GigaDevice Semiconductor Inc.

ARM® Cortex®-M3/4/23/33 32-bit MCU

Application Note
AN036

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1. Introduction

MCU often uses I2C as the master to communicate with the EEPROM. When the I2C master resets during the communication process, there will be a probability that it will no longer be able to communicate with the EEPROM. This is called a bus lock. To solve this problem, this article provides a method to release the I2C bus using software configuration.

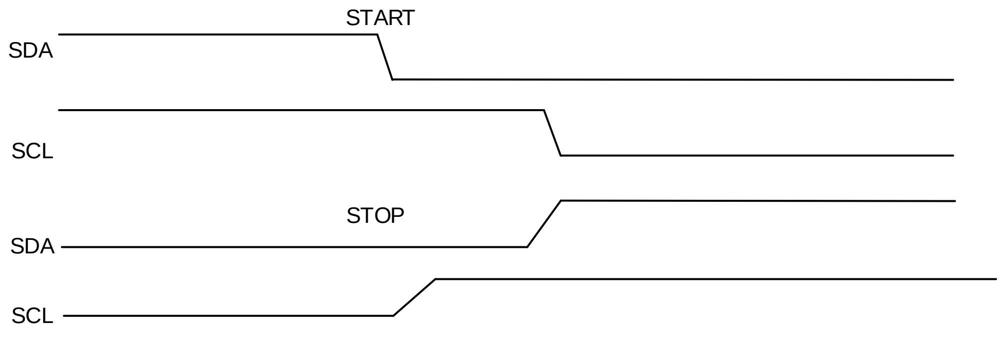
2. I2C bus lockup

2.1. I2C bus lock phenomenon

To complete a normal communication task between the master and slave of the I2C, before establishing the communication, the master must first detect the status of the I2C bus. When the SCL and SDA lines of the I2C bus are both high, the I2C bus is in an idle state. When the SCLA is high, the master pulls down the SDA signal to generate a START start signal.

When the I2C master-slave machine ends a communication task, it needs the master to generate a stop signal, that is, when the SCL is high, the SDA signal is pulled up.

Figure 2-1. I2C bus start and stop signals



Under normal circumstances, the I2C bus protocol can ensure normal read and write operations on the bus. However, when the I2C master device is reset (watchdog action, abnormal on-board power supply causes reset chip action, manual button reset, etc.), and the slave device is not reset, it may cause I2C bus deadlock. In the state of the bus lock, SCL maintains a high state, and SDA maintains a low state.

2.2. Causes of I2C bus lock

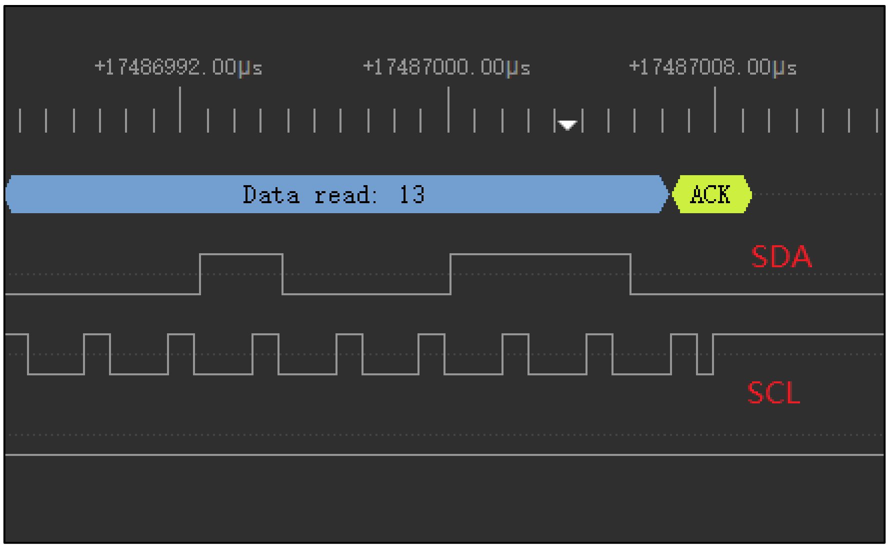
In the process of I2C master reading and writing, there are two situations that will cause the bus to lock up.

1. After the master sends the START signal, it controls the SCL to generate 8 clock pulses, and then pulls the SCL signal low. At this time, the slave outputs the response signal and pulls the SDA signal to the low level. If the host resets abnormally at this time, SCL will be released to high level. At this time, if the slave is not reset, it will continue the I2C response, pulling SDA to a low level all the time, and the response signal will not end until SCL becomes a low level. However, since the I2C host detects the state of the bus after resetting, if the SDA signal is low, the I2C bus is occupied, and it will wait for the SCL and SDA signals to become high. Therefore, when the I2C master is waiting for the slave to

release the SDA signal, the I2C slave is waiting for the master to pull the SCL signal low to release the response signal. The two wait for each other, and the I2C bus enters a deadlock state.

2. When the I2C master is reading data, the I2C slave responds and outputs data. If the I2C master resets abnormally at this moment and the data bit output by the I2C slave is exactly 0, it will also cause the I2C bus to enter a deadlock state.

Figure 2-2. I2C bus lock timing



3. Solution to I2C bus lock

The I2C bus is locked. The bus can also be released by resetting the slave. But when the EEPROM is used as a slave, the software cannot be used to reset the slave, and in some cases, the hardware cannot be reset. Therefore, it is necessary to add the bus release function when the I2C master establishes a new communication. Since the bus lock is probabilistic, the bus BUSY state timeout function can be added. The combination of the two can improve the robustness of the system. Two software solutions are provided below.

3.1. Forcibly pull up SDA and SCL

After the I2C master is reset, the master detects that the I2C bus is always in the BUSY state, and if the set time is exceeded, the bus is locked. It can be configured as push-pull output by initializing the SCL and SDA pins of I2C to ordinary GPIO functions. First pull up the SCL signal, and then pull up the SDA signal, a stop signal is generated by simulation, and then it is configured as the I2C pin multiplexing function.

Table 3-1. Configuration of forcely pull up SDA and SCL in GD project

```
/*!
    \brief      reset i2c bus
    \param[in]  none
    \param[out] none
    \retval     none
*/
void i2c_bus_reset()
{
    GPIO_BC(GPIOB) |= GPIO_PIN_6 | GPIO_PIN_7;
     gpio_init(GPIOB,          GPIO_MODE_OUT_PP,          GPIO_OSPEED_50MHZ,
     GPIO_PIN_6|GPIO_PIN_7);
    __nop();
    __nop();
    __nop();
    __nop();
    __nop();
    GPIO_BOP(GPIOB) |= GPIO_PIN_6;
    __nop();
    __nop();
    __nop();
    __nop();
    __nop();
    GPIO_BOP(GPIOB) |= GPIO_PIN_7;
    gpio_init(GPIOB,   GPIO_MODE_AF_OD,   GPIO_OSPEED_50MHZ,   GPIO_PIN_6   |
        GPIO_PIN_7);
}

/*!
        \brief          check the I2C is or not busy
        \param[in]     none
        \param[out] none
        \retval         none
*/
void check_bus_status(void)
{
        while(i2c_flag_get(I2C0,I2C_FLAG_I2CBSY))
        {
                if(--time_out == 0){
                        i2c_bus_reset();
                }
        }
}
```

3.2. SCL clock signal release bus

Add the I2C bus recovery program in the I2C master. Every time the I2C master device is reset, if the SDA data line is detected to be pulled low, the SCL clock line in the I2C is controlled to generate 9 clock pulses (for 8-bit data), so that the I2C slave device can be suspended The operation is recovered from the deadlock state.

The I2C master initializes the SCL pin as a normal GPIO function and configures it as a push-pull output. Ensure that 9 clock pulses are sent continuously. In order to ensure normal I2C communication, first reset the I2C module, then set it, and finally configure it as the I2C pin multiplexing function. The software configuration under GD32 project is shown in the following table.

Table 3-2. Configuration of SCL clock signal release bus in GD project

```
/*!
        \brief          reset i2c bus
        \param[in]     none
        \param[out] none
        \retval         none
*/
void i2c_bus_reset()
{
        uint8_t I = 0;
        gpio_init(GPIOB, GPIO_MODE_OUT_PP, GPIO_OSPEED_50MHZ, GPIO_PIN_6);
        /* SCL output clock signal */
```

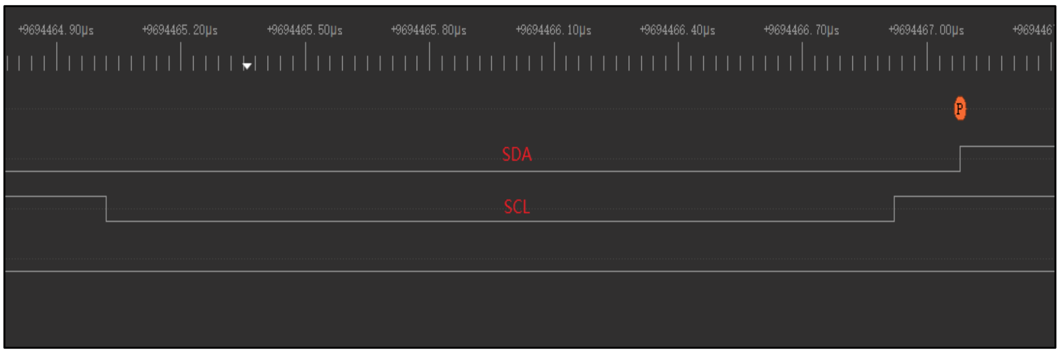
```
    for(I = 0; I < 10; i++){
    gpio_bit_reset(GPIOB, GPIO_PIN_6);
    delay_1us(2);
    gpio_bit_set(GPIOB, GPIO_PIN_6);
    delay_1us(2);
    }
    /* reset I2C */
    i2c_software_reset_config(I2C0, I2C_SRESET_RESET);
    i2c_software_reset_config(I2C0, I2C_SRESET_SET);
    gpio_init(GPIOB,    GPIO_MODE_AF_OD,    GPIO_OSPEED_50MHZ,    GPIO_PIN_6    |
    GPIO_PIN_7);
}

/*!
    \brief       check the I2C is or not busy
    \param[in]   none
    \param[out] none
    \retval      none
*/
void check_bus_status(void)
{
    while(i2c_flag_get(I2C0,I2C_FLAG_I2CBSY))
    {
        if(--time_out == 0){
            i2c_bus_reset();
        }
    }
}
```

3.3. Test results

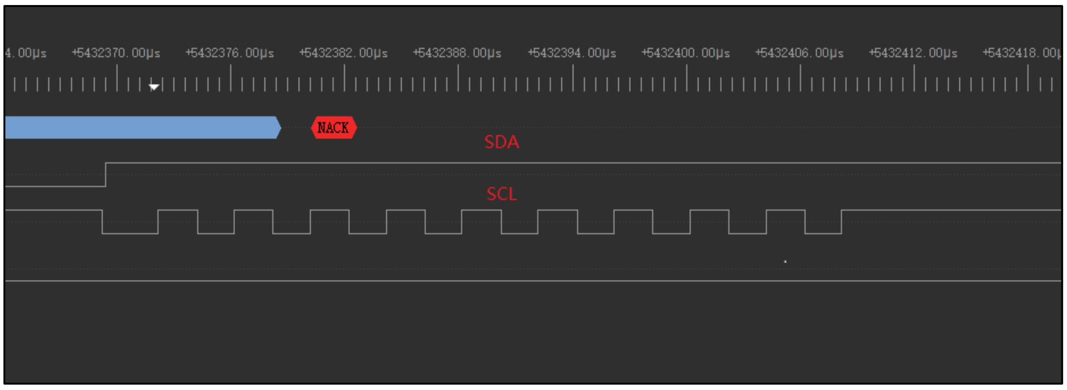
Test two bus release methods on the GD32F303 platform. The test results are shown in ***Figure 3-1. The test of forcely pull up SDA and SCL*** and ***Figure 3-2. SCL clock signal release bus test***. The forced pull-up SDA and SCL test is shown in the following figure. When the I2C bus is locked, SDA is in the low state and SCL is in the high state. When the bus is released, first pull SCL low, then pull high, and then pull SDA high. Finally, a STOP signal appears on the I2C bus, and the bus is released. The master can start to establish a new communication.

Figure 3-1. The test of forcely pull up SDA and SCL



The SCL clock signal release bus test is shown in the following figure. After the I2C bus is locked, 9 clock signals are sent continuously. Finally, both SDA and SCL are pulled high. The master detects that the bus is in an idle state and can start to establish a new communication.

Figure 3-2. SCL clock signal release bus test



4. Revision history

Table 4-1. Revision history

Revision No.	Description	Date
1.0	Initial Release	Dec.13 2021