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Suggestion for method to improve power consumption of the ZigBee RF4CE platform

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Abstract

This paper proposes a method for reducing the amount of current consumption by the transceiver based remote control and the ZigBee RF4CE network layer step. We have studied how to improve power efficiency at short transition time through duty rate management. Also, comparing the measured current consumption before and after the improvement, we confirmed the correlation between the data transmission speed improvement and the current reduction.

Key words: RF4CE, ZigBee, power consumption, topology, RC

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I. Introduction

The new generation of IoT products will be eco-friendly products. It will not consume power at all or use very little power, its interaction will be high, and Radio Frequency (RF) technology will be used instead of infrared to send it towards the whole house. ZigBee RF4CE (ZigBee Radio Frequency for Consumer Electronics) will be used by a number of household devices such as next-generation remote controls, set-top boxes and TVs as well as security monitors, sensors and control devices. The ZigBee Alliance extended the ZigBee RF4CE standard to multiple end-user application areas based on the 2.4 GHz, IEEE 802.15.4 standard. ZigBee RF4CE should have possibly the lowest power consumption and optimal performance. ZigBee chips for set-top boxes and TVs do not need to optimize power consumption, but they must provide an appropriate interface for easy integration. [1], [2]

II. RF4CE performance improvements

The transceiver can transmit and receive data independently from the microprocessor, so the microprocessor is woken up only when needed to process the data. Synchronizing the wake-up function means that the communication controller will determine when to wake up to acknowledge the message. The device is turned off for most of the time so that it will be greatly reducing overall energy consumption.

This is particularly effective for a variety of home environment, security and position sensors. Owing to the synchronization with the scheduler in the communications controller, the system checks for messages during a very short time that have been awake and then goes back to sleep.

The wireless device wakes up only when it is needed and looks for data that has to be sent. If it does not exist, wireless device goes back to the sleep state again. [3], [4] If there is data to transmit, the controller wakes the microcontroller. Then, after the information is delivered, it will return to the dormant state until the next scheduled time to wake up again.

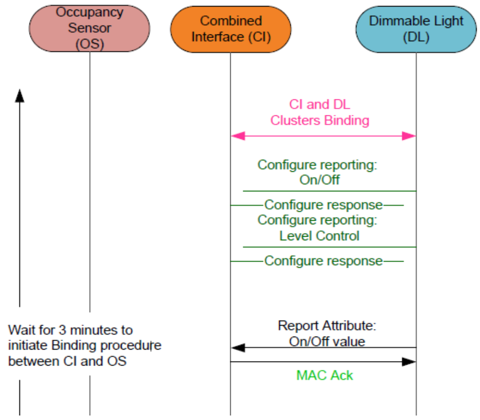

Fig. 1. ZigBee IoT Demo Flow Diagram

In Fig. 1, ZigBee devices provide low power and stable communications in the wireless space by using a duty cycle. This is the same meaning as Equation (1) below, and 'Long Data Frame' means the sum of 'Preamble time' and 'Time packet'.

$$\text{Total Time} = \frac{\text{Data (Long Data Frame)}}{\text{Duty Cycle}} \quad (1)$$

It specifies only the ratio of the transmission packet time during the whole time, and it is not discriminated either a long packet or a short packet. [5], [6]

The battery charge amount mAh is inversely proportional to the current consumption time ms, as shown in Equation 2.

$$\text{Total(day)} = \frac{\text{Battery Life time}}{\text{(Sleep count+Active count)}} \quad (2)$$

As packet data transmission/reception time gets longer, the current loss will be greater. Changing the duty cycle can reduce energy usage compared to typical packet transmission and reception.

III. Performance improvement experiment

In the measurement setup, TX packets are transmitted at 0-dBm power.

Because 10-Ω resistors are used, 10 mV in the measurement is converted to 1 mA current consumption, so 50 mV is converted to 5 mA.

Receiving a toggle command and sending a default response command are shown in Fig. 2, from points 3 to 4, respectively.

Fig. 2 Current Consumption Measurement (Before duty cycle application)

The time length of each unit operation interval is constant except Point 1 - 2 and Point 5 - 6 which vary according to the channel condition. As a result, compared to Table 1, the differences in the current consumption estimation in Fig. 3 are the same as in Table 2.

A closer look at the current consumption behavior reveals that at first it looks like a flat current curve, but it resembles a mountain range with mountain peaks and valleys evidently.

Table 1. Current Consumption Measure Description (Before duty cycle application)

Section	Unit Operation Description	Voltage (mV)	Current (mA)	Time (ms)	Consu −mption (mA*ms)
Before 0	Power Mode 2		0.001		
Point 1 to 2	Radio in TX mode	320	32	1.2	38.4
Point 3 to 4	Receiving Toggle command	230	23	1.22	28.06
Point 5 to 6	Processing and shut down	75	7.5	7.8	58.5
After 7	Power Mode 2		0.001		
				10.22	**124.96**

When certain functional blocks are activated, they consume the maximum current.

When two function blocks are turned on at the same time, the maximum amplitude doubles. The solution to lowering peak current consumption is that carefully managing data transmission and reception times to avoid doubling the maximum amplitude.

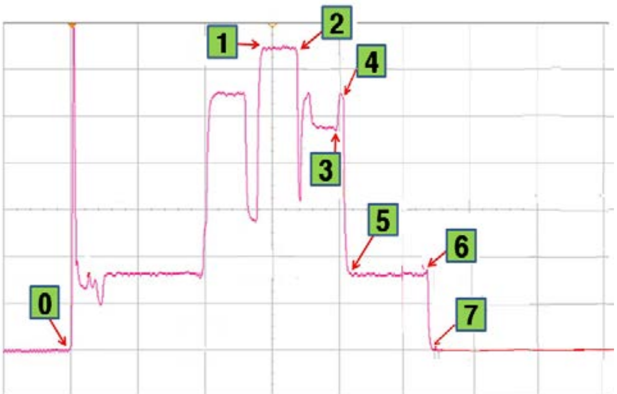

Fig. 3 Current Consumption Measurement (After duty cycle application)

Table 2. Current Consumption Measure Description (After duty cycle application)

Section	Unit Operation Description	Voltage (mV)	Current (mA)	Time (ms)	Consu –mption (mA*ms)
Before 0	Power Mode 2		0.001		
Point 1 to 2	Radio in TX mode	320	32	0.85	28.15
Point 3 to 4	Receiving Toggle command	230	23	1.2	27.6
Point 5 to 6	Processing and shut down	75	7.5	6.13	44.22
After 7	Power Mode 2		0.001		
				8.18	**99.97**

Ⅳ. Conclusion

Most improving current consumption method is that avoiding the peak amplitude doubling by carefully managing the time that the main functions are turned on and off. In this paper, existing use of ZigBee RF4CE, we propose a method to improve the power efficiency of short transition time by managing duty rate. As a result of measurement of the current consumption before and after application of the duty rate scenario, by increasing the data transmission / reception speed 2.04 ms than existing speed, it leads to result in current consumption's reduction 24.99 mA.

According to the above research, 99.97 (mA * ms) /124.96 (mA * ms) ≒ 0.8, means decreased about 20% of power consumption. Hence this can lengthen battery life cycle of the core product configuration of IoT with reducing current consumption. Further research will be needed for this reason.

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