AN13833

LPC86x UART的接收IDLE（空闲）中断

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应用笔记

文档信息

信息	内容
关键词	LPC86x、USART、UART
摘要	LPC86x是一款基于Arm Cortex-M0+的低成本32位MCU系列，它支持三个USART、一个I^2C接口、一个I3C接口和两个SPI接口。LPC86x支持高达64KB的闪存和8KB的SRAM。

1 介绍

LPC86x是一款基于Arm Cortex-M0+的低成本32位MCU系列，它支持三个USART、一个I²C接口、一个I3C接口和两个SPI接口。LPC86x支持高达64KB的闪存和8KB的SRAM。

LPC86x在LPC84x的基础上更新了UART，能支持接收空闲超时中断，也就是说只有LPC86x支持UART接收空闲超时标志位和中断，LPC80x、LPC81x、LPC82x、LPC83x和LPC84x等均不支持。

LPC86x的UART接收空闲超时标志位和中断只是一个标志，此中断不能用于终止UART DMA传输。如果检测到UART接收空闲超时，必须通过软件来终止DMA传输。

当LPC86x的UART接收器处于空闲状态的时间达到一定长度后（由**CTL.RXIDLETOCFG**设置），寄存器位**STAT.RXIDLETO**标志被置位，并触发一个中断（若启用）。将1写入**STAT.RXIDLETO**会清除该标志位。当该标志位被清除后，直到接收器接收到一个新的字符（非空闲字符）后它才能再次被置位。

2 寄存器

配置以下寄存器，可以启用UART接收空闲超时中断并获取空闲超时状态。

2.1 USART STAT寄存器

USART STAT寄存器主要提供了一组USART状态标志位（不包括FIFO状态）供软件读取。除了那些只读标志位外，其他标志位可以通过向STAT的相应位写入1来清除。那些只读且不能通过软件清除的中断状态标志位可以使用INTENCLR寄存器来屏蔽；参见表1。

用于接收到噪声、发生奇偶校验错误和帧错误的错误标志位在检测到后会立即被置位，并保持置位状态，直到被STAT中的软件操作清除。

注意：*接收空闲超时标志位使用STAT寄存器的位：17。*

STAT：偏移量 = 0x008

表1. USART状态寄存器（STAT）中的接收空闲超时状态位

位	名称	类型	描述
17	RXIDLETO	R/W	RX IDLE（空闲）超时标志。 当接收器处于空闲状态的时间达到一定长度后（由CTL.RXIDLETOCFG设置），该标志位被置位。写入 1 会清除该标志位并减少相应的中断。当该标志位被清除后，直到接收器接收到一个新的字符（非空闲字符）后它才能再次被置位。

2.2 USART控制寄存器

该控制寄存器用于控制USART操作的各个方面，这些方面在操作期间很可能发生变化。

USART **CTL.RXIDLETOCFG**（位20:18）寄存器用于设置接收空闲超时时间。参见表2。

CTRL：偏移量 = 0x004

表2. USART控制寄存器（CTL）中的接收空闲超时配置位

位	名称	类型	描述
20:18	RXIDLETOCFG	R/W	RX IDLE（空闲）超时配置。

表2. USART控制寄存器（CTL）中的接收空闲超时配置位

位	名称	类型	描述
			配置在RXIDLETO标志被置位之前必须接收的空闲字符的个数。空闲字符是指整个帧全为1的字符，包括起始位、数据位和停止位（接收线上没有活动）。 000b—1个空闲字符 001b—2个空闲字符 010b—4个空闲字符 011b—8个空闲字符 100b—16个空闲字符 101b—32个空闲字符 110b—64个空闲字符 111b—128个空闲字符

2.3 USART INTENSET寄存器

INTENSET（中断使能读取和置位）寄存器用于使能各种USART中断源。INTENSET中的使能位被映射到与STAT寄存器中的标志位相对应的位置。可以从这个寄存器读取完整的中断使能配置。将1写入该寄存器的已实现位可以使这些位置位。INTENCLR寄存器用于清除此寄存器中的位。参见表3。

INTENSET：偏移量 = 0x00C

表3. USART中断使能读取和置位寄存器（INTENSET）中的接收空闲超时INTSET位

位	名称	类型	描述
17	RXIDLETOEN	R/W	RX IDLE（空闲）超时中断使能。 0：RX IDLE（空闲）超时中断关闭。 1：当STAT.RXIDLETO置位时，会触发一个中断。

2.4 USART INTENCLR寄存器

INTENCLR寄存器用于清除INTENSET寄存器中的位。参见表4。

INTCLR: 偏移量 = 0x010

表4. USART中断使能清除寄存器（INTENCLR）中的接收空闲超时INTCLR位

位	名称	类型	描述
17	RXIDLETOCLR	WO（只写）	写1以清除INTENSET.RXIDLETOEN。 写0无效。

2.5 USART INTSTAT寄存器

这个只读的INTSTAT寄存器提供了一个当前启用的中断标志位的视图，这可以简化软件对中断的处理。有关中断标志位的详细说明，请参见表5。

INTCLR：偏移量 = 0x010

表5. USART中断状态寄存器（INTSTAT）中的接收空闲超时状态位

位	名称	类型	描述
17	RXIDLETOINT	RO（只读）	RX IDLE（空闲）超时中断标志位。

3 软件

3.1 软件配置流程

步骤1：使用Switch Matrix API将一个引脚配置为USART的TXD和RXD。

步骤2：使用CLOCK_Select()选择USART时钟源。

步骤3：使用USART_GetDefaultConfig()初始化USART配置参数。

步骤4：使用USART_Init()初始化USART。

步骤5：**使用USARTx->CTL启用接收空闲超时定时。**

步骤6：**使用USART_EnableInterrupts()设置USART中断。**

步骤7：使用EnableIRQ()在NVIC中启用USART中断。

当USART接收到一个空闲超时后，USARTx->STAT的位17将被置为1并触发USARTx_IRQHandler()。

3.2 源代码

UART接收空闲超时的测试代码如下：

```
void USART0_IRQHandler(void)
{
    GPIO->NOT[1] = 1UL<<6;  // toggle GPIO
    uint8_t data;
    uint32_t status;
    status = USART0->STAT; // Get USART status
    /* If new data arrived. */
    if ((kUSART_RxReady) & status)
    {
        data = (uint8_t)USART0->RXDAT & 0xFFU; // Received 1 byte
    }
    if((status&0x20000) != 0) // Receive idle time out
    {
        USART0->STAT = (1UL << 17); // Clear USART timeout int Status flag
    }
}
/*!
 * @brief Main function
*/
int main(void)
{
    usart_config_t config;
    /* Define the init structure for the output pin*/
    gpio_pin_config_t output_config = {
        kGPIO_DigitalOutput,
        1,
    };
    /* Board pin, clock, debug console init */
    CLOCK_EnableClock(kCLOCK_Iocon);     /* Enables clock for IOCON.: enable */
```

```
    CLOCK_EnableClock(kCLOCK_Swm);        /* Enables clock for switch matrix.:
 enable */
    CLOCK_EnableClock(kCLOCK_Gpio0);      /* Enables the clock for the GPIO0
 module */
    CLOCK_EnableClock(kCLOCK_Gpio1);      /* Enables the clock for the GPIO1
 module */
    /* USART0 */
    IOCON->PIO[IOCON_INDEX_PIO1_16] =  (IOCON_MODE_PULLUP | IOCON_HYS_EN);
    IOCON->PIO[IOCON_INDEX_PIO1_17] =  (IOCON_MODE_PULLUP | IOCON_HYS_EN);
    SWM_SetMovablePinSelect(SWM0, kSWM_USART0_TXD, kSWM_PortPin_P1_17); /*
 USART0_TXD connect to P1_17 */
    SWM_SetMovablePinSelect(SWM0, kSWM_USART0_RXD, kSWM_PortPin_P1_16);
  /* USART0_RXD connect to P1_16 */
    /* Select the main clock as source clock of USART0. */
    CLOCK_Select(kUART0_Clk_From_MainClk);
    USART_GetDefaultConfig(&config);
    config.enableRx     = true;
    config.enableTx     = true;
    config.baudRate_Bps = 115200;
    /* Initialize the USART with configuration. */
    USART_Init(USART0, &config, SystemCoreClock);
    USART0->CTL &= (0xFFC3FFFF);  // Clean USART CTL.RXIDLETOCFG
    USART0->CTL |= (0UL << 18);   // 0 idle characters
    USART_EnableInterrupts(USART0, (uint32_t)((kUSART_RxReadyInterruptEnable)|
(1UL<<17)));
    USART_ClearStatusFlags(USART0, (1UL << 17));
    EnableIRQ(USART0_IRQn);
    /* P1_6 */
    IOCON->PIO[IOCON_INDEX_PIO1_6]  =  (IOCON_MODE_PULLUP | IOCON_HYS_EN);
  /* P1_6 output */
    GPIO_PinInit(GPIO, 1, 6, &output_config);
    while(1)
    }
}
```

4 超时定时

接收空闲超时定时时间是在CTRL.RXIDLETOCFG寄存器（位[20:18]）中配置的。该位用来配置在RXIDLETO标志位被置位之前必须接收到的空闲字符的个数。空闲字符是指整个帧全为1的字符，包括起始位、数据位和停止位。

4.1 什么是字符

图1是一个标准的UART传输数据包，包括起始位、数据帧、奇偶校验位和停止位。

Start Bit (1 bit)	Data Frame (7 to 9 Data Bits)	Parity Bits (0 to 1 bit)	Stop Bits (1 to 2bits)

图1. UART传输字符包

4.2 RXIDLETOCFG设置后的效果

本部分以UART设置为115200bps波特率、8个数据位、无奇偶校验位、1个停止位（115200, 8n1）为例。此设置是UART应用中常见的设置。

对于115200, 8n1，该字符的定时时间为86.81μS = 1/（115200/（1起始位+8数据位+0校验位+1停止位））

若RXIDLETOCFG设置为000b，1个空闲字符表示86.81μS。

若RXIDLETOCFG设置为001b，2个空闲字符表示173.62μS。

若RXIDLETOCFG设置为010b，4个空闲字符表示347.24μS。

若RXIDLETOCFG设置为011b，8个空闲字符表示694.48μS。

若RXIDLETOCFG设置为100b，16个空闲字符表示1388.96μS。

若RXIDLETOCFG设置为101b，32个空闲字符表示2777.92μS。

若RXIDLETOCFG设置为110b，64个空闲字符表示5555.84μS。

若RXIDLETOCFG设置为111b，128个空闲字符表示11111.68μS。

在示例代码中，UART中断处理程序设置了一个GPIO切换。当UART接收到有效数据且发生空闲超时后，该GPIO会切换状态，并将UART中断处理程序分配到SRAM中，从而以更高的精度测量定时时间。不同**RXIDLETOCFG**设置下的超时定时时间如下图所示。

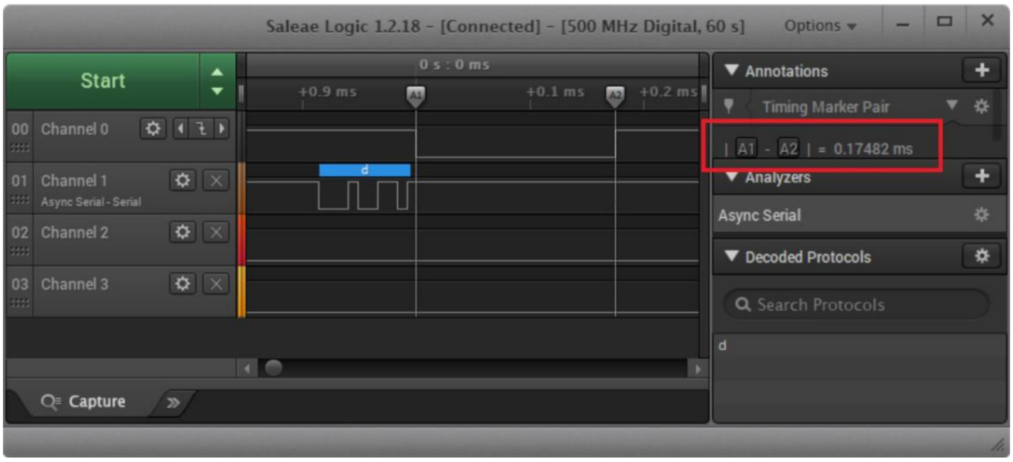

图2. 当RXIDLETOCFG设置为000b时，接收空闲超时的定时时间

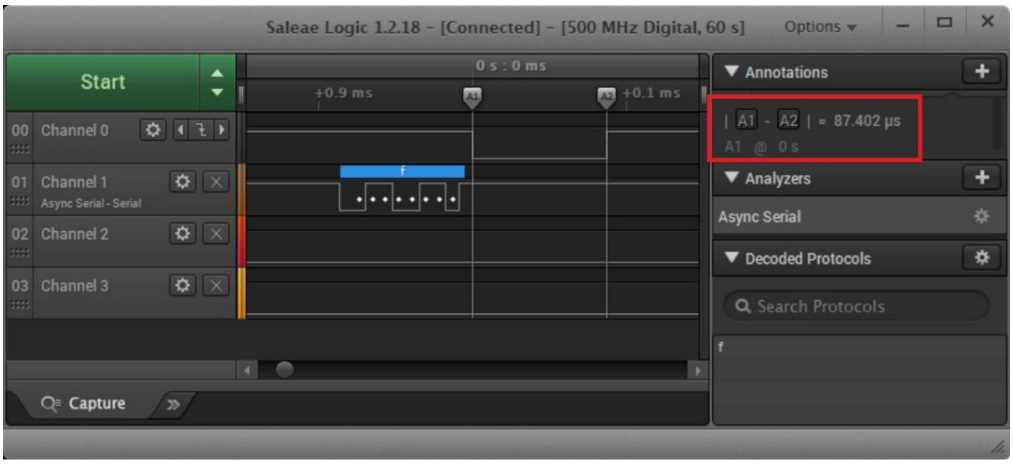

图3. 当RXIDLETOCFG设置为001b时，接收空闲超时的定时时间

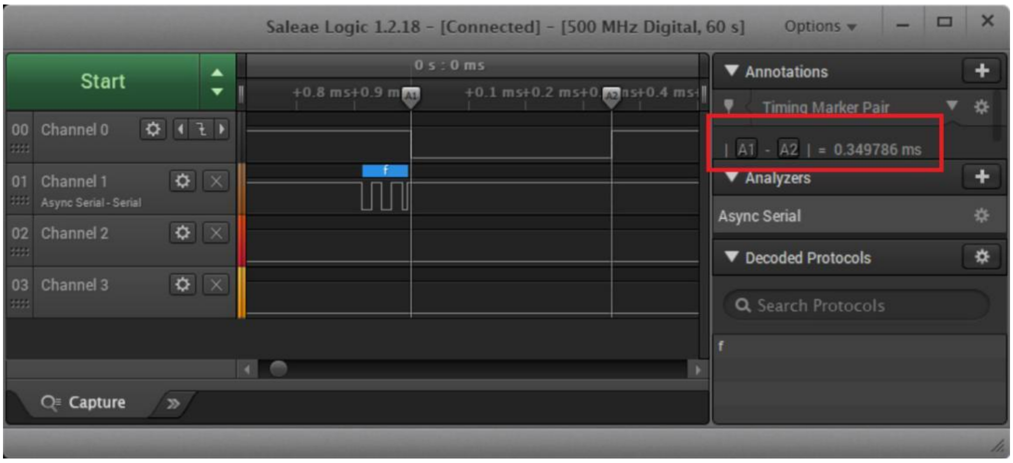

图4. 当RXIDLETOCFG设置为010b时，接收空闲超时的定时时间

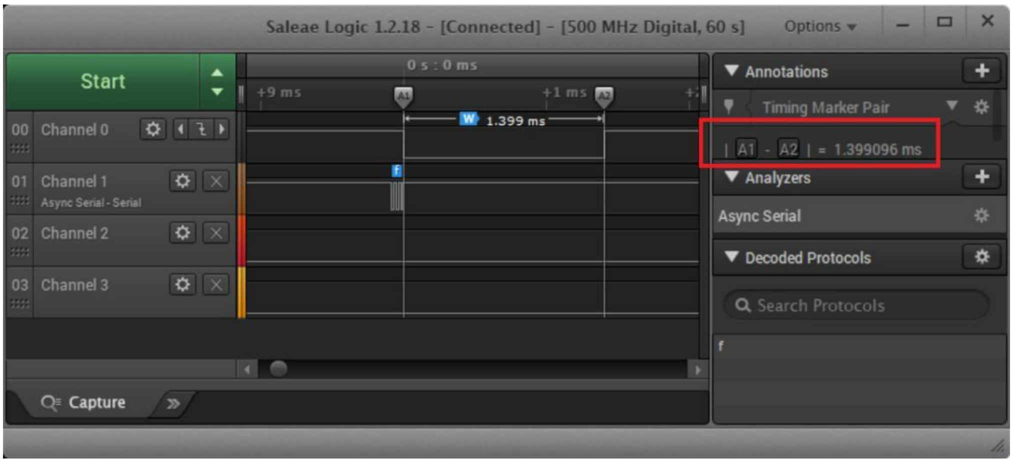

图5. 当RXIDLETOCFG设置为011b时，接收空闲超时的定时时间

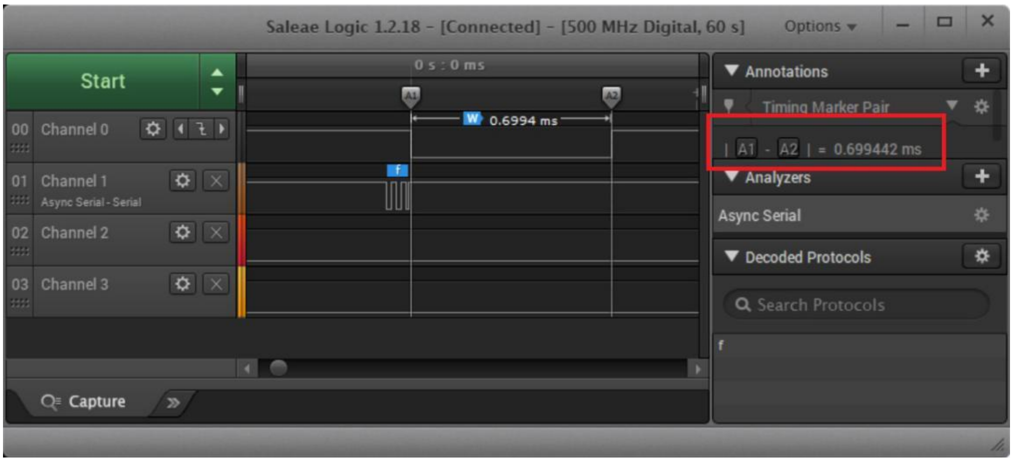

图6. 当RXIDLETOCFG设置为100b时，接收空闲超时的定时时间

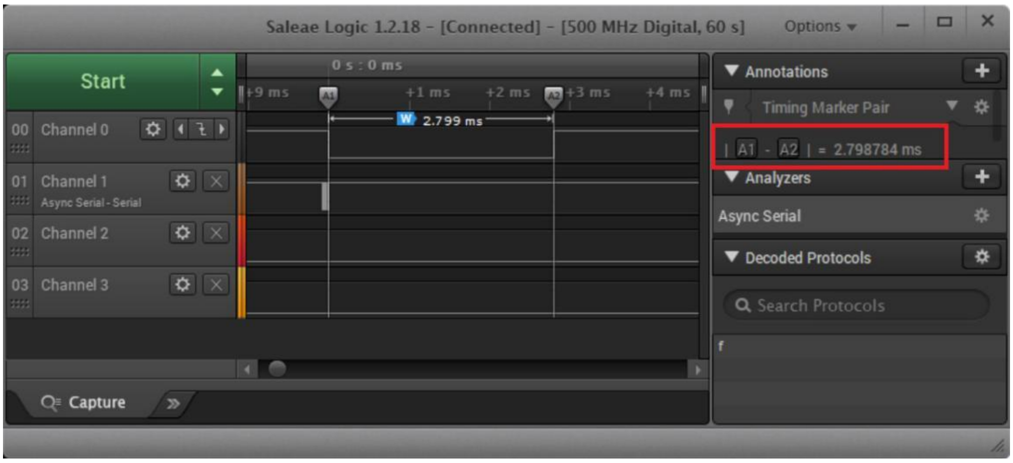

图7. 当RXIDLETOCFG设置为101b时，接收空闲超时的定时时间

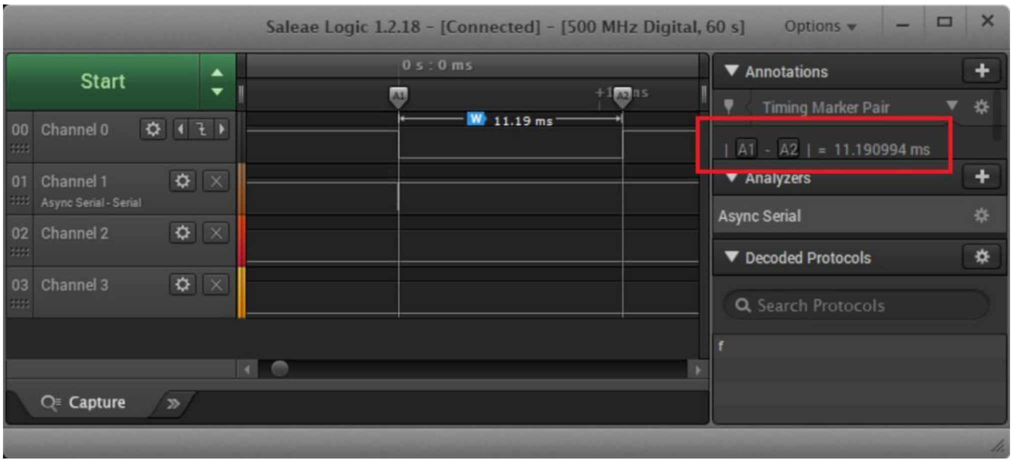

图8. 当RXIDLETOCFG设置为110b时，接收空闲超时的定时时间

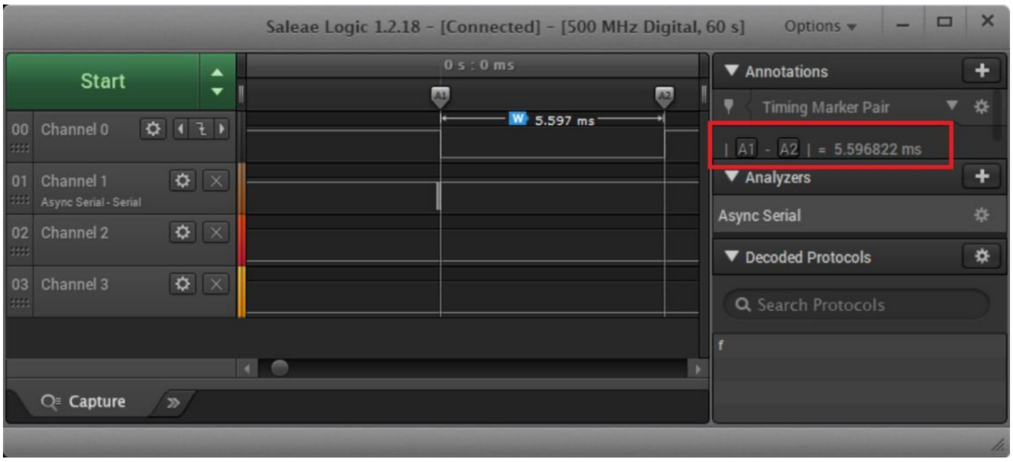

图9. 当RXIDLETOCFG设置为111b时，接收空闲超时的定时时间

5 结论

本应用笔记介绍了LPC86x USART接收空闲超时的功能。通过此超时功能的支持，可以通过软件终止DMA，或从UART接收一串未知长度的数据。

6 参考资料

[1]《LPC86x 用户手册》（文档UM11607）

7 修订历史

表6汇总了本文档所做的更改

表6. 修订历史

版本号	日期	实质性变更
第0版	2023年5月10日	初版发布

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