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Design of a System for Multichannel Data Acquisition and Two Channel Display Based on Freescale Microcontroller Unit

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***Abstract*—This paper presents that hardware and software are designed to realize a system for eight channel data acquisition and two channel LED nixie tube display using Freescale MC9S12XET256 microcontroller unit (MCU). The design project of the system, the programming flow chart and the main programming codes are described. The system is proved to be effective through an experimental rig. This system will be able to be used to measure all kinds of parameters such as temperature, pressure and flow rate etc.**

Keywords—MC9S12XET256; analog to digital; data acquisition;programming;nixie tube

I. INTRODUCTION

Data acquisition is an important way to gain signal information. The systems of data acquisition and display are widely used in MCU applications. They are mainly used to sample non-electrical analog signals and to directly sample on-off signals which possess certain characteristics, and to finally output the sampled data to some display devices. They also send the data to other computers through serial ports, to control outside devices by digital to analog converters (DAC) [1].In this paper, a system for eight channel data acquisition and data display is designed. Eight key-presses are designed to assign the corresponding channels to sample analog signals to be output to display in left or right four LED nixie tubes. According to the design of the system, a portable tester (such as automobile tester) will be manufactured to be used to sample and display data [2].

II. DESIGN OF THE SYSTEM HARDWARE

A. System Framework

The MC9S12XET256 MCU is a 16-bit device composed of standard on-chip peripherals including a 16-bit central processing unit (HCS12 CPU), 256K bytes of Flash EEPROM, 4K bytes of RAM, 1K bytes of EEPROM, a 8-channel IC/OC enhanced capture timer, two 8-channel, a 8,12-bit analog-to-digital converters (ADC), a 8-channel pulse-width modulator (PWM), a 8-channel IC/OC enhanced capture timer,11 I/O ports including 91 I/O pins etc. The MC9S12XET256 has a function of background debug module. With the help of this function a compiled program of C language can be downloaded easily to the MCU flash memory. The MCU PLL circuit allows power consumption and performance to be adjusted to suit operational requirements [3].

The system circuits include MC9S12XET256 MCU, reset circuit, oscillation circuit, BDM circuit, power circuit, key-press circuit, analog voltage generating circuit and LED nixie tube display circuit. Figure 1 shows the system framework.

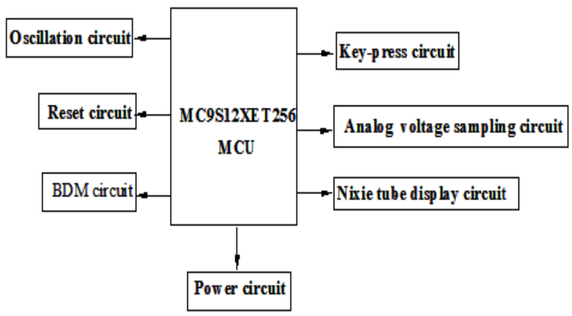

Fig.1. *Framework of the system*

B. Circuit Diagram of the System

According to the above system framework, the Circuit diagram of the system is designed as figure 2.

1) Circuit of LED Nixie Tube Display

Eight LED nixie tubes are designed which are controlled by two 74HC573 latches. In the 74HC573 latch, OE Pin and LE pin are respectively defined as Output Enable and Latch Enable. If OE is input into high electrical level, the output of the latch is in high-impedance state no matter what the LE pin and D port are in what kind of electrical levels. The latch chip is disabled. So the OE pin is deigned to link to ground, that is the 74HC473 chip is always enabled. When OE is in low electrical level and LE in high electrical level, the D port and Q port are simultaneously in same electrical level. When LE is in low electrical level, the Q port is kept to be in the last electrical level no matter what the D port is in what kind of electrical level. The latch can latch the current data until it is removed [5].

The two D ports of the latch are shared to link to the P port of the MCU. The upper latch latches the segment codes. Its LE links to the PK0 pin of the MCU to control segment code latch. The lower one latches the bit codes. Its LE links to the PK1 pin of the MCU to control bit code latch. The P port first outputs the bit codes and then the segment codes.

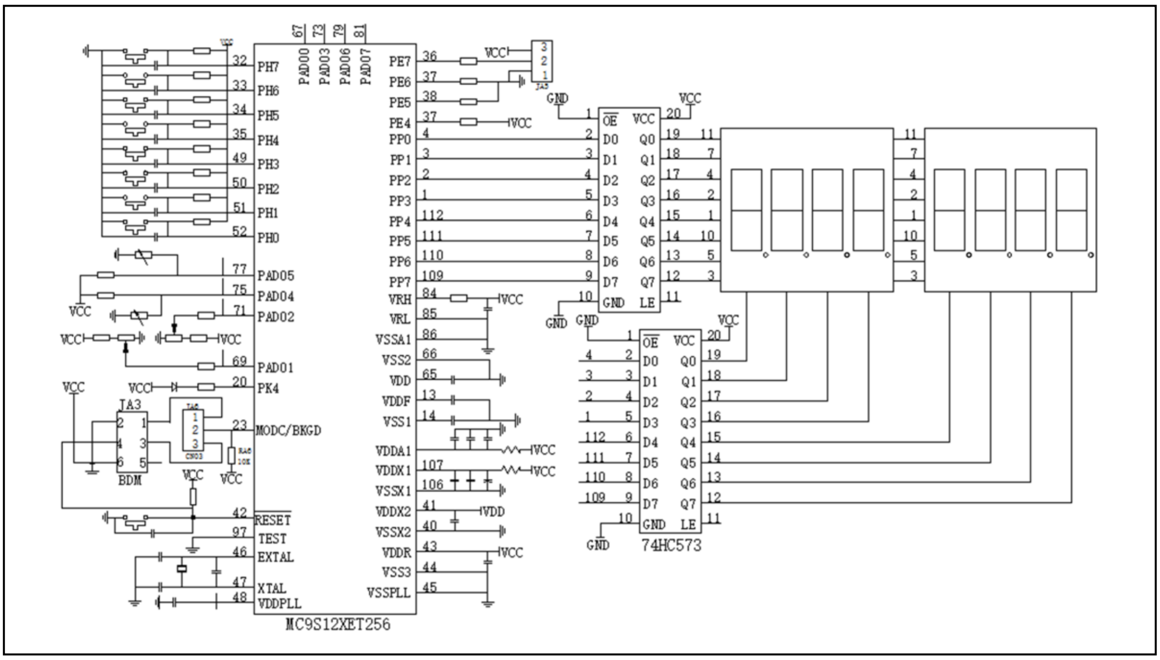

Fig.2. *Circuit diagram of the system*

2) Key-press Circuit

Eight key-presses (KEY1-KEY8) which link to the MCU H port(PH0-PH7) are designed to control the corresponding eight channel data acquisition(AD0-AD7).When a key-press button is not pressed down, the P port pin linking to the key-press obtains a high electrical level due to the pull-up resistance. When the key-press is pressed down, the pin gets a low electrical level as it links to the ground.

3) Analog Voltage Generating Circuit

Two rotation rheostats are used to produce respectively two analog voltages to be input into the first channel(AD1) and the second channel(AD2) which link to the MCU pin 69 (PAD01) and the MCU pin 71(PAD02) with the help of two jumpers. When the two jumpers are removed, PAD01 and PAD02 become the common ATD pins. There we also design the pin 75(PAD04) and the pin 77(PAD05) linking respectively to the thermistor channel(AD4) and the light dependent resistor(AD5) with two jumper. Other four channels AD00(67),PAD03(73),PAD06(79) and PAD07(81) are placed in the upper side of the MCU.

III. DESIGN OF THE SYSTEM SOFTWARE

A. *Programming Flow Chart*

The basic programming method is that the main program is employed to call each module subroutine. This makes the total program structure simple to be clear and easily modify to debug. Figure 3 shows the programming flow chart.

B. *Programming Codes*

The programming codes of data acquisition are introduced which are the most important parts of the system software. Two subroutines are used to be called by the main program, the one is the analog to digital (ATD) module initialization subroutine and the other one is the eight channel data acquisition subroutine. The main codes are listed and explained as follow.

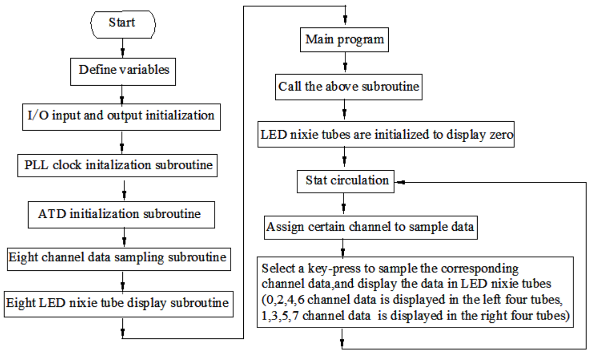

Fig.3. *Programming flow chart*

```
void INIT_AD(void)     //Name of ATD module initialization subroutine.
{
ATD0CTL2 = 0x40;      //Start ATD module, quickly clear zero, disable interrupt.
ATD0CTL1_SRES=2;   //Select 12 bit ATD mode.
ATD0CTL3 = 0x88;      //Convert one channel data at a time.
ATD0CTL4 = 0x07;    //Set ATD sampling clock frequency 2MHz.
}
unsigned int AD_capture(unsigned int x)        //Name of certain channel data acquisition subroutine.
{
```

```
unsigned int AD_data;    //Set the sampling data variable as a integer.
 if(x==0)      //If the channel is the first channel.
ATD0CTL5 = 0x00;   //Convert the first channel(AD00) data.
if(x==1)        //If the channel is the second channel.
ATD0CTL5 = 0x01;      // Convert the second channel(AD01) data.
if(x==2)// If the channel is the third channel.
ATD0CTL5 = 0x02;      // Convert the third channel(AD02) data.
if(x==3) //If the channel is the fourth channel.
ATD0CTL5 = 0x03;      // Convert the fourth channel(AD03) data.
if(x==4) //If the channel is the fifth channel.
ATD0CTL5 = 0x04;      // Convert the fifth channel(AD04) data.
if(x==5) //If the channel is the sixth channel.
ATD0CTL5 = 0x05;      // Convert the sixth channel(AD05) data.
if(x==6) //If the channel is the seventh channel.
ATD0CTL5 = 0x06;      // Convert the seventh channel(AD06) data.
if(x==7) //If the channel is the eighth channel.
ATD0CTL5 = 0x07;      // Convert the eighth channel(AD07) data.
while(!ATD0STAT2_CCF0);     // Is the conversion over? if not over, wait.
AD_data = ATD0DR0;   //The sampled data is stored in the ATD0DR0 register.
 return(AD_data);      //Return the sampled data.
}
```

IV. Experiment Testing

An experimental rig is developed which integrates many multipurpose platforms including this system. The system software compiled by the CodeWarrier5.1 with a computer is debugged repeatedly to be correct and downloaded to the flash memory of the MCU by a BDM debugger. Figure 4 shows the running cases of the experimental rig. The relative names are labeled in the corresponding places of the figure. When testing, three channels (AD1,AD2 and AD6) are used. The channels (AD1 and AD2) are input respectively into with two analog voltage signals generated by rheostat No.1 and rheostat NO.2.The channel(AD6) links to a 1.5V battery. We can see that Key-press(KEY2) is pressed down to control data(AD1) to display 1.777V in the right LED nixie tubes, KEY7 is then pressed down to control data(AD6) to display 1.663V in the left LED nixie tubes. A multimeter is used to measure the above three channel current voltages. The testing values are recorded in table 1. In the figure, the multimeter is now displaying the battery voltage value 1.616V. Table 1 demonstrates the comparison of testing values between the system and the multimeter. The relative errors are very little. According to the results, the system is proved to be reliable and successful.

TABLE I. Comparison of testing values between the system and the multimeter

Test tool and Error	Sampling Voltage Value(V)		
	AD1	***AD2***	***AD6***
System	1.777	2.167	1.663
Multimeter	1.739	2.118	1.616
Relative error	2.185%	2.314%	2.908%

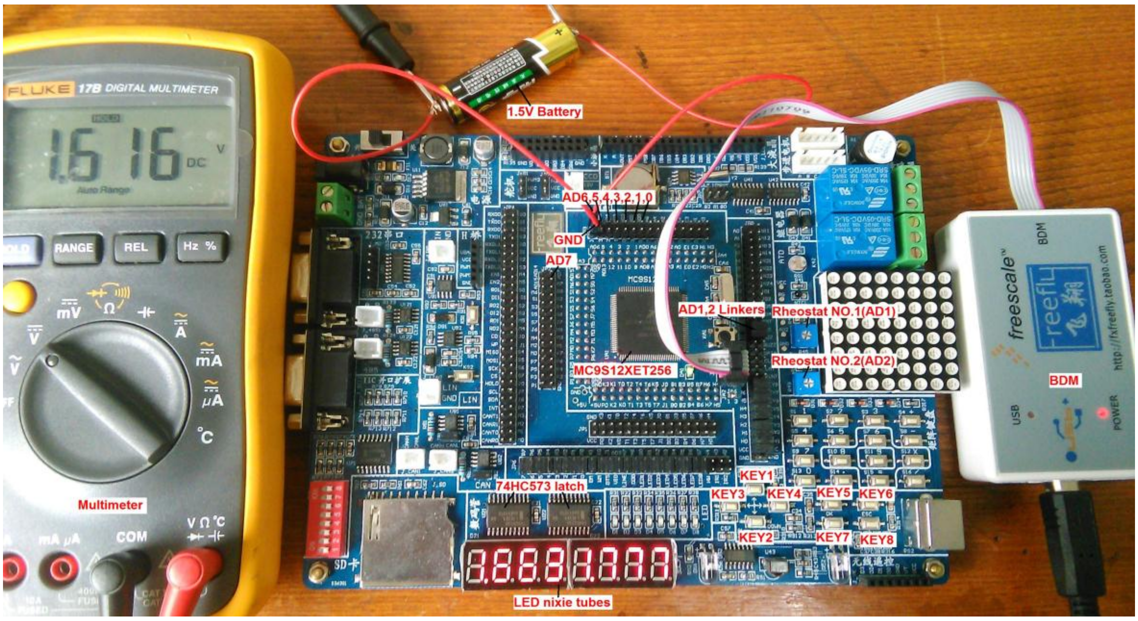

Fig.4. *Running case of the experimental rig*

V. Conculisons

The MC9S12XET256 MCU is utilized to carry out a system for eight channel data acquisition and two channel LED nixie tube display in this paper.

Hardware is designed including the MC9S12XET256 minimum system, the Key-press circuit, the circuit of two analog Voltage generating and the circuit of eight channel LED nixie tube display etc. C language is used to be compiled for the system with the help of CodeWarrior5.1. Finally the designed system is tested on an experimental rig, and it is proved to be successful. It can be easily manufactured a portable tester (such as automobile tester) which is used to measure and display multichannel analog parameters in industry.

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