Design and Fabrication of a Testing Table for a Switch

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Abstract. A new design of a computer control testing table applied to inspect the contact points of a cam switch is presented in this work. The testing table also provides a working life test by means of a continuous switching test. The control unit adopts a personal computer (PC) associated with a programmable logic controller (PLC), where PC handles data processing while PLC deals with sequential movement. Therefore, the rotating angle, switch stages, and testing torque can be automatically arranged in the testing table. The device not only efficiently decreases testing time but also properly increases the product quality.

1. Introduction

Intense competition in the international arena has deteriorated the production environment in Taiwan. To survive and thrive, automated production is one of the means of cutting costs to gain competitive advantage. Testing plays an important role throughout the production process from designing, manufacturing and marketing. Efficient testing can ensure that the components involved in the different production stages conform the design requirements, and thus guarantee the quality of the final products. However, labor-intensive manual testing is prone to error, not to mention time-consuming and expensive. Hence, either semi- or full automatic testing system is not only desirable but also of urgent need.

Compared with traditional manual testing system, automatic computer-controlled testing system is not only faster and more efficient, but can also avoid human errors in fault detection, thus enhancing inspection accuracy. Cost of labor involved can also be reduced, enabling the production to be more cost effective and profitable. Data collected by the automatic testing system will be stored and processed by the computer and the testing results can be promptly transmitted to the departments involved via the Internet. In view of these advantages, this study aims to develop an automatic computer-controlled testing system so as to enhance the efficiency and quality of production for gaining competitive edge in the industry.

Cam switches of simple design and low price are widely employed for the controlling electrical devices. However, defective products with contact point not meeting the design requirement are often found as a result of poor assembly during the production. The automatic computer-controlled testing system developed in this study is employed for inspecting the contact point of cam switches and assessing their life cycle to see if they comply with the design requirements.

2. Manual testing bench description

Introduction of manual testing bench Figure 1 shows the original test bench. The tested article is fixed
between the clamps, and the probe will move forward to contact the switch contacts which are wired to the front panel and related indicators. When turning the switch, the indicator will show the test result. It is time and labor consuming, and not reliable. The switching torque and life time test can not be conducted. Either if the probe showed in Figure 1 is used, that may cause the damage of the probe. If the tested article is placed in vertical direction, the probe direction will be designed to follow the contact line easily.

![Figure 1. The picture of manual testing bench.](image)

### 3. Testing mechanism design

For intending the automatic testing, this system develops specific mechanism for fixing the tested article, turning the knob and leading out the test signal. The followings detail the mechanism design.

#### 3.1. Probe mouldboard

The maximum 12 layers is designed for the moldboard, four contacts for each layer. For general purpose and time saving of fixture exchange, testing module board with 12 testing points is designed which made from PVC with openings for mounting the probes. When the probe contacts with the object, it will extend backward and keep a constant pressure on the object. Each probe will be wired to measure the output signal. Figure 2 is the schematic of the probe moldboard, there are two openings for wires marshalling.

![Figure 2. Probe mouldboard.](image)

#### 3.2. Probe forward-backward mechanism

A Probe forward-backward mechanism is designed with pneumatic mechanism. By using four 50mm stroke pneumatic double cylinder which can bring the probe forward or backward. The moldboard move along the slot to avoid deforming the mouldboards which may affect the testing result. The probe will draw back 10 mm to provide contact pressure for testing. Figure 3 shows the design schematic which does not show the slot.

![Figure 3. Probe forward-backward mechanism.](image)

#### 3.3. Switch turning mechanism

In order to acquire the switch position, a switch rotation mechanism is necessary. The rotation angles are 30°, 45°, 60°, 90°. The start and stop angle will change according to the type of switch. For fulfilling the above requirements, the rotation mechanism must find its current position and then rotate
to the position required. Here we choose the encoder with origin signal for the location detective element. On the other hand, we use a permanent magnet DC motor as the actuator for the rotational mechanism. Since torque of the permanent magnet DC motor is proportional to current, we have to measure current to find out magnitude of torque. In this case, torque of testing sample can be judged to be within the set point or not. Figure 4 shows the DC motor with encoder using different timing belt to connect to each other.

3.4. X-Z axis movement mechanism
The switch rotational mechanism shall relocate to the above of testing sample and merge to the turning knob below. In order to set up the testing sample, it has to be disconnected when it is not testing. An X-Z axis movement mechanism is designed to move the switch rotation mechanism in the direction of sideward as well as upward. An air pressure mechanism is used for X-axis to stretch out and support the weight of Z-axis and the switch rotational mechanism. Therefore, X-axis uses a twin rod cylinder with larger load. The maximum dimension of connecting flange of switch mechanism is 60 mm. In order to keep a safety distance, stroke for X-axis is 100 mm and 50 mm for Z-axis, as the same as cylinder of base plate. Figure 5 shows the diagram of the X-Z axis movement mechanism connecting to switch rotational mechanism.

3.5. Frame Design
Above-mentioned organization department utilize aluminium frame that form of testing table structure. Figure 6 finishes design drawing for the testing table; there are three layers in all. The organization for X , Z axle in addition, switch over the rotator organization of switch lay aside in the upper formation, the middle level advances and goes backwards the organization for the probe mouldboard and forward-backward mechanism, put the controller and relay in the lower floor.

4. The control system designing
The switch testing system besides organization, there is one most important control system, and than to operation and collection of the test data. The control system includes the design of the pneumatic circuit, electrical circuit and man-machine interface. The whole structure is shown in Figure 7 shows, the PC (personal computer) is good at number value operation and data process, so utilizing the PC to establish and counting the operation, setting operating data and data analysis. The programmable
logical controller have stability for the sequence control, and procedure write easy, so utilize for the relevant test movements in the testing table.

4.1. Pneumatic circuit design
In order to make the pneumatic cylinder work normally, so has designed relevant direction and flow control valve, such as Figure 8, the cylinder each one utilizes the meter out to control speed, control advancing the directional control valve that went backwards of the cylinder, adopt the 5/2 solenoid direction valves to control it, when emergency state happened, it is urgent according to push emergency button, cut off the power of the directional control valve, the cylinder gets back to the primitive position, use to protect the system.

4.2. Electrical circuit design
Up to several dozen amperes current can pass through switch, if the programmable logical controller is used to detect and examine the conductive state of the switch directly, misjudgment may take place. Therefore, utilize switch contacts and relays as well as display lights to make sure the testing results by using contact of relay as testing point. In additional to introduce R, S, and T signals for the correct testing results, it is also necessary to observe the signal source for testing the damage of relay contacts, as shown in Figure 9. DC motor uses two relays to control the rotational direction. To avoid DC motor rotating forward and reverse simultaneously and resulting short circuit, an interlock circuit is utilized. A PLC is used to control the relays for motor rotation.

As indicated earlier, sequences of testing process is controlled by a PLC. Models FBs40MC and FBs4AD provided by Yuan-Hong are used. Current of DC motor read by FBs4AD was used as the standard of set point of torque. Using encoder as the location detector inputs through the contact of high-speed counter of PLC. There is a design for the recover process of damage and emergency. For examples, when the emergency button is pushed, power output of all contacts will be cut except the display lights. Necessary process procedures are also design for over-torque or delay of time to the set point to avoid the damage of machine platform and itself.

4.3. Man-machine interface design
For the purpose of more convenient operation, a PC with interface program is utilized. By using a Window software, Visual Basic, functions such as operation buttons, monitoring, and databases for different kinds of switch and testing results, etc. are also included, as shown in Figure 10.
5. Conclusion
Through the step of conceiving, drawing the part, adopting and constructing, processing, writing the procedure and testing etc., have finished the switch testing system. The system has auto-diagonal function in order to judge performance the test table. The rotating angle, switch stages, and testing torque can be automatically arranged in the testing table. The device not only efficiently decreases testing time but also properly increases the product quality. It just only need 5 seconds to test an component.

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