AN1605
APPLICATION NOTE

USING AN ACTIVE RC TO WAKEUP THE ST7LITE0 FROM POWER SAVING MODE

by Microcontroller Division Applications

1 INTRODUCTION

This application note investigates the power consumption during the operation of a typical application which puts the MCU (ST7Lite0) in HALT mode and wakes it up at regular intervals by an external interrupt generated by an active RC circuit.

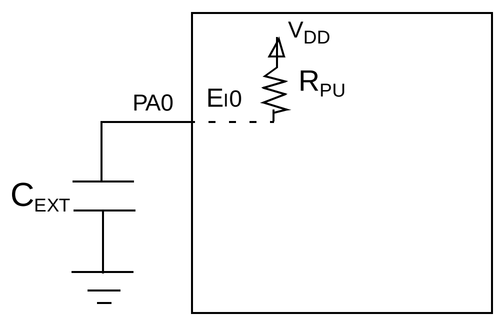
It also lists the typical consumption values and the parameters on which this consumption depends. The internal Pull up (Rpu) of an I/O port is used for the active RC to minimise the number of external components. The value of the Rpu varies with the supply voltage of the MCU and with temperature. Externally, only one capacitor is used.

The ST7LITE0 clock source is configured by option byte to be internal RC with PLL*8. All measurements are taken at ambient temperature.

1.1 HARDWARE SOLUTION

Figure 1 shows the Hardware setup used to measure the consumption (I_{DD}) at different power supply voltages.

Figure 1. Hardware Setup



1.2 POWER CONSUMPTION

The power consumption depends mainly on the time period between each wakeup from HALT (external interrupt interval). The wakeup time period is controlled by the RC time constant. The value of the C_{ext} is fixed but the internal pull-up value varies with the MCU power supply voltage and with temperature.

The typical values of the Rpu at different power supply voltages is given in Table 1.

Table 1. Rpu values for different power supply conditions

Setup No.	Conditions	Rpu (Minimum)	Rpu (Typical)	Rpu (Maximum)
1	V_{DD} = 5.0 V	50 kΩ	120 kΩ	250 kΩ
2	V_{DD} = 3.0 V	-	160 kΩ	-

The consumption is measured for two different values of C_{ext}, given in Table 2 and Table 3.

Table 2. Consumption for C_{ext} = 1 µF

Setup No.	V_{DD} (Volts)	Average I_{DD} (mA) Consumption in Run mode	Average I_{DD} (µA) Consumption in Power saving mode	Ext Interrupt Interval (ms)	I_{DD} (µA) Consumption when MCU is in HALT
1	2.4	1.44	15.6	154.0	0.1
2	2.6	1.73	20.6	131.2	
3	2.8	2.0	26.6	114.0	
4	3.0	2.28	35.2	101.2	
5	3.2	2.59	41.8	90.8	
6	3.4	2.95	48.6	80.8	
7	3.6	3.34	56.6	72.4	
8	3.8	3.55	66.2	67.2	
9	4.0	3.73	75.3	62.6	
10	4.2	3.93	83.4	59.2	
11	4.4	4.12	95.4	55.2	
12	4.6	4.31	105.2	53.0	
13	4.8	4.54	117.4	50.6	
14	5.0	4.75	129.4	48.0	

Table 3. Consumption for C_{ext} = 0.47 µF

Setup No.	V_{DD} (Volts)	Average I_{DD} (mA) Consumption in Run mode	Average I_{DD} (µA) Consumption in Power saving mode	Ext Interrupt Interval (ms)	I_{DD} (µA) Consumption when MCU is in HALT
1	2.4	1.45	19.6	69.8	0.1
2	2.6	1.74	25.1	60.0	
3	2.8	2.01	32.1	52.2	
4	3.0	2.29	39.0	46.6	
5	3.2	2.60	46.2	42.1	
6	3.4	2.95	54.2	38.0	
7	3.6	3.34	62.5	35.2	
8	3.8	3.54	71.7	32.8	
9	4.0	3.75	81.2	30.8	
10	4.2	3.91	91.8	29.2	
11	4.4	4.12	101.9	27.7	
12	4.6	4.31	112.6	26.5	
13	4.8	4.51	124.0	25.4	
14	5.0	4.73	135.4	24.3	

The parameters on which the consumption depends are as follows:

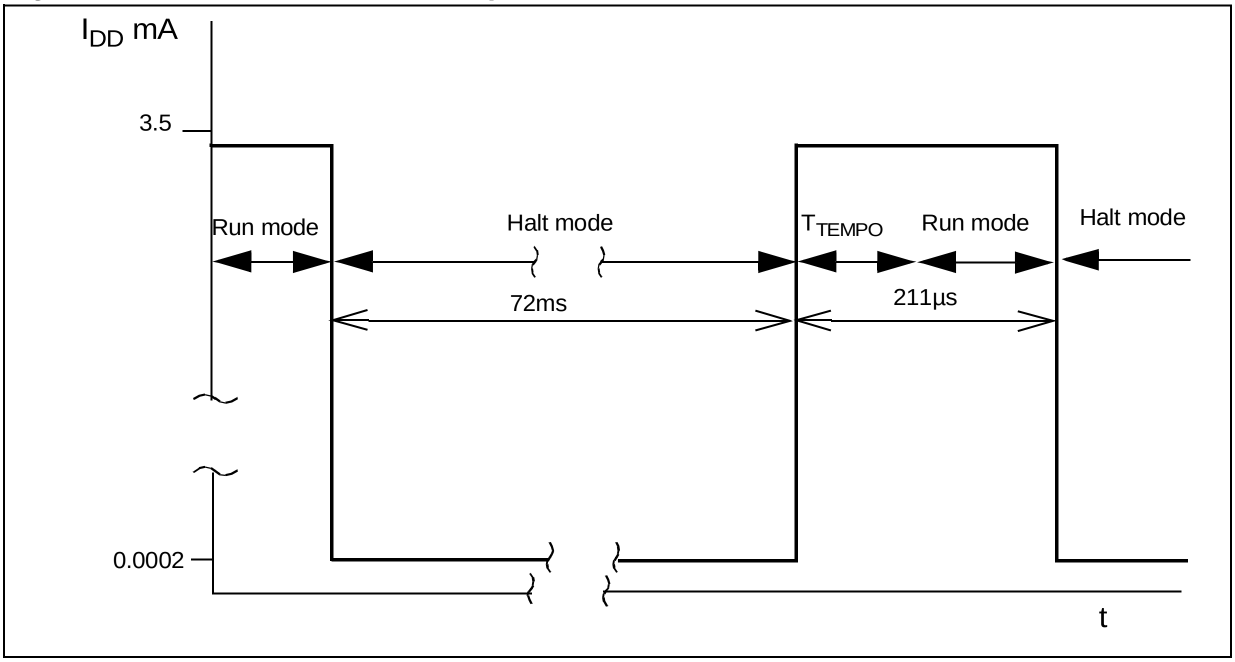
- The MCU inserts a delay of 256 CPU cycles to stabilize the internal RC, during this time it consumes some current.

For example at 3.6V, the details of the duration of different modes are as follows:

– MCU in Halt mode: 72.00 ms

– MCU in Run mode (delay period + capacitor discharge time) : 211.2 µs

Figure 2. Overview of the Consumption Parameters



The exact calculation of the delay period is given as follows:

When the PLLx4x8 is selected, it delivers the clock after 60 cycles of the clock source (for a 1 MHz clock source, the delay due to the PLL is 60µs).

The total delay at oscillator start up with PLLx4x8 is given by the formula:

Ttempo = [(60*Tclock_source) + (256*Tcpu_clock)]

where,

Tclock_source represents the time period for one clock cycle of the clock source, and

Tcpu_clock represents the time for one cpu clock cycle.

- To discharge the capacitor, a software delay of 294 cycles has to be inserted before putting the MCU in Halt again, so that the capacitor is fully discharged before recharging it. This is the optimum delay at which minimum consumption is achieved.
- For minimum consumption in Halt mode: all the port pins should be configured as push pull output at low level (normally the consumption in this configuration is approx. 0.1 ~ 0.2 uA), but the pin to which the external interrupt is connected (PA0), has to be configured as pull up interrupt. Hence, while the MCU is in Halt mode with this configuration, it consumes more than 0.2 µA.
- The MCU cannot be kept in Halt for longer than the time it takes the capacitor to charge up to Vdd level. This is because as soon as the capacitor charges to approximately 0.7Vdd, the MCU detects it as external interrupt (the interrupt sensitivity is configured for rising edge) and comes out of Halt mode.

- The charging time is mainly controlled through the capacitor value. But if the capacitor value is increased beyond 1uF, although the interval between external interrupts (in ms) is increased, the capacitor itself consumes more current while charging. Hence, the average consumption is high in this case. A summary of the consumption and the external interrupt interval for C_{ext} = 2.2uF and 4.7uF is shown in Table 4. It can be seen from this table that even though the external interrupt interval is longer than in Tables 2 & 3, the consumption is higher.

Table 4. Power Consumption and Ext. Interrupt Interval for C_{ext} = 2.2 µF and C_{ext} = 4.7 µF

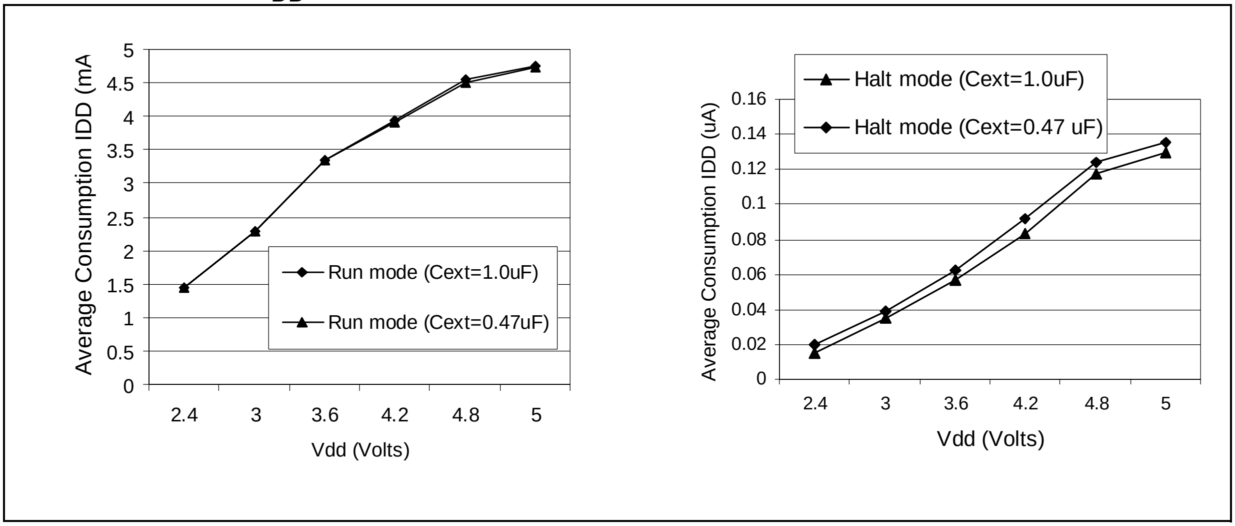
Setup No.	V_{DD} (Volts)	C= 2.2µF		C= 4.7µF	
		Average I_{DD} (µA) Consumption in power saving mode	Ext Interrupt Interval (ms)	Average I_{DD} (µA) Consumption in Power saving mode	Ext Interrupt Interval. (ms)
1	3.0	35.6	171.6	48.9	200.0
2	4.0	86.4	107.6	114.5	124.2
3	5.0	146.6	83.6	189.6	97.2

If a different hardware setup is used, where an external series R (to generate the external interrupt through an external RC combination) is connected, the capacitor charging time decreases drastically. For example, when a series R of 490K is added, the charging time decreases to 6.7µs. Hence, the period the MCU stays in Halt mode is very small, causing more consumption.

As a conclusion, the best result (minimum consumption) is achieved with a 1µF capacitor value and using an internal pullup. This is illustrated in Figure 3.

Figure 3 shows the average I_{DD} consumption in Halt mode and Run mode respectively with the two different capacitor values (Cext = 1.0 uF and 0.47uF) used for the active RC.

Figure 3. Average I_{DD} Consumption Run and Halt Mode



1.3 SOFTWARE SOLUTION

The software is written in assembly.

First the PA0 port (through which the external interrupt is taken to the MCU) is configured as pull-up interrupt.

The sensitivity of the interrupt is configured as rising edge.

Then the capacitor is charged through software and immediately the MCU is put into HALT.

As soon as the capacitor charges to nearly 0.7Vdd, the MCU detects it as an external interrupt and comes out of Halt mode.

The capacitor is discharged through software. And a small software delay of 294 cycles is then provided to let the capacitor discharge fully before it recharges and wakes up the MCU from Halt mode with another external interrupt.

The MCU is again put into Halt and the same process is repeated.

All the source files in assembly code is given in the zip file with this application note.

The source files are for guidance only. STMicroelectronics shall not be held liable for any direct, indirect or consequential damages with respect to any claims arising from use of this software.

THE PRESENT NOTE WHICH IS FOR GUIDANCE ONLY AIMS AT PROVIDING CUSTOMERS WITH INFORMATION REGARDING THEIR PRODUCTS IN ORDER FOR THEM TO SAVE TIME. AS A RESULT, STMICROELECTRONICS SHALL NOT BE HELD LIABLE FOR ANY DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES WITH RESPECT TO ANY CLAIMS ARISING FROM THE CONTENT OF SUCH A NOTE AND/OR THE USE MADE BY CUSTOMERS OF THE INFORMATION CONTAINED HEREIN IN CONNECTION WITH THEIR PRODUCTS."

STMicroelectronics Group of Companies
Australia - Brazil - Canada - China - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan
Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - U.S.A.

http://www.st.com