# COLLEGE OF ENGINEERING & TECHNOLOGY

**Department : Electrical & Control Engineering**

**Lecturer : Dr. Mostafa Abdel-Geliel**

**Course : Advanced Automation system**

**Course Code: EE 710** **Time : 3 Hours**

***Date : 7 / 6 / 2014*** **Marks: 40**

**Final Exam**

***(Q1) 15 marks [1b, 2a]***

a- Differentiate between SCADA and DCS system and their application.

b- Write a PLC program in Ladder diagram to read two analogues variables "x" and "y" and send an analogue output "u":

$$u(t) = k_p e(t) + k_d \frac{de(t)}{dt} + k_i \int e(t)dt + [k1 \;\; k2] \begin{bmatrix} x \\ y \end{bmatrix}$$

Where $e = y - x$ and $k_p$, $k_i$,$k_d$, *k1* and *k2* are constant

***(Q2) 25 marks [1d,1e,2c, 3b, 3c, 4d]***

Multi-pump system is designed to supply water dammed for an urban area as illustrated in Fig. 1. Four pumps are employed in the pumping station. The water consumption is controlled by monitoring the pressure of the pipeline. The pumps energy is supplied through islanded hybrid renewable sources of wind and PV systems as shown in Fig. 2. Each energy source should be controlled to feed the network by the maximum allowable energy by monitoring the atmospheric conditions such as wind speed, solar irradiation and temperature. The relation between the wind speed and wind power is given in the form of lookup table. Also, the PV power is related to the solar irradiation and temperature in a form of table. The reference power of each source given from the lookup table is used to control its inverter in order to inject its power to the network. The two sources should be synchronized using individual synchronizer.

Only one AC drive is used to switch between the four pumps. At any instant, the drive will control one pump and the others either off or operate direct online (without drive) according to the single line diagram Fig. 3 and the following scenario:-

- At low pressure (<3bar), one pump is controlled using AC drive until it reaches full speed ($K_{di}$ is on and $K_i$ is off); where *i* is the pump number *i*
- If the pump reach the full speed and pressure<3 bar then disconnect the pump from the drive and operate it direct online ($K_{di}$ is off and $K_i$ is on).
- The drive is used to control another pump and so on until the pressure reach 3 bar.
- If the pressure is increased (>3 bar) the drive decrease the speed until it reaches to zero
- If the pump reaches zero speed and pressure>3 bar then disconnect the pump from the drive and switch off the pump ($K_{di}$ is off and $K_i$ is off) .
- The drive is used to control another direct online pump and so on until the pressure reach 3 bar.
- The sequence of pumps is the first-in-first-out (FIFO).
- It is recommended to change the order of pumps in order to keep all pumps have almost the same operation time; an equal load for all pumps should be ensured.
- In addition to the automatic operation, it shall also be possible to operate each pump manually.
- The pumping output of a pump which has been released for maintenance shall be automatically taken over by a pump with free capacity.

Design a complete automation system with different level that achieves the required control task illustrating:-

a. The operating station remotely and locally and their functions
b. Loop control tasks using PID controller
c. Sequence task of the system illustrated in ladder and sequential flowchart

d. Supervision tasks illustrating the pumping system and generation system operation mode, data logging, alarming, trending, loading, tuning, etc…
e. Trends should include water flow and pressure change during the operation in addition to the wind and PV power.
f. The automation levels hardware components, tasks and connection diagram
g. Networks standard, protocol and topology and the allowable baud rate knowing that the drive and inverters are supported by modbus protocol. Describe the data massage frames that are handled through modbus and its size.
h. Discuss how to manage the task priorities (scan time control)

Note: state any assumption and data required to perform the design

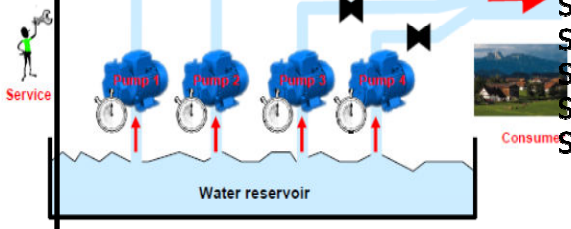



Fig. 1 Pumping system

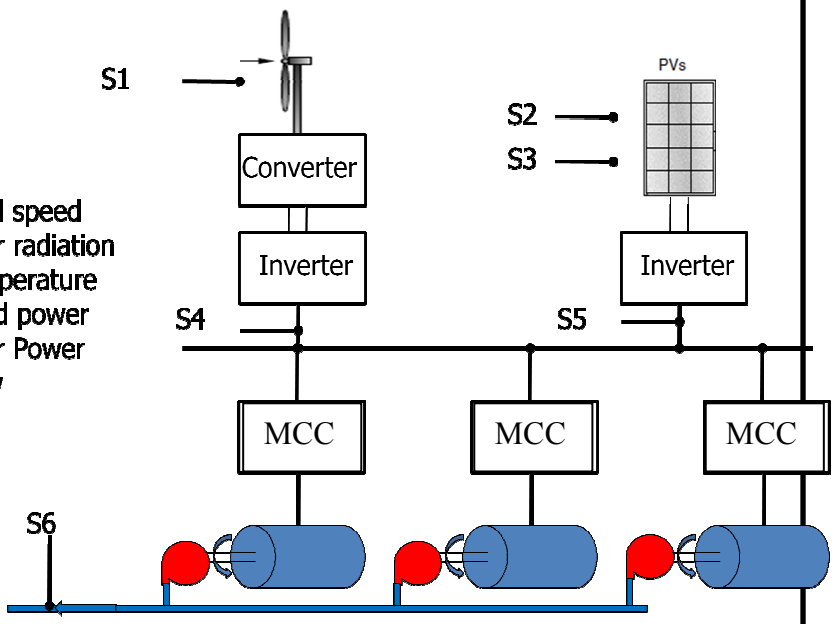
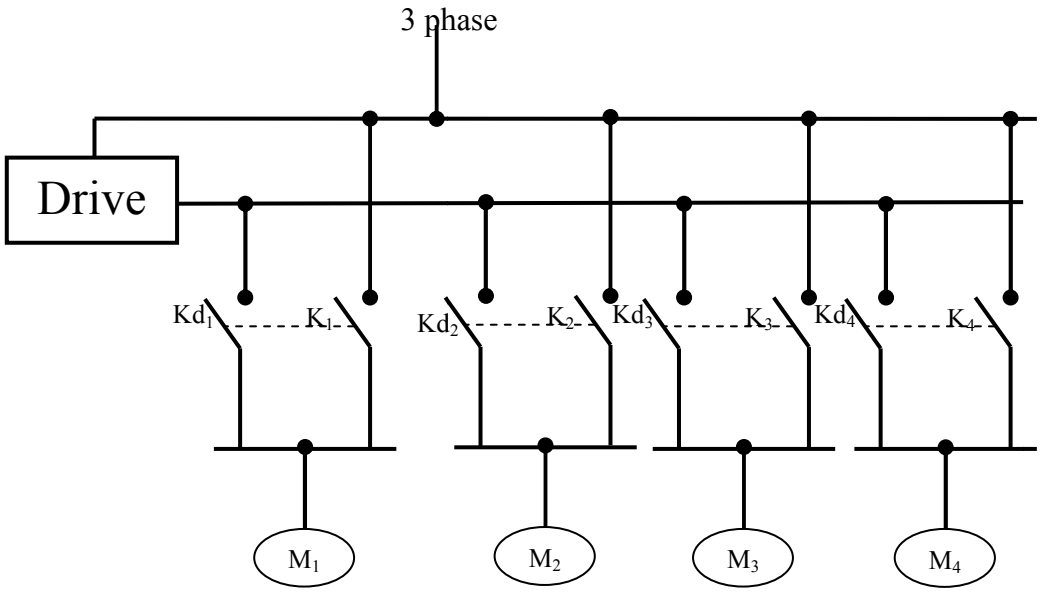



Fig. 2 schmatic diagram of the system




***Good Luck***

Fig. 3 Single line diagram of pumps

| **Members of course Examination Committee:** | **Signature:** | **Date:** |
|---|---|---|
| **Lecturer:** Dr. Mostafa Abdel-Geliel | | 7/6/2014 |
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