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MOTOR CONTROL SYSTEM FOR CONVEYOR

Khin Thandar Tun[1], Hay Man Oo[2], May Lwin Thant[3]

[1]Lecturer, Department of Electronic Engineering, Technological University (Meiktila), Myanmar
[2]Lecturer, Department of Electronic Engineering, Technological University (Meiktila), Myanmar
[3]Assistant Lecturer, Department of Electronic Engineering, Technological University (Meiktila), Myanmar

Abstract

This paper describes motor control system for conveyor. Conveyors use in many industries and airport to transport the products and things for the purpose of decrease employees and save time. The control of conveyor is very important. If the conveyor system does not operate properly, the products can be damaged. This paper intends to save products by choosing advanced components to construct the belt conveyor. The first portion of this paper concerns motor controller. The conveyor motor controller is built with 12 V DC gear motor and L298 motor module. This conveyor are run DC gear motor in clockwise and anti-clockwise direction by L298 motor module and stop it by using a single switch. Moreover, there is also a counter circuit to count the products on the conveyor belt. The counting system is constructed with counting circuit, seven segment decoder and a few discrete components. Laser module, LDR module and IR module are used for counting system to sense products and things. 0 to 99 digits are counted and displayed by this counter circuit. The conveyor motor controller circuit uses 12 V power supply and the counting system uses 5 V power supply which is built to get 5 V from 12 V Switch Mode Power Supply (SMPS). Keywords—Counting system, Motor, Laser module, LDR module, IR module, 7-Segment display, Micro-switch, 555 timer.

Keyword: Counting system, Motor, Laser module, LDR module, IR module, 7-Segment display, Micro-switch, 555 timer

1.INTRODUCTION

Conveyor systems are commonly used in many industries, including the airport, food processing, automotive and packaging. Using conveyor operation gives helpful some individual area such as transportation, accumulation the material and picking up the materials according to sizes weights and shapes of the material where the loading. The design and development of this paper is divided into two parts; conveyor motor control system and counting system.

2.SYSTEM BLOCK DIAGRAM

The block diagram of conveyor motor control system operates the main four sections. The first section is power supply. The second section is switch. The third section is controller. And then, the last section is motor. Initially, the motor is in stop condition. There are three switches at conveyor part that STOP switch, FORWARD switch and REVERSE switch. They are connected by motor module L298. DC motor is supplied 12 V. L298 is connected by DC 12 V gear motor, and them, the conveyor running.

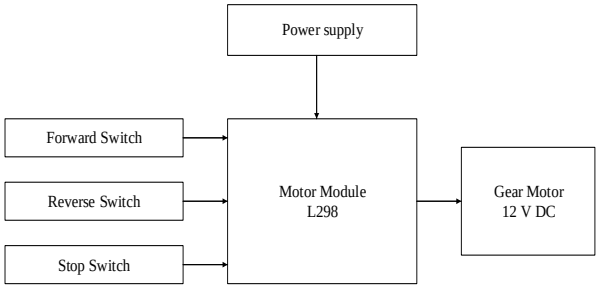

Fig1: Block Diagram of Conveyor Motor Control system

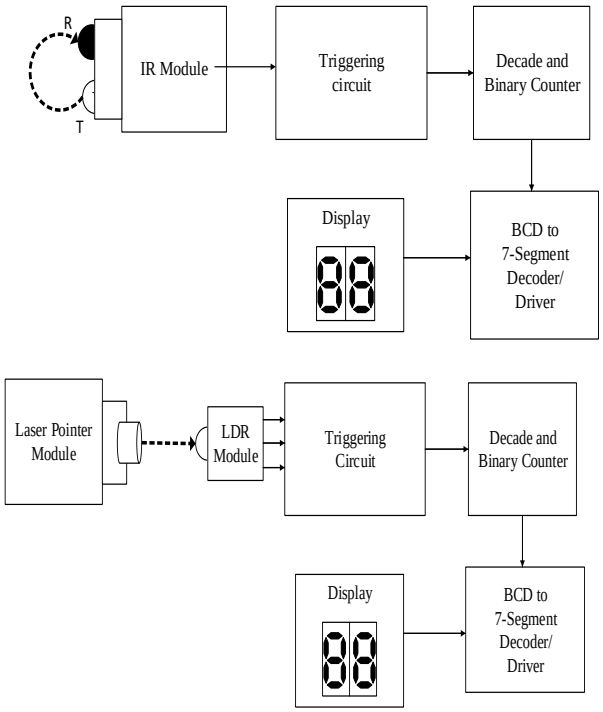

Fig2: Block Diagram of Counting System

The block diagram of the counting system is shown in Fig.2. This counting system is divided by five sections. The first section uses IR module or Laser pointer module. The second section is triggering circuit. The third section is decade and binary counter. And then, the four section is BCD to 7-segment decoder. Finally, the last section is display. The principle of an IR sensor work as an object detection sensor. An IR sensor consists of an IR LED and an IR together they are called as photo-coupler. When the IR transmitter emits radiation, it reaches the object and some of reflects back to the IR receiver. Based on the intensity of the reception receiver, the output of the sensor is defined. When somebody crosses the path of the IR beam falling on the sensor or Laser sensor, the triggering circuit activates to trigger the monostable multivibrator. The output of the monostable mode timer starts giving pulses to the counter module. The 7-segment drivers use the output of decade counters to display numbers on seven segment displays. This circuit counts from 0 to 99.

3.DESIGN AND CONSTRUCTION

There are two main parts in this paper. First part is conveyor motor controller and second part is counting system.

3.1. Operation of Conveyor Motor Control System

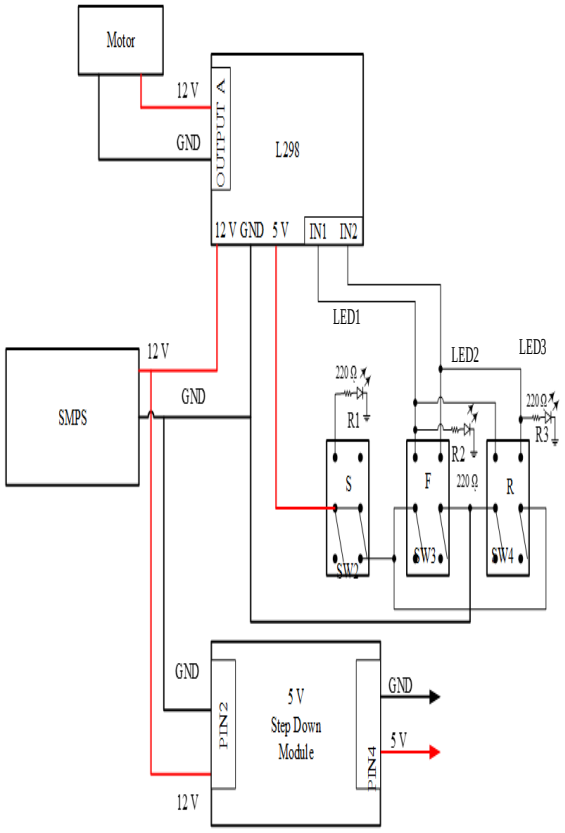

Fig 3: Circuit Diagram of Motor Control System for Conveyor and its Power Supply

The conveyor motor control circuit can run a DC motor in clockwise or anti-clockwise direction and stop it using a single switch. It provides a constant voltage for proper operation of the motor. The glowing of LED 1 through LED 3 indicates that the motor is in stop, forward, and reverse conditions, respectively. Conveyor needs to get 12 V power supply for maximum 12 V can get from switch mode power supply: 12 V/5 A. There are five pins on SMPS board. Pin 1 and pin 2 are AC inputs. Pin 3 is for ground. Pin 4 and pin 5 are 12 V DC pins and this pin connected with 12 V gear motor. 12 V power supply is sent to the DC gear motor through the L298 motor module. It is connected from pin 4(-V), pin 5(+V) of SMPS to pin 4(+V), pin 5(-V) of L298 motor module. L298 motor module control DC gear motor of the

conveyor. +V and –V pin of DC gear motor is connected to the output A pins of L298 motor module to run DC gear motor. To run the conveyor belt by forward, reverse, and stop, three switches is built by IN1 and IN2 pins of L298 motor module. The colours of LED show to separate the stop, forward, and reverse functions. Red LED glows to stop conveyor. Green LED glows for forward motion of conveyor. And yellow LED glows for reverse motion of conveyor. Thereafter, the cycle repeats.

3.2. Operation of Counting System

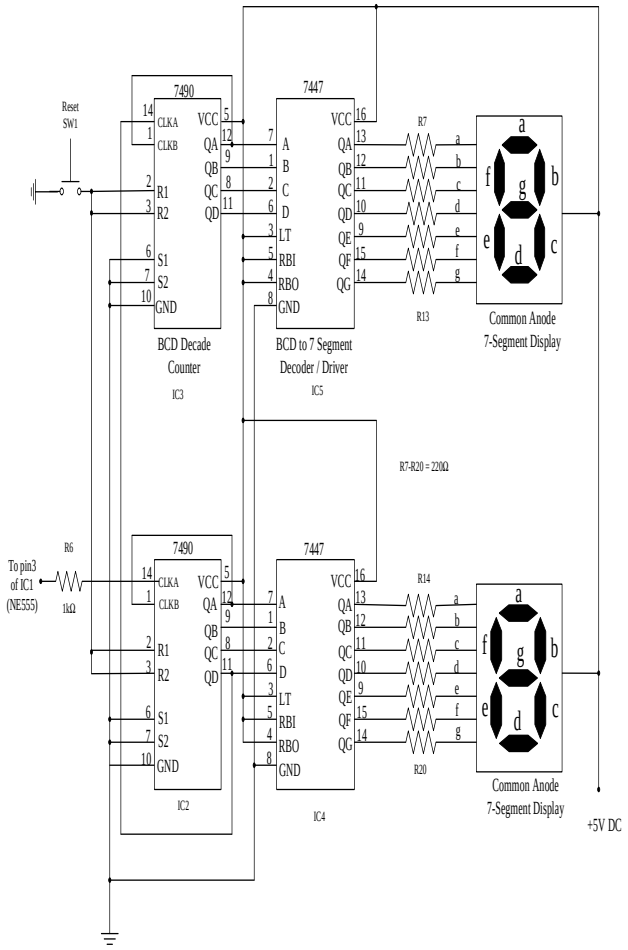

Fig 4: Circuit Diagram of Counting System

In counting system, 5 V power is need to supply. So, counter circuit cannot use 12 V power supply directly from SMPS. To get 5 V power supply, it needs to use 5 V power module to be safe. There are two divisions in counting system, sensor system and counting with decode counter. IR sensor and Laser sensor module are meant for pulsed operation. During a brief interruption of the IR module or laser module beam, a pulse appears to trigger the monostable formed by IC1. The monostable multivibrator is set for a time delay of nearly second. At triggering circuit, pin 2 is input pin and pin 3 is output pin of NE555 timer. Input (pin 2) is connected to output pin of IR module or output pin of LDR module. And then, output (pin 3) is connected pin 14 of IC2 from counter circuit. At counter circuit, 74LS90 IC acts a decade counter and 74LS47 IC uses the output of 74LS90 IC is display numbers on 7- segment display. IC2 shows any number from 0 to 9 according to input square wave given to pin14. After each pulse a carrying pulse is produced by counter IC and given to another one (i.e. from IC2 to IC3). IC4 and IC5 are BCD to 7-segment latch decoder drivers. The counter can be reset to zero at any time by pressing the reset micro-switch SW1.

Table 1. Component List of Motor Control System for Conveyor

Name	Type	Value	Number
SMPS	Switch mode power supply	12 V	1
5V Power supply		5 V	1
L298	Module card	-	1
IR Sensor	Module card	-	1
Laser Sensor	Module card	-	1
LDR Sensor	Module card	-	1
Gear Motor	Motor	12 V - 60 rpm	1
R_1 , R_2 , R_3	Resistor	220 Ω	3
R_4 , R_5	Resistor	10k	2
R_6	Resistor	1k	1
R_7 to R_{20}	Resistor	220 Ω	14
C_1	Capacitor	47 µF	1
C_2	Capacitor	2.2 µF	1
C_3	Capacitor	0.01µF	1

LED1,LED2,LED3	LED	-	3
SW1,SW2,SW3,SW4	Switch	-	4
IC1	NE555	-	1
IC2,IC3	74LS90	-	2
IC4,IC5	74LS47	-	2
7-Segment Display	Display	-	2

4.RESULTS

Calculation for 74LS90

Assume; V_{IN} = 5 V, I_{IN} = 0.198 A,

V_{OUT} = 4.4 V,I_{OUT} = 0.2 mA,

$$P = V \times I \quad (1)$$

From Equation 1,

$P_{IN} = V_{IN} \times I_{IN}$

$= 5 \times 0.198 = 0.99$ W

$P_{OUT} = V_{OUT} \times I_{OUT}$

$= 4.4 \times 0.2$ m $= 0.88$ mW

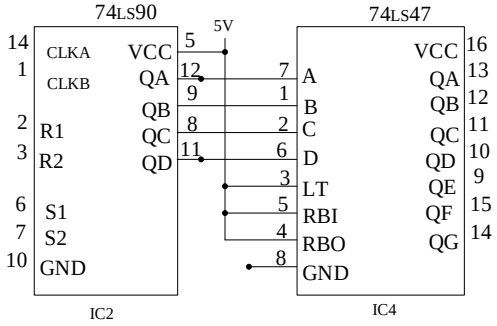

Fig 5: The Part of the 74LS90 and 74LS47 IC

Power losses; $P_L = P_{IN} - P_{OUT}$ (2)

$= 0.99 – 0.88$ m $= 0.989$ W

Voltage losses; $V_L = V_{IN} - V_{OUT}$ (3)

$= 5 – 4.4 = 0.6$ V

Current losses; $I_L = I_{IN} - I_{OUT}$ (4)

$= 0.198 – 0.2$ m

$= 197.8$ mA

Power losses for two 74LS90; $2P_L = 2 \times 0.989$

$= 1.978$ W

Calculation for 74LS47

Assume; V_{IN} = 5 V, I_{IN} = 0.198 A,

V_{OUT} = 0.26 V, I_{OUT} = 1.2 mA,

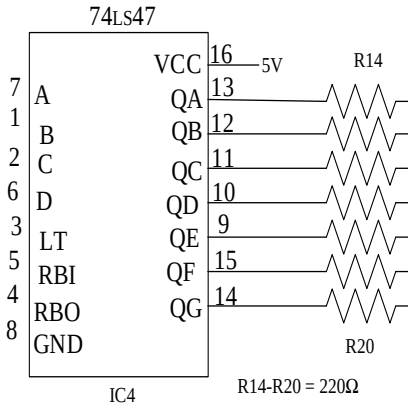

Fig 6: The Part of the 74LS47 IC

From Equation 1,

$P_{IN} = V_{IN} \times I_{IN} = 5 \times 0.198 = 0.99$ W

$P_{OUT} = V_{OUT} \times I_{OUT} = 0.26 \times 1.2$ m $= 0.312$ mW

From Equation 2,

Power losses; $P_L = P_{IN} - P_{OUT} = 0.99 – 0.312$ m $= 0.9896$ W

From Equation 3,

Voltage losses; $V_L = V_{IN} - V_{OUT} = 5 – 0.26 = 4.74$ V

From Equation 4,

Current losses; $I_L = I_{IN} - I_{OUT}$ = 0.198 – 1.2 m = 196.8 mA

Power losses for two 74LS47; $2P_L = 2 \times 0.9896 = 1.979$ W

V = 0.26 V, I = 1.2 mA, R = 220 Ω

By Ohm's Law,

$V = IR$ (5)

$R = \frac{V}{I} = \frac{0.26}{1.2m} = 216.6 \approx 220\ \Omega$

Calculation for 7-Segment Display

V = 4.95 V, $I_a = I_b = I_c = I_d = I_e = I_f = I_g = 0.01$ mA

$I_{Total} = I_a + I_b + I_c + I_d + I_e + I_f + I_g$ (6)

= 0.01 m + 0.01 m + 0.01 m + 0.01 m + 0.01 m +

0.01 m + 0.01 m

= 0.07 mA

From Equation 1,

$P = V \times I$

$= 4.95 \times 0.07$ m

= 0.3465 mW

Power for two 7-Segment Display; $2P = 2 \times 0.3465$ m

= 0.693 mW

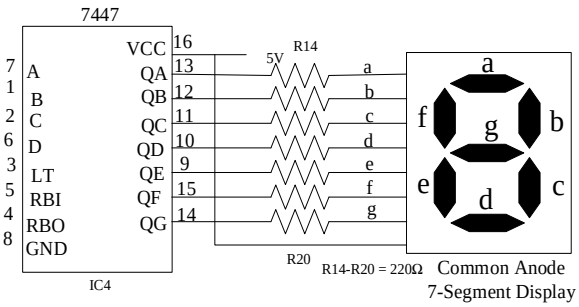

Fig 7: The Part of the 74LS47 and 7-Segment Display

Calculation for Path Width of Rectangular of Triggering Circuit

R = 10 kΩ, C = 22 µF

$T = t_{ON}$ = 1.1 RC (for monostable) (7)

= 1.1 × 10k × 22µ = 0.24 s

$F = \frac{1}{T}$ (8)

$= \frac{1}{0.24} = 4.13$ Hz

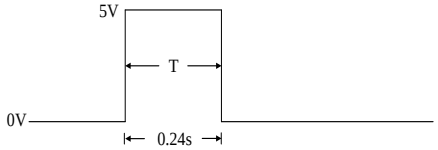

Fig 8: Path Width of Rectangular of Triggering Circuit

Duty Cycle, $D = \frac{t_{ON}}{T} \times 100\ \%$ (9)

$= \frac{0.24}{0.24} \times 100\ \% = 100\ \%$

Fig.9 shows stop condition of conveyor. When the stop switch is ON, red LED glows, and both motor and counter display stop. If the object passes through the sensor, that sensor does not operate during in stop condition.

Fig 9: Result for Stop Condition of Conveyor

Fig.10 shows forward condition of conveyor. When the forward switch is ON, green LED glows, and the motor

starts running in forward (clockwise) direction. If the IR sensor and Laser sensor are active, the object passes through the sensor and then counter displace is increased 0 to 99. After this, the counter can be reset to zero at any time by pressing the reset micro-switch SW1.

Fig 10: Result for Forward Condition of Conveyor

Fig.11 shows reverse condition of conveyor. When the reverse switch is ON, yellow LED glows, and the motor starts running in reverse (anti-clockwise) direction. If the both sensors operate, the object passes through the sensor and then counter displace is increased 0 to 99. After this, the counter can be reset to zero at any time by pressing the reset micro-switch SW1.

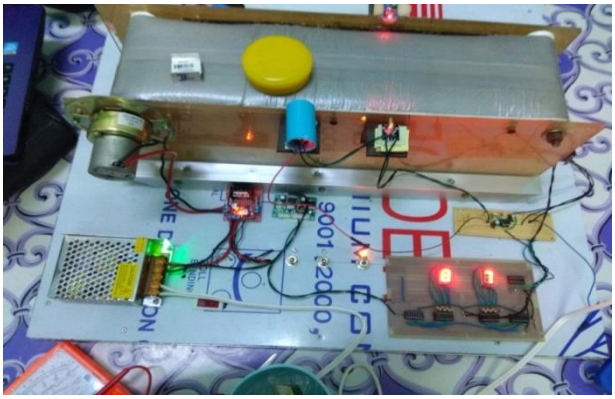

Fig 11: Result for Reverse Condition of Conveyor

Initial condition shows in Fig.12. In counter circuit, 00 condition displays on two 7-segments.

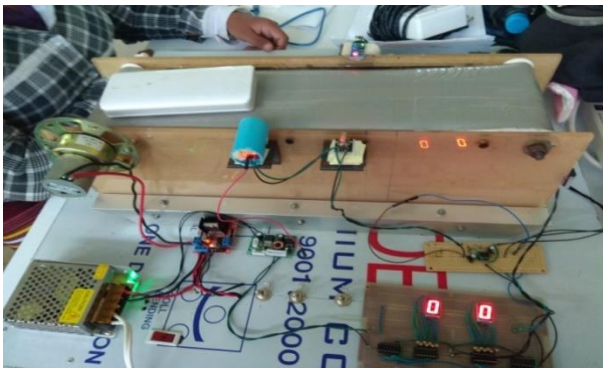

Fig 12: Initial Condition

Final condition shows in Fig.13. In counter circuit, 99 condition displays on two 7-segments.

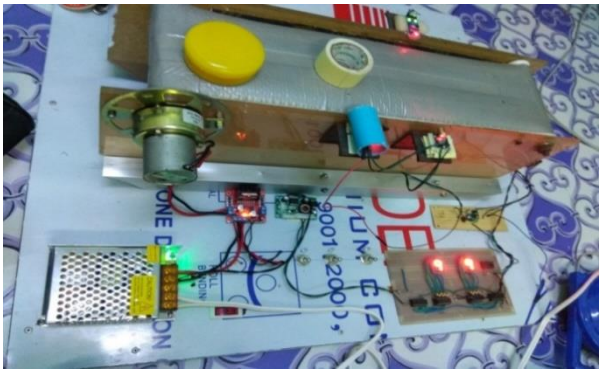

Fig 13: Final Condition

Recycle condition shows in Fig.14. Counter circuit returns to display 00 condition on two 7-segment.

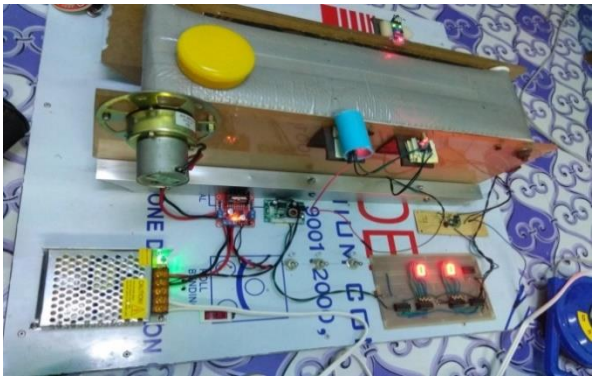

Fig 14: Reset Condition

5.DISCUSSION

This paper presents a discussion about conveyor motor controller. The DC gear motor controller circuit for conveyor belt is implemented utilizing available components from local market and its application. In choosing motor, gear motor is selected because it is available in local market. Other facts that gear motor is suitable for speed control and it has the advantages over the other type of gear DC motors. Its construction is also simple and not difficult to control in applications. Stop and change of direction of the motor are controlled by single push to ON switch and indicated by three colour LEDs for stop, forward and reverse directions. Counting is very important in this paper. Some examples are counting of time (clocks), counting of objects, etc. Various types of counting circuit using Complementary Metal Oxide Semiconductor (CMOS) such as 4543 with common cathode type of 7-segment LED display are commonly available. But the circuit given in this paper differs from all these circuits. This circuit is designed using Transistor to Transistor Logic (TTL) IC 7447 with common anode type of 7-segement LED displays, which is becoming more and more popular due to its own advantages. The advantages of TTL ICs over popular CMOS circuits are: it protects to electrical damage, it has strong drive capability, it is faster in some versions, TTL ICs require only one supply voltage unlike CMOS which needs two (i.e. Vdd and Vss). Vdd is between 3 V and 16 V and Vss is ground, it has noise immunity better than CMOS, it has power per gate of about 1 - 22 mW, the average propagation delay time is nominal and between 1.5 ns to 33 ns. This is better compare to CMOS. The IR module is used which is readily available in the market. Most optical counters make use of a light bulb with Light Dependent Resistor (LDR) as the sensor. These counters work satisfactorily in darkness only and cannot be used outdoors because of the chances of false counting due to light sensed from other light sources like sun, light bulb, etc. The issue of the count starting from any random number has been resolved by introducing a simple reset switch in the circuit. By reset switch made using a push button, the counter is momentarily given a signal that sets the counter to 0 before starting the count.

6.CONCLUSION

This motor control system for conveyor is reliable and easy to operate. The triggering circuit works well as an obstacle counter and a burglar alarm or an intruder detection system. The circuit also works well as objects counter. This counter is installed at the entry gate to count the total number of objects entering any venue. For example, it is used at the many industries, railway stations or bus stands to count the objects. This paper will be a better foundation for development of industrial technology in developing countries.

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