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H8/300L Super Low Power（SLP）系列

使用 I/O 端口的 I²C™ I/F 实现方法

内容

在本应用说明中，说明在使用 SLP 系列的 I/O 端口实现 I²C 时所需的信息和使用方法。

要点

I²C 总线支持任何制造工艺（NMOS、CMOS、双极型）的 IC，通过串行数据（SDA）和串行时钟（SCL）的 2 条信号线，进行连接在总线上的器件间的信息交换。与 I²C 总线兼容的器件全部内置了能通过 I²C 总线进行直接通信的接口。

SLP 系列没有支持 I²C 的专用内部硬件，但是能通过软件控制 2 个 I/O 管脚，模拟 I²C 总线。

【注】将 SLP 系列的 I/O 端口用作 I²C 总线端口的例子，请参照应用说明《使用 I/O 端口的 I²C™ EEPROM I/F 实现方法》（RCJ05B0020-0100）。

动作确认器件

H8/38024

目录

1. I²C 的一般特性

【注】 关于 I²C 的概要，请参照应用说明《使用 SCI 的 SPI 实现方法》（RJS06B0003-0100Z）。

2. 硬件结构

I²C 总线上的器件具有将全部的总线信号置为低电平的能力是很重要的。当从属器件对主器件的查询要返回应答时，从属器件需要将 SDA 信号置为低电平。如果低速器件慢于高速器件的速度，低速器件就将 SCL 信号置为低电平，降低通信速度。

当多个器件同时要成为总线主器件时，保持 SDA 为低电平时间最长的器件成为主器件。因此，各 I²C 器件就必须一旦结束自身的运行就释放总线，而其他器件在必要时能将总线信号置为低电平。为了实现这一功能，SLP 系列的 I/O 端口由集电极开路驱动器构成。

要将信号线置为低电平时，将 I/O 端口的方向寄存器设定为输出，并且将数据寄存器置“0”。要将信号线置为高电平时，将数据寄存器置“1”，禁止其他器件将信号线置为低电平。将此 I/O 端口的方向寄存器置“0”，将 I/O 端口设定为输入。这样，此端口就能通过外部上拉电阻变为逻辑值“1”。通过如下所示的程序 SciOut()和 SdlOut()实现此步骤：

```
/* Both SDA_DATA_REG and SCL_DATA_REG are the data register for each respective
I/O port. It may change to map to other ports. The setting example as following:
       #define SDA_DATA_REG             P_IO.PDR7.BYTE
       #define SCL_DATA_REG             P_IO.PDR8.BYTE

SCL_IO_REG and SDA_IO_REG are the control register for each respective I/O port.
The setting example as following and is changeable by user.
       #define SDA_IO_REG               P_IO.PCR7.BYTE
       #define SCL_IO_REG               P_IO.PCR8.BYTE
*/


/* Drive SCL bus */
void SclOut (unsigned char status)
{
if (status == LOW)
{
      SCL_DATA_REG = 0;               //Drive Port LOW
      SCL_IO_REG |= SCL_IO_SET_BIT;   //Port is output
   }
else
{
      SCL_DATA_REG = 1;               //Port is Input & using external
                                      //pull-up resistor to go high
      SCL_IO_REG |= SCL_IO_SET_BIT;   //Port is output
   }
}

/* Drive SDA bus */
void SdaOut (unsigned char status)
{
   if (status == LOW)
{
      SDA_DATA_REG = 0;               //Drive Port LOW
      SDA_IO_REG |= SDA_IO_SET_BIT;   //Port is output
   }
else
{
      SDA_DATA_REG = 1;               //Port is Input & using external pull-up
                                      //resistor to go high
      SDA_IO_REG |= SDA_IO_SET_BIT;   //Port is output
   }
}
```

3. 时序

还必需考虑时序，但是 I²C 时钟的时序不需要那么准确。当低速器件连接在总线时，能降低高速器件的速度。能通过几种方法给时钟设定定时器。能使用 NOP 命令和用于延迟的 for 循环，通过软件进行延迟。另外，也能使用 MCU 的内部定时器或者定时器中断，反转时钟的输出。

但是，在设定时钟时，需要注意影响 I²C 协议的重要参数。对于 START 或 STOP 等所有条件的上升时间、下降时间、保持时间以及准备时间等参数，必须按照使用的器件规格（min 和 max 时间）正确设定。确认器件的 AC 特性和 I²C 的执行结果非常重要。

虽然 I²C 没有规定最小总线频率，但是有最大 100KHz 的标准模式和最大 400KHz 的高速模式的 2 种运行模式，可以通过端口实现。

I²C 也没有规定超时的限制。所以为了提高协议的效率，有时必须由用户决定发送和接收的超时时间。

4. 位的传送

因为 I²C 总线能连接各种不同技术（CMOS、NMOS、双极型）的器件，所以逻辑值“0”（低电平）和“1”（高电平）的电压电平不固定，取决于有关 V_{cc} 的电平。传送数据的每 1 位生成 1 个脉冲时钟。

如下例所示，作为在传送位数据时被广泛使用的逻辑之一，有“0 ”（LOW）和“1 ”（HIGH）。

```
void SendBit (unsigned char data_byte)
{
        if (data_byte != 0)
   {
        SdaOut(HIGH);
}
else
{
        SdaOut(LOW);
    }
}
```

在 START 条件和 STOP 条件之间，没有限制从发送器传送到接收器的数据的字节数。由 8 位构成的各字节从最高位开始进行串行传送，在最后附加应答位。

5. START 条件和 STOP 条件

在 I²C 总线的步骤中，将产生被定义为 START（S）条件和 STOP（P）条件的特有状态。在产生此条件时必须充分考虑的事情之一是时序。如上所述，需要特别注意保持时间和准备时间。

在器件为发送器的情况下，要设置对应 SCL 下降沿的未确定区时所需的最小内部迟延时间（300ns），并且要注意不能错误产生 START 条件和 STOP 条件。

通常，按如下方法生成附加迟延的（取决于器件和时钟）START 条件和 STOP 条件：

```
void SendStartBit(void)
{
      SclOut(HIGH);    //SCL && SDA must be HIGH to indicate bus-free.
      SdaOut(HIGH);
      SdaOut(LOW);
      Delay();
      SclOut(LOW);
      Delay();
}

void SendStopBit(void)
{
      SdaOut(LOW);
      Delay();
      SclOut(HIGH);
      Delay2x();
      SdaOut(HIGH);
}
```

6. 错误

任何传送都能被从属器件或者主器件中止。无论已传送了多少字节，只要主器件发出 STOP 条件，从属器件就能不发出应答而结束传送。当器件检测到错误时，就不发出应答。I²C 的规格规定了在读操作的最后字节不需要发出应答。

在以下所示的状况中只要发生有一种以上的状态时，器件就能通知错误：

- 器件尚未准备好数据要求（读或写）的处理
- 器件不能识别命令码和被要求的运行
- 器件不允许命令码和被要求的运行
- 溢出或者下溢
- 以块读/块写传送的数据长度出错
- 在处理中，使用了不能识别或者不支持的数据传送协议
- 其他已知或者未知的错误状况

7. 软件例程

I²C 的实现只需要 2 个例程，并且根据功能的需要决定例程为 i2cRead()或者 i2cWrite()。LCD 驱动器只作为接收器工作，存储器和 I/O 芯片作为发送器和接收器运行。

调用 i2cWrite()时需要以下参数：

(1) 写数据的从属地址
(2) 保存写数据的数据缓冲器的起始地址
(3) 写数据的字节数

i2cRead()发送以下的值：

(1) 从属地址
(2) 主器件要求读的数据的字节数

如果运行成功，就在读/写后发送应答，进入下一步运行。

【注】 关于各种类型的读/写例子，请参照应用说明《使用 I/O 端口的 I²C™ EEPROM I/F 实现方法》（RCJ05B0020-0100）。

8. 参考文献

1. The I²C-Bus Specification (Version 2.1), January 2000, Koninklijke Philips Electronics N.V.
2. H8/38024, H8/38024S, H8/38024R, H8/38124 Group Hardware Manual, 10 Mar. 2005, Renesas Technology, Inc.
3. Leonard Haile, Renesas H8/3437 Series Microcontroller I²C Peripheral-A practical SMBus/I²C Firmware Design Guide (Revision 1.2), 12 June 1998, Renesas Technology America.
4. http://www.esacademy.com/faq/i2c/

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