Based on PSoC Electric Angle Meter

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Abstract- This paper presents a new design scheme that an electronic protractor includes two swing arms and one variable resistor located on the top of swing arms for measuring angles. The variable resistor connects the liquid crystal display (LCD) screen through an angle-to-voltage (A/V) controlled circuit, an analog-to-digital (A/D) converter, a single chip processor, and a LCD driver. The protractor can change the resistance of the variable resistor simultaneously and display the measuring angle on the LCD screen through the processing of the A/V controlled circuit, the A/D converter, single chip processor, and the LCD driver when the swing arms are open or close to make the angular deviations. The present electronic protractor is claimed on those measuring devices through the above process.

I. INTRODUCTION

The angles measurement is used extensively in industry or daily life. For example, exact elevator, aileron, rudder throws, compare wing and tail incidence, etc. they can all use it. The traditional tool that is used to measure angles is called as a protractor. The protractor is the common tool which is used to measure an angle. This paper presents a new design scheme of angles measurement. The new, patent-pending Electric Angle Meter can measure precisely to 1/10 of a degree and displays the angle clearly on its easy-to-read digital screen.

The design of electric angle meter is based on potentiometer method. We select Cypress PsoC Cy8C29456 as its core component, the whole design is flexible and simple, has very few peripheral devices and a high reliability. And meanwhile, we realize equal precision measurement of signals by potentiometer measurement method.

Most if not all of the microcontroller designs that involve analog signal processing will require an ADC to convert an analog signal into a digital value that can be processed by the CPU. PSoC 1 has a vast selection of ADCs that can be used depending on the application, ADCINC, ADCINCVR, ADCINC14, DELSIG8, DELSIG11, DelSig to name a few. Most of the users, beginners to experts face some or other problem while using an ADC like ADC not completing the conversion, ADC result always zero, ADC result incorrect etc. Below are Five Golden Rules that will help us to tame the PSoC 1™ ADC. They are the global interrupts, analog power parameter sets, clock source selects, clock phase operation, and waiting for the result inside the ISR. We choose one of them, for instance, analog power parameter sets to tame the PSoC.

II. THE PRINCIPLE OF ACTING

This paper offers a new design of angles measurement, which was realized on base of an easy way of measurement. Up to now, almost all the angles measurement apparatus are No matter contact or Contact-free, not just optics type, exactly electromagnetic type. They are either complex, or the cost too high [1-4]. The angles measurement is composed of potentiometer structure, PSoC (programmable system on chip) [5] and LCD display. The block diagram of design is shown as Fig. 1.

![Figure 1. Block Diagram of Design](image)

The potentiometer is a continuous operation device destined for angles detection and signal varying that is proportional to angles to clip from both sides. It is calibrated and sends a message if the angle is change. The design of device is very simple due to use PSoC with analog interface. That has provided high accuracy and low prime cost of the device as a whole.

The operation process of this circuit is that the output voltage of potentiometer is firstly digitized through ADCINC12, transformed to the measured angle, and then displayed on the LCD. Since the range of the input voltage is between 0 and 5 volts. The range of the measured angle is between 0 and 270 degrees and the ADC is with 12 bits, the data range is within -2048 and 2047. To simplify the computation, the digitized values would be added with 2048 to modify the range from 0 to 4095. The relationship of potentiometer and ADCINC12 is shown in Fig. 2. In such case, the relationship of transformation between measured angle $\theta$ and digitized value $X$ is

$$\theta = X \frac{270}{4095} = 0.065934X$$  \hspace{1cm} (1)

It means when the digitized value $X$ is obtained from ADCINC12, the measured angle $\theta$ can be calculated with multiplying by 0.065934.

For the data display, it can be observed from the following example. Assume that the measured angle $\theta$ in (1) is 24.5°. Since the process to display data on the LCD is digit by digit, it is necessary to multiply $\theta$ by 100 to become 2450 and then display ten thousands digit, thousands digit,
hundreds digit, tens digit, respectively. After putting the decimal point behind the hundreds digit, the data on the LCD display would be 24.5°. In this way, the quantity in (1) would be modified to 6.5934X°.

![Figure 3. PSoCI System Internal Structure Diagram](image)

**III. BRIEF INTRODUCTION ABOUT CY8C29466**

We construct the hardware system of electric angle meter according to the above analysis, considering that the system needs one analog module circuits are relatively large, so we select Cypress PSoCI CY8C29466 as the core component of the system. PSoCI is comprised of four main areas: PSoC Core, Digital System, Analog System, and System Resources. Configurable global buses allow all the device resources to be combined into a complete custom system. The automotive PSoC CY8C29x66 family can have up to three I/O ports that connect to the global digital and analog interconnects, providing access to 16 digital blocks and 12 analog blocks. Therefore it is an embedded system which is very suitable for hybrid analog-digital signal processing.

In addition, The PSoC device incorporates flexible internal clock generators, including a 24 MHz IMO (internal main oscillator) accurate to ±5% over temperature and voltage. A low power 32 kHz ILO (internal low speed oscillator) is provided for the Sleep Timer and WDT. If crystal accuracy is desired, the ECO (32.768 kHz external crystal oscillator) is available for use as a Real Time Clock (RTC) and can optionally generate a crystal-accurate 24 MHz system clock using a PLL. The clocks, together with programmable clock dividers (as a System Resource), provide the flexibility to integrate almost any timing requirement into the PSoC device. It can meet design requirements of most embedded applications and the internal structure of PSoC is shown as Fig. 3.

CY8C29466 is a chip which has the richest internal resources in PSoCI series chips, it has 16 digital units which can be configured as 8-32 bit timer, counter and PWM, etc, and connected to all GPIO pins; it has 12 analog units which can be configured as 14-bit ADC, 8-bit DAC, PGA, LPF and CMPLP, etc, one 32KB Flash program memory which can erase 50000 times, one 2KB SRAM data memory which can simulate Flash as E2PROM to use in system serial programming (ISSP) and one flexible protection mode; the clock frequency range of M8C processor is between 93.7KHz and 24MHz, its maximum operation speed can reach 4MIPS, its working voltage is between 3V and 5.25V and it has characteristics of high speed and low power consumption.

**A. Design of Module CIRCUITS in CY8C29466 Chip**

Cypress Company provides a graphic-based integrated development environment (IDE) PSoC Designer 5.0 for its PSoCI products. It helps users harness the power and flexibility of PSoC devices. With two project design modes, system-level and chip-level, users can choose to do designs with no coding, with all coding, or any combination of the two. By operating at a higher level of abstraction and not requiring firmware development, a system-level project enables new designs to be created, simulated and programmed to the targeted PSoC device in hours or days instead of in weeks or months. A chip-level project provides the user with a catalog of peripheral functions (called "user modules") that they can select, place and route to pins using flexible analog and digital PSoC block technology and then develop the firmware for a custom mixed-signal design. For a system-level project, PSoC Designer automatically generates the chip-level design information and all firmware, but also allows the user to add user modules and additional functions programmed in C language or assembly language.

This powerful, easy-to-use IDE comes with an extensive user module catalog, pre-configured, pre-characterized embedded peripheral functions, and extensive user assistance in the form of "help" dialog boxes, pull-down menus and other graphical user interface aids. User modules take the chip-level design information and all firmware, but also allows the user to add user modules and additional functions programmed in C language or assembly language.
SPI and I2C, as well as comparators, programmable gain blocks, filters and even boot loaders. Each user module includes the hardware configuration data, startup code, an interrupt service routine when applicable, and a set of APIs. These APIs, or application programming interface software functions, provide instant control of all aspects of the user module. This innovative approach helps the designer get to a fully functional custom device without weeks or months of tiresome datasheet scouring, tedious low-level coding and repetitive debugging. Our design selection is based on Chip-level Designs and the hardware design in PSoC chip is shown as Fig. 4 and Fig. 5.

B. Design of System Peripheral Circuit

For the purpose of the angle detect, we select the variable resistor as the potentiometer. We can change the resistance of the variable resistor simultaneously and display the measuring angle on the LCD screen through the processing of the A/V controlled circuit, the A/D converter, single chip processor, and the LCD driver when the swing arms are open or close to make the angular deviations. The present electronic protractor is claimed on those measuring devices through the above process.

The display part is a character type liquid crystal display and we use the single I/O port of main control chip CY8C29466 as the interface of industry standard HD44780ALCD controller. The interface is composed of 8 data bits, read/write (R/W), register selection "RS" and enable signal "E". Considering the number of character bits to be displayed and refresh speed, etc, a 4-bit interface mode is adopted in this design. The hardware circuit of frequency meter system is shown as Fig. 6.

V. SYSTEM SOFTWARE DESIGN

According to the principle of synchronous measurement and user module configuration in PSoC chip, this paper gives the design scheme of system main program and the workflow diagram of main program is shown as Fig. 7.
In the main program design of CY8C29466 chip, after the system is powered up, its internal start-up file boot.asm initializes system programs, including C language global variable, after start-up is finished, the system operates normally. First, declared character array as index value of display; start LCD, PGA and ADCINC12; set ADCINC12 to continuous mode; when it is detected that the transfer in the ADCINC12 is completed, transform into the measured angle, and then displayed on the LCD.

The main codes of main program are as follows:

```c
#include <m8c.h> // part specific constants and macros
#include "PSoCAPI.h" // PSoC API definitions for all User Modules

int digital; // save data
const unsigned char A[] = {%0123456789ABCDEF"};

void main()
{
    M8C_EnableGInt;
    LCD_Start(); // Start LCD
    ADCINC12_Start(ADCINC12_HIGHPOWER); // Start ADCINC12
    ADCINC12_GetSamples(0);
    PGA_Start(3); // Start PGA

    for(;)
    {
        //Input data ADCINC12
        while(ADCINC12_fIsDataAvailable() == 0);
        ADCINC12_ClearFlag(); // Clear ADCINC12
        digital=2043+ADCINC12_iGetData();
        digital=digital*6.5934;

        LCD_Position(0,4);
        LCD_WriteData("GOOD JOB");
        LCD_Position(1,4);
        LCD_WriteData(A[digital/10000]);
        LCD_Position(1,5);
        LCD_WriteData(A[(digital%1000)/1000]);
        LCD_Position(1,6);
        LCD_WriteData(A[(digital%100)/100]);
        LCD_Position(1,7);
        LCD_WriteData(A[(digital%10)/10]);
        LCD_Position(1,8);
        LCD_WriteData(0xdf);
    }
}
```

VI. CONCLUSION

This paper introduces a design scheme of electric angle meter based on potentiometer which can measure precisely to 1/10 of a degree and displays the angle clearly on its easy-to-read digital screen. We select PSoC CY8C29466 as its core component, which embodies the flexibility and simplicity of the unique programmable system on chip design, greatly simplifies the workflow of the design and shortens the development cycle of the system. In addition, it has advantages of low cost, expandability and high reliability, etc.

REFERENCES