

# **BALI/EVIA series**

**WiFi 802.11ac + BT5.0 LGA Wireless Modules**

## **BALI/EVIA BALI M.2/EVIA M.2 PCIe Power Measurement Guide**

**Version 0.3**

## Table of Contents

1. Scope of the Document .....	3
2. Introduction .....	4
2.1 How do you save power.....	4
2.2 Power save in WLAN .....	4
2.3 Power save mode.....	4
2.4 Constraints of Power Save Mode.....	6
3. PCIe and PCIe M.2 Power Measurement procedure .....	7
3.1 Measurement Setup .....	7
3.1.1 Procedure with Power measurement device .....	8
3.2 Deep sleep Power save measurement procedure.....	8
3.3 Legacy (DTIM) Power save measurement procedure.....	9
3.4 Continuous Tx/Rx Power measurement procedure .....	11
3.5 Power Consumption numbers on BALI PCIe and PCIe M.2.....	12
3.5.1 Graphical representation .....	12

### Table of Figures

Figure 1: Active mode vs Power save mode .....	5
Figure 2: Power measurement tapping point on PCIe and PCIe M.2 .....	7
Figure 3: BALI PCIe M.2 Power consumption measurement setup.....	7
Figure 4: JP20 2 <sup>nd</sup> (VDD_3P3_MOD) pin.....	8
Figure 5: Deep sleep current measurement in Power measurement device(Otii Arc) .....	9
Figure 6: Communication between AP and STA while STA is in PSM .....	10
Figure 7: DTIM Power consumption results .....	11
Figure 8: Power consumption numbers graphical representation.....	12

### Table of Tables

Table 1: BALI/EVIA WLAN current numbers .....	12
---	----

## 1. Scope of the Document

This document describes how to measure Power consumption numbers on BALI PCIe and PCIe M.2 EVK in different modes like Standby mode and Power save mode, also describes what is Standby mode and what power save mode how it is enabled, those all things are covered in this document.

---

## 2. Introduction

### 2.1 How do you save power

- Physical
  - Sending information determined by physics of RF transmission
  - 802.11 specifications is defined and limited by regulatory limits
  - Existing Transmit power management in proprietary hardware
- Transmit efficiency
  - Increasing the % of real data in the information consuming energy
- Turning things off
  - Minimizing power draw while waiting for information to send

### 2.2 Power save in WLAN

- Power save modes have always been part of 802.11 specification
  - Included in original 1999 specification
- Originally designed for wirelessly connecting laptops to networks
  - Large batteries
- Only recently with the addition of WiFi to mobile devices have smaller batteries been used with WiFi enabled devices
- Greater focus on power save within WLAN
- Latest applications are the motivation
  - IP phones
  - IP video distribution (Netflix, Hulu, etc.)
  - Internet radio (Milk, Slacker, etc.)

Here we are discussed about Deep sleep and Legacy Power Save Mode

Standby mode means when device is receiving power but is not running, that mode is named as standby mode. In standby mode the device goes to Deep sleep state, it is not completely turned off.

### 2.3 Power save mode

- Part of the original 802.11 standard
- Constrained by the infrastructure (AP and STA)
- Looking to address the demands of the modern platforms (1999)
- What is PSM?
  - It utilizes the beacon period of the AP
  - A Power save bit in the packet from the client
  - The Traffic Indication map (TIM)
  - A listening period called DTIM
  - A PS-Poll packet to initiate information delivery
- Why use it?
  - Provides a method by which the STA can sleep when information is not being transferred

- Below diagram represents the difference between Active mode station and Power Save Mode enabled station.

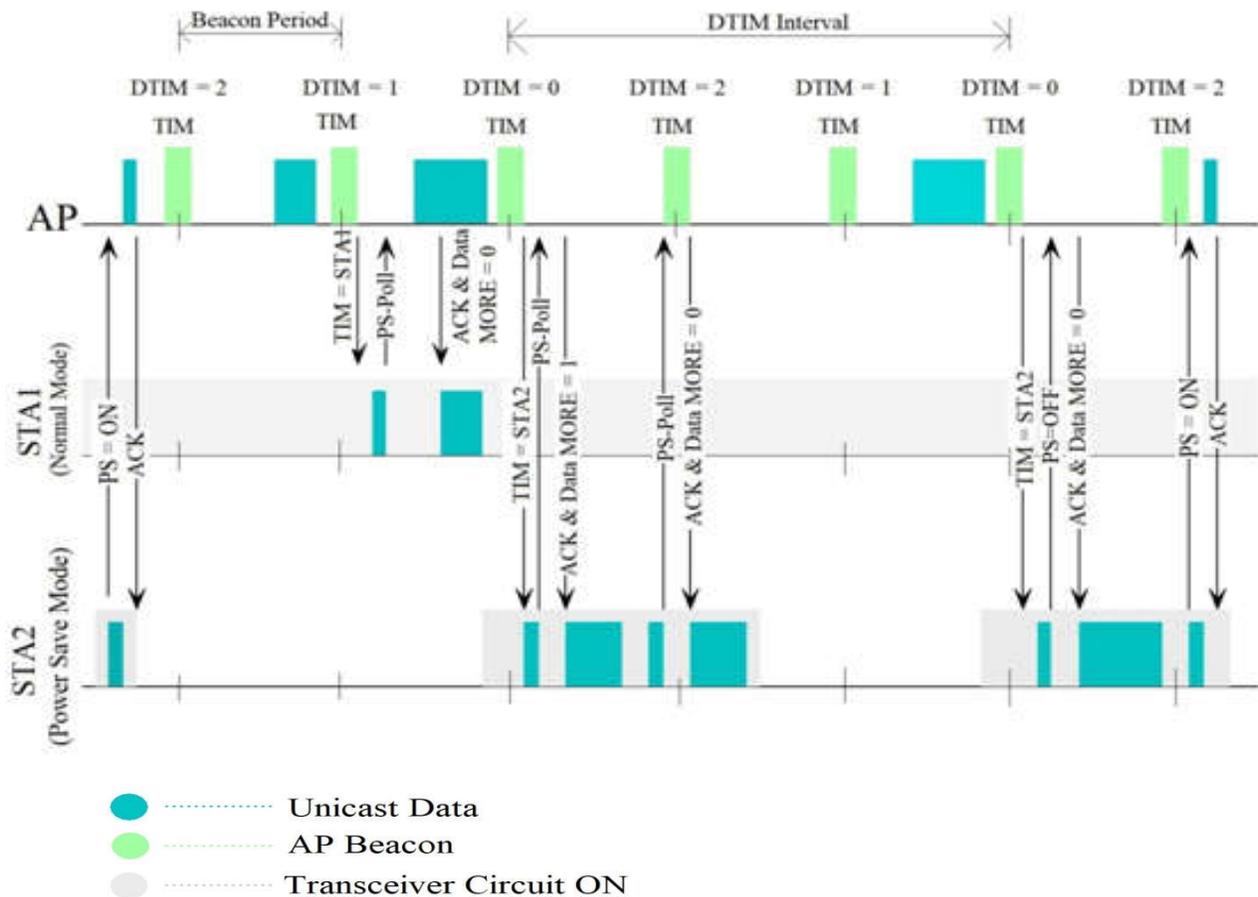


Figure 1: Active mode vs Power save mode

### Beacon Period:

A beacon is a packet broadcast sent by the router that synchronizes the wireless network. A beacon is needed to receive information about the router, included but not limited to SSID and other parameters.

The beacon interval is simply the frequency of the beacon – how often the beacon is broadcast by the router. Most routers are automatically set to a default of 100 milliseconds.

### DTIM Period (Listen Interval):

The Listen Interval field is used to indicate to the AP how often a STA in power save mode wakes to listen to Beacon management frames. It is expressed in units of beacon interval. The value 0 might be used by a STA that never enters power save mode.

DTIM stands for Delivery traffic indication map or message. It is basically an additional message added after the normal beacon broadcast by your router or access point.

Depending on the timing set for your router, the router “buffers” broadcast and multicast data and let your mobile devices or clients know when to “wake up” to receive those data.

The more often that DTIM is transmitted, the more often that your mobile devices wake up, and the more battery that it uses (due to the lack of “sleep”). By setting a low value of DTIM and beacon interval, you can effectively keep your devices awake indefinitely so they never go into sleep mode when idling. In some cases the “no sleep” setup can use up to 10~20% additional power consumption.

The following is a tool-tip message when you check for DTIM setting for Asus branded routers: DTIM (Delivery Traffic Indication Message) is included in Beacon packet. The DTIM interval (1-255) means the period of time to wake up wireless clients from Sleep Mode. The default value is 3.

Router settings typically let you setup the “DTIM Interval” where you can calculate the DTIM period. However, some routers may also let you setup the period directly but that is rare.

Coming to BALI, the BALI PCIe and PCIe M.2 supports Legacy power save mode, it DTIM based power save. The Legacy power save management is summarized with followed below steps,

- Before STA\_UT goes into the doze state, it sends a frame, usually null data frame, to the AP indicating that power management is enabled.
- Once STA\_UT indicates that it is in Power Save mode, the AP begins to buffer all frames destined to that station.
- When the STA\_UT goes into awake state, it sends a PS-Poll frame to the AP in order to begin the data retrieval process
- When AP has finished sending all buffered data to the station, the STA\_UT goes back into the doze state

## 2.4 Constraints of Power Save Mode

- Latency vs. band width vs. power
  - Bound to AP beacons
  - Trade-off between latency and power
  - Leads to a trade-off between bandwidth and power
- Compatibility with AP, too long a DTIM and data can be discarded and even stability of association to AP’s can suffer.
- PSM is not suited to high data demand due to PS-Poll packet.
- Applications like IP phones and video streaming impacted by the PSM process.
- Difficult to balance network performance and power save demands
  - AP’s set conditions
  - STA are driven by applications

### 3. PCIe and PCIe M.2 Power Measurement procedure

On BALI PCIe and PCIe M.2 the Power measurement tapping point is JP20.

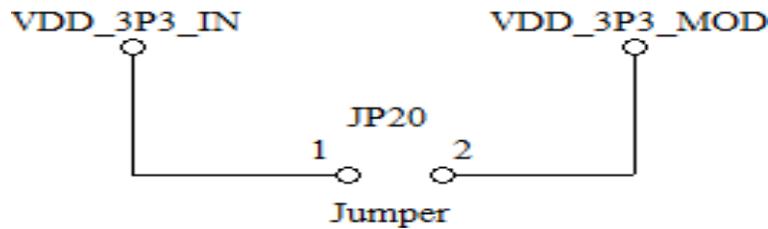


Figure 2: Power measurement tapping point on PCIe and PCIe M.2

#### 3.1 Measurement Setup

The BALI PCIe/PCIe M.2 Power consumption numbers are measured with below setup

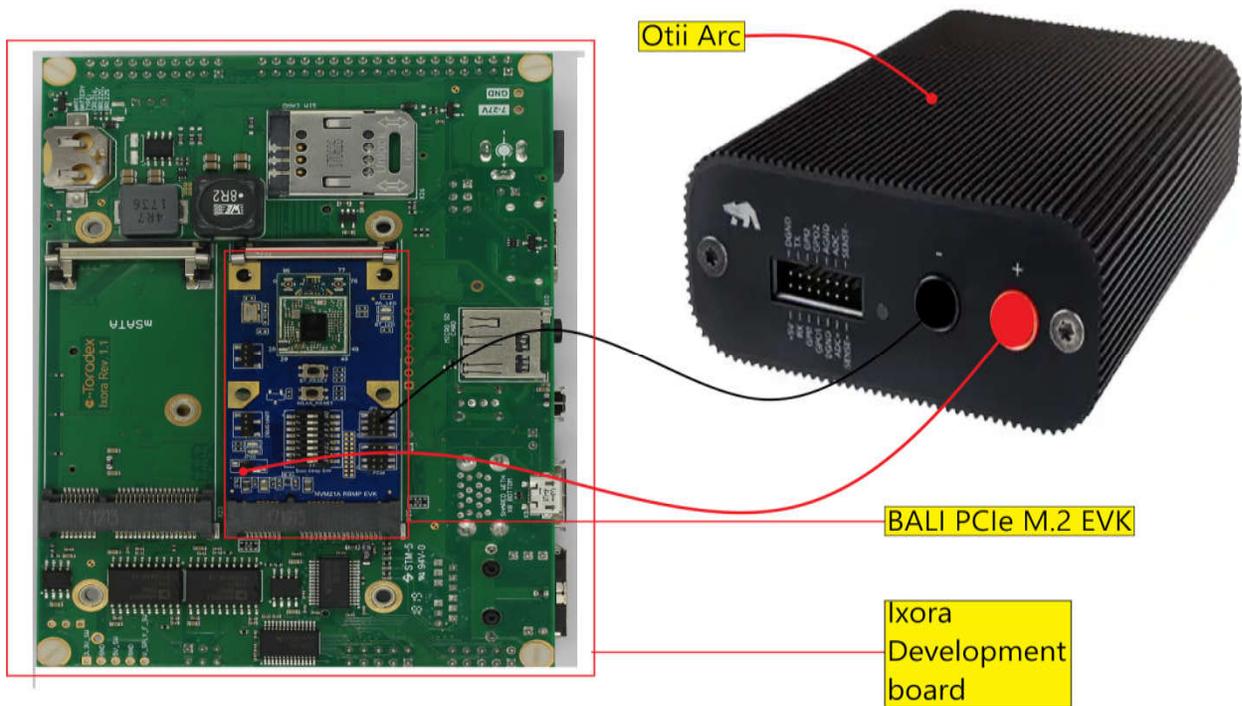


Figure 3: BALI PCIe M.2 Power consumption measurement setup

Here the Otii Arc is used as a current measurement unit for BALI PCIe/PCIe M.2 EVK.

The Otii Arc acts both as a power supply to the IoT device being tested, and as a current and voltage measurement unit. It provides up to 5 V output voltage and 5 A current, and runs nA resolution current measurements with a sample rate up to 4 ksp/s.

You connect the main out of the Otii Arc to either the DC-input, or for a battery powered device, to the battery connectors of your device (remember to remove the battery first).

The Power measurement device (Otii Arc) can either be powered by USB, or by using an external DC-adapter.

### 3.1.1 Procedure with Power measurement device

- Connect the Power measurement device –ve to Ground(In above image –ve is connected to JP9 7th pin)
- Connect the Power measurement device +ve to JP20 2nd pin(VDD\_3P3\_MOD), in below image the highlighted pin is JP20 2nd pin

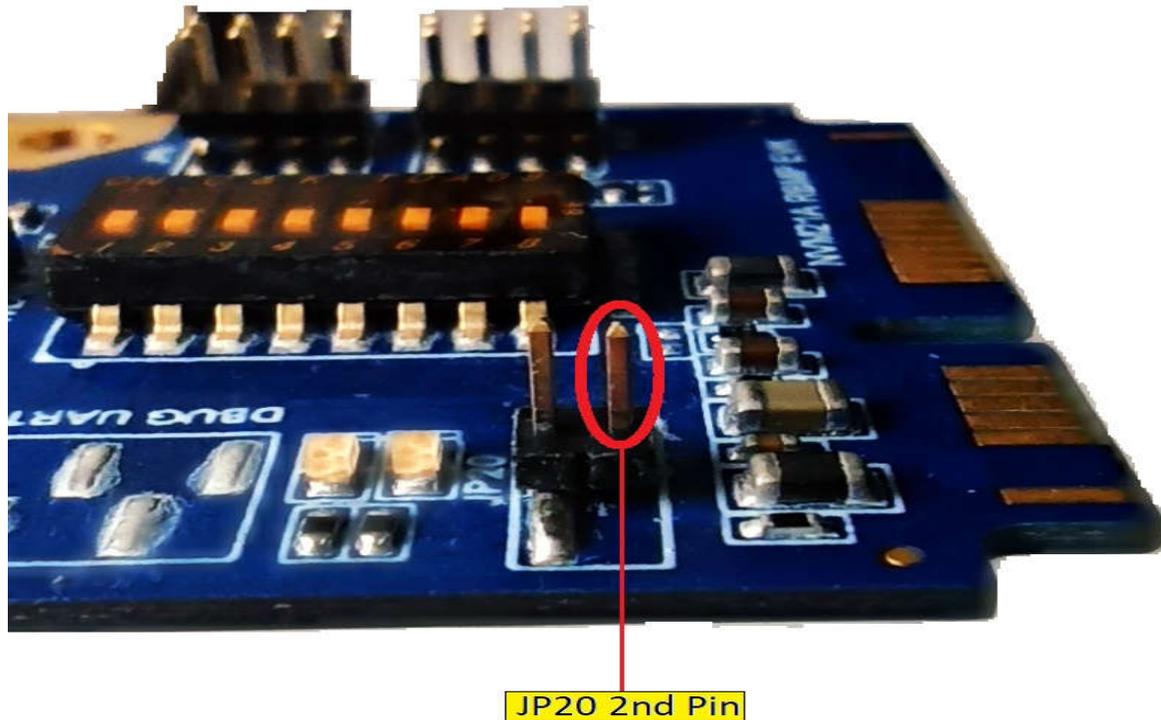


Figure 4: JP20 2<sup>nd</sup> (VDD\_3P3\_MOD) pin

- Follow below link and connect Power measurement device to PC and then in Quick configuration give input voltage as 3.3V/1.8V  
<https://www.qoitech.com/products/standard>
- Now insert the EVK into proper slot and power ON the Ixora board

**Note:** Here you need to turn on Ixora board as well as 3.3V/1.8V from Otii Arc then only device is detected

### 3.2 Deep sleep Power save measurement procedure

- Insert the EVK, load the driver files if needed and up the Interface
- Enable Power save by using below command

```
$ iw <wlan_interface> set power_save on
```

- Observe the current in Power measurement device(Otii Arc), that is the Deep sleep current in standby mode

- The output is just like below



Figure 5: Deep sleep current measurement in Power measurement device(Otii Arc)

- Measure the average current in Power measurement device
- In above image the average current is the deep sleep current for BALI PCIe M.2

### 3.3 Legacy (DTIM) Power save measurement procedure

Make sure the DTIM is enabled in AP and set DTIM value and beacon interval, by default beacon interval is 100ms. Based upon the DTIM value and beacon interval the power values are changed. If the DTIM value increased, the power values are decreased i.e., the DTIM value is directly proportional to the power save. Increase the DTIM value until the loose connection from AP to STA\_UT. The power save time is calculated by using below formula,

Power save time = DTIM interval \* beacon interval

For suppose DTIM value is 2 and beacon interval is 100 means, for every 200ms the STA\_UT sends PS-Poll control frame to request AP to send a buffered unicast frame. In that frame if AP set “more data” bit to 1 the STA\_UT understand AP has more data to send & therefore remain in awake state & send another PS-Poll frame to get next frame. After that the STA\_UT again goes to sleep state for 200ms.

Below image represents communication between AP and STA\_UT, while ST A is in power save mode. The above procedure is diagrammatically represented in below picture.

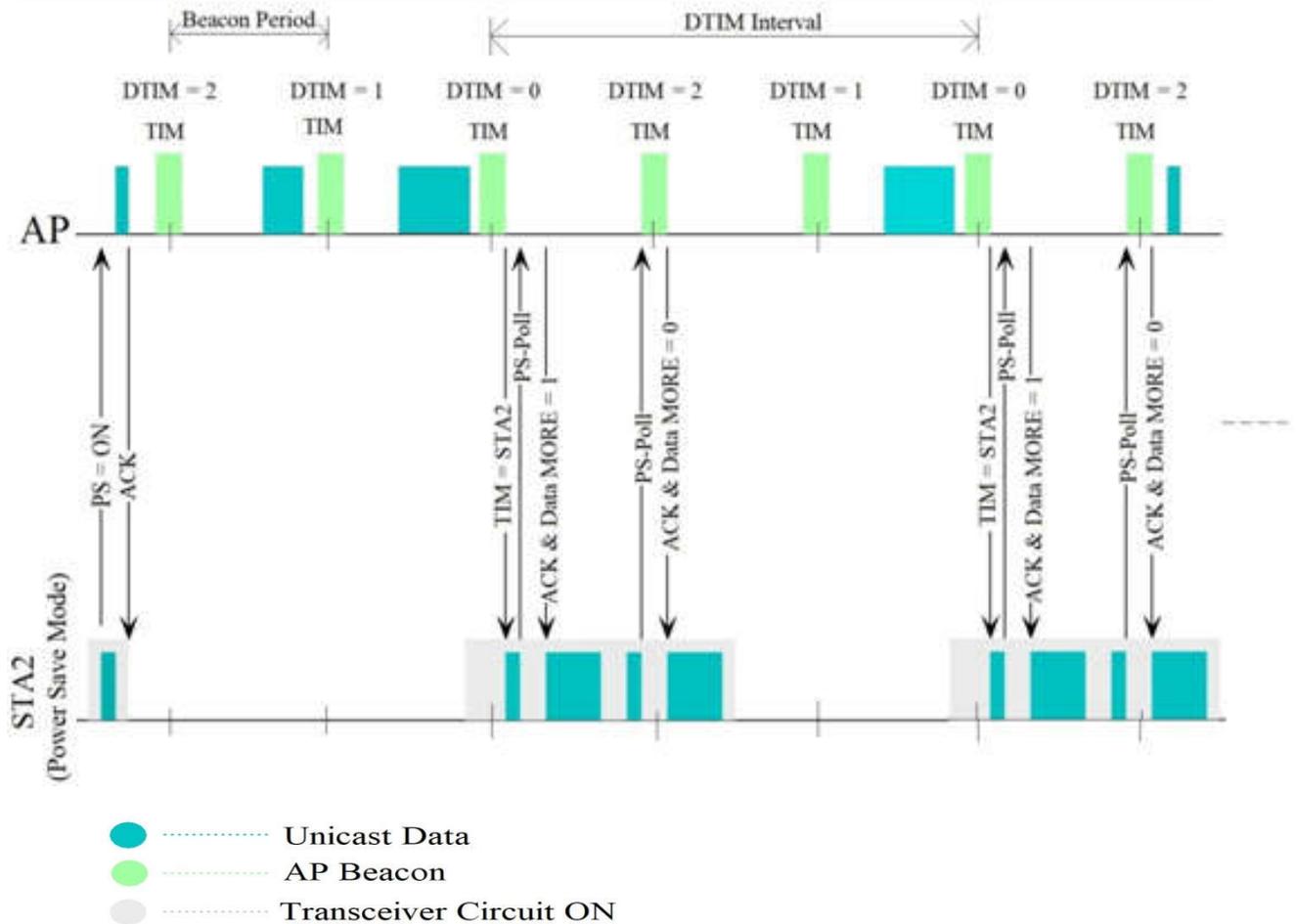


Figure 6: Communication between AP and STA while STA is in PSM

- After changes done in the AP, save the settings in AP and logout.
- Insert the PCIe EVK, load the driver files if needed and up the interface
- Enable Power save by using below command

```
$ iw <wlan_interface> set power_save on
```

- Connect to the AP by using below command

```
$ sudo iw dev <wlan_interface> connect <AP_SSID>
```

- Now observe the DTIM Power numbers in Otii Arc
- Follow same procedure with different DTIM numbers

- The output is just like below



Figure 7: DTIM Power consumption results

- Measure the average current between two PS-Polls , that is the DTIM current consumption number
- The above diagram represents BALI PCIe M.2 DTIM based power consumption numbers

### 3.4 Continuous Tx/Rx Power measurement procedure

- Insert the PCIe EVK, load the driver files if needed and up the interface
- Connect to AP and get the IP by using below commands

**Note:** Below commands is for connect to open AP.

```
$ sudo iw dev <wlan_interface> scan
```

```
$ sudo iw dev <wlan_interface> connect <AP_SSID>
```

```
$ dhclient -i <wlan_interface> -v
```

- Ping with AP to verify connection status

```
$ ping <AP_IPaddr>
```

- Run the server at another side by using below command

```
$ iperf3 -s -i 1
```

- Now run continuous Tx from STA\_UT by using below command

```
$ iperf3 -c <servr_IP> -u -i 1 -t 100
```

- Now observe the current in Otii Arc for continuous Tx
- Run continuous Rx from STA\_UT by using below command

```
$ iperf3 -c <servr_IP> -u -i 1 -t 100 -R
```

- Now observe the current in Otii Arc for continuous Rx

### 3.5 Power Consumption numbers on BALI PCIe and PCIe M.2

#### 3.5.1 Graphical representation

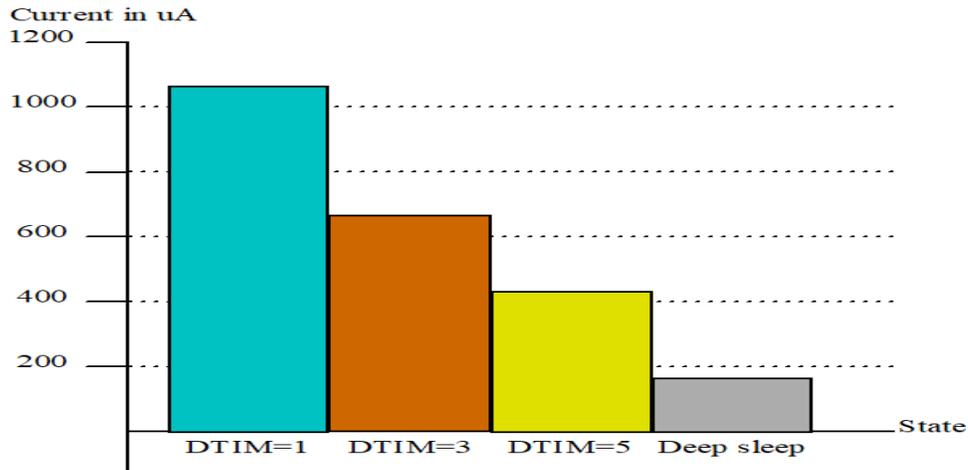


Figure 8: Power consumption numbers graphical representation

Mode	State	Power consumption (in mA)
Standby	Deep sleep	TBD
Power save 2.4 GHz	DTIM = 1	TBD
	DTIM = 3	TBD
	DTIM = 5	TBD
Power save 5 GHz	DTIM = 1	TBD
	DTIM = 3	TBD
	DTIM = 5	TBD
Regular	Continuous Tx	TBD
	Continuous Rx	TBD

Table 1: BALI/EVIA WLAN current numbers