

Design of Electronic Work Card Using E-ink Display Panel

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Abstract

The electronic work card has potential application market in personnel information display, outdoor staff management and etc. Considering the needs of long-time display and the movable application scenario, an electronic work card with Low-power display technology has been designed. The work card can display the personnel information, the external temperature, system power and other information.

Keywords

Electronic Work Card; E-ink; Low-power; Temperature.

1. Introduction

Under the background of normalization of COVID-19, the development of electronic work cards is significant for the personnel information display, nucleic acid detection process control and so on. Nowadays, there are few products on the market of intelligent electronic work cards, and the existing functional technology is not mature. Traditional paper, plastic, acrylic and other materials are used to make work cards. Once the design is completed, the content cannot be changed, and the cards cannot be recycled, which will cause a waste of resources. The existing electronic work card mainly uses LED technology, which has low resolution, poor display effect and high power consumption. At present, Low-power display technology mainly adopts reflective display technology. This kind of display technology does not need external power supply to maintain the display state without switching the display content. The mainstream e-paper technologies include E-ink, electrowetting, cholesteric liquid crystal and so on [1-5]. Among them, the light scattering of the display panels using particle based technologies, such as electrowetting, E-ink and etc, makes the panels look more like paper than other technologies such as liquid crystal. Since there is no polarizer, the paper-like display panels have higher reflectivity [6]. At present, the most common technology is E-ink technology. After the display contents is refreshed, the screen will no longer consume power to maintain the original screen display state, which is significantly different with traditional display technologies. After a sudden power failure, the display effect will not be affected.

An electronic work card is designed using E-ink display panel in this paper. Low power consumption and real-time information display are considered to meet the actual needs of such application scenarios.

2. Hardware Structure Design

2.1. Overall Design

The specific design is provided in Figure 1.



Figure 1. System structure diagram

The system uses STM32F103 to drive the E-ink panel through SPI interface. The temperature is collected through the thermistor. The information is displayed on the E-ink screen in real-time. At the same time, the power of the equipment is also collected and displayed.

2.2. E-ink Display Panel

E-ink display panel is a kind of paper-like display panel with the core material E-ink. Like traditional ink, E-ink can be printed on the surface of many materials and the color can be changed with staining materials. The colored charged particles are encapsulated in microcapsules. In the initial state, the particles are suspended in the microcapsules. When an electric field in a certain direction is applied, the corresponding colored particles will be pushed to the top. The microcapsules will display different colors through pushing different colored particles to the top.

E-ink display panel is used to display the job number, temperature and power in this design. The display module is shown in Figure 2. The module consists of a display screen and a flexible circuit board. The structure of E-ink module is shown in Figure 3.



Figure 2. E-ink display Panel

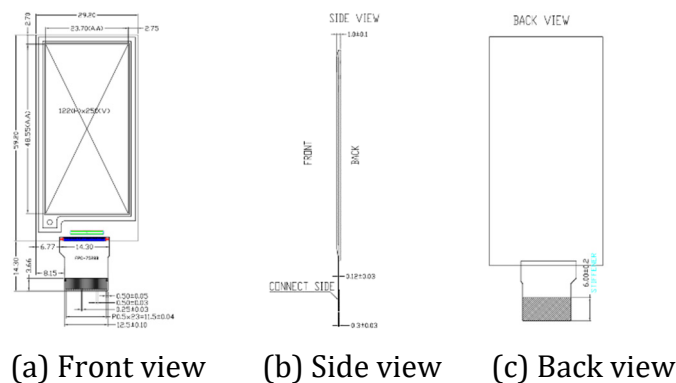


Figure 3. E-ink structure diagram

E-ink panel is connected with the outside circuit through the flexible circuit board. The power is supplied externally. The driving control signal of the panel is from MCU through SPI interface. The connection diagram is shown in Figure 4.

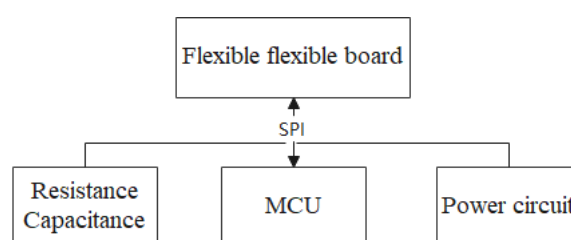
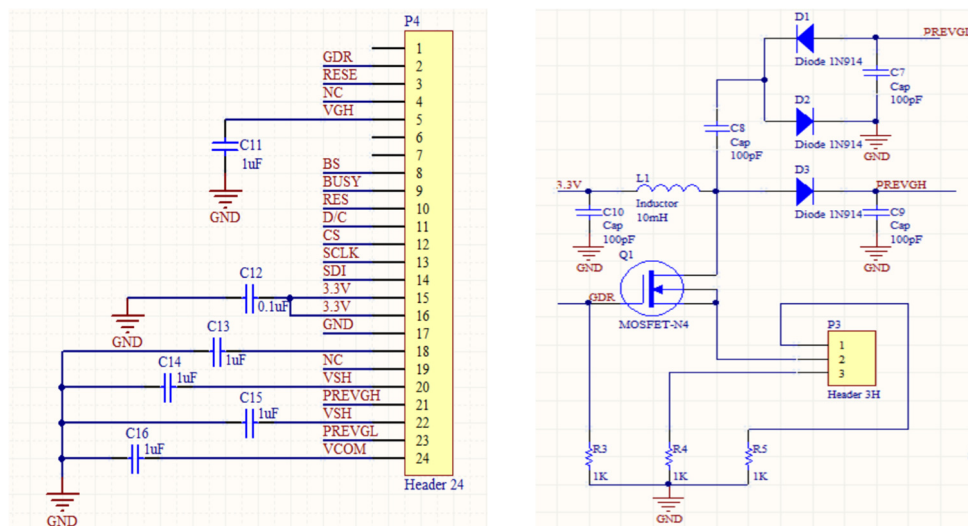


Figure 4. Connection diagram

2.3. The Core Hardware Circuits

The E-ink display interface circuit is shown in Figure 5(a). The interface has 24 pins. Power and standard SPI are included. Two different SPI modes, three wire SPI mode and four wire SPI mode, can be selected. When three wire SPI mode is used, three pins should be connected, including CS, SCLK and SDI. When four wire mode is used, CS, SCLK, SDI and D/C should be connected. Among them, the D/C (11 pin) provides control signal to distinguish whether the received information is data or command. The CS (12 pin) is to select equipment for data communication. The SCLK (13 pin) is to provide clock signal. The SDI (14 pin) is used to receive data sampling or read main chip data.

Positive and negative voltages are required to control the state of E-ink charged particles. The positive and negative voltages are generated through the circuit shown in Figure 5(b). The PREVGH (21 pin) and the PREVGL (23 pin) provide positive and negative voltages respectively. The GDR (2-pin) determines the positive or negative voltage is generated. Filtering and voltage stabilization in the circuit mainly rely on capacitance.



(a) E-ink interface

(b) positive and negative voltage

Figure 5. Display interface circuit

3. System Software

3.1. Workflow for Software Design

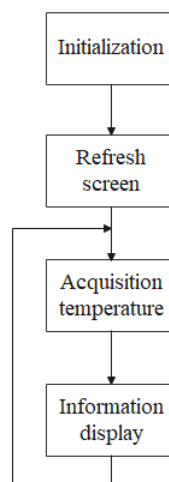


Figure 6. Workflow of the system

The workflow is shown in Figure 6. After the system is powered on, initialize of peripheral device is started at the beginning. The E-ink panel should be refreshed. And then, temperature is collected through reading the voltage from circuit built by thermistor and AD conversion module. The voltage is converted into temperature by looking up the table. Finally, the temperature value is displayed using E-ink panel.

3.2. Display Control

Since the E-ink display panels have be driven and displayed through special waveform, following procedure is required to brush the screen panel. Full screen black and white mode is alternated. Time delay is also necessary between the state switching.

```
EPD_HW_Init();
EPD_DeepSleep();
driver_delay_xms(1000); // Delay Functions
EPD_HW_Init();
```

Different states are shown in Figure 7.

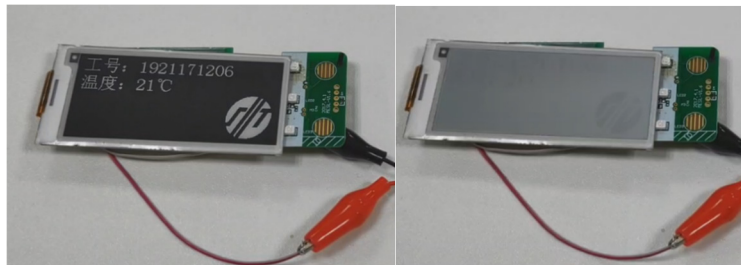


Figure 7. Screen brushing process

Serial peripheral interface includes serial clock SCL, serial data D / C #, CS #, SDA.

The waveform of writing process in four wire SPI mode is shown in Figure.8 and Table 1. According to the specification, the CS pin provides selection signal to communicate with MCU. When CS is at low potential, communicate with MCU is started. When CS is at high potential, communication with MCU is stoped. The SCL provide clock signal. On each rising edge of SCL, the SDA provide data or command with 8bits data from D7 to D0. The D/C is used to distinguish whether the signal is data or command. When it is at high potential, the signal is regarded as data. Otherwise it is regarded as a command.

Table 1. Signal of writing process

Function	CS#	D/C#	SCL
Write command	L	L	↑
Write data	L	H	↑

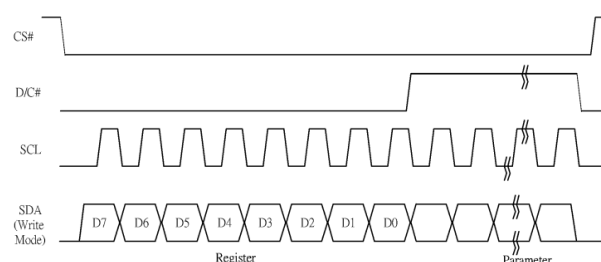


Figure 8. Waveform of writing process

The code of writing command and data is as follows respectively.

```
void Epaper_Write_Command (unsigned char CMD) // command of electronic paper
{
    EPD_W21_CS_1; // CS is high level
    EPD_W21_CS_0; // CS is low level
    EPD_W21_DC_0; // DC is low level
    Epaper_Spi_WriteByte(cmd);
    EPD_W21_CS_1; // CS is high level
}

void Epaper_Write_Data (unsigned char data) // data of electronic paper
{
    EPD_W21_CS_1; // CS is high level
    EPD_W21_CS_0; // CS is low level
    EPD_W21_DC_1; // CS is high level
    Epaper_Spi_WriteByte(data);
    EPD_W21_CS_1;
}
```

3.3. Temperature Acquisition

Temperature acquisition converts the collected voltage into the corresponding temperature by establishing a look-up table. According to the product manual, the relationship between the resistance of thermistor and the temperature is shown in Figure 9.

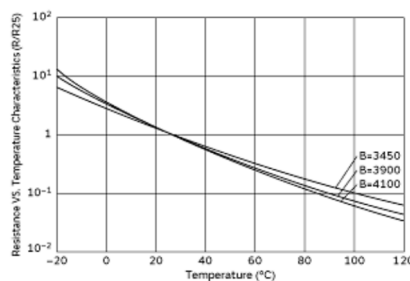


Figure 9. Resistance and Temperature characteristic

Table 2. Relationship between temperature, resistance and voltage

Temperature	Resistance (K)	Voltage(mv)
0	357.0117	1178.139
10	209.7098	692.0423
20	127.0802	419.3647
30	79.2216	261.4313
34	66.0608	218.0006
35	63.1671	208.4514
36	60.4150	199.3695
37	57.7969	190.7298
38	55.3056	182.5085
39	52.9343	174.6832
40	50.6766	167.2328
45	40.9035	134.9816

Fix the value of temperature and resistance according to the manual. The relationship between temperature, resistance and voltage is shown in Table 2.

4. Conclusion

Using E-ink display panel and thermistor, an electronic work card is designed. The display content is controlled by MCU through high-speed SPI interface. Personnel information, the external temperature, system power and other information can be displayed (Figure. 10). This work card is significant in medical management, attendance management and other application scenarios.

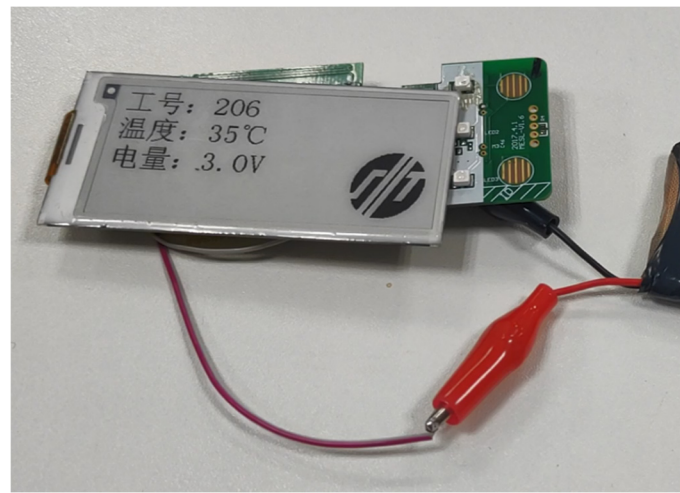


Figure 10. Display effect

Acknowledgments

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