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Design & Simulation of PLC Control and Electro-Hydraulic System for a Punching Machine

Dr.Majid A. Oleiwi* Abdul Muhsin M. Al-Timimi* & Ammar Abdulhussein*

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Abstract

Automatic control has become an important and integral part of modern manufacturing and industrial processes .Automatic control provide means for attaining optimal performance of dynamic systems, improve the quality and lower the cost of production, expand the production rate, relive the drudgery of many routine, repetitive manual operations, etc.. In this paper it has been designed a control system which controlled the operation of punch machine .As shown in Fig. (1) this system consists of: (1) the programmable logic controller (PLC) which is used to control time and regulate the sequence. (2) The Hydraulic system receives and implements the logical commands of PLC. (3) Electrical interfacing circuits which are very important to compromise in the stages of system. In order to avoid mistakes of direct design and implementation in the industrial and production processes and what follows from high material cost, therefore Automation Studio Software has been used to design the hydraulic system according to the required giving's by using Simulation software before the machine is fabricated, also it is distinguished in the simplicity of using ,have a very good specification in design and the ability of exposing the parts of the system in one screen and show the connection between them ,this led to have expected programmable results.

Keywords: PLC applications, Automation Studio, Automatic control systems, Fluid Power system

تصميم وتمثيل الكترو هايدروليك لماكنة تثقيب باستخدام المسيطر المنطقي المبرمج

الخلاصة

إن عملية التحكم الذاتي Automatic control لمكائن الإنتاج والتصنيع مهمة جدا وعنصر تكامل لتحقيق زيادة في الإنتاج ، تقليل الكلفة،تحسين النوعية والتخلص من الأعمال اليدوية المتكررة. في هذا البحث تم تصميم وتمثيل منظومة سيطرة تتحكم ذاتيا بعملية إنتاج لماكنة التخريم Punch machine , من الشكل رقم (1) تتكون هذه المنظومة من 1- المسيطر المبرمج (PLC), الذي أصبح جزءا مهما في العمليات الإنتاجية والصناعية التي تتميز بسلسلة ثابتة من العمليات وتوليد الخطوات المنطقية والقرارات استنادا إلى قراءة متحسسات المنظومة (sensors) (2) المنظومة الهايدروليكية التي تقوم بتنفيذ الأوامر المنطقية الصادرة من PLC إضافة إلى بناء دوائر التعشيق الالكترونية الضرورية واللازمة لأجراء عملية التوافق ما بين مراحل المنظومة . ومن أجل تلافي أخطاء التصميم والتنفيذ المباشر في العمليات الصناعية والإنتاجية وما يتبعها من تكاليف مادية عالية تم استخدام برنامج Automation Studio Software لتصميم المنظومة وفقا للمعطيات المطلوبة وذلك بأجراء عملية تمثيل Simulation للمنظومة واختبارها لأكثر من مرة للحصول على أفضل أداء قبل البدء بعملية

*Control and Systems Engineering Department, University of Technology/ Baghdad

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

التصنيع أو التركيب للمنظومة وكذلك يتميز بسهولة الاستخدام والحصول على دقة في التصميم وإمكانية عرض أجزاء المنظومة(المسيطر المبرمج ,المنظومة الهايدروليكية ,دوائر التعشيق الالكترونية) بشاشة واحدة وإظهار الترابط مابينهما بشكل واضح مما ساعد إلى التوصل لنتائج جيدة ومطابقة للمخطط إليه.

Introduction

There is a constant need for process control systems in the manufacturing Industries to produce a better product more efficiently and at a low cost. This has led to the evolution of the automated system. Experience has shown that hydraulic is now indispensable as a modern method of transferring energy. Hydraulic drives and controls have become more and more important due to automation and mechanization. Today, a very large amount of modern and powerful machinery is controlled either partly or completely by hydraulics. It is difficult to find steel works, Machine tool applications, Injection moldings machines, Mobile machinery, Handling equipment, Marine application, Civil Engineering, and complicated controls of Dish, Which are not fitted with extensive hydraulic equipment and PLC control. The high production level on these valuable machines couldn't be considered without these "hydraulic muscles", with the development of computer technology for above industrial application the programmable logic controller was developed to replace the discrete relay, timer and counter.[1] .The programmable logic controller (PLC) is a sequential controller as in Fig.(2).A sequence of instructions is programmed by the user to the PLC's memory and when this program is executed the controller will operate a system to the correct processing specifications more complex manufacturing systems will combine both closed loop and sequential control methods to be implemented.[2] .The programming language is based on familiar relay symbol ladder diagram technique that electricians and technicians know and use. [3] .To allows easy diagnosis in the case of failures in a production system automated by PLCs, the quality of the PLC software is of crucial importance. [4].

Electro-Hydraulic system Design

Engineering technology curriculum is a combination of a hands-on and minds-on approach to real word application designs. The present work required to use the simulation software called Automation Studio Vr.5. [5] for hydraulic circuit design. As shown in Fig. (3).

The operation steps of the designed circuit are:

1- Alloys are feed to machine from hopper.
2- After alloy reach to punching machine it clamp in it is position to start punching.
3- After punching prose complete the alloy release and the elevator bring it down to drop in the basket.

4- After basket flied the conveyor bet move to bring a blank basket and process restarted.

Hydraulic pump used wdisplacement of 70 l/min the following formulas is related to hydraulic pump [6, 9]:

Flow:

$$Q = \frac{V.n.\eta_{vol}}{1000} \left[\frac{l}{min}\right]$$

Drive power:

$$P_{an} = \frac{P.Q}{600.\eta_{tot}} \ [\,KW\,]$$

Total output:

$$\eta_{tot} = \eta_{vol}.\eta_{hm}$$

Q = flow [l/min].
V = geometric flow (pump or motor) [cc].
n = driver speed of hydraulic pump [rev/min].
η_{tot} = total output (0.8-0.85).
η_{vol} = volumetric output (0.9-0.95).
η_{hm} = hydraulic mechanical output (0.9-0.95).
Hydraulic motor used with displacement of 60 l/min the following formulas is related to hydraulic motor:

Flow:

$$Q = \frac{V.n}{1000.\eta_{vol}} \left[\frac{l}{min}\right]$$

Speed:

$$n = \frac{Q.\eta_{vol}.1000}{V} \ [\,min^{-1}\,]$$

Drive torque:

$$M_{ab} = \frac{\Delta p.V.\eta_{hm}}{2.\pi.100}$$

ΔP = pressure drop between motor inlet and outlet [bar].

Hydraulic control cylinders are used with the following specifications as shown in table (1).

The following formulas are related to hydraulic control cylinder:

Effective area:

$$A = \frac{d1^2.\pi}{4.100} \ [\,cm^2\,]$$

Force:

$$F = P.A \ [\,daN\,]$$

Stroke speed:

$$v = \frac{h}{t.1000} \left[\frac{m}{s}\right]$$

Required flow:

$$Q = \frac{Q_{th}}{\eta_{vol}} \left[\frac{l}{min}\right]$$

$$Q_{th} = \frac{V}{t}.60 \left[\frac{l}{min}\right]$$

Stroke volume:

$$V = \frac{A.h}{10000} \ [l]$$

Stroke time:

$$t = \frac{A.h.6}{Q.1000} \ [s]$$

d1 = Piston diameter [mm]
P = operating pressure [bar]
h = stroke [mm]
t = stroke time [sec]
Q_{th} = flow without leakage losses [l/min]
η_{vol} = volumetric efficiency (0.95)

PLC Control

Programmable logic controllers (PLCs) are still the workhorse of industrial automation. The main tasks of a PLC normally fall into the category of discrete event o logic control, possibly

with underlying time-discrete implementation
of continuous controllers like time-discrete PID algorithms. [7]. A PLC closes the loop in a system by reading sensor values produced in the plant, calculating a corresponding response, and sending the result back to the plant in the form of commands for actuators. The actuators influence the process and hence my trigger new sensor values again. PLCS have been gaining popularity on the factory floor and will probably remain predominant for some time to come. Most of this is because of the advantages they offer. [8]

§ Cost effective for controlling complex systems.

§ Flexible and can be reapplied to control other systems quickly and easily

§ Computational abilities allow more sophisticated control.

§ Trouble shooting aids make programming easier and reduce downtime.

§ Reliable components make these likely to operate for years before failure.

Table (2) explained the sequence operation for energize hydraulic control valves, which is control punch machine.

From table (2) we designed PLC program. The program which is executed for PLC is shown in Fig.(4) to Fig.(8) .These can be used before , during and after a controls machine .These forms can then be kept in design or maintenance offices so that others can get easy access and make updates the controller is changed.

Interfacing circuit

The interfacing circuits as shown in Fig (9) are very important to make compatible between the signals of Hydraulic system and the signals which transmitted or received from programmable logic control (PLC).

Conclusion

There are so many conclusions from this paper but the main are:
The electro-hydraulic system and PLC program were tested many times by simulation before it was delivered to the local manufactured. The tested data shows that the designed system is quite reliable and meets the intended design expectations. The process of designing, building the electro-hydraulic circuit, PLCs program and using software tools, has triggered us interest in real-world applications Flexible and can be reapplied to control other systems quickly and easily. Program testing can be done on machine, but this is not always possible or desirable. In these cases simulation allow the programs to be tested without actual machine. All details and privileges of motors & cylinders motion (linear position, speed, acceleration, etc.) for designed Hydraulic circuit can be analyzed and known .The Hydraulics devices are quite rugged and can perform control and computational functions in adverse environments .Hydraulic devices can with stand wide temperature changes ,extremely high temperature , shock , vibration and radiation . In addition, the simplicity of basic Hydraulic devices assures high reliability, long life and very low maintenance. PLC program forms can then be kept in design or maintenance offices so that others can get easy access and make updates the controller is changed.

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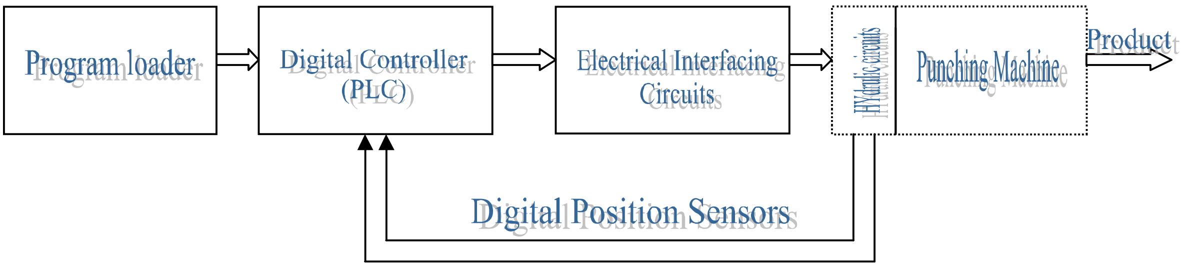
Table (1) Hydraulic cylinder specifications

Cylinder Name	Dimensions	Cylinder Type
Feeder Cylinder	Rod diameter =5 cm Piston Diameter=10 cm Stroke length=25 cm	Single acting cylinder
Clamping Cylinders	Rod diameter =5 cm Piston Diameter=10 cm Stroke length=25 cm	Double acting cylinder
Punching Cylinder	Rod diameter =5 cm Piston Diameter=10 cm Stroke length=20 cm	Double acting cylinder
Elevation Cylinder	Rod diameter =5 cm Piston Diameter=10 cm Stroke length=100 cm	Single acting cylinder
Dropping Cylinder	Rod diameter =5 cm Piston Diameter=10 cm Stroke length=25 cm	Single acting cylinder

Table (2) Valves switching sequence

Solenoid / Operation	SV_FEEDER	SV_CLAMP_ON	SV_CLAMB_OFF	SV_PUNCH_ON	SV_PUNCH_OFF	SV_ELEV	SV_DROP	SV_MOTOR
Feeding	#							
Clamping		#						
Punching		#		#				
End Punching		#			#			
End Clamping			#					
Elevation						#		
Dropping						#	#	
Move Conveyor belt								#



Figure(1) Block diagram of System

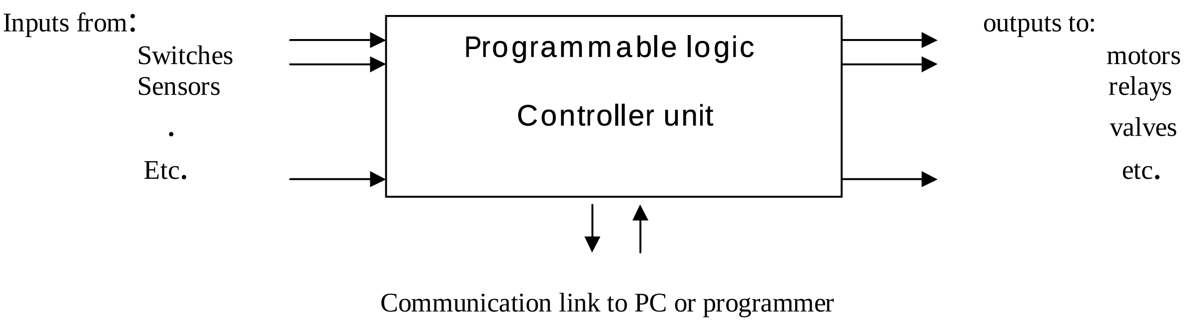


Figure (2) A sequential controller

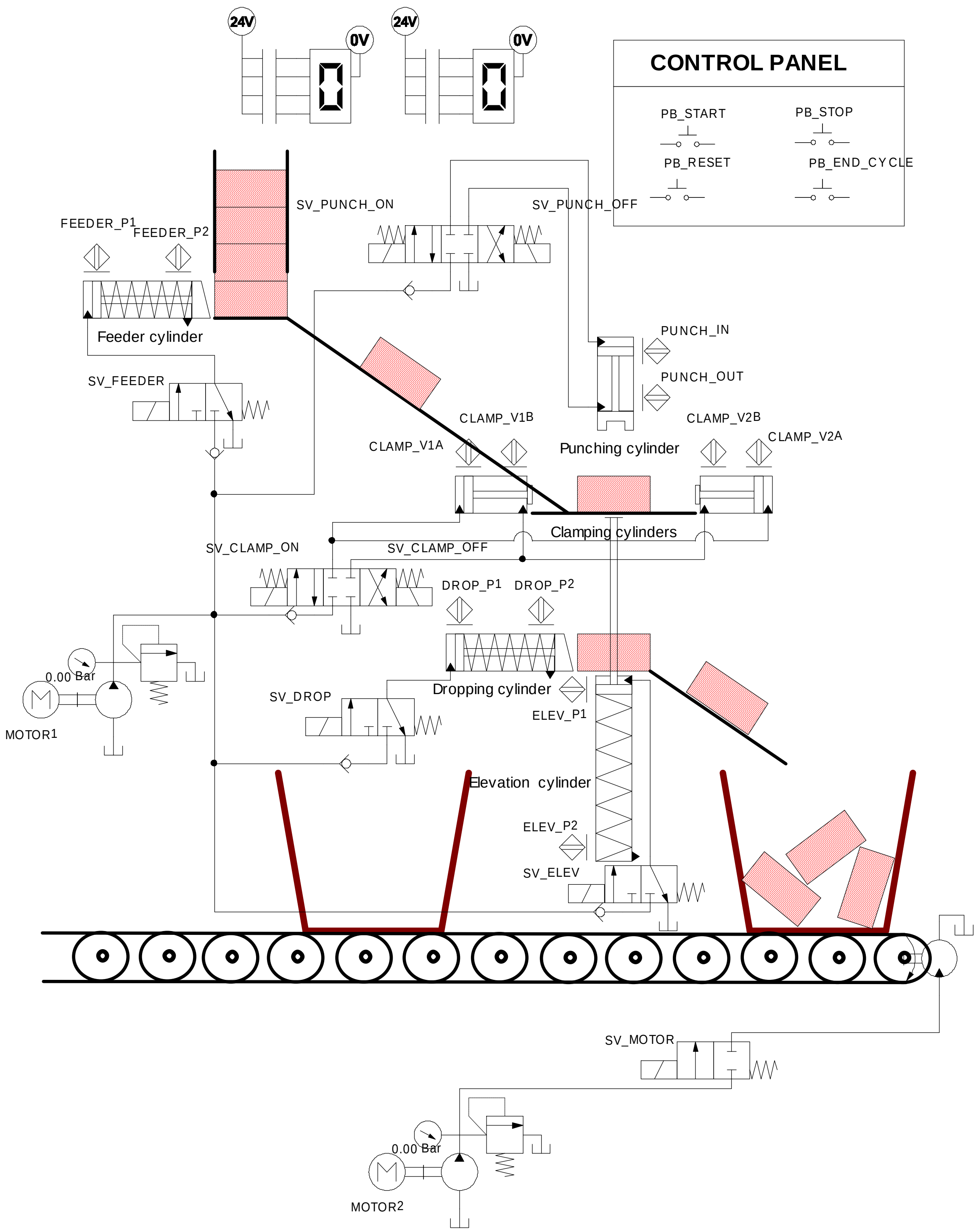


Figure (3) Designed Hydraulic control system

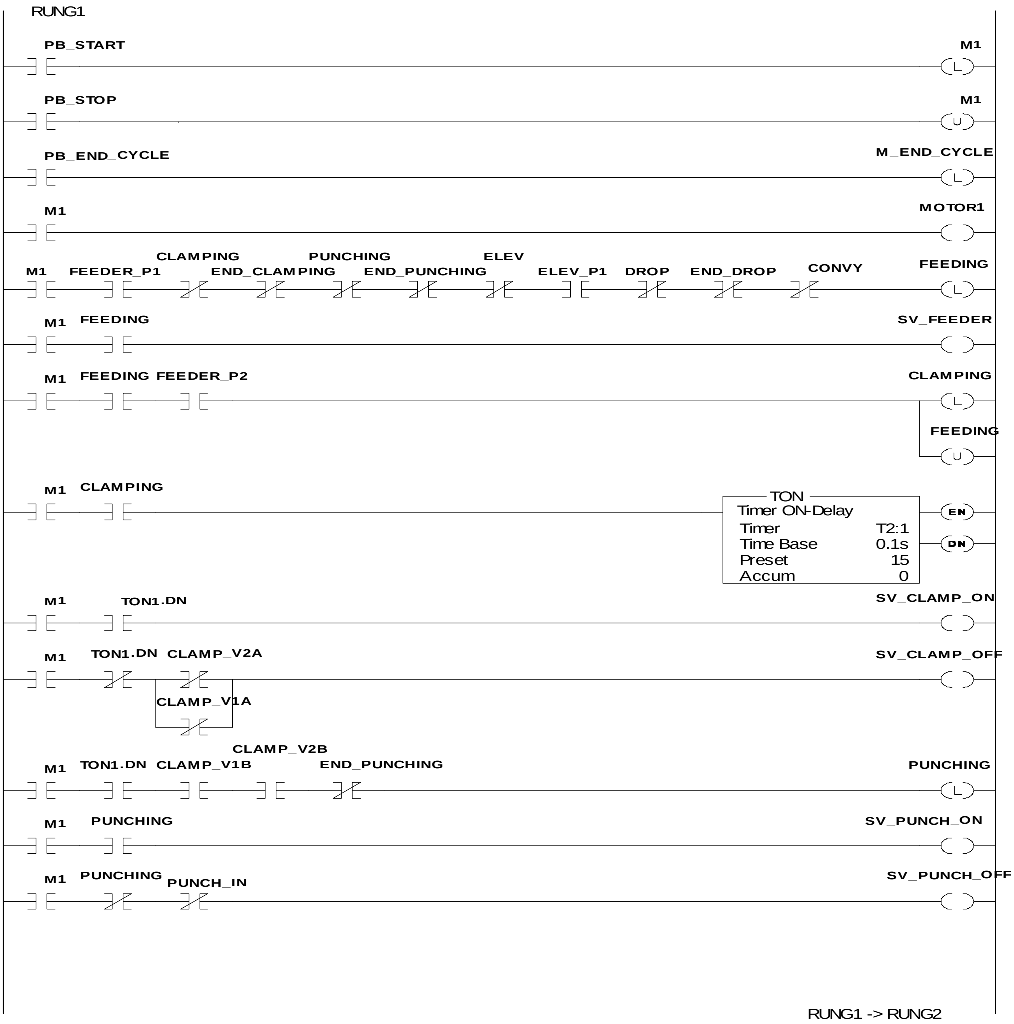


Figure (4) Rung 1 (ladder logic diagram)

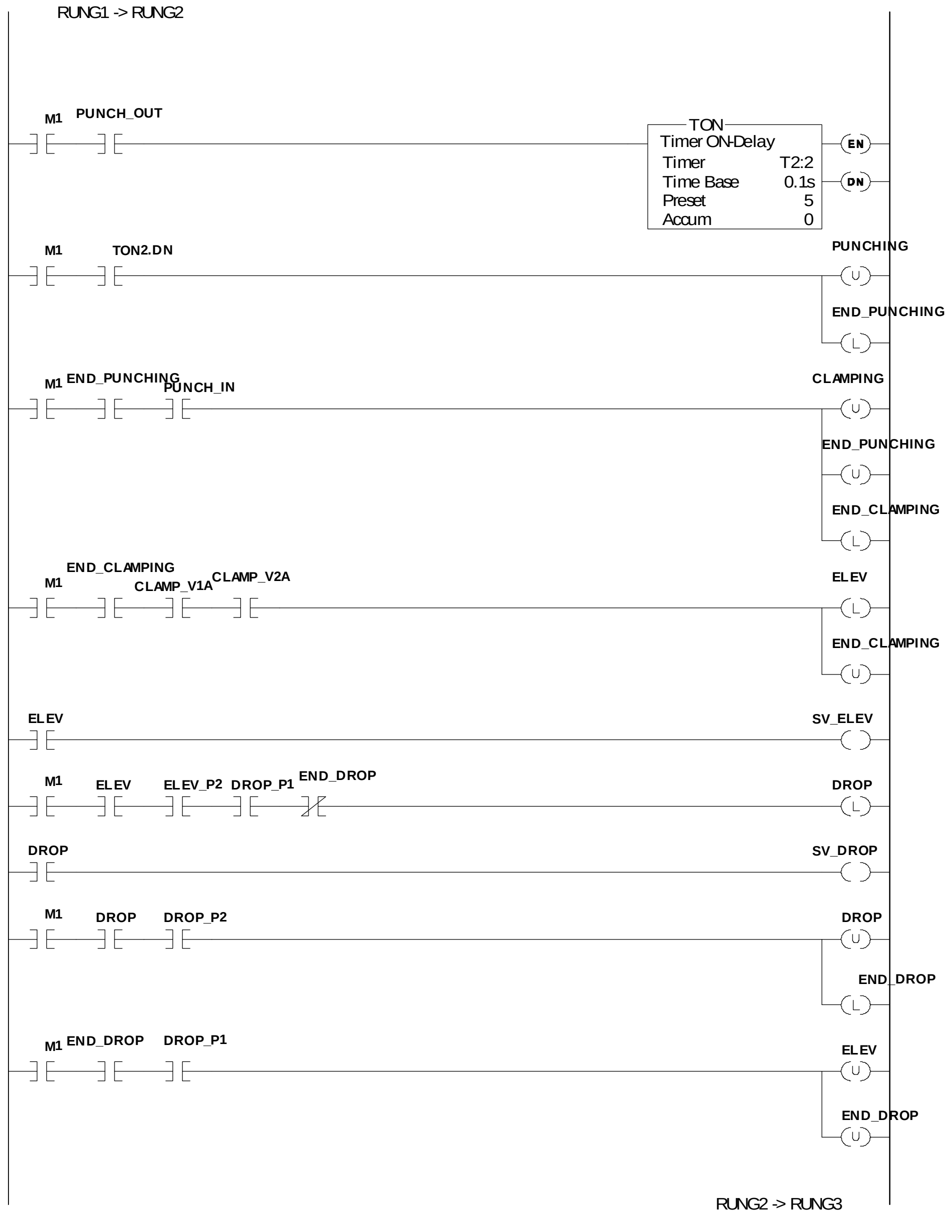


Figure (5) Rung 2(ladder logic diagram)

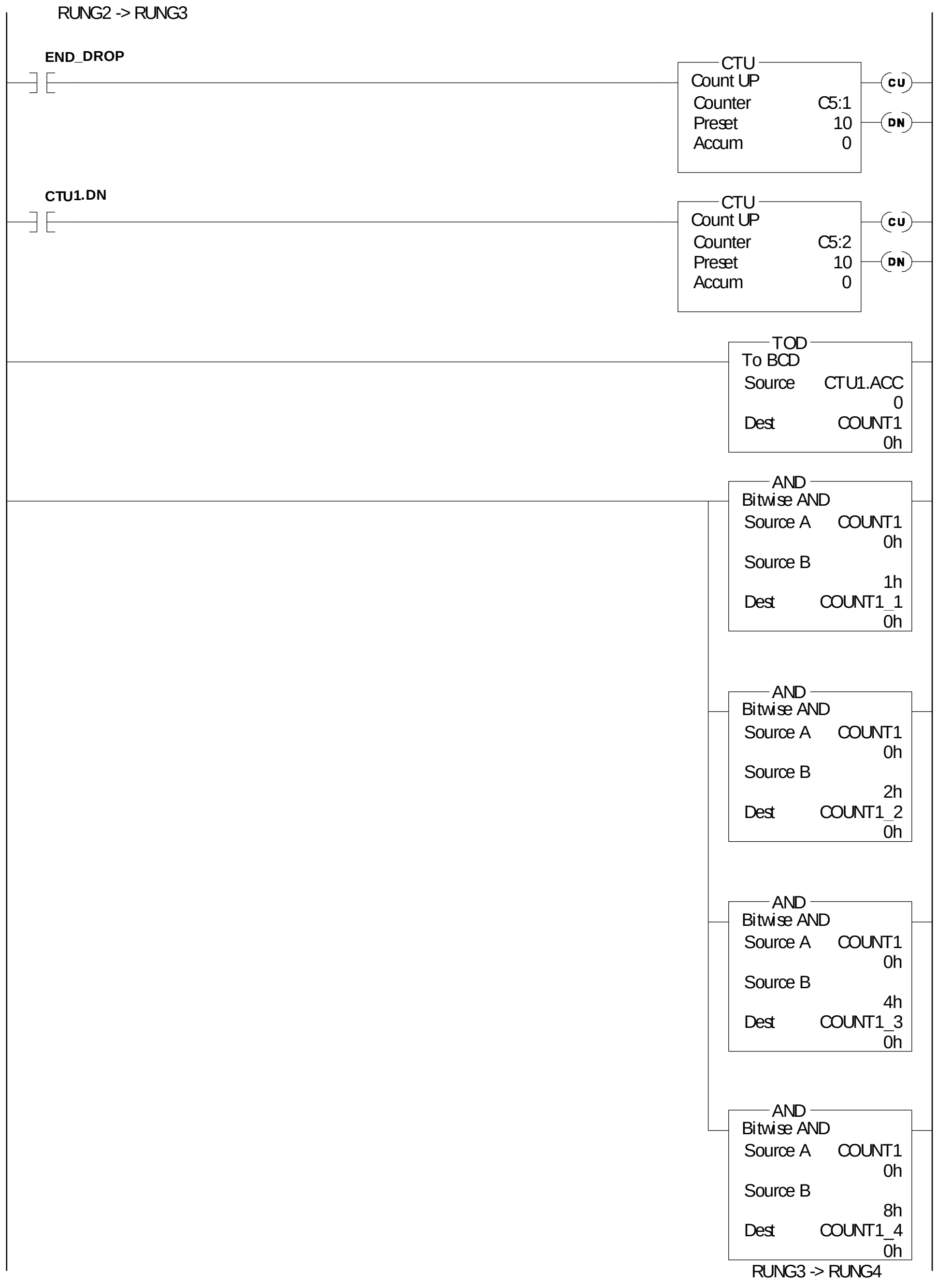


Figure (6) Rung 3(ladder logic diagram)

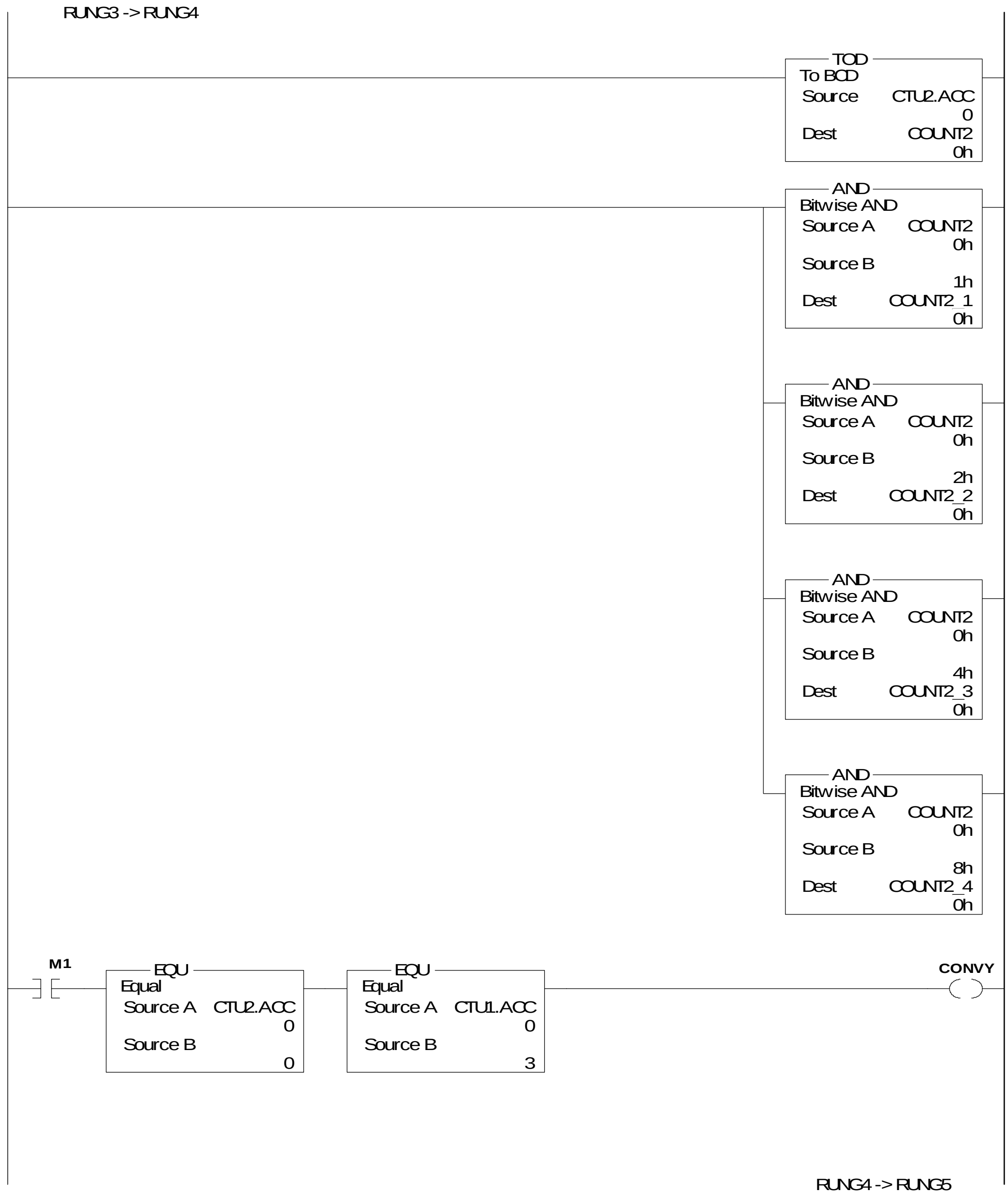


Figure (7) Rung 4(ladder logic diagram)

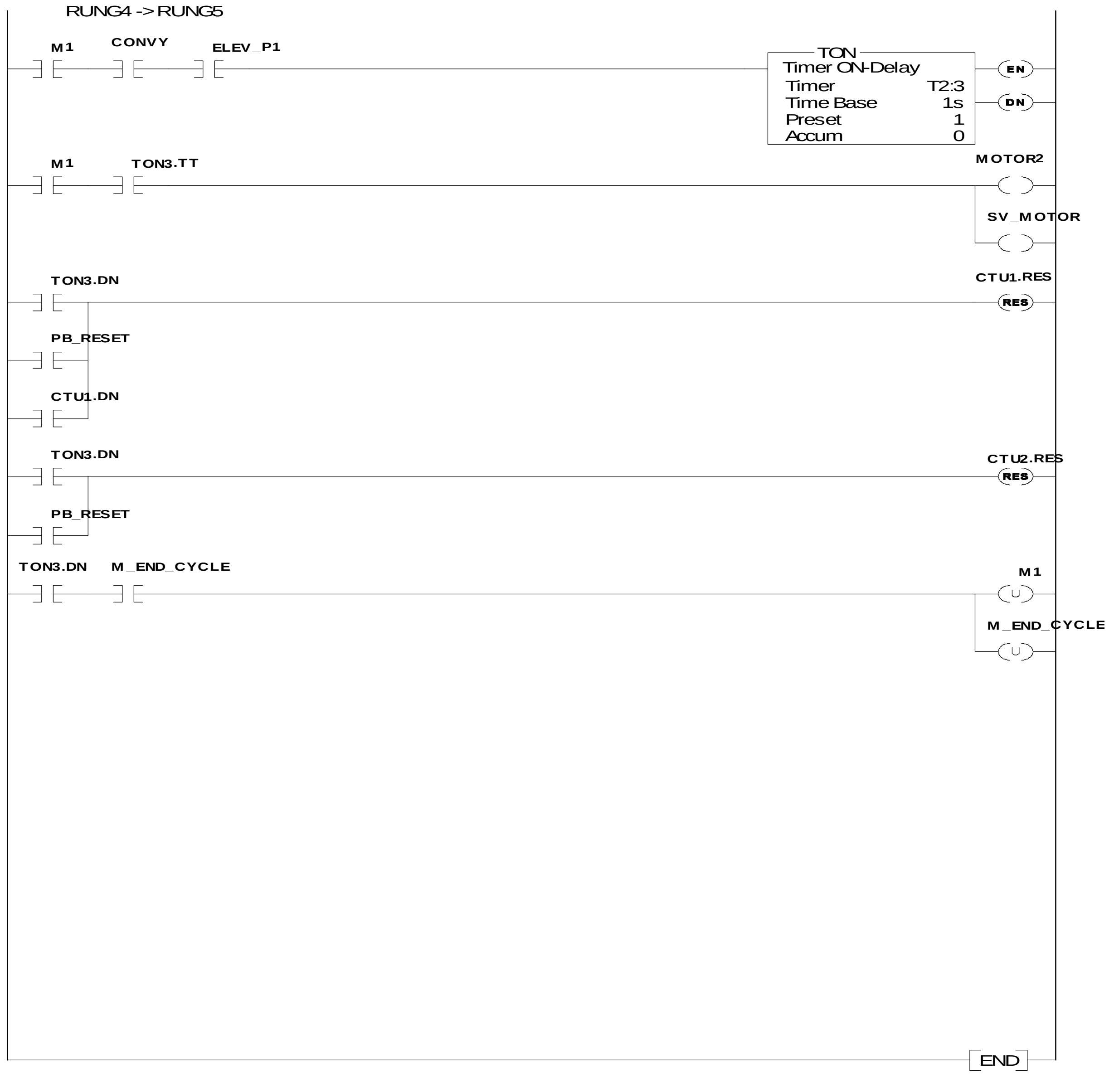


Figure (8) Rung 5(ladder logic diagram)

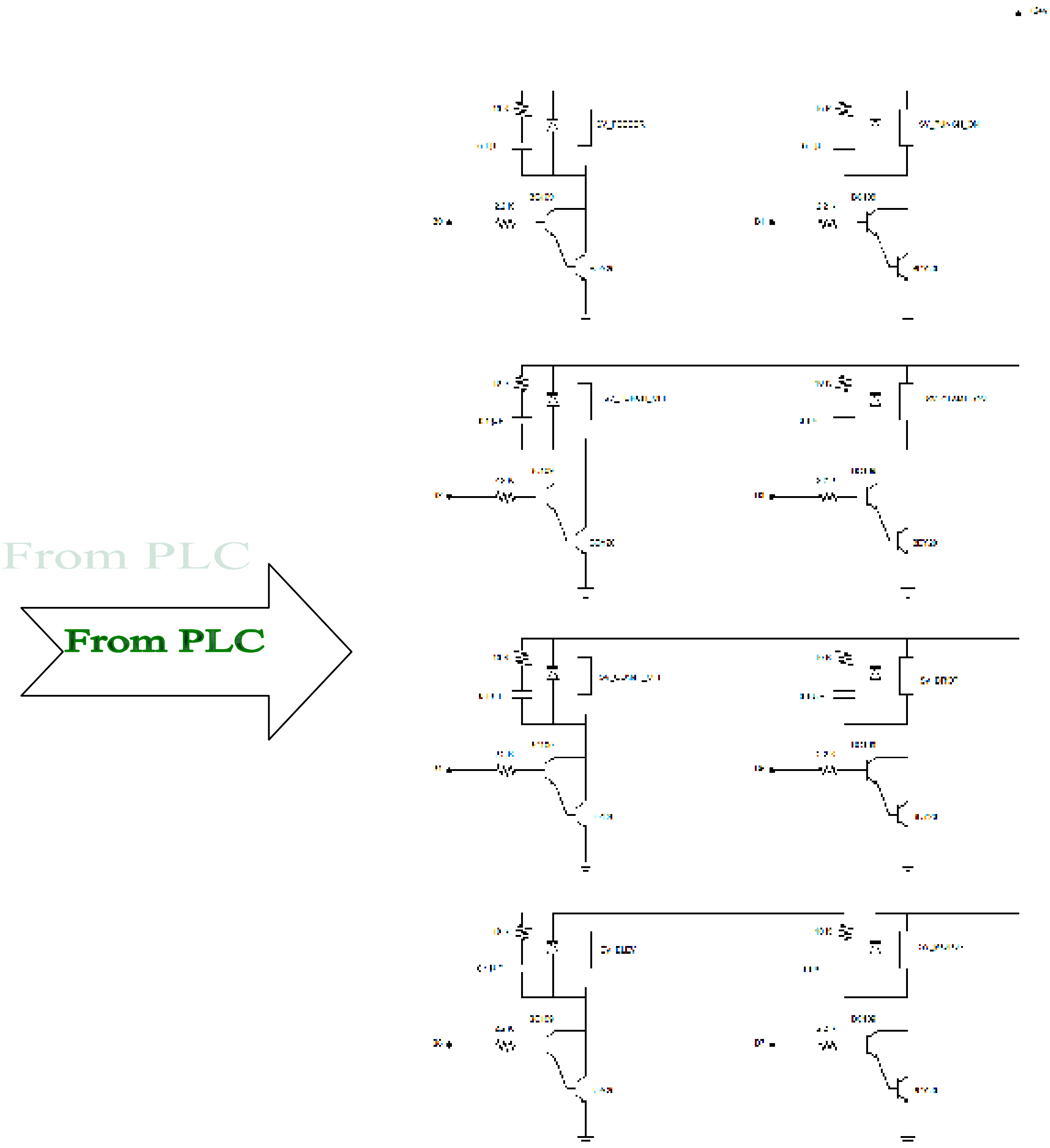


Figure (9) Electronic Interfacing circuit