Experiment 7 Dynamic Scan Display System Design

1. Purpose

1) Know the work principle of dynamic scan display.
2) Master design method of LED dynamic scan display driving circuit.
3) Implement LED dynamic scan display system by integrated circuit.

2. Work Principle

Normally there are two display ways, which are static display and dynamic display. Dynamic scan display is introduced here. In dynamic scan display, the display component of each bit works time-sharing circularly. If proper scan speed is selected, each of all bits is bright all the time for human eyes. For LED digitrons, due to the limitation of switch speed, each scan and lightening time of each bit is usually several milliseconds, leading to the scan speed of LED is about less than several hundreds of Hz. If the scan speed is too low, twinkling will occur in display. So the low limitation of scan speed is normally above 24Hz. Using dynamic scan can decrease hardware of drivers, reducing system power dissipation, cutting down cost.

1) Constitution of a scan display system

Usually, digitron display system includes two parts which are display device and decoder. In order to get dynamic display, display control circuit is also used. Typical circuit block diagram of dynamic scan display is shown in figure 6.1.

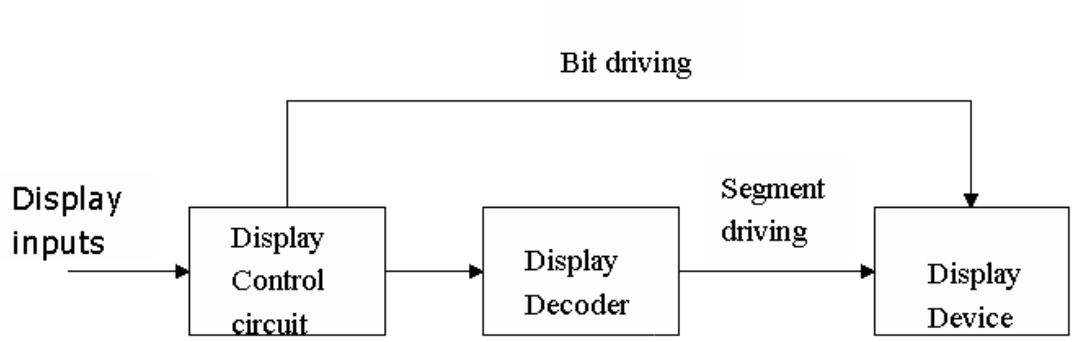


Figure6.1 Dynamic scan display system block diagram

2) Some attentions when designing a practical display system:

1) Clearness of characters being displayed.

Firstly, pay attention to the relationship between the height of characters and observing distance. Usually the characters' height of LED display is 0.5cm～30cm. Secondly, there are differences between HIGH BRIGHTNESS and NORMAL BRIGHTNESS for lighting performance. Finally, pay attention to the relationship between the lighting intensity and environment, blur, fringe and twinkle.

2) LED driving.

Normally for small LED, each character segment is a LED, the brightening voltage is 1.6～1.9V, the current is several to dozens of mA. For big LED, each character segment is composed of several LEDs connected in serial and the brightening current is around dozens of mA to hundreds of mA.

3) Type of display device.

Widely used display devices include all kinds of multisegments LED digitrons, segment-LCDs, character modules and all kinds of figure modules (display and driver and controller).

3) Circuit design

With the development of science and technology, designers gradually hope to use the display with driving circuit which can large simplify hardware and software design. The display component which assembles driving circuit and multi-bits display components in one module is called OBE (ON-BOARD—ELECTRONICS) display. Usually it includes multi-segments LED display, ROM, characters collection RAM, chip-in oscillator, bit counter, decoder, etc.

Here we focus on introducing the design process of multi-segments LED dynamic display system. When there are several multi-segments LED displays in a display device, dynamic scan (periodic refresh) driving circuit is usually adopted to save hard ware consumption. Two problems should be well solved: no display twinkle and enough display brightness. In order to display with no twinkle, normally higher character refresh frequency is used. Practice shows that the refresh frequency is not less than 100Hz. In order to get enough brightness, LED work current should be reasonably chosen, and based on it, the capability of drive circuit and the value of current limit resistors are chosen.

(1) Design basics

Dynamic display drive circuit is different from static drive circuit. If work current under static display is I_f (per segment), and work current under dynamic scan display is I_p, then:

$$I_p = I_f * Duty = I_f / N$$

If display period is T, the character gated frequency (usually called character refresh frequency) F=1/T. The duty of gated pulse Duty=1/N, therein N is the number of bits. Because the LED lighting efficiency under current pulse driving is higher than that under DC (Duty=1) current driving, usually $I_p < (I_f * Duty)$ when the mode of dynamic scan display is used.

(2) Driving circuit selection

In static multisegments LED display system, the common terminal is connected to power positive (common anode) or negative (common cathode), in which the character driving current is supplied by source. The main task of designers is to choose segment drive circuit. But for dynamic refresh multisegments LED system, the character driving current is supplied by character driver, in which designers should choose character driver based on maximum average character driving current.

Compared with multisegments LED display, dot array LED display can flexibly display more characters and figures with more artistic. The drive circuit of most dot array LED display adopts row scan and column scan. Designers can choose row and column circuits or purchase OBE dot display device with drivers, memories and decoders in it.

(3) Decoder and display selection

Semiconductor 7-segment nixie tube model XXX (for example BS201), which is cathode common, can be chosen as display device. Based on specific type selected, performance parameters can be found in products manual.

Decoder is selected based on display type and character features. For example, a 4-7-line decoder 74LS49 can be chosen do display BCD codes, in which output is HIGH active (identical to common cathode nixie tube requirement) and can drive segments of small LED.

As for the connecting circuit between display and decoder, because of dynamic display, each segment a～ g of 74LS49 is connected with other segment a～ g of 7-segment display. A pull-up resistor is needed because the output of 74LS49 is OC circuit.

(4) Display control circuit selection

Main task of this part is to choose the code to be displayed and control the position. Because in dynamic display system, each tube works alternatively while only one tube is light, data selector can be used to select one code form 4-bit BCD codes to be displayed.

74LS153 can be used to realize above function, whose inputs are connected to the bits of BCD codes, and each output to decoder.

In dynamic display system, the code display position in LED tubes should be identical to the position of input code. Normally decoder is used to control by transistors or OC gates, while a switch (a transistor of OC gate) which is controlled by the decoder, is connected between the cathode of each nixie tube and ground. 2-4 line 74LS139 can act as decoder. The control inputs of decoder and data selector connect together, and can get control sequence by 2-bit counter.

(5) Notice

a. Valid voltages cooperate correctly. For display device, there are common-cathode and common-anode. Appropriate decoder and driver should be chosen to cooperate with it.
b. Enough drive capability. Configure segment and bit drive capability appropriately.
c. Scan frequency can be adjusted to change display effects.

4) Reference Circuits

1) Reference block diagram of common cathode LEDs display

4-bit common-cathode LEDs scan display reference block diagram is shown in figure 7-2. The 2 bits binary codes from the 2-bit binary counter are used to select codes displayed (BCD codes) and confirm bit (LED). 4 BCD codes

are selected by 2 pieces of data selector 74LS153. 74LS49 can be used to decode from BCD code to 7-segment display. 2-4 decoder (74LS39) converts 2-bit code to 4 bit signals, in which only one bit is active (LOW) at a time and drives relative LED bit by OC buffer (74LS07).

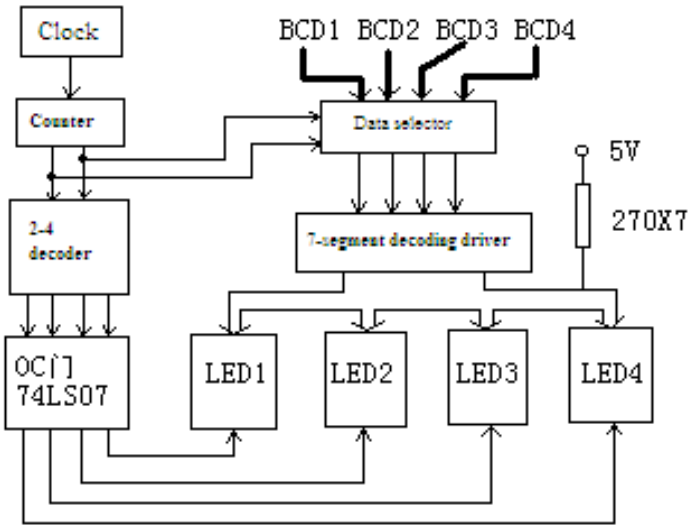


Figure 7-2 Common-cathode LEDs reference circuit block diagram

2) Reference block diagram of common anode LEDs display

4-bit common-anode LEDs scan display reference block diagram is shown in figure 7-3. 74LS47 (active LOW) acts as segments decoding driver, and PNP transistors act as bit driver. The other parts are very similar to those of common-cathode circuit.

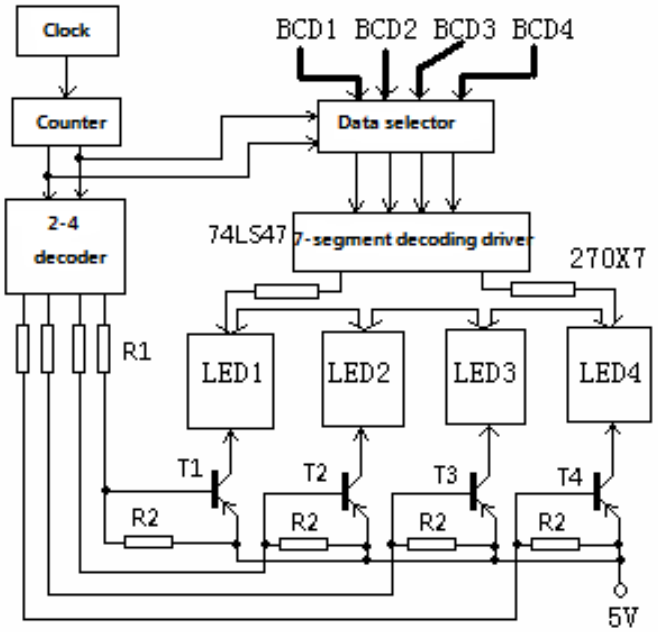


Figure 7-3 Common-anode LEDs reference circuit block diagram

5) LED nixie tubes module

The nixie tubes the lab provides is a module which combines 4 LEDs together. They share segment driving pins, which can save wires. The pin-out diagram is shown in figure 7-4. CM1, CM2, CM3 and CM4 are 4 common terminals (bit drive terminals), and they arrange from left to right. dp is radix point terminal, and other 7 terminals correspond to each segment.

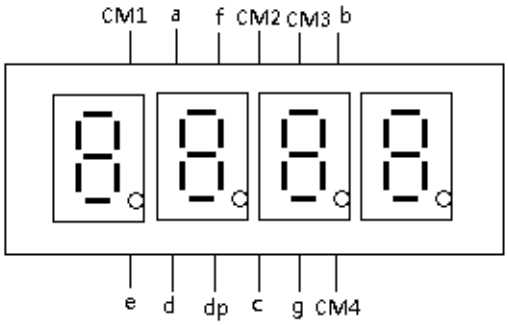


Figure 7-4 Pin-out diagram of LEDs module

3. Preparation Requirements

1) Comparing with the given LED digitrons experiment reference circuit block diagram, refer to relevant parts and components materials and finish detailed circuit design and analyze circuit work principle.
2) Design a clock circuit of a scan display by CA555.

4. Experiment Requirements

1) Design the scheme to test pins function of given nixie tubes.
2) The experiment board is shown in figure 7-5. Know and familiarize yourself with the board and components on it, and constitute the 4-bit BCD code dynamic scan display system. Adjust clock frequency and obverse phenomenon, recording and analyzing. Select the frequency with the best display effect.

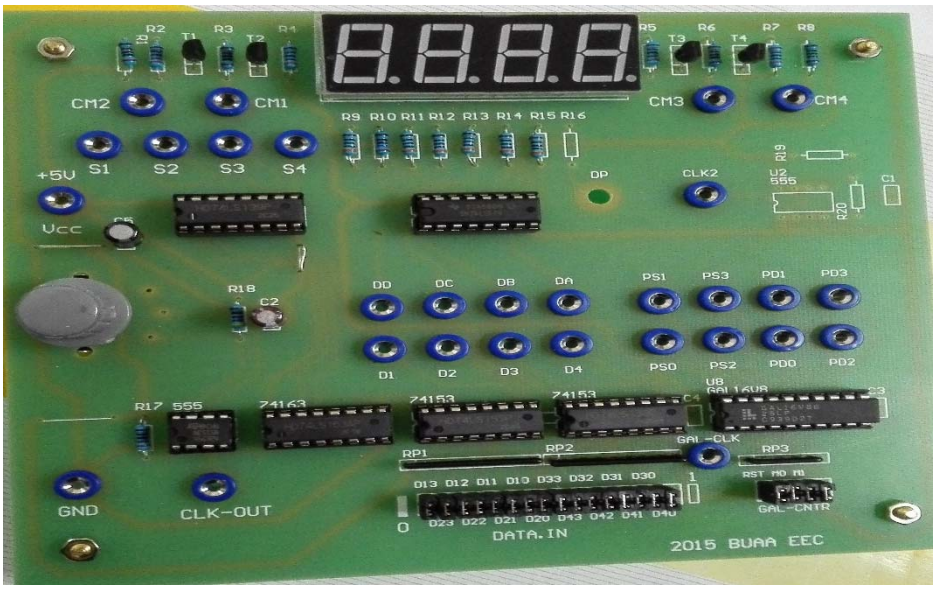


Figure 7-5 Practical experiment board

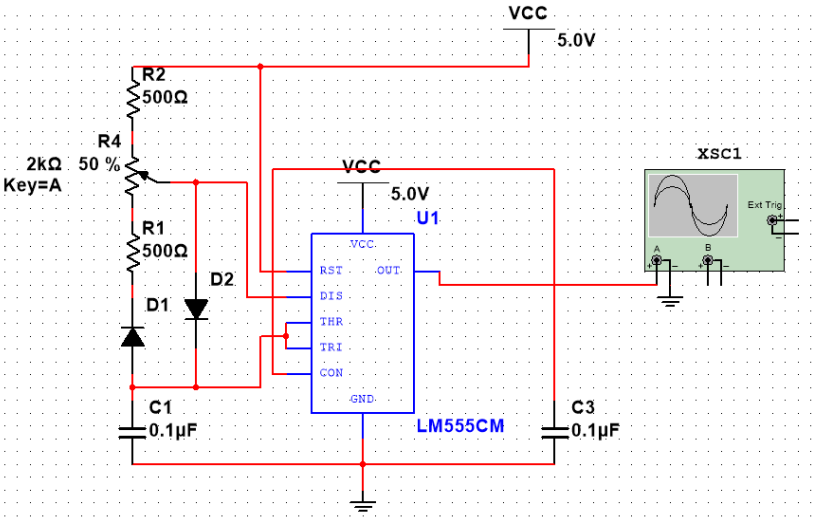
3) Use the outputs of the programmable logic device (PLD) GAL16V8 on the board to control scan display, obverse display phenomenon, and analyze the logic relation provided by PLD.

5. Apparatus Supplied

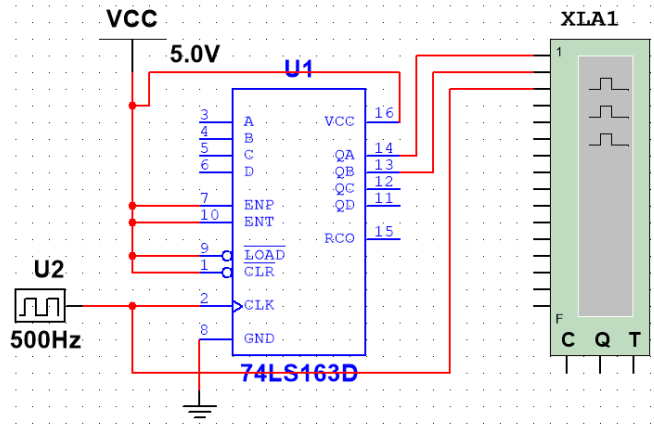
An experiment board with following components on it:

Common-anode 4-bit LED module	1 pc
74LS153	2pcs
74LS47	1pc
74LS139	1pc
74LS163	1pc
GAL16V8	1pc
CA555	1pc
Resistors	several pcs
Capacitors	several pcs

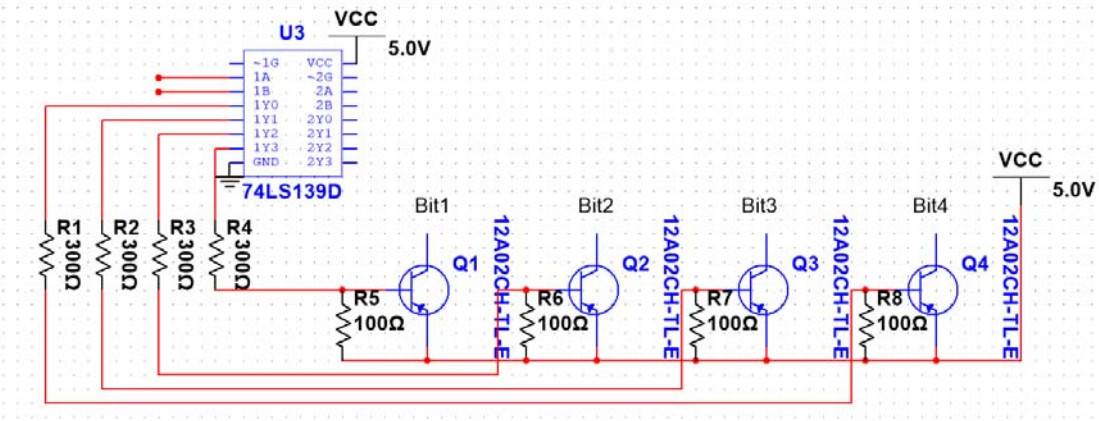
6. Experiment circuit



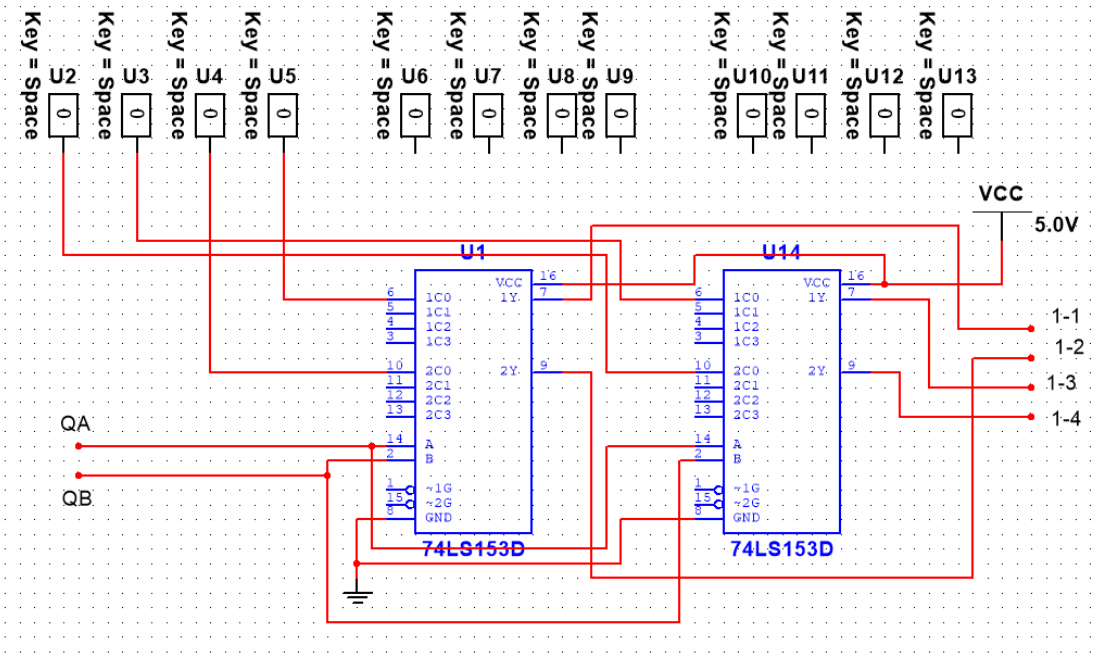
1） Clock circuit



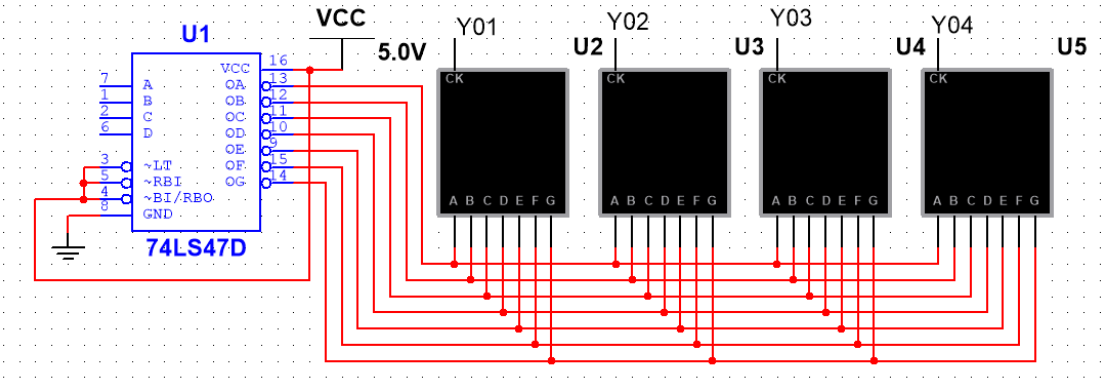
2) Count number circuit



3) Bit select circuit



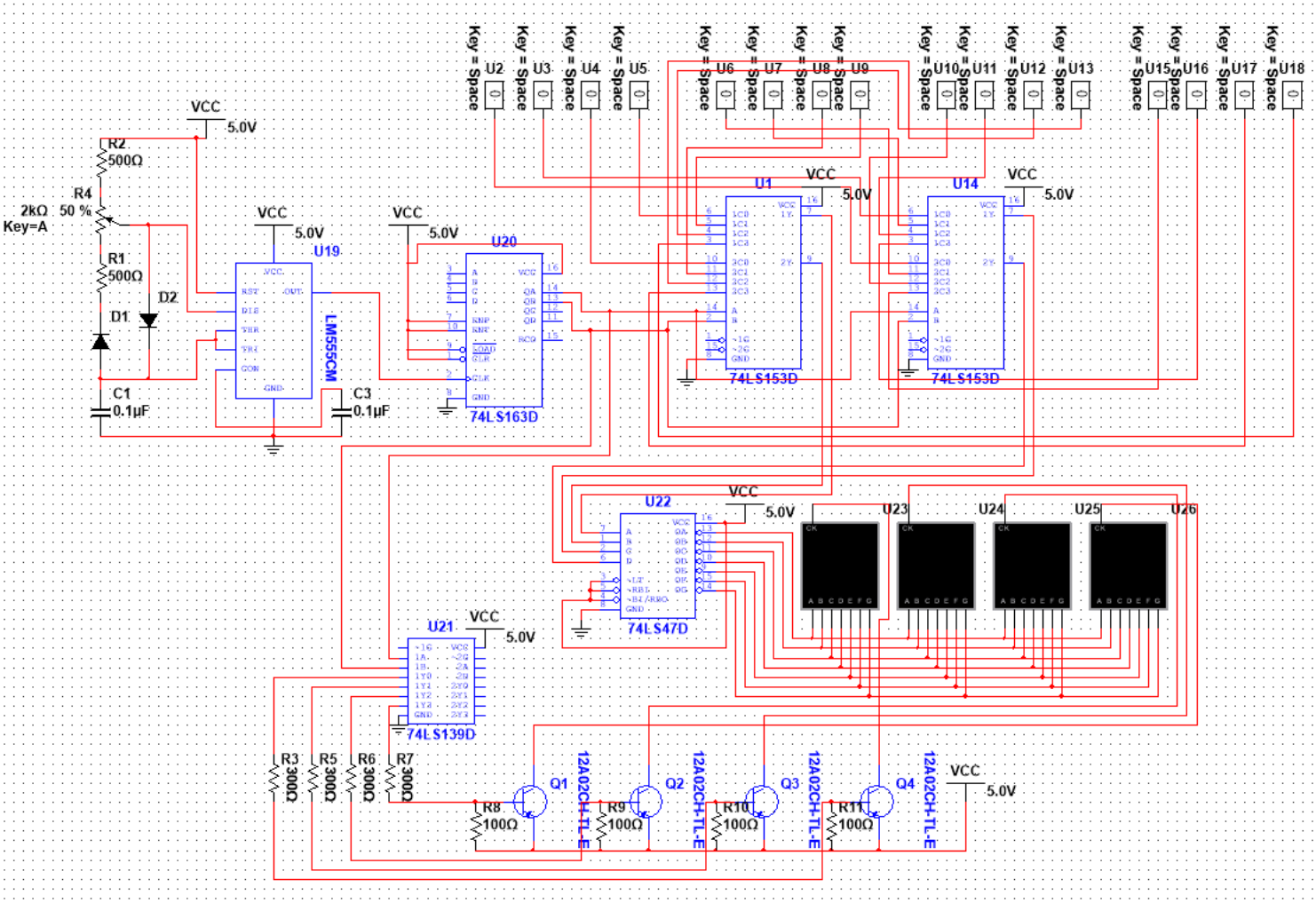
4) Data select circuit



5) Display circuit

7. Data record and analysis

1) 2) Principle diagram of whole circuit



3) Static segment current measurement has been record as follow, R=300 Ω

Segment	1	2	3	4	5	6	7
Potential/V	2.936	3.835	2.937	3.827	3.835	2.936	3.671
	0.249	3.885	0.250	3.840	3.832	0.250	3.851
Voltage U/V	2.687	-0.05	2.687	-0.013	0.003	2.686	-0.18
Current I_1/mA	8.957		8.957			8.953	

I calculate drive current based on formula $I = \frac{U}{R}$. The average static segment current I1 is 8.956 mA.

4) Dynamic segment current measurement has been record as follow, R=300 Ω .

① When connect to four digits:

Segment	1	2	3	4	5	6	7
Potential/V	2.923	3.433	2.923	3.433	3.437	2.923	3.442
	0.248	3.424	0.250	3.440	3.420	0.249	3.422
Voltage U/V	2.675	0.009	2.673	-0.007	0.017	2.674	0.020
Current I_2/mA	8.917		8.910			8.913	

Average current I2 is 8.913mA.

②When connect to just 1 digit:

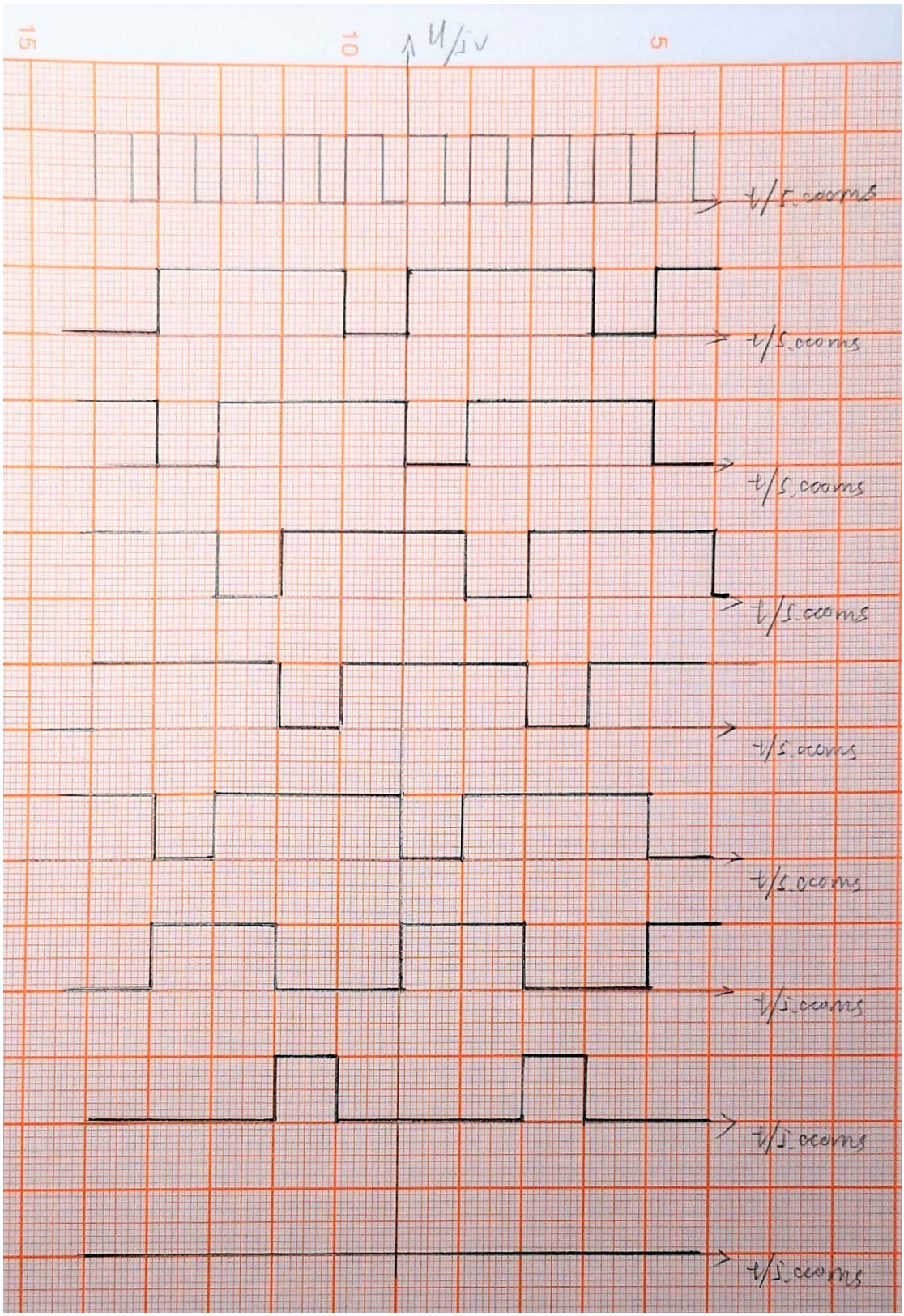
Segment	1	2	3	4	5	6	7
Potential/V	0.871	1.888	0.873	1.820	1.839	0.873	1.833
	0.171	1.908	0.172	1.801	1.802	0.173	1.867
Voltage U/V	0.700	-0.020	0.701	0.019	0.037	0.700	-0.034
Current I_3/mA	2.330		2.340			2.330	

Average current I3 is 2.333mA.

From the result, it seems that current of dynamic display is lower than that of static display. Besides, if I connect one digit into dynamic display circuit, the current would be more than I2/N (N is the number of digits). In this case, the current is altering, so it could be more precise to use AC option of multimeter.

5) The best frequency is 200.8Hz. Change frequency from low to high, and record data when digits just stop twinkling.

6) The waveform of 9 pin-out is drawn as follow:



7) Use of GAL

① Very low frequency

RST=1			RST=0		
M1	M0	phenomenon	M0	M1	Phenomenon
0	0	First digit shows number 1	0	0	4 digits show 0->1->2->3 one by one
0	1	First digit shows number 2	0	1	6->3->4->5
1	0	First digit shows number 3	1	0	5->2->3->4
1	1	First digit shows number 4	1	1	7->4->5->6

② High frequency

RST=1			RST=0		
M1	M0	phenomenon	M0	M1	Phenomenon
0	0	First digit shows number 1	0	0	4 digits show 0123 at the same time
0	1	First digit shows number 2	0	1	6345
1	0	First digit shows number 3	1	0	5234
1	1	First digit shows number 4	1	1	7456

8. Summary

From this experiment, I know that when designing a big circuit, I should firstly design small circuit of specific function, then connect them and debug, in the end connect them all.