ABSTRACT

This purpose of this application report is to provide information to understand the configuration and results that can be obtained using the ZigBee power consumption calculator.

Contents

1 Introduction .......................................................................................................................................................... 1
2 Test Setup Overview ........................................................................................................................................ 1
3 Suggestions on Setting the Knobs on the Calculator ..................................................................................... 3
4 Notes on the Results From the Power Calculator Tool .................................................................................. 3
5 References ....................................................................................................................................................... 4

List of Figures

1 Message Sequence Diagram When APS ACK is Disabled .............................................................................. 2
2 Message Sequence Diagram When APS ACK is Enabled .............................................................................. 3

1 Introduction

This document provides a resource guide pointing to the relevant collateral necessary to understand the theory of operation and bench setup settings used to measure the power consumption of a ZigBee® end device using Z-Stack™ software.

2 Test Setup Overview

To understand the hardware setup used for the power consumption measurements, see the Measurement Setup section in [1] for measurements on the SimpleLink™ CC2530 Micro Controller Unit (MCU). For measurements on the SimpleLink CC2538 Wireless MCU, see [2].

Z-Stack Sample Switch and Z-Stack Sample Light are the applications used to extract power consumption measurements implemented as ZigBee end device and coordinator, respectively. The Z-Stack software stack and applications are configured with the same options and settings provided in the power calculator tool for different user defined knobs (such as network layer security, number of application layer payload bytes for transmitted and received data, application acknowledgment service) to calculate the power consumption for various system configurations. To understand how to configure Z-Stack for various configuration settings available in the power consumption calculator tool, see the Z-Stack Developers Guide, Z-Stack API document, and Z-Stack Application level tuning documents. These documents, along with other useful collateral, are present within the “/Documents” folder in your Z-Stack installation folder.

The measurement procedure used for power consumption measurements is described in the Measurements and Application to a Practical Use Case sections [1] for CC2530 and [2] for CC2538. The application reports also show and describe the voltage vs time plot to understand power consumption for each message transaction between the coordinator and the end device in detail.
In the test setup, the end device associates to the network with the coordinator as the parent. In addition to periodic polling messages and maintaining low power mode when there is no operation to be executed for the purpose of simplifying measurements, it was assumed that only the end device would transmit application messages to the coordinator parent and receive response messages from the coordinator for those messages. The response message is typically an application layer acknowledgment of the processing of the command. When doing the measurements, the Zigbee Cluster Library (ZCL) layer default response was the response message from the coordinator to the end device. The number of times the end device sends an application message to the coordinator is a configurable value that depends on the type of the application and can be configured in the “Usage Model” tab of the ZigBee Power Consumption Calculator. For each application message transmitted by the end device a sequence of message transfer activity starts, which depends on the condition whether or not the APS layer acknowledgment is enabled or disabled. If APS acknowledgment is disabled, the message sequence is as described in the Application to a Practical Use Case section of [1] and [2], also described in Section 2.1. The power calculation method explained in the Estimation for Usage Scenario section of [1] and [2] can be used to compute the final consumption in this case. Whereas, if the APS layer acknowledgment is additionally enabled after each message that the end device sends, it would receive two messages as in response: the APS acknowledgment message and the response message to the transmitted command. This is shown in Section 2.2. For final power measurements (when APS acknowledgment is enabled) as explained in the Estimation for Usage Scenario section of [1] and [2], the power consumption due to operation of receiving APS ACK would need to be added in the calculations for accurate measurements.

2.1 Case 1

Figure 1 shows the sequence of message transfers when quality of service (QoS) is APS un-acknowledged.

![Figure 1. Message Sequence Diagram When APS ACK is Disabled](image-url)
2.2 Case 2

Figure 2 shows the sequence of message transfers when quality of service is APS acknowledged.

Figure 2. Message Sequence Diagram When APS ACK is Enabled

3 Suggestions on Setting the Knobs on the Calculator

• For ZigBee Home Automation networks, network layer security is always enabled (mandated by the ZigBee Home automation specification), whereas, the application layer security is typically disabled.

• The calculator was modeled to have the ZCL default response as the response message for the purpose of getting application layer acknowledgments to ensure end-to-end message transfers. Typically, for home automation networks, this is the only acknowledgment used for ensuring reliable end-to-end communication at application layer. Enabling APS ACK, in addition to ZCL Default response, would increase power consumption and is typically not done. Typically, either APS ACK or default response messages are used to ensure reliable end-to-end message transfer in ZigBee Home Automation networks.

4 Notes on the Results From the Power Calculator Tool

• This tool is attempted to provide a comprehensive means that will account for the most fundamental contributors, however, being a static analysis tool there is no attempt to model cycle accurate behavior.

• Approximations were used in multiple cases where it seems fit in order to reduce the calculation complexity and ease the readability. This was done in a prudent manner making sure that the effect on the overall result is negligible.

• Results do not include the first time network join operation, and do not include the power consumption (if any) due to end device losing the parent and associating either doing the Orphan Scan or the network layer rejoin.

• Results do not include current consumptions due to any peripherals such as LED, LCD, Key Press being done on the end device. Having those on the system will increase the power consumption, which would have to be taken in to account for estimating the battery life.
5 References

1. *Measuring Power Consumption of CC2530 with Z-Stack* (SWRA292)
2. *Power Consumption Measurements and Optimization for CC2538 End Device with Z-Stack* (SWRA456)
IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have not been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

<table>
<thead>
<tr>
<th>Products</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio</td>
<td>Automotive and Transportation</td>
</tr>
<tr>
<td>Amplifiers</td>
<td>Communications and Telecom</td>
</tr>
<tr>
<td>Data Converters</td>
<td>Computers and Peripherals</td>
</tr>
<tr>
<td>DLP® Products</td>
<td>Consumer Electronics</td>
</tr>
<tr>
<td>DSP</td>
<td>Energy and Lighting</td>
</tr>
<tr>
<td>Clocks and Timers</td>
<td>Industrial</td>
</tr>
<tr>
<td>Interface</td>
<td>Medical</td>
</tr>
<tr>
<td>Logic</td>
<td>Security</td>
</tr>
<tr>
<td>Power Mgmt</td>
<td>Space, Avionics and Defense</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Video and Imaging</td>
</tr>
<tr>
<td>RFID</td>
<td></td>
</tr>
<tr>
<td>OMAP Applications Processors</td>
<td>TI E2E Community</td>
</tr>
<tr>
<td>Wireless Connectivity</td>
<td></td>
</tr>
</tbody>
</table>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated