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2010年4月1日
瑞萨电子公司

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M16C/65 群
串行 I/O 操作（时钟同步串行 I/O 模式下的发送）

1. 要点
在时钟同步串行 I/O 模式下发送数据，可以选择如表 1 中所列的各种功能。在表 1 中用符号“〇”表示本篇资料所选的项目，图 1 是串行 I/O 的工作时序图。本篇资料的参考例程是使用 UART0 在时钟同步模式下发送数据的例子。

2. 说明
本篇资料，适用于 M16C/65 群单片机。

本篇应用说明也适用于 M16C 族中与上面所述的群具有相同 SFR（特殊功能寄存器）定义的产品。关于产品功能的改进，请参看手册中的相关信息。在使用本篇应用说明的程序前，需进行详细的评价。
3. 选定功能

表 1. 选定功能

<table>
<thead>
<tr>
<th>设定项目</th>
<th>设定内容</th>
<th>设定项目</th>
<th>设定内容</th>
</tr>
</thead>
<tbody>
<tr>
<td>分频前时钟选择</td>
<td>f1</td>
<td>传送格式</td>
<td>LSB 先</td>
</tr>
<tr>
<td></td>
<td>foco-F</td>
<td></td>
<td>MSB 先</td>
</tr>
<tr>
<td>外围时钟</td>
<td>f1SIO</td>
<td>发送中断请求产生条件</td>
<td>发送缓冲器空</td>
</tr>
<tr>
<td></td>
<td>f2SIO</td>
<td></td>
<td>发送结束</td>
</tr>
<tr>
<td>传送时钟源</td>
<td>内部时钟</td>
<td>输出传送时钟到多个引脚（注 1）</td>
<td>不选择</td>
</tr>
<tr>
<td></td>
<td>（f1SIO/f2SIO/f3SIO）</td>
<td></td>
<td>选择</td>
</tr>
<tr>
<td></td>
<td>外部时钟（CLKi 引脚）</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTS 功能</td>
<td>CTS 功能允许</td>
<td>数据逻辑选择功能</td>
<td>不反转</td>
</tr>
<tr>
<td></td>
<td>CTS 功能禁止</td>
<td></td>
<td>反转</td>
</tr>
<tr>
<td>CLK 极性</td>
<td>在传送时钟的下降沿输出发送数据</td>
<td>CTS/RTS 引脚独立（注 2）</td>
<td>复用引脚</td>
</tr>
<tr>
<td></td>
<td>在传送时钟的上升沿输出发送数据</td>
<td></td>
<td>独立</td>
</tr>
</tbody>
</table>

注 1: 只能在 UART1 使用内部时钟时选择。
注 2: CTS0/RTS0 独立功能是 CTS0 与 RTS0 引脚功能不复用，从 P6_0 引脚输出 RTS0，从 P6_4 引脚输出 CTS0 的功能。当选择这个功能时，不能使用 UART1 的 CTS/RTS 功能，请将 CTS/RTS 禁止位设置为“1”。

4. 串行 I/O 的操作

(1) 将发送允许位置为“1”，对 UARTi 发送缓冲寄存器中写入发送数据，进入数据发送状态就绪。
(2) 当输入到 CTSi 引脚的电平变为“L”时，发送开始（CTSi 引脚必须由接收方控制）。
(3) 与传送时钟的第一个下降沿同步，UARTi 发送缓冲寄存器中发送数据被发送到 UARTi 发送寄存器中。此时，产生 UARTi 发送中断请求位变为“1”，发送数据的 bit0 也从 TxDi 引脚发送出去。然后，发送数据与下降沿同步按照从低到高的顺序逐位被发送出去。
(4) 当一个字节的数据发送结束时，发送寄存器空标志位变为“1”，表示发送结束。并且，发送时钟停止输出，并保持为“H”电平。
(5) 如果在发送过程中将下一个传送数据设置到 UARTi 发送缓冲寄存器中（在输出当前传送数据的 bit8 之前），数据就被连续发送。
使用 UARTi 在时钟同步 I/O 模式下发送数据的工作时序图如下所示:

### 硬件连接示例

![硬件连接示例图](image)

注：由于 TxD2 引脚为 N沟道漏极开路，所以这个引脚需要上拉电阻。

### 运行示例

<table>
<thead>
<tr>
<th>步骤</th>
<th>描述</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>发送允许</td>
</tr>
<tr>
<td>(2)</td>
<td>确认 CTS</td>
</tr>
<tr>
<td>(3)</td>
<td>开始发送</td>
</tr>
<tr>
<td>(4)</td>
<td>发送完成</td>
</tr>
<tr>
<td>(5)</td>
<td>发送下一个数据</td>
</tr>
</tbody>
</table>

**传送时钟**

- 发送允许位（TE）
  - "1"
  - "0"
- 发送缓冲寄存器标志位（TI）
  - "1"
  - "0"
- CTSi
  - "H"
  - "L"

**CLKi**

**TxDi**

- 发送寄存器空标志位（TxEPT）
  - "1"
  - "0"
- 发送中断请求位（IR）
  - "1"
  - "0"

（）内标明的是位符号。

此图的设定条件为：
- 选择内部时钟
- 选择 CTS 功能
- CLK极性选择位 = "0"
- 发送中断源选择位 = "0"

$$T_c = T_{CLK} = 2(n+1)/f_i$$
$$f_i : BRgi 计数器的频率 (f_{1SIO}、f_{2SIO}、f_{3SIO}、f_{32SIO})$$
$$n : BRgi 寄存器的设定值$$

图 1. 使用 UARTi 在时钟同步 I/O 模式下发送数据的工作时序图
5. 寄存器设置

为了能实现定义在“4. 串行 I/O 的操作”的功能，下列寄存器必须按步骤顺序进行设置。对于每个寄存器的具体结构，请参考 M16C/65 群的硬件手册。

### 设定UART时钟选择计数器

（请在设定和UART0-UART2、UART5-UART7相关的其它寄存器之前设定OCOSEL0位或者OCOSEL1位。在改变OCOSEL0位或者OCOSEL1位后，再次设定和UART0-UART2、UART5-UART7相关的其它寄存器。）

<table>
<thead>
<tr>
<th>时钟选择寄存器 UCLKSEL0 (地址 0252h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>置为 “0”</td>
</tr>
<tr>
<td>UART0-UART2分频前时钟选择位</td>
</tr>
<tr>
<td>0: f</td>
</tr>
<tr>
<td>UART5-UART7分频前时钟选择位</td>
</tr>
<tr>
<td>0: f</td>
</tr>
</tbody>
</table>

注：请在UART0-UART2、UART5-UART7发送/接收停止时设定OCOSEL0位和OCOSEL1位。

### 设定UART发送/接收模式寄存器 (i = 0~2, 5~7)

<table>
<thead>
<tr>
<th>发送/接收模式寄存器 U0MR (地址 0248h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART0发送/接收模式寄存器 U1MR (地址 0258h)</td>
</tr>
<tr>
<td>UART2发送/接收模式寄存器 U2MR (地址 0268h)</td>
</tr>
<tr>
<td>UART5发送/接收模式寄存器 U5MR (地址 0258h)</td>
</tr>
<tr>
<td>UART6发送/接收模式寄存器 U6MR (地址 0268h)</td>
</tr>
<tr>
<td>UART7发送/接收模式寄存器 U7MR (地址 02A8h)</td>
</tr>
</tbody>
</table>

- **<SMD2~SMD0> 置为 “001”**
- **<CKDIR> 内部外部时钟选择位**
  - 0: 内部时钟
  - 1: 外部时钟
- **<STPS> 时钟同步I/O模式下无效**
- **<PRY> 时钟同步I/O模式下无效**
  - 0: 无效
  - 1: 有效
- **<IPOI> TxD、RxD输入/输出极性反转位**
  - 0: 无效
  - 1: 有效

通常情况下设置为 “0”
串行 I/O 操作（时钟同步串行 I/O 模式下的发送）

设置UARTi发送/接收控制寄存器（i = 0～2, 5~7）

UART0发送/接收控制寄存器 U0C0【地址 024Ch】
UART1发送/接收控制寄存器 U1C0【地址 025Ch】
UART2发送/接收控制寄存器 U2C0【地址 026Ch】
UART5发送/接收控制寄存器 U5C0【地址 028Ch】
UART6发送/接收控制寄存器 U6C0【地址 029Ch】
UART7发送/接收控制寄存器 U7C0【地址 02ACh】

<CLK1, CLK0> UICR1计数源选择位

0 0 : f1SIO或fsio（注1）
0 1 : f1SIO
1 0 : f2SIO
1 1 : 不能设定

<CRS> CTS/RTS功能选择位（在bit4 = “0”时有效）
0 : 选择CTS功能（注2）

<TXPT> 发送寄存器空标志
0 : 发送寄存器中有数据（在发送中）
1 : 发送寄存器中无数据（发送结束）

<CRD> CTS/RTS禁止位
0 : 允许CTS/RTS功能

<NCH> 数据输出选择位
0 : TxDi/SDAi、SCLi引脚为CMOS输出
1 : TxDi/SDAi、SCLi引脚为N沟道漏极开路

<CKPOL> CLK极性选择位
0 : 在传送时钟的下降沿输出发送数据，在上升沿输入接收数据

<UFORM> 传送格式选择位
0 : LSB先

注1: 当PCLKR寄存器的PCLK0位为“1”时，选择时钟fssio。当PCLKR寄存器的PCLK0位为“0”时，选择时钟fsio。
注2: 请将对应引脚的端口方向位清“0”（输入模式）。

设定UART发送/接收控制寄存器2

UART发送/接收控制寄存器2 UCON【地址 0250h】

<u0irs> UART0发送中断源选择位
0 : 发送缓冲器空（TI = 1）

<u1irs> UART1发送中断源选择位
0 : 发送缓冲器空（TI = 1）

<CLKM0> 在bit5=“1”时有效

<CLKMD1> UART1的CLK/CLKS选择位1
0 : CLK输出仅为CLK1

<RCSP> UART0 CTS/RTS独立位
0 : CTS/RTS复用引脚

注1: 当PCLKR寄存器的PCLK0位为“1”时，选择时钟fssio。当PCLKR寄存器的PCLK0位为“0”时，选择时钟fsio。
注2: 请将对应引脚的端口方向位清“0”（输入模式）。

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串行 I/O 操作（时钟同步串行 I/O 模式下的发送）

设定 UARTi 发送/接收控制寄存器1（i = 0~2、5~7）

设定 UARTi 位速率寄存器（i = 0~2、5~7）

发送允许
串行 I/O 操作（时钟同步串行 I/O 模式下的发送）

写入发送数据

UART0发送缓冲寄存器 U0TB【地址 024Bh、024Ah】
UART1发送缓冲寄存器 U1TB【地址 025Bh、025Ah】
UART2发送缓冲寄存器 U2TB【地址 026Bh、026Ah】
UART5发送缓冲寄存器 U5TB【地址 028Bh、028Ah】
UART6发送缓冲寄存器 U6TB【地址 029Bh、029Ah】
UART7发送缓冲寄存器 U7TB【地址 02ABh、02AAh】

设置发送数据

当CTS输入电平 = “L”

开始发送

查看UARTi发送/接收控制寄存器的状态（i = 0~2, 5~7）

UART0发送/接收控制寄存器1 U0C1【地址 024Dh】
UART1发送/接收控制寄存器1 U1C1【地址 025Dh】

<Ti> 发送缓冲器空标志
0: 发送缓冲寄存器中有数据
1: 发送缓冲寄存器中无数据
（允许写入下一个发送数据）

UART2发送/接收控制寄存器1 U2C1【地址 026Dh】
UART5发送/接收控制寄存器1 U5C1【地址 028Dh】
UART6发送/接收控制寄存器1 U6C1【地址 029Dh】
UART7发送/接收控制寄存器1 U7C1【地址 02ADh】

<Ti> 发送缓冲器空标志
0: 发送缓冲寄存器中有数据
1: 发送缓冲寄存器中无数据
（允许写入下一个发送数据）

写入下一个发送数据

UART0发送缓冲寄存器 U0TB【地址 024Bh、024Ah】
UART1发送缓冲寄存器 U1TB【地址 025Bh、025Ah】
UART2发送缓冲寄存器 U2TB【地址 026Bh、026Ah】
UART5发送缓冲寄存器 U5TB【地址 028Bh、028Ah】
UART6发送缓冲寄存器 U6TB【地址 029Bh、029Ah】
UART7发送缓冲寄存器 U7TB【地址 02ABh、02AAh】

设置发送数据

发送结束
6. 参考文献

数据手册
M16C/65 群硬件手册
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修订记录

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