mode acts on the measurement and not the error. After a change in set point the output will move slowly avoiding "derivative kick" after set point changes. This is therefore a standard feature of most commercial controllers.

Series (interacting) PID:

The mathematical representation of this algorithm is:

$$\frac{mv(s)}{e(s)} = k_c\left[1+\frac{1}{T_i s}\right]T_D s$$

As with the ideal implementation, the series mode can include either derivative on the error or derivative on the measurement. In which case, the mathematical representation is,

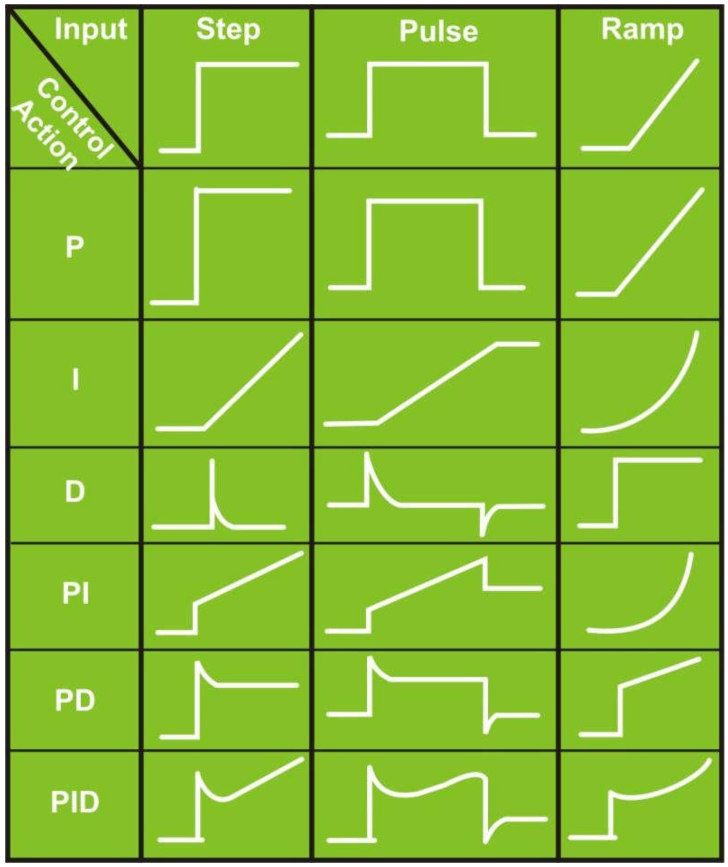
$$\frac{mv(s)}{e(s)} = k_c\left[1+\frac{1}{T_i s}\right]\text{where } e(s) = SP - T_D scv\ (s)$$

Parallel PID:

The mathematical description is,

$$mv(s) = k_c e(s) + \frac{1}{T_i s}\ e(s) + T_D se\ (s)$$

The proportional gain only acts on the error, whereas with the ideal algorithm it acts on the integral and derivative modes as well.



Controller Responses to Different Excitations

Table 1

Experiment 1

Objective: Study of Proportional + Integrator (PI)

Procedure:

Connections for Proportional + Integrator (PI) controller are as shown in the figure 12.

1. After making, all required connection on board which on the power supply and start the experiment.
2. Ground PV and inputs of summing block which are not in use.
3. Apply square wave to the set point (SP).
4. Check the output of summer block ∑ of summing block on CRO that will look like as shown in figure 13.
5. Vary slowly the KP & KI value and observe the changes in the output.
6. In the same manner, we can check by applying triangular wave.

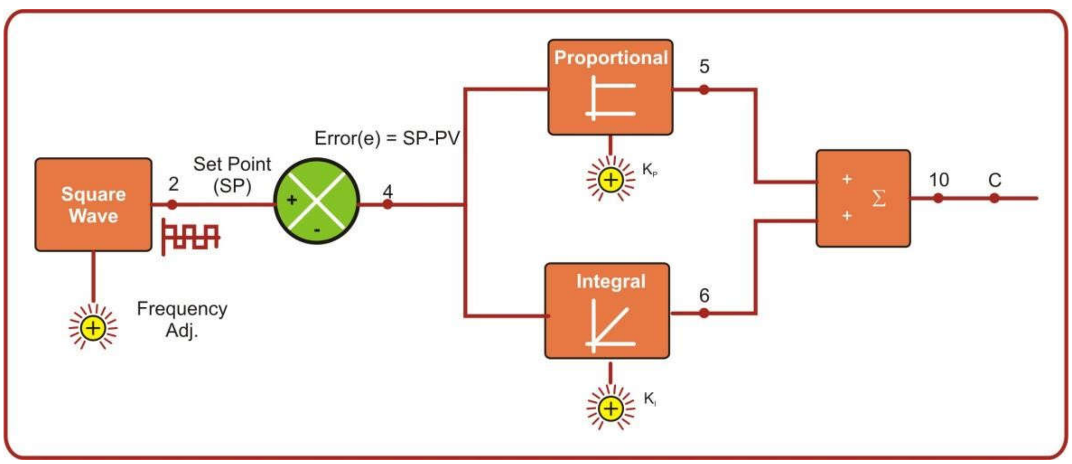


Figure 12

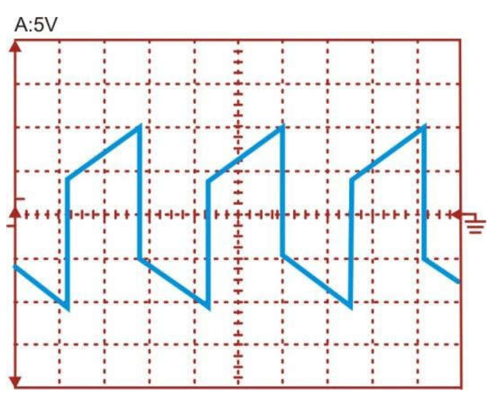


Figure 13

Experiment 2

Objective: Study of Proportional + Derivative (PD)

Procedure:

Connections for Proportional + Derivative (PD) controller are as shown in the figure 14.

1. After making, all required connection on board which on the power supply and start the experiment.
2. Ground PV and inputs of summing block which are not in use.
3. Apply square wave to the set point (SP).
4. Check the output of summer block ∑ of summing block on CRO that will look like as shown in figure 15.
5. Vary slowly the KP & KD value and observe the changes in the output and compare with table no.1 showing the.
6. In the same manner, we can check by applying triangular wave.

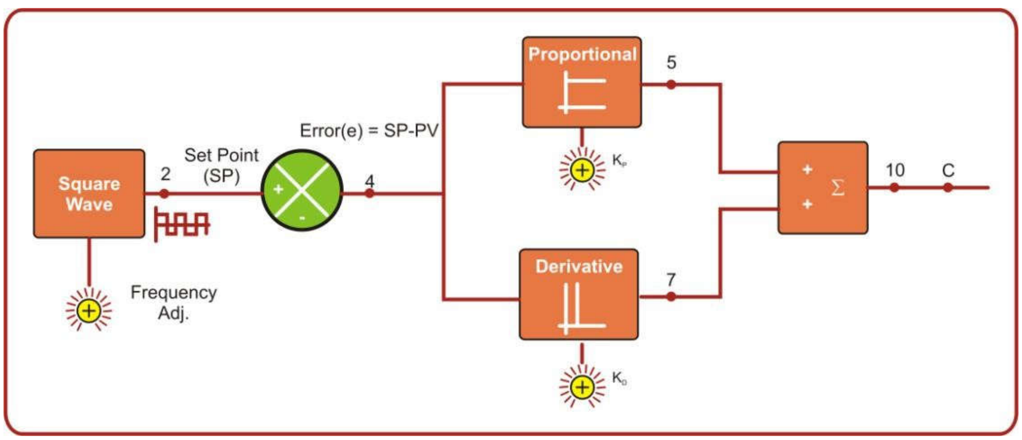


Figure 14

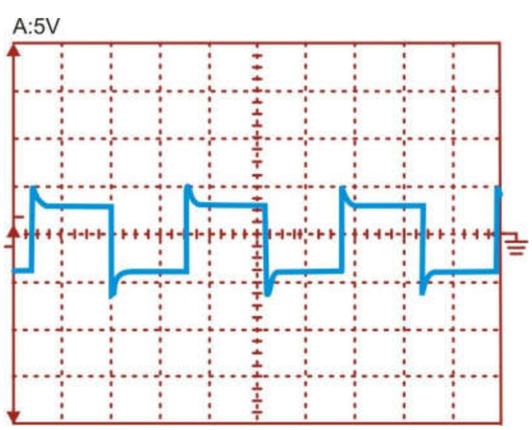


Figure 15

Experiment 3

Objective: Study of Proportional + Integrator + Derivative (PID)

Procedure:

Connections for Proportional + Integrator + Derivative (PID) controller are as shown in the figure 16.

1. After making, all required connection on board which on the power supply and start the experiment.
2. Ground PV and inputs of summing block which are not in use.
3. Apply square wave to the set point (SP).
4. Check the output of summer block ∑ of summing block on CRO that will look like as shown in figure 17.
5. Vary slowly the KP, KI & Kd value and observe the changes in the output.
6. In the same manner, we can check by applying triangular wave.

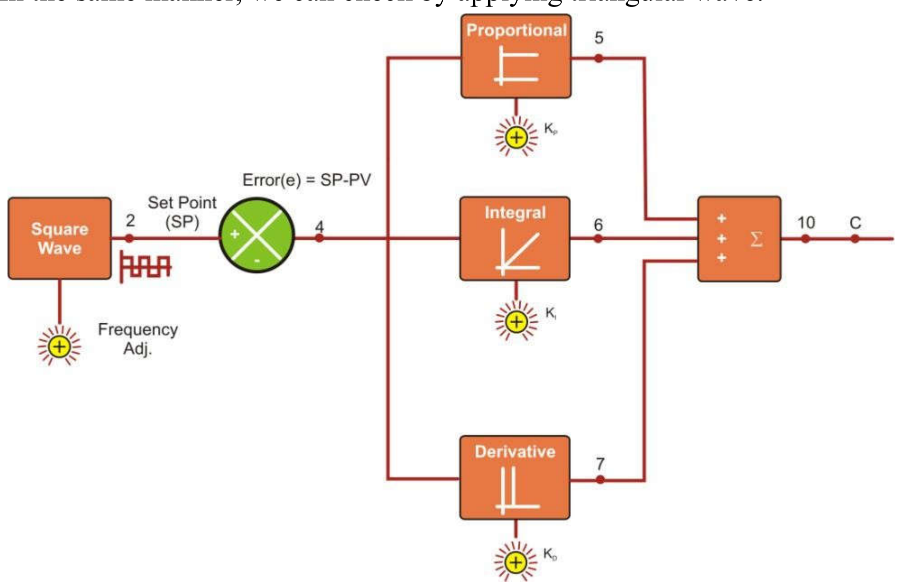


Figure 16

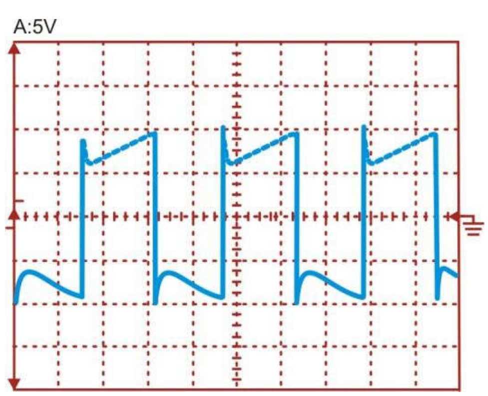


Figure 17

Experiment 4

Objective: Study of Proportional + Integrator + Derivative (PID) in close loop

Procedure:

Connections for Proportional + Integrator + Derivative (PID) controller are as shown in the figure 18.

1. After making, all required connection on board which on the power supply and start the experiment.
2. Ground inputs of summing block which are not in use.
3. Apply square wave to the set point (SP).
4. Check output of summing block on CRO, you will find that after adjusting Kp, Ki & Kd output signal will be same as input applied at SP of error detector .
5. In the same manner, we can check by applying triangular wave.

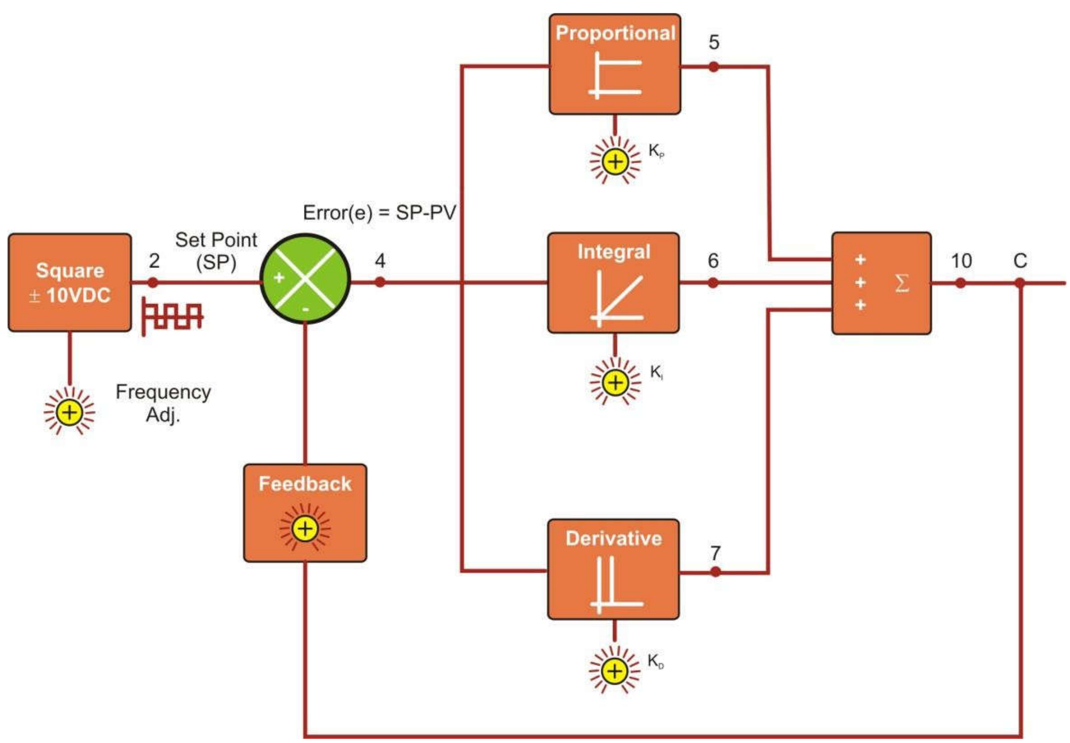


Figure 18

Experiment 5

Objective: Study of Proportional + Integrator + Derivative (PID) with first ordersystem

Procedure:

First Apply 1V to the first order system block and observe the transient response on Digital storage oscilloscope, you will observe the response as shown in figure 20.

1. Then do the Connections for Proportional + Integrator + Derivative (PID) with first order system are as shown in the figure 19.
2. After making, all required connection on board which on the power supply and start the experiment.
3. Ground inputs of summing block which are not in use.
4. Check the transient response of I^{st} order system output on Digital storage oscilloscope; you will observe the response as shown in figure 21. You can easily observe the effect of PID by adjusting Kp, Ki & Kd knobs.

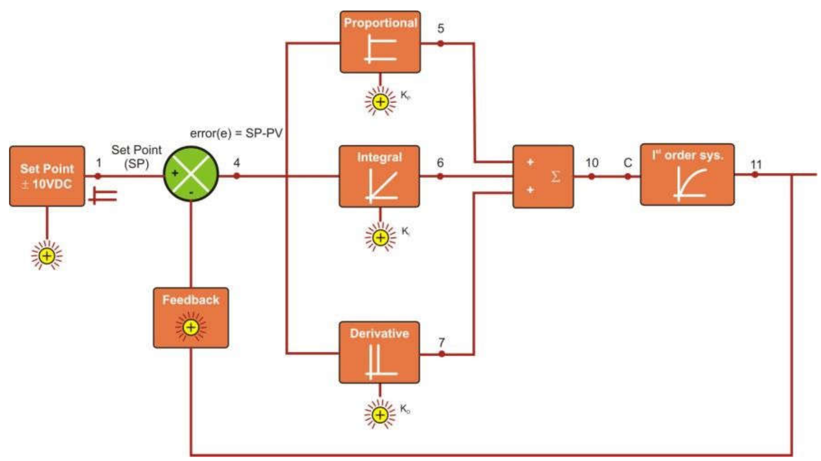


Figure 19

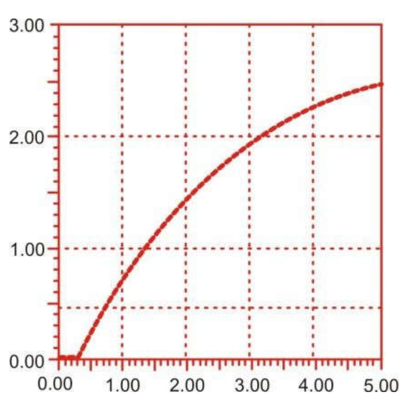


Figure 20

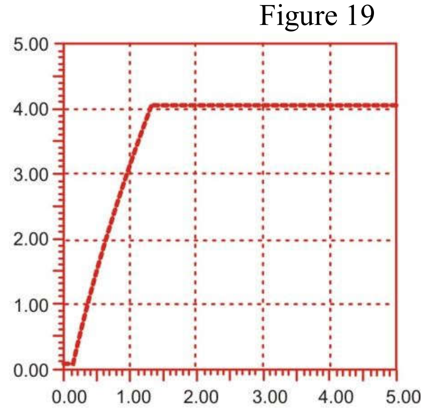


Figure 21

Experiment 6

Objective: Study of Proportional + Integrator + Derivative (PID) with second order system

Procedure:

First Apply 2V to the second order system block and observe the transient response on Digital storage oscilloscope, you will observe the response as shown in figure 23.

1. Then do the Connections for Proportional + Integrator + Derivative (PID) with second order system are as shown in the figure 22.
2. After making, all required connection on board which on the power supply and start the experiment.
3. Ground inputs of summing block which are not in use.
4. Check the transient response of II^{nd} order system output on Digital storage oscilloscope; you will observe the response as shown in figure 24. You can easily observe the effect of PID by adjusting Kp, Ki & Kd knobs.

Figure 22

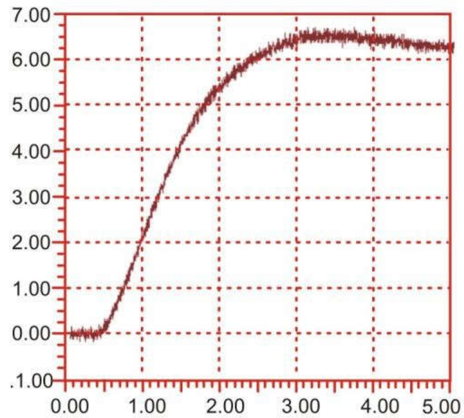


Figure 23

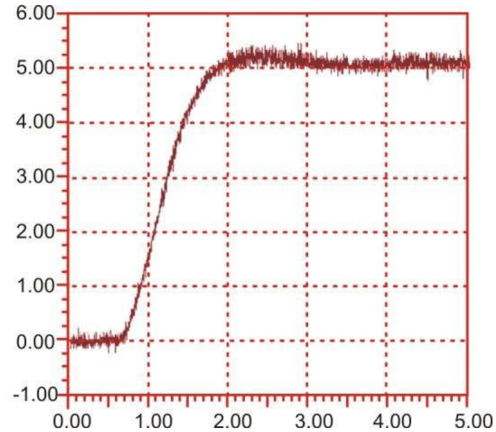


Figure 24

RESULT: the performance of PID controllers studied.

Speed Control of DC Motor by PLC

Scientech 2426

Table of Contents

Safety Instructions

Read the following safety instructions carefully before operating the instrument. To avoid any personal injury or damage to the instrument or any product connected to it.

Do not operate the instrument if suspect any damage to it.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Observe Terminal Ratings : To avoid fire or shock hazards, observe all ratings and marks on the instrument.

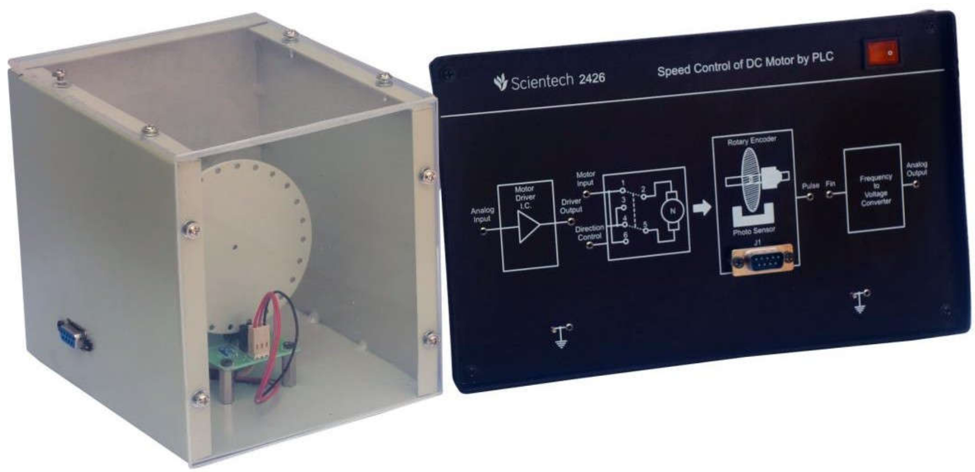
Use only the proper Fuse : Use the fuse type and rating specified for this instrument.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Introduction

Scientech 2426 Speed Control of DC Motor by PLC has a DC Motor driver which works on PWM technique. Today's industries are increasingly demanding process automation in all sectors. Automation results into better quality, increased production at reduced costs. Variable speed drives, which can control the speed of AC/DC Motors, are indispensable controlling elements in automation systems. Depending on the applications, some of them are fixed speed and some of the variable speed drives. There are several methods to control the speed of a DC Motor, out of which the PWM based DC Motor driver gives the best results. This circuit smoothly controls the speed of a general purpose DC Motor. The Permanent Magnet DC Motor (PMDC) is the most commonly used type of small Direct Current Motor available producing a continuous rotational speed that can be easily controlled. Small DC Motors are ideal for use in applications where speed control is required such as in Camera Position Control, Robots and other such electronic circuits.



Features

- Slotted disk for speed measurement
- Separated unit for Motor in see through cabinet
- Precise Signal conditioning
- Sensitive, stable and accurate
- User friendly and powerful instruction sets
- Easy to operate
- Ready to use application board
- Online Product Tutorial

Technical Specifications

Analog Input ranges	:	0-1V approximately
Analog Output range	:	0-10V
DC Motor:		
Supply Voltage	:	12V DC
Speed range	:	2400 RPM
Speed sensing	:	IR Sensor
Digital Output pin Voltage	:	5VDC when particular O/P is activated from PLC
Output of F/V Convertor	:	0-10Vmax 0 to 2400 RPM
Mains Supply	:	100-240V AC, 50/60 Hz
Dimension (mm)	:	W 255 × D 155 × H 80
Weight	:	1.2kg (approximately)

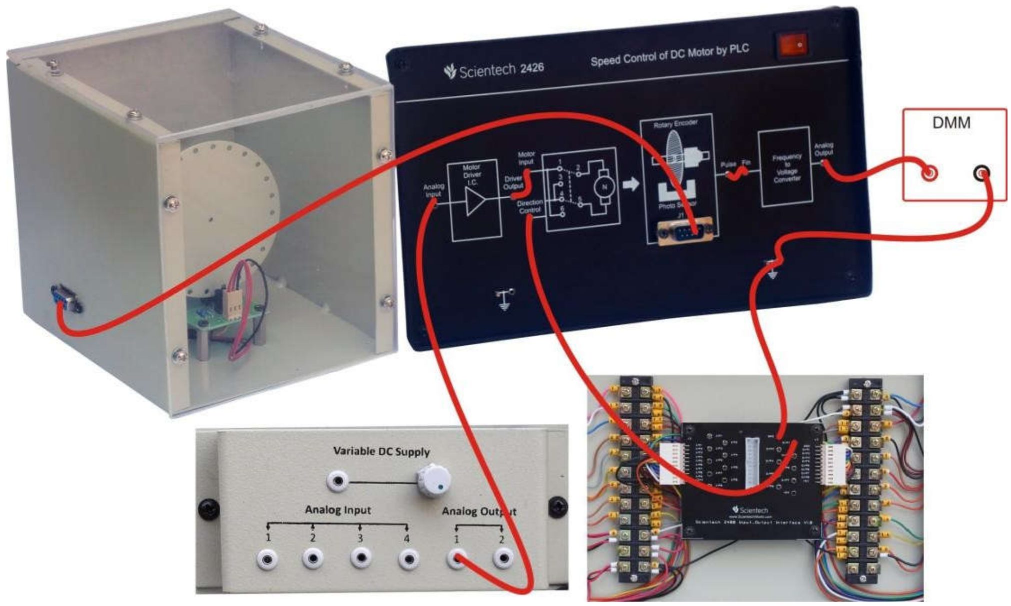
List of Accessories

1. Patch Cords 16” (2 mm) .... 5 Nos.
2. Mains Cords ....1 No.
3. Serial Cable for Motor Cabinet... 1 No.

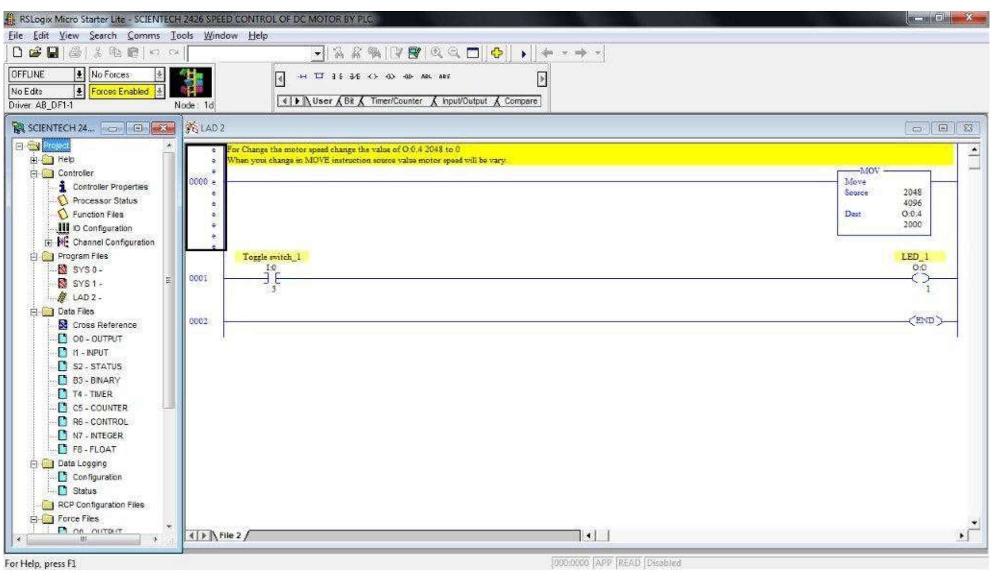
How It Works

Procedure:

- Make a connection diagram according to below given connection diagram.



- Open Scientech 2426 ladder program and compile download and run the program.



- When you enter Value of O:0.4 (Analog Output) from 0 to 4096 . When you enter 0 in move instruction then Motor will stop. When you enter 2048 then see the change in speed of dc motor.

- When you enable the I:0/3 (Toggle Switch_1) then o:0/1 (LED_1) will on then DC Motor direction will change.

RESULT:

Supervisory Control and Data Acquisition (SCADA)

Scientech 2430

Product Tutorial

Ver. 1.0

Designed & Manufactured in India by-
An ISO 9001:2008 company
Scientech Technologies Pvt. Ltd.
94, Electronic Complex, Pardesipura, Indore - 452 010 India,
+ 91-731 4211100, : info@scientech.bz , : www.ScientechWorld.com

Supervisory Control and Data Acquisition (SCADA)

Scientech 2430

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Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Safety Instructions

Read the following safety instructions carefully before operating the Scientech 2003A. To avoid any personal injury or damage to the instrument or any product connected to the instrument.

Do not operate the instrument if suspect any damage to it.

The instrument should be serviced by qualified personnel only.

For your safety:

Use proper Mains cord : Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.

Ground the Instrument : This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock, the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.

Use in proper Atmosphere : Please refer to operating conditions given in the manual.

1. **Do not operate in wet / damp conditions.**
2. **Do not operate in an explosive atmosphere.**
3. **Keep the product dust free, clean and dry.**

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Introduction

Scientech provides Wonderware Indusoft Web Studio SCADA software for industrial automation, process control and supervisory monitoring. Wonderware Indosoft Web Studio SCADA enables users to visualize and control processes while providing them with an easy-to-use development environment and extensive functionality to rapidly create test and deploy powerful automation applications that connect and deliver real-time information. SCADA software is an open and extensible HMI that enables flexibility in custom application design with connectivity to the broadest set of automation devices in the industry.

Features

- Ready-to-use symbol library
- React and respond in real-time
- Real time monitoring.
- Friendly, manageable, secure, extensible.
- Easy-to-use, easy to implement
- Easy configuration, simplified maintenance
- Communication with PLC
- Easy and flexible alarm definition
- Data collection and analysis for new and existing systems
- Easy-to-use for report generation
- Open access to historical data
- Different packages available with input/output structure

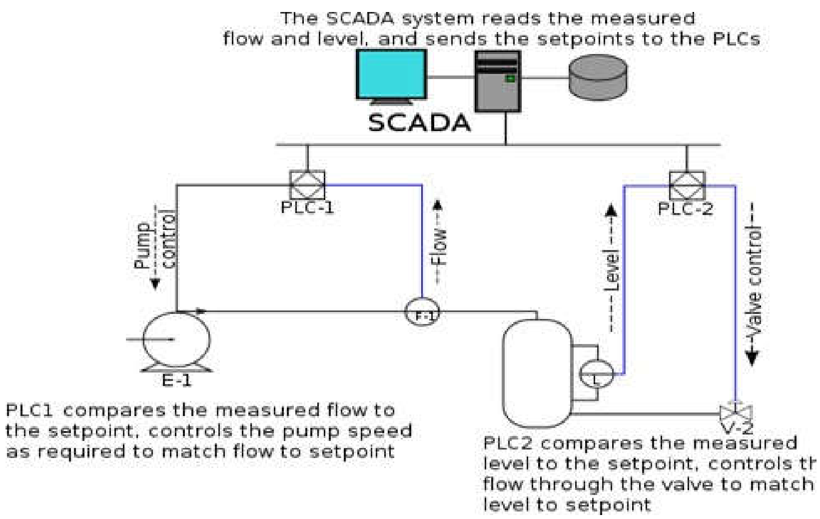
Technical Specifications

SCADA	:	150 tags
Functions	:	Trending, alarming, reporting, security, event and others functions.
Package contains	:	Software DVD, license key

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Theory

SCADA stands for supervisory control and data acquisition. It is a type of software application program for process control. SCADA is a central control system which consist of controllers network interfaces, input/output, communication equipments and software. SCADA systems are used to monitor and control the equipments in the industrial process which include manufacturing, production, development and fabrication. The infrastructural processes include gas and oil distribution, electrical power, water distribution. Public utilities include bus traffic system, airport. The SCADA system takes the reading of the meters and checks the status of sensors in regular interval so that it requires minimal interference of human.



Architecture:

Generally SCADA system is a centralized system which monitors and controls entire area. It is purely software package that is positioned on top of hardware. A supervisory system gathers data on the process and sends the commands control to the process. The SCADA is a remote terminal unit which is also known as RTU. Most control actions are automatically performed by RTUs or PLCs. The RTUs consist of programmable logic converter which can be set to specific requirement. For example, in the thermal power plant the water flow can be set to specific value or it can be changed according to the requirement.

The SCADA system allows operators to change the set point for the flow, and enable alarm conditions incase of loss of flow and high temperature and the condition is displayed and recorded. The SCADA system monitors the overall performance of the loop. The SCADA system is a centralized system to communicate with both wire and wireless technology to Clint devices. The SCADA system controls can run completely all kinds of industrial process.

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Working Procedure of SCADA system:

The SCADA system performs the following functions:

- Data Acquisitions
- Data Communication
- Information/Data presentation
- Monitoring/Control

These functions are performed by sensors, RTUs, controller, communication network. The sensors are used to collect the important information and RTUs are used to send this information to controller and display the status of the system. According to the status of the system, the user can give command to other system components. This operation is done by the communication network.

Data Acquisitions:

Real time system consists of thousand of components and sensors. It is very important to know the status of particular components and sensors. For example, some sensors measure the water flow from the reservoir to water tank and some sensors measure the value pressure as the water is release from the reservoir.

Data Communication:

The SCADA system uses wired network to communicate between user and devices. The real time applications use lot of sensors and components which should be control remotely. The SCADA system uses internet communications. All information is transmitted through internet using specific protocols. Sensor and relays are not able to communicate with the network protocols so RTUs used to communicate sensors and network interface.

Information/Data presentation:

The normal circuit networks have some indicators which can be visible to control but in the real time SCADA system, there are thousand of sensors and alarm which are impossible to be handled simultaneously. The SCADA system uses human machine interface (HMI) to provide all of the information gathered from the various sensors**.**

Human machine interface:

The SCADA system uses human machine interface. The information is displayed and monitored to be processed by the human. HMI provides the access of multiple control units which can be PLCs and RTUs. The HMI provides the graphical presentation of the system. For example, it provides the graphical picture of the pump connected to the tank. The user can see the flow of the water and pressure of the water. The important part of the HMI is an alarm system which is activated according to the predefined values.

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Who Uses SCADA?

SCADA systems are used by industrial organizations and companies in the public and private sectors to control and maintain efficiency, distribute data for smarter decisions, and communicate system issues to help mitigate downtime. SCADA systems work well in many different types of enterprises because they can range from simple configurations to large, complex installations. SCADA systems are the backbone of many modern industries, including:

- Energy
- Food and beverage
- Manufacturing
- Oil and gas
- Power
- Recycling
- Transportation
- Water and waste water
- And many more

The temperature sensors are connected to the microcontroller, which is connected to the PC at the front end and software is loaded on the computer. The data is collected from the temperature sensors. The temperature sensors continuously send the signal to the microcontroller which accordingly displays these values on its front panel. One can set the parameters like low limit and high limit on the computer screen. When the temperature of a sensor goes above set point the microcontroller send a command to the corresponding relay. The heaters connected through relay contacts are turned OFF and ON.

For example SCADA for Remote Industrial Planet:

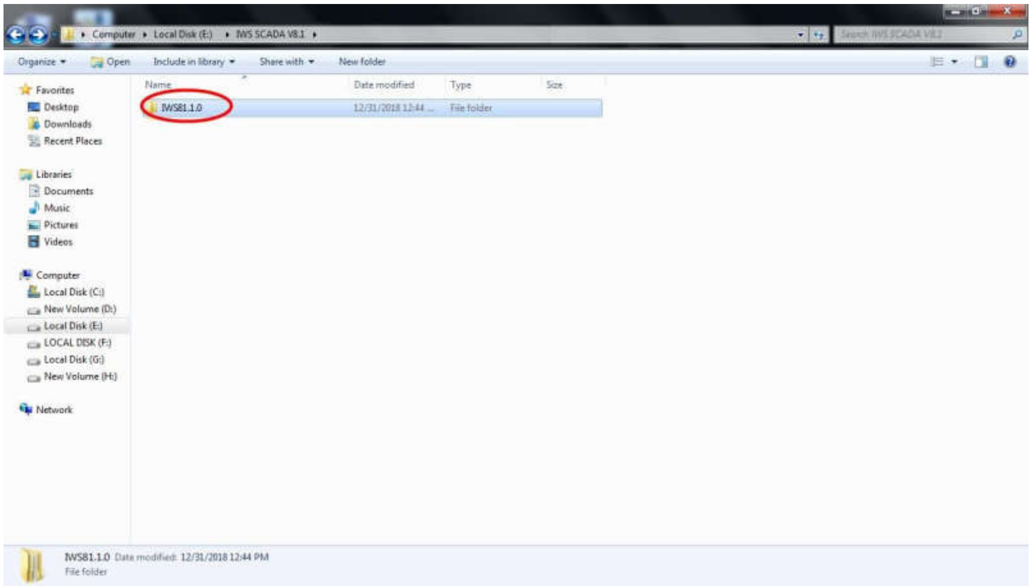
This is a temperature logging System. Here 8 temperature sensors in multiplexing mode are connected to the microcontroller through ADC 0808. Then the values of all the sensors are sent serially by microcontroller through Max 32 to the com port of the PC. A Software “DAQ System” loaded on the PC takes these values and show them on its front panel, and also logs them to the data base “daq.mdb” .One can set by interactive way some parameters like set point, low limit,and high limit on the computer screen . When temperature of some sensor increases beyond set point, the microcontroller sends commands to relay driver IC. The heaters connected through relay contacts are (specific for that sensor) turned OFF (or ON in opposite case).High limit and low limits are for alarm. When temperature goes above high limit or below low limit the alarm will be turned on.

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

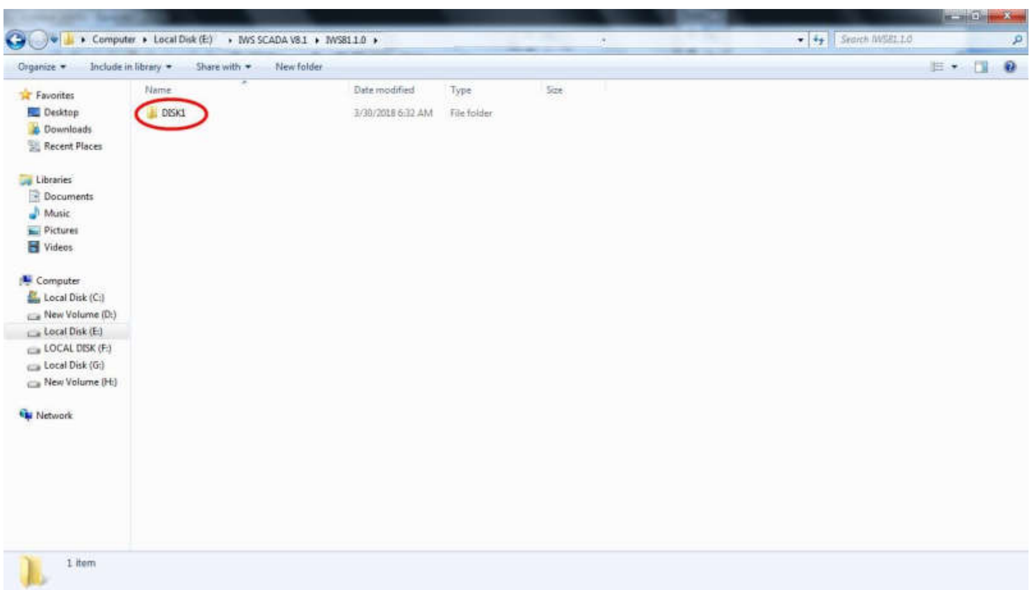
Software Installation

Note: Please connect License Key on your PC before Run a Setup.

- Open **IWS81.10** Folder as shown below**.**

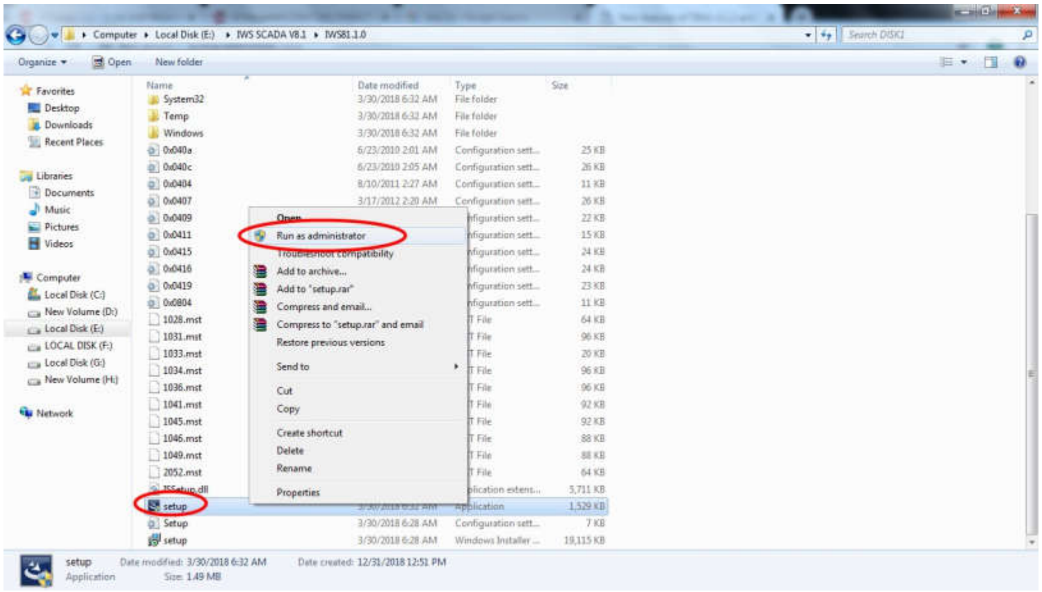


- **Disk1** Folder will open as shown below.



Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

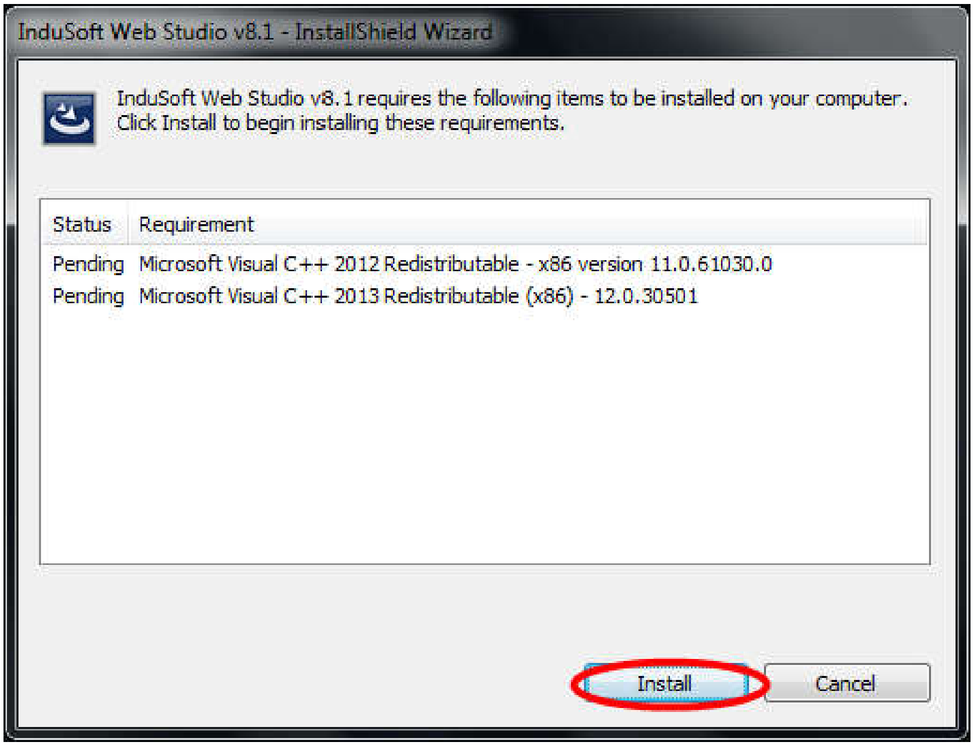
- Right Click on **Set up** icon and click on **Run as administrator** as shown below.



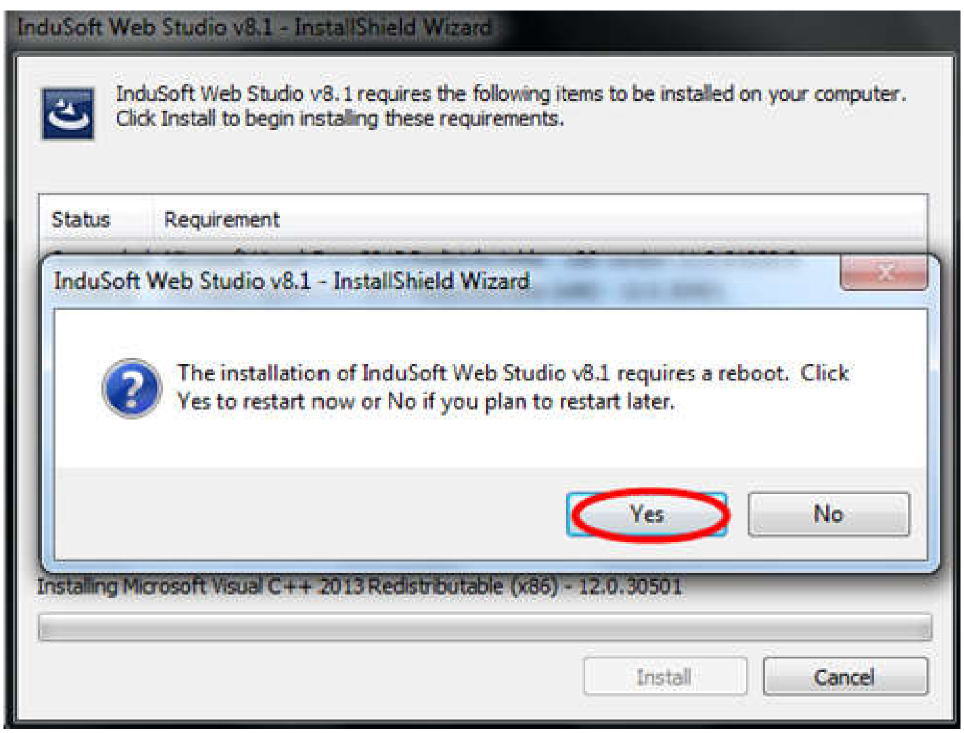
- **Select Language window** will open then select Languages **English (United States)** then click on **OK** Button as shown below.

Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

- Indosoft Web Studio v8.1 InstallShield Wizard window will open then click on Install button as shown below.

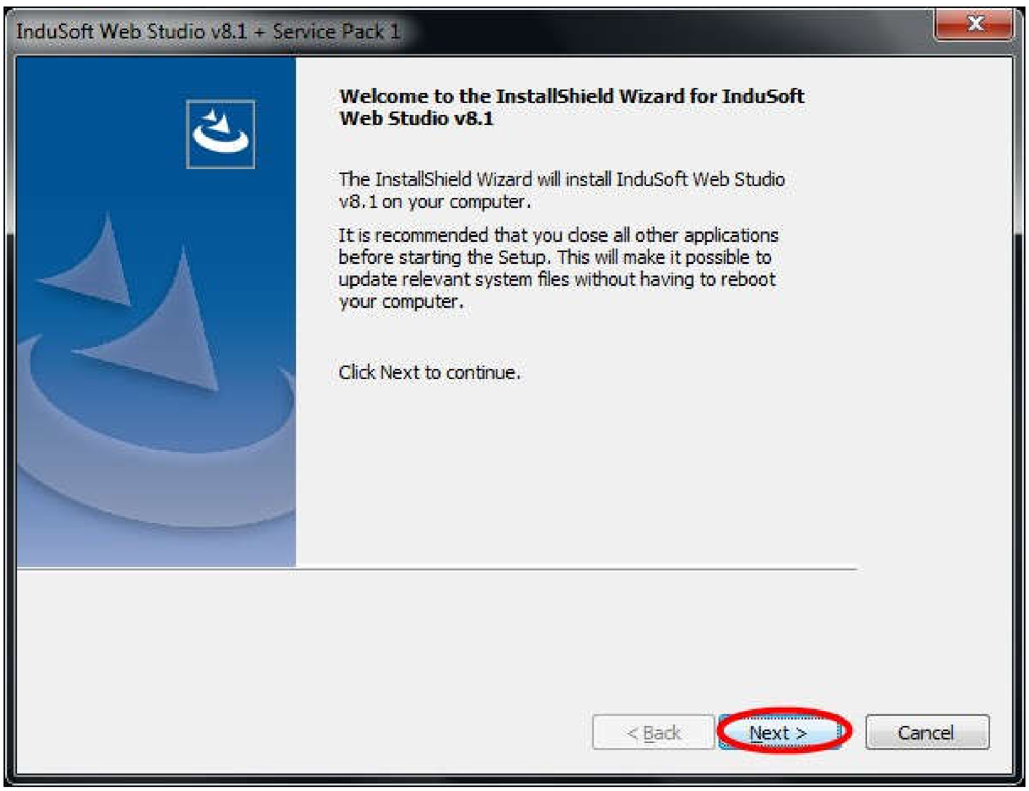


- Click on Yes button for restart a PC.



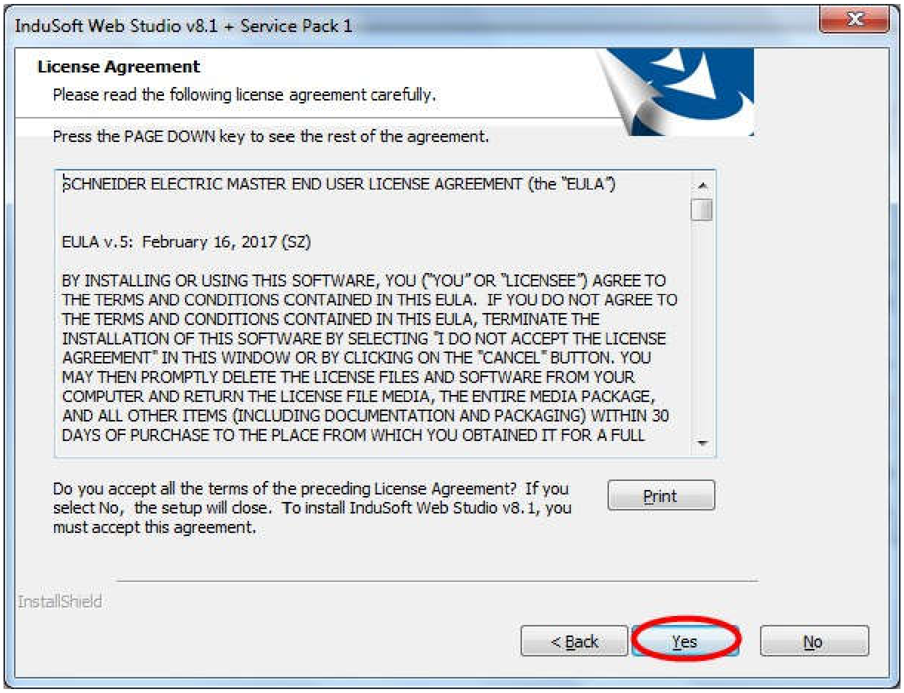
- **Select Language window** will open then select Languages **English (United States)** then click on **OK** Button as shown below.

- Welcome to InstallShield Wizard for Indosoft Web Studio v8.1 will open then click on Next button as shown below.

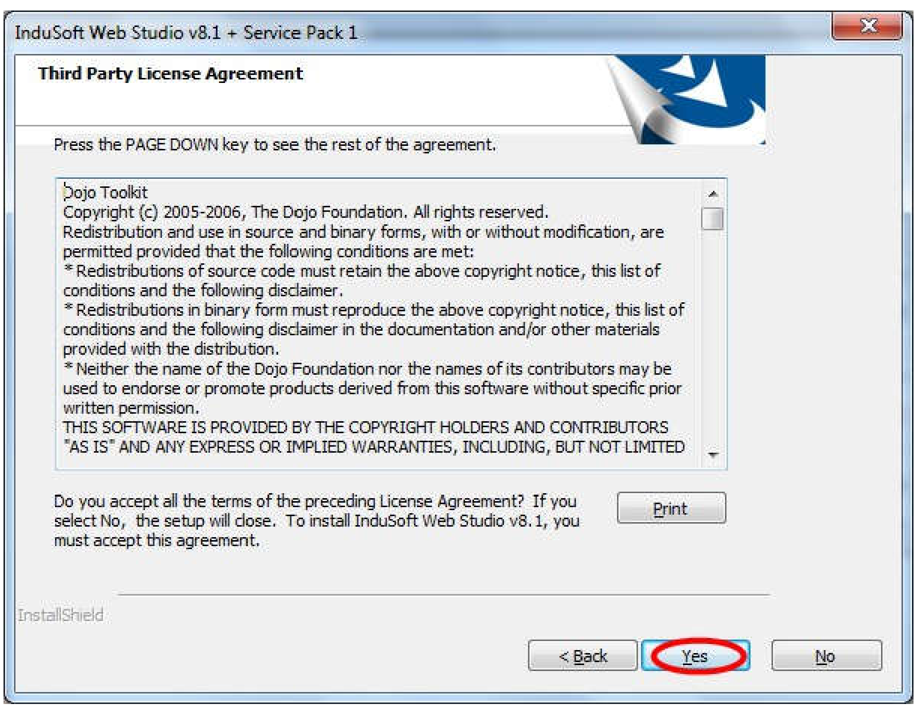


Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

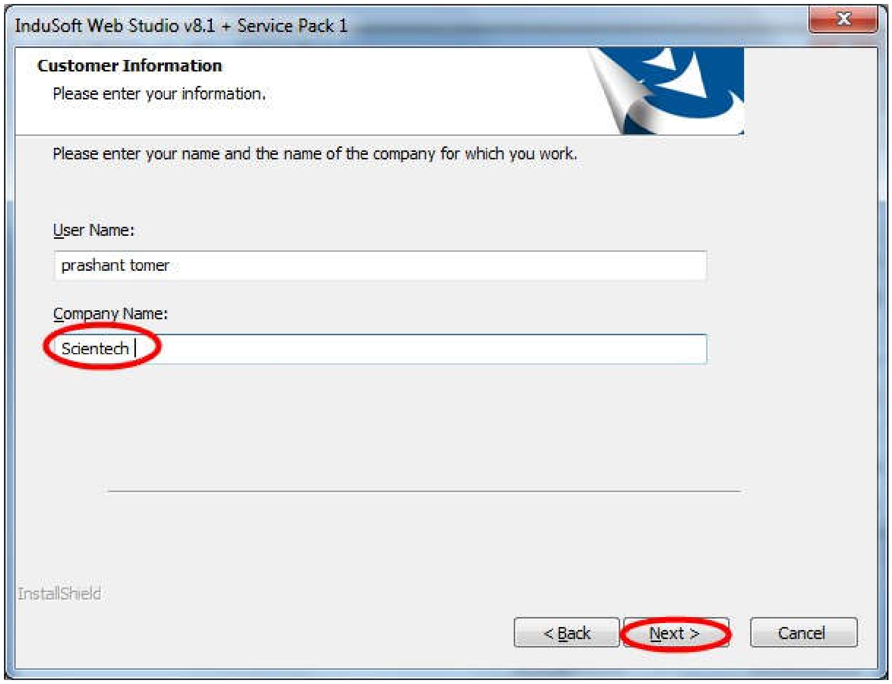
- License Agreement window will open then click on Yes button as shown below.



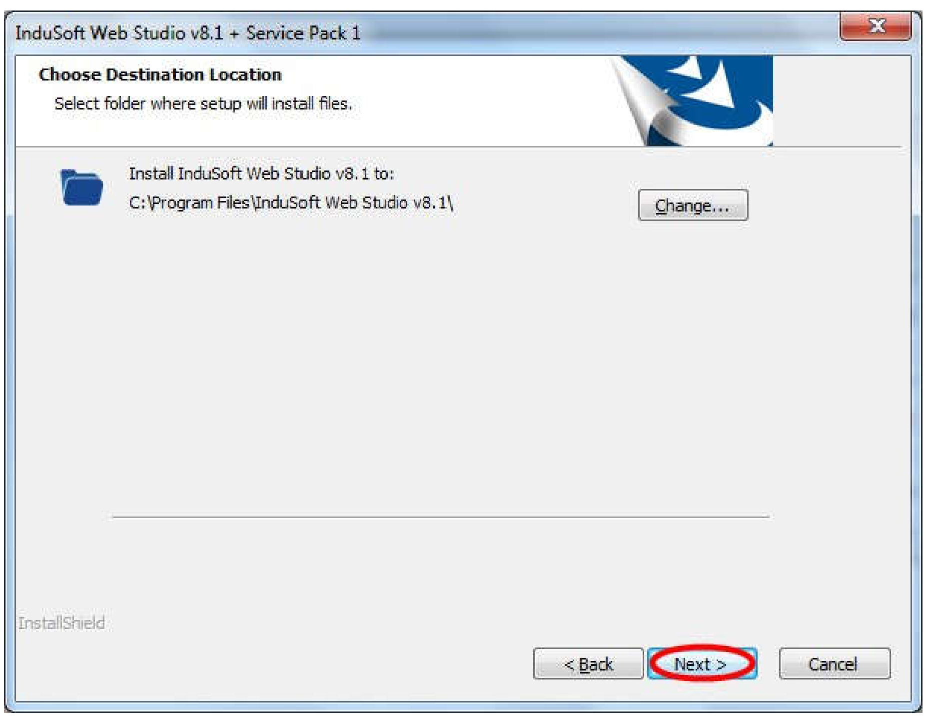
- Third Party License agreement window will open then click on Yes button as shown below.



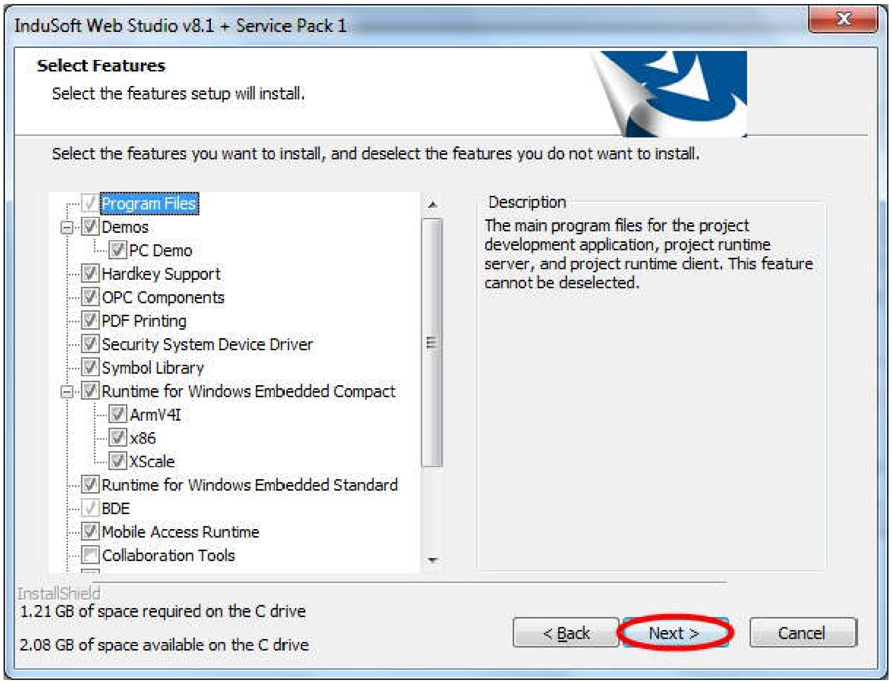
- Customer Information window will open then click on Company Name and click on Next button as shown below.



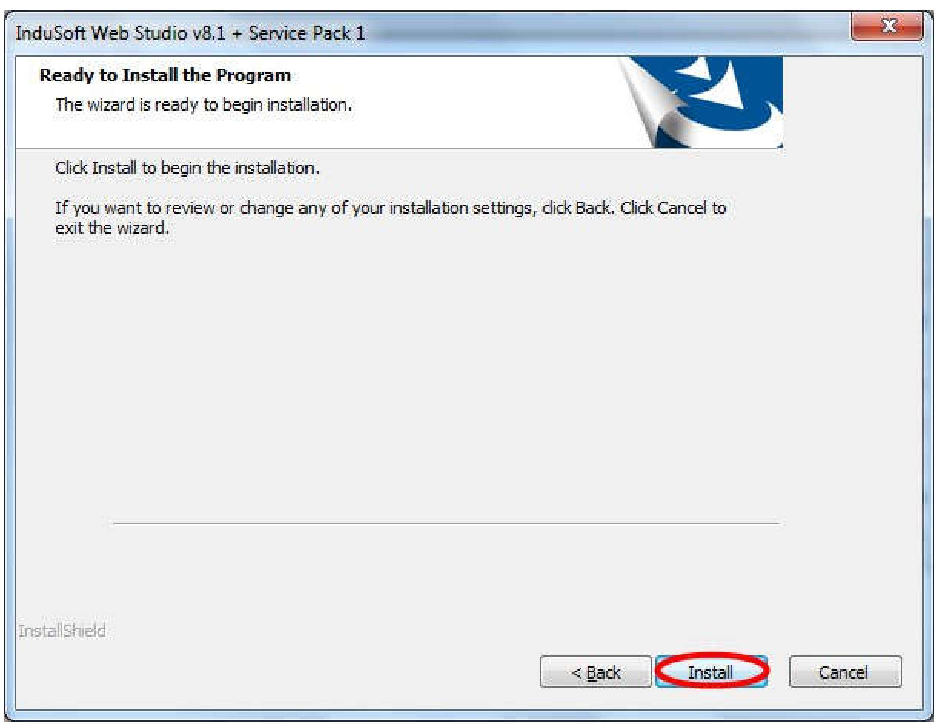
- Choose Destination Location window will open then click on Next button as shown below.



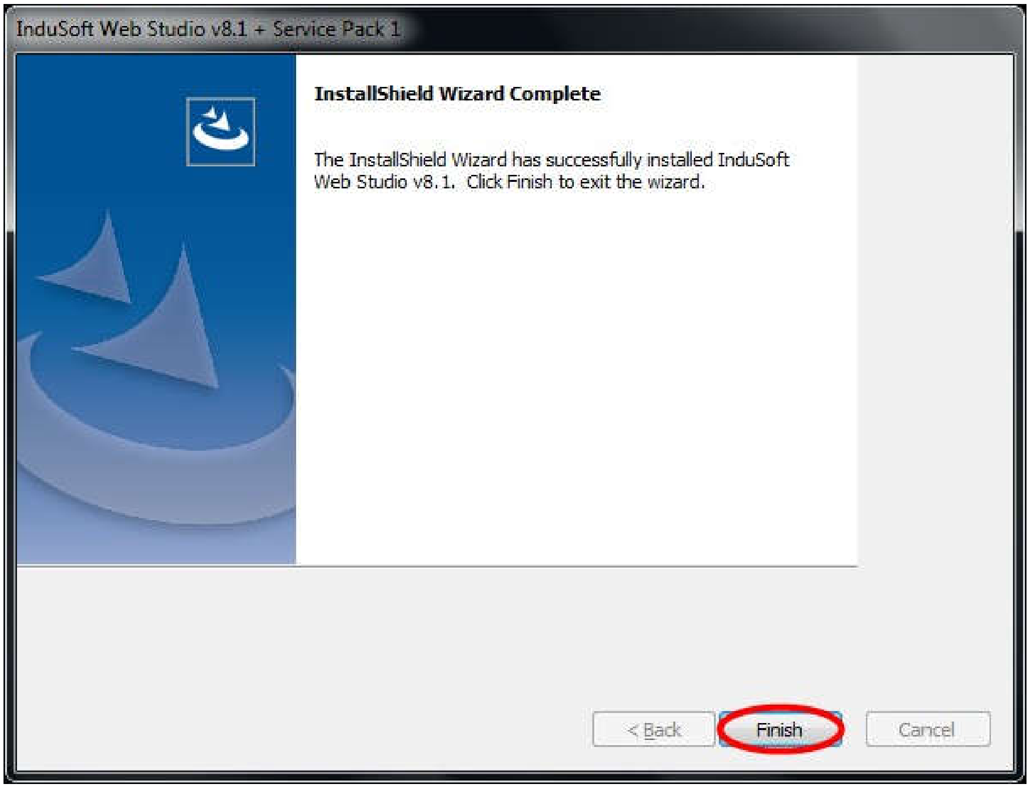
- Select Feature window will open then click on Next button as shown below.



- Ready to Install the Program window will open the click on Install button as shown below.



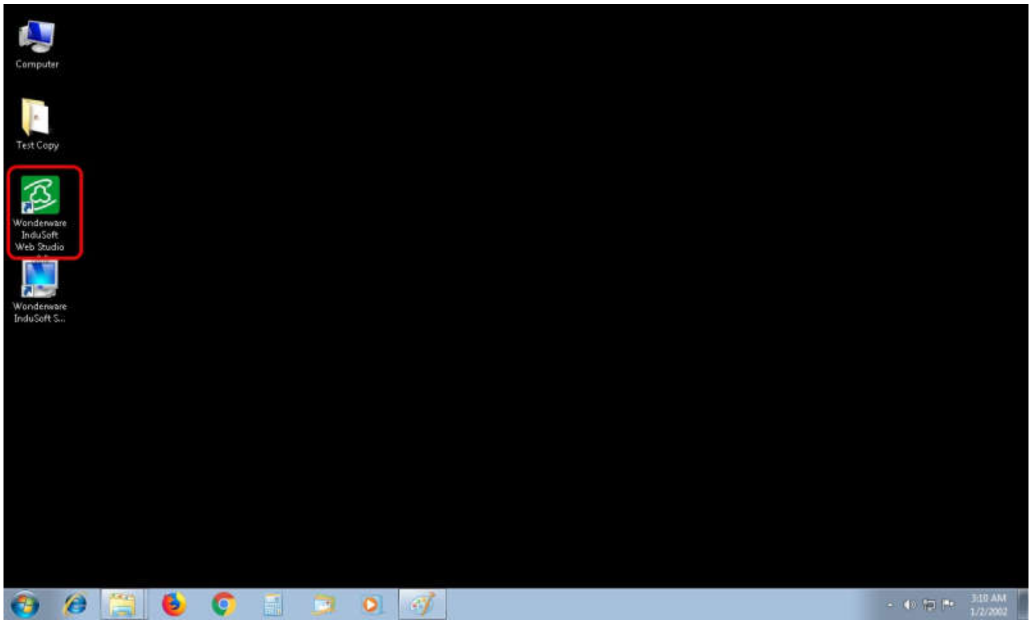
- InstallShield Wizard Complete window will open then click on Finish button as shown below.



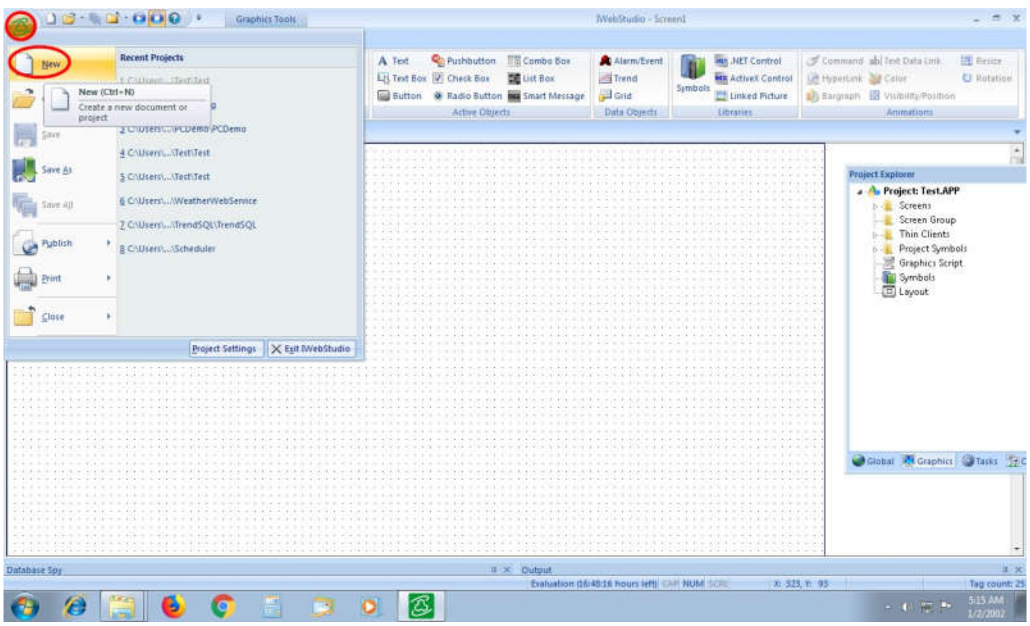
Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

How to make Test Project, Reporting, Alarming, Trending and animation function

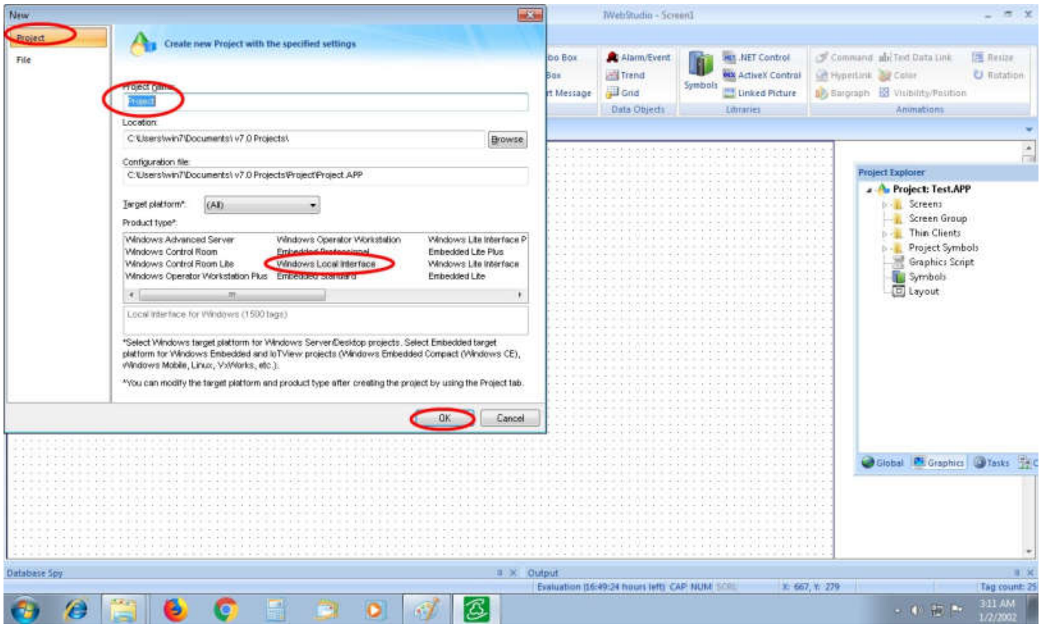
- Double click on Wonderware Indusoft Web Studio 8.10, icon as shown below.



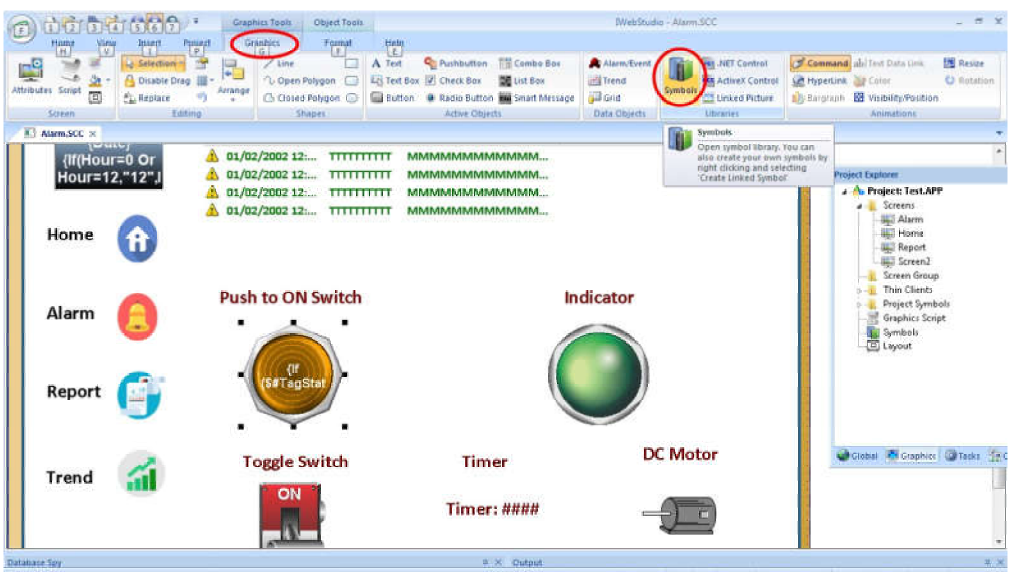
- Click on Indosoft icon then click on New button as shown below.



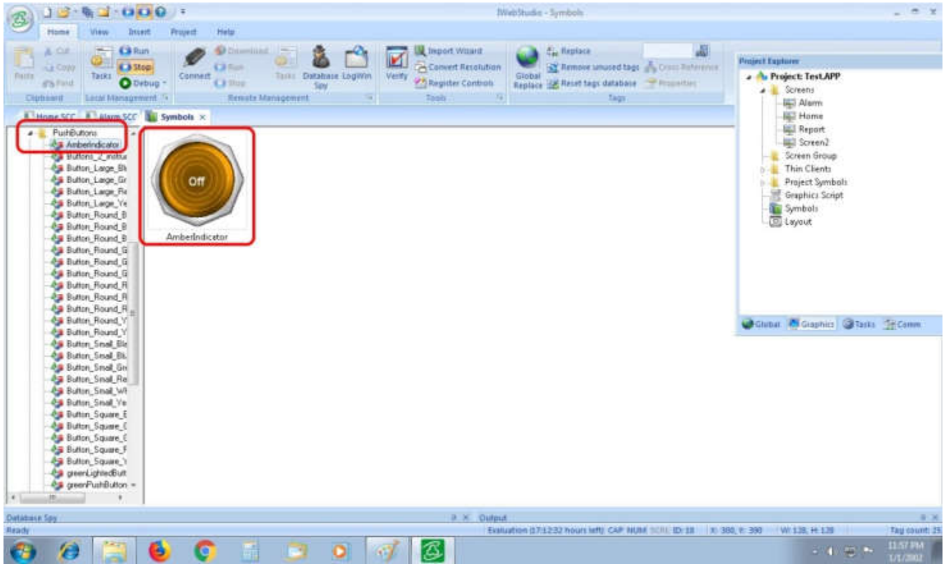
- New window will open then click on Project and give name to project then click on OK button as shown below.



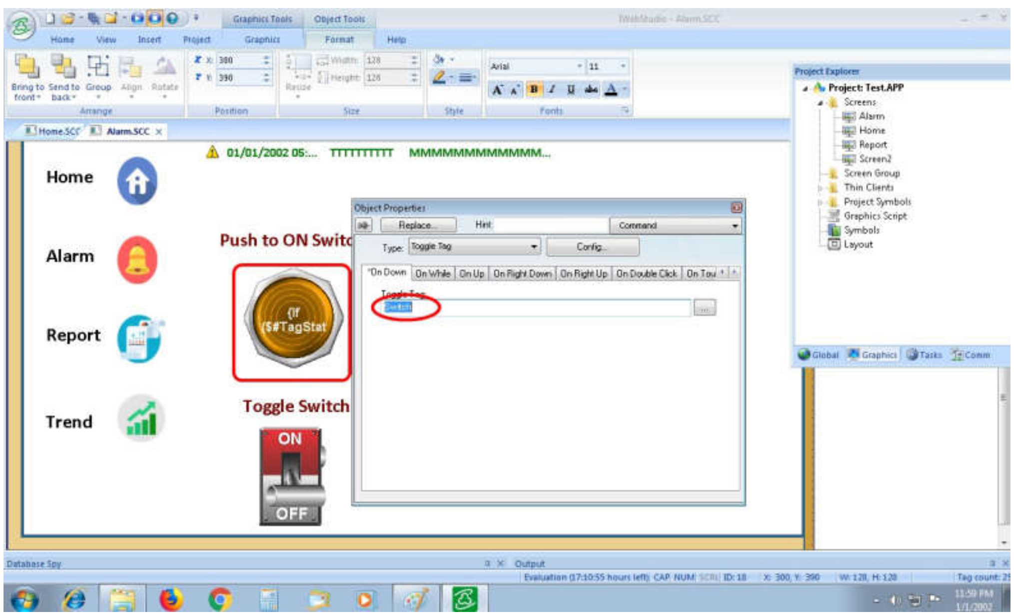
- Click on to the Graphic button then click on Symbol button as shown below.



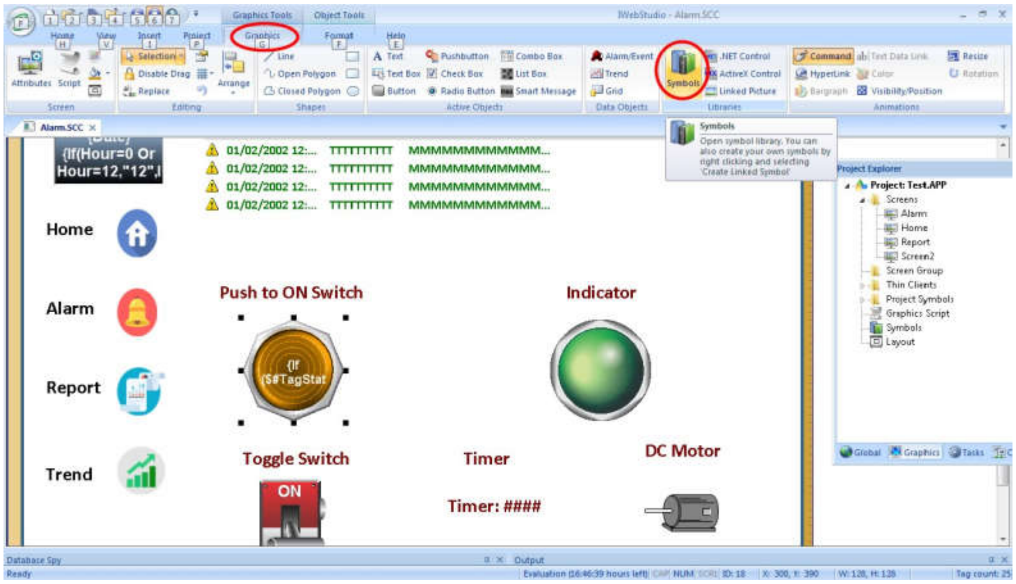
- Select Pushbuttons folder and double click on Amber indicator as shown below.



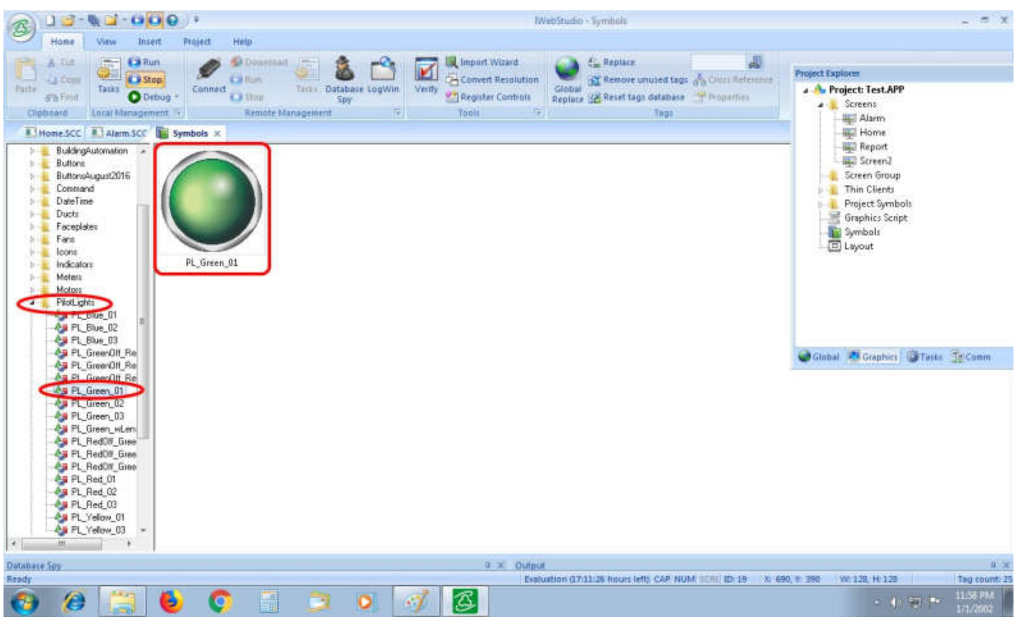
- Double Click on **Push to ON Switch** then assign Name **Toggle Tag** to **Switch** as shown below.



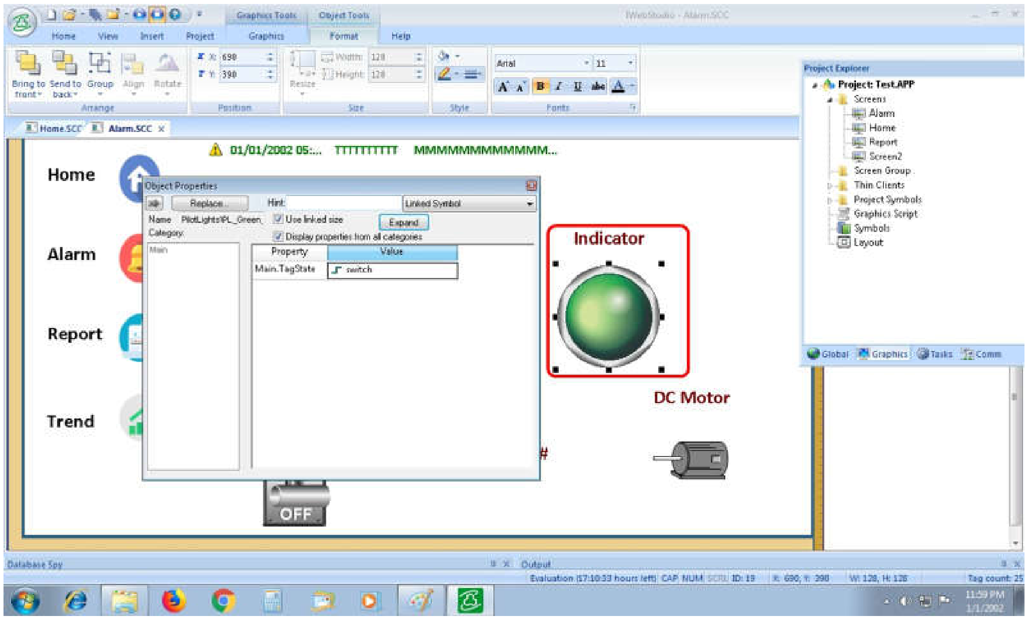
- Click on to the Graphic button then click on Symbol button as shown below.



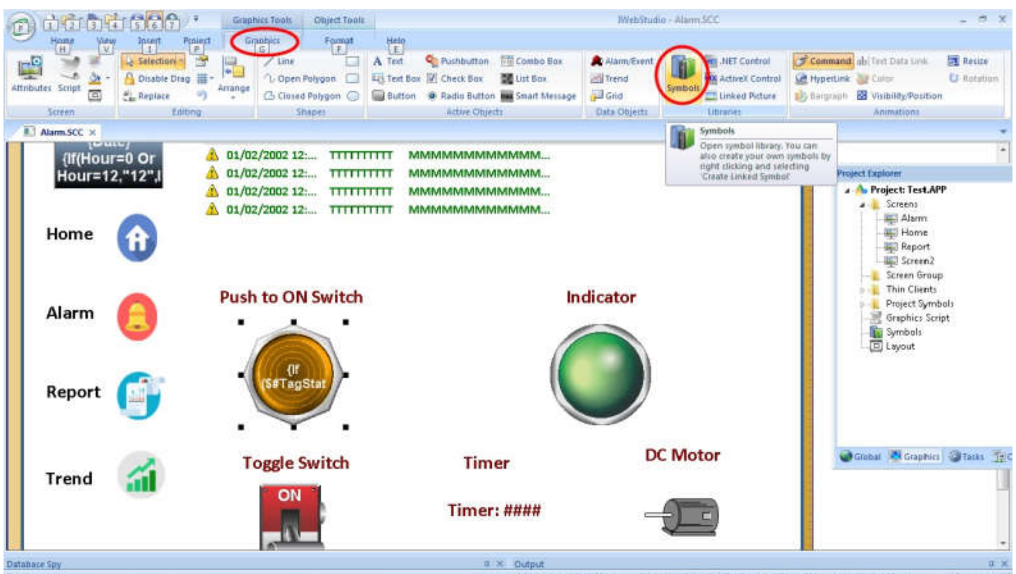
- Select Pilot Light Folder and double click on PL_Green_01 icon as shown below.



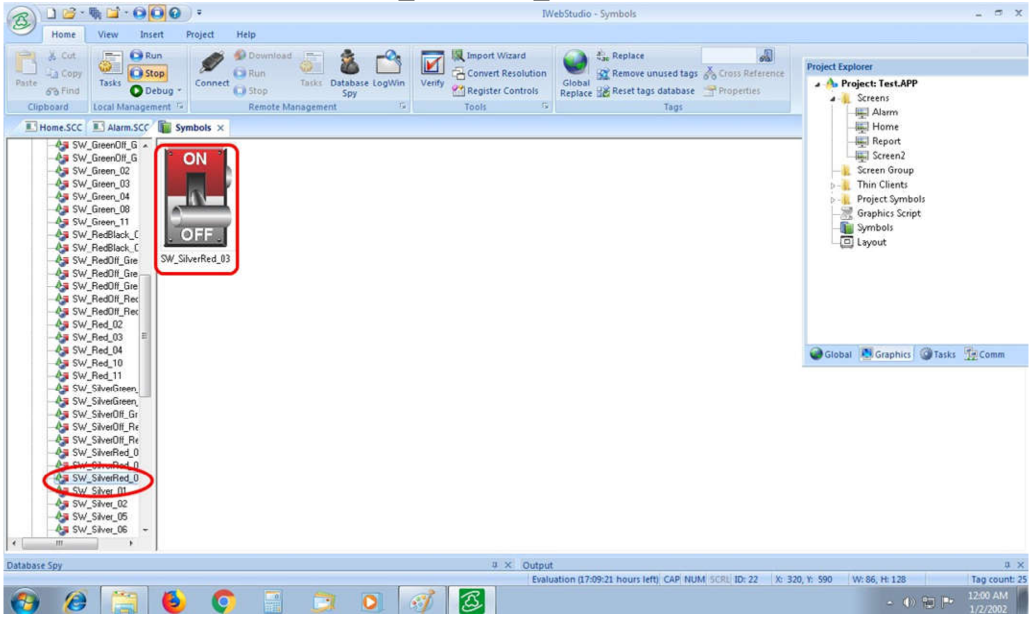
- Double Click on to the Indicator then Object Properties window will open then assign Main Tag State to Switch as shown below.



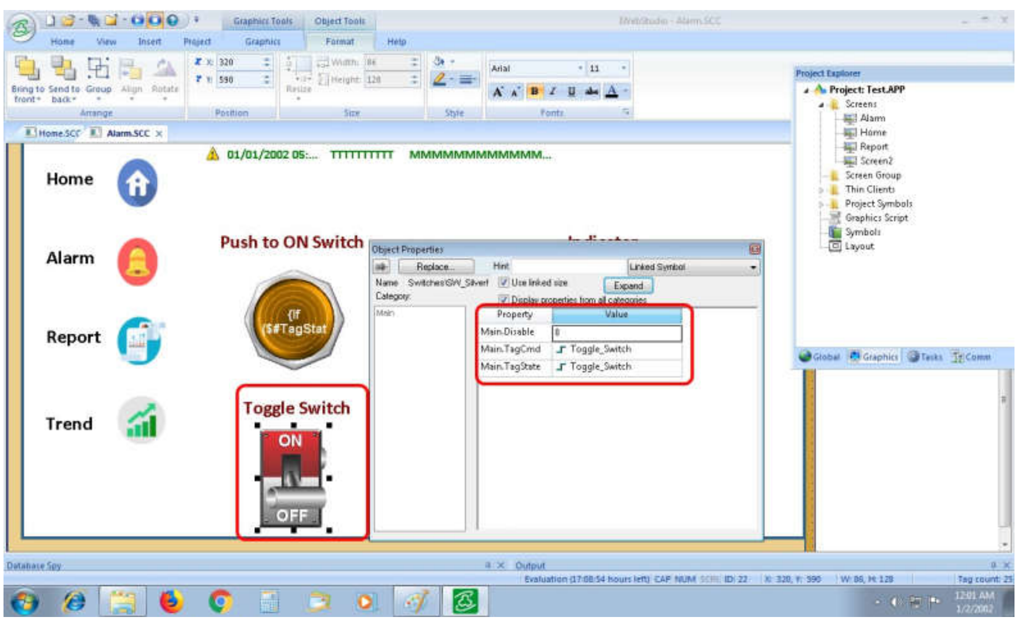
- Click on to the Graphic button then click on Symbol button as shown below.



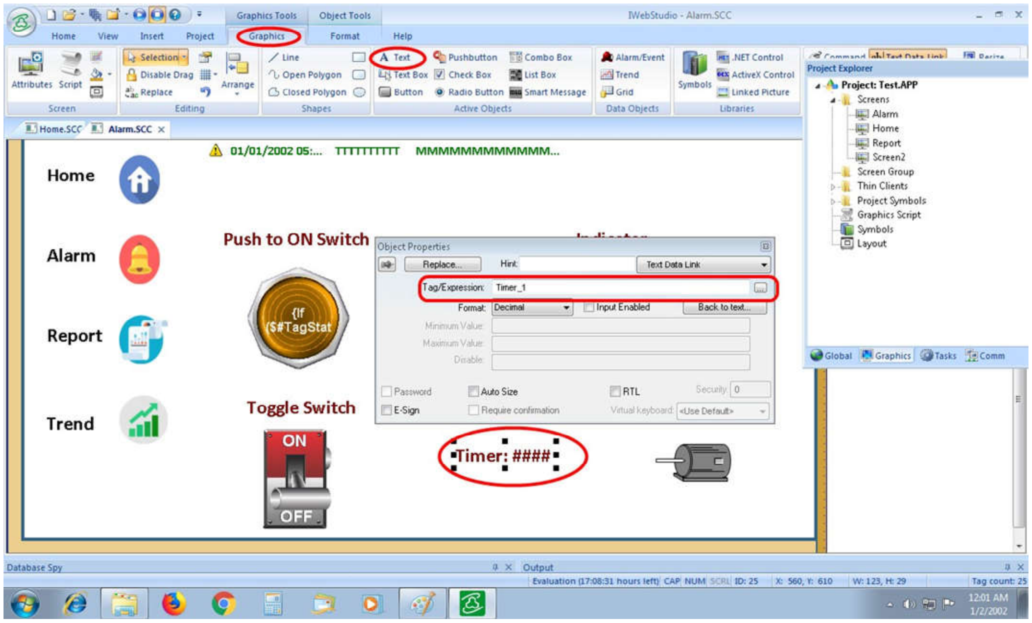
- Double Click on to the SW_SilverRed_03 button as shown below.



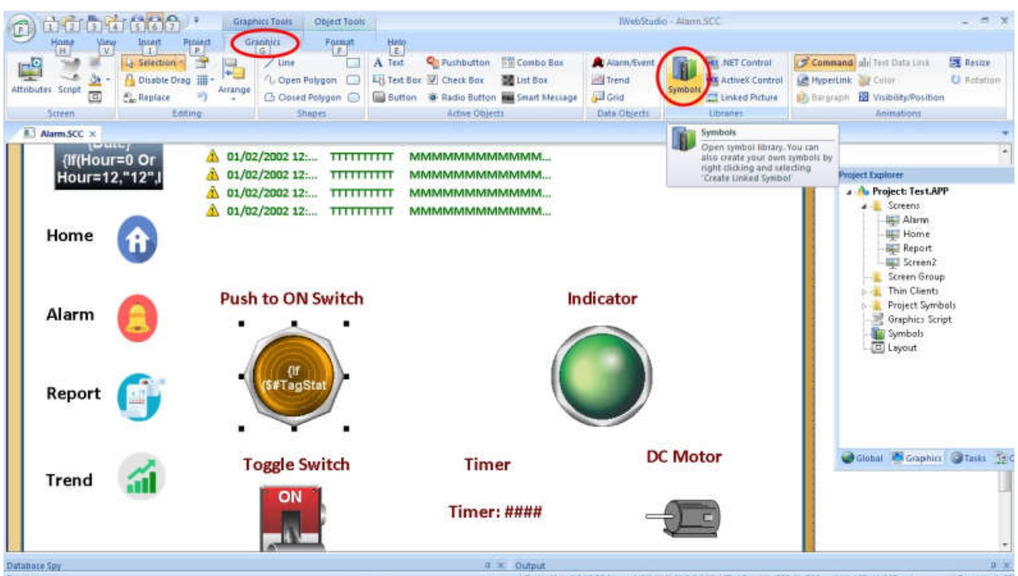
- Double Click on to the Toggle Switch then Object Properties window will open then assign Main. TagCmd to Toggle Switch and Main. Tag State to Toggle Switch as shown below.



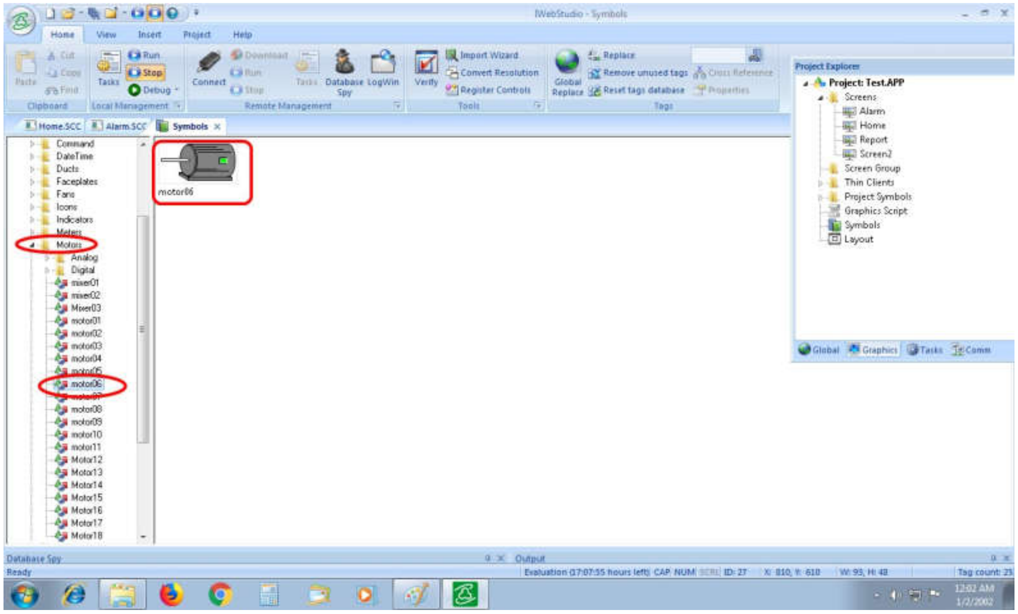
- Click on to the Graphic button then click on Text button then click on Text Data Link button then assign address Tag/Expression to Timer_1 as shown below.



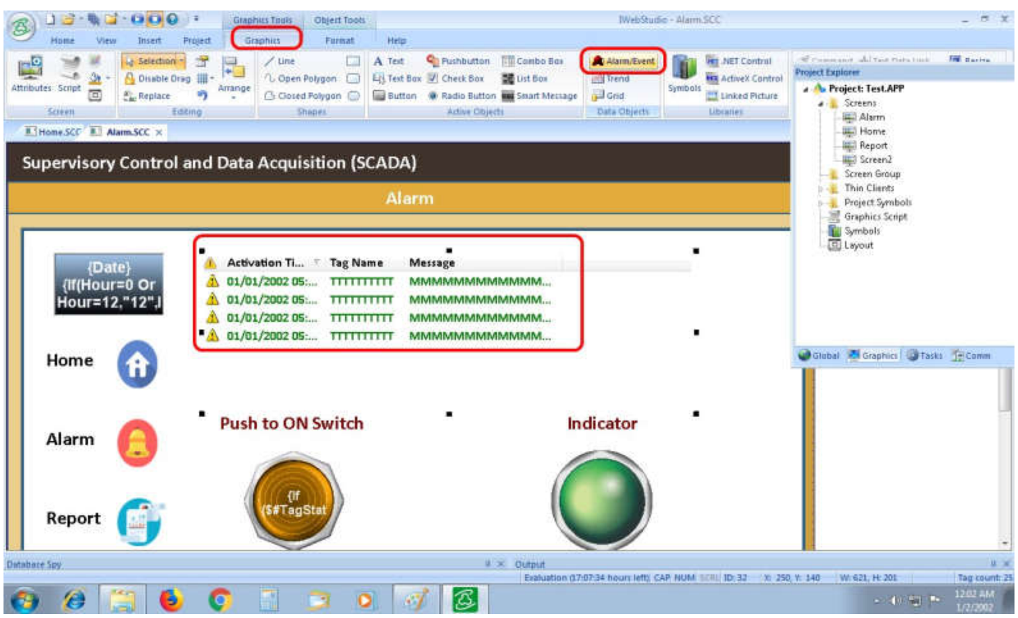
- Click on to the Graphic button then click on Symbol button as shown below.



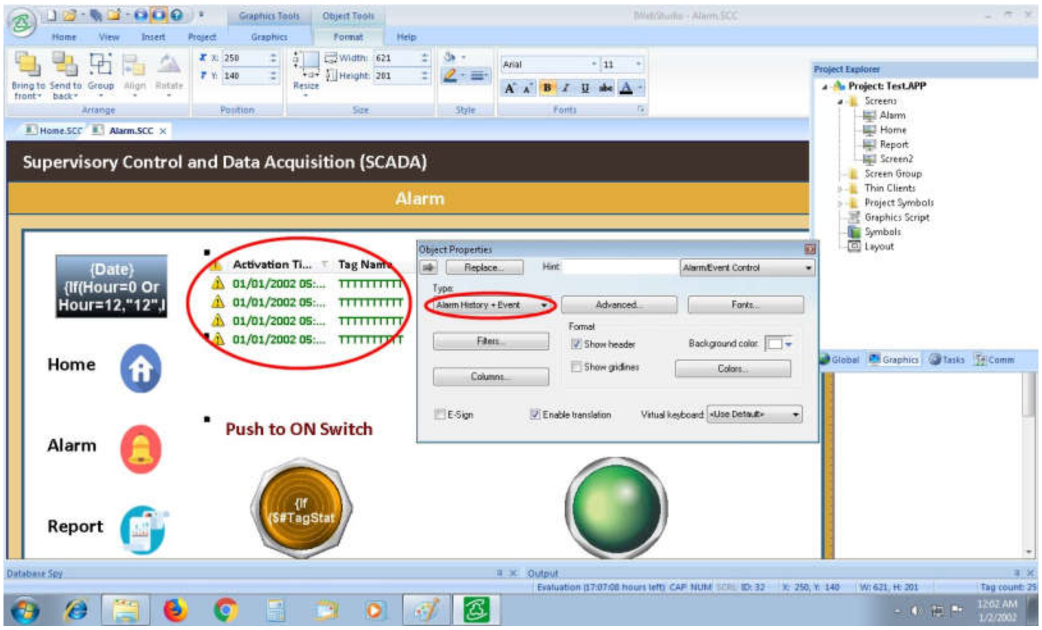
- Select Motor folder and click on to the motor06 button as shown below.



- Click on to the Graphic button then click on Alarm/Event button as shown below.

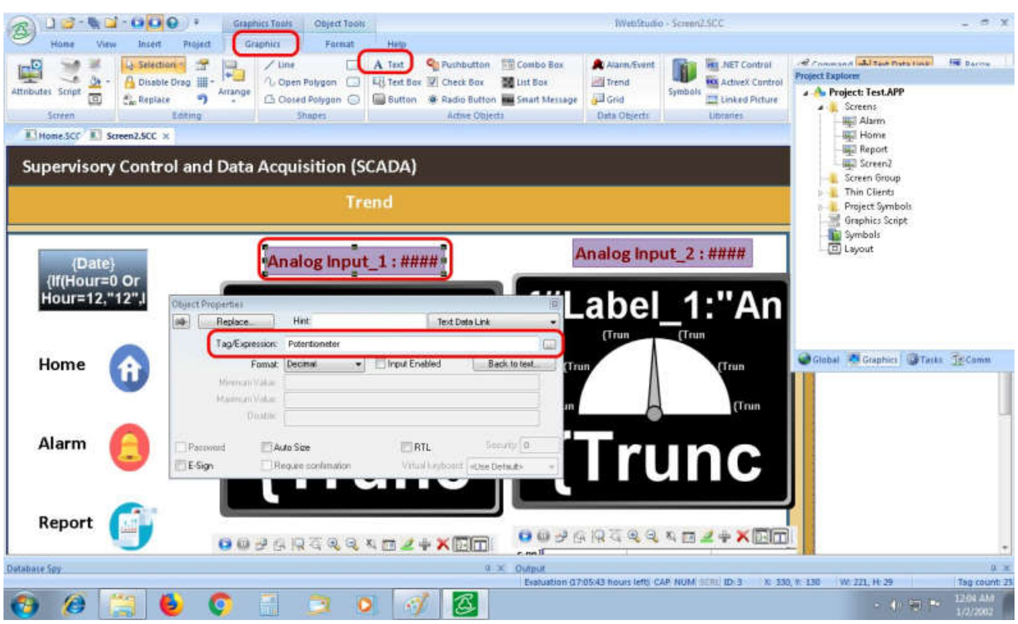


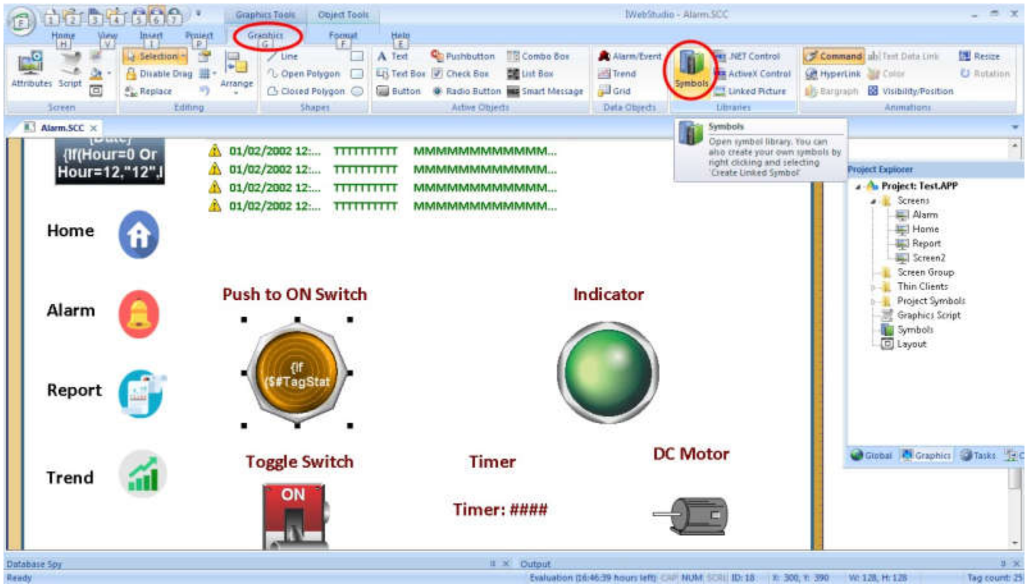
- When double click on to the Alarm button then object Properties window will open .



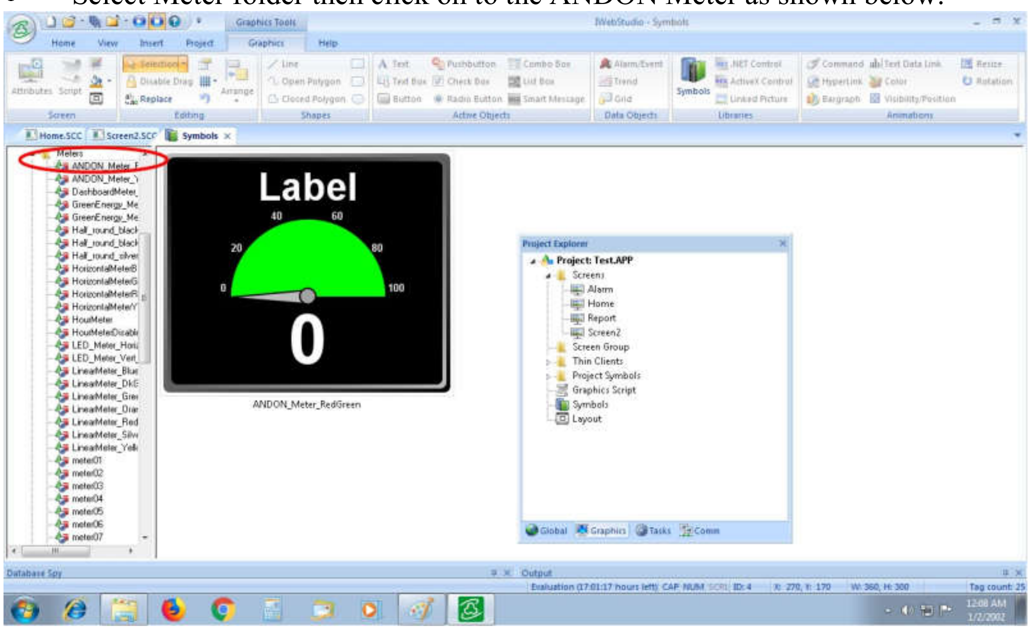
For Trend

- Click on to the Graphic button then click on Text button then click on to the Text data Link button and double click on to Analog Input_1 then Object Properties window will open then assign Tag Address to Potentiometer as shown below.

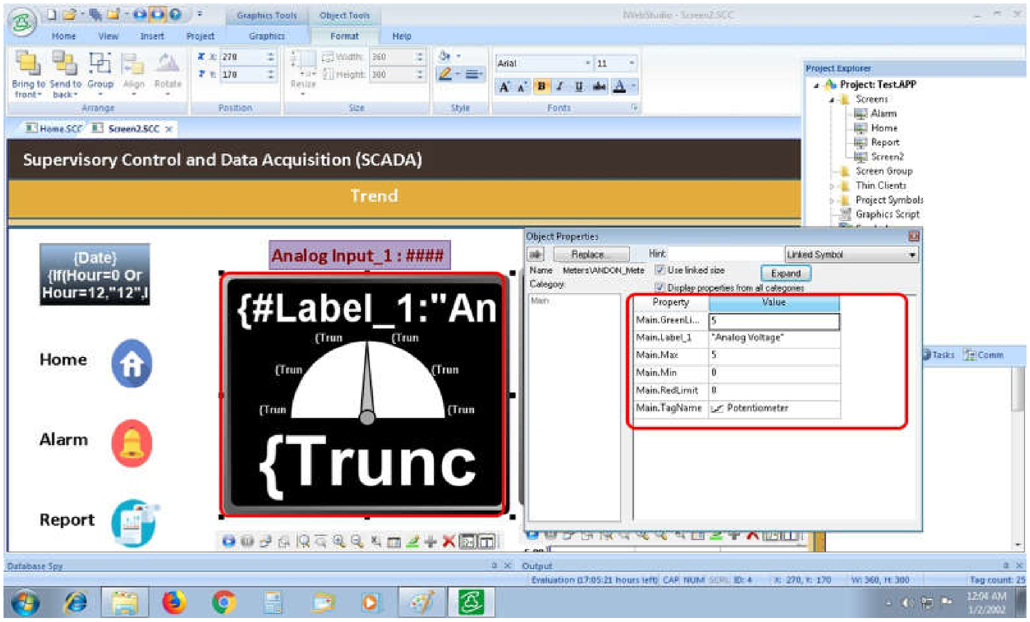




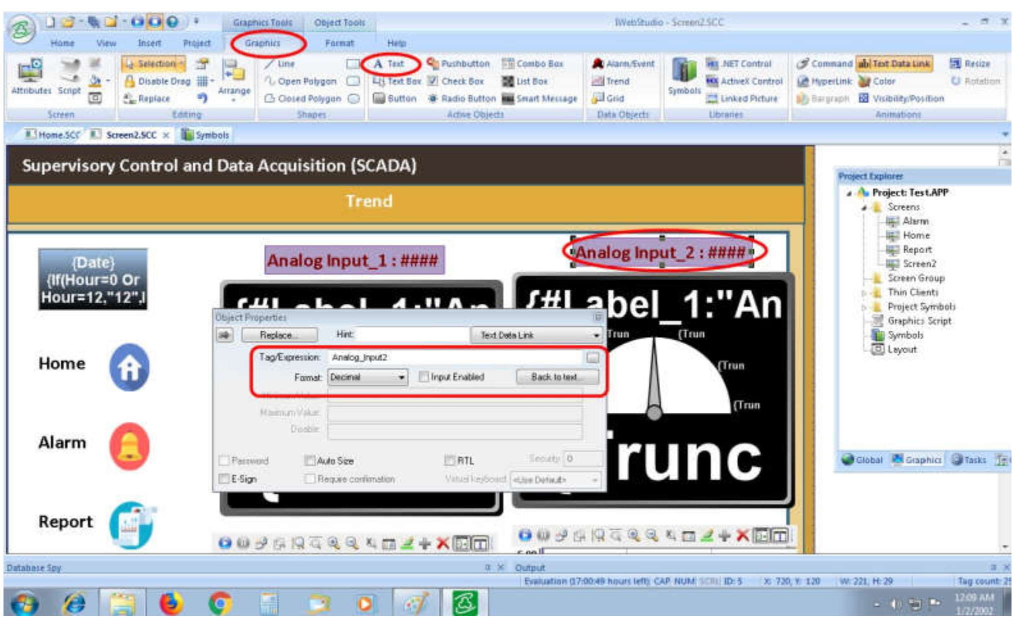
- Select Meter folder then click on to the ANDON Meter as shown below.



- Double Click on to object properties window then assign Main Label_1 to "Analog Voltage", Main. Max. to 5 and Main Min. to 0 and Main Tag Name Potentiometer as shown below.



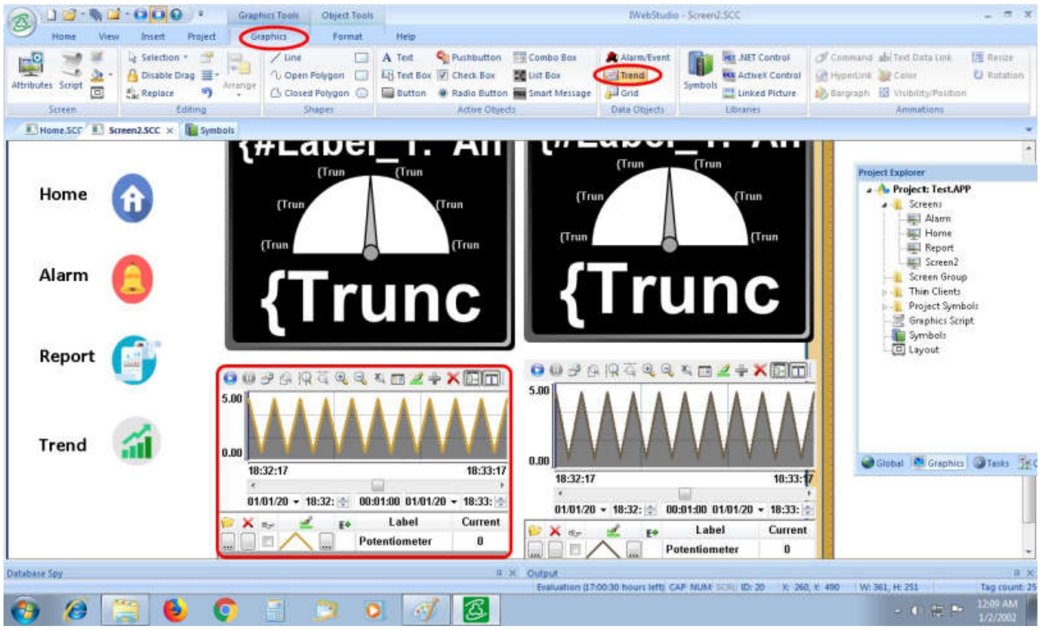
- Click on to the Graphic button then click on Text button then click on to the Text data Link button and double click on to Analog Input_2 then Object Properties window will open then assign Tag Address to Analog_Input2 as shown below.



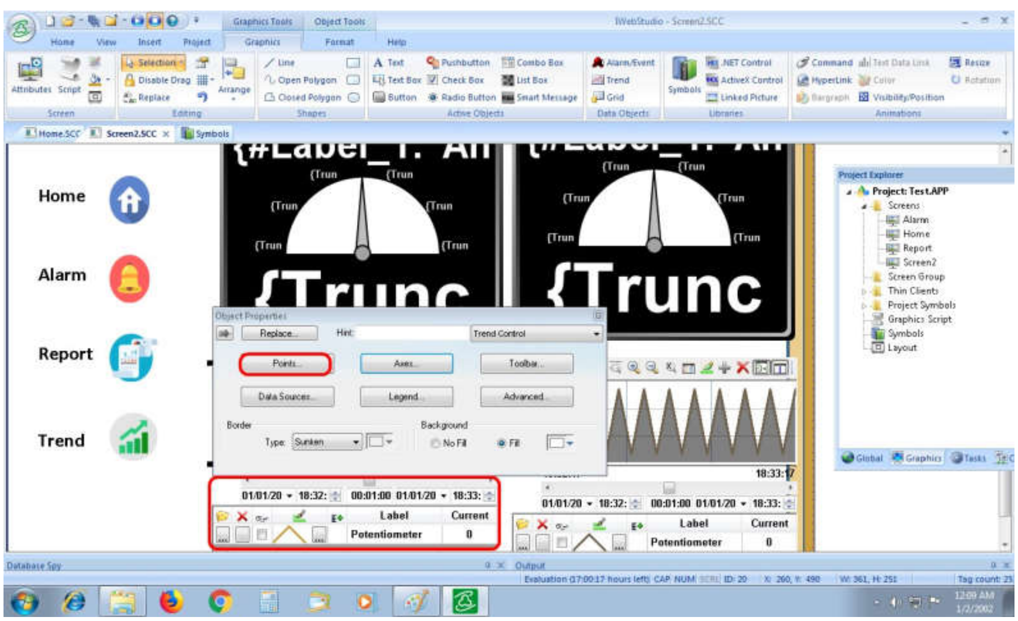
Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Trend Screen

- For Trend go to Graphic button then click on Trend button as shown below.

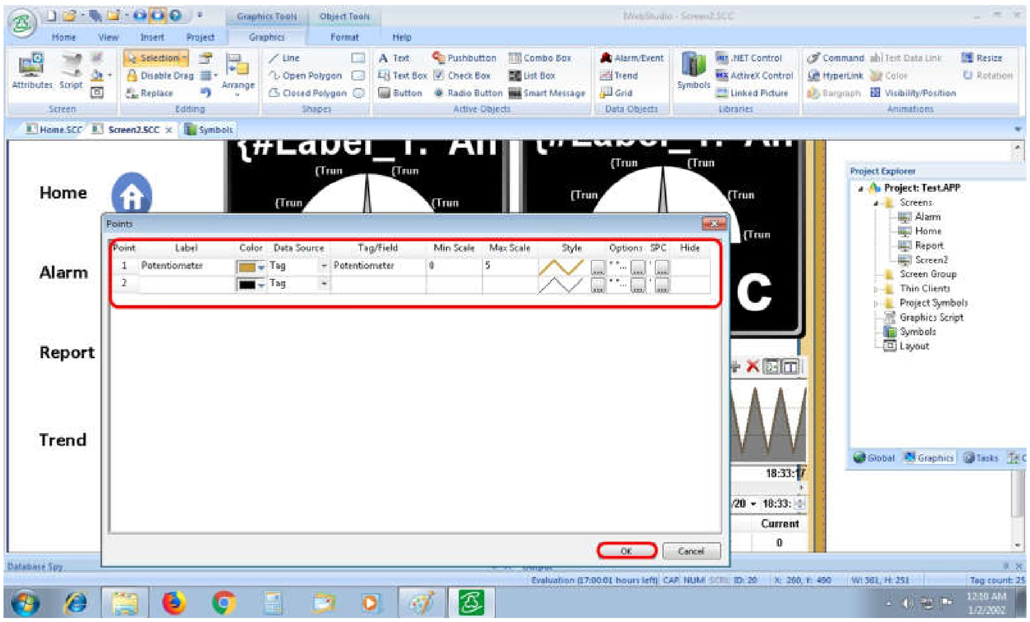


- When you double click on Trend button object properties then Click on Point button as shown below.

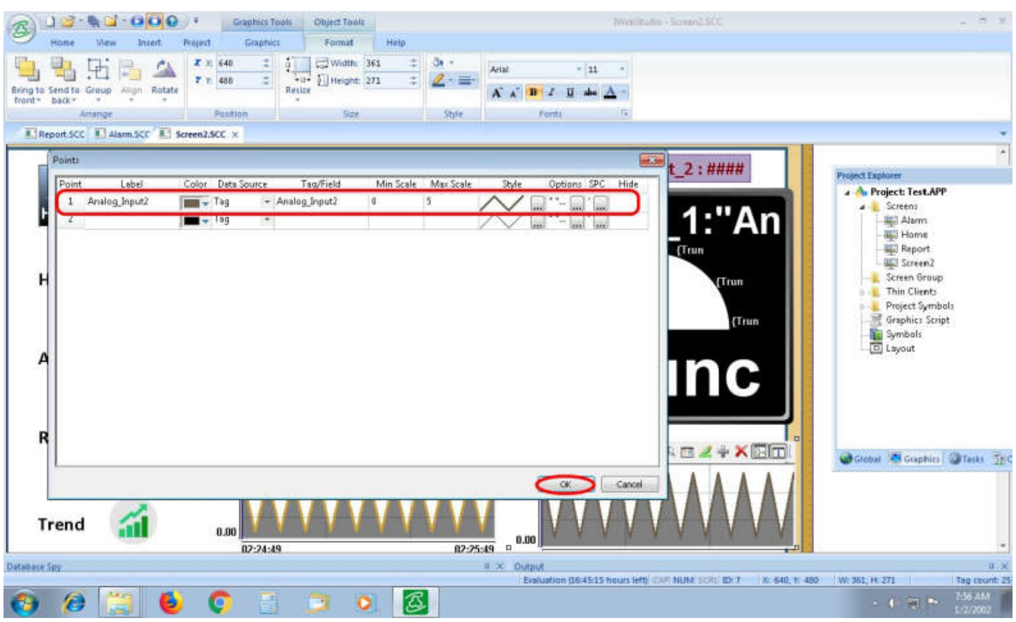


Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

- Assign Label address to Potentiometer and Tag/Field to Potentiometer and Min Scale to 0 and Max Scale to 5 then click on OK button as shown below.



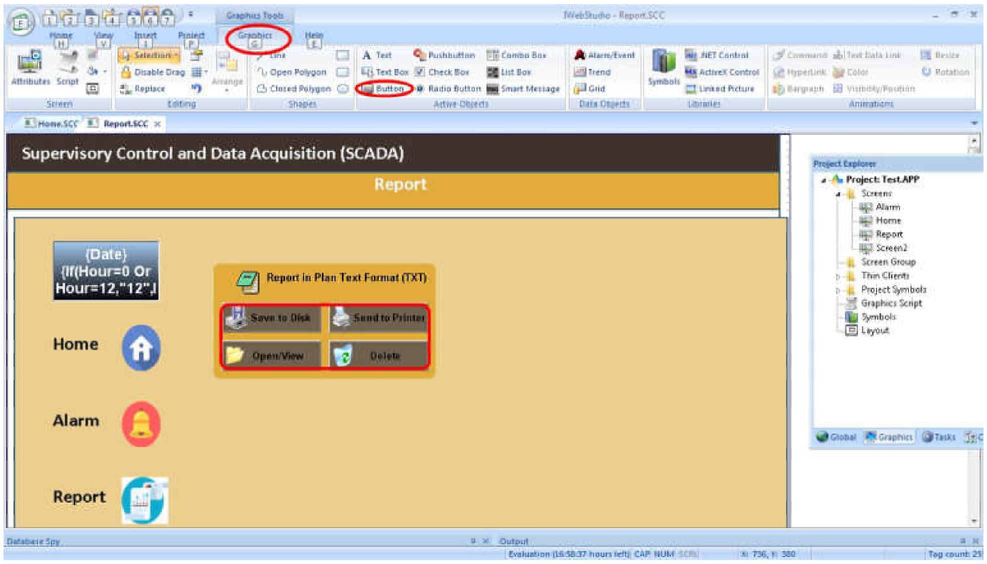
- Double Click on Second trend then assign name Label to Analog Input_2 and Tag/Field address to Analog_Input_2 and Min. Scale to 0 and Max. Scale to 5 as shown below.



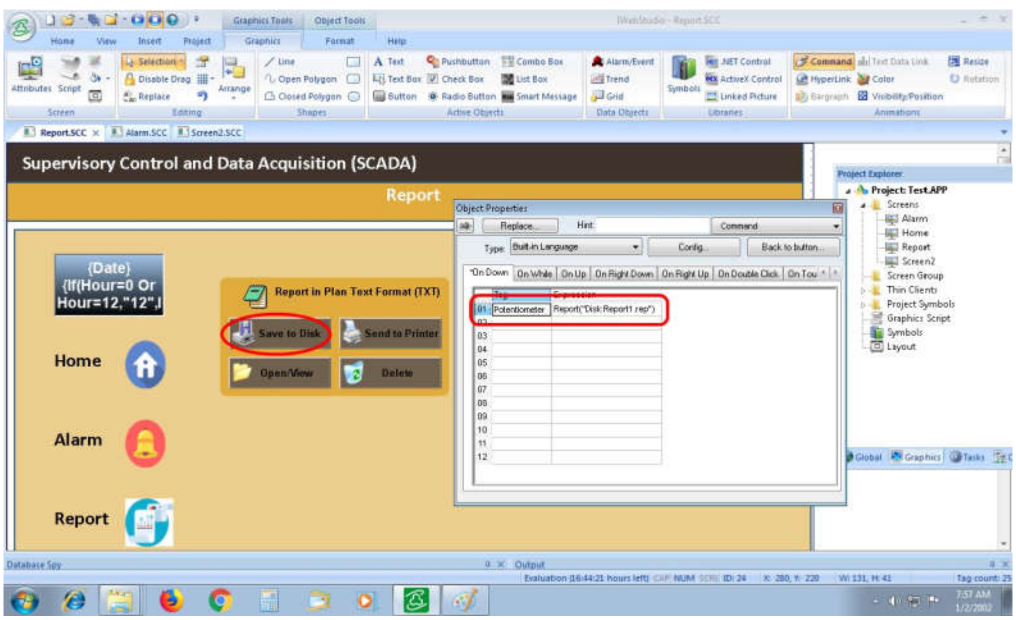
Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

Report Window

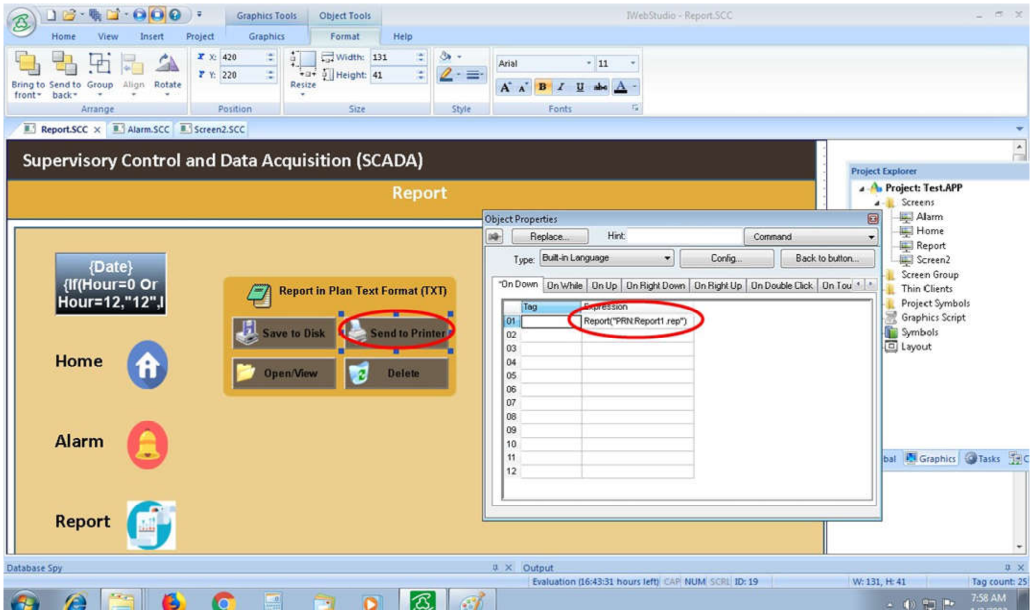
- For Report click on to the Graphic button then click on Button as shown below.



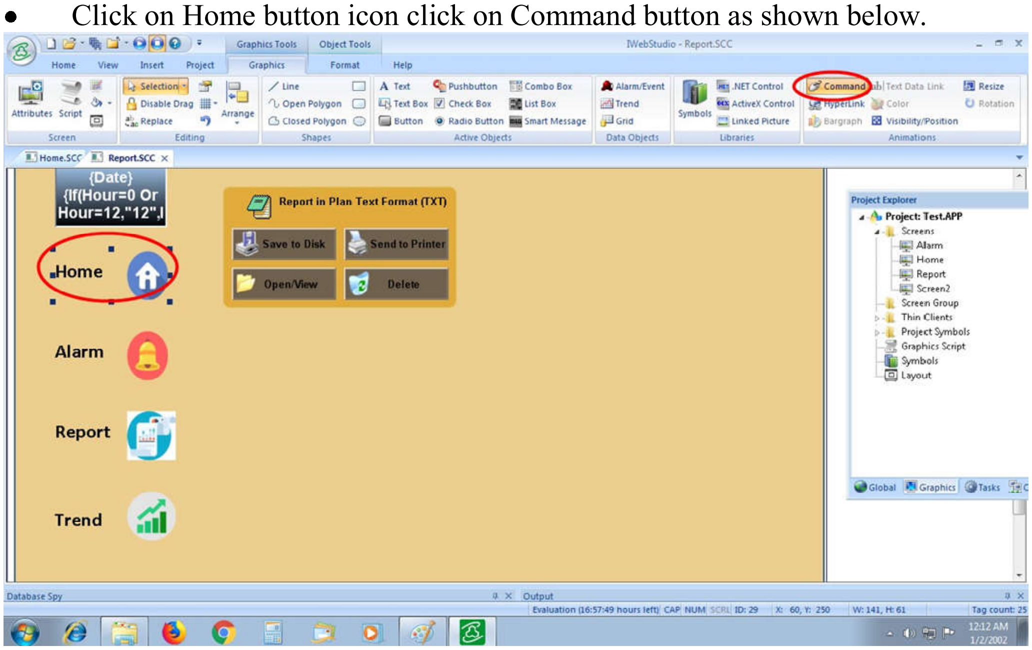
- Double Click on Save to Disk button then Object properties window will open then assign Tag to Potentiometer and Expression to Report (“Disk:Report1.rep) as shown below.



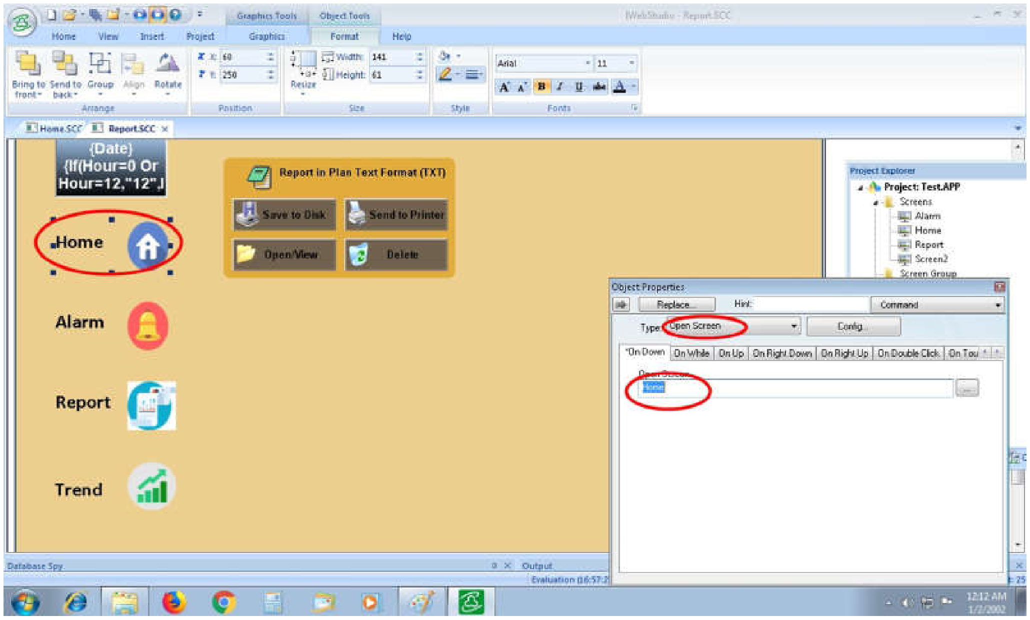
- Double click on Send to Printer button then object properties window will open then assign expression to Report("PRN:Report1.rep") as shown below.



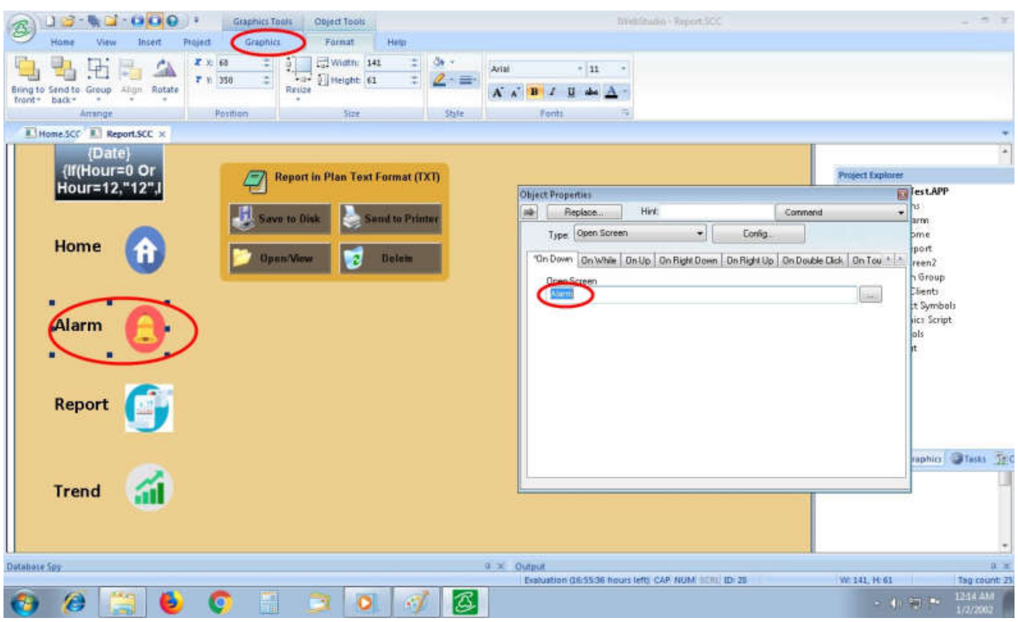
- Click on Home button icon click on Command button as shown below.



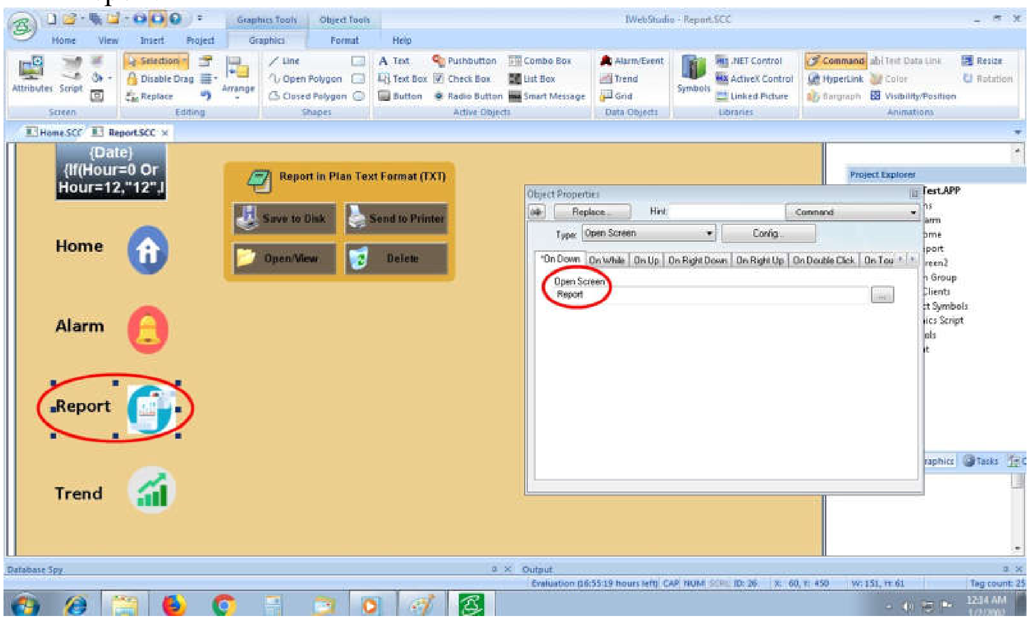
- When you click on to the Home button then object properties window will open then Select Type : Open Screen and assign address Open Screen to Home.



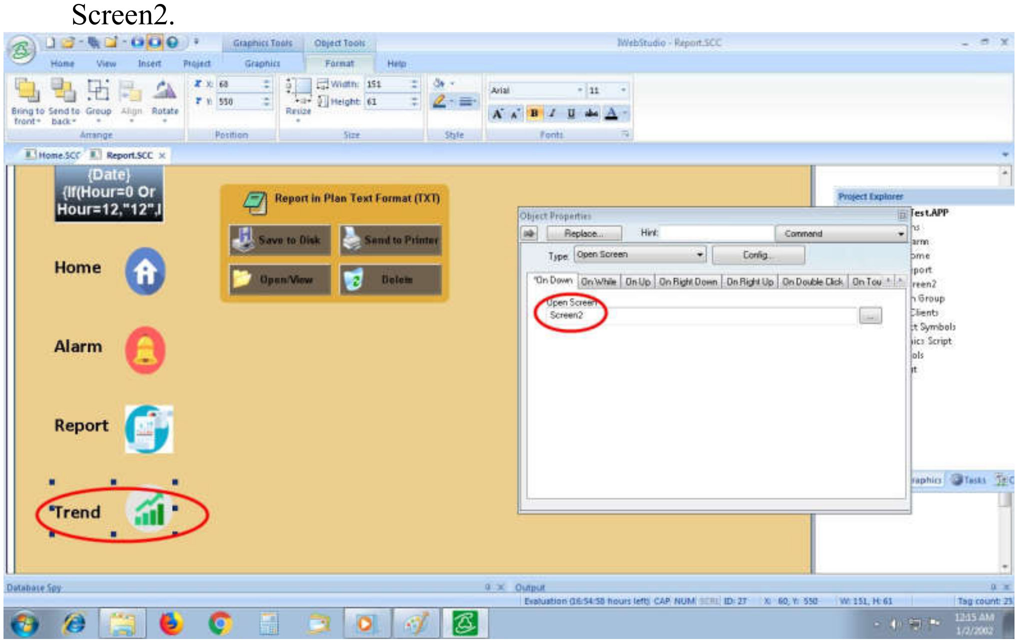
- When you click on to the Alarm button then object properties window will open then Select Type: Open Screen and assign address Open Screen to Alarm.



- When you click on to the Report button then object properties window will open then Select Type : Open Screen and assign address Open Screen to Report.

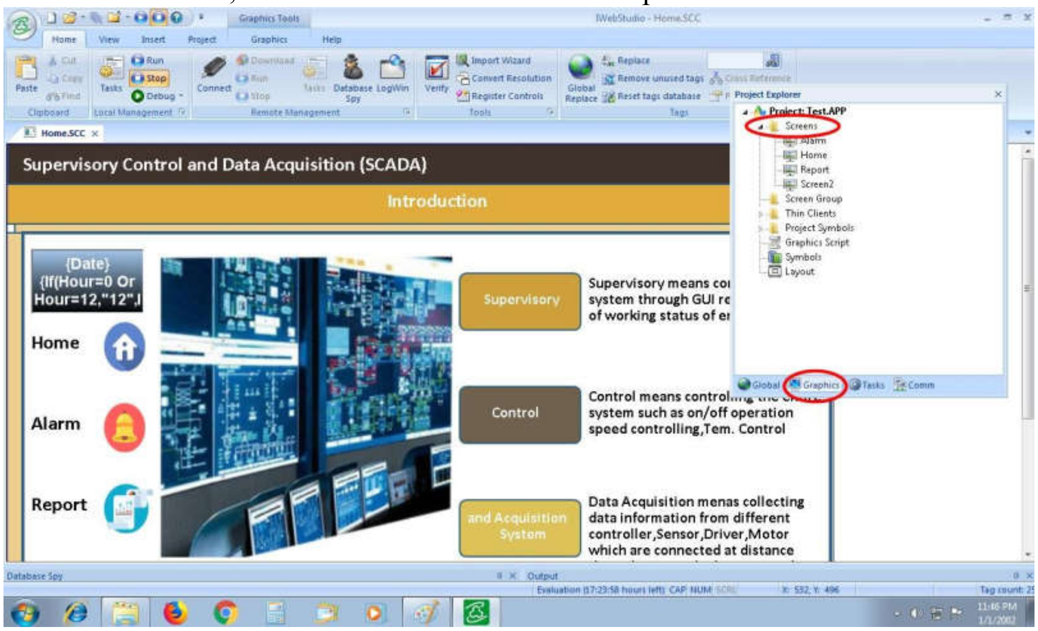


- When you click on to the Trend button then object properties window will open then Select Type : Open Screen and assign address Open Screen to Screen2.

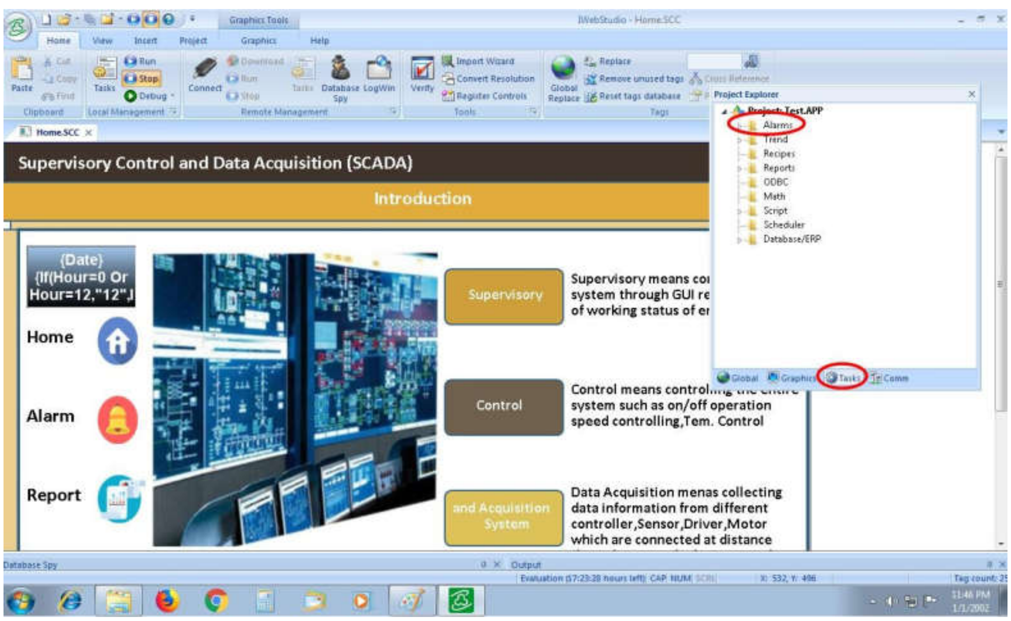


Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

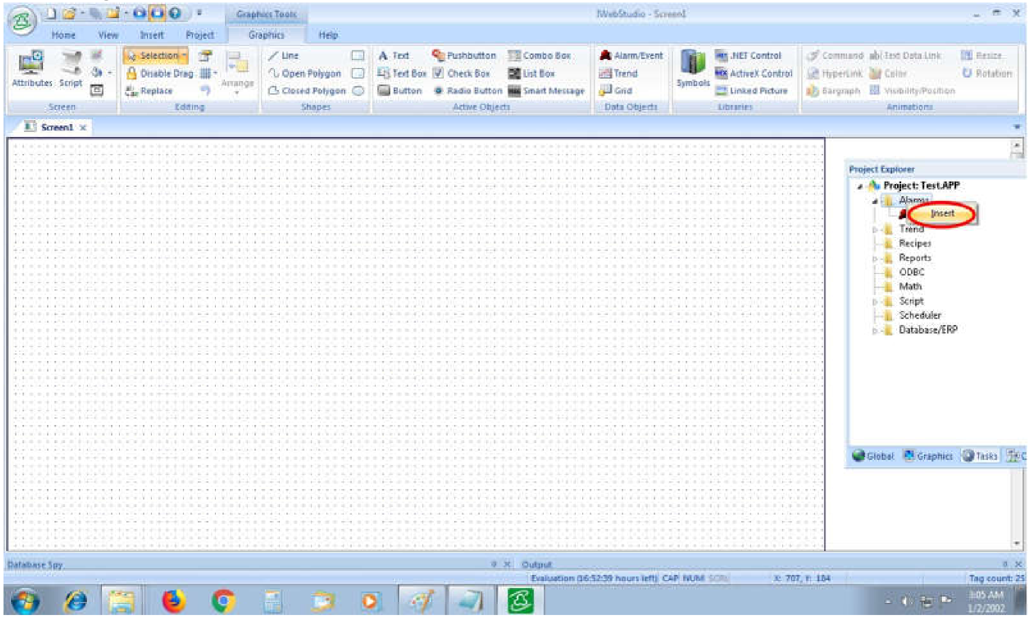
- You See the all Screen of SCADA, Click on Graphic button then click on Home button, then Home button window will open as shown below.



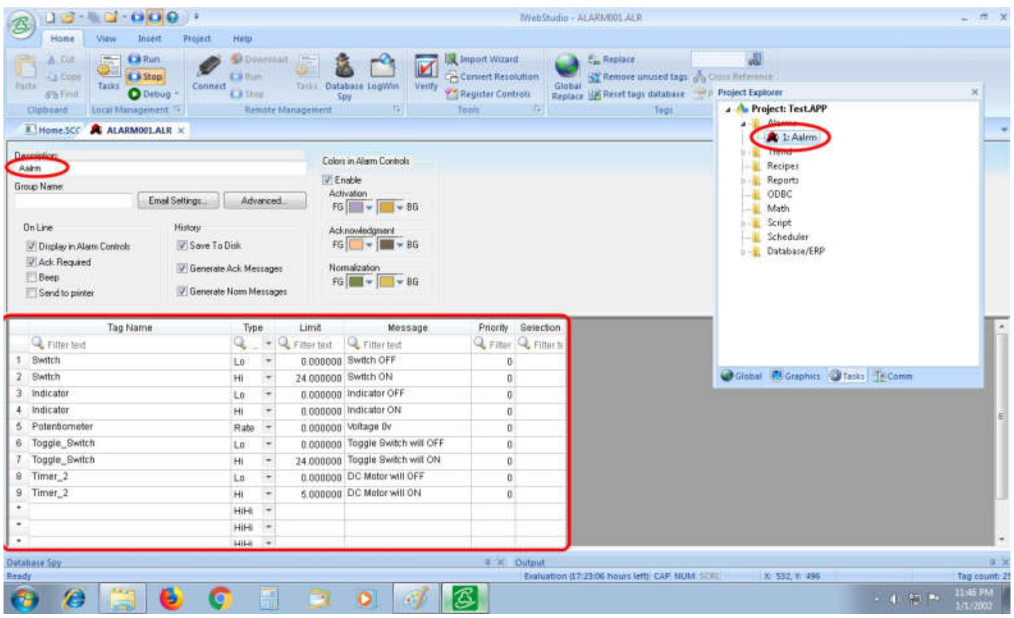
- For Assign address to Alarm screen click on to Task button then Alarms button as shown below.

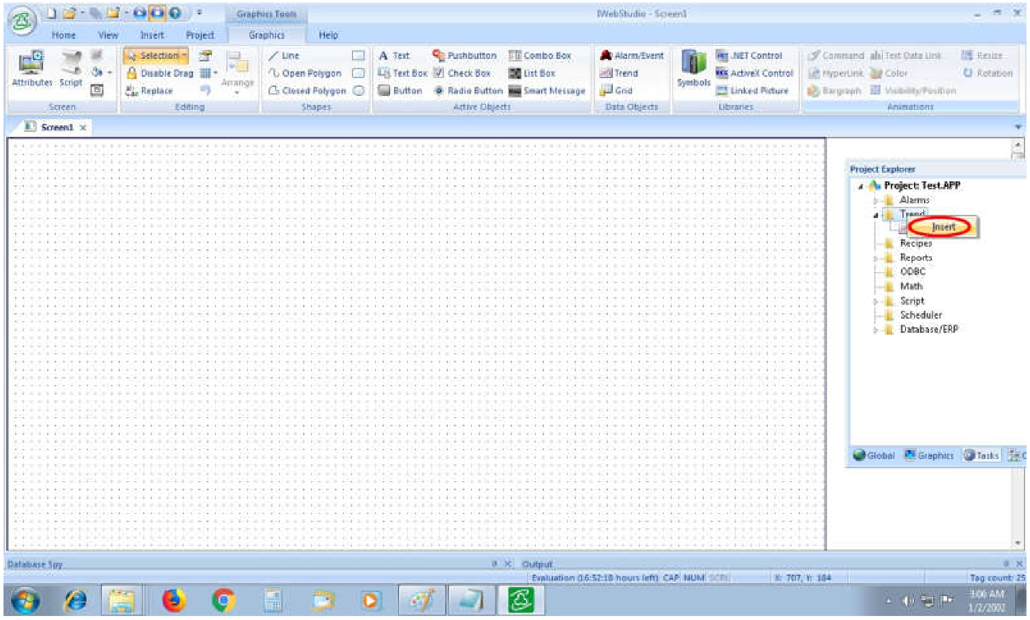


- Right click on Alarm button then Click on Insert button as shown below.

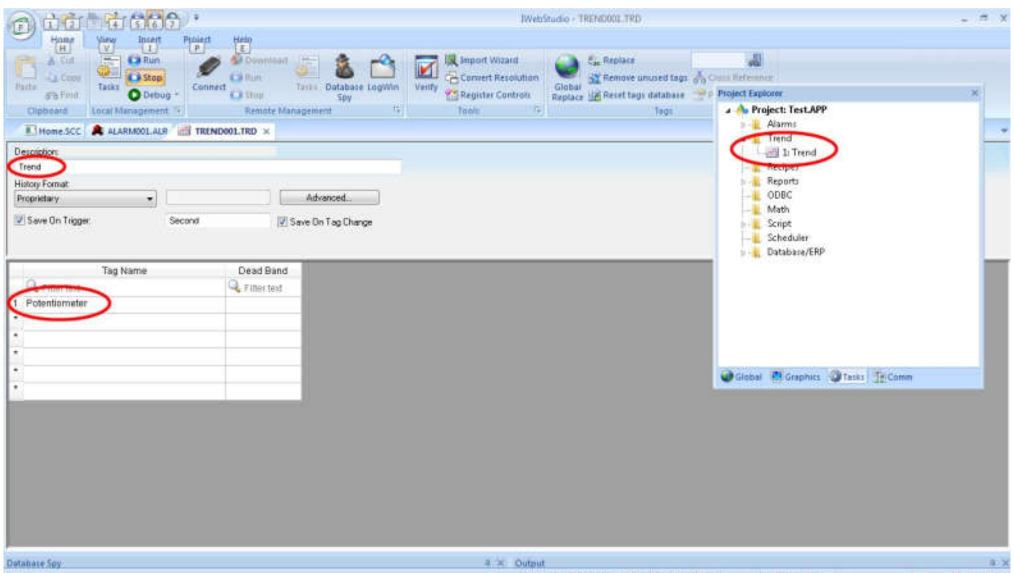


- Assign Alarm Description to Alarm then assign Tag Name and message to Alarm function as shown below.

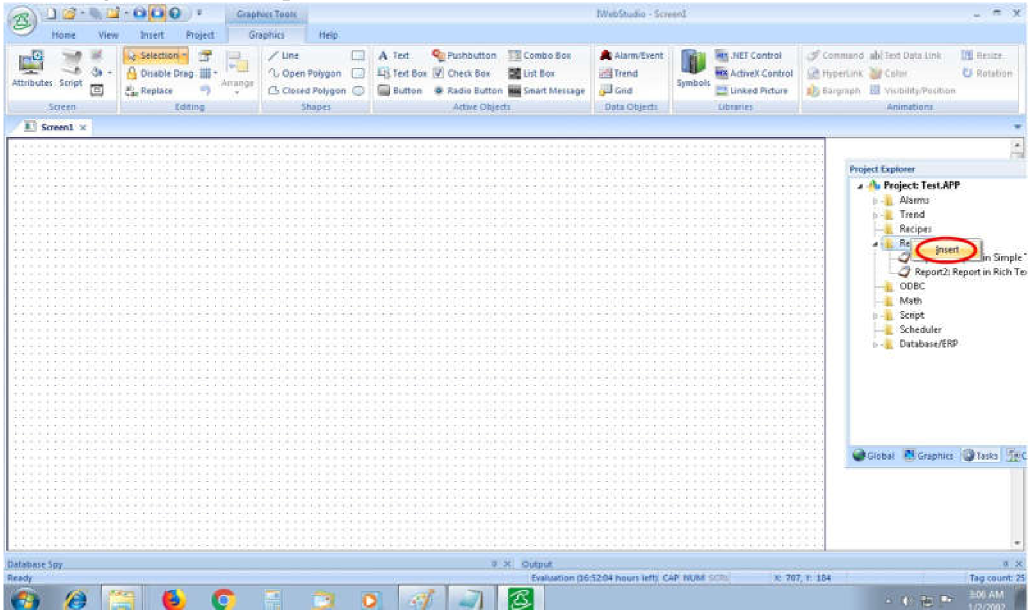




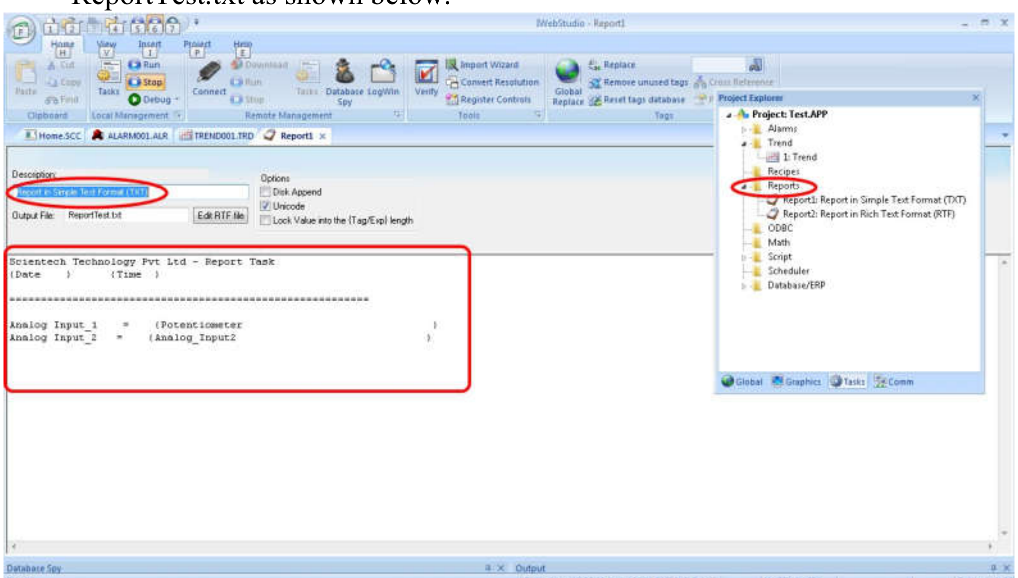
- Assign Trend Description to Trend then assign Tag Name and message to Trend function as shown below.



- Right click on Report button then Click on Insert button as shown below.

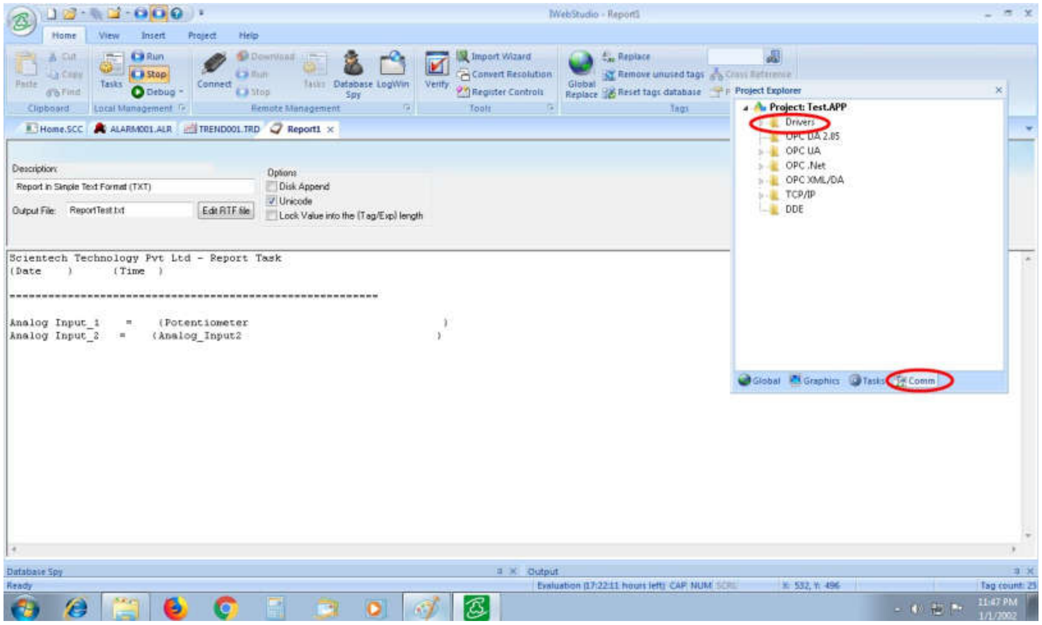


- Assign Description to Report in Simple Text Format (TXT) and Output file to ReportTest.txt as shown below.

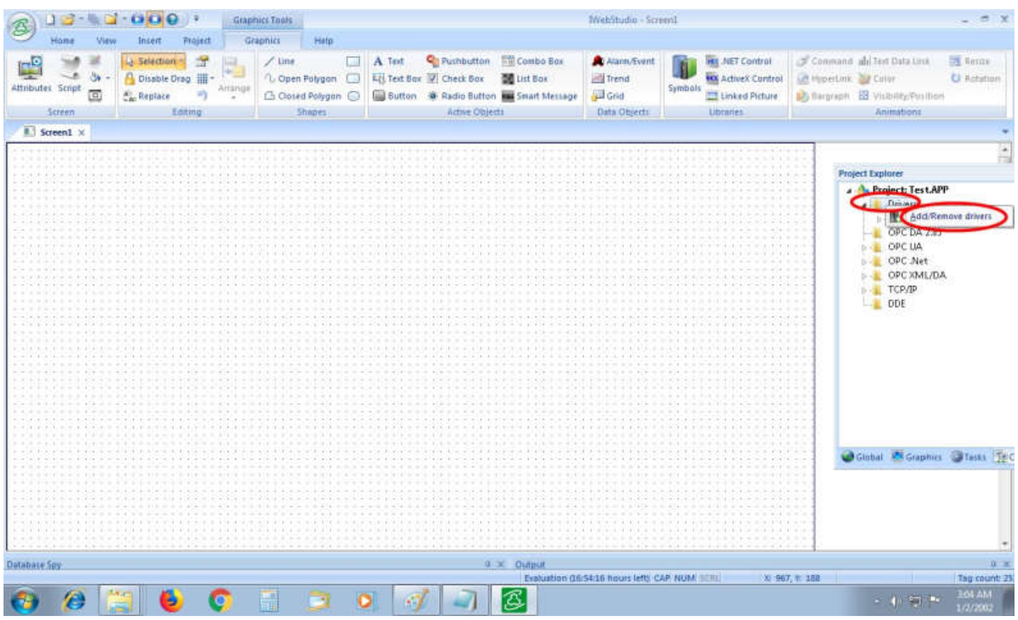


Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

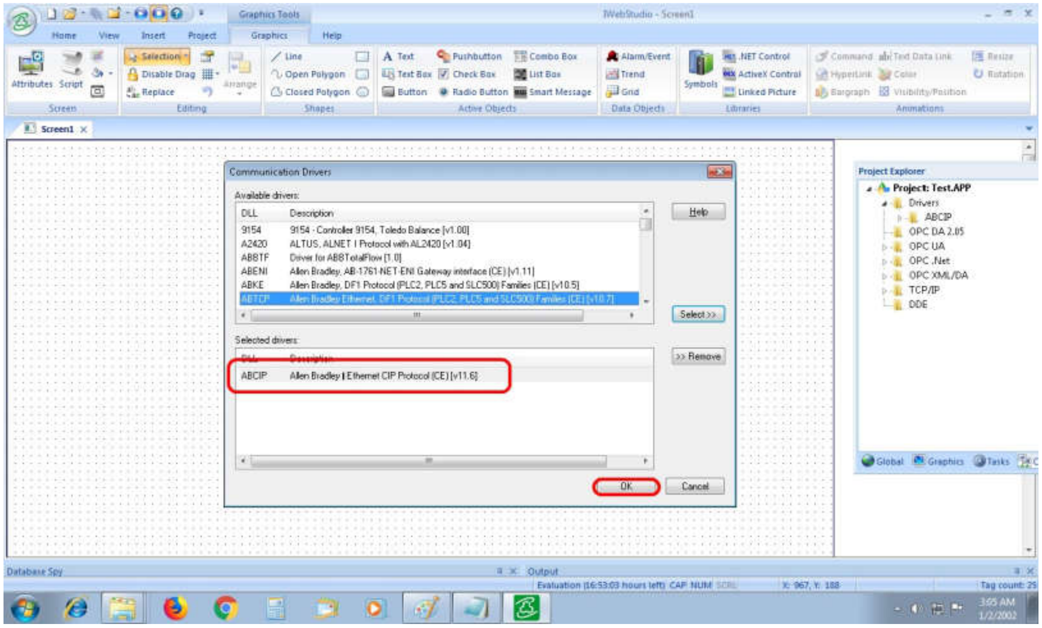
- Click on to the Comm button then Click in to the Drives button as shown below.



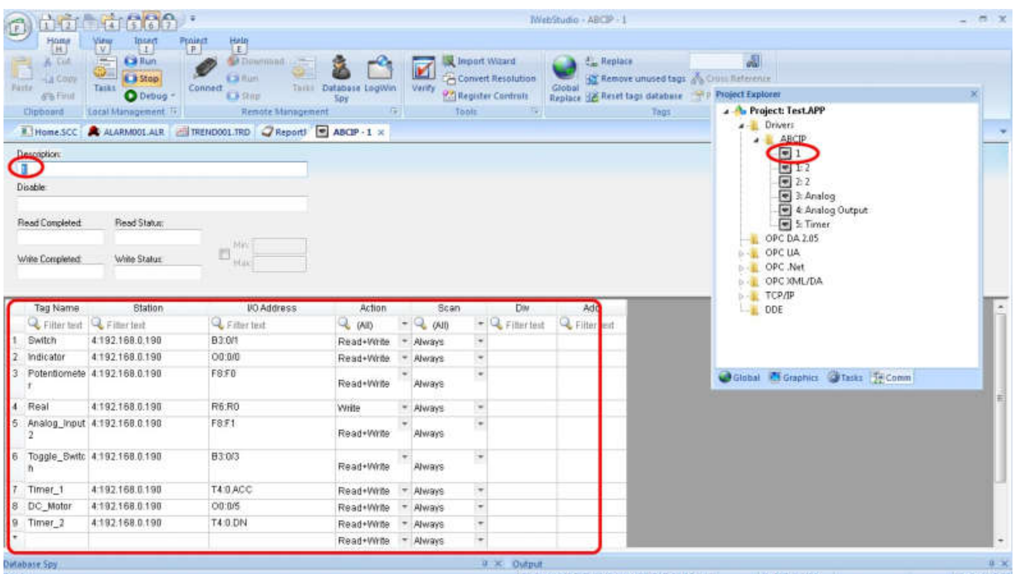
- Right Click on to the Driver button then click on to the Add/Remove Drivers button as shown below.



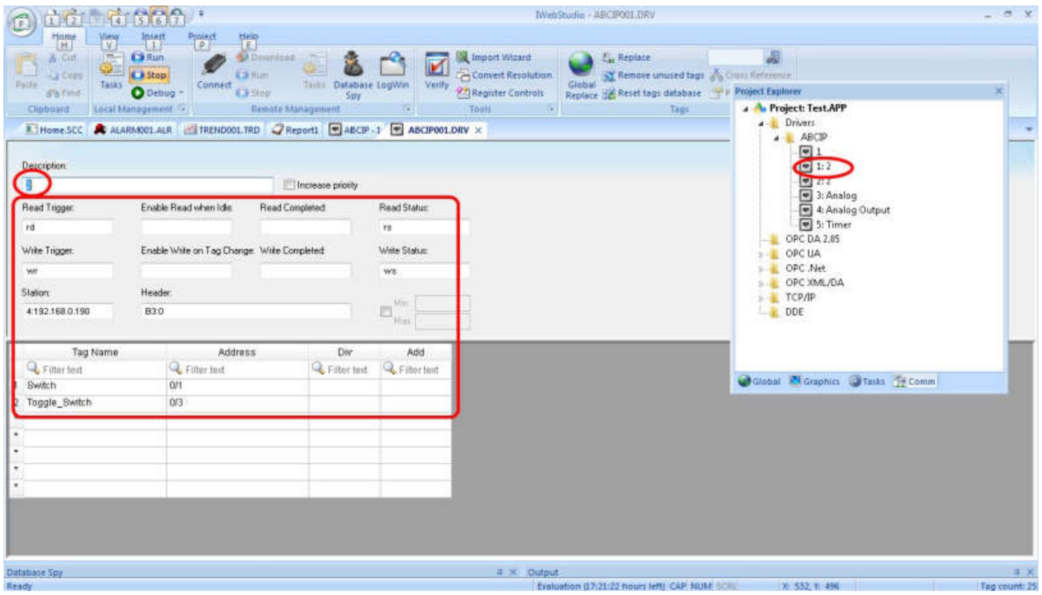
- Select Driver ABCIP and click on to the add button then your Driver ABIP is selected for Scientech 2400EH as shown below.



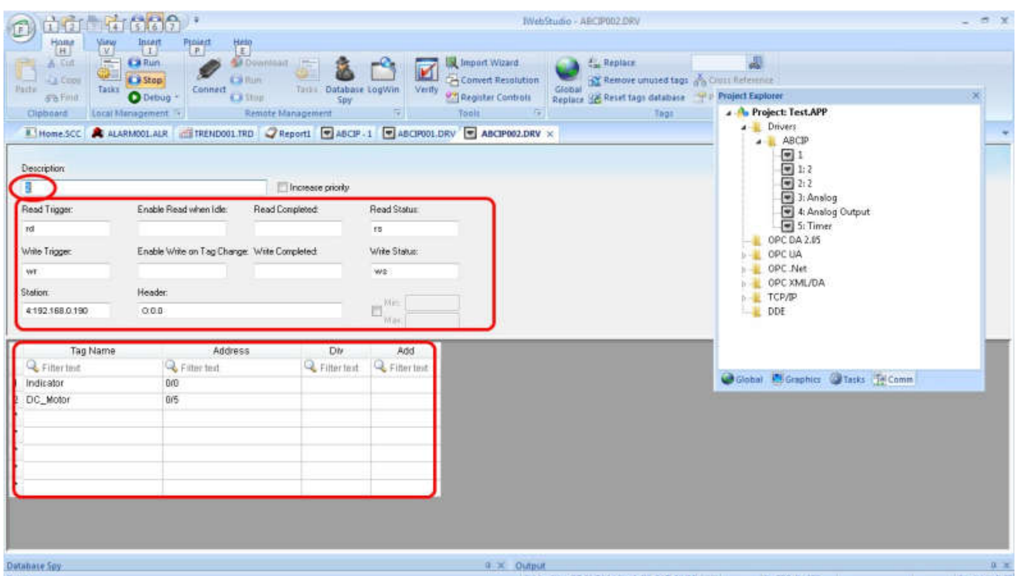
- Right Click on ABCIP Button then Descriptions window will open the Assign Description to 1 and assign Tag Name, Station no. and I/O Address, according to you PLC Ladder logic program as shown below. This is the main Sheet of Tags.



- Right Click on ABCIP Button and Insert new button then Descriptions window will open the Assign Description to 2 and assign Tag Name, Address according to you PLC Ladder logic program as shown below.

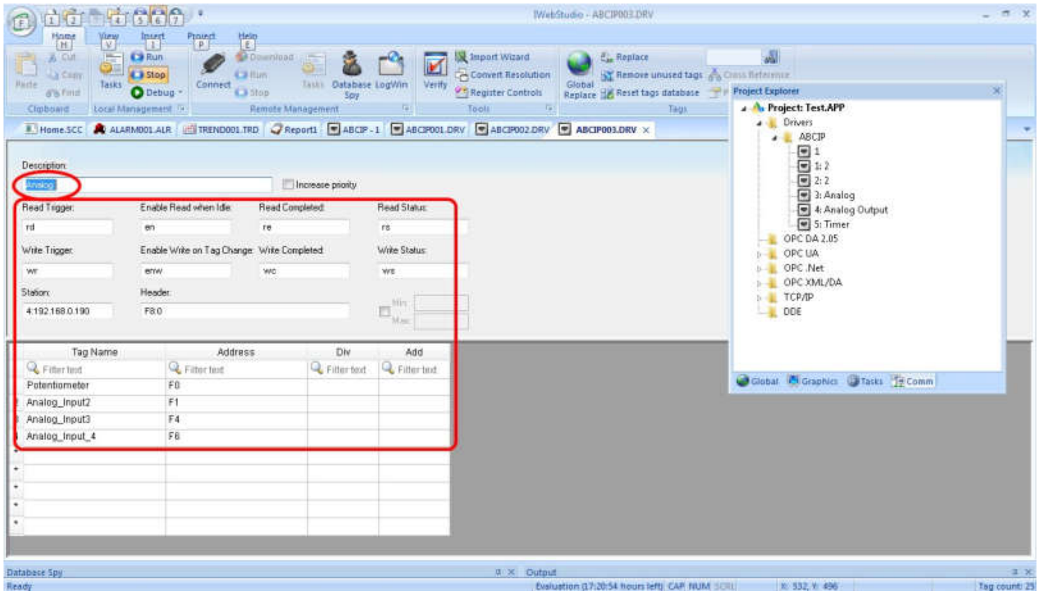


- Right Click on ABCIP Button and Insert new button then Descriptions window will open the Assign Description to 2 and assign Tag Name, Address according to you PLC Ladder logic program as shown below.

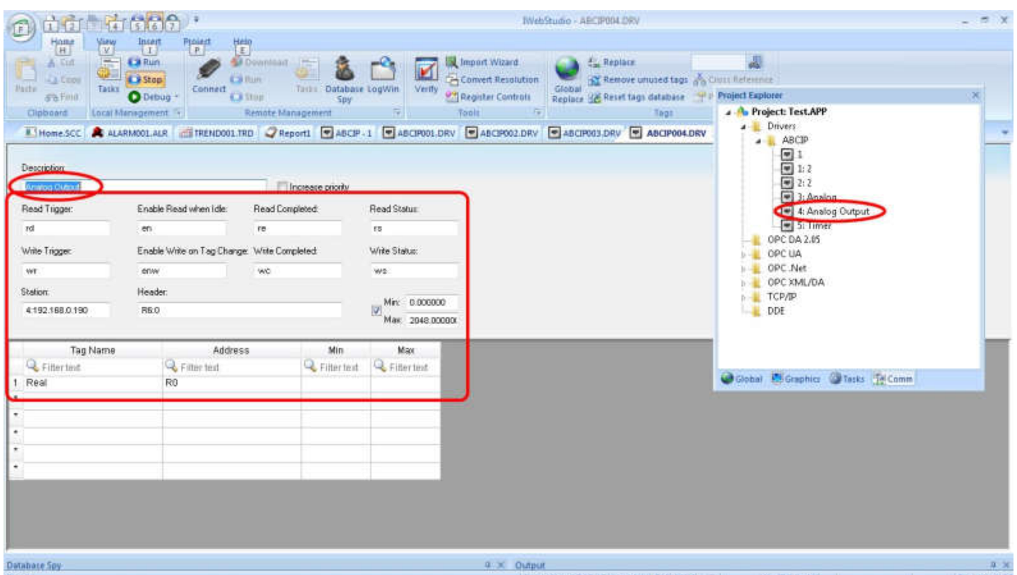


Scientech 2430 Supervisory Control and Data Acquisition (SCADA)

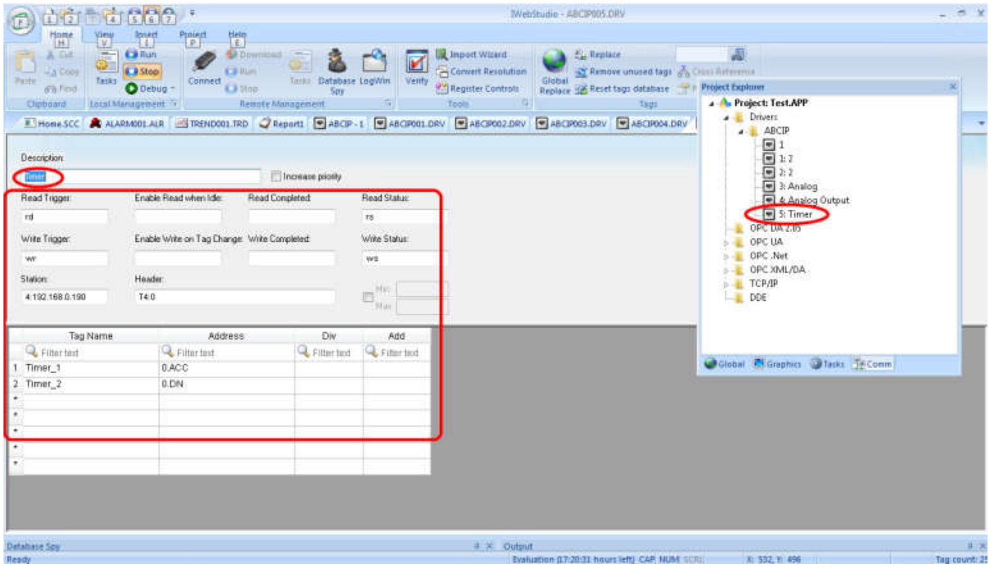
- Right Click on ABCIP Button and Insert new button then Descriptions window will open the Assign Description to Analog and assign Tag Name, Address according to you PLC Ladder logic program as shown below.



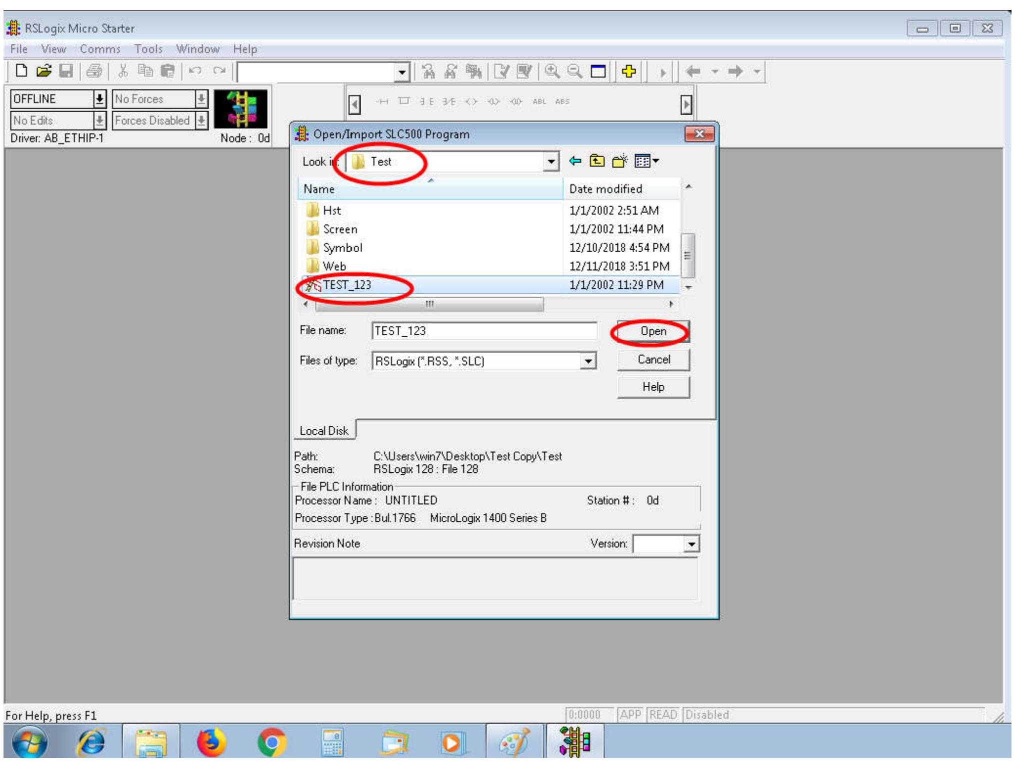
- Right Click on ABCIP Button and Insert new button then Descriptions window will open the Assign Description to Analog Output and assign Tag Name, Address according to you PLC Ladder logic program as shown below.



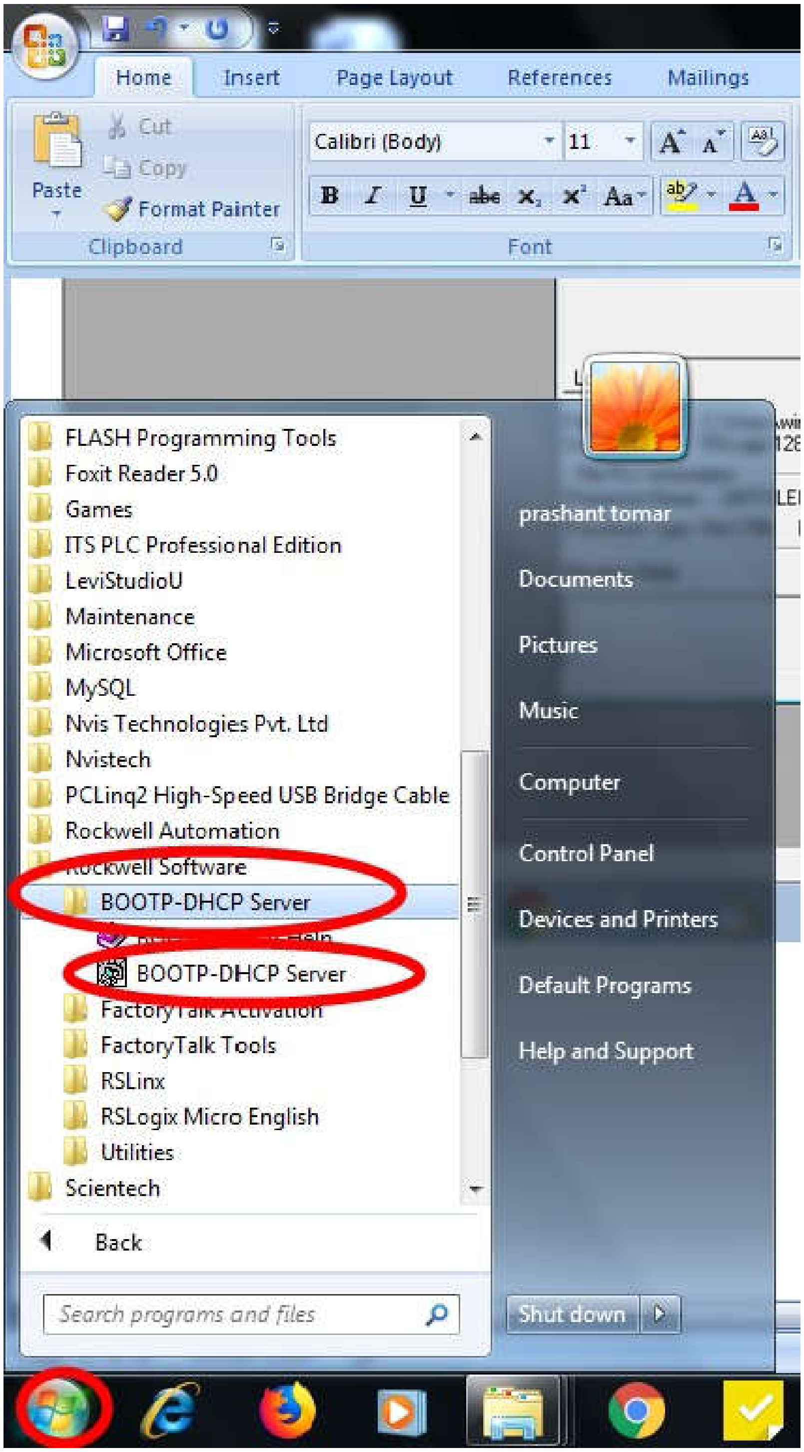
- Right Click on ABCIP Button and Insert new button then Descriptions window will open the Assign Description to Timer and assign Tag Name, Address according to you PLC Ladder logic program as shown below.



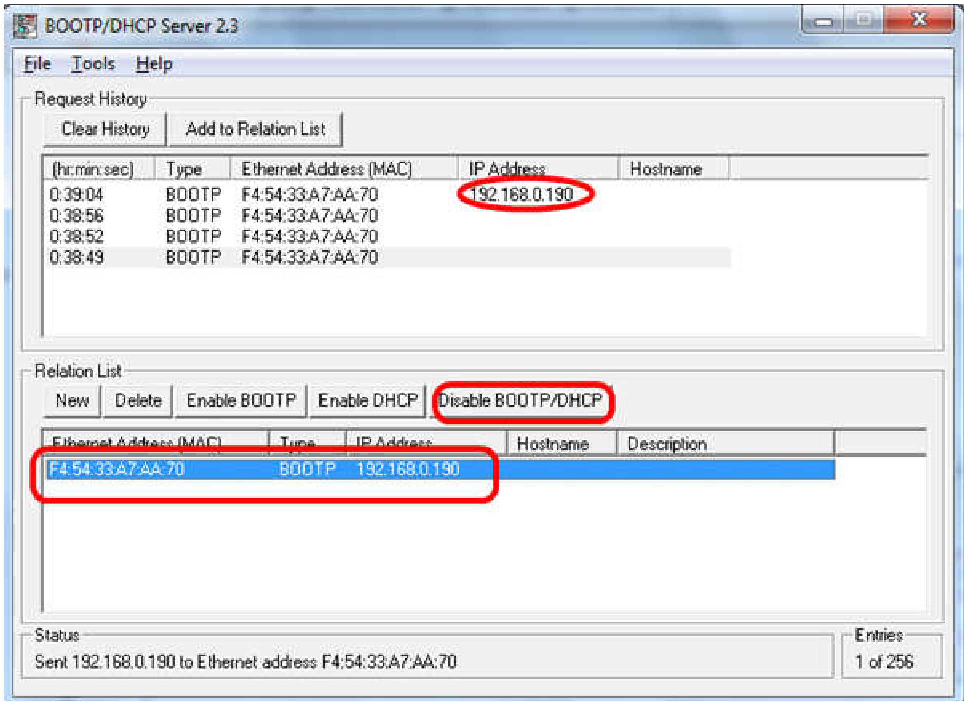
- Your SCADA window will complete.
- Open Scientech 2430 CD and Click on Program Folder then Test button then double click on to the Test_123 program as shown below.



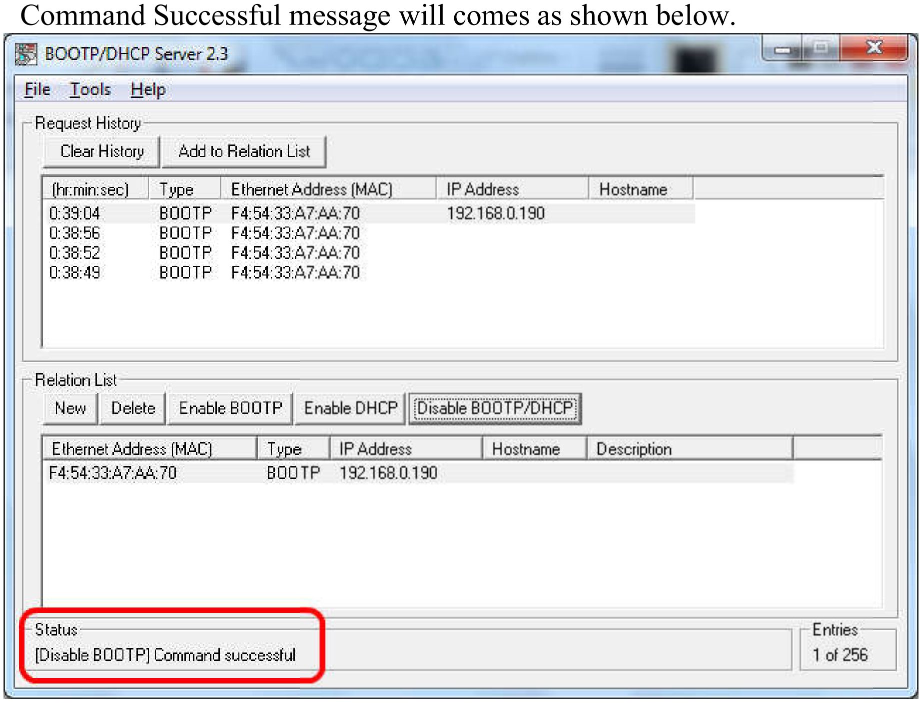
- Go to Rockwell Software Folder then open BOOTP DHCP folder then Click on to the BOOTP DHCP Server button and Please remove Ethernet cable to PLC and Connect again to PLC.



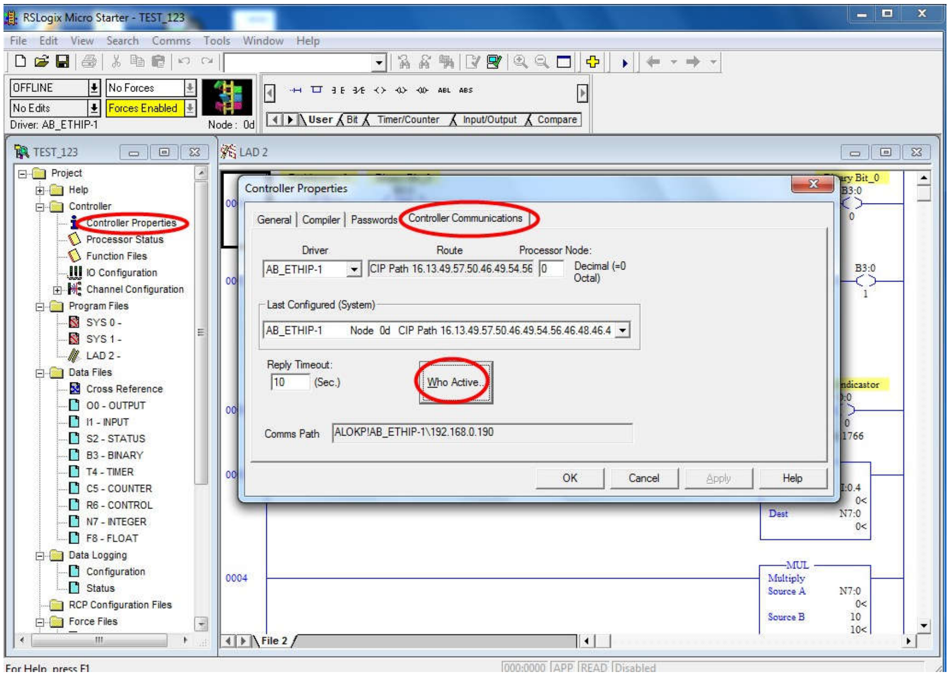
- BOOTP/DHCP Server 2.3 window will open then data will start comes in Request History and Relation List as shown below.



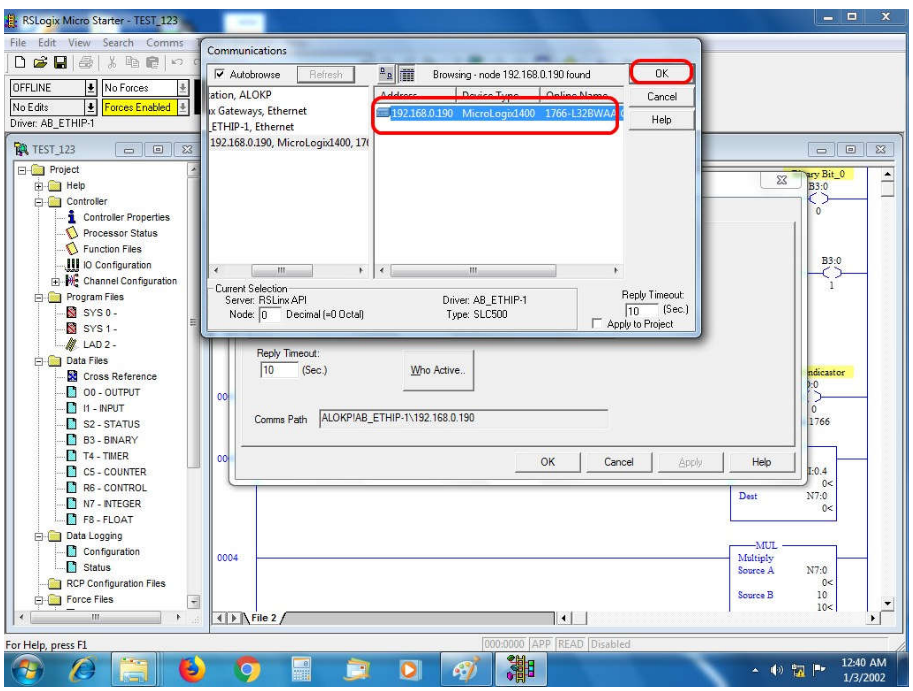
- Click on to the Disable BOOTP/DHCP button then [Disable BOOTUP] Command Successful message will comes as shown below.



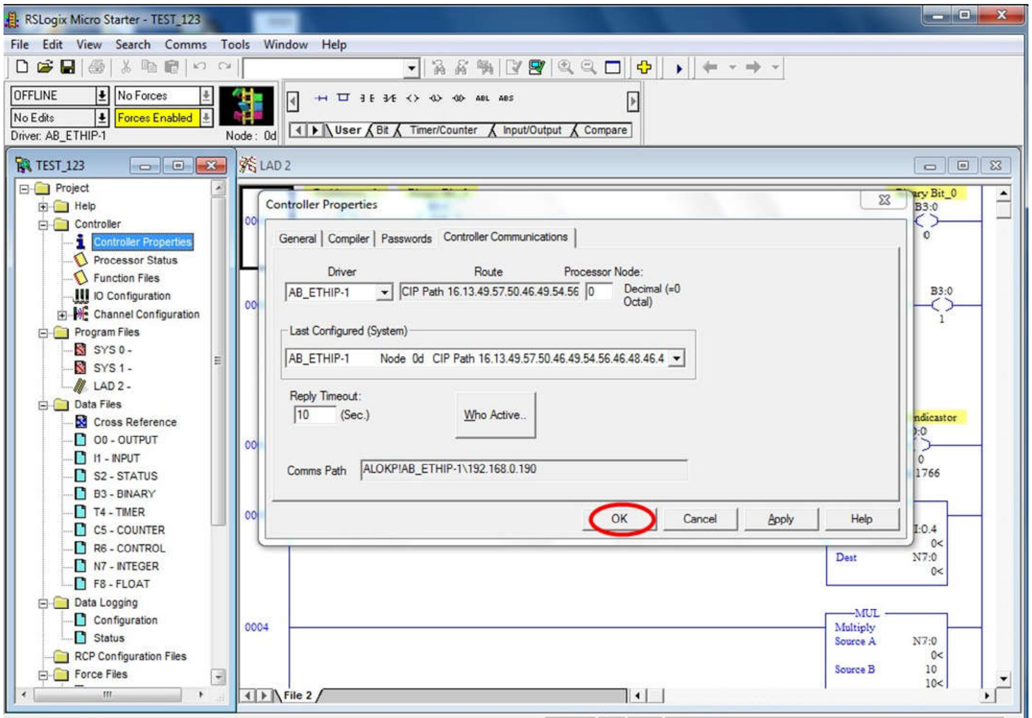
- Click on to the Controller Properties Window then click on to Who Active button as shown below.



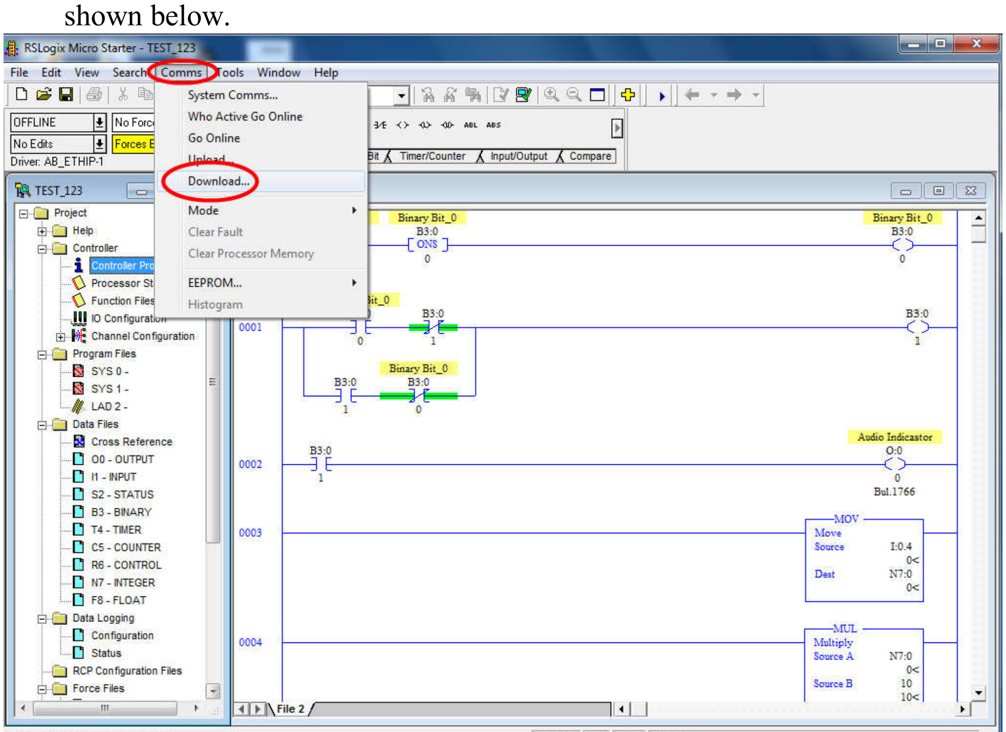
- Click on to the PLC Address 192.168.0.190 and click on to the OK button as shown below.



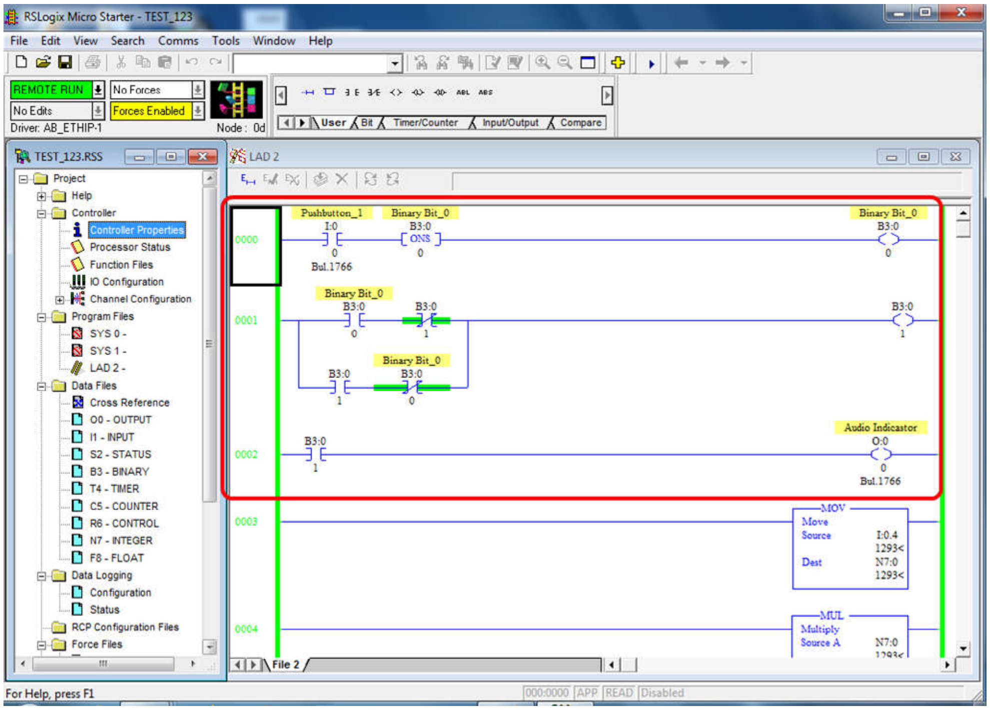
* Click on to the OK button as shown below.



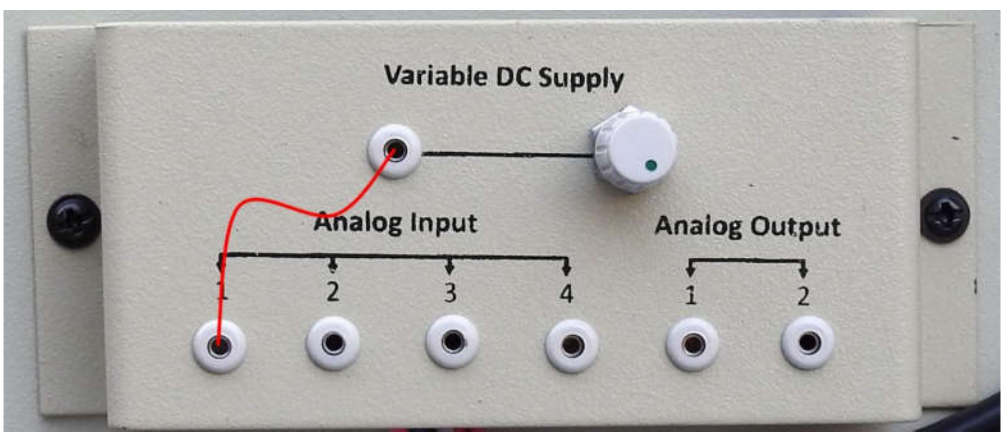
* Go to Comms button (in menu bar) then click on to Download button as shown below.

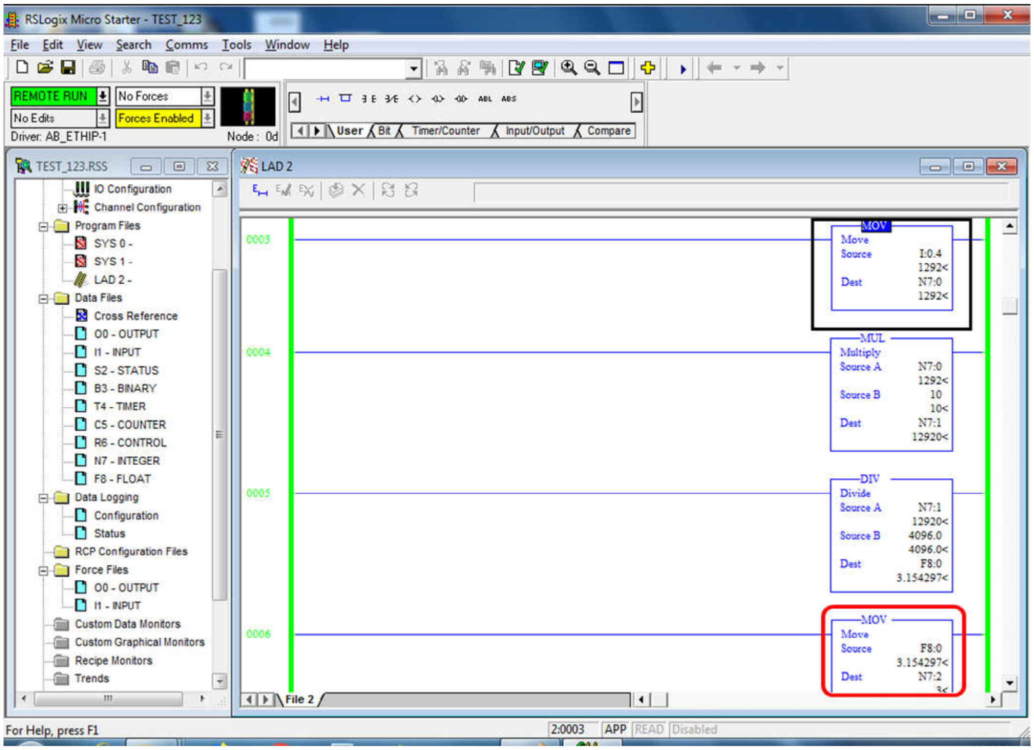


- This Ladder Logic is For Push to ON Switch and Indicator, When you press/Enable/Click on Pushbutton switch then O:0/0 (Audio Indicator) will ON, When you press/Enable/Click on Pushbutton switch then Audio indicator will OFF.

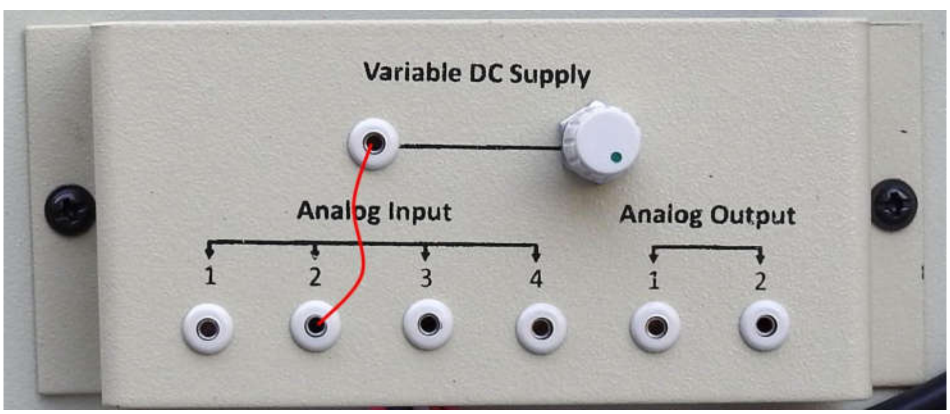


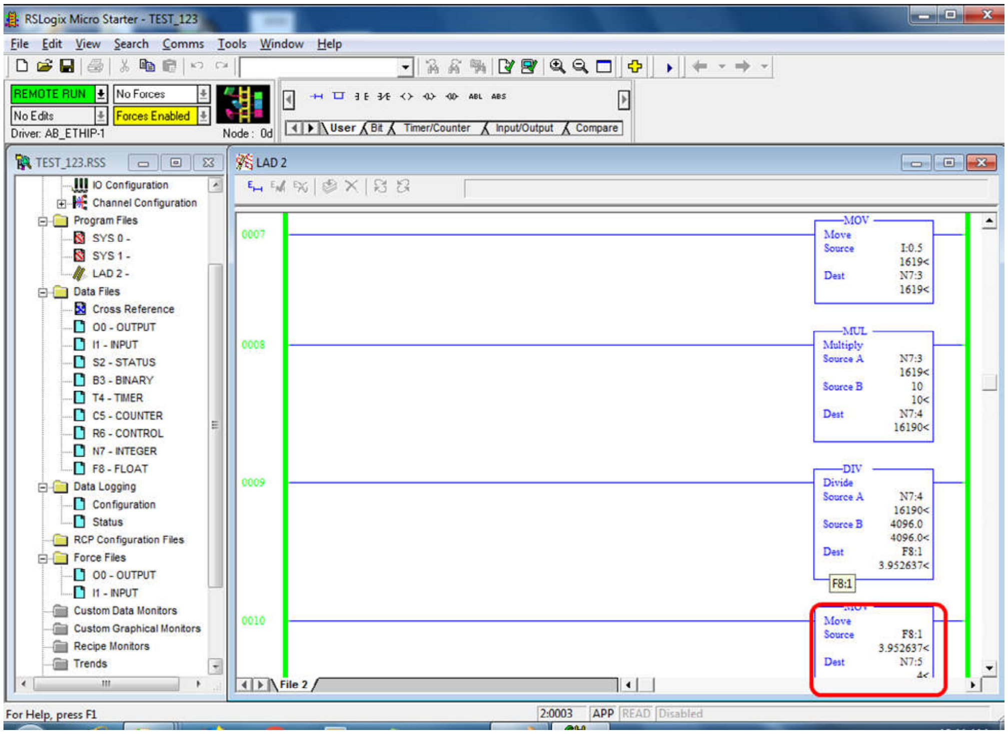
- This Ladder Logic is for Analog Input_1, I:0.4 is Shows analog Input value and F8:0/N7:2 shows the analog Input Voltage in volts, When you rotate the knob of potentiometer then I:0.4 and F8:0/N7:2 Value will change.



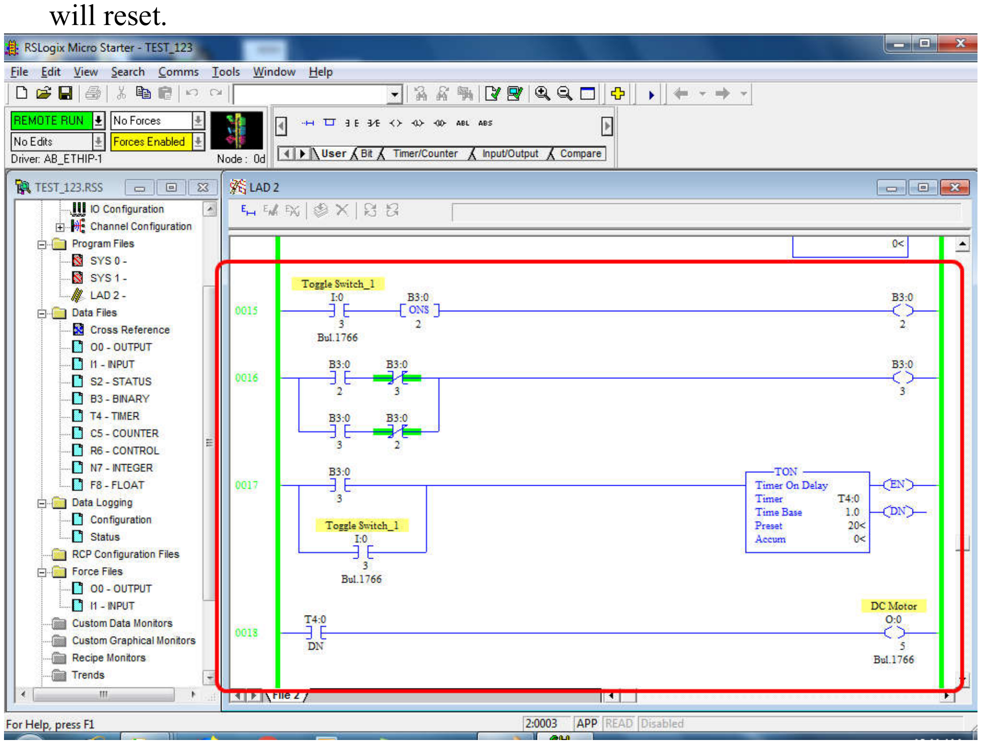


- This Ladder Logic is for Analog Input_2, I:0.5 is Shows analog Input value and F8:1/N7:5 shows the analog Input Voltage in volts, When you rotate the knob of potentiometer then I:0.5 and F8:1/N7:5 Value will change.

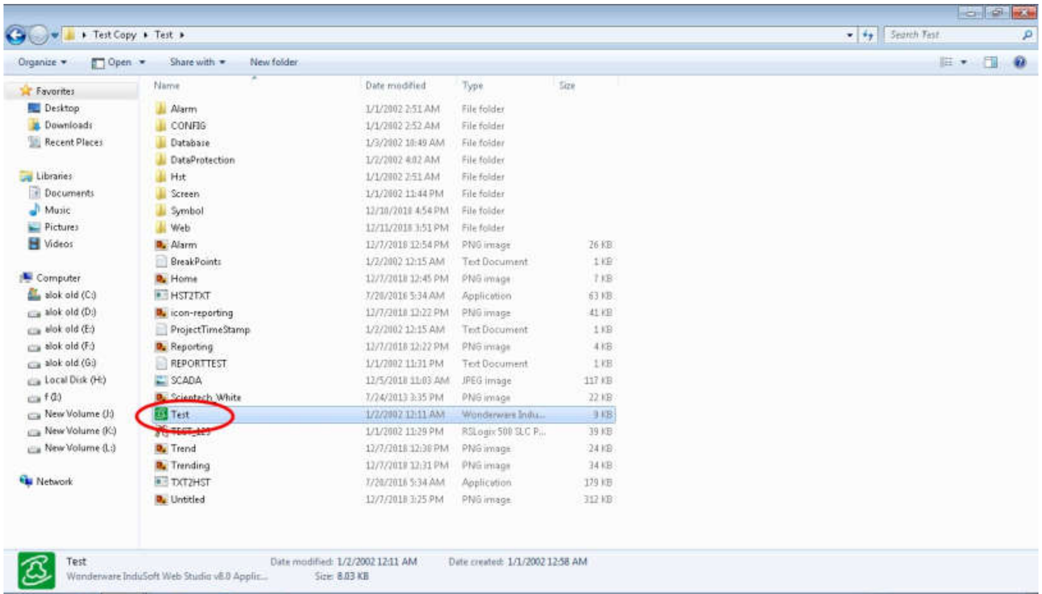




- This Ladder Logic is for Timer Example, When you enable/Click the I:0/3 (Toggle Switch_1) then Timer T4:0 will Start counting after 20S DC Motor will ON. When you disable/click on I:0/3 (Toggle Switch_1) the Timer T4:0 will reset.

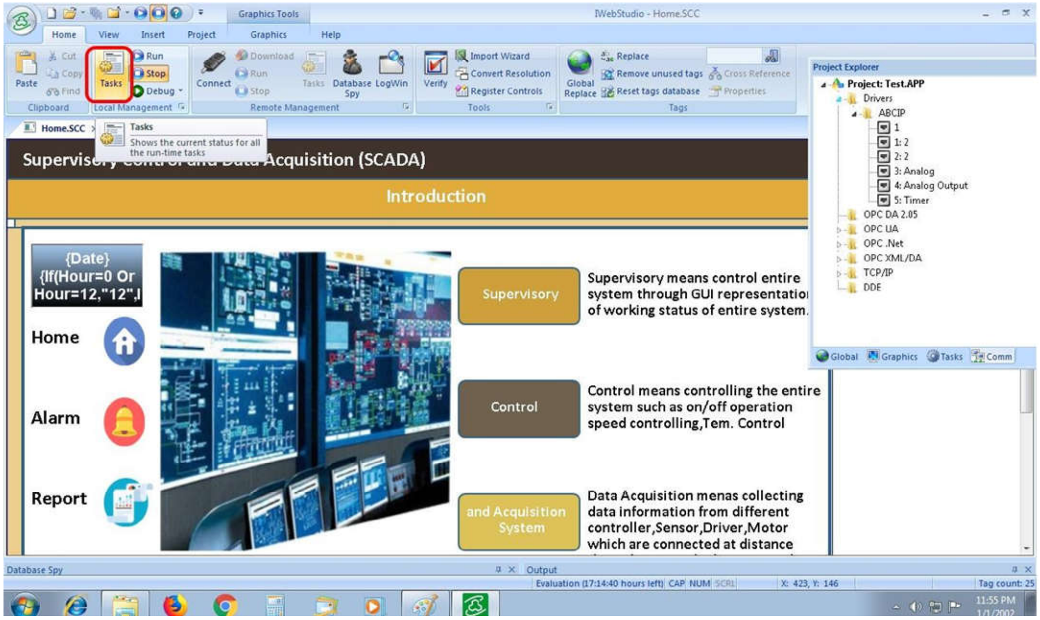


- Open Scientech 2430 CD and Click on Program Folder then Test button then double click on to the Test as shown below.

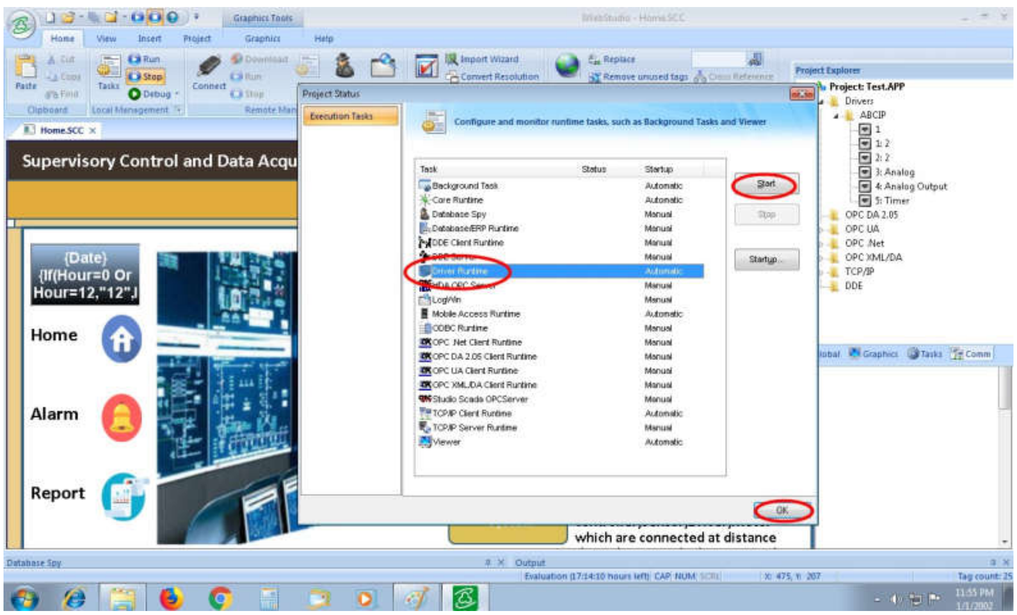


- Your SCADA window will open as shown below.

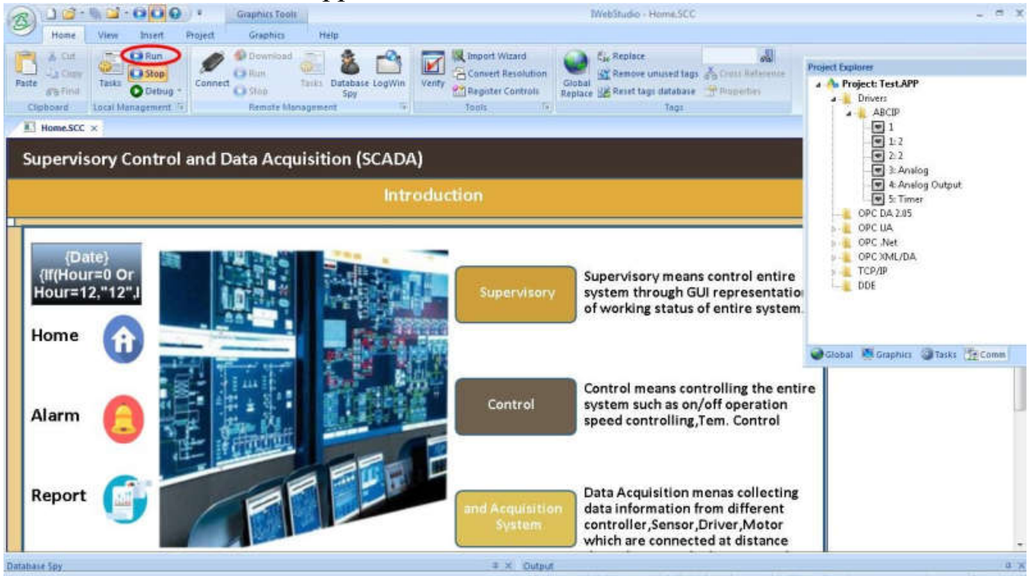
- For Start a SCADA Driver click on to Task button as shown below.



- Project Status window will open then Click on Driver Runtime then click on to Start button as shown below.

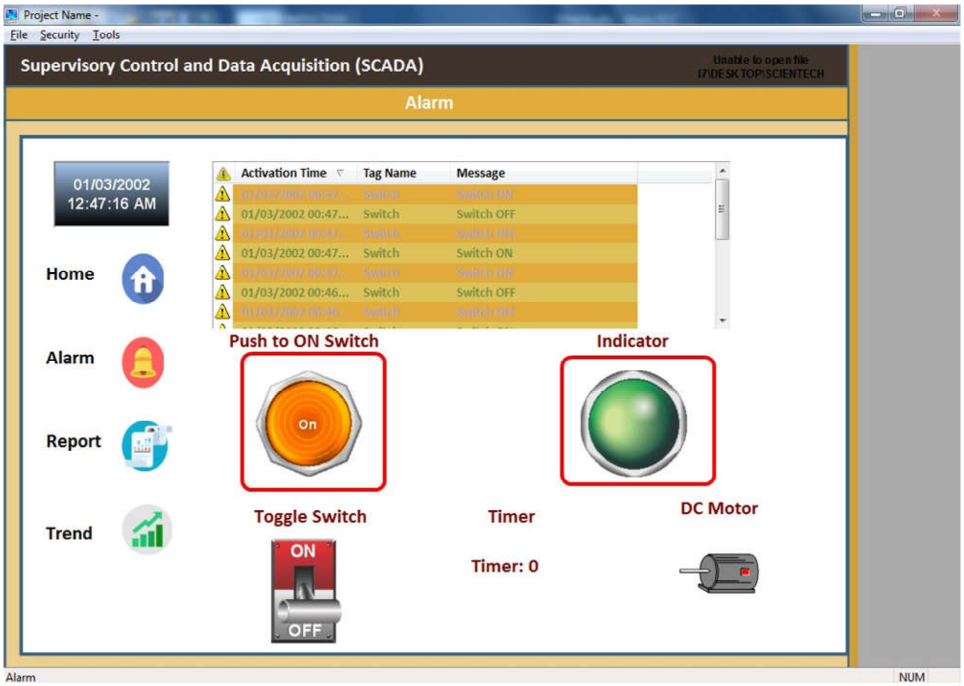


- For Run a SCADA application click on to Run button as shown below.

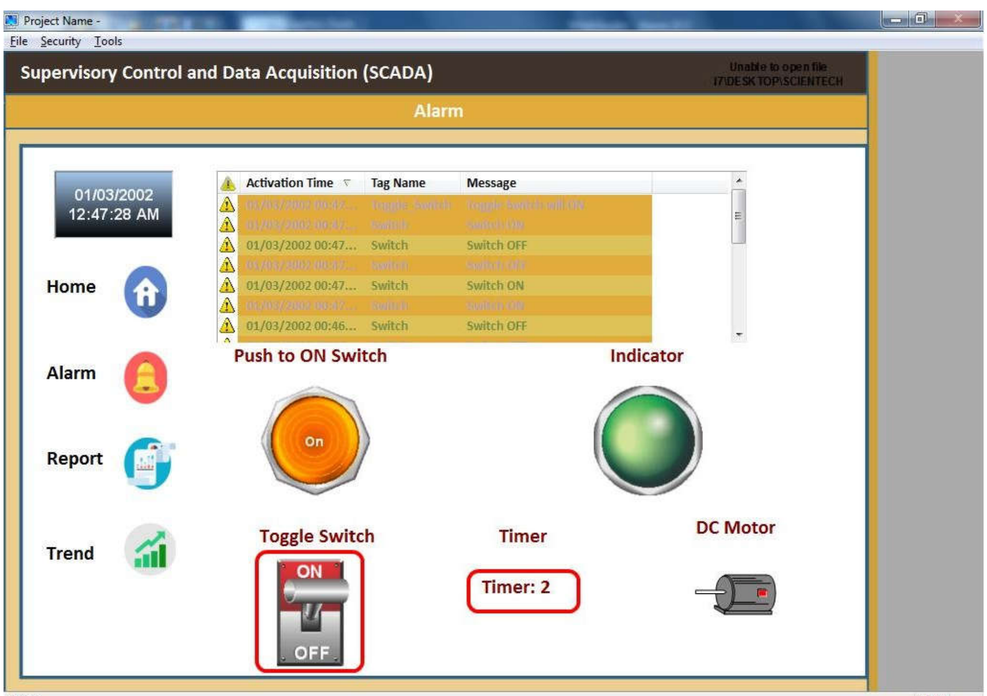


- Alarm window will open as shown below.

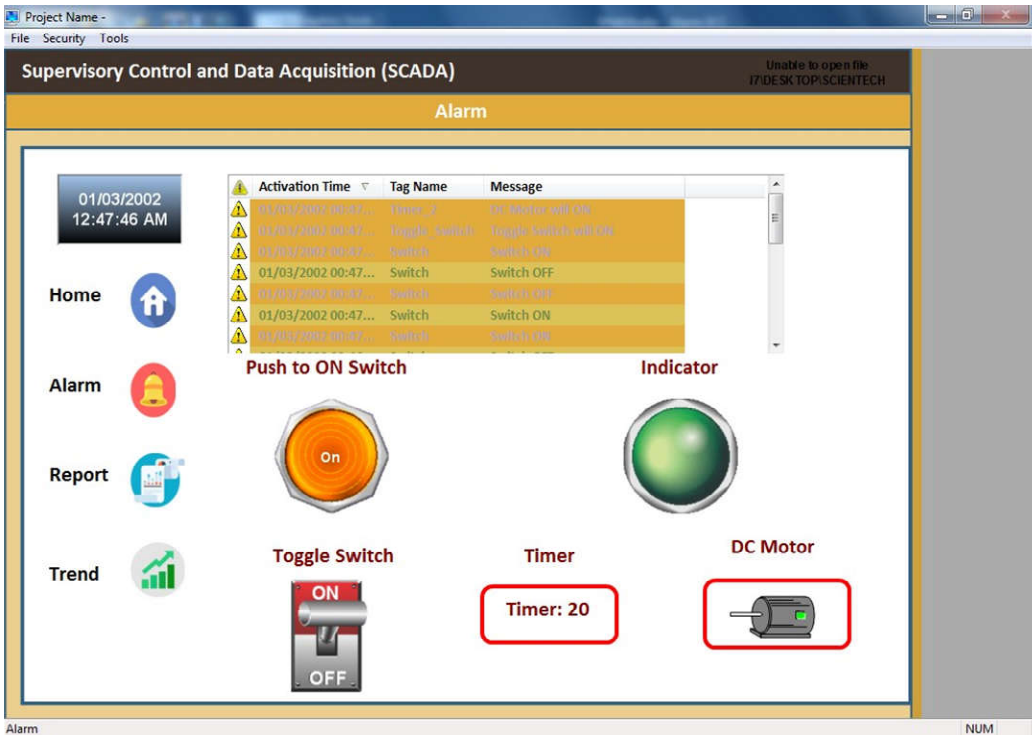
- When you click on Push to ON Switch then Indicator will ON as shown below or when you press Pushbutton_1 then Audio Indicator will ON.



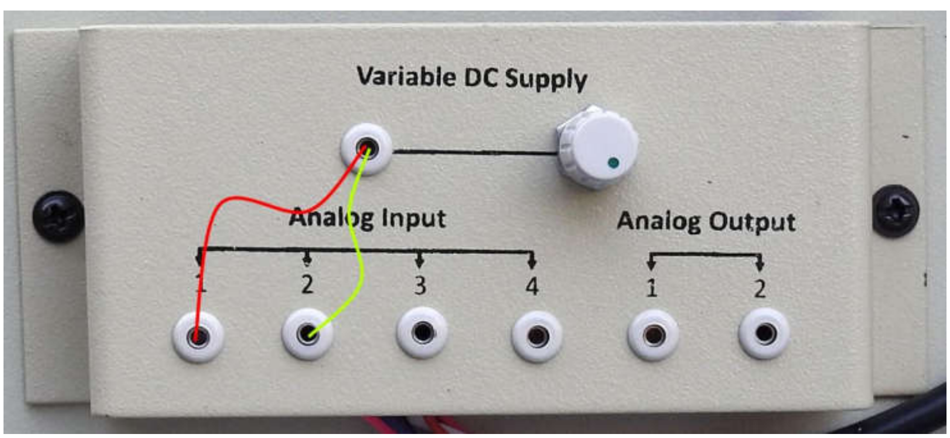
- When you enable the Toggle Switch_1 then Timer will Start counting as shown below.



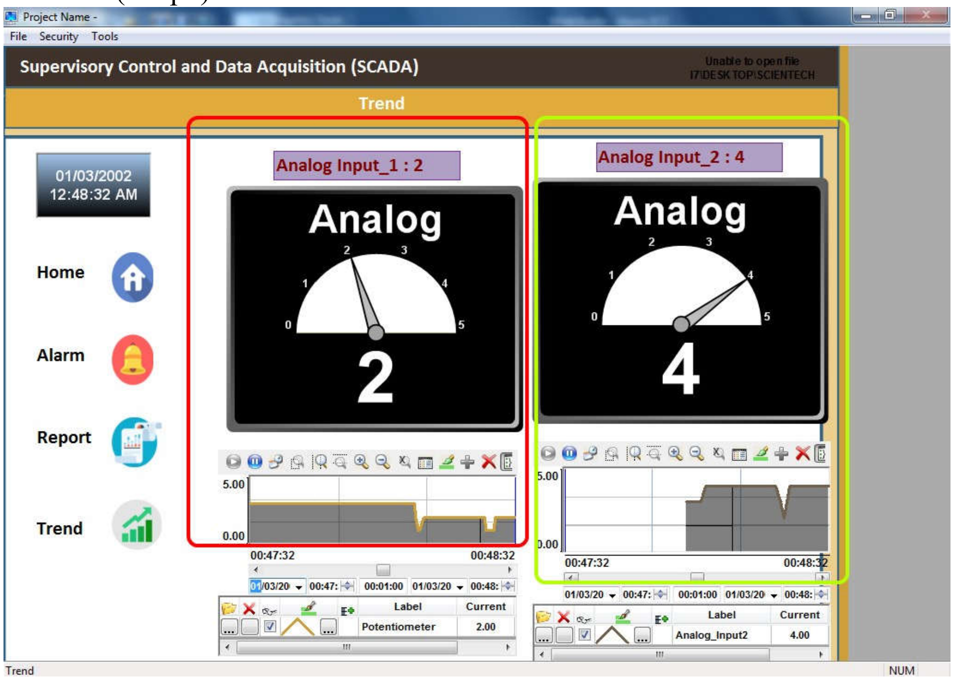
- After 20S DC Motor will on and you see the current status of Push to On Switch, Toggle Switch, Indicator and DC Motor status in Alarm function.



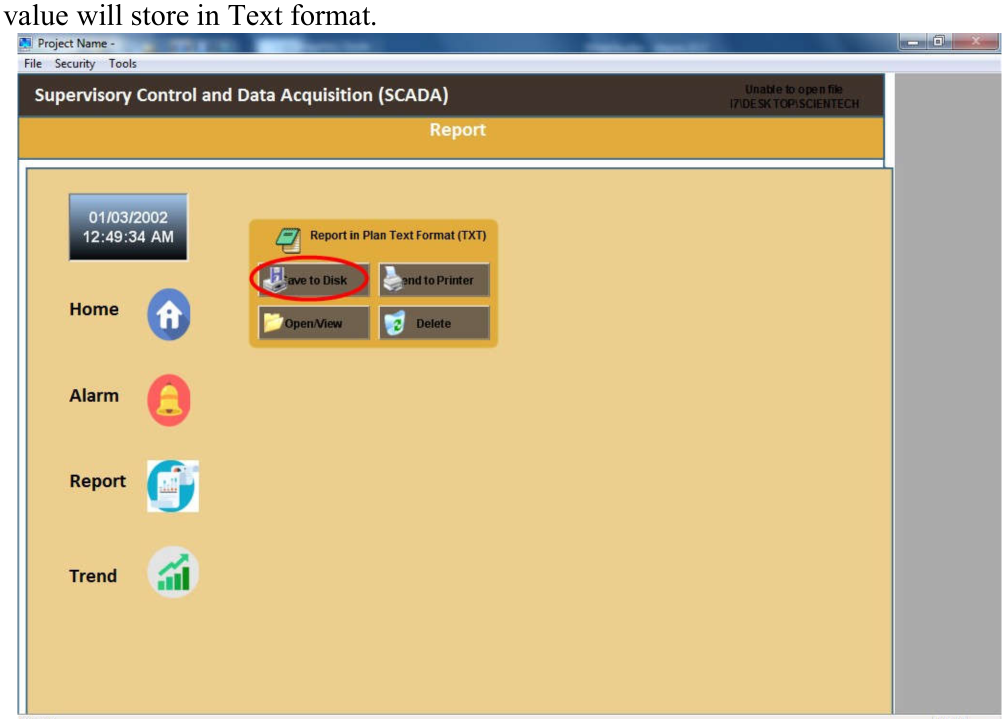
- Make a connection according to below given connection diagram.



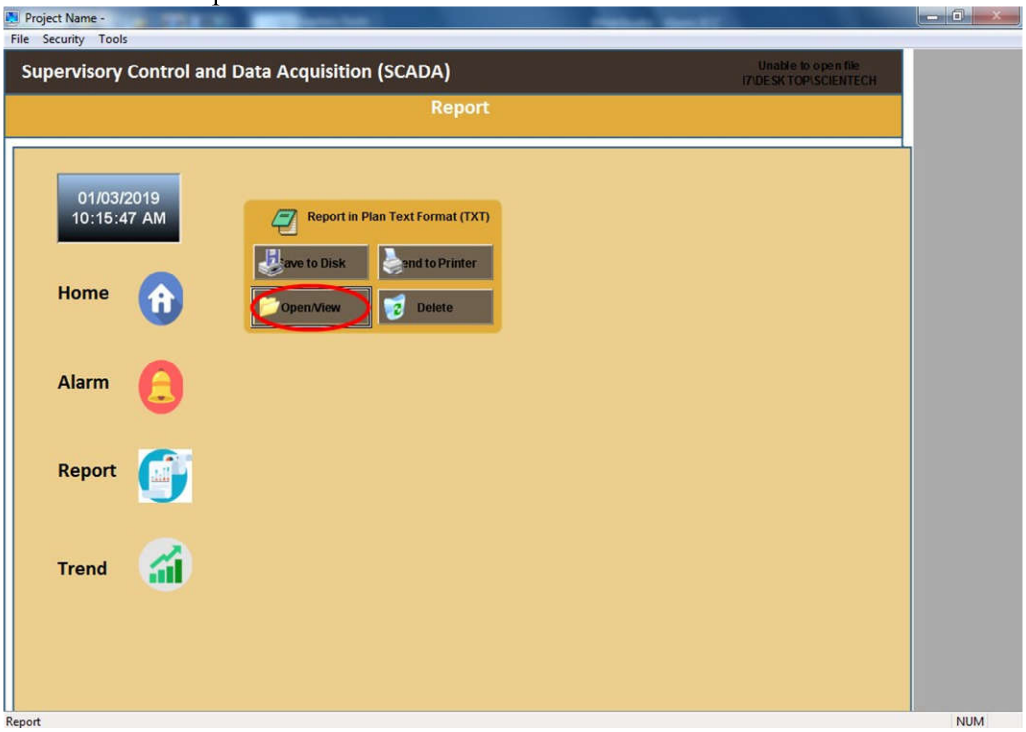
- When you click on to the Trend Button then Trend window will open as shown below. When you Rotate the Knob of Potentiometer then Value of Analog Input_1 and Analog Input_2 Value will change and you see the Real Time Trend (Graph) as shown below.



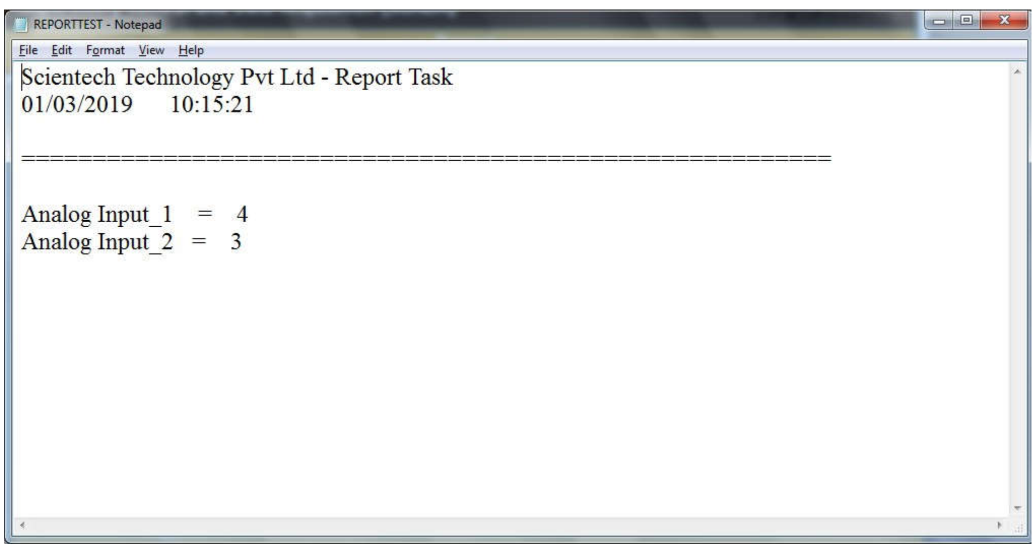
When you click on Save Disk button then your Analog Input_1 and Analog Input_2 value will store in Text format.



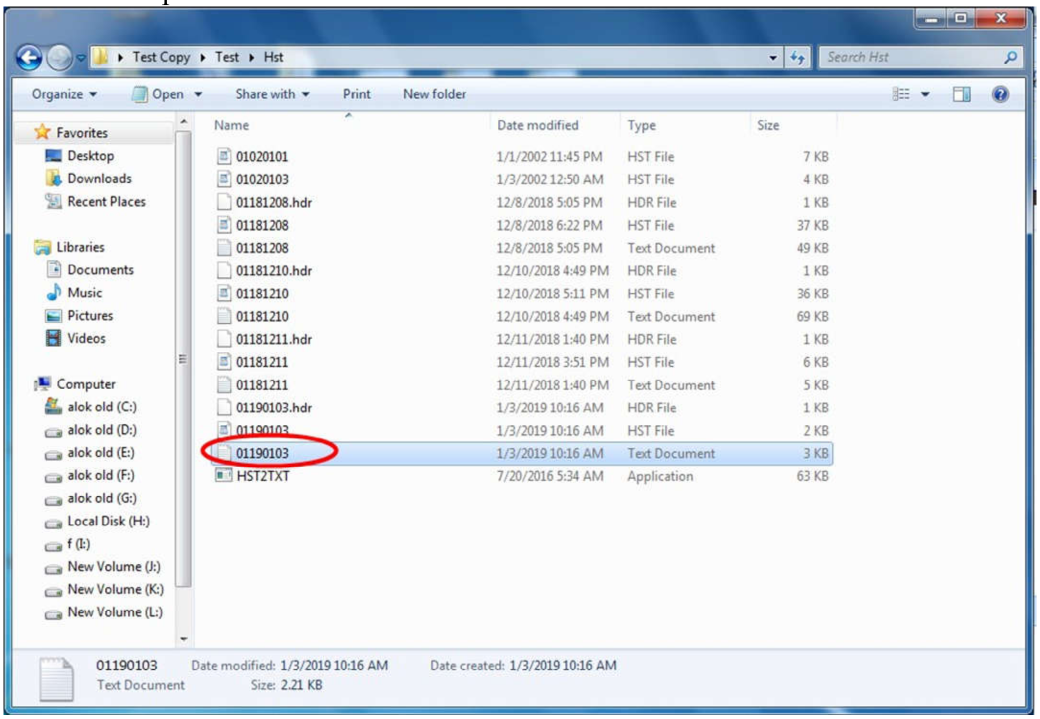
Click on to the Open/View button as shown below.



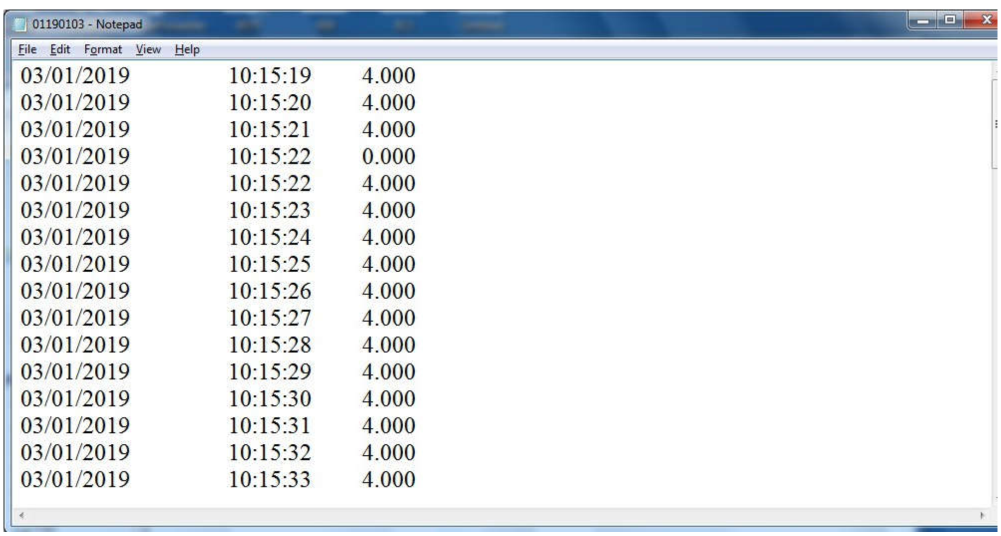
- See the Real Time Report in Notepad as shown below.



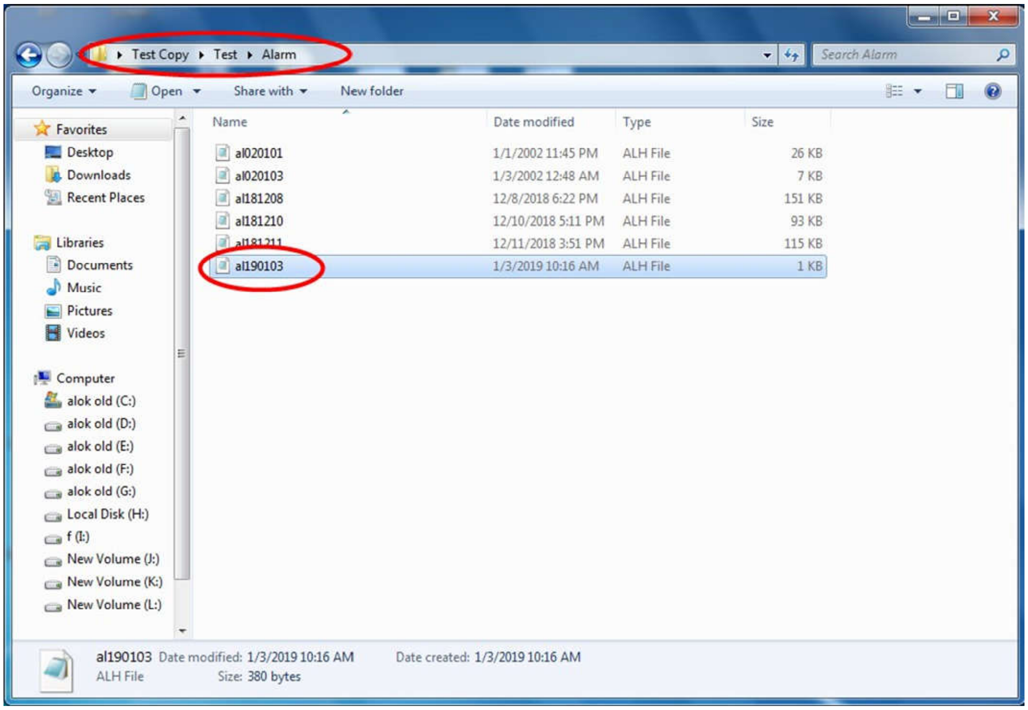
- If you want to see the Historical Data of Report go to HST folder then click on to Notepad File as shown below.



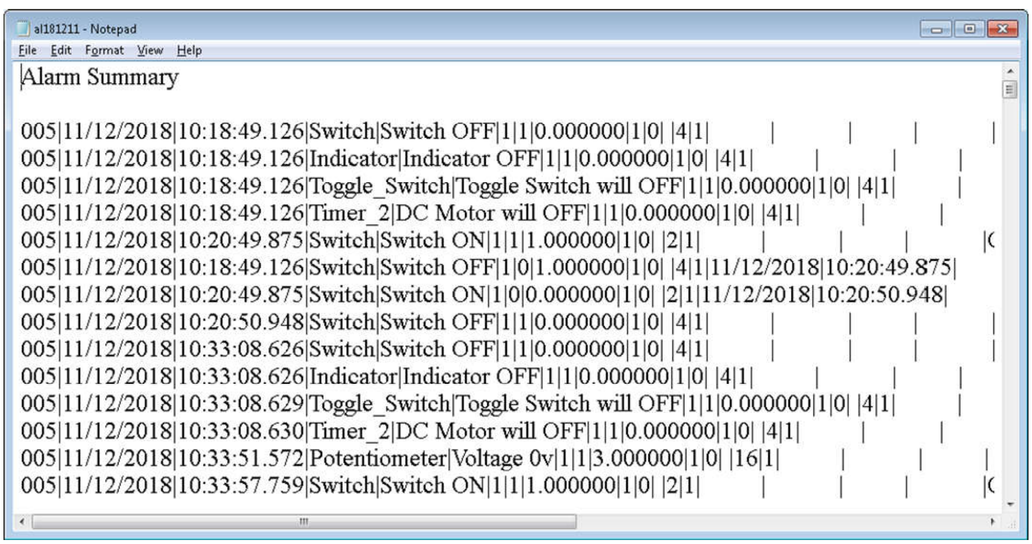
- You See the Historical Report Data as shown below.



- If you want to see the History of Alarm function then go to Alarm function folder as shown below.



- You see the Historical Data of Alarm as shown below.



- If you want to Stop the SCADA window and click on to Stop button as shown below.