EE853/1 EE853/2-1

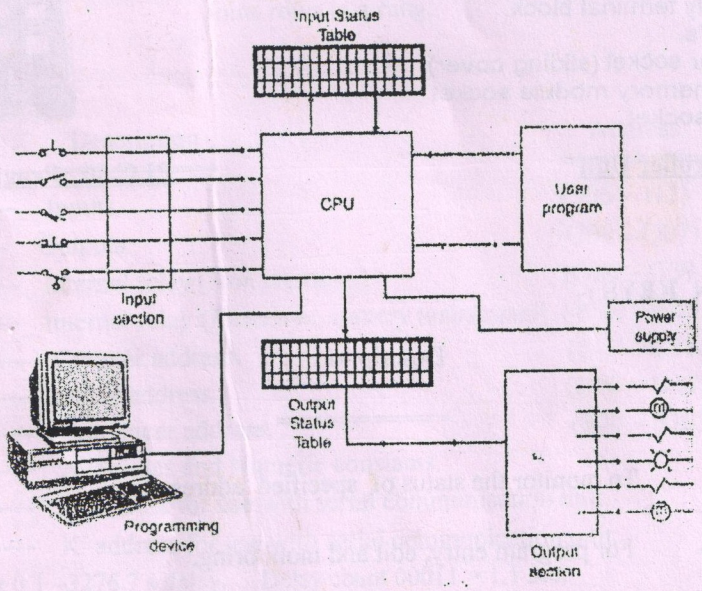
4.9.1
11-1

INSTRUMENTATION AND PROCESS CONTROL LAB.

FAMILIARISATION WITH PROGRAMMABLE LOGIC CONTROLLER (PLC)

Programmable logic controller is a micro computer based electronic system, designed for use in an industrial environment, which stores user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting, and arithmetic to control, through digital or analog inputs and outputs, various types of machines or processes.

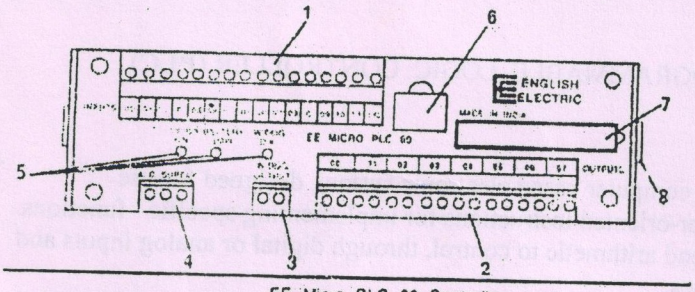
Control devices such as limit switches, push buttons, proximity or photoelectric sensors, float switches, pressure switches etc. provide incoming signals into the unit.



Signal flow into and out of a PLC

.EE MICRO PLC 60 has the following main features.:-

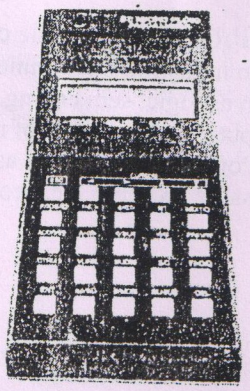
1> **Program Capacity** – 2000 Instruction.
2> **Memory Type**- Battery supported Static RAM (EEPROM optional).
3> **Execution Speed** – 1000 instruction / 5ms.
4> **Inputs/Outputs** – 12 Inputs, 8 Outputs.
5> **Input types** – Current sink or source from a 24 vdc supply (internal or external).
6> **Output Types** – Relay, Triac, Transistor.
7> **Delay (Timers)**- 32 software adjustable 0.1 – 3276.7 s, 32 software adjustable 0.01 – 327.67 s.
8>**Counters** – 32 software adjustable 1- 32, 767 counts.
9>**Flags** – 128.64.
10>**Sequencers**- 8, Each having 8.



EE Micro PLC 60 Controller

1. Input terminal block.
2. Output terminal block.
3. watchdog terminal block.
4. Power supply terminal block.
5. Status LED's.
6. Programmer socket (sliding cover)
7. EEPROM memory module socket.
8. Expansion socket.

PLC 60 Controller Unit



PLC 60 Programmer Unit

PROGRAM FUNCTION KEYS :-

Handheld Programmer Key	Description
ADDR	To monitor the status of specified addresses.
PROG	For program entry, edit and monitoring.
CTRL	Allows direct operation of the Programmable Controller / Programming Interface
BLNK	Gives a blank display for entering new rung.
ED	Edit an existing program.
FIND	Find a specific rung element.
NEXT	Display next rung in program.
PREV	Display previous rung in program.
MON	Monitor status of rung elements.
ENT	To enter instruction/element/address or value.
ESC	Escape from current operation.
DEL	**I> In program mode--** Delete the rung currently being displayed. **II>When editing --** Delete specified element, address or value.

PROGRAM ELEMENT KEYS :- (Ladder Diagram Symbols)

Handheld Programmer Key		Description
-] [-	--------	Normally open contact.
-]/[-	--------	Normally close contact.
-( )-	--------	Coil (Output and internal relay).
-< C >-	--------	Counter
-< S >-	--------	Sequencer.
-< D >-	--------	Delay.
BLK	--------	Block.(To define a block of rungs for conditional execution.)
LINK	--------	Links spacing elements in rung.
JN	--------	Joins rows in a rung.

ALPHA- NUMERIC KEYS :-

Handheld Programmer Key		Description	Address
I	--------	Inputs	(I00 - I11)
Q	--------	Outputs	(Q00 – Q07)
G	--------	Internal relay (Non retentive)	(G00 – G39)
W	--------	Internal relay (Retentive, Battery maintained)	(W00 –W39)
C	---------	Counter address.	(C00 – C31)
D	---------	Delay address.	(D00 – D63) #
S	---------	Sequencer address.	(S00 – S30)
0 - 9	---------	Addresses and Numeric constants.	
S then I	---------	J address for use with serial communication unit.	
S then Q	---------	K address for use with serial communication unit.	

\# Delay adds. D00 –D31 for 0.1 –3276.7 s delay. Delay count 00011 = 1.1 sec.
Delay adds. D32 –D63 for 0.01 –327.67 s delay. Delay count 00011 =0 .11 sec.

LADDER DIAGRAMME ---

Ladder diagram is a traditional method of representing a control circuit. It reflects a conventional wiring diagram of the physical arrangement of the various components such as Switches, Relays, Valves, Motors etc. and their interconnections. Ladder diagram programs consist of a number of Rungs, each of which are made up of a number of circuit elements in series and parallel. In MICRO PLC 60 a complete rung is constructed by entering elements from the keypad which appear on the display. Elements fall automatically onto a GRID, 10 elements wide and 5 elements high, which is known as the RUNG GRID.

```
COLUMN    1  2  3  4  5  6  7  8  9  10

ROW   1   |-] [---] [----------( )-|
      2   |-]/[-|
      3   |-] [--<D>----------( )-|
      4   |-] [--<C>----------( )-|
      5   |-] [--<S>----------( )-|
```

** For more details on Micro PLC 60 consult the operating manual.

EE 853/II ~~EE 853/2 - 2a~~

DEPARTMENT OF ELECTRICAL ENGINEERING

BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR

-: *Processcontrol and Instrumentation Laboratory* :-

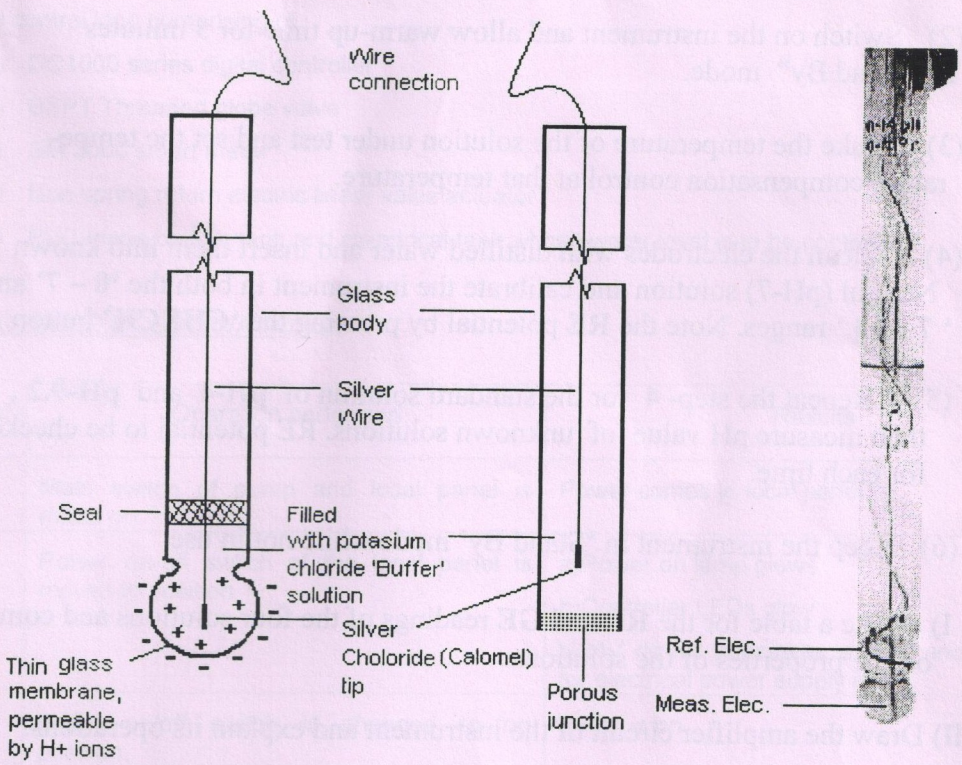
Objectives:- To measure pH value of different solutions and also to be familiar with pH measuring instruments.

pH -- pH value of a solution is a logarithmic measurement of the number of moles of hydrogen ions (H+) per liter. The lower-case "p" stands for the negative common (base ten) logarithm and upper-case "H" stands for the element hydrogen.

pH= - log (H+)

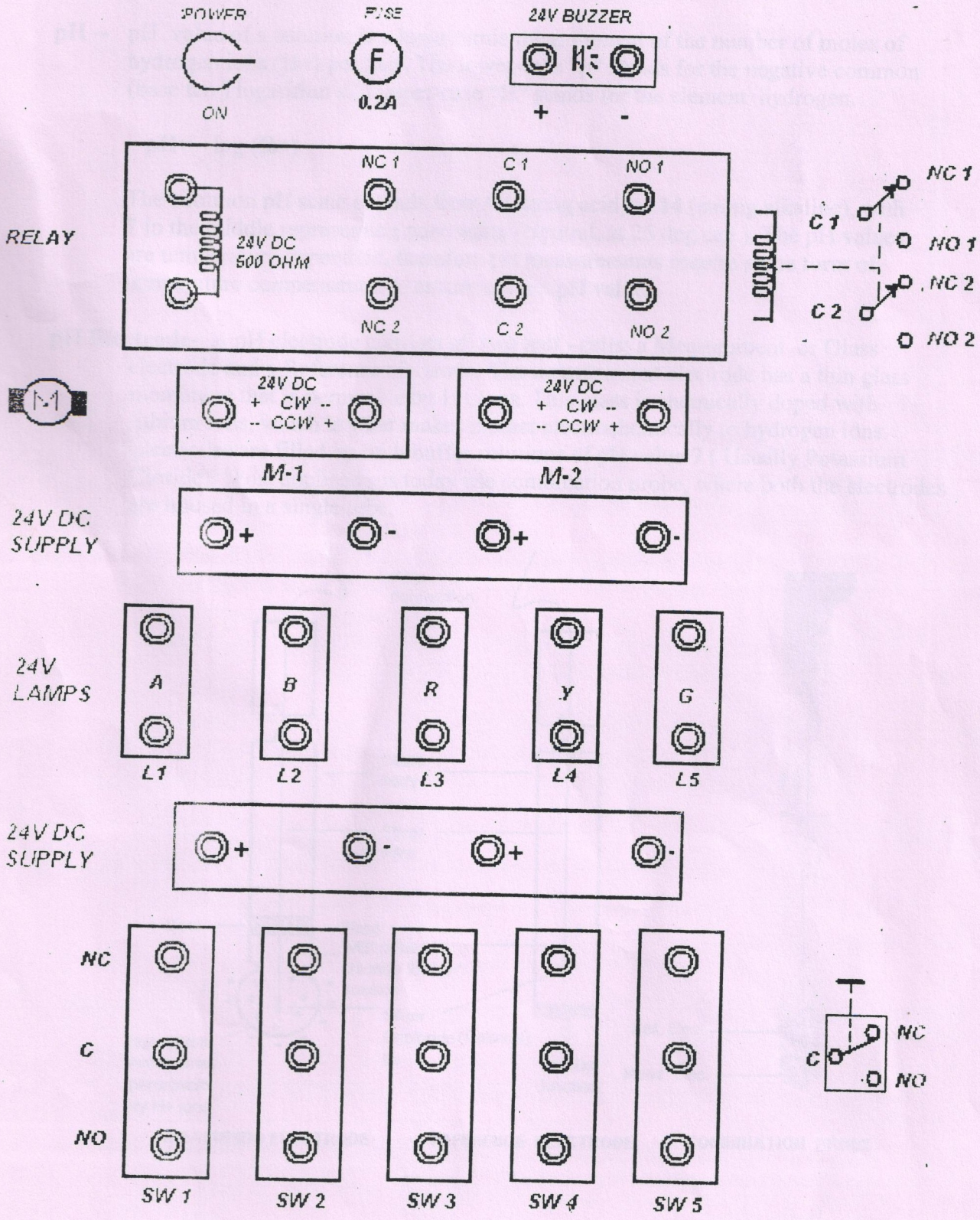
The common pH scale extends from **0** (strong acid) to **14** (strong alkaline), with **7** in the middle representing pure water (Neutral, at 25 deg.cen.). The pH values are temperature dependent, therefore pH measurements require some form of temperature compensation to ensure correct pH values.

pH Electrode- A pH electrode consists of two half –cells; a Measurement or Glass electrode and a Reference electrode. The measurement electrode has a thin glass membrane that is permeable by H+ ions. This glass is chemically doped with lithium ions, which is what makes it react electrochemically to hydrogen ions. Electrodes are filled up with buffer solutions of pH value 7 (Usually Potassium Cloride). Most applications today use combination probe, where both the electrodes are housed in a single tube.



MEASURING ELECTRODE REFERENCE ELECTRODE COMBINATION PROBE

PLC CONTROL PANEL TERMINALS



EE 853/II ~~EE 853/2 - 2a~~

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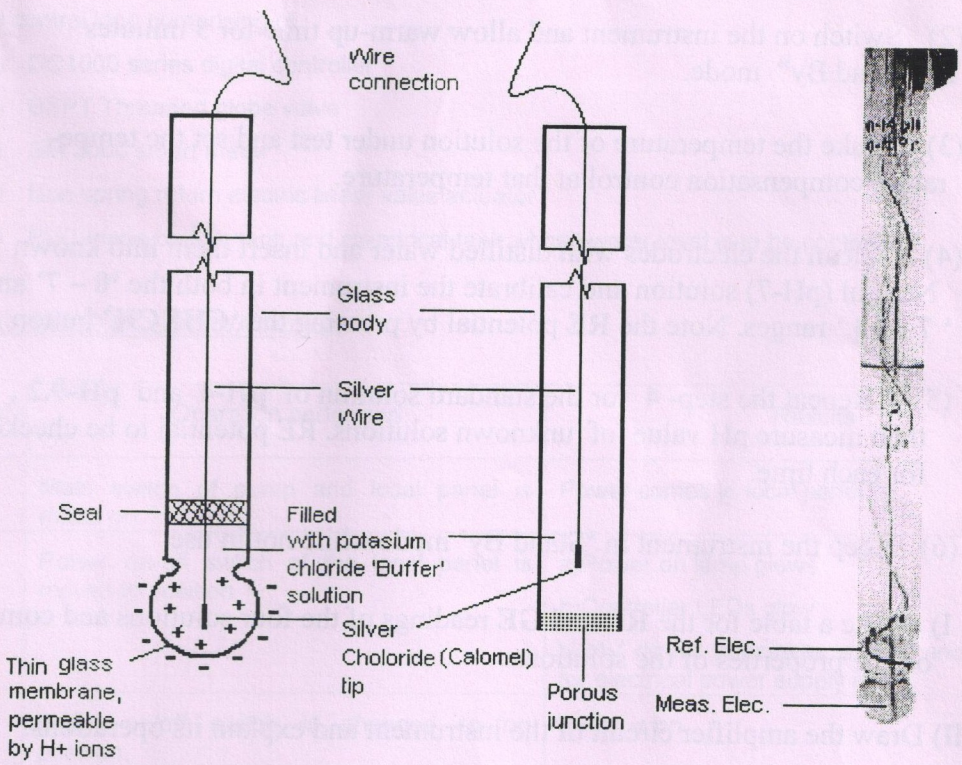
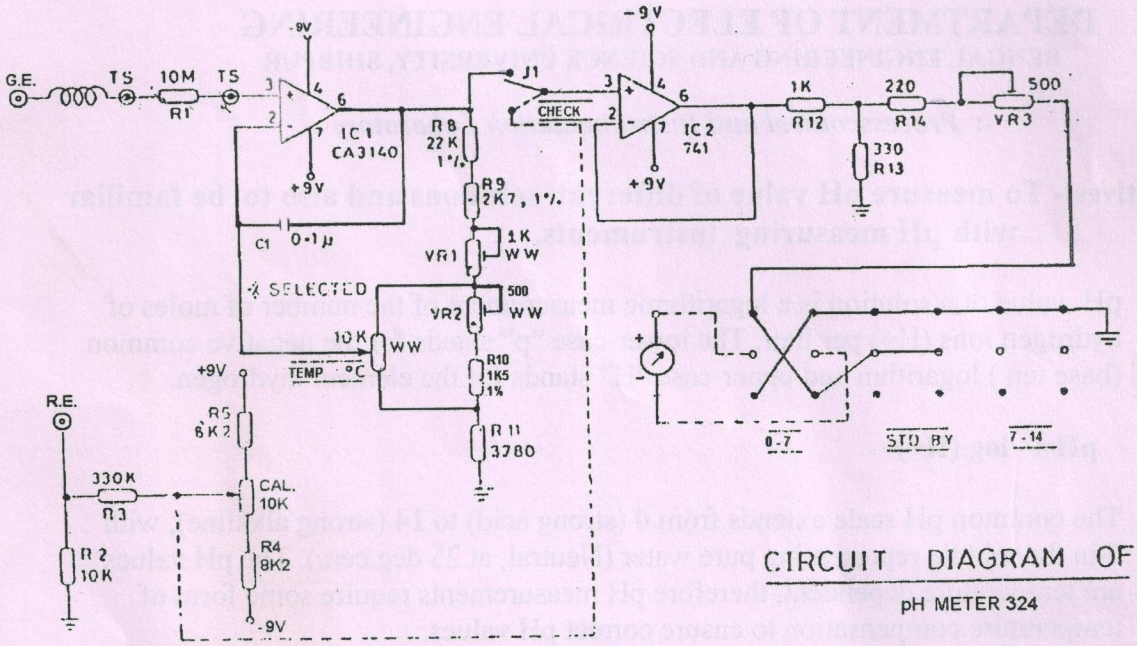


MEASURING ELECTRODE REFERENCE ELECTRODE COMBINATION PROBE



CIRCUIT DIAGRAM OF

pH METER 324

** For further details on **pH METER 324** see the operating manual.

Procedure:- (1) Study the construction of the Reference Electrode **(RE)** ,the Glass Electrode **(GE)** and the operation of the amplifier circuit used in the measuring instrument.

(2) Switch on the instrument and allow warm-up time for 5 minutes in "Stand By" mode.

(3) Take the temperature of the solution under test and set the temperature compensation control at that temperature.

(4) Clean the electrodes with distilled water and insert them into known Neutral (pH-7) solution and calibrate the instrument in both the **'0 – 7'** and **' 7 – 14 '** ranges. Note the **RE** potential by pressing the **'CHECK'** button.

(5) Repeat the step- 4 for the standard solution of **pH-4** and **pH-9.2 ,** then measure pH value of unknown solutions. RE potential to be checked for each time.

(6) Keep the instrument in 'Stand By' mode while not in use.

Report:- I) Make a table for the **RE** and **GE** readings of the four solutions and comment on the properties of the solutions.

II) Draw the amplifier circuit of the instrument and explain its operations.

III) Draw and label the diagramme of the Ref. Electrode, Glass Electrode and Combination probe.

EE 853/III

DEPARTMENT OF ELECTRICAL ENGINEERING

Bengal Engineering & Science University, Shibpur, Howrah - 711 103.

Process Control Instrumentation Laboratory (EE-853/2)

CLASS: Fourth Year (8th Sem) EE . NAME: _____.

Date: _____. Roll No.: CX / CY - _____.

Expt. No.: EE853/2-1 – 2b. .

TITLE OF EXPERIMENT: Study of LEVEL control loop and tuning of PID controller.

OBJECT: **To study the operation of a liquid level control loop and to tune Honeywell make PID controller placed in the loop.**

INTRODUCTION:

The water is flowing from the Bottom Tank through 1 inch pipe to vertical type Cylindrical Tank where level of water is to be maintained. The water level is measured by Honeywell make DP Transmitter giving 4-20 mA DC output (PV) proportional to water level(0-600 mm approx).This 4-20 mA DC output is fed to the microprocessor based single loop PID controller(Local Panel). The controller processes the PV input w.r.t. SP and gives the corrective output signal, which is fed to Honeywell make Electrically operated linear control valve located on the incoming flow line to control the desired level as per the set point generated from PID controller.

LIST OF APPARATUS & EQUIPMENT:

Level control loop comprising of

a) DC1000 series digital controller
b) BSPT Threaded globe valve
c) SM 3000 smart meter
d) Non spring return electric linear valve actuator
e) PVC made bottom tank and cylindrical tank whose water level is to be controlled.

PROCEDURE & OBSERVATIONS:

No. of steps	Operation performed	Results
1	Main switch of pump and local panel is made on.	Power comes to local panel.
2	Power on-off switch of the local panel is moved to position 1.	a)Power on lamp glows b)Controller LEDs glow c)24V dc for transmitter supply and 24V ac for electrical power supply is on.
3	Motor on/off switch is changed to on position.	Pump is on
4	**Set a value from 0 to 600 into the controller as a set point** - Press left arrow key ,when SP value blinks, press upward or	a) SP value will stop blinking b) Automatic control will start.

	downward key to set the desired value from 0-600 mm. After that press SET key to enter this value into the memory of the controller.	
5	**Set P value** – Press and hold SET key for 5 seconds. Upper display will show **P1** ,lower display will show existing **P** value. This value can be changed like SP value change.	Controller is ready with **P**.
6	**Set I and D value** - Pressing set key **I1** and **d1** parameter can be changed one by one.	Controller is ready with **I** and **D** as set.
7	**Return to the normal mode** – Press and hold set key for 5 secs	Upper display will show PV value and lower display will show SP value.

Report : 1) Note the variation of Smart meter output(4-20 mA)and controller output(4-20 mA) for 10 different values of Set Point(SP) and plot them on the same graph.

2) Note steady state error for each set point.

3) Note settling time for the controller in the range of 0-400mm and 200-400mm.

4) Fix set point at 500mm.Restart the loop and note valve opening after each 15 seconds. Plot time Vs. %valve opening.

5) Repeat step (4) for new **P** value (60) and **I** value (100). Comment on the performance of the controller.

6) Check repeatability of the actuator by keeping 3 different set points (100 mm, 300mm, 500mm) for rising level as well as falling level.

EE 853/IV ~~EE 853/2-3~~.

DEPARTMENT OF ELECTRICAL ENGINEERING

Bengal Engineering & Science University, Shibpur; Howrah – 711 103.

Instrumentation Laboratory Sessional (EE-612)

CLASS: Third Year (6thSem) CST. NAME: _____.

Date: _____. Roll No.: FY - _____.

Expt. No.: ~~CMI 612/2~~ _____. Batch No.:____. Co-Workers: _____.

TITLE OF EXPERIMENT: **STUDY ON TEMPERATURE TRANSDUCER**

OBJECT: To study the characteristics of a thermocouple and to become familiar with the use of a temperature controller.

REFERENCE:

[1] A. D. Helfrick and W. D. Cooper - Modern Instrumentation And Measurement Techniques", PHI.

[2] C. S. Rangan, G. R. Sharma, V. S. Mani - Instrumentation-Devices And Systems, TMH.

[3] D. V. S. Murti. - Transducers And Instrumentation, PHI.

INTRODUCTION: Thermocouples (T/C's) are perhaps the most commonly used transducers for temperature measurement. The sensing is based on the Seebeck effect. The magnitude of the sensitivity of a thermocouple depends upon the chemical composition and the physical treatment of the materials used in the thermocouple which is composed of junctions of two dissimilar metals [e.g. Type K: Chromel(+)/Alumel(-)].

Temperature Controllers are electronic circuits for maintaining constant temperature of the furnace at the set-value by sensing the temperature with the help of a thermocouple and error signal is utilised to switch ON and OFF the heater element using an electronic circuit.

USE OF APPARATUS & EQUIPMENT: Prepare a List of apparatus and equipment in a tabular form showing Sr. No., Item, Type/Model, Specification/ Range, Make, Lab. No. etc.

(i) Themocouple (Type-K),
(ii) Electric Furnace
(iii) Contactor,
(iv) Multimeter,
(v) Electronic Temperature Controller,
(vi) Connecting Cables and wires etc.

PROCEDURE & OBSERVATION:

1. Study the ON-OFF Type TEMPERATURE CONTROLLER panel, the connection diagram as per Fig.1 and the CONTACTOR circuit.
2. Connect the thermocouple to the controller as per the given circuit diagram of Fig. 1. DO NOT insert the sensor in the furnace or DO NOT connect the furnace to the circuit.
3. Switch ON the power of the controller and after 5 minutes note the reading of AMBIENT temperature from the display of the controller and the voltage across the thermocouple terminals.
4. Now adjust the SET-POINT to the temperature 10°C above the ambient temperature and switch OFF the power to the controller.
5. Insert the sensor through the hole provided for on the wall of the furnace. Close the door of the furnace and interconnect the contactor and furnace heater circuit to the controller as shown in Fig. 2.

6. Make the power of the controller along with the heater through contactor ON.
7. Observe the rise of temperature inside the furnace and note the READINGS of the current temperature of furnace and corresponding voltage across the terminals of thermocouple at 5°C interval of temperature, till the set-point is reached and the controller is making the heater OFF through the contactor.
8. Open the door of the furnace and let it to cool down to the temperature below the set-point making the furnace ON again.
9. Note the temperatures when the contactor "makes" and "breaks".
10. Repeat the procedure up to 90°C for different set-points at 5°C interval.
11. Fill up the table as given below and draw the characteristicsc/calibration curve.

No. of Obs.	Set-point Temperature (°C)	Contactor - OFF Temperature (°C)	Contactor - ON Temperature (°C)	Furnace Temperature (°C)	Voltage across T/C (mV)	Error

NOTE: Keep the Power Supply OFF during interconnection. SWITCH OFF the Power Supply after completion of the experiment.

REPORT: (1) Copy the observations on your report sheet and draw the curves as mentioned in the procedure. Show a Sample Calculation, if any.

(2) Write a short note on "Types of Thermocouples".

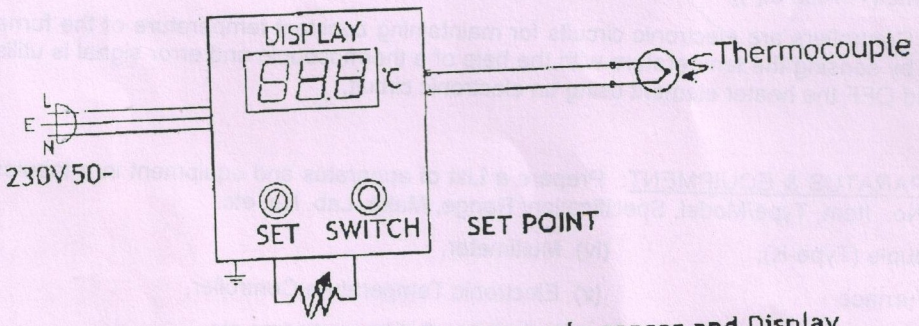


Fig. 1. Controller with Thermocouple sensor and Display

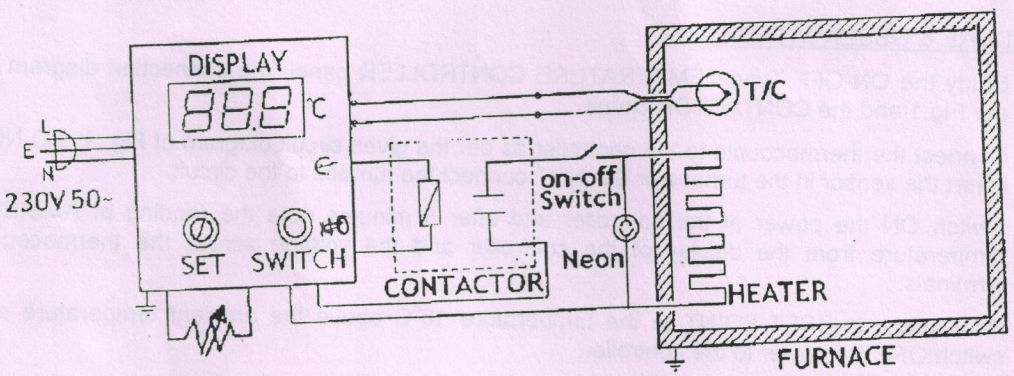


Fig. 2. ON/OFF Type Temperature Controller Circuit

LE II NICKEL-CHROMIUM vs. NICKEL-ALUMINUM TYPE K

(Chromel-Alumel)

Temperature in Degrees C — Reference Junction at 0°C

THERMOELECTRIC VOLTAGE IN ABSOLUTE MILLIVOLTS

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
-270	-6.458											-270
-260	-6.441	-6.444	-6.446	-6.448	-6.450	-6.452	-6.453	-6.455	-6.456	-6.457	-6.458	-260
-250	-6.404	-6.408	-6.413	-6.417	-6.421	-6.425	-6.429	-6.432	-6.435	-6.438	-6.441	-250
-240	-6.344	-6.351	-6.358	-6.364	-6.371	-6.377	-6.382	-6.388	-6.394	-6.399	-6.404	-240
-230	-6.262	-6.271	-6.280	-6.289	-6.297	-6.306	-6.314	-6.322	-6.329	-6.337	-6.344	-230
-220	-6.158	-6.170	-6.181	-6.192	-6.202	-6.213	-6.223	-6.233	-6.243	-6.253	-6.262	-220
-210	-6.035	-6.048	-6.061	-6.074	-6.087	-6.099	-6.111	-6.123	-6.135	-6.147	-6.158	-210
-200	-5.891	-5.907	-5.922	-5.936	-5.951	-5.965	-5.980	-5.994	-6.007	-6.021	-6.035	-200
-190	-5.730	-5.747	-5.763	-5.780	-5.796	-5.813	-5.829	-5.845	-5.860	-5.876	-5.891	-190
-180	-5.550	-5.569	-5.587	-5.606	-5.624	-5.642	-5.660	-5.678	-5.695	-5.712	-5.730	-180
-170	-5.354	-5.374	-5.394	-5.414	-5.434	-5.454	-5.474	-5.493	-5.512	-5.531	-5.550	-170
-160	-5.141	-5.163	-5.185	-5.207	-5.228	-5.249	-5.271	-5.292	-5.313	-5.333	-5.354	-160
-150	-4.912	-4.936	-4.959	-4.983	-5.006	-5.029	-5.051	-5.074	-5.097	-5.119	-5.141	-150
-140	-4.669	-4.694	-4.719	-4.743	-4.768	-4.792	-4.817	-4.841	-4.865	-4.889	-4.912	-140
-130	-4.410	-4.437	-4.463	-4.489	-4.515	-4.541	-4.567	-4.593	-4.618	-4.644	-4.669	-130
-120	-4.138	-4.166	-4.193	-4.221	-4.248	-4.276	-4.303	-4.330	-4.357	-4.384	-4.410	-120
-110	-3.852	-3.881	-3.910	-3.939	-3.968	-3.997	-4.025	-4.053	-4.082	-4.110	-4.138	-110
-100	-3.553	-3.584	-3.614	-3.644	-3.674	-3.704	-3.734	-3.764	-3.793	-3.823	-3.852	-100
-90	-3.242	-3.274	-3.305	-3.337	-3.368	-3.399	-3.430	-3.461	-3.492	-3.523	-3.553	-90
-80	-2.920	-2.953	-2.985	-3.018	-3.050	-3.082	-3.115	-3.147	-3.179	-3.211	-3.242	-80
-70	-2.586	-2.620	-2.654	-2.687	-2.721	-2.754	-2.788	-2.821	-2.854	-2.887	-2.920	-70
-60	-2.243	-2.277	-2.312	-2.347	-2.381	-2.416	-2.450	-2.484	-2.518	-2.552	-2.586	-60
-50	-1.889	-1.925	-1.961	-1.996	-2.032	-2.067	-2.102	-2.137	-2.173	-2.208	-2.243	-50
-40	-1.527	-1.563	-1.600	-1.636	-1.673	-1.709	-1.745	-1.781	-1.817	-1.853	-1.889	-40
-30	-1.156	-1.193	-1.231	-1.268	-1.305	-1.342	-1.379	-1.416	-1.453	-1.490	-1.527	-30
-20	-0.777	-0.816	-0.854	-0.892	-0.930	-0.968	-1.005	-1.043	-1.081	-1.118	-1.156	-20
-10	-0.392	-0.431	-0.469	-0.508	-0.547	-0.585	-0.624	-0.662	-0.701	-0.739	-0.777	-10
0	0.000	-0.039	-0.079	-0.118	-0.157	-0.197	-0.236	-0.275	-0.314	-0.353	-0.392	0

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C
0	0.000	0.039	0.079	0.119	0.158	0.198	0.238	0.277	0.317	0.357	0.397	0
10	0.397	0.437	0.477	0.517	0.557	0.597	0.637	0.677	0.718	0.758	0.798	10
20	0.798	0.838	0.879	0.919	0.960	1.000	1.041	1.081	1.122	1.162	1.203	20
30	1.203	1.244	1.285	1.325	1.366	1.407	1.448	1.489	1.529	1.570	1.611	30
40	1.611	1.652	1.695	1.734	1.776	1.817	1.858	1.899	1.940	1.981	2.022	40
50	2.022	2.064	2.105	2.146	2.188	2.229	2.270	2.312	2.353	2.394	2.436	50
60	2.436	2.477	2.519	2.560	2.601	2.643	2.684	2.726	2.767	2.809	2.850	60
70	2.850	2.892	2.933	2.975	3.016	3.058	3.100	3.141	3.183	3.224	3.266	70
80	3.266	3.307	3.349	3.390	3.432	3.473	3.515	3.556	3.598	3.639	3.681	80
90	3.681	3.722	3.764	3.805	3.847	3.888	3.930	3.971	4.012	4.054	4.095	90
100	4.095	4.137	4.178	4.219	4.261	4.302	4.343	4.384	4.426	4.467	4.508	100
110	4.508	4.549	4.590	4.632	4.673	4.714	4.755	4.796	4.837	4.878	4.919	110
120	4.919	4.960	5.001	5.042	5.083	5.124	5.164	5.205	5.246	5.287	5.327	120
130	5.327	5.368	5.409	5.450	5.490	5.531	5.571	5.612	5.652	5.693	5.733	130
140	5.733	5.774	5.814	5.855	5.895	5.936	5.976	6.016	6.057	6.097	6.137	140
150	6.137	6.177	6.218	6.258	6.298	6.338	6.378	6.419	6.459	6.499	6.539	150
160	6.539	6.579	6.619	6.659	6.699	6.739	6.779	6.819	6.859	6.899	6.939	160
170	6.939	6.979	7.019	7.059	7.099	7.139	7.179	7.219	7.259	7.299	7.338	170
180	7.338	7.378	7.418	7.458	7.498	7.538	7.578	7.618	7.658	7.697	7.737	180
190	7.737	7.777	7.817	7.857	7.897	7.937	7.977	8.017	8.057	8.097	8.137	190
200	8.137	8.177	8.216	8.256	8.296	8.336	8.376	8.416	8.456	8.497	8.537	200
210	8.537	8.577	8.617	8.657	8.697	8.737	8.777	8.817	8.857	8.898	8.938	210
220	8.938	8.978	9.018	9.058	9.099	9.139	9.179	9.220	9.260	9.300	9.341	220
230	9.341	9.381	9.421	9.462	9.502	9.543	9.583	9.624	9.664	9.705	9.745	230
240	9.745	9.786	9.826	9.867	9.907	9.948	9.989	10.029	10.070	10.111	10.151	240
250	10.151	10.192	10.233	10.274	10.315	10.355	10.396	10.437	10.478	10.519	10.560	250
260	10.560	10.600	10.641	10.682	10.723	10.764	10.805	10.846	10.887	10.928	10.969	260
270	10.969	11.010	11.051	11.093	11.134	11.175	11.216	11.257	11.298	11.339	11.381	270
280	11.381	11.422	11.463	11.504	11.546	11.587	11.628	11.669	11.711	11.752	11.793	280
290	11.793	11.835	11.876	11.918	11.959	12.000	12.042	12.083	12.125	12.166	12.207	290
300	12.207	12.249	12.290	12.332	12.373	12.415	12.456	12.498	12.539	12.581	12.623	300
310	12.623	12.664	12.706	12.747	12.789	12.831	12.872	12.914	12.955	12.997	13.039	310
320	13.039	13.080	13.122	13.164	13.205	13.247	13.289	13.331	13.372	13.414	13.456	320
330	13.456	13.497	13.539	13.581	13.623	13.665	13.706	13.748	13.790	13.832	13.874	330
340	13.874	13.915	13.957	13.999	14.041	14.083	14.125	14.167	14.208	14.250	14.292	340
350	14.292	14.334	14.376	14.418	14.460	14.502	14.544	14.586	14.628	14.670	14.712	350
360	14.712	14.754	14.796	14.838	14.880	14.922	14.964	15.006	15.048	15.090	15.132	360
370	15.132	15.174	15.216	15.258	15.300	15.342	15.384	15.426	15.468	15.510	15.552	370
380	15.552	15.594	15.636	15.679	15.721	15.763	15.805	15.847	15.889	15.931	15.974	380
390	15.974	16.016	16.058	16.100	16.142	16.184	16.227	16.269	16.311	16.353	16.395	390
400	16.395	16.438	16.480	16.522	16.564	16.607	16.649	16.691	16.733	16.776	16.818	400
410	16.818	16.860	16.902	16.945	16.987	17.029	17.072	17.114	17.156	17.199	17.241	410
420	17.241	17.283	17.326	17.368	17.410	17.453	17.495	17.537	17.580	17.622	17.664	420
430	17.664	17.707	17.749	17.792	17.834	17.876	17.919	17.961	18.004	18.046	18.088	430
440	18.088	18.131	18.173	18.216	18.258	18.301	18.343	18.385	18.428	18.470	18.513	440
450	18.513	18.555	18.598	18.640	18.683	18.725	18.768	18.810	18.853	18.895	18.938	450
460	18.938	18.980	19.023	19.065	19.108	19.150	19.193	19.235	19.278	19.320	19.363	460
470	19.363	19.405	19.448	19.490	19.533	19.576	19.618	19.661	19.703	19.746	19.788	470
480	19.788	19.831	19.873	19.916	19.959	20.001	20.044	20.086	20.129	20.172	20.214	480
490	20.214	20.257	20.299	20.342	20.385	20.427	20.470	20.512	20.555	20.598	20.640	490
500	20.640	20.683	20.725	20.768	20.811	20.853	20.896	20.938	20.981	21.024	21.066	500
510	21.066	21.109	21.152	21.194	21.237	21.280	21.322	21.365	21.407	21.450	21.493	510
520	21.493	21.535	21.578	21.621	21.663	21.706	21.749	21.791	21.834	21.876	21.919	520
530	21.919	21.962	22.004	22.047	22.090	22.132	22.175	22.218	22.260	22.303	22.346	530
540	22.346	22.388	22.431	22.473	22.516	22.559	22.601	22.644	22.687	22.729	22.772	540
550	22.772	22.815	22.857	22.900	22.942	22.985	23.028	23.070	23.113	23.156	23.198	550
560	23.198	23.241	23.284	23.326	23.369	23.411	23.454	23.497	23.539	23.582	23.624	560
570	23.624	23.667	23.710	23.752	23.795	23.837	23.880	23.923	23.965	24.008	24.050	570
580	24.050	24.093	24.136	24.178	24.221	24.263	24.306	24.348	24.391	24.434	24.476	580
590	24.476	24.519	24.561	24.604	24.646	24.689	24.731	24.774	24.817	24.859	24.902	590
600	24.902	24.944	24.987	25.029	25.072	25.114	25.157	25.199	25.242	25.284	25.327	600

DEG C	0	1	2	3	4	5	6	7	8	9	10	DEG C

TYPE K

NEW REFERENCE TABLES
SUPERSEDES N.B.S. CIRCULAR #561