Experiment 2

**Background and Fundamentals of PLC**

**Objectives:**
After successfully completing this laboratory, you should be able to:

- Identify and Explain of DELTA’s PLC DVP Series Model.
- How to use the DELTA’s PLC.
- Programming the PLC.
- Make different types of PLC input and output wiring.

**Overview:**
DVP-ES/EX series provides MPU (The main processing units) with 14 ~ 60 points and 8 ~ 32 points of extension. The maximum I/O points including those on the MPU can reach 128 points. DVP-ES/EX can be used for various applications with its different I/O points, power supply and digital I/O extension modules. In addition, DVP SS Series has the special modules (AD/DA/PT/TC/XA) used for extending its functions and the maximum special modules can be extended up to 8 units.

- **Serial Number Explanation:**

  32ES00R 2 T 3 100004

  - Production number
  - Production week
  - Production year 2003
  - Production factory (TaoYuan Plant)
  - Version type
  - Production model

- **Model Explanation:**

  - **Product Series:** DVP Series
  - **Inputs+Outputs points / unit:** 08~60points
  - **Models:**
    - E: Main Processing Unit (Base Unit)
    - X: Extension Unit
    - S: S-TYPE Main Processing Unit
  - **Model Types:**
    - S: Standard
    - X: A/D, D/A Functions
    - C: Reversibles
    - M: Digital Input (X Input extend)
    - N: Digital Output (Y output extend)
    - P: Digital Input/Output (XY extend)
    - 2: Upgrade Model
    - R: Relay
    - T: Transistor
    - N: No Output Module
  - **Model Numbers:**
    - 00: AC Input H TYPE
    - 01: DC Input L TYPE
    - 11: DC Input H TYPE
Product Profile and Outline:

- **Wiring Notes:**
  - **Power Input Wiring**

There are two power inputs provided in DVP series PLC, AC input and DC input.
**Input / Output Point Wiring:**

The input signal of the input point is the DC power DC input. There are two types of DC type wiring: SINK and SOURCE, defined as follows:

**Sink** = Current flows into the common terminal S/S  
**Source** = Current flows out of common terminal S/S

Be careful with the connection of the common terminals when wiring output terminals. For example, when wiring DVP14ES00R, note that there are six normally-open SPST relays available. They are organized into 4 groups with individual commons. The figure below shows the relays and the internal wiring of the PLC. Note that each group is isolated from the other groups:
**Background and Functions of PLC:**

PLC reads the status of the external input devices, e.g. keypad, sensor, switch and pulses, and execute by the microprocessor logic, sequential, timing, counting and arithmetic operations according the status of the input signals as well as the pre-written program stored in the PLC. The generated output signals are sent to output devices as the switch of a relay, electromagnetic valve, motor drive, control of a machine or operation of a procedure for the purpose of machine automation or processing procedure.

- **The Working Principles of Ladder Diagram:**

  which is the oldest and most widely adopted language in automation. In the initial stage, there were only A (normally open) contact, B (normally closed) contact, output coil, timer and counter…the sort of basic devices on the ladder diagram (see the power panel that is still used today). After the invention of PLC, the devices displayable on the ladder diagram are added with differential contact, latched coil and the application commands which were not in a traditional power panel, for example the addition, subtraction, multiplication and division operations. The working principles of the traditional ladder diagram and PLC ladder diagram are basically the same. The only difference is that the symbols on the traditional ladder diagram are more similar to its original form, and PLC ladder diagram adopts the symbols that are easy to recognize and shown on computer or data sheets. In terms of the logic of the ladder diagram, there are combination logic and sequential logic.

Examples of traditional ladder diagram and PLC ladder diagram for combination logic:

<table>
<thead>
<tr>
<th>Traditional Ladder Diagram</th>
<th>PLC Ladder Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Traditional Ladder Diagram" /></td>
<td><img src="image2.png" alt="PLC Ladder Diagram" /></td>
</tr>
</tbody>
</table>

**Row 1:** Using a normally open (NO) switch X0 (“A” switch or “A” contact). When X0 is not pressed, the contact will be open loop (Off), so Y0 will be Off. When X0 is pressed, the contact will be On, so Y0 will be On.

**Row 2:** Using a normally closed (NC) switch X1 (“B” switch or “B” contact). When X1 is not pressed, the contact will be On, so Y1 will be On. When X1 is pressed, the contact will be open loop (Off), so Y1 will be Off.

**Row 3:** The combination logic of more than one input devices. Output Y2 will be On when X2 is not pressed or X3 and X4 are pressed.
Delta PLC memory:

<table>
<thead>
<tr>
<th>Device</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Relays</td>
<td>The input relay is an internal memory (storage) unit in the PLC corresponding to a external input point and is used for connecting to the external input switches and receiving external input signals. Device indication: X0, X1, …, X7, X10, X11,…</td>
</tr>
<tr>
<td>Output relay</td>
<td>The output relay is an internal memory (storage) unit in the PLC corresponding to a external output point and is used for connecting to the external load. Device indication: Y0, Y1, …, Y7, Y10, Y11,…</td>
</tr>
<tr>
<td>Internal relay</td>
<td>They are indicated with M sequence in Decimal numbering mode ranging from M0 to M1279. M1000 and above are used for system flags and special purpose auxiliary relays.</td>
</tr>
<tr>
<td>Steps</td>
<td>DVP series PLC offers a step-type control program input method. STL instruction controls the transfer of step S, which makes it easy for the writing of the control program. If you do not use any step program in the control program, step S can be used as an internal relay M as well as an alarm point. Device indication: S0, S1, …, S1023 are indicated as S and numbered in decimal form.</td>
</tr>
<tr>
<td>Timers</td>
<td>The timer is used for timing and has coil, contact and register in it. When the coil is On and the estimated time is reached, its contact will be enabled. Every timer has its fixed timing period (unit: 1ms/10ms/100ms). Device indication: T0, T1, …, T255 are indicated as T and numbered in decimal form. Different No. refers to different timing period.</td>
</tr>
<tr>
<td>Counters</td>
<td>Indicated by C sequence in Decimal numbering system. Similar to Timers, each counter has a holding register and a single bit contact. There are 128 16-bit counters ranging from C0 to C127 and there are 13 32-bit counters indicated as C235 to C238, C241, C242, C244, C246, C247, C249, C251, C252, and C254. These later counters are referred as high speed counters.</td>
</tr>
<tr>
<td>Data Registers</td>
<td>16-bit variables indicated by D sequence in Decimal numbering mode ranging from D0 to D599 and from D1000 to D1143. D1000 and above are special purpose registers.</td>
</tr>
<tr>
<td>Index Registers</td>
<td>Two pointers indicated by E and F. They are D1028 and D1029 respectively.</td>
</tr>
</tbody>
</table>

The structure of a ladder diagram:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Explanation</th>
<th>Instruction</th>
<th>Devices Used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normally open, contact A</td>
<td>LD</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Normally closed, contact B</td>
<td>LDI</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Normally open in series connection</td>
<td>AND</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Normally closed in series connection</td>
<td>ANI</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Normally open in parallel connection</td>
<td>ORI</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Normally closed in parallel connection</td>
<td>ORF</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Rising-edge trigger switch</td>
<td>LDP</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Falling-edge trigger switch</td>
<td>LDF</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Rising-edge trigger in series connection</td>
<td>ANDP</td>
<td>X, Y, M, S, T, C</td>
</tr>
<tr>
<td></td>
<td>Falling-edge trigger in series connection</td>
<td>ANDF</td>
<td>X, Y, M, S, T, C</td>
</tr>
</tbody>
</table>
- **How to Edit a PLC Ladder Diagram:**

  The operation of the ladder diagram program is scanning from top left to bottom right. The coil and the operation frame of the application instruction belong to the output side in the program and are placed in the right if the ladder diagram. Take the figure below for example, we will step by step explain the process of a ladder diagram. The numbers in the black circles indicate the order.

  ![Ladder Diagram](image)

  **The order of the instructions:**

  1. LD X0
  2. OR M0
  3. AND X1
  4. LD X3
     AND M1
     ORB
  5. LD Y1
     AND X4
  6. LD T0
     AND M3
     ORB
  7. ANB
  8. OUT Y1
     TMR T0 K10

  The structure of LDP and LDF instructions are the same as that of LD instruction, and the two only differ in their actions. LDP and LDF instructions only act at the rising edge or falling edge when the contact is On, as shown in the figure below.
Functions on PLCs:

- **Counters:**
  When the operation result of instructions preceding the CNT instruction has changed from OFF to ON, 1 is added to the count value. When the counter has counted out (count value = set value), the state of the counter contacts are toggled. In the following example the output Y0 is activated after entering 5 clock pulses at input
  
  ![Diagram](https://via.placeholder.com/150)

  When the operation result of the instructions preceding the CNT instruction remain on, counting is not performed. After the counter has counted out, the count value and the status of the contact will not change until the RST instruction is executed. A negative number cannot be used as a set value. When the set value is 0, the same processing as for 1 is performed.

  The instruction CNT uses 16-bit registers to accumulate counted values in the valid counters domain (C0 to C127). On the other hand, the instruction DCNT uses 32-bit registers for high speed counters.

- **Timers**
  When the operation result of instructions preceding the TMR instruction are on, the coil of timer turns on and counts up to the set value. When the timer times out (counted value >= set value), the timer contacts are toggled. In the following example the output Y0 is activated 3 seconds after activating the input X0.

  ![Diagram](https://via.placeholder.com/150)

  Delta PLCs support 128 timers (T0 to T127). The timer will be reset when the operation result of instructions preceding the TMR instruction change from ON to OFF. Moreover, The RST instruction may be used to reset the timer values. Timers use 16-bit registers and a negative number (-32768 to -1) cannot be set as a set value.

- **Other useful functions**
  In the User manual you will find plenty of functions that facilitate data movement, arithmetic, comparison, and other operations similar to instructions provided for traditional microprocessors.

  For example, the instruction **MOV K14 D0** moves the decimal value 14 to data register D0.

  Another example, the instruction **CMP D7 K23 M0** compares the value of D7 with the decimal number 23. If larger M0 will be set, else if equal M1 will be set, otherwise if smaller then M2 will be set.
Procedure:

Part 1

1. Connect the circuit as shown in the Figure 2.1 on the control board and make the required wiring and connections.

![Circuit Diagram]

**Fig. 2.1** Energizing and de-energizing relay using on-off switch

2. When you are finished the connections. Starting a new project in Wpl and programming a PLC by using ladder diagram.

3. The program should satisfy the following conditions:
   - The load 1 should run, if you press on SW1,
   - The load 2 should run, and the load 1 should off. If you press SW2 and SW1 still ON.

4. When you are finished the connections, check it for you and make sure that it is correct.

5. Connect the circuit to the power source.
Part 2

1. Connect the circuit as shown in the Figure 2.2 on the control board and make the required wiring and connections.

![Circuit Diagram]

**Fig. 2.2** Energizing and de-energizing relay using on-pushbutton and off-pushbutton

2. When you are finished the connections. Starting a new project in Wpl and programming a PLC by using ladder diagram.
3. The program should satisfy the following conditions:
   - The load 1 should run after 5 sec. If you press on pushbutton 1.
   - The load 1 should off and the load 2 should run after 5 sec. If you press on pushbutton 2.
4. When you are finished the connections, check it for you and make sure that it is correct.
5. Connect the circuit to the power source.