Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 9 Issue 10, October - 2022

Demultiplexer (1x16) Control Small DC Motor

Shih-Ping Hu
Department of Architecture
Hungkuo Delin University of technology
New Taipei City, Taiwan, Republic of China
hushihping@yahoo.com.tw

***Abstract*—Since the industrial revolution, the mankind has achieved rapid economic growth due to the advancement of production tools and technologies, but the consequent increases in labor costs. Although the increase of labor costs is the principle of the global economic, it also swallow reversely the harvest of the economic growth. From this point of view, the development of automatic control industry is an inevitable non-return, especially the development of digital logic technology is even more contributing to the advancement of automatic control industry. The major objective of this paper is to integrate the digital logic with automatic control. With the rapid response of digital logic, it is necessary to activate (turn on) automatic control equipment, reduce man-made operations, reduce error and significantly reduce costs, and further advance in the economic growth.**

Keywords—digital logic, BJT transistor, multiplexer, demultiplexer,

I. Introduction

This paper can be divided into two major parts. The first part is demultiplexer (1X16). Through the selection of digital code in binary (BCD code) [$S_3S_2S_1S_0$=Ø/Ø/$_{(2)}$], the start signal I is transmitted to the specified address Y_5. The second part is analog circuit system. It can starts (turns on) a small DC motor through many analog electronic components (operation amplifier, BJT transistor of npn type, relay, etc.) from the specified address Y_5.

II. Literature review

There were studies about demultiplexers in previous years. We take some examples to explain. In the literature [1], Zhan Zhaoming graduate student in his master's thesis studied "the design and manufacture of the demultiplexer and CATV network transmission protocol". The advantage of this paper is that it is a good and new method, but its disadvantage is that its circuit is very complicated and easy to make mistakes. In the literature [2], Huang Mingjie graduate student in his master's thesis researched "the tunable photomultiplexer /filter/gain equalizer by using liquid crystal elements". The advantage of this paper is that it is good applications of crystal elements, but its disadvantage is that its theory is very difficult and difficult to understand. In the literature [3], Huang Chunwei graduate student in his master's thesis studied "the integration of long-wave plastic optical fiber and optical multiplexer /demultiplexer". The advantage of this paper is that it is a great application of plastic optical fiber, but its disadvantage is that it is easy to produce errors and is not easy to find. In the literature [4], Chen Reisong graduate student in his master's thesis studied "the servo control of DC motor system with self- adaptive controller". The advantage of this paper is that it is a creation application in control

system, but its theory is very difficult and difficult to understand.

III. principle explanation

(1)The electronic components used in this paper are ① logic IC 74154*1, 7483*1, 7411*1, 7432*1, 7447*2 ② operation amplifier (HA17741) *3 ③ resistance (1/4W) 200Ω*20, 10kΩ*3, 2kΩ*3, 5KΩ*3 ④ LED light*6 ⑤ common anode 7- segment LED displayer*2 ⑥ small DC motor (3 voltage)*3 ⑦ relay (numbering: TRD- 12VDC –SB -CL)(12voltage) *3 ⑧ Diode (numbering: IN4001) *3 ⑨BJT transistor of npn type (numbering: C9013)*3

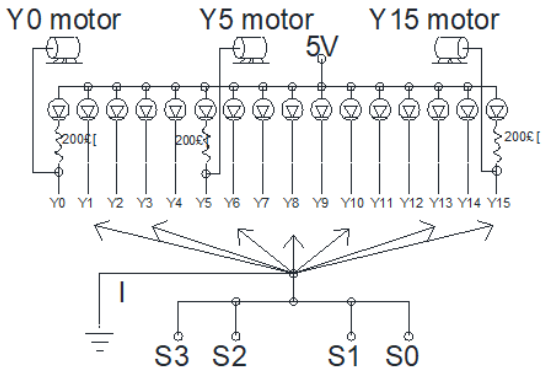
(2)The schematic diagram of this paper is shown in figure (1). Transfer the signal I to the corresponding address Y by the binary digital code $S_3S_2S_1S_0$ (BCD code). If the selected digital code (BCD code) $S_3S_2S_1S_0$ is equal to the decimal number 0, 5, 15, then it can be linked to the Y_0, Y_5, Y_{15}, motors respectively.

(3)The entire wiring diagram of this paper is shown as figure (2). In figure (2), the number above the logic IC represents the pin number of the logic IC and IC74154 itself is a 4X16 demultiplexer. Input the 4-bit digital code (BCD code) $S_3S_2S_1S_{0(2)}$ from the 20, 21, 22, 23 pins of IC74154, then the IC can decodes this digital code into decimal output code (0~15) and send it to the corresponding output address Y_0 ~Y_{15}. Because the meaning of the digital code $S_3S_2S_1S_{0(2)}$ is that humans cannot understand, then it must be converted into decimal numbers that can read by humans through ICs 7483, 7411, 7432, 7447 and displayed on the two common anode 7-segment displayers.

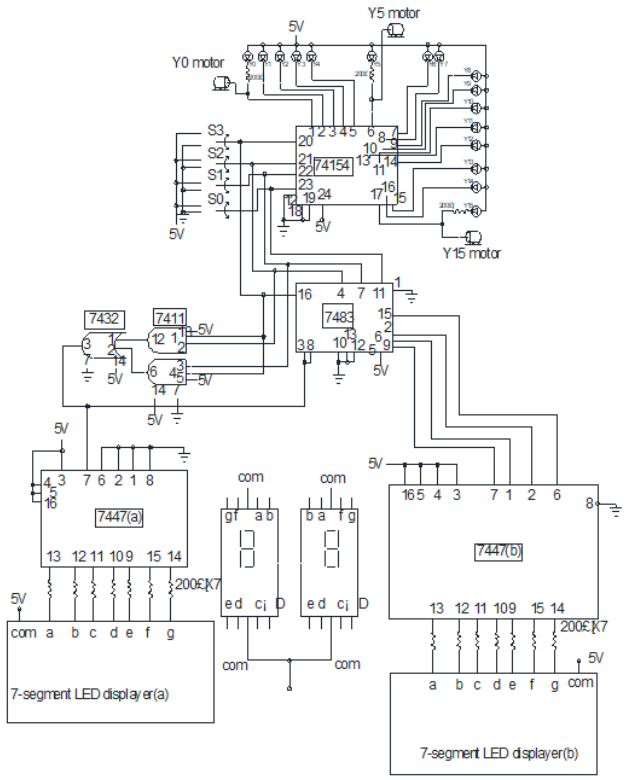
(4)In the above description of (3), if the decimal digit of the input $S_3S_2S_1S_{0(2)}$ is 0, 5, 15, then it can drive the Y_0, Y_5, Y_{15} DC motor. In the entire process of parallel connection to a DC motor, analog electronic components used include an operational amplifier, a npn-type transistor(BJT), a relay, etc, and the detailed wiring diagram is shown in figure (3).

(5)Figure (3) represents the detailed wiring diagram of analog electronic components. The working principle of analog electronic components will be explained at the fourth item.

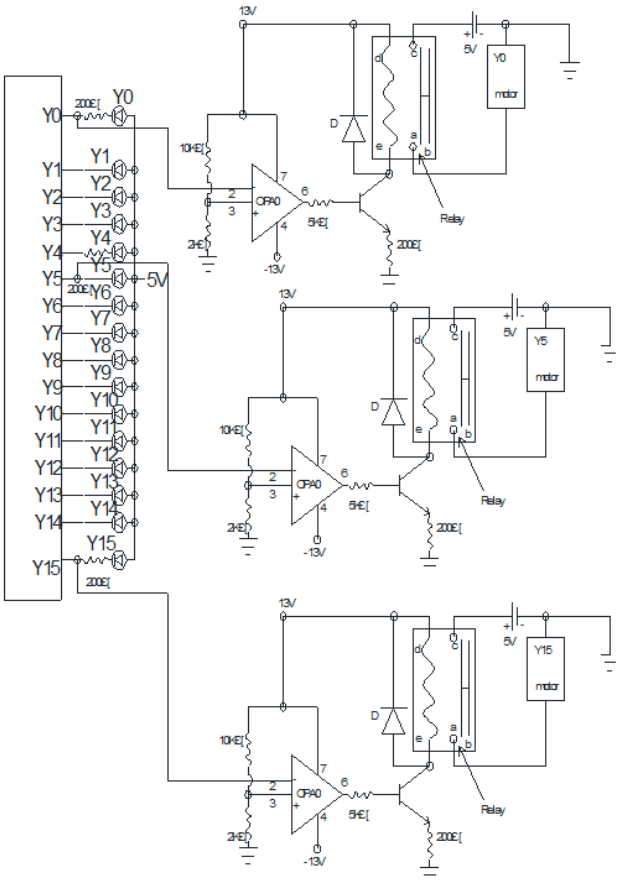
IV. All circuit diagram



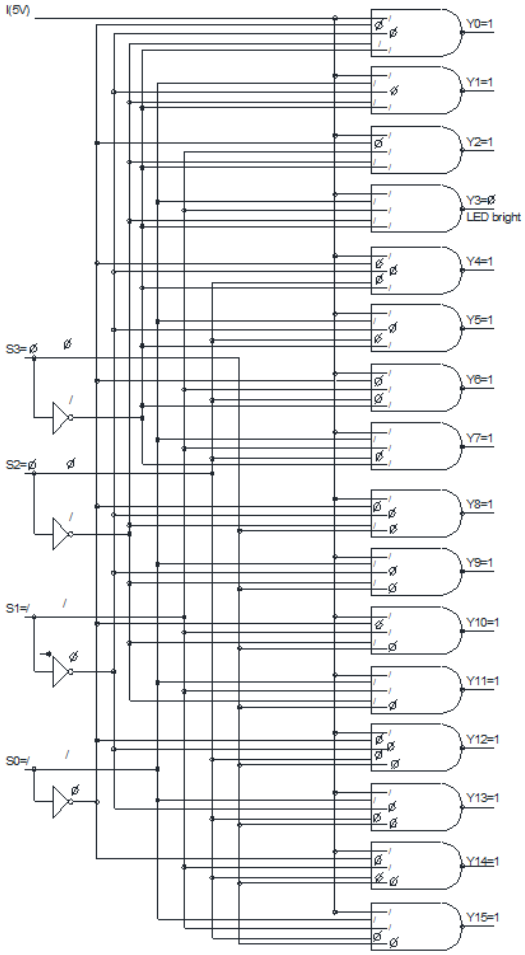
Fig(1) the schematic diadram of the overall circuit



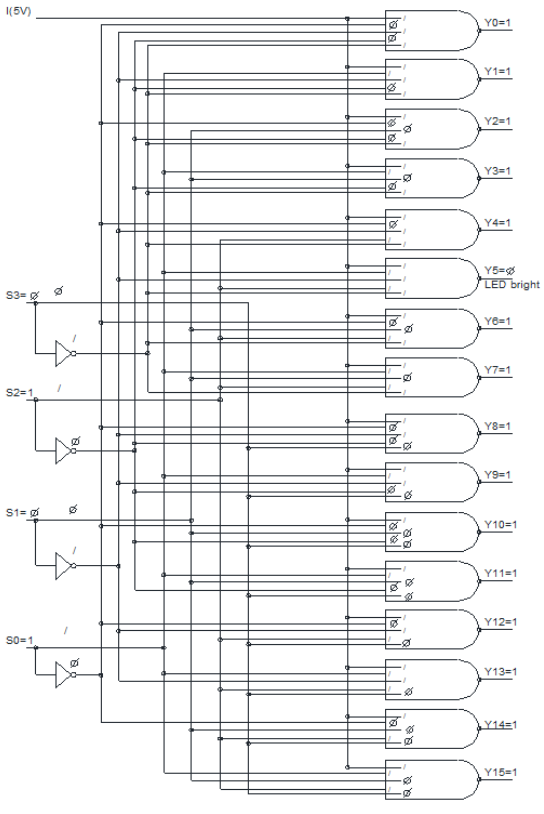
Fig(2) the wiring figure of overall circuit



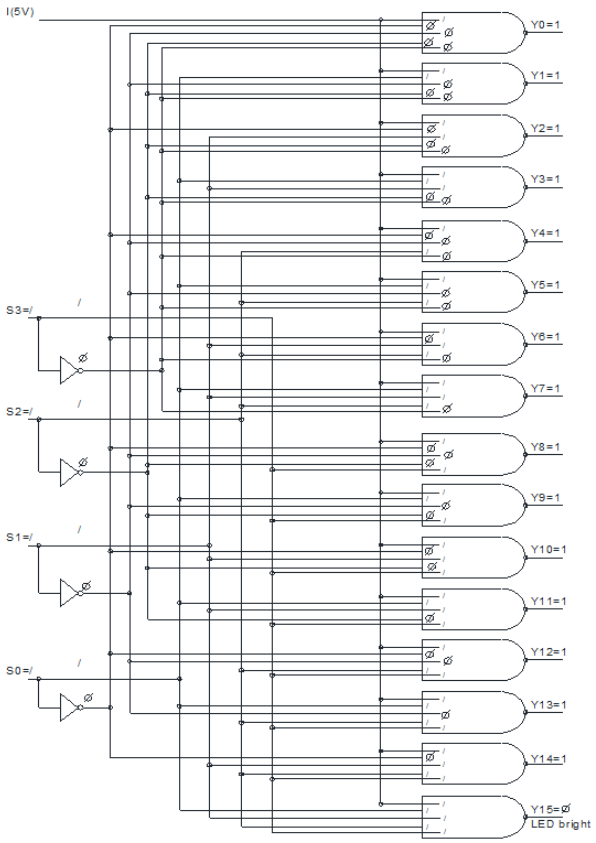
Fig(3) the detail figure of analong circuit



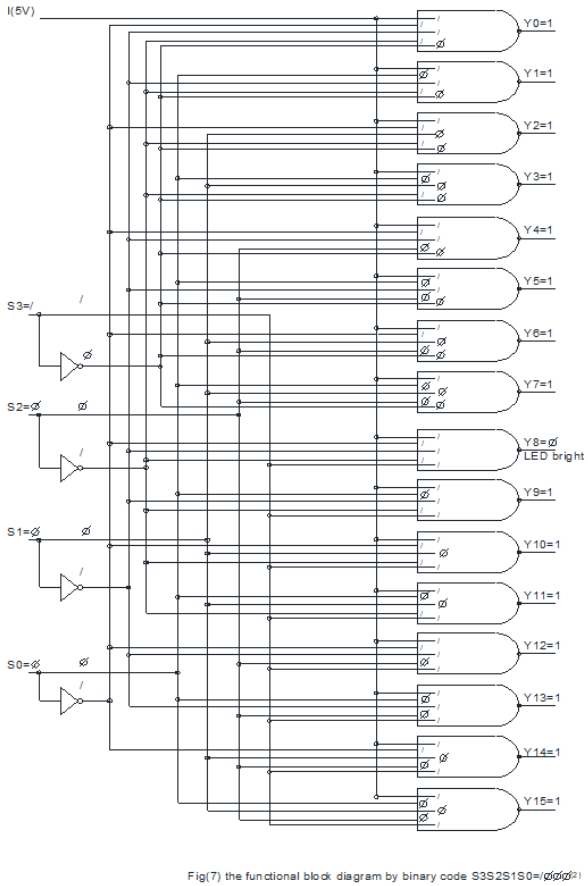
Fig(5) the functional block diagram by binary code S3S2S1S0=ØØ/(2)



Fig(4) the functional block diagram by binary code S3S2S1S0=Ø/Ø/(2)



Fig(6) the functional block diagram by binary code S3S2S1S0=////(2)



Fig(7) the functional block diagram by binary code S3S2S1S0=/ØØØ(2)

V. The detail principle of internal in the logic IC74154

(1) Select the input 4-bit digital code (BCD code) $S_3S_2S_1S_0$=Ø/Ø/$_{(2)}$=$5_{(10)}$, we can get the logic circuit shown in figure (4). The output potential of Y_5 address is Ø (low potential) and the LED light of Y_5 is on, the potential of remaining addresses are / (high potential) and their LED lights are extinguished. Since the DC motor is connected in parallel after the Y_5 address, therefore the Y_5 motor runs and the Y_0 & Y_{15} motors stop.

(2) Select the input 4-bit digital code (BCD code) $S_3S_2S_1S_0$=ØØ//$_{(2)}$=$3_{(10)}$, we can get the logic circuit shown in figure (5). The output potential of Y_3 address is Ø (low potential) and the LED light of Y_3 is on, the potential of remaining addresses are / (high potential) and their LED lights are extinguished. Since the DC motor is not connected in parallel after the Y_3 address; therefore, total motors stop.

(3) Select the input 4-bit digital code (BCD code) $S_3S_2S_1S_0$=////$_{(2)}$=$15_{(10)}$, we can get the logic circuit shown in figure (6). The output of Y_{15} address is Ø (low potential) and the LED light of Y_{15} is on, the potential of remaining addresses are / (high potential) and their LED lights are extinguished. Since the DC motor is connected in parallel after the Y_{15} address; therefore, the Y_{15} motor runs and the Y_0 & Y_5 motors stop.

(4) Select the input 4-bit digital code (BCD code) $S_3S_2S_1S_0$ = /ØØØ$_{(2)}$=$8_{(10)}$, we can get the logic circuit shown in figure (7). The output of Y_8 address is Ø (low potential) and the LED light of Y_8 is on, the potential of remaining addresses are / (high potential) and their LED lights are extinguished. Since the DC motor is not connected in parallel after the Y_8 address; therefore, total motors stop.

VI. The analog current operation of a DC motor

(1) In figure (8), the positive terminal voltage (V_+) of the operational amplifier is fixed. According to the partial voltage theorem, V_+ is calculated as follows:

$$V_+=13V*\frac{2K\Omega}{(10+2)K\Omega}=2.17V$$

(2) In figure (8), the voltage at address Y_5 approaches zero due to the input BCD code $S_3S_2S_1S_0$ $=Ø/Ø/_{(2)}=5_{(10)}$. Because the negative terminal voltage ($V_-=0V$) is smaller than the positive terminal voltage ($V_+=2.17V$), therefore the output voltage V_{out5} of OPA5 (the operational amplifier of address Y_5) equals to the DC bias V_{cc} of OPA5. ($V_{out5}=V_{cc}$= +13V)

(3) Boldly assume that the BJT transistor operates in the saturation region, ie, the voltage V_{BE}=0.8V between the base (B) and the emitter (E) and the voltage V_{CE}=0.2V between the collector(C) and emitter(E). Follow the loop5, ie, OPA5→B→E→g(grounded). According to the Kirchhoff voltage law:

V_{out5}- I_{B5}*5kΩ-V_{BE}=0

→13-I_{B5}*5-0.8=0

→I_{B5}=2.44mA

(4) In figure (8), follow the loop5, ie, d →e→c →E →g(grounded). According to the Kirchhoff voltage law:

V_{CC}-I_{C5}*1kΩ-0.2=0

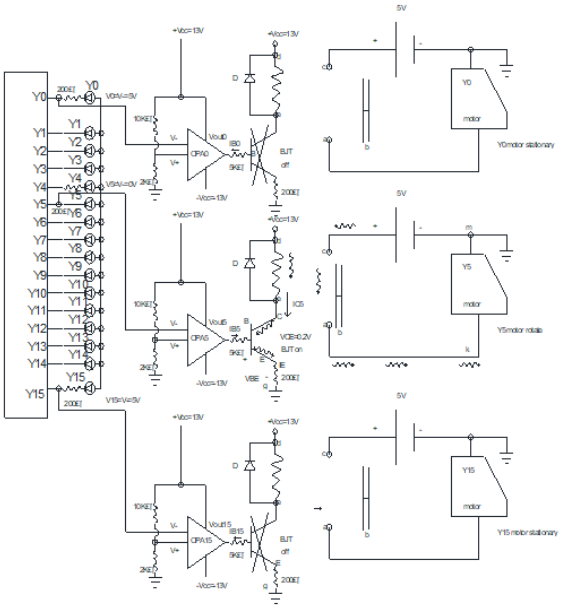
→13-I_{C5}*1-0.2=0

→I_{C5}=12.8mA

(5) In figure (8), because (I_{C5}=12.8mA) is less than (ßI_{B5}=150*2.44=366mA); therefore, we can confirm that the previous hypothesis V_{BE}=0.8V and V_{CE}=0.2V is correctly. When the I_{C5} is circulated, the internal coil of the relay is magnetically generated and the H-shaped cast iron(b) is sucked to the ca terminal, so that, the ca terminal can pass the current. Once the current is passed through the ca terminal, a closed circuit is formed on the right side of the relay, so that, the Y_5 motor starts operating.

(6) In figure (8), the purpose of installing a diode outside the ed terminal is to protect the coil of the relay and prevent I_{C5} current from flowing backwards.

(7) In figure (8), because the input BCD code is $S_3S_2S_1S_0=Ø/Ø/_{(2)}$ $=5_{(10)}$, then output voltages of the addresses Y_0 and Y_{15} are both 5V (V_0=5V, V_{15}= 5V). Since the negative terminal voltage $V_{15}=V_-$=5V is greater than the positive terminal voltage V_+=2.17V, therefore the output voltages V_{out0} and V_{out15} of OPA0 and OPA15 are negative bias voltages ($-V_{CC}$)(V_{out0}= V_{out15}= -13V), so that, the BJTs at this time are all off and Y_0 and Y_{15} motors are stopped.



Fig(8) the current diagram when DC motor (Y5) is operating [S3S2S1S0= Ø/Ø/(2)=5(10)]

VII. Logic circuit of seven-segment LED displayers.

(1) When the input BCD code is $S_3S_2S_1S_0$ $=////_{(2)}=15_{(10)}$, as shown in figure (9). Under the

operation of logic ICs 7411 and 7432, the signal with the number of bits "/" among the decimal place is transferred to the logic IC 7447(a). In addition, the single digit "5" among the decimal places is transferred by the logic IC 7483 to the logic IC 7447(b).

(2) When the input BCD code is $S_3S_2S_1S_0$ =Ø/Ø/$_{(2)}$=5$_{(10)}$, as shown in figure (10). With the operation of logic ICs 7411 and 7432, the signal with number of bits "Ø" among the decimal place is transferred to the logic IC 7447(a). In addition, the single digit "5" among the decimal place is transferred by the logic IC 7483 to the logic IC 7447(b).

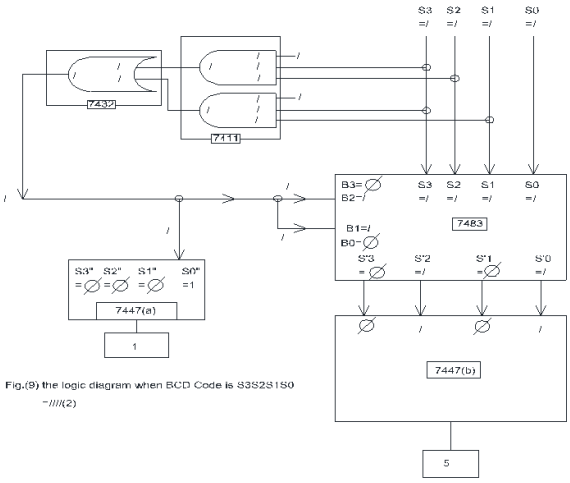


Fig.(9) the logic diagram when BCD Code is S3S2S1S0 =////(2)

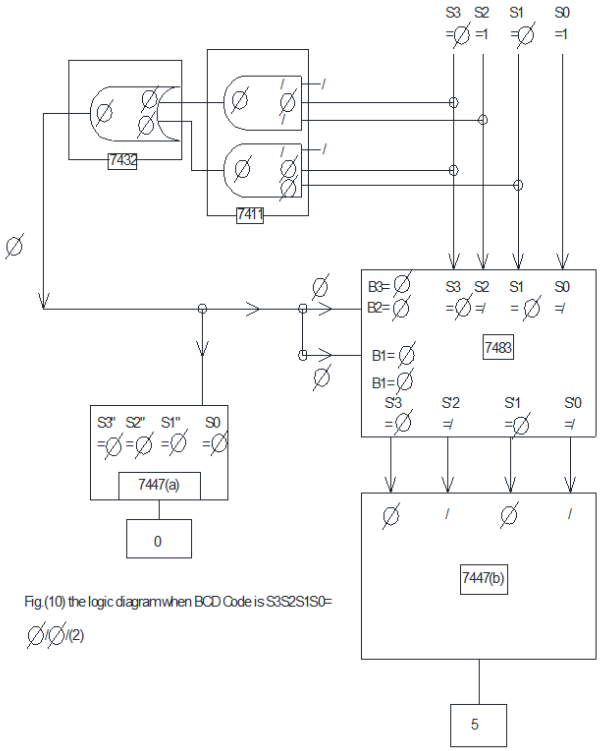


Fig.(10) the logic diagramwhen BCD Code is S3S2S1S0= Ø/Ø/(2)

VIII. Experimental results (truth table)

Digital selection (BCD code)				Displaied number by 7-segment LED	Bright LED number	Number of Operating motor
S_3	S_2	S_1	S_0			
Ø	Ø	Ø	Ø	0	Y_0	Y_0
Ø	Ø	Ø	/	1	Y_1	/
Ø	Ø	/	Ø	2	Y_2	/
Ø	Ø	/	/	3	Y_3	/
Ø	/	Ø	Ø	4	Y_4	/
Ø	/	Ø	/	5	Y_5	Y_5
Ø	/	/	Ø	6	Y_6	/
⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮
/	/	/	/	15	Y_{15}	Y_{15}

Fig. (11)Truth table

IX. All completed photos.

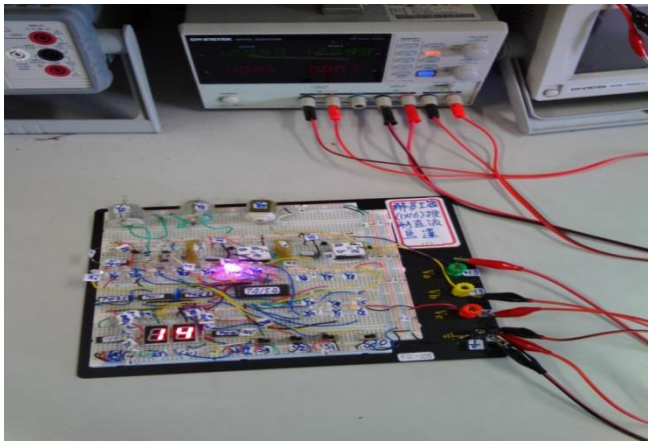


Fig. (12)completed photo

X. Conclusion

(1) In figure (8), the 200Ω resistance are placed between the emitter (E) and the ground (g) of the BJT transistor and the resistance acts as a current limiting resistance. The main purpose of the device is to make the BJT transistor more stable. The fifth item

above does not calculate the 200Ω effect when we are calculating I_{C5} and I_{B5} (In other words; because the effect of 200Ω is minimal, therefore the effect of the 200Ω resistor on I_{C5} and I_{B5} is ignored).

(2) The logic gate inside the logic IC74154 is a NAND gate (please refer to figure (4)) When the input BCD code $S_3S_2S_1S_0$ =Ø/Ø/$_{(2)}$ =5 $_{(10)}$, the output voltage is still 0V at address Y_5 (please refer to figure (8)). Connect this output voltage (V_5=0V) in parallel to the negative terminal voltage of the operational amplifier (V_5=V_-=0V) (V_- is the second pin voltage of μA741) to compare it with the positive terminal voltage (V_+=2.17V)(V_+ is the third pin voltage of μA741).

(3) The function of the BJT transistor (npn type) here is an electronic switch. When the operational amplifier (OPA 5) outputs a positive voltage (V_{out5}=+13 V), the BJT is turned on. It promotes the operation of the relay and further turns on the rear DC motor (Y_5 motor).

(4) When the operational amplifier outputs a negative voltage (V_{out0} =V_{out15}=-13V), the BJT is turned off and the relay behind is stopped and the DC motor behind is stopped (like as the Y_0 and Y_{15} motors in figure(8))

XI. Reference:

[1]Zhan Zhaming graduate student , (1996) "*Studies the design and manufacture of the demultiplexer and CATV network transmission protocol",* master's thesis; Hsinchu, Taiwan; national Chiao-Tung university, institute of information science and engineering.

[2]Huang Mingjie graduate student, (2001) "*Research on tunable photomultiplexers /filters/gain equalizers using liquid crystal cells"*, master's thesis; Hsinchu, Taiwan; national Chiao-Tung university, institute of optoelectronic engineering.

[3]Huang Chunwei graduate student, (2003) "*Research on integration of long wave plastic optical fiber and optical multiplexer/demultiplexer",* master's thesis; Taoyuan, Taiwan; Chang-Gung university, institute of optoelectronic engineering.

[4]Chen Ruisong graduate student, (1994) *"Servo control of DC motor system with direct self-adaptive controller",* master's thesis; Chungli, Taiwan; Chung-Yuan christian university, institute of electrical engineering.

[5](2001), "*Exchange table of the specification between TTL/IC in the world'*, (page58,65,116,117,222), Taiwan, Chuan-Hwa book company LTD.

[6]Shih-Ping Hu (2016) "*Demultiplexer (1X8) control small DC motor',* Journal of Delin, 30th issue, page 29~37, New Taipei city, Taiwan

[7]Yang Zhanyun translate (2008), "*Electronic Devices Conventional Current Version",* 8e, by Thomas L. Fload, Taiwan, published by Pearson education Taiwan, copyright by Chuan Hwa book company LTD.