Ameba-Z WAKEUP ON UART

This document introduces usage of UART & LOGUART WAKEUP.

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1. Summary

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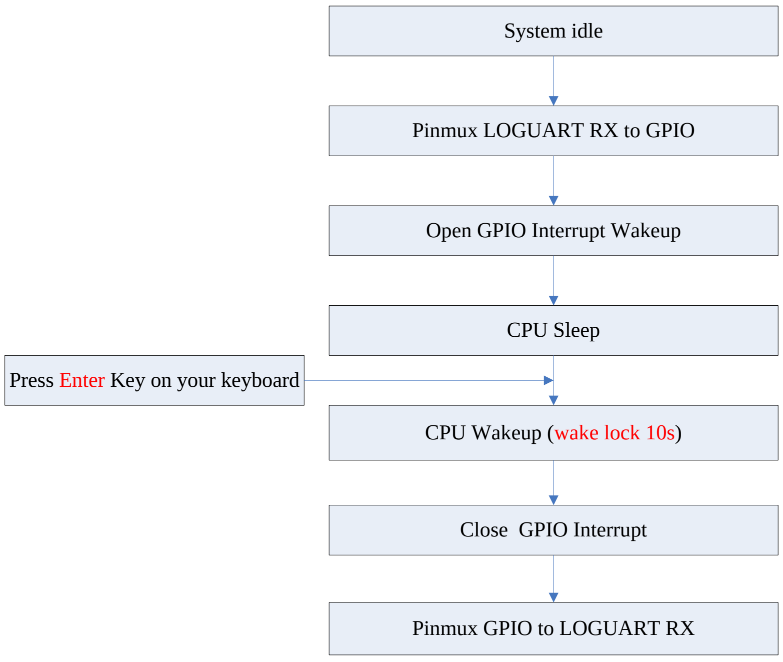
2. LOGUART wakeup

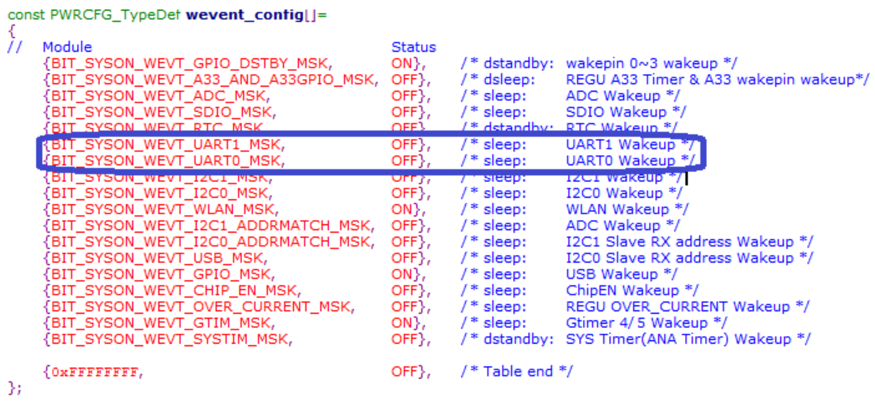
LOGUART is not in wakeup sources of sleep mode. To support wake from LOGUART, we can treat LOGUART signal as GPIO interrupt signal and then wake system by GPIO interrupt.
SDK will auto switch LOGUART pin to GPIO pin and open GPIO wakeup function when enter sleep mode, and switch back to LOGUART pin when resume, so you can wakeup sleep mode when press "Enter" key two times.


System idle
Pinmux LOGUART RX to GPIO
Open GPIO Interrupt Wakeup
CPU Sleep
Press Enter Key on your keyboard
CPU Wakeup (wake lock 10s)
Close GPIO Interrupt
Pinmux GPIO to LOGUART RX

SDK set 10 seconds wake_lock for LOGUART wakeup, so system will enter sleep mode again after 10 seconds.

3. Normal UART wakeup

UART0 and UART1 can receive data under sleep mode. You should open UART wakeup event in SDK wevent_config, then UART will wakeup system when receive data.

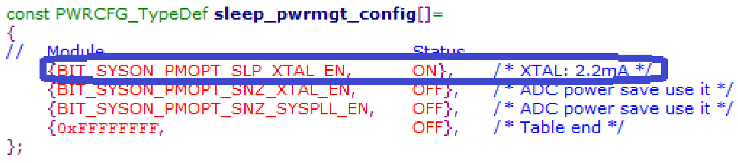


```
const PWRCFG_TypeDef wevent_config[]=
{
//	Module                                  Status
	{BIT_SYSON_WEVT_GPIO_DSTBY_MSK,         ON},    /* dstandby:  wakepin 0~3 wakeup */
	{BIT_SYSON_WEVT_A33_AND_A33GPIO_MSK,    OFF},   /* dsleep:    REGU A33 Timer & A33 wakepin wakeup*/
	{BIT_SYSON_WEVT_ADC_MSK,                OFF},   /* sleep:     ADC Wakeup */
	{BIT_SYSON_WEVT_SDIO_MSK,               OFF},   /* sleep:     SDIO Wakeup */
	{BIT_SYSON_WEVT_RTC_MSK,                OFF},   /* dstandby:  RTC Wakeup */
	{BIT_SYSON_WEVT_UART1_MSK,              OFF},   /* sleep:     UART1 Wakeup */
	{BIT_SYSON_WEVT_UART0_MSK,              OFF},   /* sleep:     UART0 Wakeup */
	{BIT_SYSON_WEVT_I2C1_MSK,               OFF},   /* sleep:     I2C1 Wakeup */
	{BIT_SYSON_WEVT_I2C0_MSK,               OFF},   /* sleep:     I2C0 Wakeup */
	{BIT_SYSON_WEVT_WLAN_MSK,               ON},    /* sleep:     WLAN Wakeup */
	{BIT_SYSON_WEVT_I2C1_ADDRMATCH_MSK,     OFF},   /* sleep:     ADC Wakeup */
	{BIT_SYSON_WEVT_I2C0_ADDRMATCH_MSK,     OFF},   /* sleep:     I2C1 Slave RX address Wakeup */
	{BIT_SYSON_WEVT_USB_MSK,                OFF},   /* sleep:     I2C0 Slave RX address Wakeup */
	{BIT_SYSON_WEVT_GPIO_MSK,               ON},    /* sleep:     USB Wakeup */
	{BIT_SYSON_WEVT_CHIP_EN_MSK,            OFF},   /* sleep:     ChipEN Wakeup */
	{BIT_SYSON_WEVT_OVER_CURRENT_MSK,       OFF},   /* sleep:     REGU OVER_CURRENT Wakeup */
	{BIT_SYSON_WEVT_GTIM_MSK,               ON},    /* sleep:     Gtimer 4/5 Wakeup */
	{BIT_SYSON_WEVT_SYSTIM_MSK,             OFF},   /* dstandby:  SYS Timer(ANA Timer) Wakeup */

	{0xFFFFFFFF,                            OFF},   /* Table end */
};
```

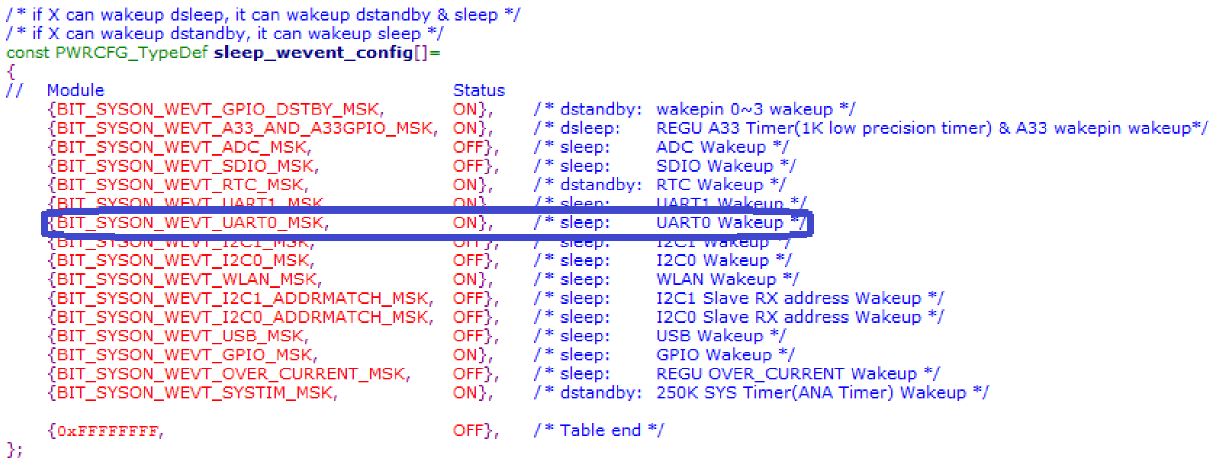
There are two solutions used for UART RX when CPU sleeps:

3.1. High Speed Mode

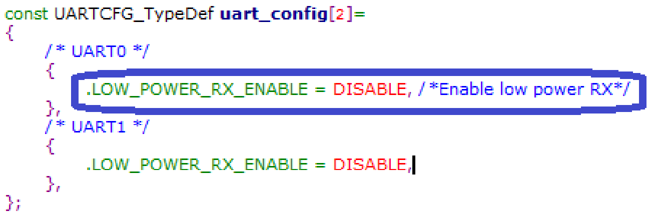
If you use UART under high speed mode, you should configure SDK like following:



```
const PWRCFG_TypeDef sleep_pwrmgt_config[]=
{
//	Module                          Status
	{BIT_SYSON_PMOPT_SLP_XTAL_EN,       ON},    /* XTAL: 2.2mA */
	{BIT_SYSON_PMOPT_SNZ_XTAL_EN,       OFF},   /* ADC power save use it */
	{BIT_SYSON_PMOPT_SNZ_SYSPLL_EN,     OFF},   /* ADC power save use it */
	{0xFFFFFFFF,                        OFF},   /* Table end */
};
```



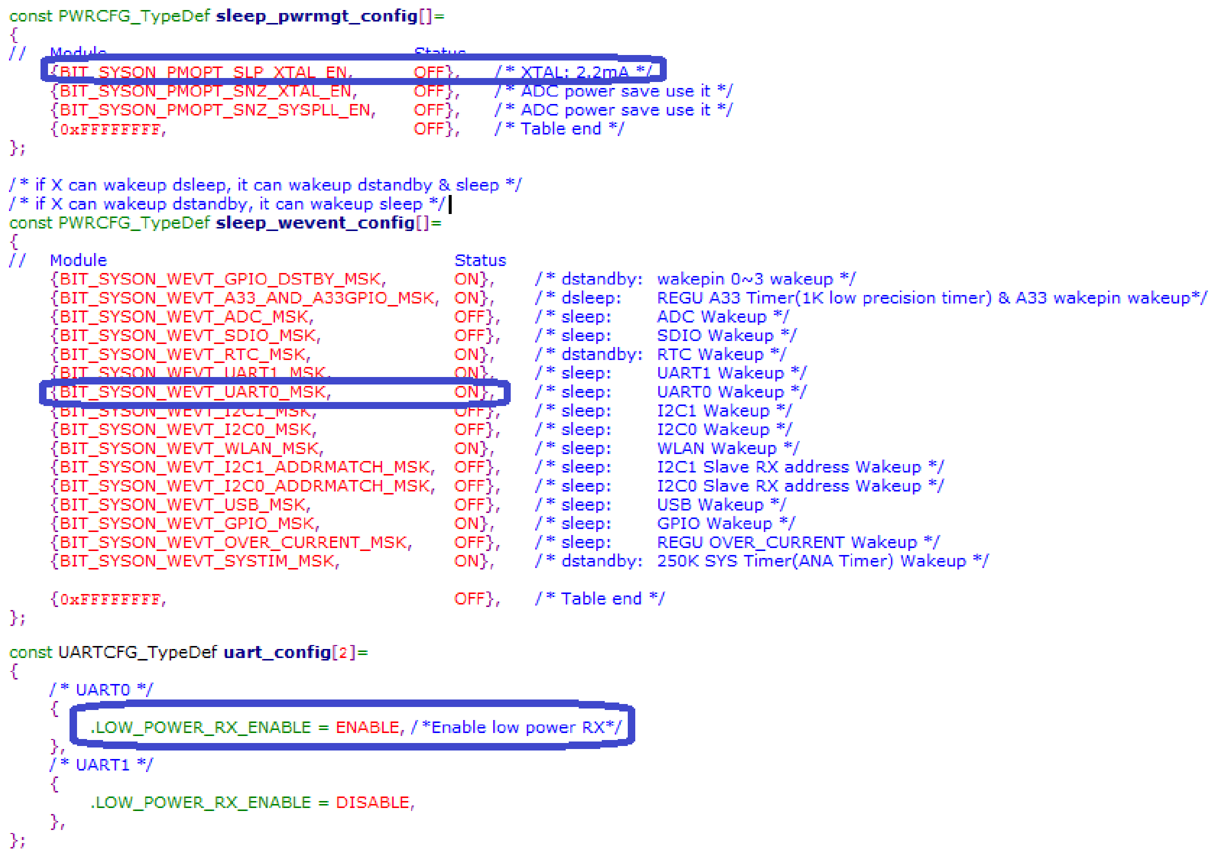
```
/* if X can wakeup dsleep, it can wakeup dstandby & sleep */
/* if X can wakeup dstandby, it can wakeup sleep */
const PWRCFG_TypeDef sleep_wevent_config[]=
{
//	Module                                  Status
	{BIT_SYSON_WEVT_GPIO_DSTBY_MSK,         ON},    /* dstandby:  wakepin 0~3 wakeup */
	{BIT_SYSON_WEVT_A33_AND_A33GPIO_MSK,    ON},    /* dsleep:    REGU A33 Timer(1K low precision timer) & A33 wakepin wakeup*/
	{BIT_SYSON_WEVT_ADC_MSK,                OFF},   /* sleep:     ADC Wakeup */
	{BIT_SYSON_WEVT_SDIO_MSK,               OFF},   /* sleep:     SDIO Wakeup */
	{BIT_SYSON_WEVT_RTC_MSK,                ON},    /* dstandby:  RTC Wakeup */
	{BIT_SYSON_WEVT_UART1_MSK,              ON},    /* sleep:     UART1 Wakeup */
	{BIT_SYSON_WEVT_UART0_MSK,              ON},    /* sleep:     UART0 Wakeup */
	{BIT_SYSON_WEVT_I2C1_MSK,               OFF},   /* sleep:     I2C1 Wakeup */
	{BIT_SYSON_WEVT_I2C0_MSK,               OFF},   /* sleep:     I2C0 Wakeup */
	{BIT_SYSON_WEVT_WLAN_MSK,               ON},    /* sleep:     WLAN Wakeup */
	{BIT_SYSON_WEVT_I2C1_ADDRMATCH_MSK,     OFF},   /* sleep:     I2C1 Slave RX address Wakeup */
	{BIT_SYSON_WEVT_I2C0_ADDRMATCH_MSK,     OFF},   /* sleep:     I2C0 Slave RX address Wakeup */
	{BIT_SYSON_WEVT_USB_MSK,                OFF},   /* sleep:     USB Wakeup */
	{BIT_SYSON_WEVT_GPIO_MSK,               ON},    /* sleep:     GPIO Wakeup */
	{BIT_SYSON_WEVT_OVER_CURRENT_MSK,       OFF},   /* sleep:     REGU OVER_CURRENT Wakeup */
	{BIT_SYSON_WEVT_SYSTIM_MSK,             ON},    /* dstandby:  250K SYS Timer(ANA Timer) Wakeup */

	{0xFFFFFFFF,                            OFF},   /* Table end */
};
```



```
const UARTCFG_TypeDef uart_config[2]=
{
	/* UART0 */
	{
		.LOW_POWER_RX_ENABLE = DISABLE, /*Enable low power RX*/
	},
	/* UART1 */
	{
		.LOW_POWER_RX_ENABLE = DISABLE,
	},
};
```

3.2. Low Power Mode

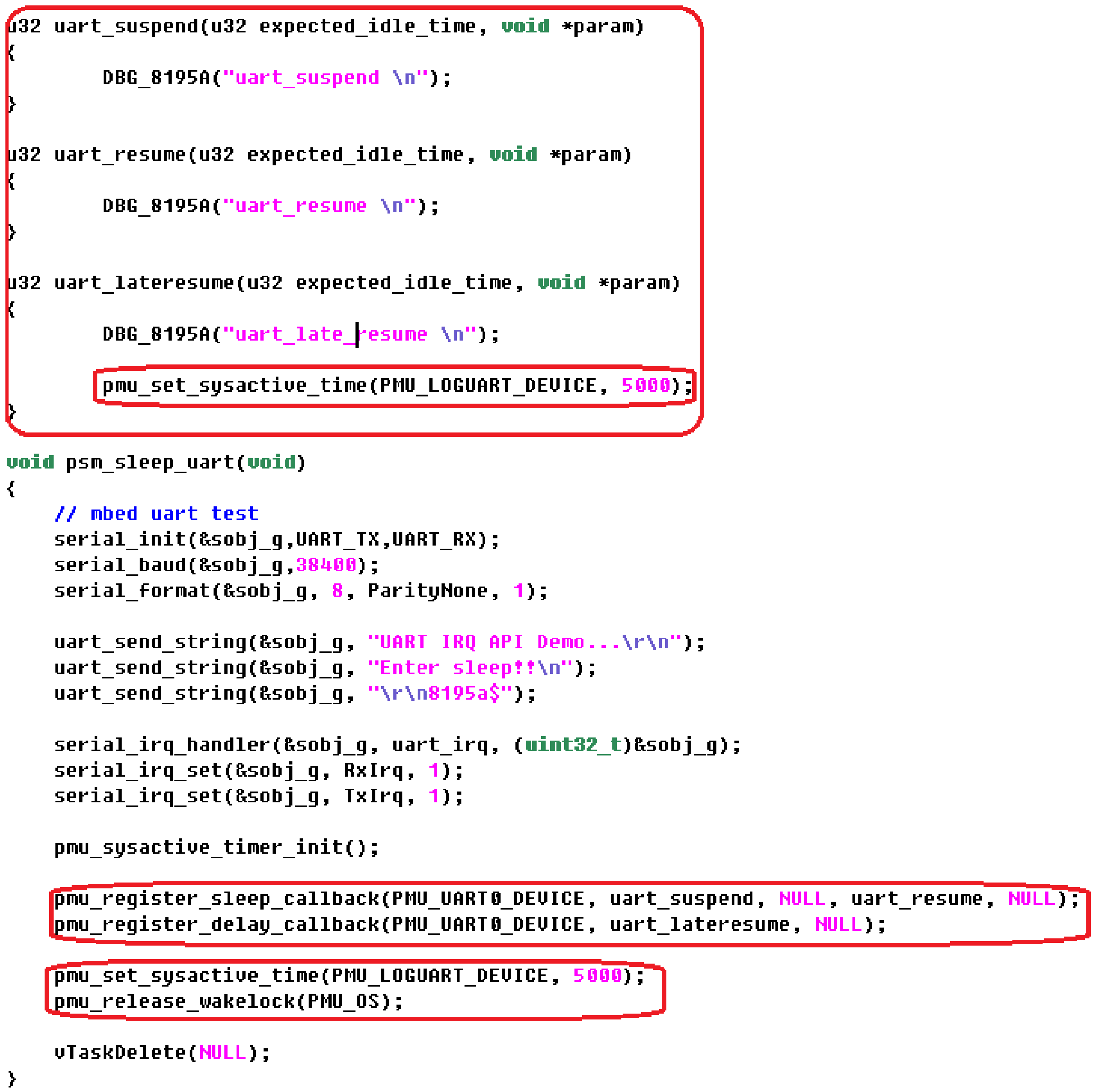
If you use UART under low power mode, you should configure SDK like following:



```
const PWRCFG_TypeDef sleep_pwrmgt_config[]=
{
//    Module                              Status
    {BIT_SYSON_PMOPT_SLP_XTAL_EN,         OFF},     /* XTAL: 2.2mA */
    {BIT_SYSON_PMOPT_SNZ_XTAL_EN,         OFF},     /* ADC power save use it */
    {BIT_SYSON_PMOPT_SNZ_SYSPLL_EN,       OFF},     /* ADC power save use it */
    {0xFFFFFFFF,                          OFF},     /* Table end */
};

/* if X can wakeup dsleep, it can wakeup dstandby & sleep */
/* if X can wakeup dstandby, it can wakeup sleep */
const PWRCFG_TypeDef sleep_wevent_config[]=
{
//    Module                                   Status
    {BIT_SYSON_WEVT_GPIO_DSTBY_MSK,            ON},      /* dstandby:  wakepin 0~3 wakeup */
    {BIT_SYSON_WEVT_A33_AND_A33GPIO_MSK,       ON},      /* dsleep:    REGU A33 Timer(1K low precision timer) & A33 wakepin wakeup*/
    {BIT_SYSON_WEVT_ADC_MSK,                   OFF},     /* sleep:     ADC Wakeup */
    {BIT_SYSON_WEVT_SDIO_MSK,                  OFF},     /* sleep:     SDIO Wakeup */
    {BIT_SYSON_WEVT_RTC_MSK,                   ON},      /* dstandby:  RTC Wakeup */
    {BIT_SYSON_WEVT_UART1_MSK,                 ON},      /* sleep:     UART1 Wakeup */
    {BIT_SYSON_WEVT_UART0_MSK,                 ON},      /* sleep:     UART0 Wakeup */
    {BIT_SYSON_WEVT_I2C1_MSK,                  OFF},     /* sleep:     I2C1 Wakeup */
    {BIT_SYSON_WEVT_I2C0_MSK,                  OFF},     /* sleep:     I2C0 Wakeup */
    {BIT_SYSON_WEVT_WLAN_MSK,                  ON},      /* sleep:     WLAN Wakeup */
    {BIT_SYSON_WEVT_I2C1_ADDRMATCH_MSK,        OFF},     /* sleep:     I2C1 Slave RX address Wakeup */
    {BIT_SYSON_WEVT_I2C0_ADDRMATCH_MSK,        OFF},     /* sleep:     I2C0 Slave RX address Wakeup */
    {BIT_SYSON_WEVT_USB_MSK,                   OFF},     /* sleep:     USB Wakeup */
    {BIT_SYSON_WEVT_GPIO_MSK,                  ON},      /* sleep:     GPIO Wakeup */
    {BIT_SYSON_WEVT_OVER_CURRENT_MSK,          OFF},     /* sleep:     REGU OVER_CURRENT Wakeup */
    {BIT_SYSON_WEVT_SYSTIM_MSK,                ON},      /* dstandby:  250K SYS Timer(ANA Timer) Wakeup */

    {0xFFFFFFFF,                               OFF},     /* Table end */
};

const UARTCFG_TypeDef uart_config[2]=
{
    /* UART0 */
    {
        .LOW_POWER_RX_ENABLE = ENABLE, /*Enable low power RX*/
    },
    /* UART1 */
    {
        .LOW_POWER_RX_ENABLE = DISABLE,
    },
};
```

4. Example

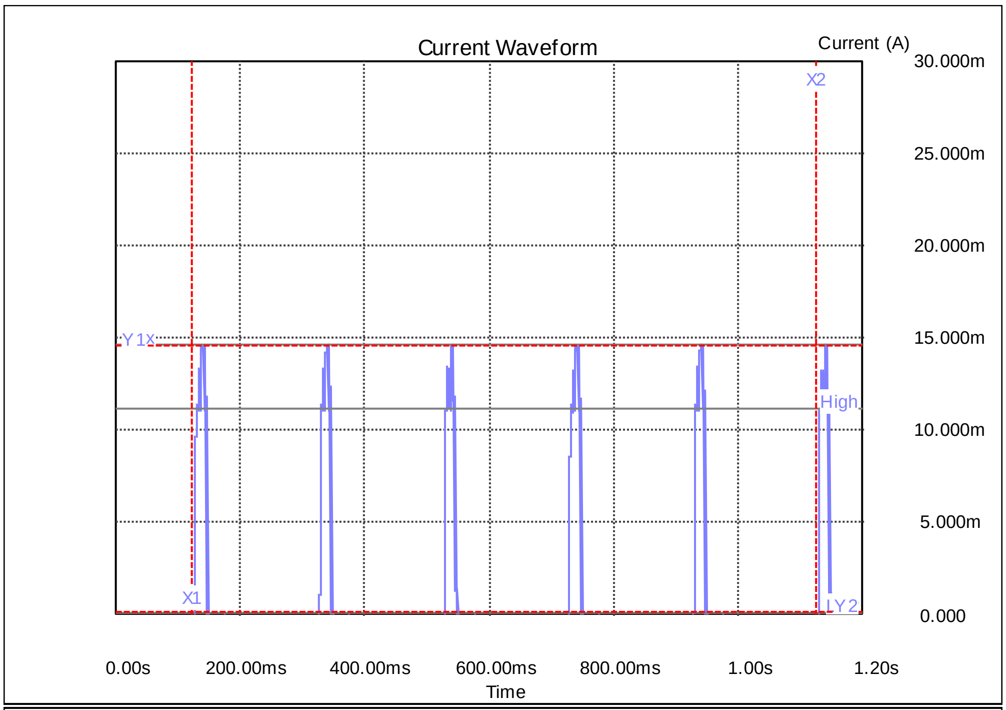
Step1: Register suspend/resume/late_resume callback functions
Step2: Set system active for 5000ms
Step3: Release os wakelock
Step4: After 5000ms system will enter sleep, and “uart_suspend” will print
Step5: Uart Rx wakeup system and “uart_resume” will print
Step6: “uart_late_resume” will print
Step7: After 5000ms system will enter sleep again



```
u32 uart_suspend(u32 expected_idle_time, void *param)
{
        DBG_8195A("uart_suspend \n");
}

u32 uart_resume(u32 expected_idle_time, void *param)
{
        DBG_8195A("uart_resume \n");
}

u32 uart_lateresume(u32 expected_idle_time, void *param)
{
        DBG_8195A("uart_late_resume \n");

        pmu_set_sysactive_time(PMU_LOGUART_DEVICE, 5000);
}

void psm_sleep_uart(void)
{
    // mbed uart test
    serial_init(&sobj_g,UART_TX,UART_RX);
    serial_baud(&sobj_g,38400);
    serial_format(&sobj_g, 8, ParityNone, 1);

    uart_send_string(&sobj_g, "UART IRQ API Demo...\r\n");
    uart_send_string(&sobj_g, "Enter sleep!!\n");
    uart_send_string(&sobj_g, "\r\n8195a$");

    serial_irq_handler(&sobj_g, uart_irq, (uint32_t)&sobj_g);
    serial_irq_set(&sobj_g, RxIrq, 1);
    serial_irq_set(&sobj_g, TxIrq, 1);

    pmu_sysactive_timer_init();

    pmu_register_sleep_callback(PMU_UART0_DEVICE, uart_suspend, NULL, uart_resume, NULL);
    pmu_register_delay_callback(PMU_UART0_DEVICE, uart_lateresume, NULL);

    pmu_set_sysactive_time(PMU_LOGUART_DEVICE, 5000);
    pmu_release_wakelock(PMU_OS);

    vTaskDelete(NULL);
}
```

5. Power Consumption

UART receive data and wakeup CPU every 200ms.



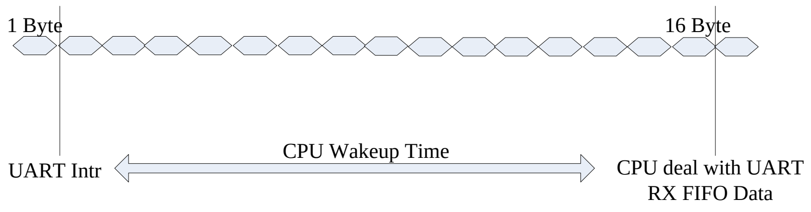
Calculated Measurements (3374Hz sample rate)

Dc 1.1978mA	Rms 3.6333mA	X1 123.7500ms	Y1 14.6101m
Low 145.3806uA	Min -35.6241uA	X2 1.1231s	Y2 155.9792u
High 11.2563mA	Max 14.6531mA	dX 0.9994s	dY -14.4541m

6. Baud Rate Support

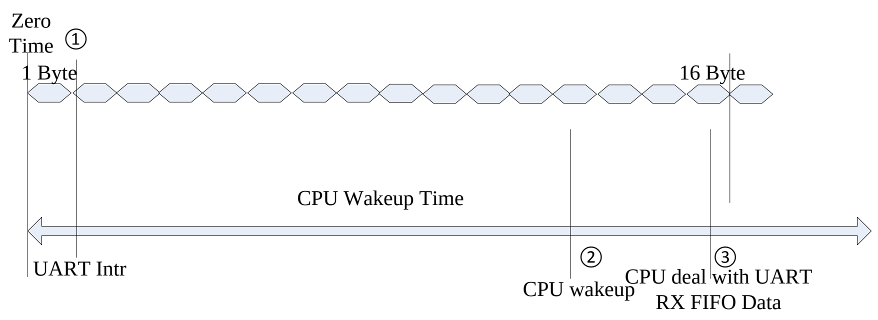
6.1. Introduce

When UART RX FIFO received the First Byte, it will raise the interrupt to wakeup CPU. To avoid data loss (covered by the later data), CPU must wakeup and deal with the data in UART RX FIFO before the FIFO full. The depth of UART RX FIFO is 16. So the time receive the later 15 bytes should larger than the time from the uart interrupt to CPU deal with data in RX FIFO.



So CPU Wakeup Time < ((1/baudrate) *10(bit) *15)

6.2. Test Result



Test the time from CPU wakeup to CPU deal with UART RX FIFO：

①: the time UART RX Interrupt raise

②: the time CPU wakeup

③: the time CPU start dealing with UART RX FIFO

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Baudrate	③	②	①	③-②	②-①	Byte loss（Byte）
115200	1038.375	987.250	86.687	**51.125**	900.563	0
	1037.438	986.687	68.563	**50.751**	918.124	0
128000	1236.813	981.501	77.937	**255.312**	903.564	0
	1254.375	977.250	77.937	**277.125**	899.313	0
	1030.500	979.250	78.063	**51.25**	901.187	0
	1348.125	976.814	78.001	**371.311**	898.813	1
	1432.064	978.937	77.813	**453.127**	901.124	2
153600	1016.250	965.564	65.000	**50.686**	900.564	0
	1051.126	967.063	65.000	**84.063**	902.063	0
	1242.874	968.124	64.938	**274.75**	903.186	3
	1343.689	965.750	65.000	**377.939**	900.75	4
Averagte					902.65918	

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Baudrate	③	②	①	③-②	②-①	Byte loss（Byte）
115200	1276.000	936.187	86.564	**339.813**	849.623	0
	1148.000	935.938	86.750	**212.062**	849.188	0
	1038.938	936.813	86.688	**102.125**	850.125	0
	1033.502	939.000	86.937	**94.502**	852.063	0
	986.688	936.313	86.626	**50.375**	849.687	0
128000	1111.376	928.438	78.062	**182.938**	850.376	0
	1377.187	928.875	77.938	**448.312**	850.937	1
	1065.438	927.062	78.063	**138.376**	848.999	0
153600	1025.814	916.250	65.000	**109.564**	851.25	0
	1332.375	917.126	65.063	**415.249**	852.063	4
	1254.063	916.813	65.000	**337.25**	851.813	3
Average					850.55673	

From data above, we can find the CPU wakeup time is comparatively fixed, but the interval from wakeup to dealing with data is floating.
The floating is mainly because of the time CPU executes the UART IRQ Handler, It is find that the time has nothing to do with the priority of UART IRQ.

According to the test, the board best support the baud rate of 115200.