RemoTI™ Power Consumption

Keywords

- *RemoTI™*
- *CC2533*
- *Power Consumption*
- *Remote Controller*
- *Target*
- *ZRC*
- *ZID*
- *RF4CE*

1 Introduction

This application note describes the setup and power consumption measurements for the CC2533 based remote controller and target node.

It is assumed the reader of this application note has knowledge about the ZigBee RF4CE ZRC and ZID profiles.

The current consumption measurements are made using the *BasicRemote* sample application included with the RemoTI 1.3 release.

The current consumption measurements are presented, and battery life time is calculated for two example remote controller usage models. An accompanying Excel sheet is provided so that users can estimate their battery life based on their custom usage scenario.

Note that the results presented in this document are intended as a guideline only. A variety of factors will influence the battery life calculation and final measurements and calculations should be performed on customer hardware, in expected environment and under target application scenario.

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2 Abbreviations

ACK	Acknowledgement
EM	Evaluation module
MAC	Medium Access Control
NWK	Network
PMx	Power Mode x
RC	Remote Controller
RF	Radio Frequency
RX	Receive
RF4CE	Radio Frequency for Consumer Electronics
STB	Set Top Box
TX	Transmit
ZRC	ZigBee Remote Controller profile
ZID	ZigBee Input Device profile

3 Glossary

Active mode	The RF receiver is turned on continuously
Standby mode	The RF receiver is duty cycling

4 Important ZigBee RF4CE network layer, ZRC and ZID profile parameters

This section describes important RF4CE network layer, and ZRC and ZID profile parameters that will be referenced in subsequent sections.

4.1 RF4CE

The ZigBee RF4CE specification [1] provides a means for a target node (TV, STB, etc) to enter standby mode when the equipment is turned off. A target node in standby mode must enable the RF receiver for a certain time at regular intervals to receive potential messages from a RC. The specification dictates the active period *nwkActivePeriod* > (*nwkcMinActivePeriod* = 16.8 ms) and the duty cycle *nwkDutyCycle* < (*nwkcMaxDutyCycle* = 1 s). This is illustrated in Figure 1.

Note that these two parameters can be configured by the application within the limitations stipulated by the specification. The target node sample application (RNP) included with the RemoTI 1.3 release is configuring *nwkDutyCycle* = 330 ms and *nwkActivePeriod* = 16 ms.

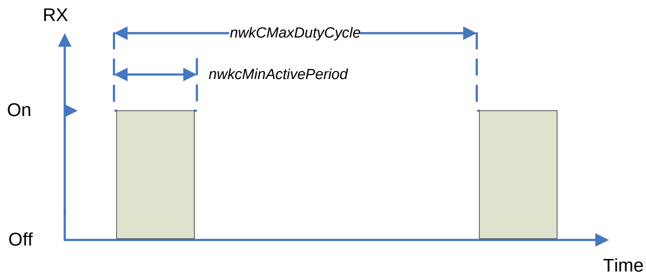

Figure 1. RF4CE Target Node Active Period and Duty Cycle

ZigBee RF4CE provides a frequency agility mechanism by operating on three MAC channels as defined in [1]. The target node monitors the noise on the current operating channel and can decide to switch channel if the channel quality is compromised due to noise from other sources. This ensures the target node always operates on the channel with the least noise present.

The ZigBee RF4CE specification provides multiple TX options when an RC sends a message to a target node. A message can be sent as a combination of

- Unicast or broadcast transmission
- Multi-channel or single channel operation
- With ACK or w/o ACK from receiving node

The TX options are controlled by the application and are passed to the RF4CE network layer together with the message data. The network layer will set specific MAC layer parameters based on the TX options before instructing the MAC layer to send the message over-the-air. The details of the TX options and the implications on the send procedure can be found in [1]. The RemoTI API document [2] describes the details of the RTI_SendDataReq() API and the various TX options parameters provided to the RemoTI application programmer.

The unicast, multi-channel, ACKed TX option deserves special attention. This TX option is designed to ensure a message is sent on each of the three channels within *nwkcMinActivePeriod*, and repeated for *nwkcMaxDutyCycle* or until an ACK is received. This TX option must be used to successfully wake up a target node from standby mode with one key press, i.e. the <power> key. It is prudent design to use this TX options when the target is in active mode as well to maximize the likelihood the message reached the recipient.

4.2 ZRC Profile

The ZRC profile specification [3] dictates the RC to send a '*user control pressed*' command when a key is pressed. If the key is not released within *aplcMaxKeyRepeatInterval* < 100 ms, the RC must send a '*user control repeat*' command. The 'user control repeat' command will be repeated every *aplKeyRepeatInterval* until the key is released. *aplKeyRepeatInterval* = 50 ms in RemoTI 1.3 which is the default value stipulated by the specification. It is optional to send a '*user control released command*' when the key is released only if no '*user control repeat*' command has been issued.

The implication of the 'user control repeated' command construct is that a single key press may result in multiple messages sent by the RC to the target node.

4.3 ZID Profile

The ZID profile specification describes two ways to send data:

- Control Pipe (user can choose either acknowledge multichannel, unicast multichannel or broadcast packet).
- Interrupt Pipe (mix of unacknowledged and acknowledged packets).

This can be used either to send key press, or sensor data (gyro, accelerometer, touchpad, etc…).

Control pipe is very similar to what is done in the ZRC profile.

Interrupt pipe is used to send low latency high frequency packet: first an acknowledged packet is sent multichannel to confirm/find the Target's channel. Then unacknowledged packets are sent on the detected channel. After aplIntPipeUnsafeTxWindowTime ms, another acknowledged multichannel packet is sent to confirm the presence of the target on this channel, and then unacknowledged packets are sent for another aplIntPipeUnsafeTxWindowTime period, and so on.

This is typically used for the 'air mouse' feature of our Advance Remote, where ZID mouse reports are sent through the interrupt pipe. With aplIntPipeUnsafeTxWindowTime of 50ms and a packet sent every 10ms; 1 ACK packet, followed by 4 UnACK packets will be sent.

5 RC Current Measurements

This section describes the current measurement setup, and establishes the RC sleep and active current consumption. The active current consumption is established for four components;

1. Key de-bounce – An event triggered by every key press.
2. TX w/ACK – One message sent over-the-air with ACK received from the target node.
3. TX w/o ACK – One message sent over-the-air without an ACK received from the target node.
4. TX UnACK – One message sent over the air without ACK needed.

These components will be used in section 6 to establish the current consumption for a RC sending a message to a target node in active mode and in standby mode.

It will also be use to establish the current consumption for a RC sending ZID report in an interrupt pipe.

5.1 Active Current Measurement Setup

An Agilent Oscilloscope is used to capture the current waveform components. The voltage across a 10.4Ω resistor (±2%) is captured, and hence the current draw is 1/10.4 of the captured voltage.

The setup is shown in Figure 2.

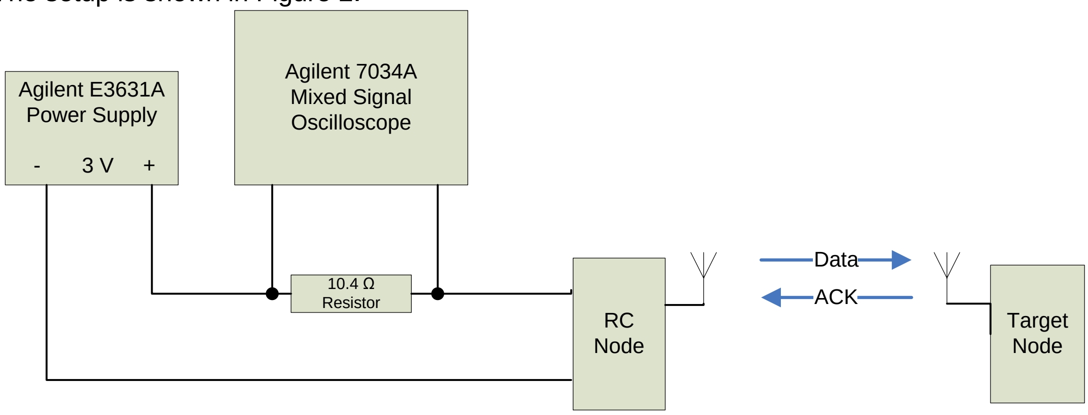

Figure 2. RC Active Current Measurement Setup

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5.1.1 Key De-Bounce Component Measurement

It is important that the RC consumes as little current as possible to enable long battery life. The RC is in deep sleep mode (PM3) as much as possible and wakes up on a key press to process the input and send the message over-the-air. In order to avoid input jitters when a key is pressed, the device wakes up on a key press and sets the sleep timer to expire in 25 ms and enters PM2. At this point we need to be in PM2 since the sleep timer is running.

Figure 3 shows the current waveform for the key de-bounce component. It shows both the sampled signal, and the integral. The integral takes into account the actual current consumption.

$Vi(t) = \int V(t)\,dt$

Voltage during key press = $\int_{X1}^{X2} V(t)\,dt = Vi(X2) - Vi(X1) = V2 - V1$,
where V1 and V2 are read out the measurement, see Figure 3.
Hence current during key press = 74,66uVs/10.4Ω = 7.179uAs = 7.179mAms

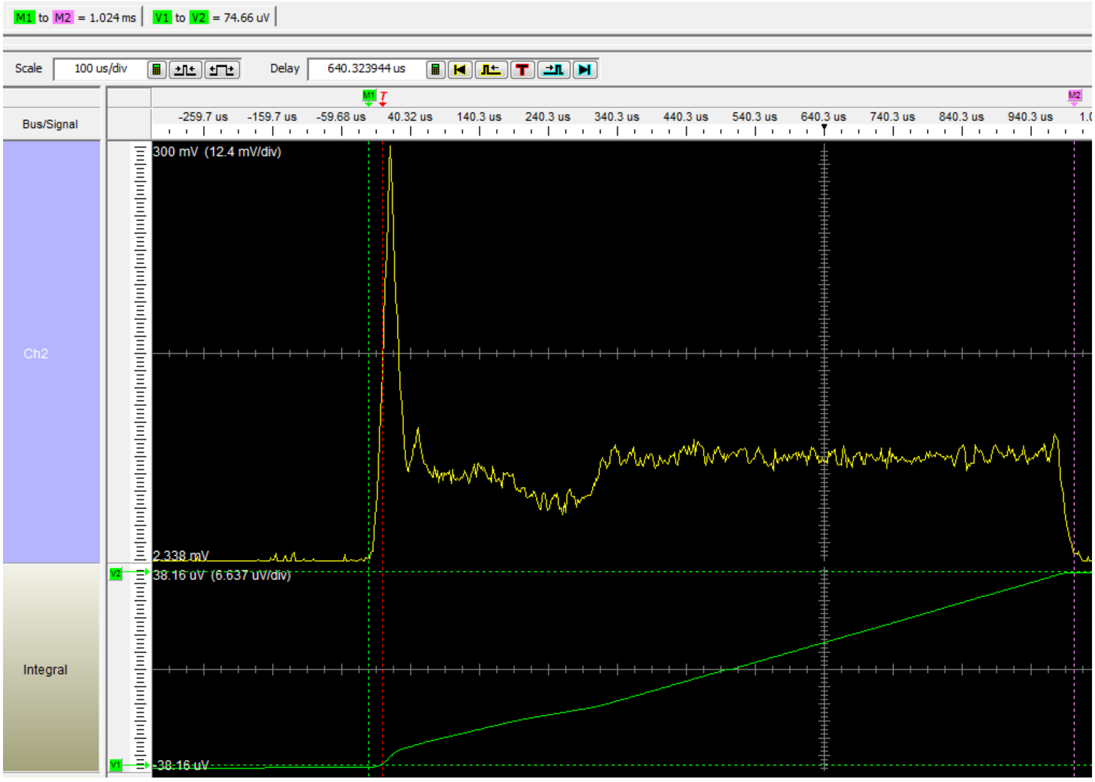

Figure 3. RC Key De-bounce Current Waveform, sampled (yellow) and integrated (green)

The current consumption for the key de-bounce component is summarized in Table 1.

Key De-Bounce (per event)	Time us	Current mA	mAms
1. Wake-up sequence, timer configuration, PM2	1024,00	7,01	7,18
Total	**1024,00**		**7,18**

Table 1. RC Key De-Bounce Component Average Current Consumption

5.1.2 TX w/ACK Component Measurement

The device wakes up after the sleep timer expires following the key de-bounce component. The RC reads the key, prepares the message, performs CCA, sends the ZRC 'user controlled pressed' command over-the-air and waits for an ACK from the target node.

After the ACK is received, the RC configures the sleep timer to expire in 50 ms and enters PM2. At timer expiration, the RC checks if the key is still pressed. It sends a ZRC 'user control repeated' command if the key is still pressed, configures the sleep timer to expire in 50 ms and enter PM2 again. This will repeat until the key is release upon which the RC sends a ZRC 'user control released' command and enters PM3.

A ZRC 'user control pressed/repeated/released' command exhibit the same current waveform characteristics. Only the payload content of the messages will be different.

The waveform in Figure 4 shows a successful TX w/ACK component based on either of the ZRC commands.

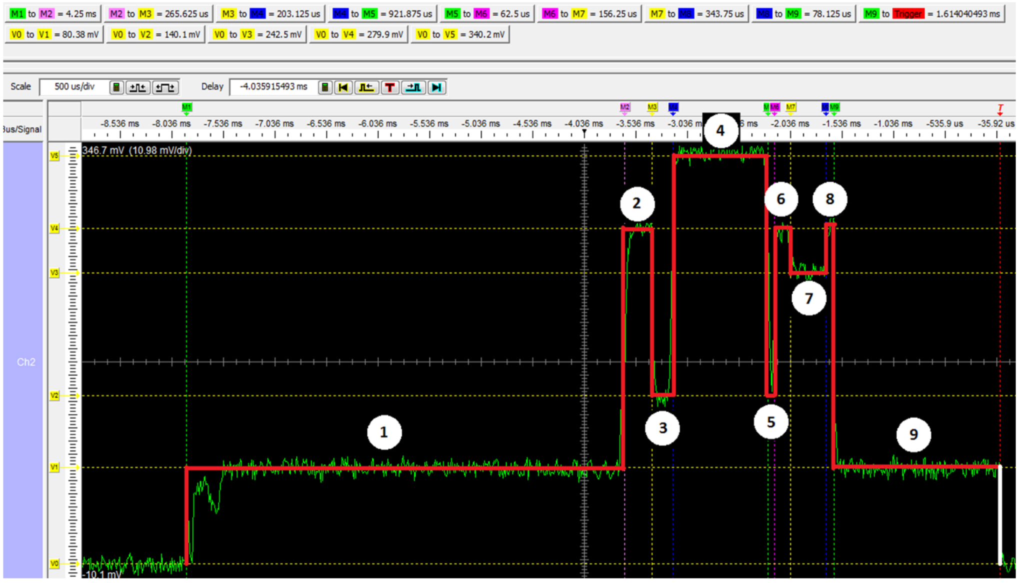

Figure 4. RC TX w/ACK Current Waveform

The current consumption for the TX w/ACK component is summarized in Table 2.

TX w/ACK (per event)	Time us	Current mA			mAms		
		0dBm	4.5dBm	7dBm	0dBm	4.5dBm	7dBm
1 - Wake-up and processing	4250,00	7,09	7,09	7,09	30,14	30,14	30,14
2 - CCA, radio in RX	265,63	25,27	25,27	26,00	6,71	6,71	6,91
3 - RX/TX switch	203,13	12,27	12,27	13,00	2,49	2,49	2,64
4 - TX, For a 2 Bytes Packet (zrc Key Press)	921,88	28,27	31,55	36,45	26,06	29,08	33,61
OR 4 - TX For a 7 Bytes Packet (zid mouse report)	1100,00				31,10	34,70	40,10
5 - TX/RX switch	62,50	12,27	12,27	13,00	0,77	0,77	0,81
6 - Wait for ACK, radio in RX	156,25	25,27	25,27	26,00	3,95	3,95	4,06
7 - ACK, radio in RX	343,75	21,82	21,82	22,73	7,50	7,50	7,81
8 - Post ACK, radio in RX	78,13	25,27	25,27	26,00	1,97	1,97	2,03
9 - Processing and shut-down	1614,40	7,09	7,09	7,09	11,45	11,45	11,45
Total for 2 Bytes packet	**7895,65**				**91,04**	**94,06**	**99,46**
Total for 7 Bytes packet	**8073,78**				**96,08**	**99,68**	**105,95**

Table 2. RC TX w/ACK Component Average Current Consumption

Note that the TX power level can be configured by the application programmer. The recommended output power is +4.5 dBm.

A boost mode is available to set the TX power to 7dBm, measurement at this power level can be found inside the accompanying Excel sheet.

For the ZRC profile, the packet size is 2 Bytes.

For ZID mouse report however, the packet size is 7 Bytes, which increase the power consumption (TX event is longer).

5.1.3 TX w/o ACK Component Measurement

A RC sending a message to a target node in standby mode should use the unicast, multi-channel, ACKed TX option as explained in section 4.1. This ensures the RC continuously repeats the message for *nwkcMaxDutyCycle* or until the target node receives and ACKs the message.

Figure 5 shows the waveform when the RC is repeating the message without receiving the ACK.

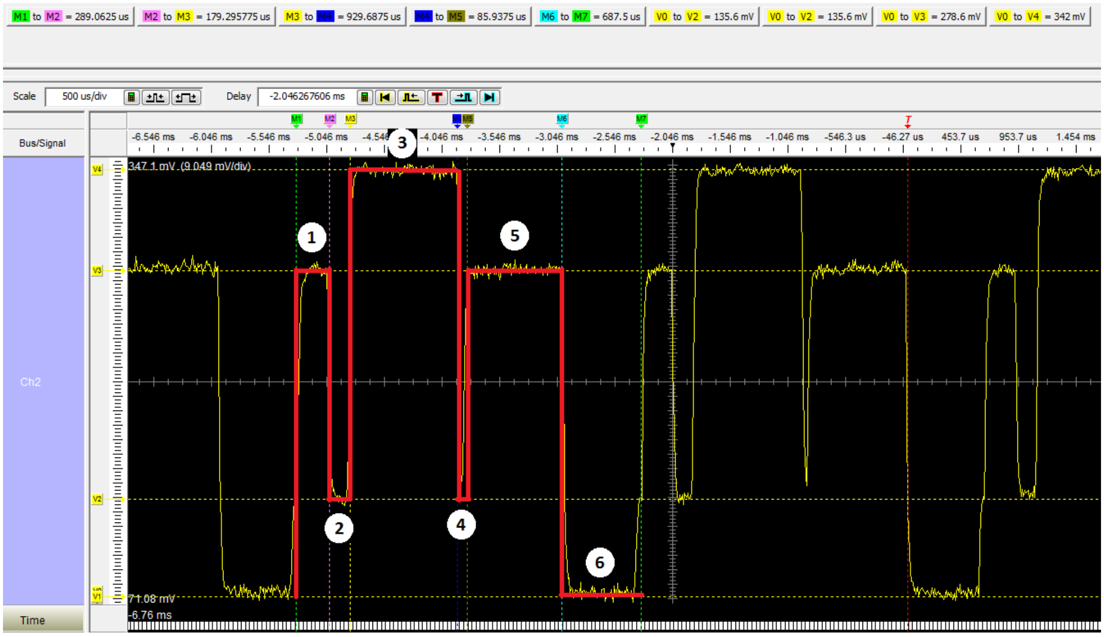

Figure 5. RC TX w/o ACK Current Waveform

The current consumption for the TX w/o ACK component is summarized in Table 3.

TX w/o ACK (per event)	Time us	Current mA			mAms		
		0dBm	4.5dBm	7dBm	0dBm	4.5dBm	7dBm
1 - CCA, radio in RX	289,06	25,27	25,27	26,00	7,31	7,31	7,52
2 - RX/TX switch	179,30	12,27	12,27	13,00	2,20	2,20	2,33
3 - TX, For a 2 Bytes Packet (ZRC Key Press)	929,69	28,27	31,55	36,45	26,28	29,33	33,89
OR 3 - TX For a 7 Bytes Packet (ZID mouse report)	1100,00				31,10	34,70	40,10
4 - TX/RX switch	85,94	12,27	12,27	13,00	1,05	1,05	1,12
5 Wait for ACK, radio in RX	820,31	25,27	25,27	26,00	20,73	20,73	21,33
6 - Processing and shut-down	687,50	7,09	7,09	7,09	4,88	4,88	4,88
Total for 2 Bytes packet	**2991,80**				**62,45**	**65,49**	**71,06**
Total for 7 Bytes packet	**3162,11**				**67,27**	**70,87**	**77,27**

Table 3 RC TX w/o ACK Component Average Current Consumption

5.1.4 TX UnACK Component Measurement

This type of packet is sent inside a ZID interrupt pipe.

The device wakes up after the sleep timer expires following a previous Send Packet. The RC reads any value to report (key, gyroscope, accelerometer, touchpad), prepares the message, performs CCA, sends the packet command over-the-air and shut down immediately its radio (no ACK awaiting).

The RC configures the sleep timer to expire in 10 ms, or whatever period which corresponds to the wanted rate, and enters PM2. At timer expiration, the RC checks if there are still data reports to be sent. If so, it sends a new packet (ACK or UnACK) in the interrupt pipe. This will be repeated until no more report is needed to be sent.

For example, the event can be a key press that triggers the sending of Gyro/ accelerometer measurement.

The accompanying Excel file gives an example of Gyro/Accelerometer current consumption whose value can be changed to match particular parts. This value does not affect the current consumed to send an UnACK packet.

Figure 6. RC TX UnACK Current Waveform shows the waveform TX UnACK.

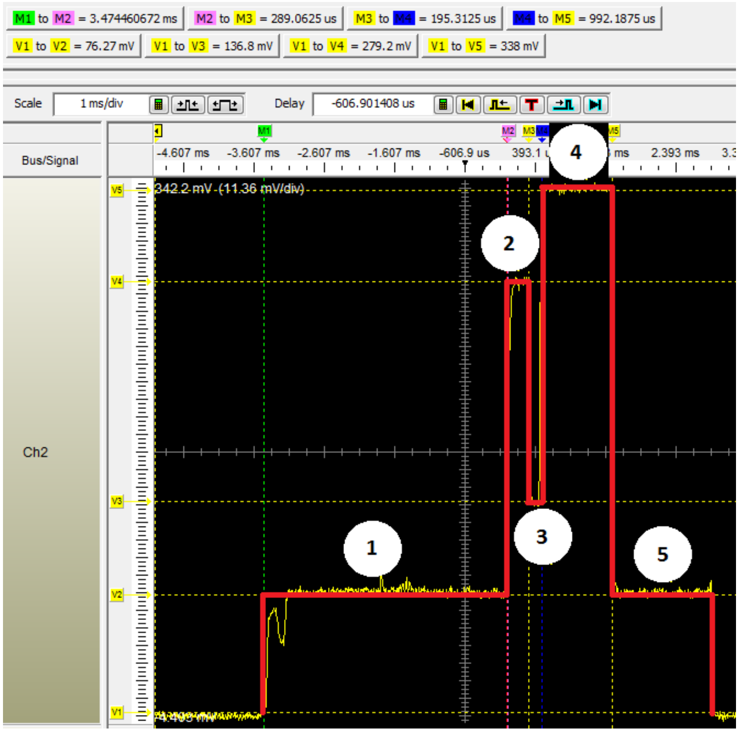

Figure 6. RC TX UnACK Current Waveform

The current consumption for the TX UnACK component is summarized in Table 4.

TX UN ACK (per event)	Time us	Current mA			mAms		
		0dBm	4.5dBm	7dBm	0dBm	4.5dBm	7dBm
1 - Wake-up and processing	3474,46	7,09	7,09	7,09	24,64	24,64	24,64
2 - CCA, radio in RX	273,44	25,27	25,27	26,00	6,91	6,91	7,11
3 - RX/TX switch	203,13	12,27	12,27	13,00	2,49	2,49	2,64
4 - TX For a 7 Bytes Packet (ZID mouse report)	1100,00	28,27	31,55	36,45	31,10	34,70	40,10
7 - Processing and shut-down	1492,19	7,09	7,09	7,09	10,58	10,58	10,58
Total for 7 Bytes packet	6543,21				75,72	79,32	85,07

Table 4. RC TX UnACK Component Average Current Consumption

6 RC Current Consumption Usage Model

This section uses the current consumption measurement in the previous section to establish the average RC current consumption when sending a message to a target in active mode and in standby mode.

The active mode and standby mode RC current consumption is used at the end of this section to calculate battery life time for the example usage model.

Note that interference triggering retransmissions at MAC and NWK layer is not accounted for in this model.

It is assumed that the full capacity is available to the device, i.e. it is within the cut off margin of 1.0V per cell. When estimating battery lifetime a self-discharge is subtracted. Research show that this self-discharge is between 8% and 20% per year. Based on the datasheet of the Energizer Eveready AA (http://data.energizer.com/PDFs/1215.pdf) the average capacity at 0.8V cut-off is 1100mAh. Since the self-discharge is a percentage of the capacity it is calculated recursively with a resolution of 1 day. This error margin on this discretizing is minimal.

6.1 Active Mode

The target receiver is always turned on when in active mode. The assumption is therefore that a message sent by the RC is ACKed within a short time. No assumptions are made with respect to a compromised channel triggering message retries.

The RC active mode current consumption is comprised of the key de-bounces component and 3 TX w/ACK components as shown in next table. The 3 messages come from ZRC transmission scheme. When a key is pressed for more than a certain interval, whose default value is 50ms, more than one message is sent. The first packet is a 'Pressed' message, and then the consecutive messages are 'Repeat'. The 'Repeat' messages continue until the key is de-pressed when a 'Release' message is sent. If we assume a user will keep a key pressed for 150ms we will generate 3 messages per key press.

Active Mode (per key press)	mAms		
	0dBm	4.5dBm	7dBm
Key Debounce	7,18	7,18	7,18
TX w/ACK, 2 bytes packet size	91,04	94,06	99,46
Packets per key press 3			
Total for 2 Bytes packet	**280,31**	**289,36**	**305,55**

Table 5. RC Active Mode Current Consumption for a key press generating Acknowledged Packet

Active Mode (per key press)	mAms		
	0dBm	4.5dBm	7dBm
Key Debounce	7,60	7,60	7,60
TX wo/ACK, 2 bytes packet size	64,67	67,71	73,27
Total for 2 Bytes packet	**194,00**	**203,13**	**219,82**

Table 6. RC Active Mode Current Consumption for an event generating Unacknowledged Packet

6.2 Standby Mode

The target receiver is duty cycling when in standby mode. The message sent by the RC is therefore likely to be repeated multiple times before an ACK is received. The assumption is the target will respond to the message within a short time after enabling its receiver.

The RemoTI 1.3 target node sample project (RNP) is configured with nwkDutyCycle= 330 ms. This means the receiver is turned off for *nwkDutyCycle – nwkcMinActivePeriod* = (330 – 16.8) ms

Elapsed time for each TX w/o ACK component is 2.78 ms as seen in Table 3. Statistically, it is reasonable to assume a uniform distribution such that the number of TX attempts to wake up the target node from standby mode on average is (330 -16.8) ms / 3.0 ms x 0.5 = 52.

The standby mode current consumption is comprised of the key de-bounce component, the statistically averaged number of TX w/o ACK components and the TX w/ACK component as shown in Table 7.

Standby Mode (per key press)	mAms		
	0dBm	4.5dBm	7dBm
Key Debounce	7,18	7,18	7,18
TX w/oACK, 2 bytes packet size	3268,93	3428,19	3719,40
TX w/ACK, 2 bytes packet size	91,04	94,06	99,46
Total for 2 Bytes packet	**3276,11**	**3435,37**	**3726,58**

Table 7. RC Standby Mode Current Consumption

6.3 Example Usage Model with ZRC Profile

A RC usage model is application specific in terms of how many target nodes it controls, number of messages sent when the target is in standby mode and in active mode. This application note assumes a usage model where the RC is controlling four target nodes with the following occurrences per day, using only ZRC profile command;

1. TV
   a. 2 RC key presses when in standby mode
   b. 50 RC key presses when in active mode
2. Receiver
   a. 2 RC key presses when in standby mode
   b. 100 RC key presses when in active mode
3. DVD/Blu-ray
   a. 1 RC key press when in standby mode
   b. 20 RC key presses when in active mode
4. STB
   a. 0 RC key presses when in standby mode (always powered on)
   b. 100 RC key presses when in active mode

In order to calculate the total average current consumption for the example RC usage model, we need to summarize the RC sleep, active mode and standby mode contributions for one day as seen in Table 8.

System	Number of units	Standby mode key presses	Active mode key presses	Standby mode current consump. (1)	Active mode current consump. (2)	Standby mode current consump.	Active mode current consump.	Standby mode current consump.	Active mode current consump.
				0dBm		4.5dBm		7dBm	
TV	1	2	300	6552	84094	6871	86809	7453	91664
Receiver	1	2	100	6552	28031	6871	28936	7453	30555
DVD/Bluray	1	1	20	3276	5606	3435	5787	3727	6111
Cable/Satellite	1	0	100	0	28031	0	28936	0	30555
Active current				16381	145762	17177	150469	18633	158885
Active Total (3)					162143		167646		177518
Sleep Total (4)					34560		34560		34560
Total Power consumption in a day (mAms)					**196703**		**202206**		**212078**

Table 8. RC Usage Model Total Average Current Consumption per Day

[1] Calculated by multiplying number of standby mode key presses with the RC standby mode current consumption (from Table 7)
[2] Calculated by multiplying number of active mode key presses with the RC active mode current consumption (from Table 5). In addition, it is assumed that a single key press will send a total of 3 messages to the target. This is to account for the repeat function of the ZRC specification.
[3] This is the sum of standby and active mode current consumption
[4] Sleep current is assumed for the entire day, in other words, the time the radio is active is not subtracted from the total sleep time. This is a fair assumption since the sleep current "adder" to the active current is negligible. Total sleep current for a day: 24h * 3600 s/h * 1000 ms/s * 0.4µA = 34560 mAms

The average RC power consumption with the described usage model is therefore, at 0dBm TX power:

(Total power consumption mAms)/day / (1000 ms/s) / (3600 s/h) / (24 h/day) =
(196703 mAms/day) / (1000 ms/s) / (3600 s/h) / (24 h/day) = <u>0.0023 mA</u>

With a 2000mAh battery, this effectively translates to a battery life time of:

(Battery capacity mAh) / (Average current consumption mA) / (24h/day) / (365 days/year) =
(2000 mAh) / (0.0023 mA) / (24 h/day) / (365 days/year) = <u>~100 years</u>

If one adds the battery's "self-discharge" it is apparent that, for this usage model, the battery's "self-discharge" is the main contributor to reducing battery lifetime, see Figure 7. Considering the battery's "self-discharge" the battery lifetime is reduced from ~100 years to between 15 and 28 years. The different curves in Figure 7 show that it is not the output power which is the determining factor, but the "self-discharge" factor.

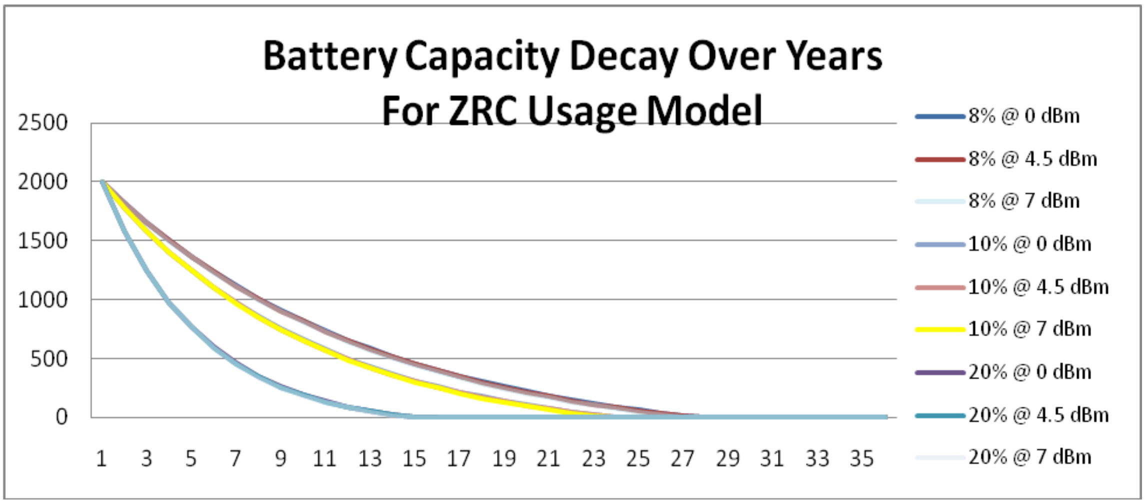

Figure 7. Battery Capacity Decay Over Years for ZRC Usage Model

See the accompanying Excel sheet for all the details.

6.4 Example Usage Model with ZID Profile – Pointing Remote

For this usage model, we start from the same one as the ZRC profile, and add 10 minutes of 'Air Mouse' usage per day.

For this feature, an interrupt pipe will be created that will send packets for an average time of 10 minutes. Each packet contains a mouse report containing mouse coordinate and button status for a total of 7 bytes.

Note the following important points:

- 10mn of 'air mouse' use is usually not consecutive. This can represent several session of 15s each of e.g. causal gaming, menu navigation, web surfing etc. that add up to a total of 10 minutes a day …
- The major assumption is that the Gyroscope is always activated during the 'air mouse' event. Some power optimization can be done here by activating them only when a new sensor reading is necessary. It is possible to model the active duration of those sensors during the active period. For the usage model presented in this report it is considered that the Gyro is 100% active. Sensors have an important impact on the overall consumption: it represents **54%** of the total consumption (at 0dbm) in the presented use case model.
- The Accelerometer is assumed duty cycled at 13.7%. This is based on 100Hz sensor reading rate from KXTF9. This device has 50us startup time, that combined with a sampling period equaling 1.32ms gives 1.37ms on-time. This is performed every 10ms, i.e. at 100Hz, in 'air mouse' mode.

The interrupt pipe model chosen is the following:

- aplIntPipeUnsafeTxWindowTime = 100ms: every 100ms an acknowledge multi channel packet is sent. All other packets sent are 'unacknowledged single channel'.
- Interrupt Pipe frequency = 100Hz: a new packet is sent every 10ms.

Mouse coordinate comes from a Gyro + accelerometer sensor. An example of consumption for those sensors is the following:
Gyro (IMU-3000)

- Active mode = 5.9mA
- Sleep mode = 5uA.

Accelerometer (KXTF9-4100)

- Active mode = 230uA
- Sleep mode = 0.1uA.

The interrupt pipe will add the following consumption:

System	Number of units	Active mode current consumption	Active mode current consumption	Active mode current consumption
		0dBm	4.5dBm	7dBm
	Number of mn			
Air Mouse (1)	10	2848125	2977725	3187739
	% Active			
Gyro Active	100	3540000	3540000	3540000
Accelerometer Active	13.7	18906	18906	18906
Gyro Sleep (2)		0	0	0
Accelerometer Sleep (2)		8580	8580	8580
ZRC use case (3)		162143	167646	177518
Total		**6612674**	**6747777**	**6967663**

Table 9. 'Air Mouse' Usage Model Total Average Current Consumption per Day

[1] Calculated by multiplying number of ACK packet sent with the current consumption of those packet(from Table 5) and added with the number of UnACK packet with the current consumption of those packet.(from Table 6).
[2] Sleep current is assumed for the entire day, in other words, the time the sensor is active is not subtracted from the total sleep time. This is a fair assumption since the sleep current "adder" to the active current is negligible. Note that the Gyro is in power down during sleep. Total sleep current for a day: 24h * 3600 s/h * 1000 ms/s * 1µA ~= 43500 mAms
[3] Value taken from Table 8

If we add those numbers to the ZRC profile model, the average RC power consumption with the described usage model is therefore, at 0dBm TX power:

(Total power consumption mAms)/day / (1000 ms/s) / (3600 s/h) / (24 h/day) =
(6612674 mAms/day) / (1000 ms/s) / (3600 s/h) / (24 h/day) = 0.0765 mA

With a 2000mAh battery, this effectively translates to a battery life time of:

(Battery capacity mAh) / (Average current consumption mA) / (24h/day) / (365 days/year) =
(2000 mAh) / (0.0765mA) / (24 h/day) / (365 days/year) = ~2,98 years

See the accompanying Excel sheet for all the details.

7 Target Node Current Consumption

7.1 Active Mode

The target node will keep the receiver on continuously when in active mode. The target will, however, enter TX mode and switch between RX/TX and TX/RX when ACKing a message received from the RC. The TX current is higher than the RX current, but since this event is very short and the contribution therefore is minimal it is reasonable to assume the target being in RX mode all the time for this calculation. As such, the average current consumption will be 26.90 mA as seen in Table 2, events 2 and 6.

7.2 Standby Mode

The target node standby current consumption depends on the active period and the duty cycle;

The most optimal power consumption is when *nwkDutyCycle = nwkcMaxDutyCycle*:
25.27 mA * *nwkcMinActivePeriod* / *nwkcMaxDutyCycle =*
25.27 mA * *16.8 ms* / *1000 ms = 0.42 mA*

The target node sample project (RNP) included with RemoTI 1.3 is setting *nwkDutyCycle* = 330 ms to enable low latency in addition to the power savings:
25.27 mA * *nwkcMinActivePeriod* / *nwkDutyCycle =*
25.27 mA * *16.8 ms* / *330 ms = 1.28 mA*

8 RC Current Consumption Usage Model Excel Sheet

An Excel sheet accompanies this application note to enable users to change the example RC usage model to match their application specifics.

The Excel sheet is comprised of the following tabs:

- ZRC Usage Model – This tab is used to configure the ZRC usage model specifics. The formulas uses data from the Power consumption Breakdown tab for the calculations.
- ZID Usage Model – This tab is used to configure the ZID usage model specifics. The formulas uses data from the Power consumption Breakdown tab for the calculations.
- Power Consumption Breakdown – This tab is used to calculate the power consumption components based on the Key Debounce, TX with ACK, TX UnACK and TX without ACK current profile measurements.
- Key Denounce – Current profile of the key de-bounce event.
- TX with ACK - Current profile of one message transmission with ACK received from the target node.
- TX without ACK - Current profile of repeated messages transmission without ACK received from the target node.
- TX UnACK - Current profile of repeated messages transmission unacknowledged.

The yellow cells in the RC Usage Model tab can easily be changed by customers to modify the model to match their specific application scenario.

9 Conclusion

This application note has illustrated that the power consumption for the RF part of an RC is very small. When the usage is low the self discharge is about 85% of the current consumption, as shown with the ZRC usage model described in this application note. Other system components e.g. LED, backlight, LCD, sensors etc. will likely be the major contributors to an RC total current consumption.

This application note has also illustrated the standby mode feature of a target node is instrumental for energy savings when the equipment is turned off.

References

[1] ZigBee RF4CE Specification (ZigBee Alliance document 094945r00ZB)

[2] http://focus.ti.com/docs/prod/folders/print/cc2530.html

[3] ZigBee RF4CE ZRC Profile Specification (ZigBee Alliance document 094946r00ZB)

[4] RemoTI API, SWRA268

10 General Information

10.1 Document History

Revision	Date	Description/Changes
SWRA263	2009.04.29	Initial release.
SWRA263A	2012-03-1	Correction, update for RemoTI1.3.
SWRA263B	2012-11-20	Update for RemoTI-1.3.1

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