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Automation of a Hydraulic Press Machine Using Bosch Rexroth PLC for remote operation through mobile communication

Mr. G. C. Mekalke

Mechanical Dept. DKTE's TEI
Ichalkaranji, India
gcmekalke@gmail.com

Mr. A.V. Sutar

Mechanical Dept. DKTE's TEI
Ichalkaranji, India
Avsutar1987@gmail.com

Abstract— This research paper focuses on automation of a press tool for production of sheet metal components. The operation of press tool consisted of sequences of operations. This sequence of operations had to automate for increase in productivity. For that purpose, PLC is used from Bosch Rexroth, Germany made. With the help of DTMF module it was made possible to operate the press by using mobile calling from remote locations. In this article, the press thus designed served for the purpose with 73% reduction in production time, with enhanced quality and helped in enabling mass production by eliminating several processes such as marking, cutting done with the help of a cutter, shaping, and so on.

Keywords—Press Tool, Bosch Rexroth PLC, DTMF module, Automation, etc.

I. INTRODUCTION

Most of the mechanical industries produce products in mass. The prime idea of mass production is mainly to meet the requirement of the consumer, to maintain consistent quality & to make the product cost effective. Almost all products like television, tape recorders, radio, refrigerator, cars, watches, computer etc. which consists no. of components made of either plastic or sheet metal. Sheet metal components are produced by a device called "Press Tool".

This sort of critical analysis & design of the product in many occasion lead to considerable saving in the cost of the product. Materials used for the manufacture of press tools & production of components are easily degradable, hence "Press tools may be treated as environment friendly." The press is a metal forming machine used to shape or cut metal by applying mechanical force or pressure. It is used for producing some quantities of articles quickly, accurately and economically for cold working of mild steel and other ductile material

A press is a machine that supplies force to a die used to blank, form, or shape metal or non-metallic material. A press is composed of a frame, bed and a reciprocating member called a ram or slide, which exerts force upon work material through special tools mounted on ram and bed. Energy stored in rotating flywheel of a mechanical press (or supplied by a hydraulic system in a hydraulic press) is transferred to ram to provide linear movement.

HYDRAULIC CIRCUIT

For application of this press tool hydraulic is used. The hydraulic circuit developed is shown in the following fig. This circuit contains solenoid valves, hydraulic cylinder and power pack. For strip feeding the DC servo motor is used.

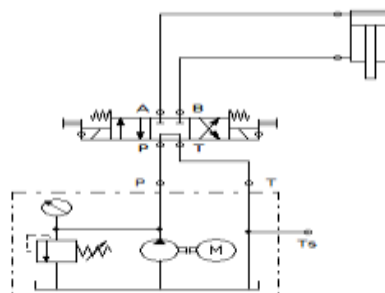


Fig.1. Hydraulic circuit

PLC

The Programmable Logic Controller (PLC) is a type of controller used to control robots which plays a vital role in today's automation field. The main purpose of PLC is to replace hundreds and thousands of hard wired relays. The PLC can be programmed and controlled using ladder diagram which is easy to learn and write. But employing this type of highly sophisticated laboratory facility is almost impossible for many institutions due to high initial cost.

For this application Bosch Rexroth PLC is used. It works on Indra Logics software and programming language used is ladder logic.



Image.1. Programmable Logic Controller (PLC)

PLC PROGRAMMING LANGUAGES

With its INDRALOGICS, the organization identifies these five programming languages and their abbreviations as:

1. Ladder Diagram (LD)
2. Instruction list (IL)
3. Function Block Diagram (FBD)
4. Structured text (ST)
5. Sequential Function Chart (SFC).

LADDER DIAGRAM

This programming, invented in U.S. decades ago, invented to replace hardwired relay control system. Ladder Diagram languages has experienced such widespread adoption that almost every programmer in any country or industry can read and write this languages, because it resembles the familiar electric circuit format. It's easy to start writing program in Ladder Diagram. Most implementations of Ladder Diagram allow a program to be organized into folders or sub programs that are downloaded to the PLC, allowing for easy segmentation. Ladder Diagram programming is ideal for a simple material handling applications.

There may be timers in the program, or some basic comparisons or math, but there are no complex functions involved. Functions such as trigonometry and data analysis are commonly required in many control applications, but difficult to implement. Another challenge is that as the program size grows, the ladder can become very and interpret, unless it is extensively documented. Finally, implementing full processes in ladder diagram can be daunting- picture a ladder rung with an output used in several phases of a process with many input conditions attempting to control exactly when that output needs to turn on.

PROBLEM STATEMENT

Devise a ladder diagram for the Press machine who's working procedure as when switch is pressed then the motor is start for 2 seconds for material feeding, after this the forward stroke of the cylinder is takes place for the 4 seconds, then after forward stroke is completed then the reverse stroke of cylinder is takes place for next 4 seconds and the cycle is repeated continuously.

LADDER DIAGRAM

The ladder program for press tool application developed is as follows. The rung wise description is given bellow the ladder diagram.

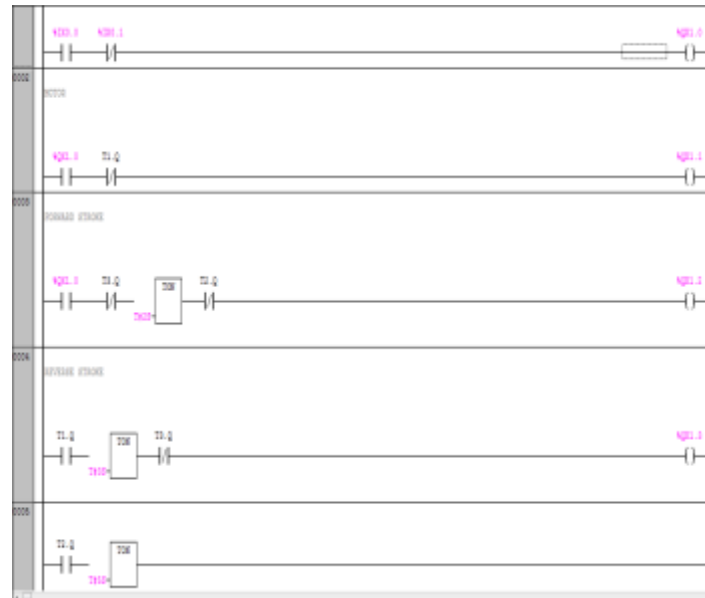


Image.2. Ladder Diagram

RUNG WISE DESCRIPTION

Rung 1: When the call is received from mobile and user presses 1 button then the input relay (%QX1.0) is energises.

Rung 2: When the input relay is energises then the motor (QX1.1) is run for material feeding for production, the done bit (DN) of timer (T1. Q) is placed for stopping of motor after 2 seconds.

Rung 3: When the input relay is energised then the TON timer T1 is start for motor starting whose pre-set is 2 seconds, after that the forward stroke (QX1.2) of the cylinder is started. The done bit (DN) of timer (T2. Q) is placed for the completing the forward stroke of cylinder.

Rung 4: When the done bit (DN) of timer T1 is energises, then the next timer T2 is start for the forward stroke of the cylinder whose pre-set is 4 second, after that the reverse stroke (QX1.3) of the cylinder is started. The done bit (DN) of timer (T3. Q) is placed for completing the reverse stroke of cylinder.

Rung 5: When the done bit (DN) of timer T2 is energises, then the next timer T3 is start for completing reverse stroke of cylinder.

For continuous repeating of the cycle the done bit (DN) of the last timer (T3. Q) is placed before the starting of the first timer T1 in Rung 3.



Image.3. Total setup of Automation of press tool

DTMF (DUAL TONE MULTI FREQUENCY) DECODER CIRCUIT SCHEMATIC USING M8870

This DTMF (Dual Tone Multi Frequency) decoder circuit identifies the dial tone from the telephone line and decodes the key pressed on the remote telephone. For the detection of DTMF signaling, the IC MT8870DE is used. It is a touch tone decoder IC.

The input to DTMF is decoded to 5 digital outputs. A digital counting technique is used by the M-8870 DTMF (Dual Tone Multi Frequency) decoder IC which determines the frequencies of the limited tones and verifies that they correspond to standard DTMF frequencies. There is a one-way communication between the dialer and the telephone exchange. The whole communication consists of the touch tone initiator and the tone decoder or detector. A computer or microcontroller is used for interfacing the decoded bits for further application (For example, Remote control of home/office electrical appliances using a telephone network, Cell Phone controlled home appliances, Mobile phone controlled robot, etc.).

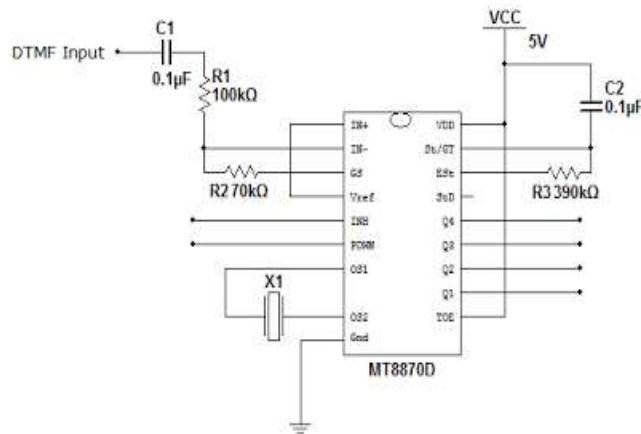


Fig. DTMF Circuit Diagram

- **COMPONENTS REQUIRED**

DTMF decoder IC (M-8870), Resistors (100kΩ; 70kΩ; 390kΩ), Capacitors (0.1µF x 2), Crystal oscillator (3.579545MHz)

- **Need of DTMF Decoding**

In the premature days, our telephone systems were operated by human operators in a telephone exchange room. The caller will pick up the phone, giving instruction to the operator to connect their line to the destination. It is a kind of manual switching. As more and more people entered in the telephone technology as useful communication gear, manual switching becomes a time consuming tedious task.

As technology established, pulse or dial tone technique were invented for telephone communication switching. It employs electronics and computers to support switching operations. DTMF is the ultimate technique used in any of the Mobile, Telephone communication systems.

The operation of DTMF method are as follows:

- Caller generates a dial tone consisting of two frequencies. It is transmitted via the telephone line (communication media).
- Telephone exchange consists of a DTMF decoder, which decodes the frequencies in to digital code.
- These codes are the address of destination subscriber; it is read and processed by a computer which connects caller to the destination subscriber.

Table No. 1. DTMF Low and High frequency tones and decoded output

Button	Low DTMF frequency (Hz)	High DTMF frequency (Hz)	Binary coded output			
			Q1	Q2	Q3	Q4
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0

There is an inbuilt Op amp present inside the M-8870 decoder IC. The electrical signals from microphone pin are fed to inverting input of the Op Amp via a series of resistance (100kΩ) and capacitance (0.1 μF).

- The non-inverting input of Op-amp is connected to a reference voltage (pin4 -VREF). The voltage at VREF pin is $V_{cc}/2$.
- Pin 3 (GS) is the output of internal Op Amp, the feedback signal is given by connecting the output pin (pin3- GS) to inverting input pin (pin2- IN-) through a resistor (270kΩ).
- The output of Op Amp is passed through a pre filter, low group and high group filters (filter networks). These filters contain switched capacitors to divide DTMF tones into low and high group signals (High group filters bypass the high frequencies whereas low group filter pass low frequencies).
- Next processing sections inside the IC are frequency detector and code detector circuits. Filtered frequency passed through these detectors.
- At last the four-digit binary code is latched at the output of M-8870 DTMF decoder IC.

RELAY CIRCUIT

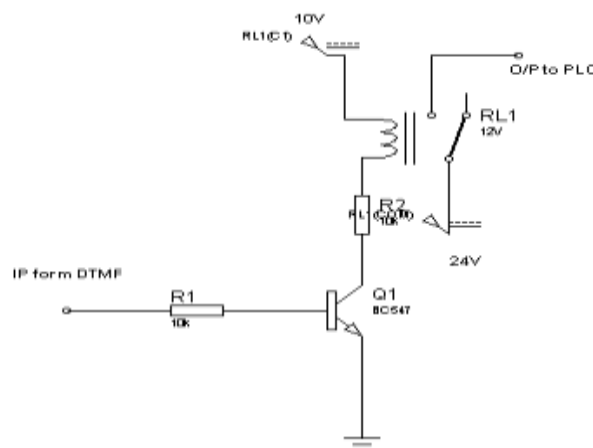


Fig.2. Relay Circuit

The relay is connected between the positive rail and the collector of the transistor. When the input signal passes through the 10k resistor to the base of the transistor, it conducts and pulls the relay. By adding a 470 uF electrolytic capacitor at the base of the relay driver transistor, a short lag can be induced so that the transistor switches on only if the input signal is persisting. Again, even if the input signal ceases, the transistor remains conducting till the capacitor discharges completely. This avoids relay clicking and offers clean switching of the relay. LED indicates the on status of the relay.

CONCLUSIONS

The following conclusions are drawn from the present study:

We have automated the system through BOSCH REXROTH PLC

- 1] It is very sensitive, precise and very accurate.
- 2] If we change the punch and die set for other applications, then we need to change only the ladder program, the programming was user friendly and flexible enough to change according to application.
- 3] The cycle time is 4.5 sec's, so the production rate per hour is 800 components.
- 4] We also add feature of DTMF, so we can operate it remotely from any distance by calling from cell phone.

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