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2010年4月1日
瑞萨电子公司

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M16C/64 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/64 群单片机。

本篇资料中的参考例程也适用于 M16C 族产品中与 M16C/64 群具有相同 SFR（特殊功能寄存器）定义的产品。

由于 M16C 系列产品中有些功能会有所改进，请参看用户手册。如果使用本篇资料中所列功能时，请仔细检查每一步操作。

3. 选定功能

表 1. 选定功能

设定项目	设定内容		设定项目	设定内容	
传送时钟源	O	内部时钟（f1SIO/f2SIO/f8SIO/f32SIO）	发送中断请求产生条件	O	发送缓冲器空
		外部时钟（CLKi 引脚）			发送结束
$\overline{\text{CTS}}$ 功能	O	$\overline{\text{CTS}}$ 功能允许	输出传送时钟到多个引脚（注 1）	O	不选择
		$\overline{\text{CTS}}$ 功能禁止			选择
CLK 极性	O	在传送时钟的下降沿输出发送数据	数据逻辑选择功能	O	不反转
		在传送时钟的上升沿输出发送数据			反转
传送格式	O	LSB 先	TxD、RxD 的 I/O 极性反转位	O	不反转
		MSB 先			反转

注 1: 只能在 UART1 使用内部时钟时选择。当选择这个功能时，不能使用 UART1 的 $\overline{\text{CTS}}$ / $\overline{\text{RTS}}$ 功能，请将 $\overline{\text{CTS}}$ / $\overline{\text{RTS}}$ 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 $\overline{\text{CTSi}}$ 引脚的电平变为“L”时，发送开始（$\overline{\text{CTSi}}$ 引脚必须由接收方控制）。

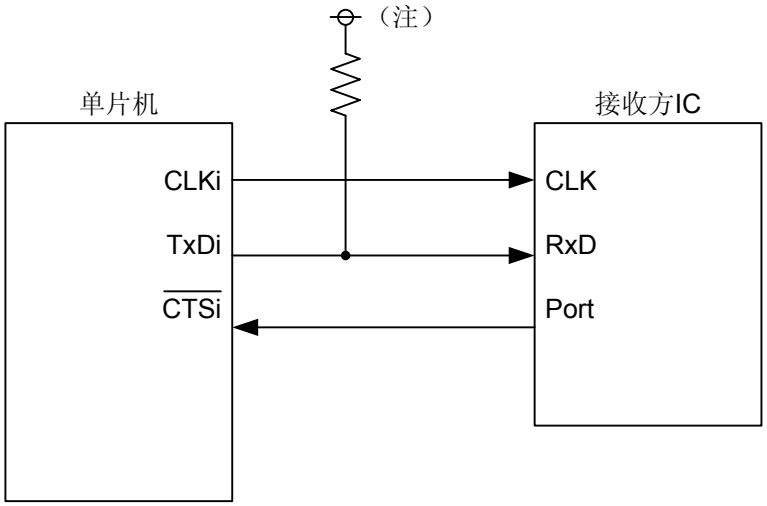
(3) 与传送时钟的第一个下降沿同步，UARTi 发送缓冲寄存器中发送数据被发送到 UARTi 发送寄存器中。此时，产生 UARTi 发送中断请求位变为“1”，发送数据的 bit0 也从 TxDi 引脚发送出去。然后，发送数据与下降沿同步按照从低到高的顺序逐位被发送出去。

(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。

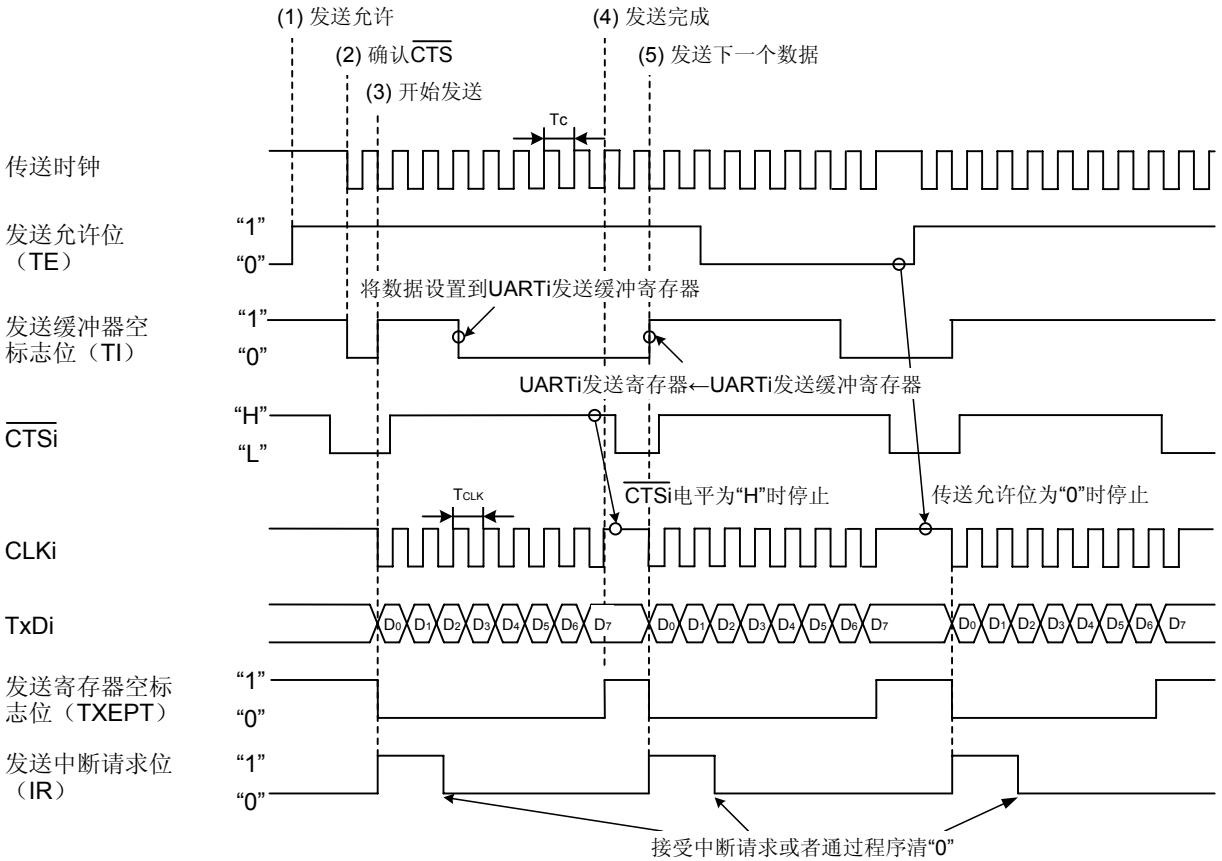
使用 UARTi 在时钟同步 I/O 模式下发送数据的工作时序图如下所示：

硬件连接示例



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



（）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”

$T_C = T_{CLK} = 2(n+1) / fi$
fi : BRGi计数源的频率（f_{1SIO}、f_{2SIO}、f_{8SIO}、f_{32SIO}）
n : BRGi寄存器的设定值

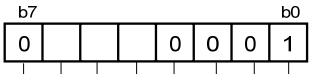
图 1. 使用 UARTi 在时钟同步 I/O 模式下发送数据的工作时序图

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/64 群的硬件手册。

设定UARTi发送/接收模式寄存器（i = 0~ 2、5~7）

UART0发送/接收模式寄存器 U0MR【地址 0248h】
UART1发送/接收模式寄存器 U1MR【地址 0258h】
UART2发送/接收模式寄存器 U2MR【地址 0268h】
UART5发送/接收模式寄存器 U5MR【地址 0288h】
UART6发送/接收模式寄存器 U6MR【地址 0298h】
UART7发送/接收模式寄存器 U7MR【地址 02A8h】



<SMD2~SMD0> 置为“001”

<CKDIR> 内部/外部时钟选择位
0 : 内部时钟

<STPS> 时钟同步I/O模式下无效

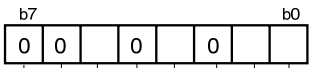
<PRY> 时钟同步I/O模式下无效

<PRYE> 时钟同步I/O模式下无效

<IOPOL> TxD、RxD输入/输出极性反转位
通常情况下设置为“0”

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> UiBRG计数源选择位
b1 b0
0 0 : 选择f_{1SIO}或者f_{2SIO}
0 1 : 选择f_{8SIO}
1 0 : 选择f_{32SIO}
1 1 : 不能设定

<CRS> $\overline{CTS}$/$\overline{RTS}$功能选择位（在bit4 = “0”时有效）
0 : 选择$\overline{CTS}$功能（注1）

<TXEPT> 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> $\overline{CTS}$/$\overline{RTS}$禁止位
0 : 允许$\overline{CTS}$/$\overline{RTS}$功能

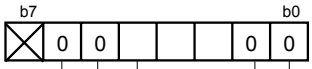
<NCH> 数据输出选择位
0 : TxDi/SDAi、SCLi引脚为CMOS输出
1 : TxDi/SDAi、SCLi引脚为N沟道漏极开路

<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：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）

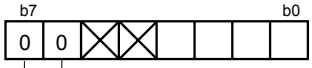
<U1IRS> UART1发送中断源选择位
0 : 发送缓冲器空（TI = 1）

<CLKMD0> 在bit5 = “1”时有效

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

<RCSP> UART0 $\overline{CTS}/\overline{RTS}$独立位
0 : $\overline{CTS}/\overline{RTS}$复用引脚

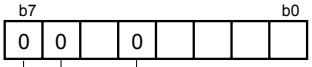
设定UARTi发送/接收控制寄存器1（i = 0~2、5~7）



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】

<UiLCH> 数据逻辑选择位
0 : 无反转

<UiERE> 错误信号输出允许位
在时钟同步I/O模式下清“0”



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】

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

<UiLCH> 数据逻辑选择位
0 : 无反转

<UiERE> 错误信号输出允许位
在时钟同步I/O模式下清“0”

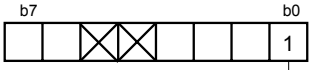
设定UARTi位速率寄存器（i = 0~2、5~7）

UART0位速率寄存器 U0BRG 【地址 0249h】
UART1位速率寄存器 U1BRG 【地址 0259h】
UART2位速率寄存器 U2BRG 【地址 0269h】
UART5位速率寄存器 U5BRG 【地址 0289h】
UART6位速率寄存器 U6BRG 【地址 0299h】
UART7位速率寄存器 U7BRG 【地址 02A9h】

在00h~FFh范围内进行设定（注1）

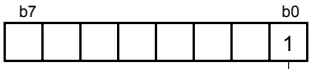
注1：请在发送/接收停止时对UARTi位速率寄存器进行写操作。

发送允许



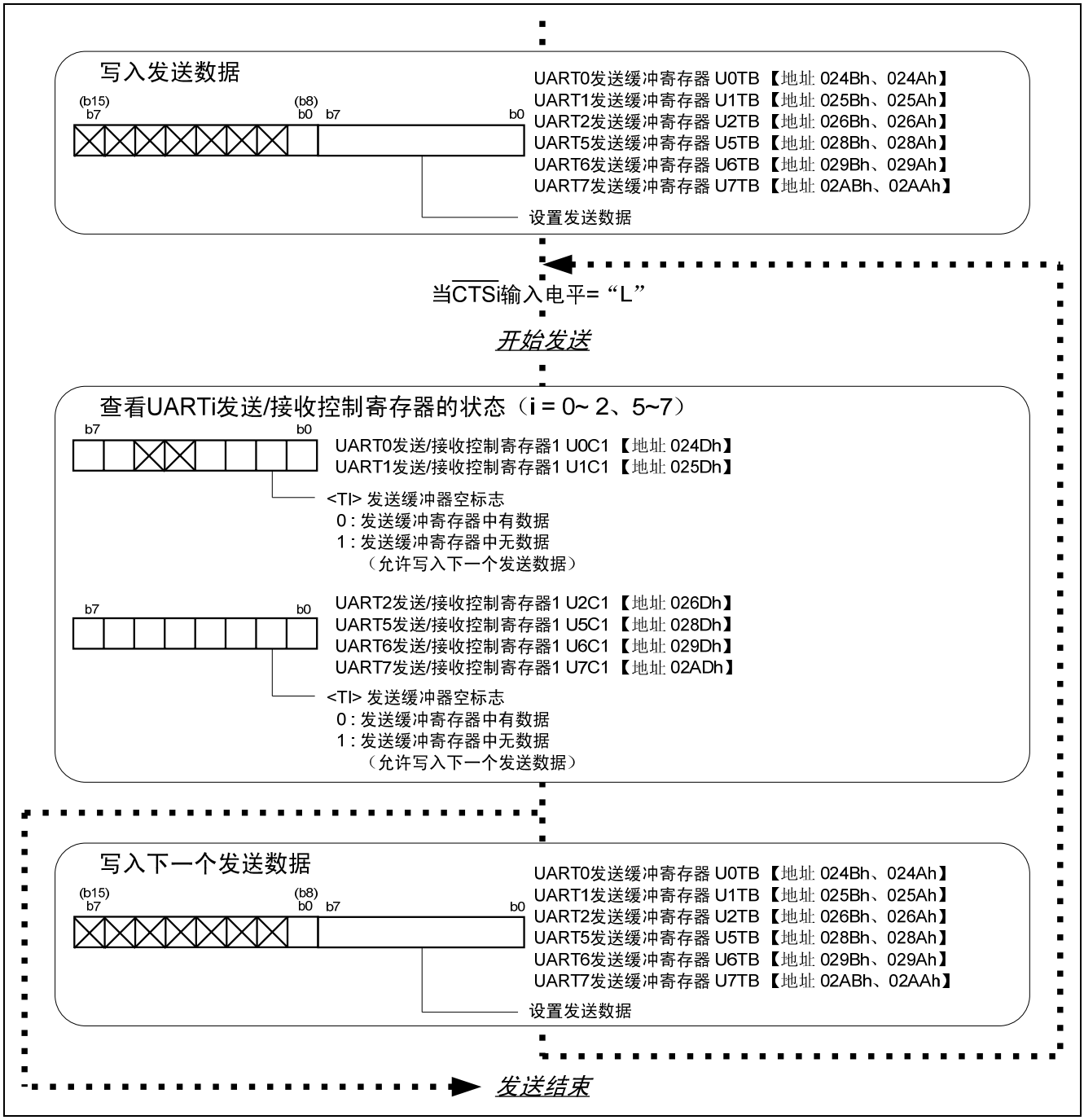
UART0发送/接收控制寄存器1 U0C1 【地址 024Dh】
UART1发送/接收控制寄存器1 U1C1 【地址 025Dh】

<TE> 发送允许位
1 : 允许发送



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】

<TE> 发送允许位
1 : 允许发送


写入发送数据
(b15) b7
(b8) b0 b7
b0
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CTSi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）
b7 b0
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
发送结束

6. 参考文献

数据手册

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